**FEDERAL ENERGY REGULATORY COMMISSION
OFFICE OF HYDROPOWER LICENSING**

FINAL ENVIRONMENTAL IMPACT STATEMENT

**PROPOSED MODIFICATIONS TO
THE LOWER MOKELUMNE RIVER PROJECT, CALIFORNIA**

FERC Project No. 2916-004

(Licensee: East Bay Municipal Utility District)

Division of Project Compliance and Administration
Federal Energy Regulatory Commission
825 North Capitol Street, N.E.
Washington, DC 20426

November 1993

MASTER

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COVER SHEET

- a. Title: Proposed Modifications to the Lower Mokelumne River Project, California, FERC Project No. 2916-004.

Proceeding to consider modifications to an existing hydropower project for the conservation and development of fish and wildlife resources. This project includes Pardee and Camanche Dams on the Mokelumne River which are currently licensed to East Bay Municipal Utility District for hydropower production.

- b. Final Environmental Impact Statement (FEIS)
- c. Lead Agency: Federal Energy Regulatory Commission
- d. Cooperating Agency: None
- e. Abstract: Chinook salmon and steelhead trout populations in the lower Mokelumne River have experienced recent declines and fish kills associated, in part, with discharges from Camanche Dam. The California Department of Fish and Game and the California Sportfishing Protection Alliance have asked the Commission to investigate and correct these problems. A wide range of different mitigation actions has been proposed by parties participating in the scoping of this proceeding, and staff has evaluated these proposed actions in this assessment. The staff is recommending a combination of flow and non-flow modifications to the existing license, including new minimum flow and minimum pool elevation requirements at Camanche Reservoir, ramping rates on dam releases, interim attraction and out-migrant spike flows, instream habitat improvements, and a series of studies and monitoring to determine feasible means for solving off-site fish passage problems.
- f. Contact: John A. Schnagl
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- g. Copies of the FEIS are available for public review at the San Francisco Regional Office of FERC.
- h. This FEIS has been prepared by the Commission's staff in connection with a proceeding to consider modifications of facilities and operation of the Lower Mokelumne River Project. Proposed modifications are for the specific purpose of conserving anadromous fisheries in the lower Mokelumne River. This final statement is being made available to the public on or about November 1, 1993, as required by the National Environmental Policy Act of 1969 and the Commission's Regulations Implementing the National Environmental Policy Act of 1969 (52 FR 47897; 47910-47911; December 17, 1987).

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LIST OF ACRONYMS AND ABBREVIATIONS

AMD	Acid Mine Drainage
BMP	Best Management Practices
CCWD	Contra Costa Water District
CDFG	California Department of Fish and Game
CDWA	Central Delta Water Agency
CDWR	California Department of Water Resources
cfs	Cubic feet per second
COE	U. S. Army Corps of Engineers
Commission	Federal Energy Regulatory Commission
CRWQCB	California Regional Water Quality Control Board
CSMR	Committee to Save the Mokelumne River
CSPA	California Sportfishing Protection Alliance
DEIS	Draft Environmental Impact Statement
DO	Dissolved oxygen
EBMUD	East Bay Municipal Utility District
EPA	U.S. Environmental Protection Agency
EVS	EVS Consultants
FEIS	Final Environmental Impact Statement
FWS	U.S. Fish and Wildlife Service
GPD	Gallons per day
IFIM	Instream Flow Incremental Methodology
JVID	Jackson Valley Irrigation District
LHS	Life-stage habitat scores
LMRMP	Lower Mokelumne River Management Plan

LMRP	Lower Mokelumne River Project
MGD	Million gallons per day
MRFF	Mokelumne River Fish Facility
MRM	Mokelumne River Mile
MSL	Mean sea level
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NPDES	National Pollution Discharge Elimination System
NSJWCD	North San Joaquin Water Conservation District
PFMC	Pacific Fishery Management Council
PG&E	Pacific Gas and Electric Company
PHABSIM	Physical Habitat Simulation
State Board	State Water Resources Control Board
staff	Staff of the Office of Hydropower Licensing, FERC
TAF	Thousand acre-feet
THM	Trihalomethanes
tWUA	temperature-modified weighted usable area
USGS	United States Geological Survey
WID	Woodbridge Irrigation District
WSMP	Water Supply Management Plan
WUA	Weighted Usable Area

EXECUTIVE SUMMARY

This final environmental impact statement (FEIS) has been prepared for the Federal Energy Regulatory Commission (Commission) to consider modifications to the existing Lower Mokelumne River Project (LMRP) (FERC Project No. 2916-004) in California. The potential need for project modifications is related to the protection of anadromous salmon and steelhead in the Lower Mokelumne River. The LMRP is a multipurpose, multiple-reservoir system that was licensed in 1981 to the East Bay Municipal Utility District (EBMUD) of Oakland, California. In addition to producing hydroelectricity, the project supplies almost all of the drinking water for the East Bay service area (approximately 1.2 million people). The LMRP facilities are located on the mainstem of the Mokelumne River in the Central Valley of California and the foothills of the Sierra Nevada Mountains, about 35 miles southeast of Sacramento and 73 miles northeast of Oakland. The facilities include Pardee Dam and Reservoir (construction completed in 1929), Camanche Dam and Reservoir (construction completed in 1964), the Mokelumne aqueducts, and a series of terminal storage reservoirs in the East Bay area. Penn Mine, an abandoned copper and zinc mine, is located partially within the LMRP project boundary on the southeast shore of Camanche Reservoir.

Chinook salmon and steelhead trout in the lower Mokelumne River have experienced recent population declines and fish kills associated, in part, with discharges from Camanche Dam. Other stresses, such as irrigation diversions and acid mine drainage, have been affecting the fishery resources in the lower river for most of this century. The current LMRP license includes articles that allow the Commission to prescribe releases from the project and to order project modifications as necessary for "the conservation and development of fish and wildlife resources." The California Department of Fish and Game (CDFG) and the California Sportfishing Protection Alliance asked the Commission to investigate and correct fishery impacts in the river. In January 1992, CDFG issued its "Lower Mokelumne Fisheries Management Plan" in which it recommended significant changes in LMRP operations. EBMUD also issued its own management plan for the lower river which also recommends modified project operation. The California State Water Resources Control Board (State Board) initiated a water rights hearing in November, 1992, to address these problems and alternative plans. The Commission's proceeding is designed to complement the State Board's hearing so that information generated by both proceedings may be shared in a timely manner.

Consistent with the Commission's responsibility under the Federal Power Act and with the authority defined in Articles 12 and 15 of EBMUD's license, this proceeding is limited to actions directly related to the fish and wildlife resources in the Lower Mokelumne River. A large number of different mitigation actions were identified during the scoping process for this assessment, and those that are within the scope of this proceeding are evaluated in this FEIS. Generally, four sets of mitigation alternatives are considered in the FEIS, each of which is comprised of a series of actions to improve conditions for naturally spawning salmon and trout in the lower river. The recommendations made by CDFG represent a comprehensive set of solutions that can be considered as the proposed action. The plan that EBMUD has developed is another alternative approach that is considered. A third alternative considered is staff's own recommendations that have been developed independently during the course of this assessment. The fourth alternative is a minimum flow regime proposed by the U.S. Fish and Wildlife Service (FWS) in their comments on the draft environmental impact statement. In addition to the CDFG, EBMUD, staff, and FWS alternatives, the no-action alternative is also considered in the FEIS. All appropriate alternatives are evaluated in terms of: 1) the benefits that would be accrued to anadromous fishery resources in the lower Mokelumne River; and 2) the costs each action would impose on EBMUD's water supply system.

The alternatives evaluated include both flow and non-flow mitigation. The flow-related actions considered in the FEIS are mitigation that would directly alter the LMRP reservoir operations and consequently have potential impacts to EBMUD's water supply system. Flow mitigation actions include minimum flow requirements from Pardee and/or Camanche dams, minimum pool elevations in the reservoirs, constraints on the rate of change of releases from the dams (i.e., ramping rates), and short-term increases in flows (pulse flows) to stimulate and facilitate upstream and downstream migrations of anadromous fish. The non-flow actions that are considered do not directly affect reservoir operations, but are intended to benefit the natural reproduction cycle of salmon and trout in the lower river. The non-flow actions considered in the FEIS include habitat enhancement measures (e.g., spawning gravel replenishment), hydraulic improvements to Woodbridge Dam and Lake Lodi that are downstream from Camanche Dam, improved fish ladders and fish screens, and water quality improvements at Camanche Dam. Improvements at Woodbridge Dam and Lake Lodi are critical to successful mitigation efforts. Although these are outside the LMRP boundary, it is not likely that the natural reproduction of chinook salmon can be improved in the lower river without eliminating the serious barriers to migration that exist in the vicinity of Lake Lodi which lies between Camanche Dam and the Sacramento-San Joaquin Delta.

Because of the implications that minimum release requirements have to the EBMUD water supply system, this issue is the most important difference among the alternatives considered. A 1961 agreement between EBMUD and CDFG that was incorporated in the LMRP license provides for 13 thousand acre-ft (TAF) of water to be released in normal and wet water years from Camanche Dam for downstream fish resources. The CDFG alternative would increase these minimum releases significantly to between 98 and 262 TAF/yr depending on the water year type. EBMUD's alternative provides between 28 and 118 TAF for fish resources, and staff's alternative provides between 51 and 160 TAF, depending also on water year type. The FWS alternative would require releases of 121 TAF in dry or critically dry water years and 193 TAF in normal or wet years. In comparison to these different release requirements that are considered, EBMUD's current (1990-normalized) water demand is approximately 247 TAF, and the median unimpaired flow of the Mokelumne River into the LMRP is approximately 700 TAF. In addition to the differences in total annual release, there are also significant differences in the seasonal patterns of the minimum flows and in the definition of water year types among the alternatives considered in the FEIS.

The assessment approach used in the FEIS accounts for and protects existing water rights in the lower river. However, the minimum flow regimes recommended by CDFG, FWS, and staff would all produce some water supply deficit to EBMUD in dry water years. Under an upper-bounding, three-year drought and staff's estimate of EBMUD's future (2020) water demand, the CDFG minimum flows would produce a supply deficit of approximately 145 TAF/yr with an annual replacement cost to EBMUD of \$20 million. EBMUD's minimum flows would produce no deficit under the same low-flow and future demand scenario. Staff's minimum flows would produce a equivalent deficit of 10 TAF/yr and a replacement cost of between \$12.6 and \$18.1 million depending on EBMUD's mode of replacement. The FWS minimum flow alternative would produce deficits and replacement costs similar in magnitude to the CDFG alternative.

Increased minimum flows at Camanche Dam would produce important environmental benefits, because they would increase available habitat and water temperatures for chinook salmon and steelhead trout. The flows required by CDFG and staff would produce the most benefit to chinook spawning, increasing the median physical habitat available by more than 50% compared to no action. The flows proposed by EBMUD would provide benefits to fry and juvenile habitat, but would have significantly less benefit to spawning. When the effects of improved habitat availability from minimum flows are combined with the benefits of decreasing water temperatures and stabilizing flows with ramping rates, the natural conditions in the river would be significantly better compared to the no-action alternative.

Water temperatures downstream of Camanche Dam could be maintained at lower levels throughout the summer months of hot, dry years if minimum pool elevations were required at Camanche Reservoir, but these requirements could also have additional adverse impacts on EBMUD's water supplies. The costs to EBMUD's water supply system would occur mostly in dry years and be roughly proportional to the volume withheld (e.g., 238 TAF for the CDFG alternative or 156 TAF for the staff alternative). However, these costs would also depend on the implementation strategy that was ultimately adopted. If deficit sharing were implemented as staff recommends, then costs to EBMUD's system could be minimized. For example, staff's alternative allows for the minimum pool elevation of Camanche Reservoir to be reduced from 190 to 175 ft in the second or third consecutive dry water year. The benefits and costs of other flow-related actions are even more difficult to quantify. There is little disagreement over the need for ramping rates among alternatives, but the biological response to this mitigation is poorly understood. Evidence for a biological response to attraction flows is also lacking. Therefore, staff recommends interim measures combined with monitoring to evaluate the effectiveness of the proposed mitigation.

Non-flow mitigation actions have important advantages, because they do not incur direct effects on the operation of EBMUD's water supply system. The overall cost of these actions can be high, however. Staff has not estimated the cost of all the non-flow alternatives in the FEIS because of lack of specific design information. Improvements in the hydraulics of Lake Lodi are the most important non-flow action that can be taken. Staff encourages that EBMUD participate in a cooperative effort to resolve the fish passage problems at Woodbridge Dam and Lake Lodi. If improvements cannot be made in this area in the near future (e.g., within 5 years), the recommendations in the FEIS may have to be reconsidered.

Based on the analyses presented in the FEIS, the staff recommends a combination of flow and non-flow modifications to the existing license: we recommend new minimum flow and minimum pool elevation requirements at Camanche Reservoir, ramping rates on dam releases, experimental attraction and out-migrant pulse flows in the fall and spring, and instream habitat improvements. A series of studies and monitoring are also recommended to determine feasible means for solving off-site fish passage problems. Staff's final recommendations are based on an independent analysis of an extensive record of studies and testimony, including the exhibits and testimony presented at the State Water Resources Control Board's water rights hearing on the lower Mokelumne. This record supports the need for project modification and the fact that such modifications can be made in an acceptable manner without significant adverse impacts to municipal water supplies. However, there is a high degree of uncertainty in the present and future water uses and regulatory actions within and outside the Mokelumne River basin. If and when new information is obtained as a result of the many proposed and ongoing monitoring and regulatory proceedings, these license modifications may be reconsidered.

1. INTRODUCTION

The Federal Energy Regulatory Commission (Commission) is conducting a proceeding to determine whether modifications in the facilities or operations of the Lower Mokelumne River Project (LMRP) (FERC Project No. 2916-004) are needed for the conservation and development of fish and wildlife resources. The licensee for this existing project is East Bay Municipal Utility District (EBMUD). The LMRP facilities are located in central California (Figures 1.1-1 and 1.1-2) and include two large, multipurpose reservoirs (Camanche and Pardee Reservoirs) that were licensed for hydropower operations in 1981. Modifications to this project may constitute a major federal action significantly affecting the quality of the human environment, as defined by the National Environmental Policy Act (NEPA) of 1969 (Pub. L. 91-190) and the Commission's regulations for NEPA compliance (18 C.F.R. Part 380). Therefore, the Commission's staff (staff) prepared this Environmental Impact Statement (EIS) to support any decision that may be made by the Commission to modify project facilities or operations.

Figure 1.1-1. Location of the Camanche and Pardee Reservoirs and the Mokelumne River Basin in central California. (Source: The staff 1993.)

Figure 1.1-2. Central California area showing the relationship between the Mokelumne Watershed and the service area of East Bay Municipal Utility District. (Source: EBMUD 1991.)

1.1 PURPOSE AND NEED FOR ACTION

In certain limited circumstances, the Commission has the authority and the responsibility to reevaluate the operation and facilities of an existing, licensed hydroelectric project. This authority is based on Section 10(a)(1) of the Federal Power Act and, in this proceeding, on Articles 12 and 15 of the LMRP license (see Appendix A). Under Article 15, the Commission is required to determine whether modifications are appropriate for the conservation and development of fish and wildlife resources if the Commission is petitioned by state or federal agencies. The Commission received a report of fish kills at the Mokelumne River Fish Facility (MRFF) located below the LMRP's Camanche Dam from the California Department of Fish and Game (CDFG) (1990 and 1991). The California Sportfishing Protection Alliance (CSPA) and the Committee to Save the Mokelumne River (CSMR) also raised serious concerns with respect to LMRP effects on fish and wildlife, particularly chinook salmon. In January 1992, CDFG issued a plan for managing the Lower Mokelumne River fisheries that describes numerous stresses to chinook salmon resources and recommends modifications to LMRP facilities and operation (CDFG 1991). Subsequent review of relevant information by the Commission's Division of Project Compliance and Administration indicated that complex issues exist involving competition over limited water resources in the Lower Mokelumne River, including anadromous fisheries, hydropower, irrigation, and municipal water supply. Therefore, the Commission initiated this proceeding and this EIS to further investigate the need to modify LMRP facilities and/or operations.

1.2 SCOPE OF THE ENVIRONMENTAL IMPACT STATEMENT

The proceeding to consider LMRP modifications was initiated by a Federal Register notice on July 1, 1991 following several communications between Staff and EBMUD. In response to the reports from CDFG and CSPA, letters were sent to the California State Water Resources Control Board (State Board), CDFG, U.S. Fish and Wildlife Service (FWS), California Regional Water Quality Control Board (CRWQCB)— Central Valley Region, and EBMUD requesting information about project operation and affects on downstream fishery resources. Review of the information received in response to these requests provided substantial evidence that project operation adversely affects both fishery and water quality resources in Camanche Reservoir and in the downstream Mokelumne River. Staff participated in a site visit to the LMRP facilities and the Lower Mokelumne River in late January 1992 to obtain additional information.

Preparation of a Draft EIS began with the issuance of an initial Scoping Document (FERC 1992a) and with a public scoping session held on Thursday, April 9, 1992, in Stockton, California. The purposes of the scoping process were to:

- identify significant environmental and economic issues related to potential changes in project facilities or operations;
- determine what issues should be covered in the EIS; and
- enable appropriate federal, state, and local resource agencies, developers, and other interested parties to effectively understand, participate in, and contribute to the assessment process.

During the scoping session, ten oral statements were received. The session was recorded by a stenographer, and all statements (oral and written) became part of the Commission's public record for Project No. 2916-004. Subsequent to the scoping session, 15 written comments were received by the Commission. Staff used these oral and written scoping comments to clarify the significance of issues and to distinguish between issues needing additional treatment and those that did not merit treatment in the Draft Environmental Impact Statement (DEIS). The results of the scoping process were published in a revised Scoping Document (FERC 1992b) and distributed to interested parties on August 20, 1992.

Scoping comments generally elaborated and clarified the issues identified in earlier communications among the licensee, the Commission, and other interested parties. Comments from the licensee and other water users (i.e., representatives from cities, counties, and water districts) expressed concerns over the proceeding's schedule and its relation to a water rights hearing on the Mokelumne River scheduled by the State Board. Comments from state and federal resource agencies and from conservation groups were strongly in support of the Commission's proceeding and schedule. Considering the documented fisheries-related problems in the Lower Mokelumne River, staff decided not to defer preparation of a DEIS, as some commentors had requested. The schedule for the DEIS was intended to coordinate the Commission's proceeding with that of the State Board. Staff attended planning meetings for the State Board's November hearing and followed that hearing's progress closely.

Based on information generated during the scoping process, staff identified three primary issues to be addressed: 1) water quality and quantity; 2) anadromous fisheries; and 3) socioeconomic issues related to water supply and demand. These issues were limited because of the nature of this proceeding as a compliance action at a licensed hydropower facility with specific license requirements for "conservation and development of fish and wildlife resources" (Appendix A). Substantial changes to current LMRP hydropower operations may affect the ability of the EBMUD to deliver reliable water services at reasonable costs, including water for human consumption, sanitation, and municipal and industrial uses. These services are vital to a major metropolitan area including the cities of Berkeley and Oakland. Some of the

alternatives discussed here would alter current uses of Pardee and Camanche reservoirs for water supply. Therefore, the effects of project operation on both water supply and fishery needs are major issues in this assessment.

The major water quality and quantity issues considered are:

- existing and future water availability and uses;
- water temperatures in reservoirs and in the river below Camanche Dam;
- hydrologic patterns and reservoir operations during wet, normal, and dry water years;
- reservoir and riverine chemical water quality; and
- sediment transport and river hydraulics.

The major fishery issues are:

- fishery management goals and objectives in the Lower Mokelumne River basin, including the most recent management plans produced independently by CDFG (1991) and by EBMUD (EDAW, Inc. 1992c);
- instream flows for fish, providing for upstream migration, spawning, incubation, rearing, and downstream passage;
- effectiveness of fish passage facilities and screens at diversions;
- evaluation of hatchery-stocked fish in the Mokelumne River; and
- acid mine drainage and other water quality influences.

The major socioeconomic issues are:

- economic impacts of reduced or modified water availability on municipal and industrial activities in the East Bay service area;
- costs of modifying water withdrawals in the Lower Mokelumne River basin;
- costs of structural and operational mitigation for fishery and environmental resources; and
- changes in hydroelectric power production, including benefits of increased production due to higher instream flow requirements.

The evaluation of some issues raised during the scoping process is beyond the scope of this proceeding. For example, recreational issues, such as fishing and boating access at both Camanche and Pardee Reservoirs and in the Lower Mokelumne River, are not appropriate for consideration under the limitations of Article 15 unless they are directly related to the modifications recommended to protect the anadromous fisheries in the lower river. Operation of the MRFF by CDFG at Camanche Dam (Section 2.1.2), as it constitutes a component of a statewide hatchery system, is also outside the scope of this proceeding. However, specific agreements between EBMUD and others that affect this hatchery are discussed. Proposals for the Commission to specifically require EBMUD to move its point of water withdrawal from Pardee Reservoir are not an appropriate part of this proceeding. Other issues, such as the cumulative impacts of future development in the upper Mokelumne River basin, are likewise beyond the scope of this proceeding. However, new development in the upper basin may be taken up under other Commission proceedings or licensing actions in the future.

The Notice of Availability of the DEIS on the LMRP was published in the Federal Register on October 30, 1992. The DEIS was mailed to Federal, state, and local agencies, as well as other interested parties, with a 60-day comment period. This comment period was subsequently extended to March 1, 1993, at the request of several parties. Section 8 of the Final Environmental Impact Statement (FEIS) identifies those agencies and individuals that were sent copies of the DEIS and the FEIS. Twelve comment letters

were received on the DEIS, including extensive comments from the licensee. All comments received on the DEIS and our response to these comments are contained in Appendix H of the FEIS.

A public meeting on the DEIS was conducted on November 30, 1992, in Livermore, California, to allow participants to express their views on the DEIS. A second meeting on the DEIS was tentatively scheduled for June 1-2, 1993, in Oakland, California, but was canceled at the request of the licensee. On July 16, 1993, EBMUD proposed a settlement agreement to the Commission on this proceeding. The details of this settlement agreement have been considered in the FEIS. Although the settlement agreement is not adopted explicitly as EBMUD's proposed alternative in the FEIS, the essential elements of the settlement offer are incorporated into this alternative because these elements were already part of EBMUD's earlier management plans.

All timely letters of comment that address specific analyses in the DEIS were reviewed by staff during preparation of the FEIS. Suggestions for correcting text or data and requests for expanded discussion of a subject have been considered and adopted wherever appropriate. Those editorial changes and suggestions which were practicable and reasonable, and which improved the quality of the FEIS are incorporated herein.

1.3 ASSESSMENT APPROACH

As with other parts of California and other western states, the demand for finite water resources is increasing in the Mokelumne River Basin. Two of the larger demands are: the requirements for native chinook salmon, steelhead trout, and other fish populations and growing requirements for affordable and reliable municipal water supply. This environmental assessment addresses this increasing conflict between water uses.

The Mokelumne River has historically been an important source of naturally spawned chinook salmon and has also been well known for an outstanding steelhead fishery. However, evidence suggests that these anadromous fishes have been substantially reduced in the Mokelumne River as a result of a complex history of problems which include water diversion, surface water storage, and hydroelectric power generation (Figure 1.3-1; Table 1.3-1). Because water development has altered the aquatic habitat of the Mokelumne River, the CDFG has designated the Lower Mokelumne River as a reach of considerable importance for restoration and maintenance of chinook salmon and steelhead trout. A statewide objective established in the Salmon, Steelhead, and Anadromous Fisheries Program Act of 1988 (California Fish and Game Code Section 6900 et seq.) is to increase populations of these fish. As a result of these problems and goals, much resource agency attention has focused on the protection of fisheries in the Lower Mokelumne River. The analyses in this FEIS have therefore focused on the trade-offs between anadromous fisheries downstream from EBMUD's hydropower facilities and water supply economics.

The level of analysis of pertinent issues is based in part on staff's review of comments received during the scoping process and comments on the DEIS. If preliminary analysis indicated that any of the issues presented in the scoping document had little potential for causing significant impacts, the issue(s) were identified and the reasons for not providing a more detailed analysis were given.

The FEIS is organized into five sections. The introductory section (Section 1) presents the reasons and scope for the assessment. Section 2 identifies the proposed actions, alternative actions, and a general comparison among alternatives. Action alternatives in the FEIS are generally divided into two types: 1) flow-related mitigation consisting of constraints on project operations (e.g., minimum flow requirements or minimum reservoir pool elevations) that would directly affect water availability from the project, and

Figure 1.3-1. Chronology of major events in the historical development of the Lower Mokelumne River basin. (Source: The staff.)

2) non-flow-related mitigation involving capital and operating costs but no affect on water supply. Section 3 describes the affected environment, the fish and wildlife resources of concern, and other relevant information supporting the assessment of impacts. Penn Mine and related remediation activities are discussed in Section 3.1.3. Section 4 presents the environmental and economic impacts of each alternative in detail. Finally, Section 5 presents staff's conclusions and final recommendations. Section 5 also contains an explanation of why staff did not adopt all of the recommendations made by fish and wildlife agencies.

Table 1.3-1. Stresses potentially affecting natural reproduction of chinook salmon and steelhead trout in the Lower Mokelumne River. (Source: The staff.)

Impact mechanism	Affected life stage of anadromous salmonids			
	Upstream migration	Spawning	Rearing	Downstream migration
Stream flow	Lack of large and prolonged attraction flows	Stream gravels unsuitable for salmon due to sedimentation and/or compaction Redd superposition due to limited habitat	Suitable habitat restricted to tailwater reach of river	Lack of proper cues for early emigration Entrainment at WID diversion Bypass/passage at Woodbridge Dam/ Lake Lodi
Physical habitat	Shallow water at some locations below Woodbridge Dam	Small areas of suitable spawning gravels at low flows	Unsuitable habitat at high flows Poor habitat in Lake Lodi in late spring and summer Stranding during rapid reductions in dam releases	Stream flow diverted into Woodbridge Irrigation District Canal at Lake Lodi
Temperature	High temperatures early in fall	High temperatures early in fall	High temperatures in Lake Lodi and downstream	High temperatures in Lake Lodi and downstream
Water quality	Low DO and/or elevated toxic metals (e.g., Zn, Cu, etc.) during migration	Low DO and/or elevated toxic metals during incubation	Low DO and/or elevated toxic metals for steelhead juveniles in summer	Low DO and/or elevated toxic metals during outmigration and fall hatchery releases
Migration barriers	Passage problems at Woodbridge Dam	n/a	n/a	Diversion at Woodbridge Irrigation District Canal Poor bypass/passage efficiency at Woodbridge Dam
Entrainment	n/a	n/a	Diversion at Woodbridge Irrigation District screens Diversion at unscreened intakes	Diversion at Woodbridge Irrigation District Diversion at unscreened intakes
Predation	Uncontrolled fishing catches	Uncontrolled fishing catches Redd disturbance by fisherman	Stressed prey (traps, etc.) Predation traps in Lake Lodi and at Woodbridge Irrigation District screens	Stressed prey (traps, etc.) Predation traps in Lake Lodi and at Woodbridge Irrigation District screens

2. PROPOSED ACTIONS AND ALTERNATIVES

The action under consideration in this assessment is to modify existing LMRP hydropower facilities and/or operations for the explicit purpose of conserving fish and wildlife resources in the Lower Mokelumne River (the Lower Mokelumne River is defined here as the Mokelumne River from tidal influence upstream to Camanche Dam). The specific alternatives considered in this FEIS are limited to those that would directly benefit the naturally reproducing chinook salmon population in the Lower Mokelumne River. The restricted scope of this compliance proceeding is explained in Section 1.

A large number of different mitigation measures have been proposed by different parties for solving the fisheries problems in the Lower Mokelumne River (Table 2.1-1). Initially, our definition of possible actions was based on relevant parts of the "Lower Mokelumne River Fisheries Management Plan" that was issued by the CDFG in January 1992 (CDFG 1991). The CDFG recommendations constitute a feasible starting point; they are comprehensive and address the major issue of conservation of naturally spawning chinook salmon in the Mokelumne River. EBMUD proposed their own set of actions to address fisheries problems called the "Lower Mokelumne River Management Plan (LMRMP)" (EDAW, Inc. 1992c). The EBMUD plan is part of a Draft Environmental Impact Report/Environmental Impact Statement (EDAW, Inc. 1992a) issued in support of the District's long-term water supply management planning (see Section 3.1.4 for details on this and other related proceedings). The elements of both these plans are incorporated into the action alternatives defined in this section. In addition to these CDFG and EBMUD plans, the FWS recommended its own minimum flow regime in its comments on the DEIS (see Appendix H). The FWS recommendations are considered as a separate alternative in the FEIS, as are staff's recommendations that are based on our independent analysis of the issues. Another alternative considered is to make no modification to the LMRP operations or facilities (i.e., the no action alternative).

Some actions recommended by CDFG and others involve changes that cannot be implemented through unilateral actions by the Commission or that go beyond the scope of fish and wildlife resources referred to in License Article 15 (Appendix A). Those CDFG recommendations that pertain directly to naturally spawning salmonids have been used to define the proposed action to be considered in this FEIS. Actions that will require more than Commission authority are also discussed in the FEIS so that cumulative effects to fish resources can be considered.

This second section of the FEIS contains an overview of the existing LMRP facilities and operations and the alternative approaches considered to modify it. Section 2.1 describes existing LMRP facilities and operations. Sections 2.2 and 2.3 describe the flow and non-flow alternatives that have been considered, including proposals from CDFG, FWS, EBMUD, the Commission's staff, and other participants in the scoping process.

The specific modifications to LMRP operations and facilities are separated into two categories, ones that require flow-related changes to project operation and others that involve non-flow-related actions or modifications to facilities. Flow alternatives include new constraints on operation that would directly affect downstream flow regimes (e.g., new minimum flow requirements), as well as operational constraints that would indirectly affect downstream releases (e.g., new rule curves to maintain higher pool elevations in the reservoirs). Non-flow alternatives are modifications to project facilities or operation, or to riverine habitats downstream of Camanche Dam, that would not substantially change the volume or timing of flows released from the reservoirs (e.g., stream gravel rehabilitation, improvements in fish passage facilities, construction of new fish hatcheries, or selective withdrawals).

Table 2.1-1. Mitigation measures considered for the conservation and development of naturally reproducing salmonids in the Lower Mokelumne River below Camanche Reservoir. (Source: The staff.)

Impact mechanism	Salmonid life history stage ^a			
	Upstream migration	Spawning	Rearing	Downstream migration
Flow/water quality cues	- Flow spikes - Turbidity enhancement	- Gravel enhancement - Turbidity enhancement	- Minimum flow at CR - Improve LL/WD ramping rates	- Flow spikes - Screens - Improve LL/WD
Physical habitat	- Channel clearing in low water minimum flow at CR	- Minimum flow at CR - Gravel enhancement - Ramping rates	- Minimum flow at CR - Improve LL/WD ramping rates	- Improve LL/WD
Water temperature	- Minimum flow at CR - Minimum pool at CR - Minimum flow at PR	- Minimum flow at CR - Minimum pool at CR - Minimum flow at PR	- Minimum flow at CR - Minimum pool at CR - Minimum flow at PR - Improve LL/WD	- Minimum flow at CR - Minimum pool at CR - Minimum flow at PR - Improve LL/WD
Water quality	- Hypolimnetic oxygenation - Selective withdrawal - PM remediation - CR remediation	- Hypolimnetic oxygenation - Selective withdrawal - PM remediation - CR remediation	- Hypolimnetic oxygenation - Selective withdrawal - PM remediation - CR remediation	- Hypolimnetic oxygenation - Selective withdrawal - PM remediation - CR remediation
Migration barriers	- Improve LL/WD	n/a	n/a	- Screens - Improve LL/WD
Entrainment	n/a	n/a	- New screens - Improved Woodbridge Irrigation District screens	- Screens - Improve LL/WD - Hypolimnetic oxygenation
Predation	- Fishing regulations and enforcement	- Fishing regulations and enforcement	- Hypolimnetic oxygenation - Improve LL/WD	- Screens - Improve LL/WD - Hypolimnetic oxygenation

^a CD = Camanche Dam PD = Pardee Dam
 LL = Lake Lodi WD = Woodbridge Dam
 PM = Penn Mine CR = Camanche Reservoir

The no action alternative of maintaining current operating conditions is discussed along with each mitigation alternative. Staff's final recommendations for project modifications are a combination of flow and non-flow alternatives that gives the best balance between benefits to salmonid resources and costs to the licensee, EBMUD. Lastly, Section 2.4 presents a general comparison of the major alternatives with respect to expected benefits and costs.

2.1 DESCRIPTION OF THE PROJECT

The existing LMRP is a multipurpose system of surface reservoirs and aqueducts owned and operated by EBMUD. The project is operated for purposes of water supply, flood control, hydropower production, and recreation. EBMUD is a publicly owned utility formed in 1923 to provide water supply and wastewater treatment services to municipalities in the East San Francisco Bay Area. EBMUD's service area now covers approximately 320 square miles and includes all or parts of the cities of Alameda, Albany, Berkeley, Danville, El Cerrito, Emeryville, Hayward, Hercules, Lafayette, Moraga, Oakland, Orinda, Piedmont, Pinole, Pleasant Hill, Richmond, San Leandro, San Pablo, San Ramon, and Walnut Creek (EDAW, Inc. 1992a).

Almost all of EBMUD's water supply comes from inter-basin transfers out of the Mokelumne River at Pardee Reservoir. Pardee Dam, completed in 1929, was the first water supply project constructed in the Mokelumne River Basin. Camanche Dam was completed in 1964 downstream from Pardee Dam, primarily to provide additional storage for instream flow to the Lower Mokelumne River and flood control. EBMUD received a FERC license for hydroelectric facilities at both Pardee and Camanche dams in 1981. Although hydropower facilities were constructed and operated at Pardee Dam prior to 1981, those facilities had been excluded from FERC licensing by federal legislation.

2.1.1 Location

The Camanche and Pardee facilities are located in the Sierra Foothills region of California, approximately 35 miles southeast of Sacramento and 73 miles northeast of Oakland (Figure 1.1-2). Pardee Dam (Figure 2.1-1) is at Mokelumne River Mile (MRM) 73 and Camanche Dam (Figure 2.1-2) is approximately nine miles downstream at MRM 64.

Figure 2.1-1. Aerial photograph of Pardee Dam at Mokelumne River Mile 73 looking upstream toward the northeast. (Source: EBMUD 1989.)

Figure 2.1-2. Aerial photograph of Camanche Dam at Mokelumne River Mile 64 looking upstream toward the northeast on August 25, 1986. *(Photograph by Scott D. Wilcox.)*

The principal diversion of Mokelumne River water is from the southern arm of Pardee Reservoir into the Mokelumne Aqueducts serving EBMUD's water supply system (Figure 1.1-2). The river flow that is not diverted from Pardee is routed through the sluiceway and/or the hydroelectric facility at Pardee Dam. The Mokelumne River then flows into Camanche Reservoir. The storage capacity in Camanche Reservoir is generally used by EBMUD to satisfy downstream water rights, to provide flood control, and to provide for downstream fish resources, including the MRFF. Principal water rights related to LMRP operations are those held by the North San Joaquin Water Conservation District (NSJWCD) (maximum entitlement of 20,000 ac-ft per year), the Woodbridge Irrigation District (maximum entitlement of 60,000 ac-ft per year, except during critically dry years in which entitlement is 39,000 ac-ft), the Jackson Valley Irrigation District (JVID) (3,850 ac-ft), and downstream riparian and appropriators (see Section 3.2.1 and Appendix G for further details on water rights). As specified in the original FERC license, fishery flows of 13,000 ac-ft per year (5,400 ac-ft during dry years) are released from the project for the MRFF. Camanche releases in excess of 264,000 ac-ft per year are for flood control. The hydropower facilities at both Camanche and Pardee dams make use of downstream releases to produce electricity.

2.1.2 Facilities

The LMRP facilities consist of the two mainstream surface water reservoirs behind Pardee and Camanche dams, the dams themselves, powerhouses, three parallel aqueducts, recreational areas, and a fish hatchery (EBMUD 1992i; EDAW, Inc. 1992a).

Pardee Dam and Reservoir

Pardee Dam (Figure 2.1-1) is a 345-ft high, 1337-ft long, concrete gravity-arch structure that impounds a reservoir with a total capacity of 209,950 ac-ft (1,000 ac-ft is alternatively abbreviated as TAF) at spillway crest elevation of 568 ft above mean sea level (MSL). The spillway at Pardee Dam is an ungated, ogee type structure with a crest length of 800 ft and a discharge capacity of 26,385 cubic feet per second (cfs) at elevation 572.7 ft MSL.

Withdrawals to the Mokelumne aqueducts are made from a multiple-port outlet tower in the south arm of Pardee Reservoir. The most commonly used outlets in the withdrawal tower are a series of three 36-inch x 30-inch openings at four different elevations: 550, 520, 490, and 460 ft MSL. There are also two other outlets at the bottom of the tower at elevations 400 and 395 ft MSL, but these outlets are used by EBMUD only in a low-water emergency. The "dead" storage in Pardee Reservoir below the withdrawal tower outlets is approximately 17 TAF.

The powerhouse at the base of Pardee Dam contains three Francis turbines with a total generating capacity of 28.6 MW. The maximum generating capacity of the turbines at Pardee is 1,100 cfs (375 cfs from two turbines and 350 from another). The total discharge capacity through the turbines and three other sluiceways in Pardee Dam is 5,200 cfs. Discharges into Camanche Reservoir are essentially bottom withdrawals from Pardee Reservoir (either 250 or 325 ft MSL discharge elevations).

Camanche Dam and Reservoir

Camanche Dam (Figure 2.1-2) is a 171-ft high, zoned earth-filled structure with a 2,640-ft long impervious core. Completed in 1964, it was licensed for hydropower production along with Pardee Dam in 1981. Total storage volume of the reservoir is 430,880 ac-ft at a maximum pool elevation of 235.5 ft MSL. The spillway at Camanche is an ungated, ogee type structure with a total length of 400 ft and a discharge capacity of 182,000 cfs at elevation 260 ft MSL.

In addition to the spillway, there are two main outlet structures at Camanche Dam: a lower-level outlet structure drawing from approximately elevation 100 ft MSL and an upper-level outlet structure with an invert elevation of approximately 201 ft MSL. Epilimnetic releases through the upper-level outlet are practical from Camanche only when total reservoir storage exceeds approximately 210 TAF. There is also a small, floating pumping plant with a total capacity of 35 cfs that discharges into the upper-level outlet. The floating pumping plant can withdraw selectively from depths between 30 and 50 ft below the water surface. This pumping plant was installed in 1990 to help mitigate water quality problems that had been adversely affecting operations of the fish facility. Dam releases through the sluiceways can be routed to the powerhouse or discharged directly to the river. There are Howell-Bunger aeration valves on the end of the two main sluiceways at Camanche Dam.

The Camanche powerhouse contains three 3.56 MW Kaplan turbines with a total installed capacity of 10.7 MW. Discharges through the power plant come only from the lower-level outlet and are at times affected by poor water quality. The combined maximum generating capacity of these turbines is 1,200 cfs and the maximum discharge through Camanche Dam from all sources excluding the spillway is 5,000 cfs.

The average annual generating capacity of the Camanche facility is approximately 40 GWh; EBMUD sells this hydroelectricity to PG&E.

The federal government contributed \$10.1 million of the \$36.7 million construction cost of the Camanche project for flood control benefits in the Mokelumne River. Up to 200 TAF of reservoir storage capacity is reserved for flood control under an agreement between the U.S. Army Corps of Engineers (COE) and EBMUD. According to an agreement between EBMUD and COE, Camanche Reservoir is drawn down to its winter pool elevations between September 15 and November 5 each year (Figure 2.1-3). A certain proportion of the flood control storage volume in Camanche is transferable to upstream storage reservoirs [i.e., Pardee and several Pacific Gas & Electric (PG&E) reservoirs]. Camanche and other reservoirs provide flood control benefits to the towns of Lodi, Woodbridge, and Thornton, and to 69,000 acres of agricultural land in the lower basin.

Mokelumne Aqueducts

The vast majority of EBMUD's water supply is withdrawn from Pardee Reservoir through the Mokelumne Aqueducts, which consist of three 82-mile steel pipelines that deliver water to terminal storage reservoirs and treatment plants in the East Bay area. The three aqueducts range in diameter from 65 to 87 in and in age from 5 to 30 years (the first was constructed in 1928 and the third in 1963). The total withdrawal capacity of the aqueducts depends on the elevation of Pardee Reservoir and on whether pumps or gravity feed are used. Maximum capacity via gravity flow is approximately 202 million gallons per day (MGD) (310 cfs or 224 TAF/yr) when Pardee Reservoir is at its maximum pool elevation. Pumping is needed to increase withdrawals above this amount. Pumping can achieve a withdrawal rate of 325 MGD (495 cfs), but this option is not used frequently by EBMUD, in part due to the age and condition of the aqueducts. The aqueducts are buried for most of their length except for where they cross the Sacramento-San Joaquin Delta. A 10-mile segment of the aqueducts, between the towns of Holt and Bixler, is elevated; in this

Figure 2.1-3. Combined flood control requirements for Camanche and Pardee Reservoirs in agreement between East Bay Municipal Utility District and the U.S. Army Corps of Engineers. (Upper set of lines is maximum reservoir storage constraints and lower set of lines is minimum empty flood storage requirement.) (Source: The staff.)

area the aqueducts cross three rivers: the San Joaquin River, the Old River, and the Middle River. Aqueduct security in the Delta and potential damage due to earthquakes or levee failure is a major issue in EBMUD's long-term water supply planning (EDAW, Inc. 1992a).

Terminal Storage Reservoirs

EBMUD has the capacity to store up to 155 TAF of water in five terminal storage reservoirs in the East Bay area. The five reservoirs and their capacities are: Briones (60.5 TAF), Chabot (10.3 TAF), Lafayette (4.2 TAF), San Pablo (38.6 TAF), and Upper San Leandro (41.4 TAF). The combined capacity of these reservoirs would provide a four-to-six month supply of water to EBMUD in the event water delivery via the aqueducts is terminated. EBMUD schedules water deliveries to and withdrawals from the terminal reservoir so as to maintain a total storage of approximately 142 TAF at the end of March and 117 TAF at the end of September. Average annual runoff into the terminal reservoirs amounts to approximately 30 TAF, but in dry years, evaporation can exceed this local runoff (EBMUD 1992i).

Bixler Pumping Station

EBMUD maintains an emergency pumping facility along the Mokelumne Aqueducts at the western edge of the Sacramento-San Joaquin Delta, near the town of Bixler. This facility was developed in response to the drought conditions of 1976-77 that seriously depleted EBMUD's water supply in Pardee Reservoir. EBMUD held a permit from the COE that expired on June 30, 1992, allowing for the withdrawal of up to approximately 58 MGD (90 cfs) from the Delta at this facility.

Mokelumne River Fish Facility

A fish hatchery and rearing installation was constructed by EBMUD in 1963 below Camanche Dam as mitigation for the loss of spawning habitat for fall chinook salmon and steelhead trout in the Mokelumne River between Pardee and Camanche dams (Figure 2.1-4). CDFG (1959) determined that the river downstream of Pardee Reservoir was capable of sustaining an annual run of 15,000 adult chinook salmon and 2,000 adult steelhead. Under conditions of optimal water quality and flow, CDFG estimated that the then-existing spawning beds could have accommodated up to 60,000 chinook salmon. A hatchery capable of handling 10,000 adult chinook salmon and 2,000 steelhead was recommended. The remaining suitable spawning area in the river below Camanche Dam was assumed to be able to handle 5,000 naturally spawning chinook salmon, whereas the hatchery would assume production of all the steelhead. On January 3, 1961, the CDFG and EBMUD signed an agreement that provided for the MRFF with a full capacity to produce 100,000 yearling steelhead and to process 15 million chinook salmon eggs per year. The chinook eggs would yield juvenile fish to be released in the spring of their first year. The subsequent FERC license to operate a hydropower facility endorsed the existing 1961 agreement.

2.1.3 Current Operation

The current operation of Pardee and Camanche reservoirs is optimized to meet the water supply needs of EBMUD subject to the downstream water rights in the basin. Camanche Reservoir allows EBMUD to take its full water allocation out of Pardee Reservoir by providing downstream storage for irrigation, streamflow regulation, flood control, fishing needs and the rights of other riparian and senior appropriator entitlements. The operational priorities of the LMRP system are to: 1) maintain terminal reservoirs as full as possible by transferring water from Pardee Reservoir via the Mokelumne aqueducts; 2) minimize releases from Pardee Reservoir so as to keep it as full as possible at all times; 3) satisfy the flood control rule curve established by the COE for Camanche Reservoir (Figure 2.1-3); and 4) release sufficient water from Camanche Reservoir to satisfy downstream water users while retaining as much storage as possible for

Figure 2.1-4. Photograph of the Mokelumne River Fish Facility at Camanche Dam. (Photograph by Charles C. Coutant.)

carry over to subsequent years (see Section 3.2-1 and Appendix G for descriptions of downstream water users and their rights).

The flood control agreement between EBMUD and COE (e.g., EBMUD 1992i) requires that a large proportion of the storage volume in Camanche and Pardee reservoirs be vacated during the months of November through June to control rainfall and snowmelt floods (Figure 2.1-3). This agreement identifies 130 TAF of non-transferable storage capacity that must be provided in Camanche and/or Pardee reservoirs (light solid lines in Figure 2.1-3) and a total of 200 TAF that must be maintained in the aggregate of EBMUD's reservoirs plus other upstream reservoirs (heavy solid lines in Figure 2.1-3), the principle of which is PG&E's Salt Springs Reservoir. Because EBMUD's operating priorities are to keep Pardee as full as possible throughout the year, normal procedure is to provide the majority of EBMUD's flood storage in Camanche Reservoir. The effect is to reduce Camanche Reservoir to about half its capacity for much of the year.

Drawdown of Camanche Reservoir for flood control purposes begins on September 15 of each year. Between March 15 and June 30, the requirement for empty storage capacity is flexible, depending on the expected snowmelt runoff for the remainder of the water year as specified by the EBMUD-COE agreement. Seasonal runoff forecasts that determine March through June storage requirements are based on the unregulated runoff, precipitation, and observed water content in the watershed's snow pack.

Between July 1 and September 15, there are no flood control constraints on operations of EBMUD's reservoirs.

There are currently no requirements for minimum pool elevations on either Pardee or Camanche reservoirs specified in either the existing FERC license or any other third party agreements. Pardee Reservoir reached its lowest elevation of record at 455.0 ft (47 TAF) on March 25, 1977. Camanche Reservoir reached its lowest elevation of record at 124.5 ft (8.5 TAF) on October 5, 1988. This extreme drawdown of Camanche coincided with the water quality problems that, in part, initiated this proceeding.

The current minimum flow constraints on Camanche Reservoir are described in the following section describing the no action alternative (Section 2.2.1).

2.2 FLOW ALTERNATIVES

The flow alternatives considered in the FEIS as mitigations for demonstrated or potential adverse impacts of the Lower Mokelumne River are constraints on hydropower and reservoir operations that would result in changes in the volume and timing of releases from Pardee or Camanche dams. The most obvious flow alternative is a minimum flow requirement designed to protect fish and riparian resources in the Mokelumne River. Examples of other flow-related actions are:

- new rule curves regulating reservoir pool elevations to control water quality [i.e., water temperatures and dissolved oxygen (DO)] in Camanche Reservoir releases;
- limits to flow fluctuations (i.e., rate of change) at Camanche or Pardee dams; and
- short-term pulses of higher releases from Camanche Dam for attraction and outmigration of anadromous fish.

2.2.1 Minimum Flow Requirements

Five alternative minimum flow regimes are evaluated in the FEIS, ranging from existing conditions (no action) to the recommendations made by CDFG in their Lower Mokelumne Fisheries Management Plan. Other flow regimes considered are: EBMUD's current proposal from their Updated Water Supply Management Plan (WSMP) (EDAW, Inc., 1993a), a flow regime identified by FWS in their comments on the DEIS (see Appendix H), and new recommendations developed independently by staff. The flow alternatives differ both in the magnitude of streamflows provided and in the definition of the water year type that specifies when minimum flow criteria apply. The definition of water year type has a strong influence on the benefits and costs of each alternative. Another important part of each flow alternative is the location where compliance is to be measured. Compliance location is critical because there are substantial conveyance releases from Camanche Dam to provide for downstream water users in addition to the minimum flow releases needed for fish and wildlife conservation.

CDFG Alternative for Minimum Flows

The CDFG recommended that minimum releases from Camanche Dam be increased significantly to meet the agency's estimates of fish requirements for physical habitat and water temperature (CDFG 1991). The CDFG minimum flow requirements below Woodbridge Dam are shown in Table 2.2-1. CDFG also proposed minimum flows that should be maintained above Lodi, at Highway 99 (MRM 43.0), but these flows would be satisfied whenever the flow requirements below Woodbridge Dam were met because of intermediate flow requirements for irrigation water rights (see Section 3.2). The CDFG minimum flows (excluding pulse flows for migration periods) would require 98, 207, and 262 TAF of releases from

Table 2.2-1. Minimum flows recommended by the California Department of Fish and Game. All values are in cubic feet per second measured at the United States Geological Survey stream gage below Woodbridge Dam (MRM 38.4). (Source: CDFG 1991.)

Time Period	Water Year Type		
	Dry	Normal	Wet
October 1-14	20 ^a /130 ^c	250/470 ^c	300/520 ^c
October 15-31	20 ^a /130 ^c	300/520 ^c	350/570 ^c
November 1-15	200/310 ^c	300/520 ^c	350/570 ^c
November 16-February 29	200	300	350
March 1-31	200	350	400
April 1-14	200	400	450
April 15-30	250	400	450
May 1-31	300	450	450
June 1-30	20 ^b	400	400
July 1-31	20 ^b	150	300
August 1-September 30	20 ^b	100	300

^a Flows at Highway 99 Bridge above Lodi Lake (MRM 43) would be equal to or greater than 100 cfs due to conveyance releases for downstream water users.

^b Flows at Highway 99 Bridge above Lodi Lake (MRM 43) would be equal to or greater than 200 cfs due to conveyance releases for downstream water users.

^c Includes pulse flows for salmon migration.

Camanche Dam annually for instream fishery purposes in dry, normal, and wet years, respectively. Including pulse flows, the corresponding releases for fishery purposes would be 108, 227, and 276 TAF under the CDFG alternative.

The CDFG definition of water year type is based on the 50-year average unimpaired runoff of the Mokelumne River above Pardee Reservoir. Unimpaired runoff is an estimate of the streamflow that would have occurred without the influence of upstream reservoirs, water withdrawals, or other man-made changes to natural hydrology. Unimpaired runoff is estimated every year by the California Department of Water Resources (CDWR). A "dry" CDFG water year denotes that the annual unimpaired runoff into Pardee Reservoir is less than half of the 50-yr average. A "normal" CDFG water year means unimpaired runoff is between 50% and 110% of the 50-yr average. A "wet" CDFG water year means unimpaired runoff exceeds 110% of the 50-yr average. The historical unimpaired runoff into Pardee Reservoir is estimated by CDFG as 730 TAF or approximately 1,000 cfs (CDFG 1991). Therefore, the CDFG upper

thresholds in terms of average annual flows in dry and normal water years are approximately 500 cfs (365 TAF) and 1100 cfs (803 TAF), respectively. These thresholds will change over time because the unimpaired runoff criterion is a 50-yr running average.

In addition to minimum releases from Camanche Dam, the CDFG also recommended that a minimum release of 250 cfs be maintained at Pardee Dam at all times. The purpose of this release is to help maintain a cold hypolimnion in Camanche Reservoir. Our analysis of this option indicated that it was redundant with the minimum pool requirement in Camanche Reservoir (i.e., during critical periods, a minimum release from Pardee is needed to maintain Camanche pool elevations). Because the purpose of minimum Pardee releases is essentially the same as minimum pool elevations in Camanche, further discussion of the Pardee releases is included within the minimum pool alternatives (see next subsection).

EBMUD Alternative for Minimum Flows

As part of their ongoing WSMP process, EBMUD developed a new minimum flow regime for Camanche releases (Table 2.2-2). These new flow requirements are designed to provide improved upstream

Table 2.2-2. Minimum flows proposed below Woodbridge Dam (MRM 38.4) by East Bay Municipal Utility District as part of their updated Water Supply Management Plan. (Source: EDAW, Inc., 1993a.)

Time period	Water year type (cubic feet per second)			
	Critically dry	Dry	Normal	Wet
October 1–15	20	20	20	20
October 16–31	20	100	200	200
November 1–10	100	200	300	300
December 1–15	100	200	300	300
December 16–31	50	100	100	100
January 1–31	50	100	100	100
February 1–29	50	100	100	100
March 1–31	50	100	100	100
April 1–15	20	100	100	100
April 16–30	20	150	150	150
May 1–15	20	300	300	300
May 16–31	20	400	400	400
June 1–30	20	20	500	500
July 1–31	20	20	20	20
August 1–31	20	20	20	20
September 1–30	20	20	20	20

mitigation and spawning habitat for chinook salmon during the winter months, as well as improved rearing habitat for chinook salmon fry in the early spring. The EBMUD minimum flows would be satisfied below Woodbridge Dam. On an annual basis, the EBMUD flows would provide releases of 28, 77, and 118 TAF from Camanche Dam for instream fishery purposes in critically dry, dry, and normal/wet water years, respectively.

The definition of water year type for EBMUD's flow alternative is different from CDFG's approach that uses unimpaired runoff estimates. EBMUD bases its definition of water year type on the forecasted storage volume at the end of October in Pardee and Camanche reservoirs. For May through October, estimates are made of the end-of-October storage using observed streamflow, snow pack, and storage volume as predictor variables. Normal or wet year flow requirements are met whenever the EBMUD reservoirs are predicted to be full. Dry year minimum flows are released when the combined Pardee and Camanche storage is less than the maximum allowed by EBMUD's flood control agreement with the COE. Critically dry year flows are provided if projected total storage is less than 190 TAF at the end of October. November through April, Camanche minimum releases are based on the known volume at the end of the previous October, using the same storage volume thresholds. This approach to defining water year type puts the highest priority on filling both Camanche and Pardee reservoirs whenever possible.

FWS Alternative for Minimum Flows

The FWS has recommended that minimum releases from Camanche Dam be increased significantly. The FWS minimum flow requirements below Woodbridge Dam are shown in Table 2.2-3. The FWS minimum flows require 121, 121, and 193 TAF of releases from Camanche Dam on an annual basis for instream fishery purposes in critically dry, dry, and normal/wet years respectively. The FWS definition of water year type is essentially the same as staff's definition used in the DEIS (see comment No. 11-11), although FWS included a "critically dry" water year type not included by the staff. In the FWS minimum flow recommendation, the dry/critically dry regime would be required when inflows to Pardee are less than 360 TAF, or annual average flows are below 500 cfs for the water year.

Staff Alternative for Minimum Flows

Staff's alternative for minimum flows at Camanche Dam is based on an independent analysis of all available data, including the instream flow study conducted for the CDFG (1991). The methods used to design staff's flow alternative are described in Appendix F. We assumed that fisheries management objectives for the lower river focus only on anadromous salmonids (i.e., optimizing naturally spawning chinook salmon and steelhead trout). Habitat response functions [Weighted Usable Area (WUA)] versus streamflow were those produced by CDFG's instream flow study conducted in 1988. The minimum flows defined by staff's analysis would provide 51, 108, and 160 TAF of releases from Camanche Dam annually for instream fishery purposes in dry, below-normal, and above-normal years, respectively. The seasonal distribution of these flow requirements is shown in Table 2.2-4.

Our minimum flow alternative in the FEIS is somewhat reduced from that presented in the DEIS due to further analyses and responses to DEIS comments, particularly with respect to our integration of water temperature and physical habitat dynamics (see Section 4.1 and Appendix F for analysis details). In all water-year types, there are two parts of staff's minimum flow requirements: 1) one block of water to be released in the months of October through February to provide for upstream migration, spawning, and incubation; and 2) a second block of water to be released in the months of May through June to provide for rearing and out-migration. There is a relative break between these two blocks of water in the month of March through April when our analyses indicate that slightly reduced flows are favorable for physical

Table 2.2-3. Minimum flows recommended by the U.S. Fish and Wildlife Service. All values are in cubic feet per second measured at the United States Geological Survey stream gauge below Woodbridge Dam (MRM 38.4). (Source: FWS 1993)

Time Period	Water year type (cubic feet per second)		
	Critically dry	Dry	Normal/Wet
October 1–5	200	200	200
October 6–11	200	200	450
October 12–17	200	200	450
October 18–31	200	200	300
November	200	200	300
December	200	200	300
January	200	200	300
February	200	200	300
March	200	200	300
April	200	200	300
May 1–10	300	300	400
May 11–20	400	400	550
May 21–31	500	500	700
June 1–10	50	50	400
June 11–30	50	50	100
July	50	50	100
August	50	50	100
September	50	50	100

habitat for rearing chinook salmon and that water temperatures are not limiting (i.e., there is no benefit to increased reservoir releases for temperature reasons).

Staff's definition of water year type is based on a combination of unimpaired runoff into Pardee Reservoir (the measure used by the CDFG alternative) and the end-of-year storage volume in Pardee and Camanche reservoirs (the measure used by EBMUD). This water-year definition differs from that used in the DEIS as we have responded to DEIS comments and conducted further analyses. During the months of October through February, the minimum flows for in-migration, spawning, and incubation would be based on EBMUD's end-of-the-year total storage capacity. In March, after the first estimate of annual unimpaired flows are available from the CDWR, and in subsequent months (April through June), minimum flow requirements would be based on CDWR's unimpaired runoff forecast. This approach relies on readily

Table 2.2-4. Minimum flows proposed below Woodbridge Dam (MRM 38.4) based on staff's independent analysis of physical habitat requirements of chinook salmon and steelhead trout. (Source: The staff.)

Time Period	Water year type (cfs)		
	Dry	Below-normal	Above-normal
October 1-15	20	150	300
October 16-31	200	300	350
November 1-30	150	220	310
December 1-31	150	220	320
January 1-31	150	220	320
February 1-29	100	120	220
March 1-31	50	80	100
April 1-15	20	50	50
April 16-30	20	50	50
May 1-31	20	200	300
June 1-30	20	300	400
July 1-31	20	50	100
Aug. 1-31	20	50	100
September 1-30	20	50	100

available data that are consistent with current state practices and that minimize reliance on longer term forecasting, making our definition more feasible to implement on a real-time basis.

For the purpose of determining minimum releases in the fall and winter (October through February), staff's above-normal water years are those in which combined Camanche and Pardee storage exceeds 500 TAF on the previous September 30. Below-normal years are those in which the total end-of-September storage is less than or equal to 500 TAF and greater than 300 TAF. Dry years are those in which the total end-of-September storage is less than or equal to 300 TAF.

For the purpose of determining minimum releases for the remainder of the year, above-normal water years in staff's minimum flow alternative are those years in which unimpaired runoff to Pardee exceeds 700 TAF (the historical median value). Staff's below-normal water years are when unimpaired runoff is between 351 and 700 TAF. Our dry water years are those in which unimpaired runoff less than or equal to 350 TAF. The source of the unimpaired runoff estimate to be used is that published by the CDWR in their Bulletin 120. In the period from 1921 to 1990, these water year definitions produce 15% dry, 35% below-normal, and 50% above-normal years.

No Action Alternative for Minimum Flows

The current minimum flow requirements at Camanche Dam are based on the 1961 agreement between CDFG and EBMUD providing 13 TAF in normal and wet years and 5.4 TAF in dry years to maintain operations in the MRFF. This agreement did not provide any additional flows for any instream habitat maintenance other than the releases for the MRFF. The minimum fish flows of the 1961 CDFG-EBMUD agreement were adopted as part of the existing LMRP license when it was issued by the Commission in 1981. The seasonal distribution of the normal/wet year releases of 13 TAF has been interpreted by EBMUD as a monthly average of 50, 66, 40, 30, and 30 cfs November through March, respectively. EBMUD has interpreted the seasonal distribution of the dry year release of 5.4 TAF as monthly averages of 25 cfs during November through December and 20 cfs during February through March. In all other months for all water year types, the minimum release from Camanche Dam for maintaining instream fish habitat is zero. However, actual Camanche Dam releases in these other months are not zero, because continuous releases are required to satisfy downstream water rights of Woodbridge Irrigation District (WID), NSJWCD, and others (see Section 3.2).

The no action alternative for minimum flows would continue the historical pattern of releases at Camanche Dam that includes the statutory minimum releases defined in EBMUD's license (13 or 5.4 TAF depending on water year type) plus additional releases needed to satisfy downstream water users. Existing flow regimes below Camanche Reservoir are described in Section 3.2.1.

2.2.2 Minimum Pool Elevations

The major environmental problems at the LMRP facilities occurred when pool elevations of Pardee or Camanche reservoirs reached unusually low levels. There are currently no minimum pool requirements on either Pardee or Camanche reservoirs, so drawdowns in dry water years are unconstrained. Minimum pool requirements are intended to ensure that a cold hypolimnion is maintained in Camanche Reservoir and that water temperatures in Camanche Dam releases remain cold throughout the summer and fall months. No specific minimum pool elevation has been recommended by the FWS; recommendations by CDFG, EBMUD, and staff are described below.

CDFG Alternative

The CDFG recommendation is to maintain a minimum pool elevation of 210 ft (approximately 238 TAF) storage volume at all times (CDFG 1991).

EBMUD Alternative

EBMUD has not proposed a specific minimum pool requirement at Camanche Reservoir or a minimum release from Pardee Dam; however, there is a general strategy outlined in EBMUD's management plan to maintain a stable hypolimnion in Camanche Reservoir whenever possible. EBMUD's strategy is: 1) to limit Pardee Reservoir volume to no less than 100 TAF in all but the driest years; and 2) to provide sufficient, but unspecified, Pardee releases to maintain a hypolimnion volume in Camanche Reservoir of at least 28 TAF. Based on our modeling of reservoir hydrodynamics with available data (see Appendix C) we estimate that EBMUD's proposal would translate into minimum pool elevations in summer months between 170 and 175 ft MSL. EBMUD is also planning to test the feasibility of hypolimnetic oxygenation to improve chemical quality of hypolimnion water (see Section 2.3.5), but this mitigation would not significantly affect pool elevations or water temperatures in the releases from Camanche Dam.

Staff Alternative

We conducted an extensive simulation modeling study of the temperature and hydrodynamics of Camanche Reservoir to understand the relationship between Camanche pool elevations and water temperatures in the releases of Camanche Dam (see Appendix C). Based on these analyses, we determined that optimal water temperatures for chinook salmon would be produced by requiring that Camanche Reservoir be maintained at a minimum pool elevation of 190 ft MSL (storage volume of 156.2 TAF) from July 1 through September 30. This minimum pool elevation constraint to reservoir operations would be secondary to meeting releases for downstream water users, but it would be enforced whenever there was sufficient storage volume in either Camanche or Pardee reservoirs to satisfy downstream water users. Also, after studying the effects of this constraint on water supply deficits, we decided to relax this requirement to 175 ft MSL in the second or third years of consecutive dry water years.

No Action Alternative

Since there are currently no minimum pool requirements on Camanche Reservoir, the no-action alternative would allow drawdown of both Camanche and Pardee reservoirs whenever necessary to meet municipal water supply, downstream water rights, or other operational goals of EBMUD.

2.2.3 Other Flow Alternatives

Several other flow alternatives are considered in the FEIS, as described in the following section.

Ramping Rates

Ramping rates are limits to the rate of change of flows released from Camanche Dam. To avoid adverse impact to downstream fish and other aquatic biota, CDFG, EBMUD, and staff have proposed various ramping rates. CDFG recommended that daily flow fluctuations not exceed 10% of the average flow within any 24-hour period and weekly fluctuations not exceed 20% of the average flow within any 7-day period. EBMUD also proposes to implement ramping rates that vary depending on salmon spawning activity. Streamflow fluctuations under the EBMUD alternative would not exceed 50 cfs/d or 10 cfs/hr during the spawning and incubation period. During other months, the EBMUD alternative would limit changes in streamflow to less than 100 cfs/d or 10 cfs/hr. Staff's alternative would base ramping rates on the actual change in river stage (i.e., water surface elevation), limiting water surface fluctuations to no more than two inches per hour, and would only require these limits when total streamflow was less than 400 cfs below Camanche Dam. There would be no ramping rate constraints under the no action alternative.

Pulse Flows for Attraction Flows of Salmonids

Short-term increases in streamflow, or other factors related to natural flow fluctuations, have been identified as a potential cue for upstream migration by adult salmon. For fall-run chinook in the Mokelumne River, upstream migration from the Bay-Delta occurs in October, November, and December. Therefore, artificial streamflow fluctuations have been proposed as a management tool to stimulate improved upstream migrations. The CDFG alternative calls for 20 TAF to be allocated to short-term flow increases in normal water years during the months of October and November, above the minimum flow requirements described above. In dry water years, the CDFG alternative calls for a 10 TAF allocation to attraction flows. The EBMUD alternative incorporates its attraction flows into its 200 to 300 cfs minimum flow for October through December (Table 2.2-2). Staff's alternative calls for a minimum of 250 cfs at this time and experimental (interim) attraction flows in excess of that rate when excess water is

available in normal or wet water years. Staff's alternative also calls for additional monitoring to determine the effectiveness of any attraction flows before they are implemented permanently.

Pulse Flows for Outmigration of Salmonids

Elevated streamflows are also thought to facilitate outmigration of salmon fry and smolts which occurs in June and July in the Mokelumne River. The CDFG alternative allocates 10 TAF and 5 TAF of additional releases in normal/wet water years and dry water years, respectively. The EBMUD alternative incorporates outmigrant flows into its minimum flow regime in May and June (Table 2.2-2). Staff's alternative calls for a minimum of 250 cfs at this time and experimental (interim) outmigrant flows when excess water is available in normal or wet water years. Staff's alternative also calls for additional monitoring to determine the effectiveness of any outmigrant flows that are implemented.

Minimum Releases from Pardee Dam

The CDFG management plan for the Mokelumne River (CDFG 1991) includes a minimum flow requirement of 250 cfs from Pardee Dam for the purpose of maintaining a coldwater hypolimnion in Camanche Reservoir. Given the downstream water rights that must be satisfied, this minimum flow requirement at Pardee is redundant with the minimum pool requirements described in Section 2.2.2. Minimum flows from Pardee would have to be maintained to keep Camanche pool elevations high, so this option is not considered a separate mitigation component in the FEIS.

2.3 NON-FLOW ALTERNATIVES

Non-flow alternatives are actions that would not result in any substantial change in the volume of water released from existing facilities. These alternatives do involve direct changes in either facilities or operation (e.g., the habitat enhancement measures). Non-flow alternatives have the advantage of not affecting the limited water availability or water rights in the lower river but would benefit fisheries. Examples of non-flow alternatives include enhancing spawning habitat in the lower river, remediating contamination in Camanche Reservoir, multi-level outlet structures at Camanche Dam for control of downstream water temperatures, and fish passage facilities and fish screens. Although several of the actions considered under non-flow alternatives would involve off-site activities or actions by others, the discussion of these non-flow actions in the FEIS provides a more comprehensive view of the options available to benefit salmon and trout resources in the Lower Mokelumne River.

2.3.1 Habitat Enhancement Measures

Non-flow habitat enhancements include modifying and improving the available habitat for spawning and rearing salmon and trout in ways that would not directly affect water availability or release schedules to the lower river. Much of the Mokelumne River below Camanche Dam is uninterrupted riffle and run habitat. This habitat can be made more suitable for chinook salmon and steelhead by careful placement of instream habitat structures. Also, there is reduced gravel recruitment below Camanche Dam, and the controlled flows minimize the natural cleaning effect of floods, a process usually necessary to maintain high-quality spawning gravel. Therefore, gravel additions and cleaning are considered. Although some of the Mokelumne River above Lake Lodi has relatively good riparian vegetation, provision of streambank cover and shade where it does not exist can reduce sunlight penetration, reduce heating, and offer shelter to rearing fish. These options are considered in the FEIS.

The efficacy of instream structures has been investigated recently in the Klamath River basin, California (Olson and West 1990). They found that some of the more inexpensive methods, such as placing "digger logs" in runs, can be the most effective in providing improved habitat and greater fish production.

Staff conducted a qualitative assessment of the condition of the spawning gravel below Camanche Dam (based on its site visit and CDFG and EBMUD reports) and examined alternatives being conducted and proposed for its improvement. Artificial methods for cleaning gravel are now available. Mechanical cleaning has been used in a number of Pacific Northwest streams where gravels have become cemented by fine materials.

2.3.2 Improvements at Woodbridge Dam and Lake Lodi

A major bottleneck in movement of anadromous fish into and out of the Mokelumne River occurs at Woodbridge Dam at MRM 34.7 near the town of Lodi (Figure 2.3-1). Woodbridge Dam that forms Lake Lodi is a significant barrier to both upstream and downstream migrants (see Sections 3.2 and 3.3). Although this barrier has been identified as a problem by both CDFG and EBMUD, there are no specific

Figure 2.3-1. Aerial photograph of Woodbridge Dam at Mokelumne River Mile 38.7 looking upstream toward the northeast on August 25, 1986. (Photograph by Scott D. Wilcox.)

proposals to change the basic configuration of the dam or the morphology of the lake, except for the improvement of fish screens and ladders (see Section 2.3.3 and 2.3.4). Staff identified several different ways to improve the movement of fish through this section of the lower river (Figure 2.3-2).

The adverse impacts to anadromous salmon and trout of Woodbridge Dam and Lake Lodi are so serious that they could negate any benefits that could be gained from other actions taken in the river. Therefore, staff considers that improvements in this area are a critical part of successful conservation of the chinook salmon and steelhead trout resources of the river. We present this set of alternatives as a potential solution that does not rely on screening or other direct intervention in natural behavior of the fish.

Stratification Sills with Deep Discharge at Woodbridge Dam

This alternative would direct chinook salmon and steelhead smolts in Lake Lodi to the Mokelumne River below Woodbridge Dam rather than to the WID diversion or lethally warm shallows of Lake Lodi by making use of their tendency to follow cool water and avoid warm water ($>68^{\circ}\text{F}/20^{\circ}\text{C}$). The alternative would also route more cool water to the lower river where it is needed for salmon and trout and more of the warm water into the WID diversion canal where temperature is not relevant to water use. This selective guidance of flows with different temperatures can be accomplished by use of one or more sills (submerged dams) near the WID diversion, some channelization near the WID diversion, and a deep discharge at Woodbridge Dam (Figures 2.3-2A and 4.5-1). Because water of different temperature stratifies, it is possible to divert cool, deeper water (and fish) away from the WID diversion and toward the dam. Only warm surface water would be allowed to enter the diversion over the sill(s). The dam's deep discharge would release this deep, cool water (and fish) to the lower river. A small amount of deep, cool water could be pumped to the entrance of the fish bypass at the WID screens so the cooler water could attract any fish in front of the screens to the bypass. This alternative assumes there will be sufficient cool water discharges from Camanche Dam between April and July at flow rates low enough to allow thermal stratification in Lake Lodi. While this assumption would hold under the EBMUD and staff alternatives, the minimum releases recommended by CDFG and FWS are high enough that Lake Lodi may not stratify. Only more operational experience and monitoring data can determine the eventual success of this strategy.

Bypass Canal and Diversion/Screening Structure

This alternative would divert chinook salmon and steelhead fry and smolts into an alternative route around Lake Lodi, significantly reducing travel time in warm lake water and avoiding the risk of impingement/entrainment at the WID screens. This alternative would involve construction of a 7,000-foot-long canal with a 50-square-foot rectangular or trapezoidal cross section (e.g., a 5' x 10' rectangle) that skirts Lake Lodi and a screening/diversion structure at the upper end of the lake (Figure 2.3-2B). The diversion structure would be in place during the main outmigration period between April and June, and would consist of a temporary (inflatable) dam or removable screens that would divert the minimum flow. The canal would discharge to the Mokelumne River below Woodbridge Dam. Diversion of a fraction of river flow (if the diversion were located where many young fish pass, e.g., along a shoreline) could provide more fish survival than the 30% now estimated to survive passage through Lake Lodi.

New Channel and Deep Discharge Structure at Woodbridge Dam

A third alternative would also divert salmon and trout fry and smolts toward Woodbridge Dam in a main underflow of cold water, with release through the dam via a deep discharge. A new, more direct, 6,000-foot channel would be excavated and dredged through Lake Lodi and a submerged sill constructed across the present channel (Figure 2.3-2C). Shallow water of the existing lake would persist from surface flows

Figure 2.3-2. Three staff alternative hydraulic improvements to Lake Lodi to improve fish passage and to reduce late spring and summer temperatures below Woodbridge Dam. (Source: The staff.)

that leave the new channel and these flows would supply the WID diversion. A cool underflow of water (and fish) in the new channel from upper Lake Lodi would terminate at the upstream side of the dam that would be provided with a deep discharge. This alternative would also provide cooler water to the

Mokelumne River below Woodbridge Dam and allow the warmer water to enter the WID diversion. This alternative also assumes cool discharges from Camanche Dam in April through July at flow rates low enough to cause thermal stratification in Lake Lodi.

2.3.3 Upstream Fish Passage Facilities

The major barriers to upstream migration by adults are: 1) instream passage barriers created by existing river channel conditions, mostly downstream of Lodi; and 2) Woodbridge Dam. Options for improving these problems are included in the CDFG, EBMUD, and staff alternatives.

2.3.4 Downstream Fish Passage Facilities

Downstream passage issues include entrainment of fish in water diversions and pumps along the lower river, including the WID and NSJWCD diversion canals. Mortality of emigrating juvenile fall chinook salmon and steelhead trout could be decreased if the effectiveness of screens and the fish bypass at the WID diversion from Lake Lodi is increased. There are some known problems, including loss of fish to the diversion through faulty rubber seals (a problem common to many rotating drum screens), obstructions for fish lateral movement at the screen supports, and low attraction efficiency of the juvenile fish bypass that is partially caused by low entrance velocity. We examined information on the screens provided by both CDFG and EBMUD and concurs that the screens and the accessory fish bypass need improvement.

2.3.5 Other Non-Flow Alternatives

Several other non-flow alternatives are included in the alternatives considered. These potential actions are evaluated in a more qualitative manner due to limited information.

Water Quality Enhancement

The CDFG alternative relies on the enforcement of water quality standards to eliminate any potential effects of Camanche Dam discharges on water quality in the lower river and in the MRFF. The EBMUD alternative includes a hypolimnetic oxygenation scheme to improve water quality in Camanche discharges. These options are further evaluated in Section 4.

Selective Withdrawal

Water quality problems at Camanche Dam in summer (high temperature, inadequate DO, toxic materials from the hypolimnion) could be mitigated with selection of water for withdrawal that most closely meets criteria for downstream aquatic life. This selection requires an outlet structure capable of withdrawing water from alternative depths. Such structures are common in many water supply reservoirs; EBMUD uses one for its withdrawal of water from Pardee Reservoir for the District.

Water quality improvement in the Lower Mokelumne River may be possible if both Pardee and Camanche dams had multiple outlet structures for the downstream releases, including those used for hydropower. This type of management might be accomplished with present volumes of water flow. Colder water, being more dense, can be stored in deep reservoirs for release at a later time. While this storage is taking place, surface or mid-depth waters that meet quality standards can be discharged. Cool water from Pardee may be used to flush the deeper waters of Camanche Reservoir in a density underflow, minimizing the buildup of toxic materials and maintaining cool temperatures in the Camanche discharge. Feasibility and possible benefits of selective withdrawal alternatives are considered in Section 4.6.5.

Fish Facility Operation

CDFG and EBMUD have proposed changes in the operation of the MRFF. These options are discussed in general in the FEIS. There appears to be a tenuous working relationship between CDFG and EBMUD in the operation of the hatchery facility. There has been a notable lack of cooperation and coordination in recent years. We feel that close working ties are essential to make best use of the facility and to use it to the greatest advantage to sustain and enhance the Mokelumne River chinook salmon and steelhead that are affected by the hydropower installation in Camanche Dam.

Monitoring and Other Studies

Much effort and expense have already been spent on studies of the anadromous fisheries in the Mokelumne River by both EBMUD and CDFG. However, significant uncertainties remain about the effects that dams and diversions have on salmon and trout in the river. For example, the sources and rates of mortality of young salmon migrating out of the lower river are poorly quantified. Therefore, the information base needed to design mitigation requirements is not available, and there is an unavoidable degree of speculation associated with all the proposed mitigation actions by all parties. CDFG, EBMUD, and staff all identified additional studies and monitoring requirements that should be implemented or continued in the lower river. The unavoidable uncertainties and need for additional information lead staff to recommend that several interim measures be made conditional on information to be collected over the next five years.

The specific monitoring studies recommended include an enhanced program to characterize the transport and fate of contaminants in the system and actual ecological effects. This program would include a characterization of the heavy metal contamination in the water, sediment, and fish in Camanche Reservoir and the Mokelumne River. Particularly sensitive life stages, such as eggs and larvae, could be monitored for possible negative responses to contamination, such as poor survival or developmental abnormalities. Information gained from this monitoring would augment existing data that is limited and inconclusive and would allow better resolution of mitigation needs.

2.4 COMPARISON OF ALTERNATIVES

As described in Sections 2.2 and 2.3, in addition to the no action alternative, there are four sets of mitigation actions that are evaluated in this FEIS, those proposed by: 1) the CDFG; 2) EBMUD; 3) the Commission's staff; and 4) FWS in their comments on the DEIS (see Appendix H). The major components in each of these alternative approaches are summarized in Table 2.4-1. The four alternatives differ in the specific types of mitigation measures that they contain and in the ways in which mitigation is implemented. The FWS alternative consists only of a new minimum flow regime. All other alternatives are composed of both flow and non-flow requirements. The intent of all these alternatives is to benefit anadromous fish resources in the lower river, but some have adverse impacts on other water users in the river basin. Therefore, our comparison of alternatives in this section focuses on the tradeoffs between benefits to fish and costs to water supply systems.

The most significant differences among the alternatives are in their respective minimum flow requirements. Staff's minimum flow regime is intermediate between those of CDFG and FWS and those of EBMUD in terms of total volume of Camanche releases for fish(fish flows) (Figure 2.4-1), habitat values produced (Figure 2.4-2A, B, and C) and deficiencies created during drought conditions (Figure 2.4-3).

Table 2.4-1. Comparison of mitigation proposed under different alternative programs. (Source: The staff.)

Mitigation component	Alternative programs			
	CDFG	EBMUD	FWS	Staff
Minimum flow regimes at Camanche Dam excluding pulse flows ^a	Dry: 98 TAF Norm 207 TAF Wet: 262 TAF	Crit. Dry: 28 TAF Dry: 77 TAF Normal/Wet: 118 TAF	Dry: 121 TAF Normal: 121 TAF Wet: 193 TAF	Dry: 51 TAF Below normal: 108 TAF Above normal: 160 TAF
Minimum pool at Camanche reservoir	210 ft MSL in all years	"maintain stable hypolimnion", but no specifics	None specified	190 ft MSL from July to September except in consecutive dry years
Ramping rates	Based on percentage of daily and weekly average flows	Based on flow rates and spawning activity	None specified	Less than two inches per hour when flow < 400 cfs
Attraction flows	10 to 20 TAF	Conditional flows of 200 to 300 cfs in minimum flow regime	Included in minimum flow regime	Experiment with pulses >300 cfs in years with excess water
Outmigrant flows	5 to 10 TAF	Combined in minimum flow regime	Included in minimum flow regime	Experiment with pulses >300 cfs in years with excess water
Habitat rehabilitation	Emphasis on gravel improvement and riparian	Emphasis on all aspects of spawning habitat	None proposed	Emphasis on gravel improvement
Water quality	Standards-based criteria (e.g., DO $\geq$ 7 mg/L)	Hypolimnetic oxygenation	None proposed	Hypolimnetic oxygenation
Water temperature	Standards-based criteria (e.g., T _{max} < 65°F; 18.3°C at Hwy. 99 June through Oct.14).	Elevated flows when possible	None proposed	Rely on minimum pool requirements
Fish passage	Work with others	Work with others	None proposed	Suggestions for hydraulic improvements at Lake Lodi and Woodbridge Dam

TAF = thousand acre-feet; MSL = minimum storage level

^a See text for definitions of water year type.

We developed an integrated Habitat Score to combine the effects that minimum flows have on physical habitat and on water temperatures in the lower river (see Section 4 and Appendix F). The CDFG and FWS alternatives produce the highest habitat values for salmon migration and spawning (Figure 2.4-2A and B). Staff's alternative is similar to these agencies' recommendations, but produces slightly lower

Figure 2.4-1. Total annual releases from Camanche Reservoir for downstream fish resources under the five principal minimum flow alternatives (CDFG = California Department of Fish and Game, FWS = U.S. Fish and Wildlife Service, staff = the Commission's staff, and EBMUD = East Bay Municipal Utility District; pulse flows in the spring and fall for attraction and outmigration and ramping rates are not included in these totals). (Source: The staff.)

migration and spawning values. EBMUD's alternative produces lower habitat values than either staff's or the agencies' alternatives. All four action alternatives provide improved habitat for migration and spawning relative to no action. The no action alternative appears to provide the best habitat values for rearing of fry and juvenile salmon and trout (Figure 2.4-2C), but this may be an artifact of the habitat response data available for this assessment (i.e., physical habitat for fry and juvenile salmon is inversely related to stream flow). Because salmon redds and fry often occur at the same time, it is preferable to select a flow regime that avoids extreme advantages for one or the other life stage while providing reasonably abundant habitat for both.

Depending on assumptions of future demands and available supplies, minimum flow requirements may lead to a reduction in water supply to EBMUD. A water supply deficit would occur if demand exceeded total supplies (i.e., inflows plus carryover storage) in a given year. In the Mokelumne River-EBMUD system, deficits tend to occur only after consecutive dry water years, because EBMUD's total reservoir storage is several times larger than its annual demand. Long-term water supply planning is based on a critical drought period in which available supplies would be at their lowest. Both EBMUD's and staff's estimates of water deficits in the FEIS are based on a worst-case, three-year drought sequence of total annual inflows to Pardee Reservoir of 129, 246, 185 TAF. This sequence is more severe than any experienced in the historical record for the Mokelumne River (the first and second years actually occurred in 1976-1977; the third year is synthesized as an average of the first two years).

The specific effects of new minimum flow regimes on EBMUD's water supply system also depend on assumptions about the growth of water demand, the development of other water rights in the basin, and conveyance losses. EBMUD's current planning level of demand is 220 MGD (247 TAF). Historical demand over the last seventeen years (dating just prior to the 1976-78 drought of record) has averaged only 193 MGD (217 TAF) and nearly 200 MGD (224 TAF) from 1985 through 1991 (EDAW, 1992b).

Figure 2.4-2. Relative comparisons of the benefits to salmon habitat of alternative minimum flow regimes at Camanche Dam (abbreviations of alternatives are: CDFG = California Department of Fish and Game, FWS = U.S. Fish and Wildlife Service, staff = the Commission's staff, and EBMUD = East Bay Municipal Utility District; the CDFG alternative displayed does not include pulse flows for salmon attraction and out migration or ramping rates). The asterisk indicates the recommended alternative. (Source: The staff.)

Figure 2.4-3. Comparison of the costs to East Bay Municipal Utility District's water supply system of alternative minimum flow regimes at Camanche Dam (see text for explanation of water demand levels; abbreviations of alternatives are: CDFG = California Department of Fish and Game, FWS = U.S. Fish and Wildlife Service, staff = the Commission's staff with flexible minimum pool constraint, and EBMUD = East Bay Municipal Utility District; the CDFG alternative displayed does not include pulse flows for salmon attraction and out migration or ramping rates). (Source: The staff.)

Actual demand on the EBMUD system has been well-below planning levels (220 MGD). EBMUD's estimate of future demand in 2020 is 250 MGD (280 TAF) taking into account existing and planned conservation and reclamation activities. With additional conservation and reclamation EBMUD believes that 2020 demand could be reduced to 229 MGD (257 TAF). Staff concludes that even this lower estimate of 2020 demand is unduly conservative as it is based in part on early 1980s consumption rates for existing users and assumes higher consumption rates for new household construction. This is contrary to the growing conservation ethic that is occurring in California and the technical progress that has been made in water use efficiency. If none of the undeveloped water rights in the upper Mokelumne River basin are developed, neither the no action nor the EBMUD alternative produces a water supply deficit in a worst-case, three-year drought under any demand scenario (Figure 2.4-3). Deficits associated with staff's flow alternative range from 1 TAF with 1990 demand to 27.2 TAF with EBMUD's 2020 demand (Figure 2.4-3). Deficits with both the CDFG and FWS alternatives are significantly greater than with staff's alternative. Future development of water rights in the river basin is impossible to predict, but it would affect all flow alternatives equally.

We conclude that new minimum flows for downstream fish resources can be required at Camanche Dam without an unacceptable impact to EBMUD's water supply system. While the alternatives proposed by CDFG and FWS do clearly produce unacceptably high water supply deficits, staff's alternative produces an incremental deficit that would be tolerable and would only be incurred under a three-year drought sequence much more severe than any in the historical record. Our conclusion recognizes that EBMUD has several options to pursue more demand-side water conservation, as well as options to increase its water

supply within and outside of the Mokelumne River basin. EBMUD is likely to pursue one or more of these options in the near future under its updated WSMP regardless of the outcome of this Commission proceeding.

The levelized annual cost of meeting the water supply deficit that we predict in a three-year drought under staff's 2020 reduced demand conditions is \$20 and \$24 million, respectively, for the CDFG and FWS alternatives. These costs include \$12.6 million for implementation of EBMUD's additional water conservation and reclamation projects [i.e., the conservation level II and reclamation A1 options in EBMUD's updated WSMP (EDAW, Inc., 1992a)], to reduce demand to 229 MGD, plus the costs of groundwater development which appears to be EBMUD's low-cost supply alternative. The comparable cost of staff's alternative is significantly less, because the quantity of water involved is relatively small. However, this cost is not trivial. The levelized annual cost of staff's alternative is between \$12.6 and \$18.1 million, including EBMUD's demand reduction program plus the cost of securing a small quantity of additional water during drought periods. The cost of the additional water needed under staff's alternative depends on the acquisition strategy used by EBMUD; options range from developing groundwater storage capabilities (\$5.5 million) to water transfers from other water rights holders (\$50-200/ac-ft).

The preceding assumes EBMUD's 2020 planning demand of 250 MGD less 21 MGD demand savings from additional conservation and water reclamation projects. As noted above, staff concludes that EBMUD's forecast of future demand growth is conservative and that demand in 2020 will more likely resemble current planning demand (220 MGD). Under this demand scenario, there would be essentially no water deficit under staff's alternative (1 TAF). Deficits under CDFG and FWS would be greatly reduced.

Because staff's alternative produces the best combination of improved habitat for chinook salmon and relatively low costs to water supply (e.g., comparable to EBMUD's own proposal), we recommend it as the preferred flow alternative. Other non-flow mitigation measures and additional monitoring are also recommended. Further details of the staff's findings and recommendations are presented in Section 5.

We conclude that new minimum flows for downstream fish resources can be required at Camanche Dam without unacceptable impact to EBMUD's water supply system. While the alternatives proposed by CDFG and FWS do clearly produce unacceptably high water supply deficits, staff's alternative produces an incremental deficit that would be tolerable and would only be incurred under a three-year drought sequence much more severe than any in the historical record and is based on accepting EBMUD's projections of future demand. Our conclusion recognizes that EBMUD has several options to pursue more demand-side water conservation, as well as options to increase its water supply within and outside of the Mokelumne River basin. EBMUD is likely to pursue one or more of these options in the near future under its updated WSMP regardless of the outcome of this Commission proceeding.

3. AFFECTED ENVIRONMENT

The description of the environmental setting of the LMRP presented in this section is organized into six parts: 1) general information on the river basin, including geomorphology, water resource development, and relevant state/regional planning activities; 2) water quality and quantity; 3) fisheries and other aquatic resources; 4) terrestrial/riparian resources; 5) socioeconomics, including recreational resources; and 6) water demand and supply issues affecting the licensee, EBMUD. After the general introduction in the first subsection, Sections 3.2 through 3.5 are intended to describe the natural and human resources affected by operations of the LMRP. Section 3.6 describes unique characteristics of the EBMUD service area and water supply issues that are especially pertinent to this proceeding. The Penn Mine located on Camanche Reservoir is described in Section 3.1.3

3.1 GENERAL DESCRIPTION OF THE MOKELUMNE RIVER BASIN

The LMRP is located in the Mokelumne River basin in the foothills of the Sierra Nevada Mountains, at the eastern edge of the Central Valley of California (Figure 1.1-1). The project is approximately 35 miles southeast of Sacramento, 23 miles northeast of Stockton, and 73 miles northeast of Oakland. The general characteristics and historical development of the Mokelumne River basin are described in this subsection, as they relate to current fish and water resources. Throughout this assessment, locations within the river basin are referenced in terms of MRM, measured as miles above the confluence of the Mokelumne and San Joaquin rivers. For example, Camanche Dam is located at MRM 63.7, and the town of Lodi is located between MRMs 38 and 43.

Topography within the Mokelumne River Basin is highly varied. Elevations range from below sea level in certain irrigated sections of the San Joaquin Valley to more than 11,000 ft in the Sierra Nevada Mountains. The western portions of the river basin include the upper reaches of the Delta where the Sacramento and San Joaquin rivers join, whereas the eastern portion of the region is mountainous and includes a large, forested watershed. The climate varies directly with topography. Warm summers and mild winters are common in the valley while cool summers, and winters with heavy snowfalls, are typical of the high mountain areas.

3.1.1 River Basin Geomorphology

The Mokelumne River is the northernmost watershed in the San Joaquin River Basin in the center of the State of California, draining the western slope of the Sierra Nevada Mountains. The river's headwaters are in the pre-Tertiary "bedrock series" of the Sierra Nevadas. As it flows westward, the river passes through the foothills and the Tertiary Ione formation, which is composed chiefly of silt and clay, and the redlands, which are early Pleistocene uplifted alluvial fans. The entire river basin drains 661 sq miles, ending in the low plains, valley floodplains, and delta country where the Sacramento and San Joaquin Rivers meet in a large wetland of interlocking channels. Soils in the lower reaches are younger alluvium (Stearns et al. 1930).

The river basin is relatively narrow and spoon-shaped, much wider in its headwaters in the mountains. Overall, the basin is approximately 90 miles long. In the mountains, the basin is approximately 15 miles wide, but it narrows to less than two miles wide at Mokelumne Hill just upstream from Pardee Reservoir. Drainage areas are 544 sq miles at Mokelumne Hill above Pardee Reservoir, 578 sq miles at Pardee Dam (MRM 73.4), 621 sq miles at Camanche Dam (MRM 63.7), and 627 sq miles at Woodbridge Dam (MRM 73.4). There is very little local surface water inflow in the lower river. The portion of the Mokelumne River below the United States Geological Survey (USGS) stream gage near Mokelumne Hill (Station No. 11319500) is referred to as the "Lower Mokelumne River". A schematic profile of the lower river is shown in Figure 3.1-1. Key locations along the Lower Mokelumne River are listed in Table 3.1-1.

Figure 3.1-1. Profile of the Lower Mokelumne River. (Source: The staff.)

For purposes of simplification, four distinct segments of the lower river are discussed in the FEIS: 1) the Passage Segment below Woodbridge Dam and the upper extent of tidal influence; 2) the Lake Lodi Segment; 3) the Rearing Segment between Lake Lodi and Mackville Road, centered on the Bruella Road crossing; and 4) the Spawning or Tailwater Segment immediately below Camanche Dam (Figure 3.1-1). These river segments are defined in terms of their use in the life cycle of anadromous salmon and trout in the Lower Mokelumne River. Further details on these segments are presented in Section 3.3.

The 4.5 miles of river between Camanche Dam and Mackville Road are relatively shallow, riffle-run habitat types over gravel-cobble substrates in a generally broad channel (78–141 ft) with few to no accumulations of large woody debris. This segment of the river is where the majority of spawning of salmon and trout occurs. In the 14.5 mile river segment between the Mackville Road (MRM 59.2) crossing and the upper reach of Lake Lodi (approximately MRM 43), the channel is deeper and narrower, and water moves more slowly (run-pool type habitat) over sand-mud substrate with moderately to frequently levied banks (Simpson 1972; CDFG 1991). Much of the narrowing of the river can be attributed to the channeling from the flood control levees as the Lower Mokelumne flows through valley floodplains. Travel times of water between Camanche Dam and Woodbridge Dam are estimated to range from 1.6 days at high flows (greater than 1000 cfs) to 11.3 days at low flows (~75 cfs) (CDFG 1991).

Geology

The surface geology of the river basin generally consists of four specific zones, or geologic belts, with NNW-SSE orientations (Stearns et al. 1930; Piper et al. 1939). The river flows westward, cutting transversely across these belts. Three of the geologic belts are upstream from Camanche Dam, and the fourth is downstream from this dam. The three upstream belts are (in upstream to downstream order) the

Table 3.1-1. River mile locations along the Lower Mokelumne River. (Source: The staff.)

Mokelumne River Mile	Feature
0.0	Confluence between the Mokelumne and San Joaquin rivers in the Delta
22.5	Bridge at Interstate Highway 5
23.0	Confluence between the Cosumnes and Mokelumne rivers
25.0	Upstream extent of tidal influence
28.9	Town of Thornton
38.4	United States Geological Survey (USGS) gage below Woodbridge Dam (Station No. 11325500)
38.7	Woodbridge Dam and towns of Lodi and Woodbridge
38.8	Point of diversion for Woodbridge Canal at Woodbridge (also USGS gage, Station No. 11325000)
43.0	Bridge at State Highway 99
48.9	"Bruella" instream flow study reach
49.3	Bridge at Bruella Road
51.0	Point of diversion for north North San Joaquin Water Conservation District (NSJWCD) withdrawals
51.3	Point of diversion for south NSJWCD withdrawals
53.5	Bridge at Elliot Road
59.2	Bridge at Mackville Road (town of Clements) and Stillman-Magee Park
61.0	Bridge at Highway 88
61.5	Teichert gravel pits
62.3	"Pasture" instream flow study reach
62.7	USGS gage below Camanche Dam (Station No. 11323500)
63.0	Van Assen County Park
63.0	"Spillway" instream flow study reach
63.5	"Fish Screen" instream flow study reach
63.6	Camanche powerhouse
63.7	Camanche Dam and Mokelumne River Fish Facility
73.4	Pardee Dam and powerhouse

Sierra Nevada Mountains, the foothills, and the Arroyo Seco dissected pediment. The easternmost belt is essentially the Sierra Nevada Mountains, consisting of granitic and metamorphic rocks, andesitic sediments, and breccias with very low permeability. West of the Sierra Nevada Mountains are the foothills, which consist principally of Tertiary clays with sands, gravels, breccias and silts with very low permeability. Between the foothills and Camanche Dam site is the Arroyo Seco dissected pediment, consisting of "older alluvium" composed of partially cemented sand, clay, and gravel of the Arroyo Seco and other unnamed gravel units. These sediments are relatively impermeable.

The Victor alluvial plain extends westward (downstream) from near Camanche Dam. The Lower Mokelumne River flows across the Victor alluvial plain, past the cities of Victor and Lodi. The western boundary of the Victor alluvial plain is roughly sea level (tidewater). Deposits in the Victor alluvial plain consist of the unconsolidated sands, silts, and gravels of the Victor formation and Recent alluvium. These sediments exhibit a relatively high permeability. The Victor formation was deposited as an alluvial fan by the ancestral Mokelumne River as it exited the mountains to the east. The Recent alluvium was deposited in present stream channels and floodplains. The Victor alluvial plain comprises most of the heavily cultivated and irrigated land in the area of the Lower Mokelumne River.

In descending order from the surface, the stratigraphy of the Lower Mokelumne River area below Camanche Reservoir consists of Recent alluvium and Victor formation (200 to 300 ft thick); the "older alluvium" of the Arroyo Seco and unnamed gravel deposits (475 to 800 ft thick); Tertiary deposits of the Laguna, Mehrten and Valley Springs formations (150 to 1500 ft thick); the Cretaceous shales of the Chico Group; and pre-Cretaceous crystalline "bedrock".

Changes in Channel Form and Riparian Vegetation

The presence of Pardee and Camanche Dams has altered channel form and riparian vegetation of the Lower Mokelumne River below Camanche from its pre-dam condition. These effects have been caused primarily by an altered flood regime in which peak flows have been greatly reduced (Section 3.2.1). The geomorphic effect of this changed flood regime is to stabilize formerly active river deposits and permit encroachment of vegetation into the active channel. This change is documented from historical sources, such as old aerial photographs of the Lower Mokelumne River (back to the 1930s). The active channel is now about one-half its former width, as evidenced by distinctive bands of alders along the bank of the low flow channel. These bands look nearly identical to the alders that line the Trinity River below Lewiston Dam, whose channel has narrowed since dam construction in 1960, a period of 33 years as opposed to the 30 years on the Lower Mokelumne River.

Spawning Gravels

Spawning gravels available for use by chinook salmon and steelhead in the Lower Mokelumne River below Camanche Dam were sampled by Simons, Li and Associates (SLA) for EnviroSphere (CDFG 1988) and Biosystems (1992). SLA samples were reported to weigh between 20 and 40 lbs. each. Grain size distributions were not well constrained at the upper end because the largest sieve used was inadequate to characterize the coarsest fractions. Biosystems (1992) sampled gravels in 1991 and 1992. Sample size ranged from 8 to 15 kg in 1991, 10 to 18 kg in 1992. Given the large size of some of the gravels, these sample sizes are probably too small for accurate representation. Thus, there is cause to doubt the accuracy of both the EnviroSphere and Biosystems particle size data. The Biosystems values tend to be larger than those reported by EnviroSphere.

Using criteria for median sizes of chinook salmon spawning gravels (Kondolf and Wolman 1993), most of the sampled gravels fall within the range of acceptable framework size, although the samples with median

sizes over 50 mm have gravels larger than optimal. The size data also suggest that the bed is too fine beginning 7 miles downstream of the dam. However, samples within 7 miles of the dam have low fine sediment contents.

The suitability of the gravels with respect to fine sediment content is unclear. Most Biosystems samples were reported to have less than 1% finer than 1.2 mm. This is well below the criteria of about 12% less than 1 mm drawn from the literature (Kondolf 1988), suggesting that fine sediments do not appear to be limiting. However, the lack of fine sediment could be an artifact of the sampling procedure. The description of sampling procedure by Biosystems is unclear, but it appears that sediment was permitted to wash downstream into a sample net. It is possible that some of the finer fractions were washed away in this process, and that actual fine sediment contents are higher than reported. By contrast, the EnviroSphere samples within seven miles of the dam contained between 5 and 20% finer than 1 mm. These fine sediment contents are marginal. With cleansing by fish, they might be suitable. EnviroSphere (CDFG 1988) presented inadequate description of the sample procedures to say for certain what caused the overall size differences (as well as percentage finer than 1 mm) between the studies, but sampling procedures are probably the explanation. Based on the limited information available, it is likely that the EnviroSphere data are the more representative of true bed material sizes than are the Biosystems data. Still, sample size is inadequate and upper end of the distributions inadequately defined. Thus, most Lower Mokelumne River gravels appear to be suitable for spawning, although many deposits are too coarse.

Biosystems (1992) reported that gravels tended to be compacted and immobile below the dam. Areas of bed that may have been immobile for a long time are suggested by the accumulation of algae and interstitial fine sediments. Gravels placed in the channel immediately below the dam in 1990 have been entrained and transported downstream, some lodging amongst marginal vegetation.

EnviroSphere (CDFG 1988) presents contradictory information about gravel mobility. "Losses of spawning gravels" due to transport by the 1986 flood was reported, but in the Addendum to the report, Simons, Li, and Associates predicted that at 10,000 cfs 40–50% of the bed would remain immobile. The 1986 flood release was 6000 cfs, suggesting that their predictions of transport are probably unrealistically low.

3.1.2 Water Resources Development

The Mokelumne River has been used for water supply and hydropower production since the late 1800s. The upper basin above Pardee Reservoir has been developed by PG&E for hydropower, while the lower basin has been developed by EBMUD and others for water supply and other uses. Development of water resources begins in the headwaters (approximately MRM 145) of the basin by the PG&E hydropower reservoirs and by several municipalities for water supply. The existing hydropower development in the upper basin is restricted largely to the North Fork of the Mokelumne River (Figure 1.1-1). The Middle and South Forks of the basin are largely undeveloped.

PG&E's existing Mokelumne Project (FERC Project No. 137) in the upper basin includes seven reservoirs with a combined storage capacity of approximately 217 TAF. These facilities are storage and diversion projects operated primarily for hydropower production. Upper and Lower Blue Lakes, Twin Lake, and Meadow Lake are small reservoirs on tributaries of the North Fork draining into Salt Springs Reservoir, a storage facility with a total capacity of 130 TAF. Another PG&E storage reservoir, Lower Bear Reservoir with a capacity of 49 TAF, is located on another tributary of the North Fork. Streamflows and reservoir releases are diverted through an extensive network of penstocks and tunnels to downstream powerhouses

with a combined hydropower capacity of 194.3 MW. The lower extent of PG&E's development is at its Electra powerhouse at MRM 88 above Pardee Reservoir.

Of the proposed hydropower development in the upper basin, the most imminent is the Devil's Nose/Cross County Project (FERC Project No. 8759 and 8144). The Devil's Nose/Cross County Project would involve construction of a new, 470-ft-high dam on the North Fork of the Mokelumne downstream of PG&E's Salt Springs facility. It would also involve construction of approximately 12 miles of new diversion structures to route water down to a new powerhouse just upstream of the existing PG&E Electra powerhouse. Recently, Amador County has stated that the Devil's Nose project is primarily a water supply project and that, as a hydropower project, its economics are marginal (FERC 1993d). The feasibility of the Devil's Nose project is in some doubt.

PG&E has proposed to upgrade its existing Mokelumne project by increasing the height of two dams, increasing its diversion capacity, and building several new powerhouses. However, PG&E has recently written the Commission informing them of their intent to withdraw these upgrades (PG&E 1993). A separate proceeding by the Commission to address these two projects has been initiated, but the schedule of that proceeding is uncertain pending modifications to both Amador County and PG&E's license application and outstanding requests for additional information. Any cumulative effects and interactions between hydropower development in the upper and lower basins would be addressed in that new proceeding.

Several other projects have been proposed in the upper basin, but their future development is too uncertain to be fully considered in this FEIS. These potential projects include the Middle Bar Project on the mainstem of the Mokelumne above Pardee Reservoir (new storage capacity of 140 TAF) and the Railroad Flat Dam on the South Fork of the Mokelumne River. Both these projects face serious financial, environmental, and water rights problems before they could be seriously considered. Several pumped storage projects have also been studied in the upper basin (Wilson and Smith 1979), but none of these have developed into serious proposals.

Natural surface water hydrology downstream of the confluence of the Mokelumne and Sacramento rivers has been drastically modified by the operations of the Central Valley Project and the State Water Project that withdraw water from the Sacramento-San Joaquin Delta (CDWR 1987). The problems in this area are highly complex and controversial, and they are the subject of other ongoing proceedings involving the State Board and many other federal, state, and private parties (see Section 3.1.4). These other proceedings are not likely to come to any final conclusions in the near future (e.g., next 12 months). Although the man-made changes in water flows in the Delta have significant effects on the life cycle of anadromous fish (Section 3.3), the impacts of water projects in the Delta are beyond the scope of this FEIS. For further discussion of this issue, see Section 4.7, Cumulative Impacts.

3.1.3 Penn Mine and Related Activities

One historical development in the basin, the Penn Mine, is of particular concern for integrated water resource development in the Lower Mokelumne River. Penn Mine was operated primarily as a deep-shaft copper mine since the middle of the last century. It is now abandoned and releases acid mine drainage to the Mokelumne River. This drainage affects water quality and sediment composition and influences the uses of water downstream of the mine.

The abandoned Penn Mine is located adjacent to the southeastern shoreline of the upper end of Camanche Reservoir. This underground mine was first opened in 1861 and operated intermittently through the mid-1950s. Parts of the tailing piles and the major surface water drainage system for the

mine, Mine Run, lie within EBMUD's LMRP boundary (Figure 3.1-2). The Penn Mine was one of the four largest copper mines in California. Three other mines in the Mount Shasta region collectively provided about 90% of California's historical copper production, and the Penn Mine provided about 10% of the state's production (Hezl 1948). Although there are many other copper mines in California, their collective historical copper output was less than 1%.

Figure 3.1-3 is a geologic map of mineralized zones and mine shafts related to Penn Mine and nearby smaller mine sites (Hezl, Cox, and Eric 1948). Six vertical shafts (numbered one through six) were constructed on Penn Mine property and two other shafts were constructed on adjacent property (Gallagher and Lone Star). Another shaft (the Borger shaft, not shown in the figure) is located about 2,000 ft southeast of the Gallagher shaft. There are about 55,000 linear-ft of mine workings, including 42,000 ft of horizontal drifts and crosscuts and 13,000 ft of vertical shafts and raises. The orientations of mined mineralized zones are likely to have a strong influence on the direction of groundwater flow in the slightly metamorphosed and fractured volcanic and sedimentary strata of the region. These zones are parallel to one another; they strike from northwest to southeast and dip nearly vertically. Mine workings in these zones extend for three quarters of a mile to depths ranging to 3,400 ft. The workings are structured like a thin honeycomb wafer. Generally, the two long axes of the honeycomb structures are nearly vertical and parallel to strike (northwest-southeast), and the short axis is perpendicular to strike (northeast-southwest). Ore and waste rock were brought to the surface at the mine shafts' entrance. Most of the waste rock accumulated downslope from shafts one, three, four, and six. The ore was transported to an on-site smelter. Approximately 80 million pounds of copper were extracted from nearly one million tons of ore which accumulated as slag on the southeastern shore of the Mokelumne River. Locations of mine waste rock and the slag deposit are shown in Figure 3.1-2 (CRWQCB 1992). Approximately 40 acres of waste rock, unprocessed ore, and mill waste (tailings) were scattered on the surface throughout the Penn Mine property. The largest waste rock pile is located on the east side of Hinkley Run Creek. A smaller waste rock pile (the Shoreline pile) is located north of Mine Run Dam and near the east shore of Camanche Reservoir. The slag disposal site (1,500 ft long, 100 to 300 ft wide, and up to 40 ft thick) lies on EBMUD property and within Camanche Reservoir's full-pool level (Camanche Dam's spillway crest elevation, 235.5 ft).

To put these characteristics of Penn Mine in perspective, it is useful to describe other comparable mines in California. Copper mines in the Mount Shasta area of northern California produced two to four times as much ore and two to ten times as much waste rock as the Penn Mine (Hezl 1948; UC-B 1988). Ore was mined by the open-pit method at one of the Mount Shasta mine sites. This one open-pit mine produced about ten times more waste rock than at the Penn Mine.

Groundwater discharge is another major difference between Penn Mine and the mines near Mount Shasta (UC-B 1988). Although no groundwater studies have been completed, there is likely to be a significant component of groundwater flow along the alignment of these mined mineralized zones (northwest, toward the Mokelumne River). Water continuously discharges from entrances to shafts at Mount Shasta. Although some of these entrances were sealed by bulkheads, groundwater continues to discharge from them. Shaft entrances at Penn Mine have not been sealed. Groundwater only discharges during wet seasons from Shaft No. 4 (based on data provided by Hamlin and Alpers 1993.) Average flow rate in February and March 1993 is about 40 gpm with a peak of 77 gpm immediately following a large precipitation event. Discharge from Shaft No. 4 ceases by mid-April.

Penn Mine's waste rock is believed to be the source of most of the acid mine drainage (AMD) and associated dissolved metals that reach Camanche Reservoir from the Penn Mine property. Although the ore grade of the waste rock was too low to extract copper economically, metal (iron, copper, zinc, cadmium, and other metals) sulfides are still present. These metal sulfides react with oxygen and water to

Figure 3.1-2. Map of current evaporation ponds, diversion ditches and pump-back system at the Penn Mine site. Numbers refer to remedial measures described in the text. (Source: Modified after CRWQCB 1992)

Figure 3.1-3. Geologic map of mineralized zones and mine shafts at the Penn Mine site. (Source: Modified after Hezl, Cox, and Eric 1948.)

form strongly acidic solutions with dissolved metals i.e., AMD. Historically (before Camanche Reservoir was first filled), AMD has been released into the Mokelumne River during heavy rains or during mine dewatering. Although metals are still in the slag deposit on the shore of Camanche Reservoir, they are not present in a leachable form. Wiebelt and Ricker (1948) investigated the feasibility of extracting zinc from the slag deposit. The average zinc concentration in the slag was 6.5% by weight. However, the zinc could not be economically extracted because it was chemically bonded to oxygen in the form of silicates and oxides. Metals are largely non-reactive with the environment in this chemical form because of their low solubilities in mildly acidic solutions. Sulfur (along with most of the copper) had been removed from the ore during smelting. Therefore, the slag deposit is no source of sulfuric acid.

Current Control of Contaminated Water at the Penn Mine Site

Currently there are seven evaporation ponds, three diversion ditches, and a pump-back system for controlling AMD at the Penn Mine (Figure 3.1-2). These ponds collectively catch and store a maximum of 11 ac-ft of AMD (commingled from stormwater runoff and groundwater seepage) from mine waste rock adjacent to the creeks and the Shoreline waste rock deposit. The diversion structures on Hinkley Run Creek and Mine Run Creek (Figure 3.1-2) divert the flow of uncontaminated stormwater runoff (referred to as stormwater) away from AMD in ponds and mine waste rock. One diversion ditch collects AMD from the Shoreline waste rock pile and directs it to Mine Run Reservoir.

Water in Mine Run Reservoir is currently pumped back to ponds on Hinkley Run and Mine Run Creek. Maintenance of these upstream ponds promotes increased evaporation through increased surface area. However, this pond water also promotes accelerated AMD through prolonged contact with pyrite-bearing waste rock.

The ponds are classified as toxic pits under the California Toxic Pits Cleanup Act (TCPA) of 1984 according to the CRWQCB. During heavy rainstorms, the capacity of the ponds is sometimes exceeded, and uncontrolled releases of AMD pass through Mine Run Dam's spillway and into Camanche Reservoir (Bond 1988). AMD in the diversion ditch from the Shoreline waste rock pile crosses over the Hinkley Run diversion canal via a flume. Some AMD leaks through the bottom of the flume to commingle with stormwater in the Hinkley Run diversion canal.

Neither the diversion ditches nor the evaporation ponds are isolated from shallow groundwater. Although Mine Run Dam has a clay core wall which retards shallow groundwater discharge of AMD under the dam, none of the ponds or diversion channels is lined. Therefore, the creek beds and diversion channels are all in hydrologic contact with shallow groundwater.

The magnitude of the metals load to Camanche Reservoir via the groundwater pathway is uncertain. Data from Hamlin and Alpers (1993) provides ranges of pH and copper concentrations in groundwater samples taken between Mine Run Reservoir and Camanche Reservoir. The pH and copper concentration ranges from 3.7 to 7.8 and 0.01 to 86 mg/l, respectively. The higher copper concentrations are associated with low pH and, together, they suggest that AMD has reached groundwater downgradient from Mine Run Reservoir (MRR). Groundwater discharge rate estimates between MRR and Camanche Reservoir range from a low of 1,400 to 671,000 ft³/yr, based on the measured hydraulic gradient, range of hydraulic conductivities, and estimated cross-sectional area along the fractured rock flow path. Lower and upper bound copper loads to Camanche Reservoir are a few kg/yr and more than 1000 kg/yr, respectively. Similar uncertainties exist for zinc and cadmium. The lower and upper bound zinc load estimates are a few 10s of kg and more than 6000 kg/yr, respectively.

Short-Term Penn Mine Remedial Measures

The objective of short-term remedial measures is to improve the efficiency of existing pollution control features while long-term solutions are evaluated, designed, and implemented over the next three to five years (CRWQCB 1992). Although five short-term measures were expected to be completed by the end of 1992, before the expected onset of the next rainy season, only three of them have been implemented to date.

These five short-term remedial measures are reasonable and are likely to improve the situation significantly as described below. These measures (identified on Figure 3.1-2 as numbers one through five) are:

- 1) Installation of an impervious cover to prevent AMD formation in the Shoreline mine waste rock pile. This cover would eliminate the need for the AMD diversion ditch and flume over the Hinkley Run stormwater diversion ditch. Thus, one source of AMD into the Hinkley Run ditch and Mine Run Reservoir would be eliminated. (This measure was not funded in fiscal year 1993.)
- 2) Construction of a gravity drainage system for diverting stormwater in the upper Mine Run Creek watershed away from mine waste rock and AMD ponds, and directing it into Oregon Gulch. This action would reduce the likelihood and severity of uncontrolled releases of AMD through Mine Run Dam's spillway. (This measure was considered by CRWQCB but is now cancelled.)
- 3) Regrading and lining of Mine Run diversion channels. The regraded channel would have more efficient flow which would reduce the likelihood of stormwater overflow. Better containment of stormwater would reduce the possibility of its contact with mine waste rock or AMD. The lining of Mine Run Creek diversion channels would reduce groundwater recharge and potential contact with AMD through groundwater seepage. This action would reduce the likelihood and severity of uncontrolled releases of AMD through Mine Run Dam's spillway.
- 4) Regrading and lining of Hinkley Run diversion channels. This action would provide the same benefits as No. 3) above.
- 5) Increasing storage capacity of Mine Run Dam Reservoir. The dam crest and spillway elevations would be raised by 1.5 and 2.0 ft, respectively, providing an additional two million gallons of storage capacity (2.9 ac-ft). This action would reduce the likelihood and severity of uncontrolled releases of AMD through the spillway of Mine Run Dam. On the other hand, increased storage capacity would be achieved by increasing the surface area and hydrostatic head in the reservoir. These factors would cause increased groundwater seepage through Mine Run Dam. However, additional seepage through the dam is significantly outweighed by the benefits of reducing uncontrolled discharge of AMD through the spillway.

The above short-term remedial measures would have positive environmental impacts on Camanche Reservoir. Implementation of these measures would reduce the generation of AMD by diverting more stormwater prior to contact with mine waste rock and by reducing infiltration of groundwater into the mine waste rock. Increased storage capacity for AMD also would be provided. Together, these measures would reduce the frequency and severity of uncontrolled releases of AMD at the Mine Run Dam spillway during major storm events and reduce the frequency of recycling Mine Run Reservoir water through upstream holding ponds (a practice which is believed to promote the formation of additional AMD.). Furthermore, AMD would no longer commingle with stormwater in Hinkley Run diversion canal.

The Shoreline mine waste pile has not been covered (remedial measure No. 1). AMD from this waste pile continues to be routed to MRR. On the positive side, the flume that transmits AMD from this waste pile to MRR has been upgraded. Therefore, significantly less AMD now reaches Camanche Reservoir directly through the Hinkley Run stormwater diversion canal.

Construction of the stormwater diversion canal from upper Mine Run Creek to Oregon Gulch has been cancelled (remedial measure No. 2). Stormwater is pumped into Oregon Gulch from behind a berm that intercepts upper Mine Run Creek runoff before it reaches areas that are highly contaminated with AMD. Although dissolved metals are present in this water, their concentrations have not been adequately characterized and may be near background levels. Furthermore, background levels are not well known.

Upper bound metals load estimates from various Penn Mine sources to Camanche Reservoir are useful for distinguishing between major and minor sources of contamination. Although such estimates are highly uncertain, they provide a valid basis for comparing relative order of magnitude contributions from various sources.

A preliminary estimate of the upper bound of the metals load to Camanche Reservoir from diverted stormwater from upper Mine Run Creek is based on two assumptions. Conservatively, surface runoff is assumed to be equal to average annual volume of rainfall that falls on the upper Mine Run Creek watershed (i.e., no credit is given for evapo-transpiration and groundwater recharge). Also, the concentrations of copper and zinc are assumed to be 1% of their concentrations in MRR. Bond (1988) states that copper and zinc concentrations in MRR were 34 and 146 mg/l in 1986. Therefore, concentrations of copper and zinc in water being pumped from upper Mine Run Creek to Oregon Gulch may be no more than 0.34 and 1.46 mg/l, respectively. Although the second assumption may not be conservative, it probably is significantly larger than most background trace metal concentrations. Upper Mine Run Creek's drainage area is 56 acres and the average annual rainfall is 20 inches per year at Pardee Reservoir, a short distance upstream from the Penn Mine site. Under these assumptions and conditions, copper and zinc loads to Camanche Reservoir would be about 41 and 175 kg/yr, respectively. These estimates are between one and two orders of magnitude less than the upper bound copper and zinc load estimates for the groundwater pathway from MRR to Camanche Reservoir.

Preliminary estimates of the upper bound of metals loads also are provided for groundwater discharge from Penn Mine Shaft No. 4 to Camanche Reservoir via MRR. During February and March of 1993 an average of 40 gpm was discharged from Shaft No. 4. Rainfall during this period was abnormally heavy. If Shaft No. 4 were sealed, uncontrolled overflows from MRR during heavy periods of rain could be reduced by the amount of groundwater that would no longer be discharging from the mine. However, some increase in local spring discharge would be expected. The volume of this water and the concentrations of copper and zinc in MRR are used to calculate the hypothetical metals load to Camanche Reservoir from Shaft No. 4. Bond (1988) provides copper and zinc concentrations in MRR (34 and 146 mg/l, respectively) during an uncontrolled release in 1986. If the amount of water hypothetically released from MRR were exactly equal to the discharge from Shaft No. 4, the copper and zinc loads to Camanche Reservoir would be 450 and 1900 kg, respectively, per uncontrolled release. If uncontrolled releases have recurrence intervals on the order of once every three years, then the annual copper and zinc loads to Camanche Reservoir would be about 150 and 630 kg, respectively. These upper bound metals load estimates are nearly an order of magnitude greater than annual releases from upper Mine Run Creek via Oregon Gulch but an order of magnitude less than those of the MRR groundwater pathway.

The methodology for obtaining preliminary estimates of the upper bound metals load estimates for AMD from the Shoreline mine waste pile to Camanche Reservoir is based on both the upper Mine Run Creek-Oregon Gulch and Shaft No. 4 pathway methodologies. The volume of water transmitted from the pile

through the flume to MRR depends on the surface area of the pile (approximately one acre) and the anticipated annual rainfall for an abnormally wet year. An abnormally wet year is arbitrarily set at twice the annual average rainfall or 40 inches per year. Water would be expected to overflow MRD about every third year, as before. It is assumed that no evapotranspiration or groundwater recharge occurs. It is further assumed that the amount of water hypothetically released from MRR is exactly equal to the wet-year influx from the Shoreline mine waste pile. Finally, it is assumed that the copper and zinc concentrations in MRR are the same as they were during the 1986 uncontrolled release (34 and 146 mg/l, respectively). Under these assumptions and conditions the copper and zinc loads from the Shoreline pile to Camanche Reservoir would be 50 and 200 kg per year, or about the same as metal loads to Camanche Reservoir via the upper Mine Run Creek-Oregon Gulch pathway.

The above analyses suggest that the groundwater and Shaft No. 4 pathways to Camanche Reservoir are most significant. These analyses also suggest that metal loads from the Shoreline mine waste pile and the upper Mine Run Creek-Oregon Gulch pathways are similar. Uncertainties in these analyses could be reduced by improved knowledge of watershed hydrology and water quality data for upper Mine Run Creek.

Prioritization of remaining remedial action projects should await the outcome of further watershed hydrologic characterization throughout the Penn Mine area and water quality characterization of upper Mine Run Creek. Copper can be removed from upper Mine Run Creek by passing the discharge through a scrap iron container prior to release to Oregon Gulch. This may be a feasible alternative to construction of a diversion canal into Oregon Gulch. If metal loads from upper Mine Run Creek are incremental to other sources of contamination, then diversion or treatment of this discharge only would provide marginal benefits in water quality to Camanche Reservoir. The metals load from the groundwater pathway may be reduced either by lining MRR or by establishing a pump-back system from the most highly contaminated wells near the toe of MRD. The feasibility of sealing Shaft No. 4 would have to be determined.

To better characterize the contamination of the Mokelumne River and Camanche Reservoir by Penn Mine, releases from upper Mine Run Creek and MRR should be monitored. Measured discharge rates and concentrations of cadmium, copper, and zinc are necessary to determine their annual loads to Camanche Reservoir. There are three possible outcomes from monitoring water behind the berm across upper Mine Run Creek. If metals concentrations are: 1) near background, monitoring may be suspended; 2) somewhat higher than background, monitoring should be continued; or 3) significantly higher than background, the berm should be replaced with a diversion canal far enough upstream on Mine Run Creek to avoid contaminated soil.

Compliance with Applicable Laws and Regulations

Six unlined surface impoundments at Penn Mine are classified as toxic pits under the Toxic Substances Control Act of 1984 according to the Regional Water Quality Board. Of these six, only Mine Run Reservoir is located on EBMUD property at the confluence of Hinkley Run and Mine Run Creeks, constructed by EBMUD. The other five impoundments are located on property owned by New Penn Mines Incorporated and were built under the direction of the Regional Water Quality Board. The circulation and release of impounded water from Mine Run Dam Reservoir into the smaller impoundments and into Camanche Reservoir are jointly controlled by the Regional Water Quality Board and EBMUD. The CDFG is to be consulted before controlled releases are allowed into Camanche Reservoir.

Although previous Waste Discharge Requirements (WDRs) were issued for Penn Mine in the early 1970s, no National Pollutant Discharge Elimination System (NPDES) permit or WDRs were ever issued for the

discharge from the current facilities. In April 1990, the Regional Water Quality Board granted EBMUD a waiver and exemption from the provisions of TPCA for Mine Run Dam reservoir. The CSMR and the CSPA appealed this decision to the State Water Board. Mine Run Dam reservoir is the only pond on site that has been granted an exemption.

U.S. Environmental Protection Agency (EPA) Region IX is currently considering these impoundments for inclusion under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). In October 1990, EPA listed EBMUD's Mine Run Dam and reservoir as a point source of pollution under the Federal Clean Water Act. Among EPA actions currently under consideration is an NPDES permit for Penn Mine to establish effluent limits for copper and zinc.

On August 10, 1993, EPA issued a consent order under Section 309 of the Clean Water Act concerning remediation of contaminant discharges from Penn Mine to Camanche Reservoir (letter from Harry Seraydarian, Director, Water Management Division, EPA to Michael J. Wallis, Director of Wastewater, EBMUD). The order becomes effective only if and when it is signed by all parties to this agreement and may be terminated under a number of possible scenarios. If this consent order does not become effective, another possible outcome would be issuance by the State Board of an equivalent alternative regulatory mechanism. EPA's consent order discusses more comprehensive short- and long-term remedial action measures than those discussed herein. EPA also declares that the discharge valve and spillway on Mine Run Dam are "point sources" as defined in Section 502(14) and that EBMUD is in violation of Section 301 of the Clean Water Act.

The EPA consent order expands on some of the short-term measures that have been considered by staff in this section. For example, this consent order mandates: 1) removal and disposal of waste rock; 2) diversion of upstream inflow, including interception of both surface and ground water; 3) effluent release limits from the Inline Flow System; 4) conditions requiring batch treatment of MRDR; and 5) sludge disposal from batch treatment.

The consent order also directs EBMUD to complete an evaluation of long-term measures by November 15, 1996. This evaluation shall include: 1) plugging and sealing of adits and shafts; 2) lining of Mine Run Dam Reservoir; 3) collection and treatment of contaminated drainage prior to release; 4) removal and disposal of sludge from Mine Run Dam Reservoir; and 5) an assessment of sediment contamination and possible remedial actions related to contaminated sediment in Camanche Reservoir.

The consent order also discusses the State Board's role in remediating conditions at Penn Mine. The State Board has stated its intent to issue an NPDES permit for the In-Line System installed by EBMUD to treat and discharge the contents of Mine Run Reservoir to Camanche Reservoir.

Because there are other proceedings related to Penn Mine at both the federal and state levels and because the remedial measures described above are proceeding in a positive direction, this assessment does not directly consider Penn Mine issues in any further detail. Commission actions in relation to Penn Mine are deferred pending the actions taken in these other proceedings.

3.1.4 Related Proceedings, Planning, and Legislation

In addition to the Commission action, several other proceedings are underway in the State with direct bearing on the Mokelumne River Basin. These include: 1) a water rights hearing on the Lower Mokelumne River by the State Board that was initiated November 9, 1992; 2) the Updated WSMP and Environmental Impact Report being prepared by EBMUD; 3) the State Board's Bay Delta proceeding; and 4) listings of threatened and endangered fish species under the Federal Endangered Species Act

listings, and passage of the Central Valley Project Improvement Act of 1992. Several scoping comments expressed concern over an apparent redundancy among these actions and the Commission's proceeding.

The State Board's water rights hearing received evidence through June 1993 concerning measures needed to protect fish and other public trust resources in the Lower Mokelumne River. The hearing is intended to produce a determination of whether additional conditions should be included in the water rights permits and licenses of EBMUD and other water users in the lower river. This State Board hearing is in response to essentially the same complaints from CDFG and environmental groups that initiated the Commission's proceeding. The State Board does not expect to issue any orders on the Lower Mokelumne hearing until the end of December 1993. Staff has had access to the testimony and exhibits presented in State Board's hearing and has considered this extensive body of information in this FEIS.

The EBMUD Updated WSMP is a long-term study to evaluate options for water supply in the year 2020. Although the WSMP includes some of the fishery resource issues covered in the Commission's proceeding and the State Board's hearing, the scope of the WSMP is much more broad, considering options that would take more than a decade to implement, such as conjunctive groundwater use, new reservoir construction, desalination plants, and water conservation programs. No specific preferred program has been approved under the WSMP.

The State Board has been working toward a solution to the environmental problems in the Sacramento-San Joaquin Delta for many years (e.g., CDWR 1987). In December 1992 the State Board issued its Water Right Decision 1630 that would have established a comprehensive program of water management regulations if it had been adopted. However, in April of 1993, Decision 1630 was withdrawn by the state with future direction pending federal action. At the time of release of this FEIS, there is no apparent resolution of the Delta situation.

Endangered species listings are imminent or in place for several fish inhabiting the Delta, including winter run chinook, Delta smelt, and several other species (see Section 3.3.5). The critical habitat established for these species does not include the Lower Mokelumne River, particularly the portion of the river above tidal influences where hydropower operations have their dominant effect. Additional discussion of endangered species issues are presented under cumulative impacts (Section 4.7).

The Central Valley Project Improvement Act of 1992 (Title XXXIV of Public Law 102-575) requires federal agencies involved in the management of the Central Valley Project to revise their operation to provide for environmental resources. While this Act does not directly affect the LMRP operation, it does express the intent of Congress to achieve more balanced water management policies. The Bureau of Reclamation has initiated a programmatic study of options to achieve this Congressional mandate, but its results will not be final for many years to come. Ultimately, the results of this Act are likely to reduce cumulative impacts that are affecting chinook salmon populations in the Lower Mokelumne River.

The Commission's proceeding is designed to coordinate with these other proceedings to the degree possible to ensure that timely decisions can be made pursuant to NEPA. The DEIS was available to the State Board's hearing for their consideration, and the exhibits and testimony presented at the State Board's hearing have been used by staff, along with comments on the DEIS, in preparation of this FEIS. This approach has achieved coordination between these proceedings, provided the level of independent analysis required for Commission action, and minimized any delays in addressing adverse impacts to the fishery resources of the Mokelumne River that may be due to hydropower operations.

3.2 WATER QUANTITY AND QUALITY

The hydrology of the Lower Mokelumne River is described in this section, including water quantity and quality in the surface water reservoirs and in the tailwaters of Camanche Dam.

3.2.1 Surface Water Availability and Use

Surface water availability within the Lower Mokelumne River is primarily controlled by the operation of Pardee and Camanche dams and by major withdrawals for irrigation and municipal water supply. The annual hydrographs have both snow-melt and rainfall components, but the river system's hydrology is highly modified by the water developments described above (Section 3.1.2).

Hydrometeorological Setting

Precipitation amount and form varies greatly within the Mokelumne River basin depending largely on elevation. At Twin Lakes in the headwaters of the basin, normal annual precipitation is almost 47 inches, most of which is in the form of snowfall. At Pardee Reservoir, normal annual precipitation drops to 20 inches, most of which is rain. Most precipitation over the basin occurs between November and May, with very little rainfall occurring during the late spring and fall (EBMUD 1992c.)

Annual evaporation for a station about 40 miles southeast of Lodi at an elevation of 215 ft MSL, and typical of the low foothill country, was calculated using 10 years of data. Monthly evaporation ranges from 1 to 15 inches, with an average annual total of 83 inches (Stearns et al. 1930).

Runoff Patterns

The USGS stream gage at Mokelumne Hill (Station No. 11319500) measures streamflow on the Mokelumne River 8 miles downstream from the confluence of the North and South Forks of the Mokelumne, below PG&E development and several miles upstream of EBMUD's Pardee Reservoir. There are no significant tributaries downstream of this point until the confluence of the Cosumnes and Mokelumne Rivers well below Woodbridge Dam. Except for a small local watershed contribution and direct precipitation into Pardee and Camanche Reservoirs, discharge measured at the Mokelumne Hill gage represents the primary hydrologic input to the LMRP system. A record of daily mean streamflow values from 1927 to 1991 is available for the Mokelumne Hill station. Mean annual total streamflow into the Lower Mokelumne River system is 716 TAF (median is 658 TAF); the highest annual discharge was 1,913 TAF in 1983, and the lowest was 144 TAF in 1977 (USGS 1991) (Figure 3.2-1). The seasonality of this input follows a pattern of monthly maximum discharge occurring between April and June when runoff from snowmelt is the greatest and minimum from August to November (Figure 3.2-2). The flood events of record above Pardee Reservoir have occurred between mid-November to early April.

Moving downstream through the lower river, streamflow consistently decreases as diversions and losses to groundwater remove water from the river (Figure 3.2-3). The USGS stream gauging station at Woodbridge measures streamflow in the Mokelumne River half a mile downstream of the Woodbridge Dam. The record at this gage covers 1926–1990. The mean annual streamflow volume measured at this station is 436 TAF (median = 348 TAF), the maximum being 1,102 TAF in 1938 and the minimum being 22 TAF in 1977. Some seasonality in streamflow is observed at this downstream point, with highest mean monthly flow volumes occurring in May and lowest average monthly flows in August. The difference in long-term annual flow at the "top" of the Lower Mokelumne River system, above Pardee

Figure 3.2-1. Historical total annual discharge in the Mokelumne River near Mokelumne Hill, California. (Source: USGS 1991.)

Reservoir, and the "bottom" of the system, below Woodbridge Dam, is roughly 269 TAF. The largest difference in flow (and therefore the greatest losses from the system) is during May and June when irrigation demand is high.

Changes in Flood Regime Due to Camanche and Pardee Reservoirs

To understand the current geomorphology of the Lower Mokelumne River for fish, it is necessary to consider how the river's flow regime has been affected by construction of Pardee (1929) and Camanche (1963) reservoirs. We analyzed the record of annual flood peaks from 1905 to 1993 for the Mokelumne River below Camanche Dam (formerly "near Clements"). Data for 1905–1985 were from the Hydrodata CD ROM data base at the University of California Berkeley [(1949 was missing from this record with no acknowledgement or reason given)]. For the period 1986–1991, annual peak flows were obtained from the published Water Resources Data for California. For 1992 and 1993, we obtained provisional data by telephone from the USGS field office in Sacramento.

There has been a striking lack of scouring floods since 1983. Flood frequency analyses for these periods show a progressive decline in discharge whether expressed as recurrence interval (years) or probability (percent) (Figure 3.2-4). The mean annual flood decreased by half after construction of Pardee, and decreased by half again with construction of Camanche. Flow likely to occur every other year (probability of 50%; Figure 3.2-4) also decreased by more than half with construction of each reservoir; its present value (1,900 cfs) is only 20% of its pre-Pardee value (9,300 cfs).

Figure 3.2-2. Maximum, median, and minimum daily streamflows in the Mokelumne River near Mokelumne Hill, California, above Pardee Reservoir. (Source: USGS 1991.)

Figure 3.2-3. Comparison of median monthly streamflows at Mokelumne Hill above Pardee Reservoir, below Camanche Dam, and below Woodbridge Dam. (Source: USGS 1991.)

Figure 3.2-4. Recurrence intervals and probability of occurrence of discharges of different magnitudes below Camanche Dam for three periods, before Pardee Dam (1905-1928), after Pardee Dam but before Camanche Dam (1929-1962), and after Camanche Dam (1963-1993). (Source: The staff.)

While Pardee alone was able to control frequent floods, it was unable to control the really large floods. There were two large floods post-Pardee (29,000 cfs in 1951 and 27,000 cfs in 1956), comparable to the two largest pre-Pardee floods (26,000 cfs in 1907 and 26,000 cfs in 1928). However, the combination of Pardee and Camanche have eliminated such large floods. Since 1963, floods have rarely exceeded 5,000 cfs, roughly equivalent to flows seen nearly every year (recurrence interval of 1.25 yr in Figure 3.2-4 in the pre-Pardee flood regime. Even during the 1986 flood, with over 30,000 cfs inflow (based on peak flow of 28,500 cfs at the USGS gage at Mokelumne Hill), outflow from Camanche reached only 6,000 cfs, the largest post-Camanche flow.

Water Users in the Upper Mokelumne River Basin

The major water users in the upper basin are PG&E and Amador and Calaveras counties.

Pacific Gas & Electric (PG&E). PG&E's seven existing reservoirs account for approximately 26% of constructed storage on the Mokelumne River (the remainder in EBMUD's Pardee and Camanche reservoirs). PG&E's water use in the upper basin is non-consumptive, for hydroelectric production from its Mokelumne River Project (FERC Project No. 0137).

Amador and Calaveras Counties. The Amador County Water Agency is a retail and wholesale water provider chartered to serve municipal and agricultural needs in Amador County, which includes 3,500 rural households. Amador County Water Agency operates two points of diversion—one in PG&E's Tiger Creek Afterbay (RM 100), from which about 1.2 TAF is drawn annually, and the second at the Amador Canal (about MRM 88) from which 9 TAF/yr is withdrawn. Calaveras Public Utility District serves about 1,800 rural households by diverting about 15 TAF per year from a point below the confluence of the Licking Fork and the South Fork Mokelumne River (EBMUD 1992d).

Forty-seven TAF are reserved for eventual use in Amador and Calaveras counties; this reservation is currently held by the State Board for these "counties of origin" and is senior to EBMUD's water rights under Permit 10478. Currently, this block of reserved water is not being used completely. Both counties have been growing in the last decade (Amador County population increased by 55% during the 1980s), and water use under the Amador and Calaveras County reservation is expected to increase, reducing water available to EBMUD and other downstream Mokelumne users (EBMUD 1992c). Amador Counties water need is projected to grow from approximately 26 TAF in 1990 to approximately 40 TAF in 2020 due to increases in residential uses (CDWR 1990; CDF 1993).

Water Users in the Lower Mokelumne River Basin

A listing of the existing state water rights in the lower river is contained in Appendix G. The major water users in the lower basin downstream of Pardee Reservoir are as follows:

Jackson Valley Irrigation District (JVID). The JVID is entitled, under an assignment of a 1927 State Department of Finance filing, to transfer 3.85 TAF of Mokelumne River water annually to its storage reservoir. Water is diverted at the Jackson Creek spillway structure at the upper end of Pardee Reservoir, where EBMUD operates an outlet valve, and transported through a creek by gravity flow to Lake Amador (EBMUD 1991a, 1992c). When the elevation of Pardee Reservoir falls below 550 ft, diversion under gravity flow is not possible. JVID has no pumping facilities at Pardee Reservoir, so if pool elevations fall too low, they cannot receive water deliveries from this source.

East Bay Municipal Utility District (EBMUD). EBMUD's total annual entitlement for diversion of water to the service area is 364 TAF per year [325 MGD], subject to entitlements of other riparian and

senior appropriators. The total entitlement for diversion to storage is 570 TAF per year, when runoff is available and EBMUD has reservoir space to store the water (EBMUD 1992c).

Although EBMUD is entitled to divert 364 TAF per year to its service area if projected carryover storage in EBMUD's reservoirs falls below a certain volume, the utility imposes demand restrictions. As the carryover storage that the system is able to maintain decreases, deficiencies imposed on District customers increases. Specifically, if projected September 30 storage in Pardee and Camanche reservoirs is between 450 to 500 TAF, up to 15% deficiencies are imposed. At projected storage from 300 to 450 TAF, imposed deficiencies are from 15 to 25%. At projected storage less than 300 TAF, the imposed deficiency is 25%. Above projected storage of 500 TAF, no demand deficiencies are imposed. During the first year that such deficiencies are imposed, one half of these values are expected to be achieved (EBMUD 1992a). End of September storage is projected by EBMUD from analysis of snow survey data and estimates of runoff routed through a mass-balance model (EBMUD 1992c). During the period 1984–1991, EBMUD's projections averaged 10% off the actual storage (EBMUD 1992d, p. 9).

Data on monthly average diversions through the EBMUD aqueduct are available for the period June 1929 to June 1987 (e.g., CDFG 1991)¹. Annual total diversions through the aqueduct have been increasing since 1929, when they were generally less than 50 TAF. By the mid 1960's, annual diversions reached 200 TAF, although in 1977, the second year of the record drought, diversion through the aqueduct fell to 133 TAF. The maximum diversion occurred in 1976 (241 TAF). There is a small seasonality in the historic pattern of aqueduct draft, with maximum diversions typically occurring in June–July–August (12.5 TAF) and minimum diversions occurring in January–February–March (9.5 TAF).

North San Joaquin Water Conservation District (NSJWCD). The NSJWCD was formed in 1956 in anticipation of Folsom South Canal and the execution of the Bureau of Reclamation-American River water contract. EBMUD provides water for irrigation districts with state-granted water rights. NSJWCD has a temporary water right permit to divert and store water not used by EBMUD pursuant to its water permit 10478. EBMUD stores water for NSJWCD but also determines when water is available for NSJWCD (EBMUD 1992c); in water years that are dry and critically dry by EBMUD's definition, water is not provided to NSJWCD. The maximum entitlement for NSJWCD is 20 TAF per year, although the maximum historical diversion has been less than 10 TAF in a year.

The NSJWCD withdrawals are made by pumps located around MRM 52. Data on monthly diversions were published in the CDFG Fisheries Management Plan (CDFG 1991). Over this period, the total annual draft to NSJWCD has ranged from 0 ac-ft in early or dry years (e.g., 1976–77) to a maximum of about 9 TAF in the early 1970s. In recent years, draft has declined to between about 6 to 8 TAF annually. There is clear seasonality in this irrigation diversion. Maximum diversion occurs in May through August (average of 1,100 ac-ft in July) and drops to zero from December to March.

Woodbridge Irrigation District (WID). The WID, in combination with the Woodbridge Water Users Conservation District (with which it has cross-assigned water rights), provides irrigation water for 40,000 acres of farmland near the city of Lodi. WID's rights are based on riparian use prior to 1914 and therefore holds one of the most senior water rights on the river. Various water rights entitlements allow for a maximum amount of this diversion of 60 TAF, reduced in dry years (i.e., when annual Pardee inflow is less than 375 TAF) to 39 TAF (EBMUD 1992c, p. 5-7). Diversions into the Woodbridge Canal are controlled by gates approximately half a mile downstream of the canal intake. A USGS stream

¹The location of the point of measurement for these data is not provided; it is assumed that these amounts represent total diversion through the aqueduct as measured at the point of diversion from Pardee Reservoir, and that they include all conveyance losses not reflected in the net water supply provided to EBMUD's customers.

gauging station in the Woodbridge Irrigation Canal (Station No. 113250000) measures withdrawals at the point of diversion from Lake Lodi. The record covers 1926–1991 (Figure 3.2-5).

Mean annual flow into the Woodbridge Canal over the entire period of record is 92.7 TAF (median = 93 TAF), with a maximum of more than 140 TAF in the early 1950's. Withdrawals through the canal appear to have peaked around 1950; in recent years, withdrawals have declined considerably, to the neighborhood of 60 to 80 TAF (Figure 3.2-5A). Again, there is clear seasonality in this irrigation diversion. Highest monthly flow volumes occur in July (17 TAF) and the lowest in February. The maximum total diversion of 350 cfs is allowed for irrigation. At times, the WID diversion has withdrawn up to 80 to 90% of the total flow of the Lower Mokelumne River at Lake Lodi (Figure 3.2-5B). The magnitude of this withdrawal has significant effects on migratory fish (Section 3.3).

The WID dam, lake, and canal (Figure 3.2-6) store and divert water usually from March to late October. At the start of the irrigation season some time in March, flashboards are placed in the dam to begin filling Lake Lodi. There are no formal agreements in place that constrain this filling process and WID usually installs all the flashboards at once (Christensen 1992). The storage capacity of the lake ranges from zero at surface elevation 24 ft MSL (no dead storage when the flashboards are out of the dam) to 2 TAF at surface elevation 41 ft MSL. In late October, the flashboards at the dam are removed, the lake is lowered, and diversion in the canal falls to zero. When the lake elevation falls below 38.5 ft MSL, diversions into the canal cease. Woodbridge Dam lacks any specific structures for passing minimum flows downstream. Water that passes the dam does so either through the fish ladder outlet, which has a capacity of about 18 cfs, or as leakage through the flashboards. Woodbridge Dam rarely spills (Christensen 1992).

City of Lodi. The city of Lodi is entitled to a maximum of 36 TAF from the Mokelumne River; this water right, while senior to EBMUD's, is effective when the January groundwater elevation in the original six-square-mile Lodi well field drops below sea level for two consecutive years. To date, there have been no deliveries under this water right.

Instream Flows for Fish Resources. According to a 1961 agreement between CDFG and EBMUD, a total of 13 TAF is released annually from Camanche Dam (Section 2.2.1, no-action alternative). This right is inferior to EBMUD's water rights. Historical annual flow below Woodbridge Dam, as described earlier, totals 436 TAF. Translating this to monthly discharge, long-term mean low flows occur in August (165 cfs), and high flows typically occur in late spring (May discharge averages 1,084 cfs). The minimum annual discharge below Woodbridge Dam was 22 TAF in 1977. Annual flows below Woodbridge Dam have historically well exceeded the specified minimum annual fishery flow.

Channel Losses. The USGS in the late 1920s (before construction of Camanche Dam) conducted research to quantify groundwater recharge in the Mokelumne area (Stearns et al. 1930). They examined the principal sources of groundwater recharge: direct percolation of rain to groundwater; percolation from streams/canals; and return irrigation flow. Soils permit recharge from the Mokelumne River, primarily between Clements (a town several miles downstream of present-day Camanche Dam); above Clements, older alluvium is less permeable and allows minimal groundwater recharge. Between Clements and Woodbridge, water percolates away from the channel. In the Woodbridge area, permeable sands allow a strong relationship between stream stage and groundwater level. The study demonstrated that net seepage losses (i.e., seepage plus evaporation minus precipitation) in the reach between Lancha Plana and Woodbridge, a roughly 28-mile stretch, were approximately 12 TAF/yr.

Since 1930, the hydrology of the Lower Mokelumne River system has been altered by the construction of Camanche Reservoir in the early 1960s, and by large increases in irrigation water withdrawals for both the

Figure 3.2-5. Withdrawals from the Mokelumne River at Lodi, California, into the Woodbridge Canal: (A) total diversions per year; (B) median and maximum diversions as percentages of the corresponding median monthly flows. (Source: USGS 1991.)

Figure 3.2-6. Map of Lake Lodi and the Woodbridge Canal diversion. (Source: USGS 1976.)

river and groundwater. We examined more recent hydrologic data to gain some quantitative feeling for channel losses in the river below Camanche Dam. Briefly, for the period 1964–1988, hydrologic data for all known diversions between Camanche Dam and Woodbridge Dam (riparian and senior appropriative withdrawals, the NSJWCD, and the WID) were specified. Hydrologic input was taken as the outflow from Camanche Dam; outflow from the system was calculated as the difference between inputs and diversions. Observed outflow from the system was available from a USGS stream gauging station below Woodbridge Dam. The discrepancy between calculated outflow at Woodbridge Dam and observed is interpreted as channel losses. These derived channel losses were used to develop staff's carriage loss relationship to river flow shown in Figure 3.2-7.

Annual channel losses in recent years range from a low of about 30 TAF in 1987 to a high of roughly 104 TAF in 1982. Over the 25-yr period used in this analysis, mean total loss is 55 TAF. EBMUD's estimates of annual channel losses are determined by the amount of annual outflow from Camanche Reservoir (EBMUD 1992a). Information about soils in the 1930 USGS report would also suggest a relationship between stream stage and recharge from the river to groundwater, especially toward Lake Lodi. Figure 3.2-7 shows staff's and EBMUD's relationships between annual channel losses and Camanche outflow. There is a consistent positive relationship between the two variables.

Staff used the curve shown in Figure 3.2-7 as part of the analyses resulting in the calculation of required Camanche Dam releases shown in Appendix B, Tables B-2 through B-5. We assume that there is zero carriage loss when no water is released from Camanche Dam. EBMUD's carriage loss function is unrealistic in this respect. Both the staff's and EBMUD's analyses assume that there are no time effects on carriage losses; that is, that the carriage loss responds instantly to changes in Camanche Dam releases. This assumption is forced by the total lack of data on time-dependency of carriage losses. For steady or slowly-varying flow conditions this assumption should have a very minor effect on model accuracy. Staff's carriage loss relationship, while easily described as a logarithmic curve, was implemented as a piece-wise linear function for computational simplicity. Since the curve is relatively flat, this is not likely to introduce much error of approximation.

Figure 3.2-7. Carriage loss as functions of river flow (Camanche Dam release) for the Lower Mokelumne River between Camanche Dam and Lake Lodi. (Source: The staff; EBMUD 1992a.)

As shown in Figure 3.2-7, the staff and EBMUD carriage loss functions result in comparable estimates over a wide range of Camanche Dam release flows, being within 25% of each other over a wide range of release flows from 200 to 2400 cfs. Below 250 cfs, the fact that EBMUD's function does not have carriage loss going to zero as release goes to zero causes the EBMUD function to overestimate carriage loss for flows between 0 and 250 cfs. These lower flows are important for the range of minimum flows found in the Lower Mokelumne River.

Riparian Users and Appropriators. The Lower Mokelumne River watershed has historically supported substantial agricultural activity. In the late 1920s, with a population of 10,000, it was one of the most thickly settled rural districts in the nation and was one of the richest and most fertile parts of the San Joaquin Valley. Of the riparians and appropriators situated along the river from Camanche Dam to the confluence of the Mokelumne and the San Joaquin rivers, those with the most-senior rights are riparian landowners who may divert water for use on riparian lands only; the second-most senior rights are held by prior appropriators and pre-1914 appropriative rights (the largest is the WID, described above).

Riparians and appropriators with rights prior to EBMUD's water rights are estimated to divert approximately 21 TAF in normal runoff years, and 16 TAF in dry years (EBMUD 1992c). Withdrawal rights are tied to the river's natural flow; these entitled withdrawals are expected to increase in future decades (EBMUD 1992c). Seventy percent of the riparian and senior appropriative withdrawals are estimated to be drawn from the channel between Camanche Dam and Woodbridge Dam; the remainder are taken below Woodbridge Dam. EBMUD, in its modeling studies, assumes that these diversions are the same each year except in dry years when non-regulated river runoff ceases—in these years, senior appropriators are assumed to use half of the average withdrawal (EBMUD 1992d).

3.2.2 Groundwater

Studies of groundwater support the staff's and EBMUD's estimates of channel losses of surface water. Based on the response of groundwater levels in observation wells to fluctuations in river stage, the USGS divided the Lower Mokelumne River into three segments (Stearns et al. 1930; Piper et al. 1939). The first segment was from Pardee Dam to approximately 3.5 miles northeast of Clements (current Camanche Dam site). This reach of the river was categorized as a gaining (effluent) stream in which groundwater flowed into the river as a result of a relatively steep gradient of the water table toward the river. Groundwater levels in observation wells did not respond to changes in river stage. The second segment was from Camanche Dam to Woodbridge. In this reach, the river traverses the intensively cultivated and irrigated area of the Victor alluvial plain. Water table contours constructed from water level data measured in observation wells indicated that this segment of the river was a losing (influent) reach in which water flowed from the river into the groundwater. Groundwater levels in observation wells responded to fluctuations in river stage in this reach depending primarily on the distance of the wells from the river. Responses to diurnal fluctuations in river stage were observed in wells up to 1,000 ft from the river. Responses to major changes in river stage, occurring over longer periods of time, were observed in wells up to 0.5 mile from the river. Recent estimates by EBMUD indicate that channel losses, including losses to evapotranspiration and seepage losses from the river to groundwater, in the reach below Camanche Dam, range from approximately 56 TAF per year during low flow years to approximately 120 TAF during average to wet years (EBMUD 1992a). The third segment was from Woodbridge to tidewater at Thornton. In this reach, there appeared to be little response of groundwater levels to changes in river stage. The river was apparently insulated from the groundwater in places by beds of low permeability.

From 1906 to 1930, the water table in observation wells dropped. This decline was probably in response to pumping of groundwater for irrigation purposes. The greatest decline was observed in the Lodi area,

averaging 0.70 ft/yr over a 20-yr period (Stearns et al. 1930). Significant withdrawals of groundwater for irrigation have continued in the intervening years. Steady water level declines have been observed in unconfined alluvial aquifer wells in areas of California's Central Valley where imported water has not been available for artificial groundwater recharge (USGS 1985). Groundwater withdrawals in San Joaquin County in 1985 were approximately 1 billion gallons/day. The eastern San Joaquin Basin, encompassing the Lower Mokelumne area, has been classified by the CDWR as being subject to critical conditions of groundwater storage depletion, with withdrawals in excess of recharge (Carr et al. 1990).

In the Central Valley, dissolved solids concentrations in groundwater are typically less than 500 mg/L (the EPA interim primary drinking water standard). They range from less than 200 mg/L to greater than 2,000 mg/L, with isolated concentrations of greater than 8,000 mg/L. Dissolved solids concentrations generally increase from east to west in the valley (Moody et al. 1988). Degradation of groundwater quality may be occurring in the Lower Mokelumne River area due to recharge of the groundwater from irrigation return flows containing high concentrations of dissolved solids.

3.2.3 Reservoir Limnology and Water Quality

Water quality in Camanche Reservoir is critical not only to fisheries resources within the reservoir, but also (and possibly more importantly) to the fisheries resources in the Mokelumne River below Camanche Dam that are affected by the quality of water that is released. The primary water quality concerns both in the reservoir and in the releases are temperature, DO, and contaminants originating from Penn Mine.

To predict the response of Camanche and Pardee Reservoirs to both flow and non-flow measures to improve the fish habitat in the Lower Mokelumne River, the normal seasonal variations in the reservoirs must be understood. This section discusses these expected seasonal changes with particular emphasis on the thermal structure. The volume of cold water in the hypolimnion of both reservoirs prior to the fall migration has been computed in a relatively dry and a relatively wet year.

Description of Reservoirs

Flow in the Lower Mokelumne River is regulated by releases from Pardee and Camanche reservoirs (see Section 2.1.2). Pardee Dam was completed in 1929 to provide a water supply to EBMUD. At maximum pool elevation of 568 ft the storage capacity is approximately 210 TAF. The elevation of the reservoir floor at the upstream face of the dam is approximately 240 ft. Most of the storage is in an inundated valley lying transverse to the original river bed with only limited additional storage along the river bed upstream (Figure 3.2-8). Outlets from Pardee are located at the dam and at the diversion structure for EBMUD's Pardee Tunnel about 1 km south of the spillways. The outlet at the dam is at elevation 250 ft and at the diversion structure, outlets are available at elevation 460, 490, 520 and 550 ft although the gates at 550 and 520 ft are normally closed.

Camanche Dam was completed in 1964 to furnish storage downstream from Pardee to satisfy downstream water rights. The maximum storage of Camanche Reservoir is approximately 431 TAF at pool elevation of 235.5 ft. The reservoir floor at the upstream face of the dam is at elevation 100 ft. The central part of Camanche Reservoir on either side of the original river bed has a relatively flat bottom (Figure 3.2-9). At the edge of this flat area the bottom rises steeply to 150 ft and then more gradually to the edge of the reservoir. Most of the storage in Camanche Reservoir, especially during dry years, is located over the flat-bottomed central area. There are three outlets from Camanche Reservoir. The principal outlet is near the bottom at approximately 110 ft elevation. A second outlet lies at elevation 201 ft MSL, which is often above water surface elevation. A third outlet is available by pumping up to 35 cfs from a floating

Figure 3.2-8. Bathymetric map of Pardee Reservoir. (Source: The staff.)

Figure 3.2-9. Bathymetric map of Camanche Reservoir. (Source: The staff.)

platform. This water may be pumped from locations between 30 and 50 ft below the surface, and is mainly used to supply water for the fish hatchery.

Figure 3.2-10 shows the relationships among elevation and corresponding surface area and storage for both reservoirs. These elevation-storage data were taken from USGS publications (USGS 1991). The elevation-area functions were generated by fitting a third degree polynomial through the elevation-storage data and differentiating to determine the area.

Availability of Water Quality Data

Water of high quality suitable for all life stages of chinook salmon and steelhead must be available from Camanche Reservoir. Water supply for the MRFF is obtained from Camanche Reservoir. Discharge from Camanche is the sole factor in determining initial water quality in the Mokelumne River below Camanche Dam. For successful migration, spawning, incubation and rearing, fall-run chinook salmon prefer water temperatures below 59°F (15°C) and DO concentration above 5 ppm (CDFG 1991); also see Section 3.3. To provide for the long-term survival of aquatic resources downstream, cold water must be

Figure 3.2-10. Relationship of storage volume to reservoir surface elevation for (A) Pardee Reservoir and (B) Camanche Reservoir. (Source: USGS 1991; the staff.)

available from the hypolimnion of Camanche Reservoir, particularly in the late summer and fall. Hypolimnetic water is usually low in oxygen but discharges from Camanche Reservoir to the river may be aerated by discharging through existing Howell-Bunger valves. Other requirements for downstream habitat are pH between 6.6 and 8.5 and heavy metal concentrations below EPA recommendations.

Data to confirm that suitable water quality conditions are met are not uniformly available. Daily values of the temperature of water at the USGS gaging stations below Camanche Dam and near Mokelumne Hill upstream of Pardee Reservoir are readily available from a commercial data base (Earth Info 1992). Other relevant data available from the Earth Info database are the daily storage in each reservoir and the flow at Mokelumne Hill and below Camanche Dam. The thermal structure and water quality of the reservoirs, however, are not routinely measured. A series of depth profiles of temperature, DO, conductivity and oxidation-reduction potential were collected by EBMUD between October 1, 1987 and October 11, 1989 at several locations in Camanche Reservoir and at the outlet structure in Pardee Reservoir. These data were collected at various intervals but are more plentiful in the spring around the time when stratification is established and in the fall when overturning occurs. These profiles furnish a good picture of the thermal structure of the reservoir during both wet and dry periods and allow an approximation of the volume of cold water available in the hypolimnion during the period between stratification and overturning. The concentrations of aluminum, iron, copper and zinc were measured by EVS consultants (EVS) at various locations in Camanche Reservoir and at various times between September 26, 1988 and March 22, 1989. The data are presented in the report prepared by EVS for Brown and Caldwell (EBMUD 1990b) and indicate that there were periodic spikes of metals concentrations which are potentially toxic to fish.

Temperature Stratification and Overturning

Camanche Reservoir undergoes an annual thermal cycle in response to the strong annual cycle of solar radiation. This thermal cycle in turn strongly influences the aquatic habitat and temperature conditions within the reservoir. This section examines the structure and dynamics of temperature within the reservoir. The data available consisted of 1) a vertical temperature-depth (elevation) study that covered dates between October 1, 1987 and October 11, 1989; 2) USGS hydrologic gaging station records; 3) miscellaneous hydrologic and meteorological data published by EBMUD; and 4) EVS metals data. The following description summarizes the temperature stratification and dynamics of Camanche Reservoir between October 1988 and October 1989, for which data were available from the temperature-depth surveys. Temperature and water quality data of sufficient detail to characterize the limnology of Pardee Reservoir are not available.

Winter. By late November or early December, the water body was essentially isothermal (close to the same temperature top to bottom), with temperatures ranging from 48.2–51.8°F (9–11°C) throughout the reservoir (Figure 3.2-11A). This uniform condition was maintained throughout the winter months by continued surface cooling and mixing of the shallow reservoir pool (below 140 ft) by surface winds. By late March 1989, the reservoir water level was still below 140 ft, but temperatures in the upper 20 ft had risen to 60.8°F (16°C) with a gradual decrease to less than 55.4°F (13°C) with depth (Figure 3.2-11B).

Spring. Temperature conditions in the reservoir showed a marked change during the spring. As insolation increased, the surface was warmed and stratification developed. Temperatures in the near surface rose from 50°F (10°C) to 68°F (20°C) and winds over the reservoir caused mixing that resulted in thickening of the warm upper layer (epilimnion) to a depth of about 7 ft (Figure 3.2-11C). A strong thermocline developed, with temperatures rapidly decreasing from 68°F (20°C) to 53.6°F (12°C) from 7 to 18 ft depth. A cold deep layer (hypolimnion) was present below 20 ft. A well stratified thermal

Figure 3.2-11. Observed water temperatures at Camanche Dam, 1988–1989. Data from Hydrolab survey, CAMD Station. (A) Isothermal conditions during winter; (B) surface warming in early spring; (C) strong thermocline developed by late spring; and (D) high water levels and surface mixing during summer. (Source: Staff analysis of data provided by EBMUD 1990a.)

structure developed by mid-April. Bottom water cooler than in March may reflect inflow of cold water from Pardee Reservoir.

Summer. Water levels in the reservoir rapidly increased to greater than 180 ft in response to snow melt and runoff in the headwaters of the basin (Figure 3.2-11D). High water levels persisted throughout the summer months with a warm ($> 68^{\circ}\text{F}$; 20°C) surface layer extending to depths of 20 ft or more. A strong thermocline was present from 15–30 ft with the reservoir strongly stratified. As summer progressed, the warm surface water layer (epilimnion) thickened and the thermocline descended. The entire water body became warmer, with temperatures in the deeper sections of the reservoir ranging from $55.4\text{--}60.8^{\circ}\text{F}$ ($13\text{--}6^{\circ}\text{C}$).

Fall. Cold winds over the reservoir during the fall months and declining water surface elevations result in strong mixing in the reservoir, again creating nearly isothermal conditions. Because of the low water surface elevation during the late summer the water temperatures after overturning were atypically high ($> 64.4^{\circ}\text{F}$; 18°C), with little vertical or horizontal variation. As winter approaches and the solar insolation decreases, heat is lost from the surface layer to the atmosphere and cold surface water sinks to the bottom, setting up a general overturning of the entire reservoir.

Availability of Cold Water

During fall and early winter, chinook salmon migrate up the Mokelumne River for spawning. In order to attract fish and create an environment favorable for spawning, cold water ($< 64.4^{\circ}\text{F}$; 15°C) must be released from Camanche Reservoir. In dry years the cold water supply in the hypolimnion of Camanche Reservoir is often depleted before the fall run chinook salmon migration in October (see Section 3.3). This cold water supply problem is clearly demonstrated by comparing the 1988 and 1989 temperature structure of Camanche and Pardee Reservoirs. Data on daily storage volumes in the reservoirs have been combined with the EBMUD Hydrolab data to compute the volume of cold water in both Camanche and Pardee Reservoirs in August, September, and October of 1988 and 1989 using the elevation-storage relationships shown in Figure 3.2-10. Water year 1988 (October 1987 through September 1988) was a relatively dry year with only 235 TAF of flow into Pardee Reservoir compared with 480 TAF in water year 1989. These data and results are reported in Tables 3.2-1 and 3.2-2.

Graphs of temperature versus depth (Figure 3.2-12) in September 1988 and 1989 clearly show that in dry years (1988) the hypolimnion in Camanche is depleted while a large volume of cold water remains in Pardee. In wet years (1989), there is a large volume of cold water in the deeper parts of both Camanche and Pardee Reservoirs. As demand for water increases in the EBMUD service area, the availability of cold water for release from Camanche Reservoir will decrease under current operating guidelines.

Modeling Studies

In order to gain greater understanding of the relationships between reservoir operations and the volume of cold water available in Camanche Reservoir for release during the fall migration and spawning of chinook salmon, numerical models of Pardee and Camanche Reservoirs have been constructed. The hydrodynamic and water quality model used is CE-QUAL-W2 from the Waterways Experiment Station of the COE (COE 1992). The Camanche Reservoir model was calibrated on storage and temperature structure using the elevation and temperature data collected by EBMUD in 1987–1989. It has been used to predict the effects of various measures proposed to improve the habitat for salmon and trout in the Lower Mokelumne River and the results are reported in Appendix C and Section 4. The Pardee Reservoir model was not calibrated on temperature structure and it has been used only to predict the effects on Pardee storage of alternative operational scenarios for Camanche Reservoir.

Table 3.2-1. Reservoir storage and volume of cold water in Camanche Reservoir, 1988 and 1989. (Source: The staff.)

Date	Surface elevation (msl)	Reservoir storage (ac-ft)	Supply of 59°F (15°C) water (ac-ft)
8/7/88	147.20	34,800	< 600
9/4/88	137.07	21,300	< 600
10/09/88	124.94	8,920	< 600
8/2/89	188.20	148,500	37,900
9/6/89	187.45	145,700	16,800
10/11/89	186.43	141,300	7,500

Table 3.2-2. Reservoir storage and volume of cold water in Pardee Reservoir, 1988 and 1989. (Source: The staff.)

Date	Surface elevation (msl)	Reservoir storage (ac-ft)	Supply of <59°F (15°C) water (ac-ft)
8/10/88	558.03	189,000	75,200
9/14/88	559.87	192,800	66,600
10/5/88	560.42	194,000	66,400
8/16/89	563.85	201,300	55,200
9/27/89	562.35	198,200	55,200
10/18/89	557.00	186,700	36,900

In addition to simulating the temperature of Camanche releases for the historical period 1988–1989, the model has been used to estimate the release temperatures which would result from various proposed management practices. The simulated management practices are minimum releases from Camanche Reservoir proposed by CDFG, EBMUD, and staff while releasing sufficient water from Pardee Reservoir to maintain water surface elevations of 210 ft for the CDFG flows, 170, 190 and 210 ft for the EBMUD flows and 170, 180, 190, 200 and 210 ft for the flows recommended by staff. An operational scenario in which the water surface elevation was varied from 170 ft in the winter to 190 ft in the summer with minimum releases proposed by staff was also simulated as well as the effects of currently required minimum releases from Camanche with constant water surface elevations of 170, 180, 190, 200 and 210 ft were also simulated. Each of these simulations was performed for both dry and normal water years. The results of these simulations indicate that an effective strategy for maintaining the required low

Figure 3.2-12. Observed water temperatures at various depths at the spillway in Camanche Reservoir and at the outlet tower in Pardee Reservoir during early September, 1988 and 1989. (Source: Staff analyses of data provided by EBMUD 1990a.)

temperature of Camanche releases is to maintain a minimum pool elevation of 190 ft during the summer and early fall. The pool elevation in winter and early spring could be reduced to 170 ft and perhaps lower. These modeling efforts are described in more detail in sections 4.1 and 4.2 and in Appendix C.

Contaminants

The primary contributor of contamination in the Mokelumne River system is Penn Mine, although there may be other smaller mining operations that have contributed heavy metals (Section 3.1.3). Penn Mine is an inactive (since 1953) copper and zinc mine located adjacent to the Mokelumne River in the headwaters of Camanche Reservoir, approximately 9.5 mi above Camanche Dam. Runoff from tailings piles and settling ponds contains concentrations of copper, zinc, cadmium, iron, and manganese (CRWQCB 1989) and has been shown to be toxic to fish (Dunham 1961). Runoff from the mine has historically been blamed for the death of a variety of fish species, salmon eggs, and aquatic insects up to 30 mi downstream before the construction of Camanche Dam. Rain events that exceeded 0.5 inch in 24 hrs were positively correlated with fish kills in the river prior to the construction of Camanche Dam (Dunham 1961). Retention dams have been constructed in the watershed of Penn Mine to buffer the runoff from the mine area, but concentrations of copper and zinc in Camanche Reservoir waters near Penn Mine still exceed EPA water quality criteria (CRWQCB 1990; EBMUD 1992j).

Water samples collected from the reservoir (near Penn Mine, near the dam, and in between) contain heavy metal (aluminum, cadmium, copper, and zinc) concentrations that exceed EPA's National Ambient Water Quality Criteria for the protection of aquatic organisms. At a hardness of 20 mg/l, chronic criteria (4-day average) are 0.087 mg/l (ppm) for aluminum, 0.00032 mg/l for cadmium, 0.003 mg/l for copper, and 0.027 mg/l for zinc.

The impact on the fish and invertebrate communities of existing heavy metal in the water and sediments of Camanche Reservoir is unknown. Most likely affected would be the egg to juvenile life stages of the resident species in close downstream proximity to Penn Mine discharges of acid mine water during high runoff periods.

3.2.4 Water Temperature Regimes in the Mokelumne River

Water temperature in the Lower Mokelumne River is dependent on the release temperature and flow from Camanche Dam, the impoundment effect of Lake Lodi, and the prevailing meteorological conditions (particularly air temperature and humidity). The input (regarding both temperature and flow) from tributaries in this reach is negligible. The temperature in the upper part of this reach closely resembles the temperature at the outfall from Camanche Dam, but downstream of this point, the temperature becomes progressively more dependent on the prevailing meteorological conditions and the flow rate. As a result, temperatures downstream of Camanche Dam tend to warm during the summer and cool during the winter. This is particularly true during periods of reduced flow. From April to mid-October, the closure of Woodbridge Dam and subsequent filling of Lake Lodi effectively slows the water allowing it to heat. Temperatures downstream of Woodbridge Dam are also affected by a reduction in flow as a consequence of the water withdrawal at the Woodbridge irrigation diversion. From mid-October to April, the flashboards at Woodbridge Dam are removed and the impoundment effect of Lake Lodi is minimal. In addition, Mokelumne River temperatures downstream of the Cosumnes River confluence are affected by tides that also slow water movement.

USGS gauging stations below Camanche and Woodbridge dams have provided historical data since the 1950s. These data indicate a large amount of spatial (longitudinal) and temporal (annual, seasonal, and daily) variation in the temperatures in the Lower Mokelumne. Daily maximums and minimums for

representative dry (1976, runoff into Pardee Reservoir < 250,000 ac-ft), normal (1973, runoff into Pardee Reservoir approximately 800,000 ac-ft), and wet (1967, runoff into Pardee Reservoir > 1,100,000 ac-ft) years for both stations are illustrated in Figure 3.2-13. Both seasonal and daily variations are greater at Woodbridge than at Camanche. Differences between Camanche and Woodbridge tend to be greater during dry years. Maximum temperatures at the release at Camanche Dam were generally the same for all three years, 59–60.8°F (15–16°C), whereas, maximum temperatures at Woodbridge were markedly different among the three years. During the wet year (1967), temperatures at Woodbridge never exceeded 68°F (20°C); during the normal year (1973), temperatures rarely exceeded 68°F (20°C); and during the dry year (1976), temperatures frequently exceeded 68°F (20°C). Instream monitoring data from CDFG for a hot, dry year (1987) revealed temperature differences > 48.2°F (9°C) between Camanche and Woodbridge and > 50°F (10°C) between Camanche and the confluence with the Cosumnes River. Recent monitoring at two stations below Woodbridge Dam during 1990 revealed that temperatures at MRM 38 (Woodbridge Golf Course) occasionally exceeded 77°F (25°C) in June and July while temperatures at MRM 29.5 (Ray Road) regularly exceeded 77°F (25°C) from the end of April to mid September and regularly exceeded 86°F (30°C) from early June to early August (Walsh et al. 1992). A search for cool-water refuge in the river in July and August, 1990 turned up relatively few areas that would provide more desirable thermal habitat during times when river temperatures exceeded optimal levels (Walsh et al. 1992).

Both CDFG and Biosystems Analysis, Inc. used stream temperature models to evaluate the effect of variations in hydrological and meteorological conditions on temperature at various locations below Camanche Dam. CDFG used a stream network temperature model (SNTMP) with various combinations of hydrological data from representative wet, dry, and normal years and meteorological data from representative hot, cool, and normal years to evaluate the effect on downstream temperatures of a range of conditions from hot and dry to cool and wet (CDFG 1991). With normal hydrological and meteorological conditions, the model predicted that the mean and maximum temperatures at Camanche Dam and Cosumnes River confluence would differ by up to 42.8°F (6°C) during summer months (means differed from 59°F (15°C) at Camanche to 69.8°F (21°C) at Cosumnes, maximums 60.8–71.6°F (16–22°C). With dry hydrological and hot meteorological conditions, the model predicted that the mean temperatures at Camanche Dam and Cosumnes River confluence would differ by up to 51.8°F (11°C) (57.2–77°F; 14–25°C) during summer months. Maximum temperatures for the same conditions differed by up to 57.2°F (14°C) (60.8–86°F; 16–30°C).

Biosystems Analysis, Inc. used a combination of the SNTMP model and the Water Quality River-Reservoir System (WQRRS) model (Walsh et al. 1992). WQRRS was included to account for the reservoir characteristics of the stretch of river which becomes Lake Lodi from April to mid-October. The results of this modeling predicted that temperature differences from Camanche Dam to the Cosumnes River would range from 48.2–57.2°F (9–14°C) during June, July, and August with a flow rate at Camanche of 400 cfs. Differences were greater at lower flow rates and a little less at higher flow rates.

3.2.5 Water Quality in the Mokelumne River

Before the construction of Camanche Dam, the primary water quality concerns in the Lower Mokelumne River were related to releases of heavy metals (primarily copper and zinc) from Penn Mine (MRM 73) and low DO resulting from the release of waste materials from cannery and winery operations along the river (CDFG 1991). Several fish kills in the river were attributed to releases from Penn Mine, particularly during storm events. The impact of heavy metal contamination below Camanche Dam seems to have been significantly reduced since the dam's construction, due to the retention and dilution capacities of the Camanche Reservoir and retention dams installed on the Penn Mine watershed.

Figure 3.2-13. Historical water temperature patterns in the Lower Mokelumne River. Daily average release temperature at Camanche Dam is indicated by the thick line and daily minimum and maximum temperatures at Woodbridge Dam are indicated by the thin lines. (Differences between daily minimum and maximum temperatures at Woodbridge Dam are negligible.) (Source: Earth Info 1992.)

Presently, the primary water quality concerns are associated with the outfall from Camanche Reservoir and its effect on the Camanche Dam tailwaters and the MRFF located below the dam. These concerns are primarily 1) intermittent low DO (< 6 ppm) during the late summer and early fall; and 2) a combination of possible factors (low DO, high hydrogen sulfide (H₂S), high turbidity, and heavy metal contamination) during episodic releases of high amounts of suspended solids during fall turnover.

Low DO concentrations (1–6 ppm) were observed on several occasions from Camanche Dam to nearly two mi downstream during monitoring from August 1986 to October 1987. These concentrations are below the EPA national criteria for DO (Table 3.2-3). Low DO in the untreated water received by the MRFF has been a recurring problem which was also documented as recently as 1989. Fish kills in the hatchery from 1987–1989 have been attributed to low DO in the water released directly from the reservoir into the hatchery. From August to November 1989, DO in the hatchery's source water ranged from 0.28–4.15 ppm (Miyamota 1989).

Other potential water quality problems that were associated with hatchery fish kills from 1987–89 include high H₂S, copper, and zinc concentrations, low pH, and high turbidity. Of these, the most likely to pose a significant problem along with low DO is H₂S. During the fish kill, concentrations of H₂S in the hatchery water ranged from 0.05–0.07 mg/l and in the river below Camanche Dam from 0.03–0.10 mg/l (Nelson et al. 1989). These concentrations exceed the EPA recommended maximum level of 0.002 mg/l.

Table 3.2-3. U.S. Environmental Protection Agency (EPA) national water quality criteria for ambient dissolved oxygen (DO) concentrations. (Source: EPA 1986.)

	Coldwater criteria		Warmwater criteria	
	Early life stages ^{1,2}	Other life stages	Early life stages ²	Other life stages
30-day mean	NA ³	6.5	NA	5.5
7-day mean	9.5 (6.5)	NA	6.0	NA
7-day mean minimum	NA	5.0	NA	4.0
1-day minimum ^{4,5}	8.0 (5.0)	4.0	5.0	3.0

¹ These are water column concentrations recommended to achieve the required intergravel DO concentrations shown in parentheses. The 3 mg/L differential is discussed in the criteria document. For species that have early life stages exposed directly to the water column, the figures in parentheses apply.

² Includes all embryonic and larval stages and all juvenile forms to 30 days following hatching.

³ NA (not applicable).

⁴ For highly manipulatable discharges, further restrictions apply (see page 37).

⁵ All minima should be considered as instantaneous concentrations to be achieved at all times.

As in Camanche Reservoir, sampling since 1987 indicates that heavy metal contamination in the Lower Mokelumne River is a concern (CRWQCB 1990; EBMUD 1992)). Water samples collected from the Camanche Reservoir discharge (both in the hatchery and at the powerhouse) contain heavy metal (aluminum, cadmium, copper, and zinc) concentrations that at times exceed the EPA's National Ambient Water Quality Criteria for the protection of aquatic organisms. At a hardness of 20 mg/l, chronic criteria (4-day average) are 0.087 mg/l (ppm) for aluminum, 0.00032 mg/l for cadmium, 0.003 mg/l for copper, and 0.027 mg/l for zinc.

The impact (or lack thereof) on the fish and invertebrate communities of heavy metals in the water and sediments of the Lower Mokelumne River is not well documented. The potential impacts of greatest concern would be deleterious effects during egg incubation and fry and juvenile rearing of chinook salmon, and on the general health of the invertebrate community, the primary source of food for developing chinook. Negative impacts of heavy metal contamination are possible not only through exposure to water-borne contaminants, but also through exposure to contaminants which have accumulated in the sediments. Invertebrates and chinook eggs and larvae are the most likely organisms to be impacted by contaminants in the sediment and sediment pore water.

The fact that the MRFF regularly produces thousands of chinook suggests that the normal water quality of Camanche releases is adequate for growth and survival of young chinook. The hatchery fish are not exposed to possible contamination in the sediments as are the naturally reproduced fish are. Although the levels of heavy metals in typical Camanche releases apparently produce no acute responses, on occasions when there have been fish kills in the hatchery, the elevated levels of heavy metals can not be ruled out as a contributing factor. In the river, recent studies indicate that the hatching rate of chinook eggs is below the average of similar systems (Biosystems 1992). This could possibly be a result of exposure to sediment-associated contaminants, but could also be a result of generally poor gravel quality or other factors. The current levels of heavy metal contamination do not appear to affect the growth rates of those chinook that do hatch; recent measurements of growth rates are similar to other populations. Sampling of the invertebrate community in the Lower Mokelumne River by CDFG (1991) and Biosystems (1992) suggests that this critical resource shows no indication of a negative impact of heavy metal contamination .

3.3 FISHERY RESOURCES AND AQUATIC ECOLOGY

Before the mid 1800s, the Mokelumne River watershed hosted diverse runs of anadromous fishes typical of other Central Valley streams draining the Sierra Nevada Mountains (Moyle 1976). These included a spring run of chinook salmon to the upper tributaries where the fish spent the summer in cold mountain streams before spawning the following autumn. Steelhead trout and representatives of summer and fall chinook salmon were probably present in the upper basin. Upstream migrations of adults spaced throughout the year were matched by outmigrations of juvenile salmon and trout, usually in the spring high-water periods. California's typically cyclic pattern of wet and dry years was reflected in highly variable streamflows and variable fish reproductive and emigration success that were adapted to a fishery resource that had multiple anadromous fish runs spread over most of the year. This is typical of salmonid reproductive strategy, which relies on flexibility to deal with environmental extremes (Thorpe 1988). Much of this early history is undocumented and remains controversial.

These fishery resources received substantial, persistent, and fairly well-documented impacts over the years that seriously depleted the resource (Figure 1.3-1) (Miyamoto 1990). Effects of the natural flow fluctuations were compounded by heavy metal pollution from acid mine waste and by low DO from wine and cannery waste discharges, dams, and water diversions (Miyamoto 1990; CDFG 1991). Acid pollution occurred primarily in the upper drainage while wine and cannery discharges occurred in the lower

drainage near Thornton and Lodi. The most downstream mine drainage was (and continues to be) at the site of the Penn Mine shortly below Pardee Dam.

Fish kills attributable to AMD from Penn Mine have been documented since the late 1930s (EEI 1991). Dewatering of the mine caused fish kills in 1937 and 1943 downstream from the confluence with Mine Run Creek. Other fish kills were reported from 1957 to 1960 and in 1967 (after mining activity ceased but before Camanche Reservoir was filled). Fish kills reportedly continued after Camanche Reservoir was filled in 1968. According to Bond (1988), a fish kill in 1973 was directly attributable to discharge from Penn Mine during a heavy storm. However, the cause of fish kills since the filling of Camanche Reservoir is uncertain. Potential sources of toxicity other than AMD from Penn Mine include decaying vegetation on the bottom of the reservoir, which may release organically derived sulfur in a reducing environment.

As a consequence of the AMD from Penn Mine, in 1977 CRWQCB issued a Cleanup and Abatement Order to the site owners, New Penn Mine, Inc. The mine owners failed to respond. The CDFG, CRWQCB, and EBMUD subsequently entered into a cooperative agreement in 1979 for abatement of the Penn Mine discharges (EEI 1991).

Woodbridge Dam, an irrigation diversion dam built in 1910 at Lodi (MRM 38.7), blocked fish migrations almost completely until 1925 when the first of a series of marginally adequate fish passage facilities was installed. There is debate whether some salmon and steelhead were able to pass the dam in 1910–1925. Original upriver runs of spawning chinook salmon and steelhead trout may have been lost at Woodbridge, but some upstream passage by adults after 1925 allowed recolonization of the available basin. However, the WID's main canal intake was unscreened until 1960, so many emigrating juveniles were lost despite upstream spawning. Pardee Dam, constructed in 1928, permanently blocked access to the upper basin by anadromous fish. The river's most heavily used spawning areas for fall run chinook salmon and steelhead were inundated when Camanche Reservoir was built in 1963. With development of a hatchery and spawning channels below Camanche Dam, non-Mokelumne stocks have been imported to the Lower Mokelumne River. Whether any of the original Mokelumne River genetic stocks of fall chinook salmon and steelhead remain is doubtful but controversial.

The lower river below Woodbridge Dam has been used by warmwater and coolwater fishes. Native species were affected by introductions of eastern resident game fishes such as smallmouth and largemouth bass, sunfishes, and anadromous striped bass and American shad. Pardee and Camanche reservoirs and other smaller reservoirs built in the headwaters have been colonized by a variety of resident species, including both salmonids and warmwater and coolwater fishes. Table 3.3-1 provides a listing of fishes currently in the Mokelumne River below Pardee Dam. Major species are discussed in more detail below.

3.3.1 Chinook Salmon

Fall run chinook salmon (*Oncorhynchus tshawytscha*) is an important anadromous fish in the Lower Mokelumne River. The species is highly prized by both the ocean commercial fisheries and sport anglers. The San Joaquin River system, including the Mokelumne River, has historically been an important spawning area for this species. The fall run chinook salmon is not on any listing of threatened or endangered species. However, under the Endangered Species Act, the National Marine Fisheries Service (NMFS) proposes critical habitat designation for the Sacramento River winter-run stock of chinook salmon (NMFS 1992). Management for the species (e.g., by ocean fishing regulations and a Cooperative Agreement among the CDFG, NMFS, Bureau of Reclamation, and FWS for protecting that stock) has been based on protecting this stock and a stock from the Klamath River, California, an otherwise mixed-stock fishery. The Mokelumne River fall chinook salmon are of a race that typically emigrates to the

Table 3.3-1. Common and scientific names of fishes occurring in the Lower Mokelumne River, California, grouped as native or introduced.
(Source: Adapted from CDFG 1991; Walsh et al. 1992.)

COMMON NAME	SCIENTIFIC NAME
Native Species	
Pacific lamprey	<i>Lampetra tridentata</i>
Lamprey	<i>Lamprey</i> spp.
Chinook salmon	<i>Oncorhynchus tshawytscha</i>
Steelhead rainbow trout	<i>Oncorhynchus mykiss</i>
Hitch	<i>Lavinia exilicauda</i>
Sacramento squawfish	<i>Ptychocheilus grandis</i>
Sacramento sucker	<i>Catostomus occidentalis</i>
Tule perch	<i>Hysterocarpus traski</i>
Prickly sculpin	<i>Cottus asper</i>
White sturgeon	<i>Acipenser transmontanus</i>
Green sturgeon	<i>Acipenser medirostris</i>
Sacramento blackfish	<i>Orthodon microlepidotus</i>
Sacramento splittail	<i>Pogonichthys macrolepidotus</i>
Introduced Species	
Common carp	<i>Cyprinus carpio</i>
Threadfin shad	<i>Dorosoma petenense</i>
Goldfish	<i>Carassius auratus</i>
Golden shiner	<i>Notemigonus crysoleucas</i>
Channel catfish	<i>Ictalurus punctatus</i>
White catfish	<i>Ictalurus carus</i>
Brown bullhead	<i>Ictalurus nebulosus</i>
Black bullhead	<i>Ictalurus melas</i>
Mosquitofish	<i>Gambusia affinis</i>
Black crappie	<i>Pomoxis nigromaculatus</i>
White crappie	<i>Pomoxis annularis</i>
Green sunfish	<i>Lepomis cyanellus</i>
Bluegill	<i>Lepomis macrochirus</i>
Pumpkinseed	<i>Lepomis gibbosus</i>
Redear sunfish	<i>Lepomis microlophus</i>
Warmouth	<i>Lepomis gulosus</i>
Striped bass	<i>Morone saxatilis</i>
American shad	<i>Alosa sapidissima</i>
Largemouth bass	<i>Micropterus salmoides</i>
Spotted bass	<i>Micropterus punctulatus</i>
Smallmouth bass	<i>Micropterus dolomieu</i>
Redeye bass	<i>Micropterus coosae</i>
Inland silversides	<i>Menidia audens</i>

ocean in the spring of their first year and spend two or three years in the ocean before returning to the natal stream to spawn.

Before completion of Camanche Dam in 1964, chinook salmon spawned primarily between Clements (MRM 59.2) and the canyon about three miles below Pardee Dam. A few fish spawned upstream of the canyon below Pardee Dam and downstream between Clements and Lockford (MRM 54) (CDFG 1959). An unknown number of chinook salmon also spawned upstream of Pardee Dam before its construction. Although numbers of fish may have reached 60,000 in a year with abundant flow and suitable water quality, CDFG (1959) estimated that the river downstream of Pardee was capable of sustaining an annual run of 15,000 adult chinook salmon. Runs for the 19-year period of record before Camanche Reservoir was impounded (1940–1942, 1945, and 1948–1963) averaged 3,300 spawners (Figure 3.3-1).

The majority of salmon spawning now takes place over the 5-mile reach between Camanche Dam and Mackville Road (MRM 59.2) (Figure 3.3-2) (Walsh et al. 1992). Most of the suitable habitat (95%) lies within 3.5 miles of Camanche Dam (Taylor 1974a, 1974b). Scattered redds have been located between Elliot Road (MRM 54) and Mackville Road. For the 27-year post-impoundment period of record (1964–1990), chinook salmon runs averaged about 3,200 spawners.

Figure 3.3-1. Estimate of historical sizes of chinook salmon runs to the Mokelumne River. In 1990, estimates changed from California Department of Fish and Game (CDFG) counting to East Bay Municipal Utility District (EBMUD) counting. The CDFG counts were of mostly 3-year old fish; EBMUD counts were of all returns, including 40% jacks in 1992. Asterisks indicate periods when no estimates were made. [Source: Adapted by staff from CDFG (1991) and updated with EBMUD data provided in comments on the DEIS.]

Figure 3.3-2. Location of chinook salmon redds in the reach of the Mokelumne River between Lake Lodi (Woodbridge Irrigation District diversion) and Camanche Dam, 1990-91 spawning season. (Source: Adapted by staff from Walsh et al. 1992.)

On average, runs to the Mokelumne River documented by the CDFG have not changed in size since the beginning of record-keeping in 1940 (Figure 3.3-1). The series of low-run years since 1988 has not yet reached the low levels recorded in 1961-1962 (100 and 200 fish, respectively). Although the stated run goal of 15,000 wild and hatchery fish has been met only in one year, variations in run size and general periodicity of the recorded data are comparable before and after Camanche Dam was built (averages before and after are 3305 and 3228, respectively). We statistically analyzed the CDFG estimates for run size and found no difference before and after Camanche (t -test; $P > 0.4$). However, many questions have been raised about the reliability of the CDFG data, particularly in the earlier years. Early counts used an imprecise counting technology and often did not count the entire run. There is also concern that a high percentage of returning salmon in 1992 were precocious males ("jacks") rather than normal 2- or 3-year olds.

The annual fall run chinook salmon migration in the Mokelumne River, as determined by fish counts at the Woodbridge Dam, begins in early October, peaks in November, and tapers off in December and early January (Figure 3.3-3). As with all fall race chinook salmon, the fall migration does not begin until river flows are sufficiently high and temperatures have fallen to acceptable levels near 65°F (18.3°C) or less. A few fish have been seen as early as late August. Adults arriving in January are ascribed to a winter run that may be distinct from the fall run. Spawning in the Mokelumne River generally occurs shortly after migration, primarily in late October through January. The salmon eggs incubate and hatch in the gravel between late October and March, depending on time of spawning and water temperature. The fry remain there until the yolk sac is absorbed, and then they begin to emerge, usually starting in January and continuing until March. In the Mokelumne River there are two peaks of outmigration: fry may emigrate within a few weeks of emergence or rear in the river until the second peak of emigration as smolts in late May or early June. Most juvenile chinook in the Mokelumne River have left the spawning areas by late March and have left the river by July of their first year. A rare yearling has been found in the

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chinook Salmon												
Spawning migration												
Spawning												
Egg incubation												
Emergence												
Fry rearing/emigration												
Juvenile rearing/emigration												
Steelhead Trout												
Spawning migration												
Spawning												
Egg incubation												
Emergence												
Fry & juvenile rearing												
Emigration												
American Shad												
Spawning migration												
Spawning												
Egg incubation & hatching												
Rearing & emigration												
Striped Bass												
Spawning migration												
Spawning												
Egg incubation & hatching												
Rearing & emigration												

Figure 3.3-3. Life history periodicity for fall-run chinook salmon, steelhead trout, American shad, and striped bass in the Lower Mokelumne River, California. (Source: CDFG 1991.)

Mokelumne River, although rearing for a year or more is common in chinook salmon stocks elsewhere (particularly northern populations).

Chinook salmon fry and fingerlings prefer pool habitat (often with silt or sand substrate) over riffle habitat (Everest and Chapman 1972). Young chinook are territorial, a feature that separates size groups within the species (usually the largest in the cohort are dominant). Dominant chinook salmon juveniles orient near the bottom at the head ends of pools where there is abundant drift of benthic invertebrate food from upstream riffles. Smaller, non-dominant chinook salmon are dispersed in the upper waters of pools; the smallest are pushed to the pool margins where presence of cover is important for their survival. All chinook tend to orient to the upper layers of pools at dusk and dawn. Distribution of chinook salmon underyearlings in stream channels can be altered, however, by moving points of food input (Chapman and Bjornn 1969). As chinook salmon grow, they tend to occupy higher velocities. The Lower Mokelumne River between Camanche Dam and Lake Lodi has numerous pools interspersed between riffles and runs, although the number of pools has not been established. Changes in flow affect juvenile chinook salmon by altering the availability of the preferred head-of-pool habitats and increasing the shelter offered to non-dominant fish in pool edges (where riparian vegetation can be flooded at high flows). Juvenile chinook salmon would generally be favored by an increase in the number of pools.

The CDFG assists chinook emigration in dry years. This occurs in April-June when there is very low flow below Woodbridge Dam and when the flow of the San Joaquin River at Vernalis is less than 8,000 cfs and does not exceed the rate water is pumped from the Delta by the Central Valley Improvement Project and the State Water Project. At this time, the CDFG traps juvenile chinook salmon at the

Woodbridge diversion and releases them in the western Delta past the major diversions. Trapping rates peak between May 15 and June 19 each year.

Status of the Stock

For Pacific coast salmon statistics, the Mokelumne River stock is included with the other rivers in the San Joaquin River spawning area (PFMC 1992a) [the Pacific Fishery Management Council (PFMC) is one of the three coastal councils established by federal law to oversee U.S. anadromous fish stocks and establish fishing regulations]. The overall adult run of chinook salmon into the San Joaquin River spawning area in 1991 was the lowest since the 1976–1977 drought years. The estimated escapement totaled 900 adults, including 300 fish that were spawned in the two basin hatcheries, mostly the Merced River Hatchery (Table 3.3-2), and 600 that returned to natural spawning areas (Table 3.3-3). The 1991 run was only six percent of the 1971–1975 average (14,300) and two percent of the 1984–1988 average. The San Joaquin run formed a small proportion (one percent) of the total Central Valley fall chinook run. The PFMC considers that the production in the San Joaquin area is largely determined by spring outflows three years earlier (PFMC 1992a).

Harvest rate as well as environmental factors affected stock level (PFMC 1992b). Poor in-river environmental conditions during parental spawning, juvenile rearing, and outmigration were believed to be key factors in the low returns to natural production sites. However, during this period of apparently low freshwater and ocean survival, the current high Central Valley Index harvest rates of approximately 75% (1989–1991 average) on these depressed natural stocks were judged to be detrimental to future natural production in the Central Valley. The PFMC noted that if these high harvest rates are allowed to continue under current poor environmental conditions, these natural stocks may decline to a level where it will be difficult for them to respond positively to more favorable environmental conditions and to the restoration program currently being implemented.

Consequently, the ocean salmon fishery south of Cape Falcon, Oregon (just south of the Columbia River), which is directed toward catching chinook salmon, has been severely restricted by the 1992 fishing regulations (PFMC 1992c). Restrictions in this area will protect most chinook salmon of California origin (Figure 3.3-4). The stocks specifically being protected are the Sacramento River winter chinook run (that has been listed as threatened) and the Klamath River fall chinook. The actions will assist recovery of the Mokelumne River stock as well.

The harvest of adult fish does not stop with the ocean fishery. Despite stringent CDFG regulations that prohibit the taking of upstream migrating adults in the Mokelumne, poaching is a serious problem. Migration delays at Woodbridge Dam, plus convenient access for poachers, have made Woodbridge a prime location for illegal salmon catches. Most of this take is undocumented, but likely raises the actual harvest significantly.

Analyses of marked fish straying from hatcheries in the Central Valley indicate that the Mokelumne River fall chinook salmon is probably not a unique stock (Dettman and Kelly 1987). Assessment of straying is possible because some of the tagged fish from any Central Valley hatchery that stray are captured as adults entering the Coleman Hatchery on Battle Creek, the Tehama-Colusa facility off the Sacramento River just below the Red Bluff Diversion Dam, the Feather River Hatchery, the Nimbus Hatchery on the American River, or the MRFF. All fish that enter these facilities are checked for tags, which note where the fish originated. Straying fish also spawn in the rivers below these facilities, where annual estimates of total spawners are made but accurate counts of tagged fish are not always possible. It is assumed that the proportion of strayed fish in the river would be the same as in the hatchery.

Table 3.3-2. California Central Valley hatchery fall-run chinook salmon spawning escapements in thousands of fish.^a (Source: PFMC 1992a.)

Year	Coleman ^b		Feather River		Nimbus		Sacramento hatcheries totals		Mokelumne River		Merced River		San Joaquin hatcheries totals		Central Valley hatcheries totals	
	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks
1970	3.0	0.5	2.4	0.9	7.8	0.8	13.2	2.2	0.3	0.2	0.0	0.0	0.3	0.2	13.5	2.4
1971	1.5	0.5	2.3	1.2	7.9	1.3	11.7	3.0	0.8	0.1	0.2	0.0	1.0	0.1	12.7	3.1
1972	1.6	1.2	1.4	2.2	5.4	1.7	8.4	5.1	0.1	0.3	0.1	0.0	0.2	0.3	8.6	5.4
1973	3.0	0.8	7.2	1.3	10.8	1.7	21.0	3.8	0.3	0.1	0.3	0.1	0.6	0.2	21.6	4.0
1974	1.3	0.3	4.3	1.1	7.3	0.7	12.9	2.1	0.1	0.1	0.9	0.1	1.0	0.2	13.9	2.3
1975	1.8	0.6	4.2	1.1	6.6	0.8	12.6	2.5	0.2	0.2	0.6	0.0	0.8	0.2	13.4	2.7
1976	1.8	0.5	4.3	0.9	4.3	0.9	10.4	2.3	0.0	0.0	0.6	0.0	0.6	0.0	11.0	2.3
1977	4.7	0.5	6.8	2.0	6.4	0.5	17.9	3.0	0.0	0.0	0.4	0.0	0.4	0.0	18.3	3.0
1978	1.1	0.8	3.9	0.9	6.1	2.1	11.1	3.8	0.5	0.0	0.0	0.0	0.5	0.0	11.6	3.8
1979	4.7	3.9	3.6	0.6	7.0	3.2	15.3	7.7	0.5	0.1	0.1	0.1	0.6	0.11	15.9	7.8
1980	8.8	0.7	3.0	0.7	13.5	2.0	25.3	3.4	0.4	0.2	0.2	0.0	0.6	0.2	25.9	3.6
1981	5.7	7.5	7.3	1.0	17.8	2.8	30.8	11.3	0.0	0.0	0.6	0.3	0.6	0.3	31.4	11.6
1982	16.2	3.3	6.4	1.2	8.1	2.8	30.7	7.3	1.8	0.9	0.2	0.0	2.0	0.9	32.7	8.2
1983	5.4	3.4	6.1	1.6	6.4	2.5	17.9	7.5	1.7	2.9	0.2	1.6	1.9	4.5	19.8	12.0
1984	18.7	2.9	8.9	0.4	10.2	2.0	37.8	5.3	0.0	0.0	1.7	0.2	1.7	0.2	39.5	5.5
1985	13.1	3.2	5.6	0.2	7.3	1.8	26.0	5.2	0.2	0.0	1.1	0.1	1.3	0.1	27.3	5.3
1986	11.3	1.2	5.7	2.8	5.6	0.1	22.6	4.1	0.3	0.2	0.5	0.2	0.8	0.4	23.4	4.5
1987	11.3	7.1	6.5	3.6	3.4	2.9	21.2	13.6	0.1	0.5	0.5	0.4	0.6	0.9	21.8	14.5
1988	12.5	1.1	6.2	0.3	8.0	0.7	26.7	2.1	0.1	0.0	0.4	0.0	0.4	0.1	27.1	2.2
1989	10.2	1.8	6.5	1.1	9.2	0.5	25.9	3.4	0.0	0.0	0.1	0.0	0.1	0.0	26.0	3.4
1990	13.5	1.2	4.3	1.9	4.6	0.3	22.4	3.4	0.0	0.0	0.11	0.0	0.1	0.0	22.5	3.4
1991	10.0	0.7	7.9	1.4	6.8	0.4	24.7	2.5	0.0	0.0	0.3	0.1	0.3	0.1	25.0	2.6
Goals	9.0	7.5	5.0	-	6.0	-	20.0	-	-	-	-	-	5.5	-	25.5	-

^a Counts of less than 50 fish are shown as 0.^b Fall spawning fish. Some spring runs are included.^c Combined hatchery goal for San Joaquin is 5,500 adults.

Table 3.3-3. California Central Valley natural fall-run chinook salmon spawning escapements in thousands of fish.^a
Escapement to the Mokelumne River is included with San Joaquin River totals. (Source: PFMC 1992a.)

	Upper Sacramento River ^a		Feather River		Yuba River		American River		Lower Sacramento totals		Sacramento River totals		San Joaquin River totals		Central Valley totals	
Year	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks
1970	64.0	21.0	45.0	213.0	12.0	2.0	26.0	3.0	83.0	18.0	147.0	39.0	30.0	8.0	177.0	47.0
1971	62.6	24.4	34.0	10.0	5.3	0.4	36.0	6.0	75.3	16.4	137.9	40.8	40.0	4.0	177.9	44.8
1972	35.0	20.0	27.0	16.0	4.0	5.0	13.0	4.0	44.0	25.0	79.0	45.0	12.0	2.0	91.0	47.0
1973	48.0	19.0	52.0	13.0	22.0	2.0	77.0	5.0	151.0	20.0	199.0	39.0	6.5	0.7	205.5	329.7
1974	66.0	16.0	54.0	7.0	16.0	1.0	52.0	2.0	122.0	10.0	188.0	26.0	3.7	0.7	191.7	26.7
1975	71.0	25.0	35.0	3.0	5.0	1.0	29.0	3.0	69.0	7.0	140.0	32.0	5.8	0.9	145.8	32.9
1976	79.0	14.0	50.0	6.0	3.3	0.5	22.0	1.0	75.3	7.5	154.3	21.5	3.5	0.5	157.8	22.0
1977	46.8	28.4	36.0	2.0	7.0	2.0	40.0	2.0	83.0	6.0	129.8	34.4	0.6	0.1	130.4	34.5
1978	76.0	10.0	29.0	4.0	6.0	1.0	12.0	1.0	47.0	6.0	123.0	16.0	2.3	0.3	125.3	16.3
1979	77.0	44.0	25.0	3.0	10.0	2.0	36.0	1.0	71.0	6.0	148.0	50.0	4.0	0.5	152.0	50.5
1980	53.0	5.0	30.0	2.0	10.0	2.0	32.0	2.0	72.0	6.0	125.0	11.0	5.0	1.0	130.0	12.0
1981	51.0	35.0	41.0	4.0	12.0	2.0	38.0	5.0	91.0	11.0	142.0	46.0	15.9	8.9	157.9	54.9
1982	37.0	17.0	41.0	7.0	23.5	15.9	29.0	4.0	93.5	26.9	130.5	43.9	14.0	3.0	144.5	46.9
1983	40.6	24.7	19.1	4.5	11.4	2.4	19.0	7.4	49.5	14.3	90.1	39.0	11.1	32.2	101.2	71.2
1984	48.7	27.5	36.2	6.5	7.1	2.6	25.2	2.2	68.5	11.3	117.2	38.8	40.8	16.1	158.0	54.9
1985	103.5	24.7	46.5	3.7	10.1	2.9	44.7	11.4	101.3	18.0	204.8	42.7	72.6	3.5	277.4	46.2
1986	109.5	12.5	41.0	6.4	17.0	2.4	44.9	4.4	102.9	13.2	212.4	25.7	23.2	2.8	235.6	28.5
1987	70.3	39.7	43.6	11.6	15.2	3.5	18.2	3.0	77.0	18.1	147.3	57.8	15.8	9.1	163.1	66.9
1988	125.2	20.0	51.0	3.0	6.7	1.8	14.1	1.8	71.8	6.6	197.0	26.6	20.7	1.2	217.7	27.8
1989	65.9	16.8	31.5	3.5	8.3	1.6	14.7	2.4	54.5	7.5	120.4	24.3	3.2	0.1	123.6	24.4
1990	50.8	6.2	25.0	3.0	3.5	0.5	5.6	1.1	34.1	4.6	84.9	10.8	0.9	0.1	85.8	10.9
1991 ^b	39.1	6.2	25.2	2.5	11.4	2.7	9.1	0.5	45.7	5.7	84.8	11.9	0.6	0.2	85.4	12.1

^a Upper Sacramento River jack estimates on Red Bluff Diversion Dam samples. All other estimates generally are based on carcass surveys. Upper river estimates also include Tehama Colusa Spawning Channel. Adult and jack numbers generally are based on a 24-inch fork length cut-off (unpublished CDFG data).

^b Preliminary

Figure 3-3.4. Coastal regions north of San Francisco Bay occupied by California stocks of chinook salmon, in relation to other stocks (gray). (Source: The staff adapted from PPMC 1992c.)

Both the Feather River Hatchery and the Nimbus Salmon and Steelhead Hatchery analyzed by Dettman and Kelly (1987) were estimated to contribute large numbers of chinook salmon strays to the MRFF and the Mokelumne River spawning ground. From three to over 600 Mokelumne River spawners were estimated to be of Feather River origin each year between 1969 and 1984; up to 900 fish were estimated to be of Nimbus origin over those years (Table 3.3-4) (Dettman and Kelly 1987). Strays from these two hatcheries alone would account for 0.1–143 % of the CDFG's 1991 estimated fall chinook runs in the Lower Mokelumne River, with an average estimated contribution of 37%. Clearly, the strays cannot account for more than the run size, a result of different details of estimation. These data are significant, however, for suggesting that returning adult chinook salmon in the Mokelumne River are opportunistic members of a single, general Central Valley stock. Their high rate of straying is undoubtedly related to planting of hatchery production in the western Delta where chemical cues to specific natal tributaries are lost.

Table 3.3-4. Estimates of the number of chinook salmon from the Feather River and Nimbus hatcheries that returned to spawn in the Mokelumne River 1969–1984 and the percentage of the Mokelumne run this represented.
(Source: Adapted from Dettman and Kelly 1987.)

Year	Feather River	Nimbus	Mokelumne run (CDFG 1991)	Percent Feather and Nimbus strays
1969	3	0	3000	0.10
1970	36	4	5000	0.80
1971	108	46	5000	3.08
1972	19	89	1100	9.82
1973	52	172	3000	7.47
1974	343	459	1400	57.29
1975	205	318	1900	27.53
1976	312	75	500	77.40
1977	266	163	300	143.00
1978	610	562	1100	106.55
1979	408	648	1500	70.40
1980	301	585	3200	27.69
1981	468	939	5000	28.14
1982	283	476	9000	8.43
1983	403	468	15900	5.48
1984	208	538	5969	12.50
Average	252	346	3929	37.00

Straying to a particular river seems to be most intense when streamflow of that river is high relative to other nearby rivers. CDFG data for the Lower Mokelumne River 1987-91 shows that the percentage of chinook salmon in the total San Joaquin River run that enters the Mokelumne is higher when both base October-November average flows and special attraction flows are high in the Mokelumne relative to the San Joaquin at Vernalis (Figure 3.3-5). An exception to the relationship for peak flows occurred in 1989 when a peak Mokelumne flow in early November nearly 6 times the base flow failed to attract many more fish. Alteration of flows in the Delta also has undoubtedly contributed to poor orientation to natal streams. Straying to a particular river seems to be most intense when streamflow of that river is high relative to other nearby river. Alterations of flows in the Delta, such as the Delta Cross channel from the Sacramento River to the Mokelumne River, also has undoubtedly contributed to poor orientation to natal streams.

Factors Affecting Survival of Juvenile Chinook Salmon

Survival, ocean catch, and retrieval rates of salmon migrating from natural spawning areas or hatcheries vary greatly depending on fish size, season, environmental conditions during outmigration, and location of planting (for hatchery fish). We are able to quantify this knowledge because, over the past 25 years, the CDFG has changed its strategy for releasing hatchery-raised salmon. Through this period of change, statistics on the origins of ocean catches have been obtained by state and federal agencies. Since 1975, this has been done using coded-wire tags implanted in hatchery fish from various Central Valley locations (not from the MRFF, however). This information has aided in identifying the relative survival of fish with differing backgrounds. We presume that the data for other Central Valley hatcheries approximate the situation for Mokelumne River chinook, whether hatchery-raised or natural spawners.

Almost all chinook salmon reared by CDFG at the MRFF before about 1968 were released directly into the Mokelumne River at the hatchery as very small (young) fish. Beginning in 1967, CDFG began to experiment with releasing fish of different sizes and at different locations, with the goal of increasing the hatchery population. In response to the results, CDFG gradually changed their hatchery operations and planting policies throughout the Central Valley. Instead of releasing large numbers of small fish at the hatcheries in spring, they began to transport them downstream in late spring or early summer and planting them in the Delta, as well as Suisun and San Pablo bays.

Coded-wire tagging data have allowed inferences to be made about the effects of several biological and environmental factors on survival of young fish (both hatchery-raised and naturally produced) during seaward emigration. Dettman and Kelly (1986, 1987) analyzed the coded-wire tag information for hatchery-raised fish and estimated, by various methods, how many were caught in the ocean and how many returned to spawn. Although the details of the analytical methods have been criticized when applied to some conclusions (Hankin 1988), these studies have yielded valuable generalizations about chinook salmon survival. Additional analyses have been made by Kjelson et al. (1989). In addition to tagging studies, field studies on the Lower Mokelumne River by contractors to CDFG and EBMUD have examined several factors that may affect chinook salmon survival.

Size at Emigration. On average, larger juveniles planted into tributaries of the Sacramento River immediately below the American River, Feather River, and Battle Creek hatcheries survived better to the time they contributed to the ocean catches (of adults and subadults) than did small ones (Reisenbichler et al. 1982). Dettman and Kelly (1986) extended these results into more recent hatchery plants and included data on larger fish from another hatchery (Red Bluff). When they ignored several groups that had unusually low survival rates, there was a loose correlation between retrieval rates and size (Retrieval Rate = $0.001116696 \times \text{Weight}^{0.6890237}$; $r^2 = 0.69$). In general, retrieval rates increased from about 0.001

Figure 3.3-5. Relationships between the percentage of adult fall chinook salmon of the San Joaquin run 1987-1991 that enter the Mokelumne River and the relative flows of these rivers in October and November. Upper: ratio of average October-November base flows for each river; lower: ratio of Lower Mokelumne River peak attraction flows versus average October through November San Joaquin River flows. San Joaquin flows measured at Vernalis; Lower Mokelumne River flows at Woodbridge. Escapement data from CDFG. (Source: The staff.)

when fish were planted at an average weight of 1 g to 0.006 when planted at an average weight of 10 g. These data suggest that fish that grow to larger size before emigration in the Mokelumne River could be expected to have somewhat higher survival rates and better returns, although this will not always be the case.

Emigration Season. Fish growth requires time, so the larger fish are generally planted later in the season. To evaluate the effect of planting in different seasons, Dettman and Kelly (1986) divided all releases of fish made into tributaries of the Sacramento River into those released in spring (generally less than 10 g) and those released in fall and winter (much larger). Ocean retrieval rates of the spring-released smaller fish averaged 0.004 whereas the larger fish planted in the fall or winter averaged 0.026 (six times as much). Retrieval rates varied widely even among fish planted at about the same time and size. Rates for spring-release-1 salmon showed a range of about a hundredfold, a result which Dettman and Kelly (1986) attributed to environmental factors that affected survival after planting. These data suggest that a much higher survival of chinook salmon smolts from the MRFF could be expected from plants made at the hatchery later in the year, assuming the facility could hold them through the summer.

Migration Through Lower River and the Delta. Planting of young hatchery-raised fish in several locations that ranged from near the upriver hatcheries to San Francisco Bay demonstrated the perils of migrating through the lower river reaches and the Delta. Fingerlings and smolts, weighing 10 g or less, usually survived much better when planted in San Francisco Bay and Delta than they did when planted in tributaries of the Sacramento River or in the lower Sacramento River above Rio Vista (Table 3.3-5) (Dettman and Kelly 1986). The average ocean survival of groups planted in the western Delta and Suisun Bay was 2.5 and 8% compared to averages that ranged from 0.3–0.7% in the Sacramento River and its tributaries. There was less advantage to planting larger fish downstream. Average adjusted ocean retrieval rates for fish weighing more than 10 g and planted in the western Delta/Suisun Bay and San Francisco Bay were 3.1 and 7.4%. Rates for these larger fish planted in the Sacramento River tributaries ranged from 0.6–4%. Recent analyses of coded-wire tags by Kjelson et al. (1989) indicate from about 60 to near 100% mortality of juvenile chinook salmon during migration through the central Delta (Figure 3.3-6). These data indicate that the MRFF's practice of transporting part of its production to the Suisun Bay release site is a valuable way to increase survival. However, this practice increases straying and reduces the number of salmon that return to the Lower Mokelumne River. The data also indicate that mortality to naturally hatched chinook salmon that emigrate out of the Mokelumne River probably occurs most heavily in the river and Delta. This Delta mortality limits the effectiveness of improved flow conditions on the Lower Mokelumne River for stimulating salmon runs.

Environmental Variables. Despite the often high correlations with fish size, planting season, and planting location, Dettman and Kelly (1986) did not feel that they had sufficient information to estimate retrieval rates of unmarked fish with much accuracy. For example, retrieval rates of fingerlings and small smolts released into the lower Sacramento River ranged from 0.03–1.8%, a sixtyfold difference. They concluded that factors other than size, season, and location of planting have a large influence on retrieval rates. We suspect that the same would be true for Mokelumne River salmon.

To assess the major environmental factors of streamflow, temperature, river diversions, and Delta outflow to San Francisco Bay, Dettman and Kelly (1986) separated the groups of juvenile salmon that had been marked and planted into the Sacramento River basin by planting size, season and location. They felt that environmental conditions at or after planting time were important, and so they tested this hypothesis. They examined the relationships between the adjusted ocean retrieval rates of these groups and environmental variables using correlation and regression analyses. They used USGS streamflow and temperature records and the results of the Department of Natural Resources' "day-flow" model to describe

Table 3.3-5. Summary of average ocean retrieval rates for chinook salmon released as fingerlings and small smolts or large smolts and yearlings in several locations throughout the Sacramento river basin. Ocean retrieval rates are based upon estimated recoveries of coded wire tagged and finclipped juvenile salmon released between 1956 and 1982 adjusted for different annual levels of effort in the ocean troll fishery.

(Source: Dettman and Kelly 1986.)

Location	Fingerlings and smolts (<10 g)		Large smolts and yearlings (>10 g)	
	Average size (g)	Ocean return rate	Average size (g)	Ocean return rate
Battle Creek	5.1	0.0046	17.2	0.0063
Feather River	6.9	0.0026	61.7	0.0402
American River	5.6	0.0042	nd ^a	nd
Average of tributaries	5.9	0.0037	42.6	0.0256
Lower Sacramento River	6.0	0.0068	nd	nd
West Delta and Suisun Bay	7.1	0.0254	34.8	0.0308
San Francisco Bay at Tiburon	8.9	0.0802	42.4	0.0736

^a No data available.

environmental conditions over 7- and 14-day periods following the date when fish were planted. These times were selected as representative of fish travel times through the lower river and Delta in May and June.

For fish planted in the Sacramento River tributaries, they found good correlations. There were positive correlations between adjusted ocean retrieval rates of these fish and both river flow (0.87 and 0.89 for 1 and 2 weeks following planting) and Delta outflow (0.82 and 0.83). There were strong negative correlations between the rates and the Sacramento River maximum temperature (-0.84 and -0.85) and an index of Sacramento River diversion into interior Delta channels (-0.88 for both 1 and 2 weeks later). The strongest correlation was with river flow (Return rate = $-0.0736 + 0.00799 \times \text{Inflow}$; $r^2 = 0.91$). Dettman and Kelly (1986) caution that from this information it is impossible to define which environmental factors control survival rates because all of the factors are themselves highly correlated. These data suggest that survival of salmon smolts emigrating from the Mokelumne River might be increased similarly by higher river flow and more bayward Delta outflow. Their survival might be decreased by higher temperatures or increased flow to the southern Delta.

One might argue that fish released in Sacramento River tributaries are poor surrogates for salmon emigrating in the Lower Mokelumne River. Thus, staff examined data analyzed by Dettman and Kelly (1986) for Sacramento River fish released in spring closer to the Mokelumne River (i.e., in the lower Sacramento River near the Delta Cross Channel that connects the Sacramento and Mokelumne rivers). Like the salmon planted in tributaries, the ocean retrieval rates of these fish were positively correlated with river flows and Delta outflows and were negatively correlated with water temperatures and diversions to the lower Delta, although the correlations for both one- and two-week intervals were slightly less strong

Figure 3.3-6. Estimated juvenile chinook salmon mortality of groups of coded wire-tagged juveniles during migration through the Central Delta. Coded-wire tag analysis for reach M2-Courtland to Chipps Island. There was more than one tagged group in some years. (Source: Kjelson et al. 1989.)

(streamflow: 0.71 and 0.75; outflow: 0.68 and 0.70; temperature: -0.84 and -0.81; diversion: -0.79 and -0.81). The strongest correlation was with water temperature (Return rate = $0.003645408 - 0.001553099 \times \text{Sacramento River Temperature}$; $r^2 = -0.84$).

We conclude that the Sacramento River correlations by Dettman and Kelly (1986, 1987) provide a useful basis for estimating the factors most influential in survival of emigrating Mokelumne River chinook salmon to the time of their capture in the ocean fishery. Unlike Dettman and Kelly, we cannot develop a quantitative model for estimating ocean retrieval rates of fish from the MRFF and the natural river's production as they did for the Nimbus Hatchery and the American River. Appropriate tagging, test releases, and analyses of coded-wire tags of Mokelumne River fish would allow these correlations to be made. Coded-wire tags have been applied to groups of Mokelumne River fall chinook salmon planted from the MRFF since the 1982 brood year. In only one year (1982) were there plantings at both the hatchery and in the Delta. All other plantings were at various locations in or beyond the Delta. We found no statistical differences between the two planting sites for the 1982 brood year fish in either the ocean catches or on the inland fisheries.

Influence of Hatcheries on Natural Spawners. The production of chinook salmon in Central Valley hatcheries and their planting in zones beyond the environmental rigors of lower rivers and the Delta appear to be having a detrimental effect on naturally reared fish. Dettman and Kelly (1986, 1987) conducted their analyses of coded-wire tag experiments, ocean catches, and escapements to determine the

relative contributions of hatchery-reared and naturally reared fish to the total runs. Although their focus was on runs to other rivers such as the American, the results are likely to represent the situation for the Mokelumne River as well.

In the American River, an increase in production of the Nimbus Hatchery since about 1978 led to a concurrent decline in naturally reared fish as estimated by Dettman and Kelly (1987) (Figure 3.3-7A and B). There has been an even more pronounced increase in salmon production at the MRFF over the same time period (see Section 4.8.3). The relative strengths of hatchery-produced and natural-run fish in the American River may also parallel those in the Mokelumne River. Even considering the imprecision inherent in their estimates, Dettman and Kelly (1986) clearly observed that the hatchery-produced run had increased while the natural run had decreased. The stocking of larger smolts in the western Delta, Suisun Bay, and the Carquinez Straits, where they survive better, was judged responsible for the increase in hatchery fish. These fish must no longer contend with the low flow/high temperature problem in the lower river or with large diversions or other environmental problems of the Delta. In contrast, the run resulting from natural reproduction must surmount the full gamut of obstacles. We suggest that the same result would be found if there were data available to analyze the Mokelumne stock in the same way. These data, as well as those on straying from other hatcheries (above), suggest that any naturally produced and reared chinook salmon in the Mokelumne River are declining in importance relative to hatchery-reared and planted fish. However, Hankin (1988) criticized the methods and statistical analysis used in these calculations of relative contributions of hatcheries and natural production and the results remain controversial.

Food Supplies in the Delta. According to analyses by Dettman and Kelly (1987), abundance of the mysid shrimp (*Neomysis mercedis*) in the Delta, a food source for young salmon in their emigration, affected smolt survival. Growth of most fish, chinook salmon in particular, depends greatly on the combination of water temperature and food available (Brett et al. 1982). With high temperature an important variable affecting survival of young chinook salmon moving through the lower rivers and the Delta (above), the amount of food available was suspected to be important.

For the Feather River and Coleman hatcheries on the Sacramento River, a clear relationship existed between the combination of escapement of natural and hatchery-reared salmon, average June water temperatures in the lower Sacramento River, and the spring population density of *Neomysis mercedis* in the western Delta. The combination of June water temperature and spring population density of *Neomysis* accounted for 84% of the variation in the index of spawning escapement in the Sacramento River basin used by Dettman and Kelly (1987). These data suggest that survival of Mokelumne River fish, whether hatchery-raised or naturally spawned, will be strongly influenced by both lower river temperatures and the food resource available in the Delta in a particular year.

Food Supplies in the Lower Mokelumne River. Chinook salmon juveniles rearing in the Lower Mokelumne River do not appear to be limited by available food. Growth rates are high, even in the drought years of low flows. Smolts emigrating in May and June are larger for their age than those derived from most other river systems in the Central Valley. Water coming from Camanche Reservoir is rich in nutrients. Aquatic organisms in the Lower Mokelumne River appear to be abundant on the bottom and available as fish food in drift (Envirosphere Company 1988). Riparian vegetation is fairly dense through much of the Lower Mokelumne River and provides abundant terrestrial insects, that often make up much of the diet of young fall chinook salmon. Juvenile salmon had full stomachs of both aquatic and terrestrial insects. In principle, lower flows should produce a smaller amount of materials on which young fish can feed. There is no direct evidence for this relationship occurring, although the studies were not conducted at different flows. The normal reliance on terrestrial insects and the actual evidence of high

Figure 3.3-7. Estimates of the number of hatchery-reared and naturally reared fall chinook salmon returning to the lower American River between 1953 and 1984. (Source: Based on coded-wire tag experiments, ocean catch/escapement ratios, and other data and estimates described by Dettman and Kelly 1987.)

growth rates in low-flow years, suggests that there is no such relationship in the Lower Mokelumne River for the normal range of flows.

Estuarine Outflow and Salinity. By means of a series of workshops, efforts are currently underway to define standards for flow, salinity, or both that encapsulate the general ecological understanding that the amount of low-salinity habitat in the estuarine bay-delta system translates into the abundance of biological resources there (Schubel 1992). Part of the overall biological picture is the survival of juvenile chinook salmon emigrating through the Delta and estuary. A simple measure being tested for its predictive power (and thus its potential use as an indicator) is the position of the 2-parts-per-thousand (ppt) salinity level along the main channel of the estuary (measured as kilometers from the Golden Gate Bridge). As flow into the bay-delta diminishes, the zone of freshwater-saltwater mixing is moved upstream and the amount of low-salinity habitat in the tangle of channels of the Delta also diminishes (Schubel 1992). We believe that this salinity index is more representative of the status of the biological habitat than flow itself because of the complicated pattern of flows created by several inflowing rivers, diversions between rivers via the Delta Cross Channel, and the water extractions in the southern Delta. Available data indicate a significant relationship between the position of the 2 ppt level and mortality of chinook salmon smolts (Figure 3.3-8) (W. Kimmerer in Schubel 1992). Although the outflow of the Mokelumne River is a small percentage of the total freshwater flow into the delta, its effect is part of the cumulative total.

Figure 3.3-8. Chinook salmon smolt mortality through the Delta versus position of the near-bottom 2‰ isohaline (GGB = Golden Gate Bridge). The temperature effect has been removed from the analysis. (Source: The staff adapted from Schubel 1992.)

Habitat Availability

An instream flow study was conducted for CDFG in 1986 and 1987 using the FWS's Instream Flow Incremental Methodology (IFIM) and Physical Habitat Simulation (PHABSIM) models (CDFG 1988, 1991). Staff used the habitat response curves produced from the CDFG PHABSIM modeling to evaluate the availability of usable habitat in the lower river for chinook salmon (see Appendix H for details of habitat suitability indices, etc.). Three PHABSIM study reaches, the "Fish Screen" reach at MRM 63.5, the "Spillway" reach at MRM 63.0 and the "Pasture" reach at MRM 62.3, were aggregated to represent the relationship between streamflow and available habitat in the 4.5-mile Tailwater Segment of the river below Camanche Dam. The PHABSIM study reach at Bruella Road (MRM 48.9) was used to represent habitat conditions in the 16-mile Rearing Segment of the river. Figure 3.3-9 shows the aggregated habitat response functions for chinook salmon spawning, fry, and juveniles in the Tailwater and Rearing segments. There is no available data on physical habitat in Lake Lodi or in the Passage Segment below Woodbridge Dam.

Based on CDFG's instream flow study, spawning habitat exists only in the Tailwater Segment. While the lack of measurable spawning habitat at the Bruella study reach is probably an artifact of the transect-based modeling approach of PHABSIM, the general trend of spawning being concentrated upstream is realistic.

Habitat available for chinook spawning responds differently to streamflows than does fry and juvenile habitat (Figure 3.3-9). Total spawning habitat increases in proportion to streamflows up to about 300 cfs, is relatively constant between 300-500 cfs, and declines gradually at streamflows above 500 cfs. Habitat

Figure 3.3-9. Total habitat available for chinook salmon versus streamflow in the Tailwater and Rearing segments of the Lower Mokelumne River below Camanche Dam. (Source: The staff reanalysis of data from CDFG 1991.)

available for both fry and juvenile chinook salmon is inversely proportional to streamflows, with the greatest amount of usable habitat at or below 100 cfs. These habitat response relationships highlight the most important fisheries tradeoff in selecting minimum flows at Camanche Dam: low flows favor the fry and juvenile life stages of salmon, while higher flows favor spawning, assuming an importance of WUA estimates based on PHABSIM modeling.

The variability of streamflows also affects habitat availability for chinook salmon. To evaluate this issue, we converted daily average streamflows at the USGS gage below Camanche Dam into daily habitat values for the period since hydropower operations began in 1981 (Figure 3.3-10). In most years there have been approximately four acres of total spawning habitat available in the Tailwater Segment, but large variations occur in this total within years. For example, in 1988, 1990, and 1991, there were initially as many as seven acres of spawning habitat available, but this declined to around four acres by the end of January during incubation. This fluctuation is directly related to streamflow changes, and it is biologically significant because it indicates a high likelihood of dewatering of redds and/or stranding of fry. There have been similar variations in fry and juvenile habitat during the last decade (Figure 3.3-10) when hydropower operations have occurred.

Clearly, calculations of WUA alone are not sufficient for characterizing habitat for chinook salmon juveniles. Water temperature, cover, predation, food availability, availability of preferred locations at head ends of pools, and other factors will influence success of a cohort of juveniles. Many of these factors are not well quantified, however.

Adverse Water Quality. Chinook salmon are susceptible to several water quality characteristics of the Lower Mokelumne River. These water quality characteristics are generally unrelated to flow but are affected considerably by whether reservoir discharges are released through hydropower turbines or through aerating valves. Low DO occurs in the Lower Mokelumne River in late summer and autumn as a result of natural hypolimnetic oxygen depletion from biological decomposition in Camanche Reservoir and release of this water to the river below the dam through hydropower turbines (see Section 3.2.3). Adults may encounter these low DO levels early in their migration into the river for spawning. However, most migration occurs after fall turnover and reoxygenation. Juvenile salmon from natural river spawning have almost always left the Lower Mokelumne River before DO levels have declined markedly in summer. Fish retained in the fish hatchery facility in summer are the most susceptible. Table 3.2-1 gives EPA national criteria for ambient DO, categorized for life stages of coldwater (including salmon) and warmwater fishes.

Chinook salmon are susceptible to hydrogen sulfide, another consequence of biological decomposition in the hypolimnion of Camanche Reservoir. Hydrogen sulfide tends to occur at the same times as low DO (Section 3.2.3). Fish held in the hatchery in summer are the most susceptible. Specific data on sensitivity of chinook salmon to this material is lacking, but the national criterion is 2 µg/L.

Chinook salmon may be susceptible to elevated metals concentrations that are characteristic of reservoir tailwaters. Soluble forms of these metals are mobilized from sediments during the periods of low oxygen concentrations in Camanche Reservoir's hypolimnion and they are released to the lower river. The sediments of the Lower Mokelumne River are rich in metals (mostly not biologically available) because of high concentrations in surrounding rocks and the mining activities that have brought them to the surface (Section 3.1.3). Again, fish held in the hatchery in summer would be most susceptible to the biologically available forms of these metals. Water quality criteria for metals are given in Section 3.2.3 (Contaminants).

Stranding. The Lower Mokelumne River is not particularly susceptible to stranding of juvenile salmon. In other river systems, water flow fluctuations below hydroelectric dams have killed fish by stranding them

Figure 3.3-10. Historical habitat availability for chinook salmon in the Tailwater Segment of the Mokelumne River below Camanche Dam for: (A) spawning; (B) fry; and (C) juveniles. (Source: The staff reanalysis of data from CDFG 1991.)

in isolated pools as water levels declined rapidly (Stober et al. 1982). The damaging effects occur on gravel bars and marginal pools where bottom topography can prevent fish from maintaining contact with open water as water levels change. In the Skagit River, Washington, this effect was aggravated by numerous potholes in the river bottom that readily became isolated from the main flow. A study of stranding potential was conducted on the Lower Mokelumne River for the CDFG (Envirosphere 1988). The study found that although there are no discrete potholes to trap fish, coarse bottom materials on fairly flat cross sections can create a fairly high potential for stranding. Chinook salmon, being located in pools more than riffles, are not especially at risk from stranding, however. There is no evidence that stranding has been a major factor in survival of juvenile salmon in the Lower Mokelumne River.

Irrigation Diversions. Water diversions for irrigation can entrain juvenile salmon and prevent their downstream migration. Within the Lower Mokelumne River, the main irrigation diversion that affects chinook salmon is that of the WID on Lake Lodi upstream of Woodbridge Dam. The diversion is fitted with rotating drum screens that, by longstanding agreement, are the responsibility of CDFG. A fish bypass directs a small flow from the front of the screens to the fishladder outlet on the downstream face of Woodbridge Dam. Salmon fry that migrate downstream primarily in March and smolts in May through June would be the life stages susceptible to entrainment. However, the WID irrigation diversions (and the filling of Lake Lodi) do not begin until about April 1, thus most emigrating fry would not be at risk. Diversions are significant in May and June, although the full diversion rate is generally not attained until later in the summer. Smolts are generally of a size (>100 mm) that would not pass through the screens. Water velocities in front of the screens are designed to be low enough that fish are not impinged on the screen mesh.

Effectiveness of the screens has been subject to considerable debate. Gaps in the rubber seals between screen drums and their supporting concrete piers may allow fish to pass the screens. Piers have been modified with projecting structures that may interfere with smooth passage of fish along the set of screens to the fish bypass. Water velocities at the entrance to the bypass may not be sufficient to draw fish into the bypass, especially when debris accumulates at the entrance. Recent maintenance (1992) has attempted to correct many of these problems.

The proportion of fish lost at the WID screens, if any, probably depends on the ratio of water diversion to river flow. The greater the river flow beyond that taken by the WID diversion, the more water will pass over or through Woodbridge Dam. If downstream migrating salmon are uniformly distributed through the water mass, then more fish will pass via the dam at higher river flows than would when proportionately more water flowed to the diversion. Although intuitive, this relationship has not been explicitly tested.

Predation and Competition. Chinook salmon do not exist alone in the Lower Mokelumne River and the fry and smolts are susceptible to predation, principally by other fishes and birds, and competition from other fish species for food resources and space. No specific studies of predation and competition have been carried out in the Lower Mokelumne River. Of the fishes found in the Lower Mokelumne River (Table 3.3-1), the most likely important predators in the salmon rearing area from Camanche Dam to upper Lake Lodi are older steelhead, Sacramento squawfish, and prickly sculpin. In reaches from Lake Lodi downstream used for migration to the ocean, the list enlarges to include the catfishes and bullheads, the crappies, and striped, largemouth, smallmouth, and spotted bass. Predation is believed especially intense on fry because of their small size. Competitors would include all fishes that also occupy pools and eat aquatic and terrestrial insects in drift or on the water surface. Low water levels at low river flows would generally tend to concentrate fish in the available habitats and thus intensify both predation and competition.

Temperature Requirements

The temperature requirements of chinook salmon have been studied extensively throughout its range. The CDWR recently compiled a literature review with emphasis on the American River (Boles 1988). Staff expanded this review and compiled requirements by life stage. There is considerable variability among studies, due perhaps mostly to differences in experimental design or type of observations. Some difference may be attributed to geographic differences in stocks. However, a weight of evidence for certain thermal limitations for chinook salmon is clear. These thermal limitations include:

spawning: optimum 50°F (10°C); stressful >60°F (15.6°C); lethal >70°F (21.1°C),

incubation: optimum <50°F (10°C); stressful >56°F (13.3°C); lethal >60°F (15.6°C), and

juvenile rearing: optimum 58°F (14.4°C); stressful >65°F (18.3°C); lethal 77°F (25°C).

These limits are shown diagrammatically with historical water temperatures in the Mokelumne River at three locations at the times when the activities occur (Figure 3.3-11).

Temperature requirements of chinook salmon in warm climates can cause the population to be stressed at both ends of the freshwater phase of life (Figure 3.3-11). Adult chinook salmon enter fresh water to spawn as temperatures decline in autumn. In warm years (usually the dry years), temperatures remain high for a longer period. This situation causes spawners to either delay migration (and thus spawning) or migrate in temperatures that are detrimental to both the adult and to the gametes. At the other end of the freshwater phase smolts normally migrate late in the following spring as temperatures rise. In warm years (also often the dry years), water warms earlier causing either earlier cues to emigrate (at an abnormally small size) or outmigration in detrimentally warm temperatures. When there is both a warm autumn and a warm spring, there may not be enough time for normal development in the intervening period. Thus, later spawning can cause juveniles to be delayed in development and emigrate late in water that is detrimentally warm. Incubation and rearing temperatures in the interval between spawning and outmigration will affect the development rate and the degree to which delayed spawning will result in damage to juveniles by high temperatures. Therefore, the seasonal progression of temperatures during the freshwater phase of life, including adult spawning migration, spawning, incubation, fry rearing, and smolt emigration, must be accounted for and not just the specific temperature during a specific life stage.

Limiting Factor Analysis

Staff has tried to place the contribution of each of the above factors affecting the population of chinook salmon in the Lower Mokelumne River into some relative perspective. This could be called a general "limiting factor analysis." A more quantitative and explicit analysis would include use of a life-cycle model that quantitatively relates mortality and growth to each of the sources of potential biological influence in the full life cycle of the fish's population. The model could be used with a hydrological record of the river to establish relative probabilities of certain features being limiting under certain circumstances. Such models are available but not well quantified for the Lower Mokelumne River; future work might be directed profitably to this area of investigation.

Staff approached the analysis with four assumptions. These are: 1) that chinook salmon follow a normal biological pattern of producing many fertilized eggs that undergo a rapid decline in survivors in early life stages followed by a slower decline in later years, except as human harvest causes a large loss of mature adults; 2) that without initial spawning there are no subsequent options; 3) that the particular limiting factor for each year-class will likely differ from year to year according to variations in environmental and

Figure 3.3-11. Temperature requirements (optimal, stressful, and lethal) of chinook salmon life stages (spawning, incubation, rearing) compared to 15-day average water temperatures in three locations of the Mokelumne River in a dry hydrologic year (1964; upper panel) and a wet hydrologic year (1974; lower panel). The three locations are below Camanche Dam (square), at Woodbridge Dam (circle), and at junction with Cosumnes River (diamond). (Source: Temperature data are from CDFG 1991.)

anthropogenic factors and the number of spawners that year; and 4) that the run size is average (about 3,200 fish). Staff has ranked the factors in order of its impression of their relative importance for achieving the CDFG goal of 15,000 spawners annually above Woodbridge Dam. We have also noted whether the parties to this proceeding can do anything about the factor. The factors are, in order of decreasing importance for the escapement goal:

1. Harvest. Approximately 75–85% of the subadult and adult chinook salmon are estimated to be harvested in the ocean fishery. More are taken by poaching in the Lower Mokelumne River during the spawning run. This level of mortality of potentially reproducing adults is probably the most severe constraint on escapement of adults to the spawning grounds. There is little control of this source of mortality (except poaching) by anyone in the Lower Mokelumne River.
2. Spawning. Spawning certainly limits the number of wild juveniles produced and constrains any additional efforts to provide adequate conditions for survival. Spawning habitat quantity and quality is suitable for control by EBMUD. In years with abundant adult salmon, spawning habitat may not be the limiting factor, but rather the habitat and survival of the progeny. The numbers of spawners and the habitat availability on which this balance hinges is poorly understood and probably varies from year to year.
3. Hatchery production. Level of production and survival of fish spawned in the hatchery to replace lost natural production is both variable and problematic and can be a major limitation to the successful use of the hatchery. Numbers of fish produced, source of the stock, and method and location of release of young fish are controlled by CDFG and its arrangements with EBMUD. The importance of the hatchery as a "limitation" or a mitigation depends on management decisions by these organizations.
4. Survival of smolts in the Delta. Mortalities in the Delta are acknowledged by most parties to be excessively large, partly because of heavy predation on emigrating fry in the early emigration season and high temperatures later in the season. The timing and condition of outmigrating salmon and the water flows and temperatures in the Mokelumne portion of the Delta are determined by factors in the Lower Mokelumne River and can affect survival in the Delta. Mokelumne flows do little to affect overall Delta conditions. Most of the direct effects in the Delta are beyond control of anyone in the Lower Mokelumne River.
5. Passage in the Lower Mokelumne River. Smolt and later fry outmigration appears to be constrained by passage through Lake Lodi. Survival there is affected by the diversion screens, water temperature, predators in the lake, and unknown factors. The evidence for this is not robust. Modest engineering actions by the parties, however, can reduce these losses even without ironclad proof.
6. Rearing in the Lower Mokelumne River. Availability and quality of rearing habitat may be limiting the production of smolts. Physical habitat limitation is suggested by the early peak of fry emigration at Woodbridge that may be the result of newly emerged fish being forced downstream by those already occupying the best habitats. Fry trapping studies by EBMUD have shown relatively little fry movement out of the reach above Bruella Road, suggesting that the upstream reaches are less saturated with fry. Most of the emigrating fry appear to come from the more downstream reaches that lack the mixture of riffles, runs, and pools that characterize optimal habitat. As fry survival during downstream migration and in the Delta is probably low, provision of more habitat for rearing in the Lower Mokelumne River could yield more of the larger (and presumably better surviving) smolt emigrants in the May-June outmigration, assuming adequate spawning and incubation success. Such provision is within the capabilities of the parties in the Lower Mokelumne River.

7. Toxic metals, hydrogen sulfide, dissolved oxygen. Although highly controversial, persuasive evidence of metal toxicity is lacking. Both this factor and other water quality factors related to discharge of hypolimnetic water occur in late summer and early autumn when chinook salmon are not in the river. Metals are endemic to the system because of regional geology and past mining activities and not much can be done to remove them; management of the hypolimnion of Camanche Reservoir and its discharges can correct other problems. However, staff feels that the evidence both for and against metals being a chronic toxicity problem in the Lower Mokelumne River is insufficient at this time to be conclusive, and additional focused study is needed.

Rather than to try to identify a single limiting factor and to focus mitigation efforts there, we prefer to use mitigation and enhancement for each of the factors that are within the control of parties on the Lower Mokelumne River, specifically EBMUD. This approach presumes that other actions, beyond the current proceeding, will be taken for the other factors. Indeed, such actions are being taken, for example the protection of critical habitat for threatened winter run chinook in the Delta. Thus, provision of wild spawning areas (augmented by supplementation from the hatchery), engineering fixes of problems with fish passage through Lake Lodi and elsewhere, enhancement of rearing areas for salmon fry, and correction of water quality problems are all valid measures for recommendations by staff based on the analyses of impacts that follow in Section 4.

3.3.2 Steelhead Trout

Before completion of the Camanche Reservoir in 1963, the steelhead (the anadromous form of the rainbow trout *Oncorhynchus mykiss*) was the most important fish in the Lower Mokelumne River (CDFG 1959). Highly prized by sport anglers, they are currently considered a secondary resource to the chinook salmon. CDFG's position is that habitat management targeted toward chinook salmon will benefit steelhead because their life-stage needs are similar (CDFG 1991). There are also specific management goals for natural and hatchery production and rearing of steelhead.

Spawning had taken place roughly between Clements and the base of Pardee Dam before Camanche Reservoir. CDFG (1959) estimated that this reach of river was capable of sustaining 2,000 spawning adult steelhead. The present production of steelhead in the river is thought to be very low, with runs in the vicinity of 200 fish per year (CDFG 1991). The state manages steelhead as they do catchable trout. Eggs or fry are transferred from hatcheries located in the Feather or American rivers, reared at the MRFF to 10–16 in., and planted in the river below the hatchery as catchable trout. Efforts to reestablish a major natural run have been unsuccessful.

Steelhead migrate from the ocean to their natal streams to spawn in the fall and winter (Figure 3.3-3). In the Lower Mokelumne, the spawning migration begins as early as August, peaking in October and November, and extending through March. Spawning occurs in late winter and spring (January–April). Egg incubation and fry yolk absorption lasts into May and early June, when the fry emerge from the gravel. Fry remain in the river for one to four years before smolting and emigrating to the ocean. Steelhead mature in one to four years at sea before returning to their natal streams to spawn. Unlike salmon, steelhead do not necessarily die after spawning and may make several annual spawning migrations in a lifetime.

Juvenile steelhead are oriented to shallow (<1.5 ft; <0.5 m) riffles and runs with large rubble (Everest and Chapman 1972). Young steelhead are territorial, a feature that separates size groups within the species (usually the largest in the cohort are dominant). Dominant first-year steelhead select the slowest velocities in protected sites among shallow rubble where there is abundant drift of benthic invertebrate food from upstream parts of the riffles. Non-dominant steelhead were forced into higher velocities, but still in

rubble-filled riffles and runs. As steelhead grow, they tend to occupy higher velocities. One-year-old steelhead and older tend to occupy deeper (>1.5 ft; >0.6 m) and faster (>1.5 ft/s; >0.5 m/s) water. There are essentially no rocky, bouldery riffles or runs in the Lower Mokelumne River for juvenile steelhead. Existing riffles and runs are composed of small gravel, even in the tailwater section. Riffles and runs are also the habitats that are most dewatered at low flows often prevalent below Camanche Dam. Thus, habitat for juvenile steelhead is deficient, and perhaps one reason why steelhead have not developed a self-sustaining population in the Lower Mokelumne River after Camanche Dam (the river in the reach flooded by Camanche Dam is reported to have had much more rocky, bouldery substrate).

Juveniles of both chinook salmon and steelhead occupy the Lower Mokelumne River in the spring, but chinook salmon emerge earlier and have a size advantage. Because rubble and boulder habitat is scarce in the Lower Mokelumne River, chinook and steelhead juveniles probably are obliged to occupy the same habitats and are in strong competition for the same resources. Steelhead would be favored whenever flow changes result in an increase in rocky, bouldery riffles and runs.

Temperature requirements of steelhead and rainbow trout have been studied extensively. Staff review of this literature indicates the following:

spawning: optimum 45–50°F (7.2–10°C); stressful 68°F (20°C); lethal >72°F (22°C),

incubation: optimum 48–52°F (8.9–11.1°C); stressful >55°F (12.8°C); lethal 60°F (15.6°C), and

juvenile rearing: optimum 55–65°F (12.8–18.3°C); stressful 68°F (20°C); lethal 77°F (25°C).

The CDFG instream flow study (1991) and PHABSIM results were used to evaluate the availability of usable habitat for steelhead trout in the lower river in the same way they were used for chinook salmon (Section 3.3.1). Figure 3.3-12 shows the relationships between streamflow and total habitat for steelhead life stages. As with chinook salmon, suitable spawning habitat is restricted to the Tailwater Segment in CDFG's PHABSIM analyses. There appears to be approximately half as much suitable spawning area for steelhead than there is for chinook, but it is more stable with respect to streamflow changes. Steelhead spawning area increases with streamflow up to 200 cfs, then is relatively stable over the range of flows from 200–700 cfs. Juvenile and fry habitat is inversely proportional to streamflows, similar to the same life stages for chinook salmon. However, one significant difference between steelhead and chinook habitat availability is that there is essentially no suitable habitat for steelhead fry in the Rearing Segment of the river. This prediction is the result of the habitat suitability functions that CDFG used for steelhead which indicate a preference by fry for shallow and relatively fast riffle areas with larger substrate types. When daily habitat values were calculated from observed streamflows below Camanche, patterns of significant within-year variability were observed, similar to the patterns for chinook salmon habitat (Figure 3.3-13.).

Staff evaluated the requirements of steelhead in a general limiting factor analysis. Clearly, something is limiting steelhead markedly because attempts to reestablish the run have not succeeded. All of the factors related to chinook salmon (Section 3.3.1) apply as well to steelhead. Water quality problems could have more impact on steelhead that spend the whole year in the river. Water temperature can exceed the requirements of steelhead in late summer in parts of the Lower Mokelumne River. Also, the rearing habitat requirements of these two species differ greatly. As noted above, appropriate rearing habitat for juvenile steelhead is essentially nonexistent in the Lower Mokelumne River. Staff believes that this deficiency is the major limiting factor for this species. It is one that may be amenable to some limited corrective measures by EBMUD. The general picture for steelhead is not promising, however. Even though this species has been reduced more than any other by Camanche Dam, the prospects for

Figure 3.3-12. Total habitat available for steelhead trout versus streamflow in the Tailwater and Rearing segments of the Lower Mokelumne River below Camanche Dam. (Source: Staff reanalysis of data from CDFG 1991.)

reestablishing a major run in the low-gradient Lower Mokelumne River with mitigative measures by EBMUD or other organizations are not good. Staff does not consider a major effort to rehabilitate the physical environment and water quality below Camanche Dam for steelhead to be worthwhile.

3.3.3 Striped Bass and American Shad

Striped Bass

Striped bass (*Morone saxatilis*) is a major fishery resource of the San Francisco Bay/Sacramento/San Joaquin Delta system. It is also the major predatory fish species in the migratory pathway for juvenile salmon and trout leaving the river systems of the Central Valley for ocean waters. Thus, there are concerns for its protection as a valuable resource in the Lower Mokelumne River but concurrent concern for its impacts on salmon survival.

Striped bass were introduced to the Pacific coast from New Jersey through plantings in the Sacramento/San Joaquin Delta in 1879 and 1882 (Skinner 1962). The species is a large fish (adults can reach over 100 pounds or 45 Kg but more often range 10–30 pounds or 4.5–13.5 Kg) native to the east coast of North America from the St. Lawrence River to Florida and the northern Gulf of Mexico. With successful natural reproduction and high growth rates, the population became established rapidly. By 1888, a commercial fishery was established that produced in excess of 1.2 million pounds by 1889 (CDFG 1991).

Figure 3.3-13. Historical habitat availability for steelhead trout in the Tailwater Segment of the Mokelumne River below Camanche Dam for: (A) spawning; (B) fry; and (C) juveniles. (Source: The staff reanalysis of data from CDFG 1991.)

The main population centers are in the Sacramento/San Joaquin Delta and river system, but smaller populations have been established in rivers and estuaries of northern California and Oregon. Cold water temperature appears to limit additional spread of the population (Coutant 1985).

Striped bass colonized the Mokelumne River below Woodbridge Dam. CDFG (1959) reported that a substantial fishery for adult striped bass once existed in the lower river and that there was spawning in the North and South Forks near New Hope Landing in 1948 and 1949. Immature striped bass were commonly observed in large numbers immediately below Woodbridge Dam. No striped bass fishery currently exists in the lower river, consistent with generally low population levels in the Bay-Delta in recent years (CDFG 1991). No striped bass were observed in the normal spawning seasons of 1990–1992 by Walsh et al. (1992). The regional low levels are of considerable management concern to CDFG, and the most accepted hypothesis to explain the decline is a relationship with flow. A fairly strong relationship exists between population abundance indices for striped bass and the position of the 2 ppt salinity level in the main estuarine channel (Schubel 1992). The most commonly identified causes for the striped bass decline do not relate specifically to environmental impacts in the Mokelumne River except as low flows in this river contribute to low flows in the entire bay-delta system.

The life cycle of striped bass would include spawning and juvenile rearing in lower reaches of the Mokelumne. Adults move into the fresh water portions of the river in April through June at temperatures near 64°F (18°C) for spawning (Figure 3.3-3). Spawning occurs in large schools in main channels. Females release large numbers of eggs (a few thousand to over 1 million) into the water column. The eggs are slightly heavier than fresh water so they sink slowly toward the bottom and are kept suspended by water currents. Eggs that sink to the bottom generally do not survive. Hatching occurs in about 48 hours. Eggs, larvae, and early juveniles in the San Joaquin River system generally remain in the general area of spawning, with movement as juveniles throughout the Delta where the species spends most of its life.

American Shad

American shad (*Alosa sapidissima*) is another introduced fish species that is large, supports an important fishery, and serves as a predator on juvenile salmon and trout in their emigration to the sea. American shad were introduced into the Sacramento River in 1871 and rapidly expanded to form a commercially fished population 8 years later. In 1957, the commercial fishery was terminated to facilitate the development of a sport fishery. Popular sport fisheries were located in the Sacramento, American, Feather, and Yuba rivers. CDFG (1959) reported a large angler shad fishery in the section of the Mokelumne River below Woodbridge Dam. Flows of the Mokelumne were said to greatly influence the lower river fishery, and Woodbridge Dam was seen as an obstacle to further upstream migration. There has been an active "bump net" fishery for American shad in the North Fork of the Mokelumne River near New Hope Landing, where about 67% of the regional catch of American shad has occurred (Meinz 1981), although the catches have declined markedly in recent years (CDFG 1991). No American shad were observed spawning in the lower river in 1990–1992 in surveys by Walsh et al. (1992), although these were exceptionally dry years.

American shad rear to sexual maturity in the sea and then migrate to their natal river to spawn. The peak of upstream migration through the western Sacramento-San Joaquin Delta occurs during March through May (Figure 3.3-3). Studies of the Sacramento River drainage by Painter et al. (1979) determined that the relative magnitude of tributary discharge to that in the main stem of rivers appears to determine the distribution of American shad spawning for the first time. CDFG (1991) believes that the same relationship holds for the Mokelumne River. Spawning occurs in fresh water during late April through July (CDFG 1991). Spawning occurs in large schools near the surface in main channels. Females release

from 30,000 to 300,000 eggs and generally (but not always) die after spawning. Semi-buoyant and non-adhesive eggs and the larvae produced gradually drift downstream. Incubation takes three to six days. The Mokelumne River in the reach between the Delta Cross-Channel and the San Joaquin River has been identified as a season-long shad nursery area. Seaward migration of juvenile shad through the Delta starts in late June and extends through November (Stevens 1966).

3.3.4 Warmwater Fishes

The Lower Mokelumne River below Woodbridge Dam also contains native and introduced warmwater fish species. Many of these are both predators and competitors with migrating juvenile salmon and trout that use the lower river for rearing and as a migration corridor. The warmwater fish populations have recently been surveyed in literature references and field studies by Walsh et al. (1992) for EBMUD.

Native fishes include both true residents and semi-migratory species (Table 3.3-1). There are also numerous introduced species other than the striped bass and American shad. In recent surveys by Walsh et al. (1992), there were 23 species confirmed. The most abundant fish in the electrofishing surveys in April and June 1990 were bluegill, smallmouth bass, and spotted bass. In spring 1990 and 1991 seining surveys for smaller fishes, the most abundant were mosquitofish, bluegill, and Sacramento sucker. A list of 26 species was developed by Walsh et al. (1992).

3.3.5 Other Threatened/Endangered Species

Delta Smelt

Delta smelt (*Hypomesus transpacificus*) has been proposed for endangered status (Stevens et al. 1990, Moyle et al. 1992). This small, plankton-feeding fish is confined to the upper Sacramento-San Joaquin estuary. Historically, the upstream limits of their range have been around Isleton on the Sacramento River and Mossdale on the San Joaquin River, with a lower limit at Suisun Bay. There is no specific information regarding the upstream extent in the Mokelumne River. Before reclamation of Delta islands, the species may have occurred much farther upstream (Herbold et al. 1992).

Before their sharp decline in abundance after 1984, Delta smelt concentrated in shallow-water areas near the entrapment zone, just upstream of the salinity-stratified water column or in the river channels immediately above it, except when spawning (Herbold et al. 1992). Occurrence today is generally restricted to a small area in the entrapment zone where copepods are still abundant enough to provide food. This zone has shifted since 1984 (Herbold et al. 1992). Before 1984, the entrapment zone was located in Suisun Bay during October through March except during periods with exceptionally high outflows or during years of extreme drought. During April through September, the zone was generally upstream, in the channels of rivers. Since 1984, the entrapment zone has been located mainly in the channels of rivers throughout the year. This shift in location coincides with an upstream shift and narrowing of the location of the Delta smelt population to the deeper water of the main river channels, an unnatural habitat for the shallow-water fish.

Spawning can take place in fresh water any time from late February through May, when water temperatures are from 44.6–59°F (7–15°C), although most spawning takes place in March and April (Herbold et al. 1992). Spawning occurs in shallow water along the edges of the rivers and adjoining sloughs. Eggs are presumed to sink and to be adhesive, sticking to hard substrates such as rocks, gravel, and tree roots. Larvae are carried by currents downstream into the entrapment zone where salt water mixes with the outflowing fresh water and food has traditionally been abundant. The adult dies after

spawning. Most of the population lives only one year, so numbers can fluctuate widely based on the success of annual reproduction.

Herbold et al. (1992) identified four major factors that affect smelt distribution and abundance: electrical conductivity (a measure of salinity), temperature, depth, and freshwater outflow. All are related to the flow of the incoming rivers and the Delta flows and diversions. The decline in Delta smelt coincides with the increase in proportion of water diverted from the lower Delta since 1983 and the confinement of the entrapment zone to the channels of the lower rivers. It is unlikely that Mokelumne River flows alone could have much influence on the habitat of the Delta smolt, except as they contribute in a small way to total Delta inflow.

3.3.6 Reservoir Fisheries

Pardee Reservoir has an active fishery for both coldwater and warmwater fishes (EBMUD compilation of planting and creel census data). The catch is about 90% coldwater species and 10% warmwater species. Rainbow trout were stocked in 1980–1989 by CDFG at rates of about 30,000 to 85,000 pounds per year of one-half-pound to one-pound fish (60,000 to 100,000 fish). Approximately 70% of the planted fish were caught (30,000 to 80,000 fish per year), based on tagging studies by CDFG. Kokanee (landlocked sockeye salmon) are resident and self-reproducing in the reservoir after initial stocking that ended about 10 years ago. There is also an active fishery for non-salmonids, with significant catches of smallmouth bass (10-year average of 3,000 fish), channel catfish (1,200), and panfish (mostly crappie and bluegill 4,000). Catches of panfish have shown marked decline in the past decade from 17,000 fish per year in 1980 to less than 1,000 in 1989. There is a charge for recreational fishing, with funds used to pay for stocking.

Camanche Reservoir has a fishery more oriented to warmwater fishes (EBMUD 1992a). The 1990 fishery records show catches of about 43% rainbow trout and 57% warmwater fishes. Rainbow trout have been stocked catchable sizes by EBMUD since 1986. Florida-strain largemouth bass and channel catfish have also been stocked at the recreation areas. EBMUD has also stocked white sturgeon near the base of Pardee Dam. Sunfishes, particularly black and white crappie, were abundant in both catches and fish population surveys. Estimated catches for the whole reservoir in 1991 were 21,000 rainbow trout, 21,000 black bass (mostly largemouth but a few smallmouth), 5,000 white and black crappie, 2,000 channel catfish, and 14 white sturgeon. Population surveys show more species such as sunfish and bass in the downstream lake-like sections and more suckers, hitch, and rainbow trout in the more riverine reaches near Pardee Dam. Threadfin shad is a principal forage fish whose abundance fluctuates greatly from year to year.

3.4 TERRESTRIAL AND RIPARIAN RESOURCES

Because of the limited scope of this proceeding, the only terrestrial resources considered in this assessment are those in the narrow riparian corridor along the Lower Mokelumne River below Camanche Dam downstream to the upper extent of tidal influences (approximately MRM 25). This riverine corridor lies completely within San Joaquin County, California.

3.4.1 Land Use

This section describes the major land features associated with the Lower Mokelumne River. To facilitate the analysis, four scales are used to examine the land use patterns and physical environment. After examining the region in broad terms, the county characteristics—the types of land development, housing densities, and other physical features—are described. Next the significant land features within the area of

study or those closely associated with the river are described. Finally, the riparian character of the land adjacent to the river is examined, concentrating on the features associated primarily with the fish habitat and recreational amenities. Much of the information on the riparian habitat was taken from studies performed by CDFG's LMRMP (CDFG 1991).

Sacramento-San Joaquin Delta Basin

The Lower Mokelumne River is part of the Sacramento-San Joaquin Delta Basin that extends from the headwaters of the Mokelumne River in the Sierra Nevada Mountains westward to the confluence of the Sacramento and San Joaquin rivers, a distance of about 120 miles. The Lower Mokelumne River flows 64 miles from the Camanche Dam and reservoir storage facility to converge with the Cosumnes River east of Mokelumne City. The Sacramento River, the Sacramento-San Joaquin Delta, and the San Joaquin River basins are among the most important agricultural areas of the world. The basins occupy about one-fourth of the total area of the state and contain over 30% of the state's irrigable land. These basins also have extensive forest, mineral, and recreational resources. Surface water is extensively developed. There about 50 reservoirs in the region, with storage capacity of about 1.5 million ac-ft. (CRWQCB 1991).

San Joaquin County

The heavily irrigated Sacramento-San Joaquin Valley is renowned for the quality and quantity of its produce. Most of the land along the Lower Mokelumne River is cropped year-round with annual and perennial crops. San Joaquin County is one of California's leading producers of tomatoes, asparagus, cucumbers for processing, apples, sweet cherries, walnuts, corn for grain, safflowers, sugar beets, and winter wheat (CDFG 1991). Wine grape production sustains a viable wine industry. Restrictions on dumping effluent from the wineries since 1950 have allowed the river to remain free of pollutants from the wineries. At or below sea level, most of the irrigated agricultural land adjacent to the river is protected from flooding by levees. Irrigation pumps help pump standing water from the fields into the river or to fields upstream to be reused.

3.4.2 Riparian Habitat of the Lower Mokelumne River

Riparian habitat is related to chinook salmon and steelhead trout productivity in several ways. Riparian vegetation directly affects aquatic biota through contributions of organic detritus (dead leaves, other plant material, and insects) and indirectly, through the moderation of temperature gradients in narrow reaches and backwaters where vegetation can shade the water. Organic material becomes part of the food chain, contributing nutrients to algae (primarily periphyton), forming the basis for the aquatic food web that is eaten by a variety of aquatic insects and crustaceans (Hynes 1970) and eventually salmonids.

Overhanging vegetation also helps modify water temperature for outmigrating salmonids in the spring. In addition, vegetation buffers along banks help stabilize soils and reduce agricultural runoff, thus modifying the fertilizer and pesticide residues in the river. Last, large vegetation in the river, such as downed trees and logs, can provide shade, cover, and resting places for young salmon.

The Lower Mokelumne River from MRM 19 to 64 exhibits an almost continuous corridor, though mostly narrow (e.g., a total width of one to four overstory trees on each bank), of riparian vegetation. Analysis of data in CDFG (1991) shows that, on average [weighted average of coverage per mile on both banks (CDFG 1991 data)], only about 30% is barren or exhibits only light, scattered (<25%) canopy cover. In contrast, about 70% of both banks exhibit moderate (25–75%) or dense (>75%) canopy cover.

Figure 3.4-1 shows the percent of the riparian zone exhibiting various classes of coverage (barren, light, moderate, and dense) along various subreaches, expressed as the river-mile midpoint of each, along the

Figure 3.4-1. Riparian vegetation cover along the Lower Mokelumne River on October 6-7, 1988.
(Source: CDFG 1991.)

area of interest (CDFG 1991). In general, the riparian corridor along the lower river is characterized by an overstory of valley and interior live oak, cottonwood, Oregon ash, and box elder; an understory of box elder, elderberry, willows, blackberry, and wild rose; and ground cover of horsetails and sedges. Dominant species in the over-, mid-, and understory at CDFG (1991) study sites (see below) are presented in Table 3.4-1.

Channel narrowing is caused by encroachment of riparian vegetation into the formerly active channel and deposition of sediment within the overbank vegetation. Riparian vegetation requires an exposed surface on which to germinate, a shallow water table, and to survive to maturity, freedom from scour by floods. On California rivers with large seasonal flow variations and coarse-grained alluvium, seedlings established on the exposed active channel bed are periodically scoured by high flows. Seedlings established on higher surfaces, such as the tops of coarse-grained gravel bars, are vulnerable to desiccation by declining water tables in late summer. Thus, willows and other riparian vegetation are commonly limited to a narrow band along the low-flow channel. However, when the frequency of scouring flows is reduced below a reservoir and flood scour does not occur for several years, the seedlings on the active channel may grow to maturity. Mature riparian trees bind the sand and gravel of the channel bed with their dense root mats and induce deposition. Once dense stands of mature trees are established, such as the alders along the channel margin of the Lower Mokelumne River, an exceptionally large flood would be required to dislodge them.

Although the presence of alders along the banks of the Lower Mokelumne River probably has some short-term benefits to fisheries in shade and terrestrial food contribution, the dynamic, successional regime characterizing the natural system is gone. The normal variety of aquatic and riparian habitats is diminished without flooding. Of these changes in flood regime and riparian vegetation, most can be ascribed to effects of Camanche Dam after 1963, rather than to addition and operation of the hydropower project. The lack of floods is a function of the large combined storage of the two reservoirs, and is unrelated to addition of the power plant.

Disturbance of the riparian habitat from human activities is especially noticeable from abutting agricultural activities, gravel operations, fishing trails, camp sites, and from unauthorized dumping of trash. Exceptions are the large stands of relatively undisturbed riparian forest near the confluence of the Cosumnes River and around Tracy Lake. Riprapped banks are infrequent, except for the left bank opposite the Peltier Road site, which showed evidence of recent grading, apparently by homeowners interested in protecting several new or renovated homes along the bank. Some outside bends of the river show evidence of slippage and erosion, but otherwise banks were found generally stable, although little regeneration is apparent in the thin riparian corridor in many areas.

The study by CDFG (1991) analyzed the riparian vegetation related to salmon habitat as closely as possible by locating representative sites upstream of most salmon sampling stations. Five attributes related to the salmon habitat requirements were evaluated:

- dominant plant species in over-, mid-, and understory growth;
- tree height and canopy cover;
- vigor of vegetation and amount of decay;
- amount of downed vegetation and logs; and
- amount of overhanging vegetation contributing to instream habitat.

Of these vegetative cover types, the most critical to fish habitat are the moderate to dense types. Vegetative cover contributing to the highest volume of leaf and insect drop, as well as shade and submerged cover, was found along 68% of the river in the study areas, with both banks contributing about equally in terms of habitat for fish production. Terrestrial wildlife habitat quality is generally good, when compared with similar Central Valley habitats. Numerous species of birds and other wildlife (such as deer, mice, reptiles, and amphibians) were noted in the riparian strip found along most of the banks of the Lower Mokelumne River during the salmonid habitat study. Migrating waterfowl have been found to use the river.

3.5 SOCIOECONOMIC AND RECREATIONAL RESOURCES

Pardee and Camanche reservoirs lie along the boundary between Amador and Calaveras counties in the middle of the Mokelumne River basin. The lower portion of the Mokelumne River lies completely within San Joaquin County. EBMUD's service district lies within Alameda and Contra Costa counties.

3.5.1 Population, Employment, and Income

Since 1980, the annual civilian migration into California has varied from a low in 1984 of 22,000 to a high of 452,000 in 1990. From 1980 to 1990, the increase in total population was 6,091,459, or 26%, based on census figures. During the decade, California's growth rate was at least twice the rate of yearly

Table 3.4-1. Representative riparian vegetation along Lower Mokelumne River
in the fall of 1986. (Source: CDFG 1991.)

Overstory species	Second-story species	Ground cover
Peltier Road Site (MRM 32.3, Right Bank)		
<i>Quercus wislizenii</i> - live oak	<i>Sambucus mexicana</i> - elderberry	<i>Xanthium strumarium</i> var. <i>canadense</i>
<i>Populus fremontii</i> - cottonwood	<i>Cephalanthus occidentalis</i> - buttonwillow	- cocklebur
<i>Fraxinus latifolia</i> - Oregon ash	<i>Salix</i> sp. - willow	<i>Carex</i> sp. - sedge
<i>Acer negundo</i> var. <i>californicum</i> - box elder	<i>Rubus</i> sp. - blackberry	
	<i>Rosa californicus</i> - rose	
	<i>Symphoricarpos rivularis</i> - snowberry	
	<i>Aristolochia californica</i> - Dutchman's pipe	
Bruella Road Site (MRM 49.0, Right Bank)		
<i>Quercus lobata</i> - valley oak	<i>Acer negundo</i> var. <i>californicum</i> - box elder	<i>Equisetum laevigatum</i> - horsetail
<i>Populus fremontii</i> - cottonwood	<i>Fraxinus latifolia</i> - Oregon ash	<i>Carex</i> sp. - sedge
<i>Aesculus californica</i> - buckeyes	<i>Quercus wislizenii</i> - interior live oak	
	<i>Sambucus mexicana</i> - elderberry	
	<i>Salix</i> sp. - willow	
	<i>Rubus</i> sp. - blackberry	
	<i>Rosa californicus</i> - rose	
	<i>Vitis californica</i> - climbing	
	California grape	
Mackville Road Site (MRM 59.0, Left Bank)		
<i>Quercus lobata</i> - valley oak	<i>Acer negundo</i> var. <i>californicum</i> - box elder	<i>Equisetum laevigatum</i> - horsetail
<i>Populus fremontii</i> - cottonwood	<i>Fraxinus latifolia</i> - Oregon ash	<i>Solanum</i> sp. - nightshade
<i>Juglans hindsii</i> - black walnut	<i>Alnus rhombifolia</i> - alder	<i>Chenopodium album</i> - lamb's quarters
	<i>Salix</i> sp. - willow	
	<i>Sambucus mexicana</i> - elderberry	
	<i>Rubus</i> sp. - blackberry	
	<i>Vitis californica</i> - climbing	
	California grape	
Teichert Site 9 MRM 61.9, Left Bank)		
<i>Quercus lobata</i> - valley oak	<i>Acer negundo</i> var. <i>californicum</i> - box elder	<i>Rubus</i> sp. - blackberry
<i>Populus fremontii</i> - cottonwood	<i>Fraxinus latifolia</i> - Oregon ash	<i>Lupinus</i> sp. - bush lupine
	<i>Alnus rhombifolia</i> - alder	<i>Foeniculum vulgare</i> - fennel
	<i>Quercus wislizenii</i> - live oak	<i>Carex</i> sp. - sedge
	<i>Robinia pseudoacacia</i> - locust	
	<i>Rubus</i> sp. - blackberry	

growth for the United States at large (CDFG 1991). In 1990, the population totaled 29,976,000, indicating a 2.9% increase from a total of 29,142,000 in 1989. In 1991, California's population reached 30,351,000.

In recent years the population growth in the Central and South Coast areas has expanded, as public acceptance of long commutes to urban areas has increased. The South Coast region is expected to experience the largest growth with an increase of 5 million people by 2010, followed by the growth in the Central Valley (Sacramento and San Joaquin valleys combined) with a total expected increase of 2.8% by 2010.

San Joaquin, Amador, and Sacramento Counties

Population. The population of San Joaquin County, through which the Lower Mokelumne River flows from Camanche Dam to its convergence with the Cosumnes River, averaged 480,628 (USDC 1991) in 1990, increasing to 490,000 in 1991. In an area heavily dependent on agricultural production, persons of Hispanic origin make up 23.4% of the county, slightly lower than the state average of 25.8%. San Joaquin County around the Lower Mokelumne River is characterized by a mostly rural setting. With land area of 1436.2 square miles, San Joaquin overall averages 341 persons per square mile.

Lodi, the only community directly located on the river (about 25 miles below Camanche Dam), had a 1991 population of 52,500, an increase of 600 since the 1990 census count of 51,900. Lake Lodi, a 2,200 ac-ft lake formed by Woodbridge Dam, is operated by the WID to store waters during the irrigation season from March to October. A nature area adjacent to the lake, including an interpretive discovery center, is operated on city-owned property. All wildlife, vegetation, and geologic features are protected at the river's site.

Almost one fourth of San Joaquin County's population is clustered in or around the city of Stockton, the county seat. Between 1990 and 1991, the population of Stockton increased from 124,400 to 125,600 (CDFG 1991). The increase may be attributable to reasonably priced land, labor, and housing in the area, as compared to the urban areas in the western part of the Sacramento-San Joaquin delta region.

Amador County, where Pardee Dam is located, is much less populated, having fewer than 52 persons per square mile. Amador County's 1991 population was 31,250. However, the population in 1990 was 29,600, indicating a growth rate of almost 5%, twice the state's overall average rate.

Traversing mostly through San Joaquin County, the Lower Mokelumne River provides a boundary between San Joaquin County and Sacramento County beginning below New Hope, outside the town of Thornton. Together, the populations of Sacramento County (1,066,800) and San Joaquin County (490,000) represent a little over 5% of the state's 1991 total population. Also a major agricultural producer, most of Sacramento County's population is concentrated in Sacramento (population 374,600). The Sacramento Metropolitan Standard Area, however, experienced significant growth between 1980 and 1990 of 34.7% (USDC 1991).

Housing. The 1990 median value of a house in California was \$195,500 (USDC 1990). Housing costs in San Joaquin (median home value \$121,700), Amador (median home value \$118,500), and Sacramento (median home value of \$129,800) Counties were below the state figure. Occupancy rates of housing units tend to be high in California. Of the 166,274 housing units available overall in San Joaquin County, 158,156 (95%) are occupied. Housing units available in Sacramento County totaled 417,574, with 394,530 (94%) being occupied during 1990. Amador County overall had 12,814 housing units available with 10,518 (82%) occupied.

Labor Force and Employment. Workforce data indicates that California's civilian labor force averaged 14,670,000 in 1990, increasing 1.0% from 1989. The state's unemployment rate rose slightly in 1991 to 5.8% from the 1990 rate of 5.6%. Unemployment in San Joaquin County is almost twice that of the state overall. After dropping slightly in 1989 to 9.4%, the civilian unemployment rate in San Joaquin County rose to 9.8% in 1990. Amador's civilian unemployment rate remained at the state average of 5.6% during 1990. Sacramento County's civilian unemployment rate was slightly lower than the state's, with a rate of 4.7% in 1990.

Stockton, the San Joaquin County seat, is located near the center of the fertile Central Valley near the delta formed by the San Joaquin and Sacramento rivers. Once heavily dependent on agriculture, the employment base has diversified to include manufacturing, financial and service industries (Greater Stockton Chamber of Commerce 1991). Many residents commute to jobs in the San Francisco and Sacramento areas.

Agricultural Employment. California continues to be the nation's leading agricultural producer and exporter of agricultural commodities. Total cash receipts received from California farming in 1989 (the last available figure) totaled \$17,886,895,000. Of the 360,100 employees in agricultural establishments in California, 15,600 are located in San Joaquin County, employing approximately 167,400 persons. Of California's 83,217 farms, approximately 4,365 are in San Joaquin County. Close to 91.6% of land in San Joaquin County is farmed; harvested cropland is estimated at 457,638 acres.

Although a smaller county, Amador has only 57.6% land area in farms with 5,749 acres cropped. Although slightly smaller than San Joaquin County in size (occupying 1,015.3 square miles), Sacramento County had 65.5% of its land area in farms with 115,478 acres of cropland harvested (CDFG 1991).

Alameda and Contra Costa Counties

This section discusses trends in population and economic activity for the EBMUD service area. Projections of population growth and economic activity are important for placing estimates of future water demand in perspective.

Population. EBMUD services the western portions of Alameda and Contra Costa Counties (Figure 1.1-1). The total population served by EBMUD is about 1.2 million or slightly more than half of the combined population of Alameda and Contra Costa Counties (EBMUD 1992d). The service area covers 310 square miles and includes 20 cities and 15 unincorporated communities. Within the EBMUD service area, there are significant differences in climate, geography, land use, and incomes. These factors greatly influence demand for water.

The EBMUD service area has little room for geographic expansion. The service area is bounded by other districts, and any future growth in demand will come from infilling or development within the district's existing boundary (EBMUD 1992d). Population, as shown in Table 3.5-1, is projected to increase annually by under 0.3% for Alameda County and 0.5% in Contra Costa County. The total change in population (both counties) is projected to increase by about 0.4% between 1990 and 2020. This rate of population growth for Alameda and Contra Costa counties within the EBMUD service area is much less than that projected for the entire East Bay region. Population growth in the East Bay is projected to be double that of the EBMUD service area. Table 3.5-1 also shows projected increases in the number of households. By 2020, it is estimated that there will be an additional 79,000 households being served by

Table 3.5-1. Projected increases in population and number of households served by East Bay Municipal Utility District 1990 to 2020. (Source: EBMUD 1992c.)

EBMUD Region	1990	2020	Average annual growth	Absolute growth
Population				
Alameda	758,040	831,130	0.31%	73,090
Contra Costa	421,910	486,100	0.47%	64,190
service area	1,179,950	1,317,230	0.37%	137,280
Number of households				
Alameda	319,340	362,140	0.42%	42,800
Contra Costa	166,170	202,370	0.66%	36,200
service area	485,510	564,510	0.50%	79,000
Population per household				
Alameda	2.37	2.30	--	- 0.07
Contra Costa	2.54	2.40	--	- 0.14
service area	2.43	2.33	--	- 0.10

EBMUD. About 60% of these households will be single-family residences and the remainder will be multi-family dwellings.

In summary, population growth in EBMUD's service area is expected to be about half of that projected for Alameda and Contra Costa Counties. Moreover, the rate of increase in populations shows a downward trend. The data also show that the number of households increase slightly faster than the population. This is consistent with the general observation that household size continues to decline. In 1990, the average number of people per household served by EBMUD was 2.43, slightly lower in Alameda County and slightly higher in Contra Costa County. By 2020, the average number of people per household declines to 2.33. The net decline is 0.1 for the entire EBMUD area, 0.14 in Contra Costa, and 0.07 in Alameda.

Employment and Income. Total employment in the EBMUD service area is estimated to increase at a rate of about 1.2% annually. As with population, this rate is less than for the entire East Bay region (EBMUD 1992d). Most of the increase in employment is expected to be in the commercial and institutional sectors and not in the industrial sector. Employment growth is expected to be higher in Contra Costa than in Alameda.

Alternative projections of economic activity are available from a number of sources. Projections from the National Planning Association show a decrease (0.8%/year) in manufacturing jobs in Alameda and Contra Costa counties over the next 20 years. However, wage and salary employment are projected to increase by

about 1.4% annually. The National Planning Association also provides forecasts of per capita income. For the East Bay, per capita income is projected to increase by about 2% annually.

3.5.2 Recreational Uses of the Lower Mokelumne River

Both tourism and recreation play important roles in California's economy. In some regions in California, such as around Lake Tahoe just outside the northeast corner of the Mokelumne River basin, tourism and recreation have become an economic mainstay, with resorts and related businesses providing substantial year-round revenues. California continues to outrank all other states in attracting visitors to state parks and recreational areas. Because of its climate and varied topography, California can provide a unique array of recreational activities related to water resources. Among the most popular water related-activities are fishing, sailing, boating, rafting, kayaking, surfing and windsurfing, swimming, and tubing.

Activities associated with streams and rivers are related to both the lifestyle and general life interests of both residents and visitors. Recreational adequacy, however, depends on the water resource's physical characteristics to accommodate water-oriented recreational activities. Not all recreational pursuits need to be active, consumptive, pursued year-round. Bird watching, picnicking, and other passive relaxation pursuits are also important considerations in allocating recreational resources. Also of interest when discussing recreational activities are latent recreational resources--those resources that could be used to a much greater degree than they are at present. Such resources could provide a significantly higher level of recreational opportunities, or they may have a high value for a particular group of recreationists.

During the early 1980s, several planning district studies were conducted as part of the California Outdoor Recreational Resources Planning process. Recreational plans are maintained in accordance with Sections 5099 and 5099.2 of the Public Resources Code and the Federal Land and Water Conservation Fund Act of 1965 (P.L. 88-578). The purpose of California Outdoor Recreational Resources Planning is to coordinate and guide activities of state, local, and federal agencies, and the private sector, in planning, developing, operating, and maintaining outdoor recreational areas and facilities (CDPR 1980). The existing planning district studies provide an in-depth analysis of recreational resources in California on a regional basis and are used as guides in allocating funds to state and local government agencies from the Federal Land and Water Conservation Fund and state monies. There are ten designated recreational planning districts in California. The Lower Mokelumne River is located within District 5, but no planning study has been funded for this district.

Although agriculture is the most important consideration in the Sacramento-San Joaquin region, especially along the Lower Mokelumne River, recreation also plays an important part of the economy. Recreational activities along the Mokelumne River consist of boating, swimming, rafting, tubing, and fishing for both anadromous and resident fish. Runs of salmon and steelhead in the fall and winter bring many fishing enthusiasts to the area. Fishing for other species along the stream and shallow areas is usually available year-round. Twenty-seven species of resident and anadromous fishes are known to occur in the Lower Mokelumne River (see Section 3.3).

For purposes of analysis, the CDPR divides recreation areas in California into four categories: natural resource areas, regional parks, local parks, and special-use areas. Natural resource areas are generally associated with rivers, reservoirs, forests, and, in the Sacramento-San Joaquin basin, the 1,000-square-mile Sacramento-San Joaquin Delta area. Usually, such large, natural resource areas are developed to serve the residents of a multi-county region. The smaller regional parks--normally large recreational open spaces of 100 acres or more--provide recreational opportunities ranging from highly structured to very unstructured activities, attracting persons from one or more counties. Local parks are usually landscaped areas in neighborhoods that provide passive recreation, active sports, or for young children's play for local residents.

Special-use areas are developed to focus on a single recreational activity or a group of related activities (marinas and golf courses, for example). These areas supplement local, regional, and natural resource areas by providing recreational opportunities not otherwise available (CDPR 1980). Any one of these activities can be managed at the federal, state, or local levels, or by private organizations. For example, one wetland area of the Lower Mokelumne River is a wildlife preserve owned and managed by the Nature Conservancy.

California has 275 state parks; two state-supported recreational areas are located within San Joaquin County. These include the Caswell Memorial State Park, occupying a little over 258 acres along the Stanislaus River, and Durham Ferry, a state recreational area of 183 acres. The Carnegie State Vehicular Recreational Area (1,576 acres) straddles the San Joaquin-Alameda County line and provides varied terrain for all levels of motorcycle riding skills. Indian Grinding Stone State Historic Park is located in Amador County.

Currently tourism is not a major activity in San Joaquin County. The San Joaquin-Stockton Chamber of Commerce knows of 2,064 available housing units for visitor use. County-wide, 1,046 tent and camp sites are also available and Stockton has 77 houseboats for rent. In the last few years, visits to wineries in the area, especially in Lodi and Stockton, have become popular recreational pursuits in the area. River floats via inner tubes are also increasingly popular.

Water-Based Recreation. Changes in streamflow increase or decrease the availability of water, altering the types and opportunities of both recreational resources and the aesthetic qualities from a given flow of water. Changes in streamflow may be permanent, seasonal, or fluctuating for short periods and may or may not be the result of human activities (e.g. diversion for irrigation). Changes, either periodic, long-term, or permanent, affect the habits of fish and other wildlife dependent on certain levels or types of streamflows and the resultant habitats. Some elements may have high flow change tolerance and others a low flow tolerance that could be used to determine a range of characteristics determined by flow types.

By determining how sections of the stream or river are affected by changes in flow, staff could examine the possible range of flow changes and the consequent accommodations that are needed to provide minimum habitat conditions for fish and wildlife. Habitat conditions may or may not be related to recreational opportunities, but habitat conditions are generally related to the aesthetic qualities of streams. Thus, the recreationist engaged in a water-using activity such as canoeing, kayaking, or rafting may or may not also engage in a consumptive use (fishing, hunting) but may enjoy the stream simply for its aesthetic values.

Aesthetics in relation to streamflow is generally defined as the visual valuation of the beauty of the scene. Aesthetic qualities are also related to the streamflow as riparian vegetation depends on the pattern and timing of flow changes (CDFG 1991). A desirable flow regime would deposit sediments just prior to seed release of desirable plant species, providing a nutrient-rich seed bed for germination. Flushing flows during the winter and spring will clear debris and encroaching vegetation from the main channels and will move sediments and gravels through the channels (CDFG 1991).

Public Access to Lower Mokelumne River. Recreational activities along the Lower Mokelumne River are limited by the lack of public access and development. Private land along the river accounts for much of the river frontage. The presence of a levee system further restricts recreation opportunities on the river. There are approximately 40 miles of levees constructed on the Lower Mokelumne between Camanche Dam and Interstate Highway-5 (CDFG 1991). Public access to the river is presently limited to two locations: Van Assen Park near Camanche Dam and at Mackville Road, approximately 4.5 miles downstream of Camanche Dam. Operated by EBMUD, Van Assen Park provides visitors with picnic

areas, restroom facilities, and parking. Mackville provides only limited access to the river and no restroom facilities.

Further opportunity to use the river could occur at Lodi (population 52,500), but access appears limited to private residents. At the city of Lodi, Mokelumne River flows are stored and diverted at WID's dam and canal, usually from March to late October (CDFG 1991). When the WID dam is operational, Lodi Lake is formed from the stored waters. In late October, when irrigation is no longer needed, the flashboards at the dam are removed.

Reservoir Recreation. Camanche and Pardee reservoirs provide water-oriented contact and non-contact recreational activities. Almost all the water stored by EBMUD comes from the 577-square-mile protected watershed of the Mokelumne River. Watershed land for recreational activities allows uses of land compatible with primary watershed purposes, with an emphasis on preserving open space. Approximately 1,275 acres of the 54,605 acres of EBMUD-owned watershed land are used for recreational purposes. Some of the high country hiking requires a valid permit from EBMUD (EBMUD 1989b).

Five reservoirs owned by EBMUD are open for recreation. Four of the five reservoirs (Pardee, Lafayette, San Pablo, and Chabot) store drinking water, so water-contact activities are not allowed. Because Camanche is a flood control and irrigation reservoir, swimming, water skiing, windsurfing, and wading are permitted there. Open all year, Camanche includes cabins and campgrounds. Along with water-contact activities, boating, picnicking, horseback riding, and camping areas are also popular. Camanche has a shoreline of 63 miles and a surface area of 7,622 acres (about 12 square miles).

Pardee Reservoir, ten miles upstream from Camanche Reservoir and the primary collector of Mokelumne River water, is open daily from mid-February to mid-November. Pardee has 37 miles of shoreline with a water surface of 2,257 acres. Facilities offered by concession include a marina, boat rentals and launch ramp, children's play area, swimming pools and a campground (EBMUD 1989b).

EBMUD's records show that, in 1989, close to 47% of the 139,500 visitors to Pardee Reservoir were anglers (64,800). From 1980–1989, Pardee had 1,600,000 visitors, of whom 471,000 were anglers. An estimated 562,000 trout, 77,600 kokanee salmon, 30,700 bass, 12,200 catfish, and 40,000 crappie/sunfish were taken during the 10-year period from Pardee Reservoir. During the same period, a total of 800,000 trout representing 641,000 pounds of fish were stocked in Pardee, giving an average angler return of 70%. Camanche Reservoir provides an average 161,765 angler days per year. A creel census estimates fish taken at 242,600. The estimated catch rate averages between 0.3 to 0.4 fish per angler hour (EBMUD 1991a). Together the Pardee-Camanche recreation areas provided 4,252,162 visitor days and 1,450,390 angler days between 1980–1989. Average angler catch was 1.5 fish/angler with an average angler catch rate of 0.34 fish/angler-hour (EBMUD 1991a).

3.6 WATER DEMAND AND SUPPLY ISSUES

Potential modifications to project facilities (or operation of these facilities) that become necessary because of changes in fish flow releases could affect EBMUD's ability to meet future municipal water demands. This subsection describes EBMUD's water demand and supply system and other related issues (i.e., drought management, water pricing, water quality, and forecasts of future water demands.) This subsection also briefly discusses agricultural and other demands placed on the Lower Mokelumne River.

3.6.1 Municipal Water Demand and Consumption

A historical analysis of the demand for EBMUD's water shows a period of rapid growth from 1950 to 1970, a period of level growth in the early- to mid-1970s, and greatly reduced demand in 1977 and 1978 because of the drought and imposition of water-use restrictions (Table 3.6-1). Gross water use declined by nearly 40% in 1977 and 1978. By 1984, the demand for EBMUD water had increased back to mid-1970 levels. However, during this same period, the number of EBMUD customers also increased (about 35,000 additional accounts). Industrial conservation and changes in residential consumption patterns that emerged from the 1976-77 drought resulted in permanent water savings. The most recent drought events that began in 1988 caused a sharp reduction in demand that has continued through the present time. Relative to 1986, the last normal water year, demand in 1991 was reduced by about 20% for all major categories of water use (Table 3.6-1). As with the 1976-77 drought, some permanent water savings should be evident once the current drought is over.

The residential sector is the largest EBMUD customer class, accounting for about 62% of total metered water consumption (Table 3.6-1). About 70% of residential consumption is classified as single-family households and 30% as multi-family residences. The commercial and institutional sectors account for about 16% of total metered consumption. The industrial sector comprises about 15% of total metered

Table 3.6-1. Historical water consumption by major use category for selected years 1976-1991. (Source: EDAW, Inc. 1992b.)

Water use category	Water consumption for selected years (MGD)								
	1976	1977	1978	1984	1985	1986	1989	1990	1991
Residential									
Single-family	87.1	40.4	63.5	88.1	89.1	90.8	74.7	77.2	67.3
Multi-family	31.6	22.0	22.1	30.3	31.2	31.5	29.9	29.8	28.1
Commercial/institutional	23.5	15.2	21.3	31.0	32.2	31.8	29.4	26.7	24.4
Industrial									
Petroleum	22.6	17.7	17.6	17.0	15.3	15.1	16.5	12.9	13.6
Other	23.4	15.8	15.6	15.9	15.5	15.0	12.8	10.7	9.7
Parks, golf courses, and cemeteries	9.7	3.5	6.8	11.7	11.8	12.0	10.1	11.8	10.7
Miscellaneous	1.7	0.8	1.1	2.2	3.0	1.7	1.0	0.5	0.6
Total metered	199.6	115.5	147.9	196.3	198.1	197.9	174.4	169.6	154.5
EBMUD use	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Losses	18.0	16.0	18.1	14.4	16.5	15.8	18.0	27.2	17.2
Total gross water use	218.6	132.5	167.0	211.7	215.6	214.7	193.4	197.8	172.7

consumption. Water consumption in this sector is heavily concentrated in the petroleum industry (50% of industrial demand.) The other major use is irrigation water for parks, golf courses, and cemeteries. These combined uses account for 7% of total EBMUD water consumption. The data in Table 3.6-1 also show that system losses or unmetered water is 10% of gross water use.

EBMUD data show that about a third of total water consumption is used outside. The residential and commercial (parks, golf courses, cemeteries) sectors account for nearly all outside water use. About 90% of outside water is used for irrigation purposes (EBMUD 1989a). Table 3.6-2 summarizes consumption characteristics for EBMUD's largest customer class—residential water. The data show that toilet flushing and bathing are the two largest uses, accounting for 72% of total indoor water use or about 44% of total water use. Irrigation accounts for more than one-third of residential water consumption. Total per capita water use is estimated at approximately 110 GPD under normal or non-drought conditions.

The data in Tables 3.6-1 and 3.6-2 are based on EBMUD service area averages. In actuality, the EBMUD service area is diverse with respect to land use and socioeconomic characteristics, geography, and climate. EBMUD's service area is divided into seven districts that each have similar geographical, climatological, and land-use characteristics. (These seven districts are also used to facilitate planning for distribution facilities and to assess system capacity charges.) Among these districts there are large differences in the proportions of indoor and outdoor water use and in total household consumption. For example, outside water use ranges from a low of about 27% of total residential water consumption in Oakland to about 55% of total consumption in the drier and higher income Walnut Creek region. Overall, single-family household consumption varies from as little as 200 GPD to over 1,200 GPD (EBMUD 1989a).

Table 3.6-2. Residential water-use characteristics. (Source: EBMUD 1992d.)

Residential water use	Gallons/capita/day ^a	% ^a
Inside water use		
Toilets	28	42
Bathing	20	30
Laundry	9	14
Dishwashing	4	6
Faucets	3	4
Cooking	3	4
Total	67	100
Outside water use		
Irrigation	39	90
Other	4	10
Total	43	100
Total water use	110	100
^a Notes: Data are based on 1986 consumption and are indicative of normal (non-drought) use.		

About 11% of single-family residential customers use more than 750 GPD and account for over 35% of all water sold to this customer class. About 3.5% of these customers use more than 1,200 GPD and account for 17% of all water used by single-family households.

The data in Table 3.6-3 show how the demand for water varies over the year for major water-using sectors. The data in Table 3.6-3 are reported for two years—a normal water year (1986) and the most recent drought year (1991). Water demand rises during the summer months as outdoor uses increase. Peak water demand occurs during July and August. February is the lowest water-use month. In 1986, demand during July was nearly twice that of February. The 1991 drought year data show that winter demand was somewhat reduced over 1986 levels. However, summer demand was considerably lower in 1991. Comparing sector demands shows that industry reduced demand in 1991 by 24% over 1986 levels, the commercial sector by 20%, the residential sector by nearly 27%, and water use at parks, golf courses, and cemeteries was reduced by 10%. The percentage reductions, as expected, were higher during the summer months because much of this water is used outside. For example, total residential demand in July was reduced by 30% in 1991 over 1986 levels, but February 1991 demand was reduced by only 6% over 1986 February demand.

Drought Management and Planning

In the mid-1980s, EBMUD adopted a water supply availability and deficiency policy that required an annual review of the current and long-term adequacy of water supplies. Historically, most of the rain and snow likely to fall into EBMUD watersheds or accumulate as snowpack occurs before April 1 of each year. In April of each year estimates of water available for the remainder of the current year (April 1 through September 30) can therefore be estimated on the basis of runoff in storage and runoff remaining in the snowpack. The runoff in storage is that contained in Pardee and Camanche reservoirs plus all terminal reservoirs. If storage is projected to be less than 500 TAF at the end of the current water year, a drought management program is initiated. The degree to which the drought program is implemented depends on the projected level of storage. If projected September 30 storage is between 450 and 500 TAF, a 0 to 15% demand reduction goal may be called. If projected storage is between 300 and 450 TAF, a severe drought situation exists and a 15 to 25% curtailment is required. Critical drought situations exist when projected September 30 storage falls below 300 TAF. In this case, the maximum reduction in demand (25% overall with 32% reduction in single-family residences) is implemented. Table 3.6-4 summarizes the demand reductions required under 15% and 25% curtailments and how this demand rationing is distributed among customer classes.

In addition to implementing mandatory or voluntary water reduction goals, EBMUD initiates a number of other actions. The degree to which these actions are implemented depends on the severity of the drought. These actions include making changes in rate structures to promote conservation (and to make up for lost revenues) and conducting public information and educational campaigns. If droughts are projected to be severe, a water emergency may be declared, water-use restrictions imposed, and additional supplies sought.²

Since the end of the drought of record (1976–77), EBMUD initiated drought management actions five times. EBMUD rationing goals varied between a 12% voluntary program to a 25% mandatory program. Overall, voluntary cutback and mandated rationing have been successful (EBMUD 1992d). During the

²The water-use restrictions imposed include prohibitions on the washing of cars without shutoff nozzles, filling of decorative ponds and fountains, washing sidewalks, and landscape watering that results in excessive runoff. Regulations governing water service are outlined in Sections 28 and 29 of EBMUD's Water Service Regulations.

Table 3.6-3. Total water consumption for a normal water year (1986) and latest drought year (1991). (Source: EDAW, Inc. 1992b.)

	Total water consumption (millions of gallons)				
Month	Industrial	Commercial	Residential	Irrigation	Total
1986					
January	983	720	2636	87	4426
February	880	674	2410	87	4051
March	1041	791	2938	152	4922
April	982	815	3379	286	5462
May	1100	909	4207	495	6711
June	1082	935	4771	611	7399
July	1091	996	5117	702	7906
August	1145	1004	4814	653	7616
September	1097	925	4132	486	6640
October	1045	912	3806	377	6140
November	968	816	3286	275	5345
December	911	753	3045	170	4879
Total	12325	10250	44641	4381	71597
1991					
January	799	625	2629	106	4159
February	711	556	2239	85	3591
March	765	602	2396	89	3852
April	767	616	2545	211	4139
May	829	689	3068	402	4988
June	801	714	3284	531	5330
July	813	769	3561	594	5737
August	829	781	3545	606	5761
September	830	753	3337	519	5439
October	791	728	3120	371	5010
November	720	636	2632	216	4204
December	744	585	2495	172	3996
Total	9399	8054	34851	3902	56206

Notes: Commercial includes wholesale/retail, laundries, schools, hospital, and other institutional uses. Irrigation includes cemeteries, parks, and golf courses. Residential includes single- and multi-family households.

drought of 1976-77 demand was reduced by 39% for all classes of customers. As shown in Table 3.6-4, demand was reduced by nearly 50% by single-family residences and commercial irrigation. EBMUD estimated that the achievable reduction in 1988 would only be 35% because of the greater efficiency in water use that has been achieved since the 1976-77 drought. By 2020, achievable reductions in water use are expected to decline because of ongoing conservation actions (largely mandated by the state) and greater efficiency in water use. EBMUD states that although a 39% reduction in total demand was attained

Table 3.6-4. Maximum water rationing during drought. (Source: EBMUD 1989a.)

Customer class	Demand reduction 1977	Achievable reduction 1988	Achievable reduction 2020	15% planned reduction	Maximum planned reduction
Residential					
Single-family	49%	44%	42%	20%	32%
Multi-family	23%	23%	20%	7%	15%
Commercial/ Institutional	39%	34%	28%	10%	25%
Industrial					
Petroleum	18%	12%	0%	0%	0%
Other	29%	9%	5%	5%	5%
Commercial Irrigation	55%	47%	35%	30%	30%
Total reduction	39%	35%	31%	15%	25%

during the 1976-77 drought, it was not without substantial cost and hardship for its customers. EBMUD drought planning is therefore based on a maximum reduction in demand of 25%. The 25% reduction is from a normal water demand year (i.e., 1986).

EBMUD's current planning demand (normalized year 1990) is 220 MGD. This demand includes total metered consumption (200 MGD) plus unaccounted-for system losses (20 MGD). (As shown in Table 3.6-1, the mid-1980s was the most recent time that actual consumption approached current planned demand.) Imposing the maximum demand reduction (25%) would lower this to 165 MGD. In 2020, EBMUD projects demand to be 250 MGD after accounting for existing and adopted water conservation programs. Under conditions of normal precipitation and runoff, the amount of water available to EBMUD is more than sufficient to meet year 2020 system demands and all other entitled users (EBMUD 1992c).

Water Pricing Issues

EBMUD uses an inclining block rate structure for water consumption with allotments and maximum use limitations based on past use and customer class.³ For the single-family residential class, there is a basic

³The single-family rate structure is as follows: \$1.05 for the basic allotment of 250 GPD, \$1.30 for the next 500 GPD, \$1.97 for the next 450 GPD, and \$3.94 for water used in excess of 1200 GPD. For other customer classes, the rate structure is as follows: \$1.30 within the base allotment, \$1.97 for 0 to 10% in excess of the allotment, \$2.63 for 10 to 20% in excess of the allotment, and \$3.94 for use in excess of 20% above the allotment. Multi-family residential customers are charged \$1.18 for all water used within the allotment. EBMUD rates are from Schedule L (July 1, 1991) (1992d).

rate for the first block of 250 GPD.⁴ This block size was designed to reflect inside or essential water uses. Water consumed in excess of 250 GPD is considered a less essential use and is charged at a higher rate. Water use above 1,200 GPD is restricted to a cap of 80% of 1986 water use. An inclining block rate structure is also used for other customer classes.

About two-thirds of total EBMUD system revenues come from sales of water (EBMUD 1992d). The imposition of a drought management program with voluntary or mandated rationing reduces the amount of water sold and lowers EBMUD revenues. This presents a financial burden, as over 90% of EBMUD's water rate funded expenditures are invariant with the amount of water produced and sold (EBMUD 1992d). When under a drought management program, EBMUD must adjust water rates to maintain revenues. For example, the imposition of a 15% reduction in demand has required a 16% increase in water rates to produce the same net revenue that would have been available at the higher sales level (EBMUD 1992d). A 25% reduction in sales (mandated rationing) would require a 30% increase in rates.

The demand for water for indoor uses has generally been found to be price inelastic.⁵ Indoor water is primarily used for sanitation, drinking, and cooking. Beyond increasing the efficiency of plumbing fixtures, there is little discretionary consumption. In contrast, the demand for outdoor water (or seasonal summer use) tends to be more elastic (i.e., there is more discretionary consumption—landscape watering and car washing). Table 3.6-5 summarizes some estimated price elasticities for municipal water. These data show that summer demand is more elastic than winter demand regardless of the region and whether cross-sectional or time-series data are used. Differences in price elasticities between seasons and uses would suggest some considerable potential for exploiting seasonal water pricing to reduce demand and possibly increase revenue. Peak monthly summer demand for EBMUD water is about two times greater than the monthly average winter demand (Table 3.6-3).

Water Conservation and Demand Management

EBMUD supports California's best management practices (BMPs) for water conservation. California BMPs include interior and exterior water audits and incentive programs for single-family, multi-family, institutional, and government customers; enforcement of requirements for ultra-low flush toilets in all new construction after January 1, 1992; and plumbing retrofits and ultra-low flush toilet programs for existing construction. BMPs also include system leak detection and repair, metering for all connections, audits for facilities with large landscape areas, industrial and commercial water audits, elimination of declining block-rate structures, water landscape conservation requirements for all new non-single family developments, water conservation for new and existing single-family homes, and public and in-school education programs.

Table 3.6-6 summarizes EBMUD's expected year 2020 savings from its existing, adopted, and replacement conservation program. About 76% of total conservation savings are expected to come from interior measures, with nearly half of this from the installation of ultra-low flush toilets in new residential construction. Exterior conservation savings, which are primarily non-essential needs (landscape watering), are expected to produce only 24% of total 2020 conservation savings. Since 1987, EBMUD distributed

⁴EBMUD originally determined that 200 GPD should be set aside for households of 3 people and an additional 50 GPD be given to each additional occupant. The number of exemption requests filed to seek the additional allocation exceeded 60,000. EBMUD determined that administrative burdens would be excessive to process such requests and increased the basic residential allotment to 250 GPD.

⁵Price elasticity is a measure of the responsiveness of the quantity demanded for a good to changes in the price of the good. A good, such as indoor water, is price inelastic when a 1% change in price evokes a less than 1% change in quantity demanded.

Table 3.6-5. Price elasticities for municipal water demand. (Source: The staff.)

Location	Description	Elasticity	Source
National	cross-sectional	Winter: -0.06 Summer: East, -0.568 West, -0.427	Howe 1982
Raleigh	both	Total residential: -0.27 Sprinkling: -1.38 In-house: -0.30	Danielson 1979
National	cross-sectional	New England, -0.43; Midwest, -0.30; South, -0.38; Plains, -0.58; Southwest, -0.36; Pacific Northwest, -0.69	Foster and Beattie 1979
Raleigh	time-series	Total: -0.27, Winter: -0.305, Summer: -1.38	Danielson 1977
Tucson	time series	-0.41	Young 1973
Toronto	cross-sectional	Total: -0.93, Winter: -0.75, Summer: -1.07	Grima 1972
Illinois	cross-sectional	-0.26 to -0.82	Wong 1972
Chicago	time series	-0.018 to -0.82	Wong 1972
Massachusetts	cross-sectional	-0.05 to -0.40	Turnovsky 1969
National	cross-sectional	Total: -0.40, Winter: -0.23 Summer: East, -1.57 West, -0.70	Howe and Linweaver 1967
California	cross-sectional	-1.10	Baine, et al. 1966

over 120,000 low-flow showerhead and toilet kits. These kits produced savings of over 10 GPD for each household. Water-waster prohibitions also produced sizable savings (0.58 MGD). Total conservation is expected to save about 20 MGD by 2020. With regard to water reclamation, EBMUD has a number of projects underway or under construction that have the potential to supply 7.0 MGD by 2020 (Table 3.6-6). About 1.6 MGD of these savings are from use of reclaimed water at golf courses and for freeway landscaping. Over 75% of the savings (5.4 MGD) are expected to come from the use of reclaimed water for oil refinery cooling towers. In addition, EBMUD has had an ongoing leak detection, pipe replacement, and corrosion control program.⁶

⁶About 300 miles of pipe are surveyed each year. EBMUD repairs anywhere from 600 to 800 leaks or breaks annually. Total system losses (unaccounted-for water) are approximately 10% and are consistent with the size of losses reported by other water districts (EBMUD 1992d).

Table 3.6-6. Conservation adopted by East Bay Municipal Utility District and planned year 2020 savings. (Source: EDAW, Inc. 1992b.)

Conservation measures	Existing or adopted conservation (MGD)	Replacement and other savings (MGD)
Interior measures		
Interior audits		
Residential	0.01	--
Non-residential	3	--
Plan Review (non-residential)	1.95	--
Ultra-low flush toilets	0.85	--
New Residential	--	1.36
Existing residential	--	7.86
Low-flow showerheads	1.20	--
Low-flow faucets	--	--
Dishwashers	--	0.21
Washing machines	--	1.37
Total interior savings	4.01	10.80
Exterior measures		
Exterior measures		
Exterior audits		
Residential	0.06	--
Non-residential	0.27	--
Major irrigators	0.20	--
Rebates		
Irrigation upgrades	0.09	--
Efficiency incentives	0.18	--
Landscape standards	--	--
Water waster prohibitions		
Residential	0.58	--
Non-residential	0.11	--
Normal replacement		
Residential	--	2.92
Non-residential	--	0.54
Public information	--	--
Total exterior savings	1.49	3.46
Total interior and exterior	5.55	14.26
Water reclamation		
Golf courses	1.06	0.42
Freeway irrigation	--	0.12
Refinery cooling	--	5.40
Total reclamation	1.06	5.94

Demand Projections

EBMUD uses projections of the number of single-family households (type and location within the service area) and historic and expected (accounting for conservation and demand management) water-use patterns to forecast water use. For multi-family residential consumption, demand forecasts are based on estimates of the expected number of units and a percentage relationship between multi-family consumption and single-family residential consumption. Historically, multi-family water consumption has averaged about 60% of single-family use. For non-residential consumption, EBMUD uses the results of specific studies and percentage relationships between total residential consumption and non-residential use established over the recent past to forecast demand (EBMUD 1992d). Commercial and institutional demand has averaged about 26% of total residential use, irrigation use (parks, golf courses, and cemeteries) has been about 10% of total residential use, and non-petroleum industrial use has been about 12% of residential use. There are also some fixed demands on water that have been relatively invariant over time. Except for water used by the petroleum industry and fixed uses (miscellaneous and EBMUD), all water demands are a fixed percentage of water used by single-family households.

Unaccounted-for water losses averaged about 9.5% over the last 17 years. Unaccounted-for water losses are the difference between water delivered to the filter plants (gross demand) and the total of all metered and billed consumption. EBMUD's leak detection and repair program managed to keep these losses relatively constant over time. The magnitude of these losses is consistent with other water utilities in California. In the future, EBMUD is projecting that these losses will decline to 8% of total metered consumption. Table 3.6-7 summarizes EBMUD's general approach and assumptions that are used to forecast water demand.

As shown in Table 3.6-8, residential demand for water varies considerably within the EBMUD service territory. West of the hills that divide EBMUD's service area (Region 1), indoor uses account for most of water consumption (64 to 73%). East of the hills (Region 7), outdoor use is more dominant because of higher summer temperatures, larger homes, and the presence of larger landscape areas (EBMUD 1992d). Average water use east of the hills is as much as 2.5 times greater than average use west of the hills (comparison of Region 1 at 210 GPD with Region 7 at 518 GPD).

The data in Table 3.6-8 also show that EBMUD expects that single-family households will use more water in 2020 than in 1990 and that new single-family residences will consume more water than households already existing in 1990. For example, water consumption in existing households is projected to increase from 291 GPD to 300 GPD over all regions. The increase in household water use in existing homes presumably reflects higher incomes and the installation of more water using appliances. However, this increase in per capita household consumption is contrary to water conservation and demand management programs and to population projections. For instance, EBMUD indicates that the number of people per household actually declines over time. In 1990, there were approximately 2.75 people per household. By 2020, the number of people per household is expected to fall to 2.66.

The increase in per capita household consumption rates is projected by EBMUD to be even higher for new construction. The higher household consumption rates shown in Table 3.6-8 for new households was based on actual data for new construction in 1983 and 1984 (prior to the current drought and implementation of more aggressive conservation practices). The smaller increase in rates for 2020 between existing and new households in Regions 1, 3, and 4 is due to infilling in residential areas. The dramatically higher rates for region seven are due to new residential developments, which are projected to have much larger lots and landscaped areas.

Table 3.6-7. Assumptions used to forecast water demands. (Source: EBMUD 1992d.)

Customer class	Forecast assumptions
Residential	
Single-family	Expected number of existing and new households and consumption rates by planning region
Multi-family	Expected number of existing and new households and consumption rates based on 60% of single-family rates
Non-residential	
Commercial/Institutional	Total use is 26% of total residential use
Industrial - Petroleum	Determined by interviews before using reclaimed water
Industrial - Other	Initially 12% of total residential then 11% of residential from 2005 to 2020.
Parks, golf courses, and cemeteries	10% of total residential
Miscellaneous	Fixed assumption at 2 MGD
Gross Water	
EBMUD use	Fixed at 1 MGD
Unaccounted-for water	8% of total demand

EBMUD forecasts of future water demand are presented in Table 3.6-8. For 2020, demand is estimated to be about 277 MGD. However, savings from EBMUD's conservation and reclamation projects, which are summarized in Table 3.6-6, are expected to reduce year 2020 consumption to 250 MGD. Despite the adoption of these conservation and reclamation projects, these planning data show a substantial increase in residential water consumption over 1990 planning levels. For example, per capita water consumption (single-family residences) increases from about 106 GPD to nearly 130 GPD in 2020.⁷ Given the enactment of water conservation legislation in California, which specifically mandates conservation by requiring water-efficient plumbing fixtures and requires greater water conservation in landscaping, these planning figures may overestimate future water consumption in the residential sector

⁷For 1990, the population in single-family households was 839,119 with water use of 88.6 MGD. For 2020, the single-family population is projected to increase to 933,775 with consumption of 120.7 MGD. These data are from EBMUD, EIS/EIR, Appendix A3, December 1992.

Table 3.6-8. Forecasts of water demand and assumptions (MGD). (Source: EBMUD 1992d.)

Customer class		1980	1990	2000	2010	2020
Residential -	Single-family	75.3	88.8	111.4	116.8	120.7
	Multi-family	25.6	33.2	35.3	37.2	39.3
Commercial and institutional		26.3	31.0	38.1	40.0	41.6
Parks, golf courses, cemeteries		8.5	12.2	14.7	15.4	16.0
Industrial -	Petroleum	17.2	15.5	16.4	16.9	16.9
	Other	15.3	17.7	17.6	16.9	17.6
Miscellaneous		1.1	2.1	2.0	2.0	2.0
Total metered		169.3	200.5	235.5	245.3	254.1
Unmetered -	EBMUD	1.0	1.1	1.0	1.0	1.0
	Unaccounted-for	18.0	19.9	20.4	21.3	22.1
Total gross		188.3	221.5	257.0	267.6	277.2
% of total residential demand used to estimate non-residential demand						
Commercial and institutional		26%	26%	26%	26%	26%
Parks, golf courses, cemeteries		8%	10%	10%	10%	10%
Other industrial		15%	12%	12%	11%	11%
Unaccounted-for		9.6%	9%	8%	8%	8%
Single-family household consumption rates (GPD) used for 2020 forecasts						
		"Existing"		"New"		
	EBMUD	1990	2020	1990	2020	
	1	210	245	--	255	
	2	290	335	--	375	
	3	265	285	--	285	
	4	265	285	--	285	
	5	300	320	--	375	
	6	480	540	--	635	
	7	518	590	--	685	
	All	291	330	--	439	
Summary of 2020 forecasts with conservation and reclamation programs (MGD)						
Gross water demand					277	
EBMUD existing and adopted measures						
Conservation					5	
Reclamation					8	
Savings from others					14	
Planning level of demand					250	

Note: 1980 is actual demand and 1990 is normalized demand. Savings from others includes the installation of toilets, showerheads, other plumbing fixtures, drip irrigation, etc. as required by State Law without incentives of penalties from EBMUD.

and overstate consumption in other sectors that are based on a proportion of residential water use. If 2020 forecasts were based on normalized 1990 per capita household rates, forecasted 2020 demand would be reduced from 277 MGD to 243 MGD. Including the adoption of conservation and reclamation projects (Table 3.6-6) would reduce demand below 1990 planning levels. That is, savings from conservation and reclamation would offset projected increases due to population growth.

3.6.2 Water Quality Considerations

As with many other commodities that are bought and sold daily, water has many characteristics that help individuals determine its value. In the case of drinking water, quality is one of these defining factors. While some aspects of water quality are fixed (such as its health qualities), others are mutable and depend on, among other things, where the water comes from and how much treatment is required to ensure it is potable.

Evidence exists that higher quality upstream water in the Mokelumne is worth more than Delta water. This is shown in the trade made between EBMUD and the Contra Costa Water District (CCWD) in 1985. The transfer of water was prompted by a salinity intrusion into the Delta during the late summer/fall of 1985 and by CCWD's desire to reduce the sodium and chloride levels in their water for delivery to customers. This water trade was made so that CCWD could increase its Delta water quality with infusions of Pardee water (Gray 1990). It can be inferred from this situation that there is a difference between Pardee Reservoir and Delta water and that the Pardee Reservoir water is worth more.

EBMUD proposed treating Delta water before it is blended with water from Pardee reservoir (EBMUD 1992b). Because of the frequent salt water intrusions from the bay and various sources of non-point pollution, EBMUD's existing facilities are not adequate for treating Delta water. According to EBMUD, the blending of Delta water into their aqueduct system water caused significant water quality and treatment problems when it was done during the 1976-77 record drought. Consequently, EBMUD has proposed the construction of separate treatment facilities if the use of Delta water becomes necessary. The use of separate treatment facilities would make it possible to improve Delta water to nearly the quality of Mokelumne water. Separate and advanced treatment facilities would also increase the cost of delivered water. The cost of treating Delta water to Mokelumne standards is estimated by EBMUD to be about four times greater than treatment necessary to meet existing regulations (EBMUD 1992e).

Aesthetic Water Quality and EBMUD

EBMUD surveyed its customers about their perceptions of water quality and its possible change. The survey was undertaken by the Field Research Corporation in 1991. EBMUD customers were queried on a number of issues including their attitude about EBMUD, water quality, water shortages and conservation, and water supply and development.

In terms of water quality, 90% of the EBMUD customers are presently satisfied with the overall quality of this water. Of these customers, 65% report being very satisfied with the water they receive. These results compare with findings for the entire state of California that show just 27% are satisfied with their water supply.

For water supply issues, EBMUD customers seem to reject strongly mixing lower-quality treated Delta water with the current Mokelumne water supply. When faced with the trade-off between higher water quality or additional water supply from the Delta, 70% indicated they did not want Delta water added to their drinking water supply.

As some indication of the value people place on this trade-off, 75% of the respondents said they would prefer that EBMUD build additional storage facilities as opposed to building a treatment plant for the Delta if the price were equal. Further, when faced with a number of different scenarios for using Delta water, survey results indicated that the only acceptable case is in times of extreme shortage. Thus, the survey suggests that Delta water as a source of drinking water is an unacceptable alternative to customers. Users feel the water they are now receiving is of very high quality and, if faced with a situation where increased supply were necessary, they would rather pay for increased storage than for treated Delta water.

In addition to the qualitative aspects, EBMUD attempted to estimate water-quality-related customer costs (EBMUD 1989a). For bottled water, they estimate that households receiving water from Pardee have an average annual cost for bottled water of \$12 per year. This compares to an annual cost of \$26 per year for customers receiving their water from the Delta. When looking at water softening, the cost for Pardee recipients is \$0 and for Delta customers it is \$6 on the average per year. Related to the soft water issue is the incremental annual cost per household (compared to the current Pardee supply) for soap, detergent, and home softeners. These estimates range from approximately \$2 (American River water) to \$31 for Delta water. These estimates do not take into account the possible damage to home plumbing from increased mineral deposits, which EBMUD notes can be significant. Thus, it can be seen that by imposing a change in water quality on customers by taking diversions from the Delta may increase non-water bill costs by as much as \$50 per year.

3.6.3 Agricultural and Other Water System Demands

Agricultural water demand is by far the largest single use of water in California. Irrigated agriculture accounts for about 90% of total consumptive use in the state. Much of this water has been made available to farmers at low costs (below the marginal cost of supply) and has encouraged high consumption and production of low value crops. Low cost water and the system of appropriate water rights law has created numerous inefficiencies and now restrict the transfer of water to higher value uses. Water withdrawn from the Mokelumne River at Woodbridge Canal irrigates approximately 40,000 acres of farmland.

For the Lower Mokelumne River Basin, the amount of water that EBMUD is required to release from Camanche Dam during a dry year to irrigated agriculture is about 20% of all other upstream and downstream demands (Table 3.6-9). In 2020, the amount diverted to agriculture will not increase (Table 3.6-9). Moreover, major improvements in irrigation efficiency and/or the transfer of water rights to non-agricultural uses will not involve major quantities of water within the Lower Mokelumne River basin. Although the agricultural demands are not expected to increase in 2020, the demands (entitlements) of other water districts could possibly increase.

The data in Table 3.6-9 indicate that upstream demands could double during wet and normal water years and increase by 20 TAF during dry years. Downstream demands could possibly increase by about 10 TAF. Whether these additional demands actually materialize in 2020 is impossible to foretell at this point in time.

3.6.4 Water Marketing and Transfers

Of the various formal and informal markets for water and water rights, three types of instruments have been used by EBMUD and other agents within the Delta region. These are negotiated transactions, short-term exchanges, and organized water banks.

Table 3.6-9. Non-East Bay Municipal Utility District demands on the Lower Mokelumne. (Source: EDAW, Inc. 1992a.)

Upstream and downstream water demands	1990 (ac-ft)		2020 (ac-ft)	
	Wet and normal	Dry	Wet and normal	Dry
Upstream users				
Amador County Water Agency	10,000	10,000	18,040	18,040
Central Amador Water Project	600	600	1,960	1,960
Jackson Valley Irrigation District	3,850	0	0	0
Calaveras Public Utility District	1,482	1,482	4,910	4,910
Calaveras County Water District	498	498	6,762	6,762
Total	16,430	12,580	31,672	31,672
Downstream Users				
Woodbridge Irrigation District	60,000	39,000	60,000	39,000
North San Joaquin Water Conservation District	10,000	0	20,000	0
	20,600	16,100	20,600	16,100
Riparian and Senior Appropriators	0	0	3,600	3,600
City of Lodi	90,600	55,100	104,200	58,700
Total				
Total	107,030	67,680	135,872	90,372

In 1970, EBMUD negotiated and contracted with the Bureau of Reclamation for up to 134 MGD (150 TAF) to be delivered from the American River through the Folsom South Canal (EBMUD, 1989a). In 1972 the transaction was contested by the Friends of the American River who claimed the sale of water from that point in the river would have substantial negative impacts on instream uses. In 1990, the Superior Court confirmed EBMUD's right to take American River water subject to diversion restrictions (i.e., minimum flow requirements) that must be met before water can be transferred. Since the signing of the agreement in 1970 only once has the water of the American been diverted to the EBMUD service area. This was during the latter half of 1977 when 25 TAF were diverted for drought relief (EDAW, Inc. 1992e). This water was taken at Middle River in the Delta where EBMUD aqueducts cross the Middle River Channel. A pumping plant was constructed to supply Delta water. The plant was dismantled after the 1977 drought. Another diversion of 75 TAF had been proposed in 1988, but met with massive opposition and was denied for environmental and public health reasons. Future use of the American River will require finalization of diversion restrictions and the construction of conveyance facilities from the point of take out to Mokelumne aqueducts.

EBMUD has also been a player on both sides of shorter-term water exchanges. Between August of 1985, and April of 1986, EBMUD sold 10 TAF to the CCWD. (The sale to CCWD was split into two applications -- one for the transfers occurring in calendar year 1985 and one in calendar year 1986 each for 5 TAF.) The exchange was to improve CCWD's water quality. Seawater incursions into the Delta where CCWD draws its water had degraded the water supply. EBMUD sold higher quality water from the Mokelumne to be mixed with CCWD's Delta source.

In another such short-term trade, EBMUD purchased the right to divert 60 TAF from the Yuba County Water Agency in 1989. Expecting drought conditions in 1989, EBMUD contracted with the Yuba County Water Agency to pay \$45 per ac-ft of delivered water plus a fixed fee. Because of heavy rain and snowfall during March of that year the shortage problem was alleviated, and EBMUD decided not to exercise its option. Thus, while no actual water transfer was made, a contract was in place for EBMUD to receive short-term supplies from another water district.

EBMUD has also attempted to enter into dry year option arrangements with irrigators, specifically WID. In 1988, EBMUD offered WID a dry year option based on a payment for water of \$50 per ac-ft (NRC 1992). However, an agreement was not reached because WID felt that the offered price was too low. In another negotiation, EBMUD attempted to trade lower quality Delta water in exchange for an equivalent amount of water from the Mokelumne. Both of these exchanges if completed would have resulted in further reductions in water flows below Camanche.

More formal arrangements for exchanges of water have also developed (e.g., Wahl and Osterhoudt 1986). In 1991, California established a water bank in response to the most recent prolonged drought. The arrangement offered was for the state to buy surplus water from voluntary sellers and distribute it at cost to urban, agricultural, and fish flow uses or as carryover storage (NRC 1992). While this bank has been very important in moving water to where it is most needed, EBMUD has had little or no participation. Because water made available to municipalities has been fully subscribed, EBMUD's future participation would no doubt impact other water agencies.

3.7 HYDROPOWER PRODUCTION

EBMUD generates power from the operation of the turbines at Pardee and Camanche Reservoirs. The primary function of Pardee is to provide storage for the diversion of water to the EBMUD service area and to meet downstream obligations when storage in Camanche reservoir is inadequate. The operating objectives for Camanche are to meet downstream release obligations and to provide for flood control. Power generation at both facilities is a secondary objective and does not determine the amount of water released.

Total installed capacity is 28.65 MW at Pardee and 10.68 MW at Camanche. Average annual generation is approximately 110 GWh at Pardee and 40 GWh at Camanche. All power generated minus the on-site EBMUD uses (e.g., pumps) is sold to PG&E. EBMUD and PG&E entered into an agreement in 1981 that outlines major party responsibilities—operation and maintenance of transmission facilities, on-site power uses, and determination of the quantity of water available for power production. The agreement also spells out payments for power. PG&E purchase prices for power are based on fuel costs and the efficiency of thermal units that will have output reduced because of purchases of power. Table 3.7-1 summarizes power generation at Pardee and Camanche from 1984 through May 1992. Generation is highly variable among years. Generation over the last eight years has been less than half the historical average.

Table 3.7-1. East Bay Municipal Utility District annual power generation summary. (Source: EBMUD 1992d).

Fiscal year	Total net delivered energy (kWh)		Total revenue	\$/kWh
	Pardee	Camanche		
1984	186,648,372	64,294,600	8,864,895	0.0353
1985	72,862,220	36,479,300	4,779,708	0.0437
1986	133,965,299	41,260,400	5,990,182	0.0342
1987	33,408,829	31,624,400	1,306,687	0.0201
1988	4,774,460	4,472,100	197,532	0.0214
1989	62,577,090	1,566,600	1,338,927	0.0209
1990	46,882,240	2,442,700	1,228,335	0.0249
1991	20,412,080	1,790,600	524,746	0.0236
1992 ^a	37,916,083	3,231,600	955,832	0.0232

^a Year 1992 only includes July 1991 through May 1992.

4. ENVIRONMENTAL AND ECONOMIC IMPACTS

The environmental and economic impacts of proposed modifications to the current facilities and operations of the LMRP are presented in this section. The impact discussions focus primarily on effects to water quality and quantity, to downstream fishery resources, and to the water supply system of EBMUD, because these are the resources to which significant impacts are predicted under one or more of the alternatives. The alternatives considered are those specified in Section 2: the flow and non-flow actions recommended by the CDFG, EBMUD, staff, and FWS. The impact analyses presented here are organized by the type of mitigation, with alternative ways of implementing each mitigation discussed under each type. The primary flow-related mitigation considered includes: minimum flow requirements at Camanche Dam (Section 4.1); minimum pool elevations for Camanche Reservoir (Section 4.2); and other operational constraints (Section 4.3), such as ramping rates and elevated short-term releases (pulse flows) from Camanche Dam to attract salmon upstream in the fall and to stimulate out-migration in the spring. The primary non-flow-related mitigation considered include upstream fish passage facilities (Section 4.4) and fish screens to protect downstream migrants (Section 4.5). Other non-flow alternatives are discussed in Section 4.6.

In cases where staff used quantitative assessment approaches to evaluate alternative mitigation approaches, such as computerized simulations or modeling, a separate discussion on assessment methods is presented at the beginning of each section. Descriptions of these methods, especially modeling, is supplemented by appendices to the FEIS. Where quantitative assessment was not possible due to data limitations, qualitative evaluations and comparisons are presented.

4.1 MINIMUM FLOW REQUIREMENTS

The most commonly suggested way of improving conditions for salmon and trout in the Lower Mokelumne River is to implement new (increased) minimum flow requirements at Camanche Dam. New requirements for releases to the lower river could potentially affect the existing water users, so our assessment attempted to quantify the trade-offs between gains to fishery resources and losses to the EBMUD water supply system and other users.

4.1.1 Assessment Methods

A series of modeling techniques were used to evaluate the impacts associated with alternative minimum flow regimes at Camanche Dam. A water balance model was applied over a 25-year simulation period to estimate the release pattern that would satisfy each new minimum flow requirement for fish and all downstream water rights. The results of the water balance model were then used as the basis for habitat frequency analysis for fish, for estimating costs to EBMUD's water supply system, and for estimating hydropower production.

Water Availability

The effects of alternative reservoir operations on water availability were evaluated using a hydrologic water budget model. The model tracks inflows, outflows, diversions, rainfall, and evaporation, and includes a watershed runoff and groundwater seepage term required to preserve the integrity of the mass balance equation for the Pardee, Camanche, and the terminal reservoir system (see Appendix B). Existing operational constraints for flood control and downstream water rights were maintained, but withdrawals from Pardee Reservoir to the EBMUD water supply system and to Camanche Reservoir were allowed to vary.

The model operates on a daily time step, and allocates storage in each of the reservoirs after satisfying the required minimum releases from Camanche. Storage allocation is primarily driven by operating constraints built into the model. The water budget model, the operating constraints developed for it, and the results of the model simulations are described in more detail in Appendix B.

Fish Habitat

Two approaches were used to quantify habitat conditions in Lower Mokelumne River: 1) a standard analysis of the physical habitat area available to the various life stages of chinook salmon and steelhead trout using the Instream Flow Incremental Methodology (IFIM) and its Physical Habitat Simulation (PHABSIM) model (Bovee 1982); and 2) an examination of the effects of water temperatures on overall habitat suitability. Data for the physical habitat analysis came from an instream flow study conducted for CDFG by EnviroSphere Company in 1986 and 1987 (CDFG 1988, 1991). Thermal considerations were incorporated into this study by staff by combining output from a stream temperature model (SNTMP) with the PHABSIM analysis. This analysis produced measures of stream area that met both thermal criteria and physical habitat requirements and measures of stream longitudinal distance which met thermal criteria alone when other physical requirements were of less importance (see Appendix F for further details). The results of physical habitat modeling is emphasized in this Section on Minimum Flows because that is the primary purpose of this type of mitigation. The overall habitat conditions, including temperature effects is emphasized in the following Section (Section 4.2), because the full benefits of temperature controls are not realized without minimum pool requirements.

Under reservoir operations constrained by alternative minimum flow regimes, the amount of physical habitat available for chinook salmon and steelhead trout in two river segments, the tailwater of Camanche Dam (where chinook salmon occur from spawning through rearing of juveniles) and the Bruella segment (potentially used for rearing by both species), was calculated over a standard 25-year period of historical hydrology for alternative flows. Habitat was judged suitable for spawning, fry rearing, and juvenile rearing according to standard FWS habitat suitability curves that summarize fish preferences for water depth, velocity, and substrate. More technical details of the habitat analyses are presented in Appendix F.

Using the output from the water balance model as a prediction of reservoir releases, we calculated areas of habitat for a large number of different flow regimes, including the specific recommendations of CDFG, EBMUD, and FWS, and intermediate conditions. Flow regimes with and without pumping on the Mokelumne aqueducts, with and without minimum pool elevations, and with different future demand scenarios were examined. Not all of these simulations are presented in this FEIS, and many showed little or no significant differences. Therefore, those presented in detail and discussed here include the following: 1) CDFG's minimum flow regime at Camanche Reservoir without minimum pool elevations (Section 4.1.2); 2) EBMUD's minimum flow regime without minimum pool elevations (Section 4.1.3); 3) staff's minimum flow regime, without (Section 4.1.4) and with (Section 4.2.4) minimum pool elevations; 4) FWS's minimum flow regime (Section 4.1.5); and 4) the no action alternative (Section 4.1.6). The simulation results presented in the FEIS include pumping on the Mokelumne aqueducts and are based on normalized 1990 water demands. This scenario is the most representative of present conditions on the river and near-term impacts to fish resources.

To calculate the areas of habitat available, Camanche releases as estimated by staff's water balance model were converted to habitat values for each relevant month. We illustrate the patterns of available habitats by tabulating the habitat areas for the 25 years as a cumulative frequency distribution, from which we show the minimum, maximum, and median areas and the areas of 10, 25, 75, and 90% occurrence (Tables 4.1-1 and 4.1-2). The habitat areas available under each alternative are most useful in comparison to the other alternatives, as in the comparative discussions in the following sections.

Table 4.1-1. Predicted physical habitat values for chinook salmon under alternative minimum flow regimes (all units are in total acres). (Source: The staff.)

CHINOOK SALMON							
Alternative	Maximum	90th percentile	75th percentile	Median percentile	25th percentile	10th percentile	Minimum
Spawning habitat below Camanche (total usable area)							
CDFG	7.1	7.1	7.1	7.1	7.0	4.5	3.5
EBMUD	7.2	7.1	6.9	6.4	5.4	3.9	3.5
Staff (const pool)	7.2	7.2	7.1	7.0	6.4	3.9	3.5
Staff (var pool)	7.2	7.2	7.1	7.0	6.4	3.9	3.5
FWS	7.2	7.1	7.1	7.0	7.0	3.9	1.7
No action	7.2	7.0	6.2	4.7	3.7	2.7	0.0
Fry habitat below Camanche (total usable acres)							
CDFG	28.7	21.0	15.5	15.3	9.9	8.3	6.1
EBMUD	38.9	31.6	31.6	21.4	8.8	8.0	5.9
Staff (const pool)	36.9	31.6	25.2	18.5	9.0	8.1	6.1
Staff (var pool)	36.9	31.6	25.2	18.2	9.0	8.1	6.1
FWS	28.7	21.0	15.5	15.3	9.8	8.2	6.1
No action	38.6	35.5	27.0	15.3	8.8	7.6	0.4
Juvenile habitat below Camanche (total usable acres)							
CDFG	17.0	14.6	9.3	8.5	6.0	5.2	3.7
EBMUD	19.0	17.0	10.3	7.2	6.0	5.2	3.7
Staff (const pool)	19.0	17.5	17.0	7.6	6.0	5.2	3.7
Staff (var pool)	19.0	17.5	17.0	7.6	6.0	5.2	3.7
FWS	16.6	15.2	10.9	7.6	6.0	5.2	3.7
No action	19.6	18.2	16.6	6.9	6.0	5.2	3.7

Effects of new flow alternatives on habitat for reservoir fish resources were examined by calculating end-of-the-month pool elevations and comparing these to current reservoir operational conditions. We assumed that the available habitat for fish in Pardee and Camanche reservoirs was proportional to reservoir storage volume and that reservoir fish populations are adapted to historical water level fluctuations in these reservoirs.

Table 4.1-2. Predicted physical habitat values for steelhead trout under alternative minimum flow regimes (all units are in total acres). (Source: The staff.)

STEELHEAD TROUT							
Alternative	Maximum	90th percentile	75th percentile	Median	25th percentile	10th percentile	Minimum
Spawning habitat below Camanche (total usable area)							
CDFG	4.4	4.1	3.9	3.8	1.9	1.7	1.3
EBMUD	4.4	3.9	3.7	3.5	1.8	1.6	1.3
Staff (const pool)	4.2	4.0	3.8	3.1	1.9	1.6	1.3
Staff (var pool)	4.2	4.0	3.8	3.1	1.9	1.6	1.3
FWS	4.3	3.8	3.8	3.8	1.9	1.7	1.3
No action	4.3	3.9	3.3	2.0	1.8	1.3	0.0
Fry habitat below Camanche (total usable acres)							
CDFG	10.3	6.5	5.4	4.2	1.4	0.5	0.3
EBMUD	10.8	8.4	6.8	6.0	1.0	0.5	0.3
Staff (const pool)	10.2	7.5	6.8	5.1	1.4	0.5	0.3
Staff (var pool)	10.2	7.5	6.8	5.1	1.4	0.5	0.3
FWS	7.6	6.5	5.8	4.9	2.1	0.5	0.3
No action	10.7	9.9	7.0	5.9	0.6	0.5	0.1
Juvenile habitat below Camanche (total usable acres)							
CDFG	27.5	22.3	18.0	15.0	6.3	3.6	2.2
EBMUD	28.0	25.6	23.4	20.4	5.3	3.5	2.2
Staff (const pool)	27.4	24.7	23.4	17.2	6.4	3.5	2.2
Staff (var pool)	27.4	24.7	23.4	17.2	6.4	3.5	2.2
FWS	24.8	22.3	19.9	16.7	8.8	3.5	2.2
No action	27.9	26.9	23.9	19.9	4.0	3.4	0.3

Water Supply Deficiencies

Because of the importance of effects of minimum flows on water supplies to EBMUD, a general analysis of water supply deficiencies is provided here. Additional results are provided under the assessment of specific alternatives in Sections 4.1.2 through 4.1.6 and in Section 4.2.

The impacts of alternative minimum fish flow requirements to EBMUD's water supply were estimated using the water balance model described in Appendix B. (More details of the assumptions used to

estimate water needs can be found in Appendix D.) The need for additional water that is presented in the FEIS was based on EBMUD's three year drought planning sequence. The three year drought sequence includes actual runoff for the drought of record (1976-77) plus an additional third critically dry year. Runoff in this hypothetical third year was assumed to be an average of the previous two years of runoff. The water balance model also included EBMUD's standard water deficiency rule and assumptions about future Mokelumne use by other upstream and downstream water agencies and irrigation districts. The deficiency rule requires that reductions in demand be made when total system storage falls below 500 TAF. Specifically, the deficiency rule (or drought management program) as incorporated in the water balance model triggers a 0-15% reduction in demand when system storage falls between 500 and 450 TAF, a 15-25% reduction when storage falls between 450 and 300 TAF, and a full 25% reduction when total system storage is below 300 TAF. With regard to non-EBMUD users of the Mokelumne, it was assumed that these demands as inputs to the water balance model would be based on current use and not on speculations about future use. Finally, the maximum need for additional water was assumed to occur at the end of EBMUD's planning horizon (year 2020) when demands are projected to be greatest.

Estimated needs for additional water are summarized in Table 4.1-5. These water deficiencies are shown for three levels of demand: the 1990 normalized demand of 220 MGD (246 TAF), the 2020 normalized demand of 250 MGD (280 TAF), and the 2020 reduced demand of 229 MGD (256 TAF). The normalized demand in the year 2020 is what EBMUD is projecting less savings due to existing and planned conservation and reclamation projects (Table 3.6-8).

The 2020 reduced demand scenario is the result of implementation of EBMUD's Conservation Level II project and Reclamation A1 project (see Appendix E). In total, these projects are expected to reduce EBMUD's planning demand by about 21 MGD.

The water deficiencies shown in Table 4.1-5 are the differences between available supplies (total system storage less dead or inaccessible storage) and EBMUD customer demands after imposition of the drought management program when system storage falls below 500 TAF. The water deficiencies occur primarily during the third drought sequence year. The results show that the no action and the EBMUD fish flow release alternatives do not require any need for additional water under any of the demand scenarios. These results are in contrast to EBMUD's estimates that show a need for about 90 TAF in the third drought year based on a 2020 reduced demand scenario. The difference is due primarily to the modeling of carriage flows and assumptions about future water use by upstream and downstream water agencies and irrigators. Staff has based its estimate on current water use entitlements. To be sure, total net system storage is reduced to near zero levels under 2020 demand levels for the EBMUD alternative. Increasing demands beyond current use levels for upstream and downstream water agencies could result in the need for additional water especially for the 2020 normalized demand scenario.

The staff alternative was run with and without a minimum pool requirement at Camanche Reservoir. The Camanche pool requirement increases the need for additional water under all 2020 demand scenarios. For the reduced demand scenario, there is a need for an additional 57 TAF at the end of third drought sequence year. Eliminating the pool requirement would lower the water deficit to just 10 TAF. As noted in Section 3.6.1 (demand projections), basing year 2020 demands on current per capita household consumption rates would reduce projected demands to below 1990 normalized levels (216 MGD). That is, the adoption of EBMUD's existing conservation and reclamation projects would more than offset increased water use due to projected population increases. The 1990 normalized demand scenario in Table 4.1-5 would thus be a good approximation of this alternative demand scenario. Demands based on 1990 use patterns would lower the estimated water deficiencies for the staff alternative to 36 TAF at the end of the third drought sequence year. There would essentially be no deficit (1 TAF) if the requirement for a minimum Camanche pool was eliminated.

The higher fish flow requirements for the CDFG and FWS alternatives translate into greater needs for additional water. Under the reduced year 2020 demand scenario, there is a need for 145 TAF and 182 TAF for the CDFG and FWS alternatives, respectively. There would be even higher water deficits under 2020 normalized demands. For 1990 demand conditions (or demands based on current per capita household rates), the need for water is reduced by about 20 TAF for both the CDFG and FWS alternative.

The water deficits shown in Table 4.1-3 are total needs at the end of the third drought sequence year. The imposition of additional demand side measures and/or the development of new sources of supply will serve to reduce the need for additional water used for higher fish flow requirements. The need for additional water could also be reduced by changing early deficiency rules. For example, a full 25% reduction in demand could be imposed when total system storage falls below 400 TAF instead of 300 TAF. (Sensitivity analyses were not performed on EBMUD's standard deficiency rule.) Given these caveats about deficiency rules it was assumed that annual water needs could be approximated by apportioning the total need for additional water (i.e., the deficit at the end of the third drought sequence year - Table 4.1-1) equally over the three-year interval.

Thus, eliminating the water deficits for the staff alternative (with a minimum pool) at the end of the third drought year will require about 19 TAF annually based on the 2020 reduced demand scenario. About 12 TAF would be required to reduce the deficits under 1990 conditions (i.e., 2020 demands based on 1990 use rates). Annual needs for additional water to eliminate the water deficits are about 48 TAF for the CDFG alternative and 61 TAF for the FWS alternative under the 2020 reduced demand scenario. Annual water needs are about 7 TAF less for demands based on 1990 conditions. Finally, the need for additional water is based on a three-year drought sequence that includes a hypothetical third year. Removing the hypothetical third year would eliminate the need for additional water for the staff alternative and greatly reduce the water deficits for the CDFG and FWS alternatives.

Table 4.1-3. Need for additional water under alternative fish flow release proposals.
(Staff's alternative is presented with and without the minimum pool elevation constraint). (Source: The staff.)

Fish flow alternative	Need for additional water (TAF)		
	1990 normalized demand	2020 normalized demand	2020 reduced demand
No action	0	0	0
EBMUD	0	0	0
Staff			
no minimum pool	1	27	10
minimum pool	36	107	57
CDFG	123	197	145
FWS	160	235	182

The 2020 reduced demand scenario is based on EBMUD's implementation of additional conservation and reclamation projects. These projects are part of EBMUD's alternative composite programs to deal with projected future needs for additional water. (These projects are discussed in more detail in Appendix E.) The conservation project (Level II) has an estimated levelized annual cost of \$3.9 million and would reduce demand by about 14 MGD (Table 4.1-4). The reclamation project would cost about \$8.7 million annually and reduce demand by another 8 MGD. The total levelized annual cost of these two projects, which makes possible the reduced demand scenario, is \$12.6 million. The costs of more ambitious conservation and reclamation projects under consideration by EBMUD as part of their updated WSMP are also shown in Table 4.1-4. These projects have much higher costs.

Numerous water supply and storage projects are also under consideration by EBMUD in their updated WSMP. They have conducted preliminary screening analyses and have reduced the number of alternatives to four. These are groundwater development, the construction of the South Folsom Canal, the raising of Pardee dam, and the use of the Delta. (More discussion of these supply and storage options can be found in Appendix E.) The groundwater supply options involve indirect and direct water use. The indirect use options include agricultural exchange and river substitution. The direct use option would involve pumping groundwater directly into the Mokelumne aqueducts. The extension of the South Folsom Canal would be constructed to get access to their American River entitlement. The raising of Pardee dam would substantially increase EBMUD's system storage capability. EBMUD has also investigated the use of the Delta. They have estimated costs for a direct filtration plant designed to meet existing water quality standards and an advanced treatment plant that could produce water that would meet all current and foreseeable water quality standards.

EBMUD's estimated costs for these supply and storage projects have been made without detailed engineering studies. As such, their cost estimates are preliminary. (EBMUD gives them confidence bounds of -30 to +50%.) The cost estimates for the Delta treatment facility have been criticized for being seriously overestimated (State Board 1992). For example, a comparison of EBMUD's unit water costs for a Delta plant are about ten times higher than for a similar plant (Los Angeles Aqueduct Plant) built during the late 1980s and now in operation. Total annual levelized costs for each of the proposed water supply and storage projects are shown in Table 4.1-5. The least cost supply alternative is groundwater

Table 4.1-4. Levelized annual costs of East Bay Municipal Utility District's conservation and reclamation projects. (Source: The staff.)

Demand reduction project	Levelized annual cost (\$10 ⁶ /yr) ^a	Yield (TAF/yr)	Unit water costs (\$/ac-ft)
Conservation II	3.9	14.8	264
Conservation IV	16.5	39.2	421
Reclamation A1	8.7	7.8	1112
Reclamation A2	28.6	20.3	1406
Reclamation A3	14.0	9.0	1553

^aSource: EDAW, Inc. 1992f.

Table 4.1-5. Levelized annual costs of East Bay Municipal Utility District's water supply and storage projects. (Source: The staff.)

Supply project	Levelized annual cost (\$10 ⁶ /yr) ^a	Yield (TAF/yr)	Unit water costs (\$/ac-ft)
Groundwater AB	6.8	50.6	134
Groundwater ABC	12.2	71.3	172
Folsom Canal	21.9	162.9	135
Raise Pardee	18.2	150.0	121
Delta	33.7	67.3	500

^aSource: EDAW, Inc. 1992f. Capital costs are amortized over a 25 year period at 8%.

based on levelized annual cost. On a per unit water basis, the least cost option using EBMUD's factor costs is the raising of Pardee. The Delta treatment alternative is considerably more expensive than other options, according to EBMUD cost estimates.

The actual costs incurred by EBMUD for any of the supply alternatives would be dependent on a number of operating assumptions. Among these assumptions are how often the project would be operated (average annual water yield) and how the project would interface with existing operations at Pardee and Camanche dams and at the terminal reservoirs. If the project is to be used only intermittently, then projects with high capital costs will be more expensive to operate relative to projects that have low capital costs. Figure 4.1-1 displays levelized costs for each of the supply alternatives as a function of average annual water yield. (The terminal point on each line is the levelized annual cost in Table 4.1-5.) Figure 4.1-1 shows that projects like the raising of Pardee are relatively insensitive to annual water use because there are essentially no variable costs of operation. The Delta in contrast has high variable costs of operation.

Shown in Figure 4.1-1 are two lines for the Delta treatment alternative. The Delta high plant line corresponds to the Delta facility in Table 4.1-5 (or the A1 facility in Appendix Table E-3). Levelized annual costs would be approximately \$34 million if operated at full capacity. If the plant was not operated an annual cost of \$8.5 million would be incurred -- the cost of the amortized capital. The cost curve referred to as the Delta low plant in Figure 4.1-1 is one-half of the levelized annual cost. This line might correspond to the case where detailed engineering data showed that EBMUD could construct and operate this plant at substantially lower costs. As discussed in Appendix E, EBMUD's cost estimates are made without the benefit of detailed engineering data and could be overestimated by at least this amount. It is noted again that other users of the Delta treat water safely and do it at substantially lower costs than what EBMUD is projecting. With a 50% cost reduction, a Delta facility would compare favorably with the costs of the two groundwater alternatives depending on how the facility would be operated. The low cost Delta plant would also dominate the South Folsom Canal extension and raising Pardee at annual water yields of less than about 70 TAF.

EBMUD has other potential ways to alleviate short term water deficiencies. One such option is the purchase of water from other agencies or from the State Emergency Drought Water Bank. For example, in 1989 EBMUD entered into an agreement with the Yuba County Water Agency for the transfer of 60 TAF at a cost of \$45/ac-ft. Because of heavy rains and snowfall, EBMUD did not exercise this option to transfer water. If exercised the water would have been made available at the Delta (Bixler pumping station). EBMUD has also attempted to buy water from the WID under a dry year option agreement.

Figure 4.1-1. Levelized annual costs of alternative water supply and storage projects. (Source: The staff.)

Under this type of agreement irrigators would continue to use their water during normal years and give the option holder (EBMUD) a way to firm-up their supplies during dry years. In 1988, EBMUD offered WID a dry year option based on a payment for water of \$50 per ac-ft (NRC 1992). However, an agreement was not reached because WID felt that the offered price was too low. Successful dry year option agreements have been made based on a fixed payment for the option plus payments for the profits from the foregone crops. Figure 4.1-1 shows the cost of water transfers at \$100 and \$200/ac-ft. These agreement price lines show that there is considerable opportunity for EBMUD to undercut the cost of developing new supplies to meet short-term water deficiencies.

Another option for EBMUD is to pump Delta water directly into their supply system. EBMUD used Delta water during the 1976-77 drought when small quantities were blended and then treated at their existing facilities. The amount of Delta water treated rose to about 10% on average at the Orinda treatment plant (EBMUD 1989a). THMs in the treated water more than doubled, but remained below the existing standard. According to EBMUD, it took nearly five years for THM levels to return to original levels prior to the Delta blend. EBMUD has also investigated the possibility of upgrading their current treatment facilities to accept Delta water. EBMUD investigated numerous alternatives one of which was to blend Delta water (Indian Slough and Bixler Pumping Station) with Pardee water in a one-to-four mix (EBMUD 1991b). They concluded that their existing plants would require the addition of pre- and post-chloramination. They estimated an annual cost of \$1.2 million (Figure 4.1-1). To be sure, their studies also indicated that concentrations of certain criteria pollutants would increase, but they still would be below all currently applicable standards.

In sum, the least cost supply option based on EBMUD data appears to be the development of their indirect groundwater options. However, if it is true that EBMUD has overestimated the cost of building a Delta treatment facility, then use of the Delta could be a least cost supply option. Clearly, there is a need for a more detailed engineering cost study on the question. For that matter, additional studies should be made regarding the upgrading of existing treatment plants. Although it is true that certain criteria pollutants could rise if Delta water entered the distribution system before treatment, it is possible for EBMUD to examine how to use a Delta water source conjunctively with their Pardee source. Many of the water quality problems experienced at the Delta could be minimized through proper conjunctive use management. EBMUD may also have the option of securing water through transfers. Especially appealing are dry year options. Greater incentives could make the use of these options more appealing to irrigation districts. Relative to the cost of developing additional supplies, water transfers coupled with more aggressive demand side measures appear to be a low cost alternative to meeting drought deficits. Finally, the water deficits estimated for the staff alternative could be eliminated without resorting to the development of new supplies. For example, basing EBMUD's 2020 demand forecast on 1990 per capita household rates would lower demand below 1990 levels. The 36 TAF deficit (Table 4.1-5) that exists at the end of the three-year drought sequence could easily be eliminated with EBMUD's additional conservation and reclamation projects (Conservation II and Reclamation A1) and would not require new supplies or additional storage.

Hydropower Production

The objective of modeling hydropower production for Pardee and Camanche reservoirs was to determine potential annual revenues and compare the results from various minimum flow and storage requirements. Potential revenue is that produced if the entire volume of water released from the reservoirs were of sufficient water quality that it could be released through the existing turbines, up to the turbines' flow capacity. Water that does not have sufficient DO currently must be diverted through aeration devices and is thus unavailable for power production.

Hydropower generation was modelled as a function of available data on generating release, net head, and turbine efficiency. For Pardee, the EBMUD Water Operations Department, Water Supply Section, provided a graph of generating capacity per turbine as a function of generating release. For Camanche, generation per turbine as a function of generating release, net head, and turbine efficiency was derived from the manufacturer's turbine performance curves. The results are:

Pardee Units 1 & 2: $P = 0.8 + 0.02*(Q - 50)$, when $50 \leq Q \leq 150$
 $P = 2.8 + 0.024*(Q - 150)$, when $150 < Q \leq 200$
 $P = 4 + 0.025*(Q - 200)$, when $200 < Q \leq 375$

Pardee Unit 3: $P = 1.1 + 0.03*(Q - 70)$, when $70 \leq Q \leq 400$

Camanche: $P = 0.000085 * eQH$, or,
 assuming a constant efficiency of 88.7% (the median efficiency over the normal range of flows and heads),
 $P = 0.0000754 * QH$.

where P = power generation (MW per turbine),
 k = a constant,
 e = turbine efficiency,
 Q = flow released through turbine(s) (cfs), and
 H = net head (ft).

Monthly average outflows for both Pardee and Camanche were then taken from the results of system simulations, for the 25-year period from 1966 to 1990. The equations previously listed were then applied to determine average monthly hydropower production, in megawatts (MW). These were then multiplied by the number of hours in the month to determine the amount of hydropower produced, assuming production at the average rate. The result was in units of megawatt-hours (MWh).

For each month, the monthly revenue was determined by multiplying the power production by the unit price (\$0.0353 per kWh). A representative unit price was selected from the EBMUD Power Generation Summary (Attachment N), for fiscal years 1984–1992. The actual value of this unit price is not critical, as it scales the revenues generated by each alternative equally. However, it does determine the overall financial magnitude.

Finally, the monthly totals for each year were summed to provide potential annual revenues for the simulated years 1966–1990. The median, 10th percentile, and 90th percentile revenues were calculated for each alternative, and plotted for comparison.

4.1.2 CDFG Alternative for Minimum Flows

The minimum flows recommended by CDFG are described in Section 2.2.1 (Table 2.2-1) and shown in Figure 4.1-2. Streamflows between 20 and 300 cfs are to be maintained below Woodbridge Dam in dry years when the average annual flow entering Pardee Reservoir is less than 500 cfs. In normal and wet water years, higher releases would be required from Camanche Dam in the range of 100–450 cfs. The total annual allocation of water to fish flows under this alternative, above flow required to meet downstream water rights, is 98 TAF in dry years, 207 TAF in normal years, and 262 TAF in wet years. The CDFG alternative also included a minimum pool elevation of 210 ft MSL and a minimum release of 250 cfs for Pardee Reservoir, but these parts of the CDFG alternative are not presented in this section.

Water Availability

The new minimum flows recommended by CDFG are significantly higher than the 5 to 13 TAF that are required under present agreements (see Section 4.1.6 for the no action alternative), and satisfying these new releases would involve a major change in reservoir operations. Figure 4.1-3 shows staff's prediction of what reservoir operation would have been over the past 25 years under the CDFG alternative and current EBMUD demand (i.e., normalized 1990 demand), not including the minimum flows at Pardee or the minimum pool elevation at Camanche. Had the effects of Pardee minimum releases and Camanche minimum pool been included, minimum releases from Camanche would have been even higher, especially in the summer months when historical releases frequently dropped to approximately 100 cfs (dotted line in Figure 4.1-3A). Pardee Reservoir would have suffered frequent and severe drawdowns, being emptied in the drought of 1976–1977 and again during the most recent drought period (dotted line in Figure 4.1-3B). Camanche Reservoir would have been drained even more frequently (solid line in Figure 4.1-3B). EBMUD's terminal reservoirs would not have dropped below 100 TAF except at the end of the 1976–77 drought. Even without the adverse effects of minimum Pardee releases and Camanche minimum pool, impacts of this magnitude to the LMRP system would essentially eliminate the Lower Mokelumne River as a reliable source of water for EBMUD at the normalized 1990 demand level.

Fish Habitat

The frequency of available habitat produced by CDFG's minimum flow regime is shown in Tables 4.1-1 and 4.1-2. The CDFG recommendations generally provide greater spawning habitat but less fry and juvenile rearing habitat than currently occurs. The divergence is large among habitat areas available for

Figure 4.1-2. Minimum flow regimes from Camanche Dam under the California Department of Fish and Game alternative (the heavily shaded bars represent releases for fish resources and the lightly shaded bars represent other releases required to satisfy downstream water rights and conveyance losses). (Source: The staff.)

A. Camanche Outflow

B. Storage Volume

Figure 4.1-3. Predicted releases from Camanche Reservoir (A) and reservoir storage volumes (B) under the minimum flow regime of the California Department of Fish and Game alternative and normalized 1990 water demands (no minimum pool requirement). (Source: The staff.)

the several life stages under the CDFG alternative, and staff does not believe the overall habitat value for fish populations will be benefitted.

Chinook Salmon Spawning. Spawning habitat for both chinook salmon and steelhead trout is limited to the tailwater segment of the lower river, extending from Camanche Dam downstream 4.5 miles to Mackville Road (Section 3.3). There were wide differences among alternatives in median areas suitable for chinook salmon spawning and in the areas with 25% and 75% frequencies, although minimum and maximum areas differed little among alternatives. The CDFG alternative provided a 25-year median of 7.07 acres whereas the EBMUD alternative would provide only 5.47 acres. Staff's recommended flow conditions would provide essentially the same spawning area (7.08 acres) as the CDFG alternative while using much less water. Under current no-action conditions, the median acreage is the least, with 4.57 acres.

There is essentially no spawning habitat available under any alternatives in the Bruella segment of the river.

Chinook Salmon Fry Rearing. In the tailwater segment, there were also wide differences in fry habitats, reflecting the need by fry for shallow water. There were particularly wide differences among alternatives in the maximum habitat areas available over the 25 years, with the CDFG alternative providing 9.21 acres, the EBMUD proposal (lower flows) and the no-action alternative ranking highest (15.03 and 16.00 acres, respectively) and the staff alternative also 9.21. Median acreage for the 25-year period showed similar but less extreme differences, with the CDFG and no-action alternatives similarly low.

At the Bruella segment, the CDFG proposal (7.64 acres) and the current no-action alternative (7.19 acres) were low. Median acreage suitable for chinook salmon fry rearing was greatest under the EBMUD (9.28 acres) and staff (8.50 acres) proposals. However, the maximum acreage and those cumulative to 75% and 90% were much greater for the EBMUD and no-action alternatives, both of which have low flows (shallow water) needed by chinook salmon fry.

Chinook Salmon Juvenile Rearing. In the tailwater segment, juvenile rearing habitats showed few differences among alternatives. EBMUD's alternative and the no-action alternative showed higher areas at the 75% occurrence frequency than did the CDFG and staff alternatives. At the Bruella segment, there were only very small differences in estimated acreage among alternatives for rearing of chinook salmon juveniles.

Steelhead Fry Rearing. In the tailwater segment, the CDFG alternative provided considerably less median habitat area for steelhead fry rearing (3.46 acres) than did either the no-action alternative (highest at 5.66 acres) or the EBMUD alternative (5.54 acres). Staff's recommendation is intermediate (4.50 acres). Over the range of both existing and proposed flows, it seems very difficult for steelhead fry to find suitable habitat.

At the Bruella segment, suitable habitat for rearing steelhead fry is nearly nonexistent under all flow alternatives. CDFG's alternative (0.21 acre) was at a tiny disadvantage compared with the current no-action and EBMUD alternatives (median acreage of 0.34 and 0.33) and the staff's (0.25). These results may explain why there is no natural population of steelhead developing in the river despite years of stocking. The matter bears further study.

Steelhead Juvenile Rearing. The situation overall is better for rearing of steelhead juveniles. In the tailwater segment, the CDFG alternative is the lowest, with 9.36 acres. The current, no-action and the

EBMUD alternatives are nearly equally best with median acreage of 12.78 and 12.55 acres, respectively. The staff alternative is intermediate at 10.71 acres in the tailwater segment.

At the Bruella segment, the least amounts of median suitable habitat for juvenile steelhead are available under the CDFG alternative (4.64 acres). The largest amounts are under the no-action (7.84 acres) and EBMUD alternatives (7.61 acres). The staff alternative lies in between (5.74 acres). The differences persist or are exaggerated at the 75% and 90% frequencies, although they nearly disappear at the maximum value.

Reservoir Fish Resources. The CDFG alternative flows would diminish both Camanche and Pardee reservoir volumes available to support fish populations (Figure 4.1-3). There would be serious reductions (greater than 25% of mean) in Camanche Reservoir habitat in 11 of 25 years during low flow periods. Pardee Reservoir would have significantly reduced pool elevations in 6 of 25 years. It can be expected that with these drawdowns, there would be a near total loss of fish populations on a fairly regular basis whenever dry water years occurred. Although the minimum pool elevation requirement that is another part of CDFG's alternative (see Section 4.2.2) would alleviate this problem of frequent drawdowns at Camanche Reservoir, the situation in Pardee Reservoir, where there is a more valuable reservoir fishery, would be aggravated by the minimum pool requirement on Camanche Reservoir. The CDFG alternative results in more lost habitat for reservoir fish than any other alternative.

Water Supply Deficiencies

Under the reduced demand scenario, the CDFG alternative will require 145 TAF at the end of the third year of the drought sequence (Table 4.1-5). Adding about 48 TAF in new supplies in addition to the additional demand reduction would effectively eliminate the need for water if the three-year drought sequence would occur. As shown in Figure 4.1-1, the development of indirect groundwater themes (the low-cost supply option) would be sufficient to meet this water deficit. If indirect groundwater development is assumed to be the least cost supply alternative, then \$12.6 million on the demand side would need to be spent to meet the increased fish flow requirements. The total levelized annual cost would be about \$19.3 million. As noted earlier, 2020 demands based on 1990 per capita use rates would lower the annual need for additional water to meet fish flow requirements by about 7 TAF to 41 TAF. The total annual levelized cost would be approximately \$19 million. Upgrading existing treatment facilities could possibly handle this deficit, but it would require greater conjunctive use and would press the limit of keeping the Delta portion of the blend below 25%. Water transfers and conjunctive Delta water use coupled with existing treatment plant upgrades could lower estimated costs considerably. The upgrading of existing treatment if feasible could substantially lower the additional cost of meeting the deficits.

Hydropower Production

The CDFG minimum flow alternative was evaluated to determine its effect on potential hydropower production assuming the use of pumping on the aqueducts, no minimum Camanche storage, and no minimum Pardee discharge (Table 4.1-6). Total generation is quite variable depending largely on the type of water year experienced. Our predicted median generation under the CDFG recommendations is approximately 149 GWh/yr with most of this production at Pardee Dam. The CDFG minimum flows and reservoir storage requirements make the largest difference compared to the no action alternative during dry years (represented by the 10th percentile figures), because EBMUD's turbines now are seldom at capacity during dry years. A required increase in pool elevation or discharge would increase hydropower generation relative to generation without these requirements, but most of this difference would occur in

Table 4.1-6. Potential annual hydropower generated at Pardee and Camanche Dams under the California Department of Fish and Game alternative. (Source: The staff.)

	Annual hydropower generation (GWh)		
	Pardee Dam	Camanche Dam	Total
90th percentile	174.8	58.6	233.4
Median	118.6	30.8	149.4
10th percentile	31.8	2.3	34.1

dry years. In one out of 10 years, the total generation under the CDFG recommended flow regime would be approximately 26 GWh greater than the no action alternative.

4.1.3 EBMUD Alternative for Minimum Flows

The minimum flows proposed by EBMUD are described in Section 2.2.1 (Table 2.2-2) and shown in Figure 4.1-4. In all but critically dry water years, stable streamflows would be maintained at 100 cfs from December through April below Woodbridge Dam. Higher streamflows in the range of 200-300 cfs would be provided during the upstream migration period (mid-October to mid-December) when possible. Additional high flows would be provided during the out-migration period (May and June). EBMUD's total annual allocation of water to fish flows, above those required to meet downstream water rights, is 28 TAF in critically dry years (total storage less than 190 TAF), 77 TAF in dry years (total storage less than 100%), and 110 TAF in normal or wet years (100% of normal storage). The EBMUD alternative does not include any specific minimum pool elevations or minimum release from Pardee Reservoir.

Water Availability

The new minimum flows proposed by EBMUD are also significantly higher than those now required, but they would not have as serious an impact on LMRP operations as the CDFG alternative. Figure 4.1-5 shows staff's prediction of what reservoir operation would have been over the past 25 years under the EBMUD alternative and average EBMUD demand. Minimum releases from Camanche would have been much higher, especially in the summer months when historical releases frequently dropped to approximately 100 cfs. In fact, our simulation of reservoir performance indicates that releases from Camanche could be maintained at a higher level than under the CDFG alternative during some periods, such as the most recent drought. These higher flows during low flow periods are the result of a more flexible rule for Camanche pool elevations under the EBMUD alternative.

Under the EBMUD alternative, Pardee and the terminal reservoirs could be maintained within their normal operating range in all but the driest water years. The terminal reservoirs could be kept full through the simulation period, but Pardee reservoir would be drawn down slightly during the 1976-77 drought and, to a lesser degree, during the most recent drought. In contrast, Camanche Reservoir would be drawn down severely during both these drought periods. Although these predicted operations would produce a water supply deficit to EBMUD in the future, the magnitude of impacts to its water supply system appears to be tolerable. The LMRP system would remain a reliable source of water for EBMUD.

Figure 4.1-4. Minimum flow regimes from Camanche Dam under the East Bay Municipal Utility District alternative (heavily shaded bars represent releases for fish resources and the lightly shaded bars represent other releases required to satisfy downstream water rights and conveyance losses). (Source: The staff.)

A. Camanche Outflow

B. Storage Volume

Figure 4.1-5. Predicted releases from Camanche Reservoir (A) and reservoir storage volumes (B) under the minimum flow regime of the East Bay Municipal Utility District alternative and normalized 1990 water demands (no minimum pool requirement at Camanche Reservoir). (Source: The staff.)

Fish Habitat

The frequency of available habitat produced by EBMUD's minimum flow regime is shown in Tables 4.1-1 and 4.1-2. The EBMUD proposals deviate less from current conditions than other alternative flows. They provide a large abundance of habitat for fry and juvenile rearing but a smaller amount of habitat for spawning than other alternatives. Staff does not feel that the wide difference in habitat available for several life stages is a benefit to the fish population.

Chinook Salmon Spawning. The EBMUD alternative would provide a 25-year median of only 5.47 acres whereas the CDFG alternative provided 7.07 acres. Staff's recommended flow conditions would provide essentially the same spawning area (7.08 acres) as the CDFG alternative while using much less water. Under current, no-action conditions, the median acreage is the least, with 4.57 acres.

Chinook Salmon Fry Rearing. In the tailwater segment, there were particularly wide differences among alternatives in the maximum habitat areas available over the 25 years, with the EBMUD proposal (lower flows) and the no-action alternative ranked highest (15.03 and 16.00 acres, respectively). Median acreage for the 25-year period showed similar but less extreme differences, with the EBMUD alternative high.

At the Bruella segment, median acreage suitable for chinook salmon fry rearing was greatest under the EBMUD (9.28 acres) and staff (8.50 acres) proposals. The maximum acreage and those cumulative to 75% and 90% were much greater for the EBMUD and no-action alternatives, both of which have low flows (shallow water) needed by chinook salmon fry.

Chinook Salmon Juvenile Rearing. In the tailwater segment, juvenile rearing habitats showed few differences among alternatives. EBMUD's alternative and the no-action alternative showed highest areas at the 75% occurrence frequency. At the Bruella segment, there were only very small differences in estimated acreage among alternatives for rearing of chinook salmon juveniles.

Steelhead Fry Rearing. In the tailwater segment, the EBMUD alternative (5.54 acres) provided considerably more median habitat area for steelhead fry rearing than did either the no-action alternative (highest at 5.66 acres) or the CDFG alternative (3.46 acres). Staff's recommendation is intermediate (4.50 acres). Minimum acreages through 25% occurrence were all very low.

At the Bruella segment, suitable habitat for rearing steelhead fry is nearly nonexistent under all flow alternatives. There was a tiny advantage for the current EBMUD and no-action alternatives (median acreage of 0.33 and 0.34 compared with CDFG's alternative (0.21 acre) and the staff's (0.25).

Steelhead Juvenile Rearing. The situation is better for rearing steelhead juveniles. In the tailwater segment, the EBMUD and the current no-action alternatives are nearly equally best with median acreage of 12.55 acres and 12.78 acres, respectively. At the Bruella segment, the largest amounts are under the EBMUD (7.61 acres) and the no-action (7.84 acres) alternatives. The differences persist or are exaggerated at the 75% and 90% frequencies, although they nearly disappear at the maximum value.

Reservoir Fish Resources. EBMUD's flow alternative would produce less severe effects on reservoir water volumes than would the CDFG alternative, although the major trends in fluctuations are similar (Figure 5.4-5). Diminished volumes in Camanche Reservoir would accompany dry water years, but Pardee Reservoir would remain at least half full, avoiding major losses to the reservoir fishery in that reservoir.

Water Supply Deficiencies

The results of the water balance indicate that there would be no deficiencies under EBMUD's proposed fish flow alternative and year 2020 reduced demands. To be sure, total system storage is reduced to near zero levels (net of dead storage) by the end of the third drought year. The water balance model does not show a water deficit because of the approach used to assess carriage flows and assumptions about upstream and downstream water entitlements. It was assumed that current use would be modeled, and the analysis does not speculate about future use. The cost of implementing Conservation Level II and Reclamation A1 projects are estimated to cost about \$12.6 million annually.

Hydropower Production

Evaluation of the EBMUD alternative for effects on hydropower production assumed no minimum Camanche storage or Pardee minimum discharge. There is a negligible difference between the median hydropower generation predicted under this alternative (Table 4.1-7) and that produced by the no action alternative. In wet years represented by the 90th percentile figures, hydropower generation would not differ from those under the no action alternative, but total generation would be about 6 GWh/yr greater than that expected under the no action alternative during dry years.

4.1.4 Staff Alternative for Minimum Flows

Staff's minimum flow regime is described in Section 2.2.1 (Table 2.2-3) and shown in Figure 4.1-6. Under this alternative, streamflows would be kept higher throughout the spawning and incubation period from mid-October through February. During dry years, these flows would then be gradually reduced to a 20 cfs summer flow. During below-normal years, the summer flow would be 50 cfs with increased flows of 200–300 cfs during May and June. Similarly, above-normal years would have summer flows of 100 cfs, with May and June flows of 300–400 cfs. Flows throughout November, December, and January would be 150 cfs in dry years, 220 cfs in below-normal years, and 310 or 320 cfs in above-normal years. Staff's total annual allocation of water to fish flows, above those required to meet downstream water rights, is 51 TAF in dry years, 108 TAF in normal years, and 160 TAF in wet years.

Table 4.1-7. Potential annual hydropower generated at Pardee and Camanche Dams under the East Bay Municipal Utility District alternative. (Source: The staff.)

	Annual hydropower generation (GWh)		
	Pardee Dam	Camanche Dam	Total
90th percentile	174.7	58.6	233.3
Median	116.1	41.5	157.6
10th percentile	6.8	7.1	13.9

Figure 4.1-6. Minimum flow regimes from Camanche Dam under the staff alternative (heavily shaded bars represent releases for fish resources and the lightly shaded bars represent other releases required to satisfy downstream water rights and conveyance losses). (Source: The staff.)

Water Availability

The new minimum flows proposed by staff are intermediate to those of CDFG and EBMUD, but they also have different timing. The effects that staff's minimum flow regime would have on LMRP operations is also intermediate to the CDFG and EBMUD alternatives. Figure 4.1-7 shows staff's prediction of what reservoir operation would have been over the past 25 years under the staff alternative without the minimum Camanche pool requirement and with current EBMUD demand. As with the other alternatives, minimum releases from Camanche would be maintained at much higher levels compared to historical performance. Releases from Camanche are essentially the same with and without the minimum pool elevation (Section 4.2-4), but there is an important difference in storage volumes during drought periods.

Under staff's minimum flow regime without the minimum pool constraint, Pardee and the terminal reservoirs could be maintained within their normal operating range in all but the driest water years. The terminal reservoirs could be kept full through the simulation period unless the minimum pool constraint at Camanche is added (Section 4.2-4). The effect of the staff's minimum flow alternative on storage in Pardee and Camanche reservoirs is similar, but slightly more severe, than the EBMUD minimum flow alternative. Without the minimum pool constraint (Figure 4.1-7), Camanche Reservoir would be drained during both of the drought periods in the simulation period. However, Pardee would not be drawn down too severely until the most recent drought. This outcome would produce increased water supply deficits to EBMUD in the future, but they are not nearly as significant as the CDFG alternative. The effects of the staff's alternative on LMRP operations are similar in magnitude to those of the EBMUD alternative.

Fish Habitat

The frequency of available habitat produced by staff's minimum flow regime is shown in Tables 4.1-1 and 4.1-2. The staff's alternative flow regime provides suitable acreage for the life stages that are intermediate to extremes of the EBMUD and no-action alternatives on the one hand and the CDFG alternatives on the other. Staff's proposal provides more equivalent habitat values for each life stage compared with the current condition.

Chinook Salmon Spawning. Staff's recommended flow conditions would provide essentially the same spawning area below Camanche Dam (7.08 acres) as the CDFG alternative while using much less water.

Chinook Salmon Fry Rearing. There were particularly wide differences among alternatives in the maximum habitat areas available over the 25 years, with the staff alternative of 9.21 acres the same as the CDFG alternative, whereas the EBMUD proposal (lower flows) and the no-action alternative ranked highest (15.03 acres and 16.00 acres, respectively). Median acreage for the 25-year period showed similar but less extreme differences.

At the Bruella segment, median acreage suitable for chinook salmon fry rearing was greatest under staff (8.50 acres) and EBMUD (9.28 acres) proposals. The CDFG proposal (7.64 acres) and the current no-action alternative (7.19 acres) were lower. However, the maximum acreage and those cumulative to 75% and 90% were much greater for the EBMUD and no-action alternatives, both of which have low flows (shallow water) needed by chinook salmon fry.

Chinook Salmon Juvenile Rearing. In the tailwater and Bruella segments, juvenile rearing habitats showed few differences among alternatives.

A. Camanche Outflow

B. Storage Volume

Figure 4.1-7. Predicted releases from Camanche Reservoir (A) and reservoir storage volumes (B) under the minimum flow regime of the staff's alternative without a minimum pool elevation and normalized 1990 water demands. (Source: The staff.)

Steelhead Fry Rearing. In the tailwater segment, staff's recommendation is intermediate (4.50 acres) to the CDFG alternative (3.46 acres) and either the no-action alternative (highest at 5.66 acres) or the EBMUD alternative (5.54 acres). Minimum acreages through 25% occurrence were all very low.

At the Bruella segment, the staff's alternative (0.25) yields little suitable habitat for rearing steelhead fry but is low compared with all other alternatives (CDFG's alternative of 0.21 acres and the current no-action and EBMUD alternatives of 0.34 and 0.33 acres, respectively).

Steelhead Juvenile Rearing. In the tailwater segment, the staff alternative is intermediate at 10.71 acres between the CDFG alternative (lowest, with 9.36 acres) and the current, no-action and the EBMUD alternatives of 12.78 and 12.55 acres, respectively.

At the Bruella segment, the staff alternative (5.74 acres) lies between the CDFG alternative (4.64 acres) and the larger amounts of the no-action (7.84 acres) and EBMUD alternatives (7.61 acres). The differences among alternatives persist or are exaggerated at the 75% and 90% frequencies, although they nearly disappear at the maximum value.

Reservoir Fish Resources. Without a minimum pool requirement for Camanche Reservoir, staff's alternative produces reservoir volumes very similar to the EBMUD alternative (Figure 4.1-7). Reservoir fish habitat would be restricted during drought years to a degree indistinguishable from the EBMUD alternative (Figure 4.1-5). However, a minimum pool elevation of 190 ft MSL for Camanche Reservoir would result in additional adverse effects to the fishery in Pardee Reservoir, because water level fluctuations there would be greater (see Section 4.2.4).

Water Supply Deficiencies

There is a need for about 57 TAF by the end of the third year of the drought sequence under the reduced demand scenario. This need for additional water could be satisfied with any number of alternatives. These would include the development of groundwater, the possibility of building a Delta treatment facility, the upgrading of existing treatment facilities to handle a Delta blend, or the transfer of water from other users during dry years. Figure 4.1-1, the cost of developing groundwater and utilizing this quantity would be about \$5.7 million annually. If 2020 demands were based on 1990 rates, there would be a lower annual deficit and slightly lower costs for groundwater development. Upgrading existing treatment facilities and using Delta water conjunctively with Mokelumne sources could possibly cost much less. Water transfers are also potentially less costly depending on agreement prices. In total the staff alternative will cost about \$18.3 million based on the development of groundwater. Relative to the EBMUD alternative, there would be an additional annual cost of no more than \$5.7 million and probably much less if based on conjunctive Delta use and/or water transfers.

Hydropower Production

Two different conditions were considered in evaluating the effects of staff's alternative flows on hydropower production: 1) specified minimum flows at Camanche Dam without a minimum pool elevation; and 2) staff's minimum flows plus a minimum Camanche storage of 190 TAF (Table 4.1-8). Both the 90th percentile and median revenues are insensitive to which flow/storage alternative is used in the analysis. However, the 10th percentile generation amounts exhibit great sensitivity to flow alternative, with the generation more than twice as high in dry years when the minimum pool elevation is enforced. This difference occurs infrequently because during wet or normal years (represented by the 90th percentile and median, respectively) enough water can be released so that the turbines are at maximum generation capacity much of the time, regardless of instream flow or storage requirements. During dry years

Table 4.1-8. Potential annual hydropower generated at Pardee and Camanche Dams under the staff alternative without minimum pool elevations. (Source: The staff.)

Generation with staff's minimum flows only (GWh/yr)			
	Pardee Dam	Camanche Dam	Total
90th percentile	174.7	56.4	231.1
Median	116.1	39.6	155.7
10th percentile	10.0	6.9	16.9

Generation with minimum flows and minimum pool (GWh/yr)			
	Pardee Dam	Camanche Dam	Total
90th percentile	174.7	56.4	231.1
Median	116.1	39.6	155.7
10th percentile	28.8	10.1	38.9

(represented by the 10th percentile figures), the Camanche reservoir storage requirements make a difference because the required minimum storage in Camanche effectively requires greater discharges from Pardee (compared to what would be released without the requirement) to maintain this storage. Also, the increased pool elevation at Camanche develops more net head to drive the turbines there. The additional discharge and head almost always increase hydropower generation during dry years, because the turbines would normally be nowhere near their generating capacity (Table 4.1-8). Only during dry years is there a significant difference in hydropower generation between the staff and no action alternatives, approximately 31 GWh per year.

4.1.5. FWS Alternative for Minimum Flows

The FWS minimum flow regime is described in Section 2.2.1 (Table 2.2-4) and shown in Figure 4.1-8. Under this alternative, flows are maintained at 200-300 cfs (depending upon water year type) from mid-October through April. Flows then are gradually increased to their highest levels in late May, and then decreased to summer minimums during June-September. The FWS alternative's total annual allocation of water to fish flows, above those required to meet downstream water rights and losses, is 121 TAF during critically dry and dry years, and 193 TAF during normal and wet years. The FWS definition of water year type is essentially the same as staff's definition in the DEIS, although FWS includes a "critically dry" water year type not included by the staff (see Section 2.2.1).

Water Availability

The reservoir releases and storage volumes expected under the FWS minimum flow regime are shown in Figure 4.1-9. Stream flows would be significantly higher than current conditions (Figure 4.1-9A) and reservoir volumes would be much lower, especially during dry years. Reservoir drawdown is worse than the CDFG alternative, because FWS's minimum flows are greater in dry years. The resultant impact to EBMUD's water supply would be severe, forcing EBMUD to look for major new supplies.

Fish Habitat

The frequency of available habitat produced by FWS's minimum flow regime is shown in Tables 4.1-1 and 4.1-2. In nearly all of the predicted habitat values, the FWS alternative provides chinook salmon and steelhead values that are equivalent to those under the CDFG alternative. Reservoir habitat changes under the FWS minimum flow recommendations would be nearly the same as those under the CDFG alternative (Figure 4.1-9) and would result in similar adverse impacts to reservoir fish populations in both reservoirs.

Water Supply Deficiencies

The need for water for the FWS alternative is estimated at 182 TAF about 40 TAF more than that of the CDFG and 125 TAF more than that of the staff's alternative under reduced demands. This alternative would require the full development of EBMUD's indirect and direct groundwater options. The cost of groundwater development would be about \$11.7 million annually in addition to the cost of the conservation and reclamation projects for the reduced demand scenario. If 2020 demands were based on 1990 rates, the development of only the indirect options would be necessary. Cost (total levelized) would be reduced to \$6.8 million (indirect groundwater). As with the other proposed alternatives, the upgrading of treatment facilities with conjunctive Delta use or the purchase of dry year water options could be less costly than developing new supply sources.

Hydropower Production

The FWS alternative evaluated for effects on hydropower production assumed pumping on the aqueducts, and no minimum Camanche storage or Pardee minimum releases. There is very little difference between the median and ninetieth percentile hydropower revenues produced by the FWS, and the other alternatives (Table 4.1-9). In dry years (represented by the tenth percentile figures), hydropower revenues would be \$2,900,000 higher than those under the no-action alternative, and \$800,000 higher than those expected under the CDFG alternative.

Table 4.1-9. Potential annual hydropower generated at Pardee and Camanche dams under the U.S. Fish and Wildlife Service minimum flow alternative. (Source: The staff.)

	Annual hydropower generation (GWh)		
	Pardee Dam	Camanche Dam	Total
90th percentile	174.7	55.3	230.0
Median	118.7	34.7	153.4
10th percentile	40.1	1.8	41.9

Figure 4.1-8. Minimum flow regimes from Camanche Dam under the U.S. Fish and Wildlife Service alternative (heavily shaded bars represent releases for fish resources and the lightly shaded bars represent other releases required to satisfy downstream water rights and conveyance losses). (Source: The staff.)

A. Camanche Outflow

B. Storage Volume

Figure 4.1-9. Predicted releases from Camanche Reservoir (A) and reservoir storage volumes (B) under the minimum flow regime of the U.S. Fish and Wildlife Service alternative and normalized 1990 water demands. (Source: The staff.)

4.1.6 No Action Alternative for Minimum Flows

Under the no action alternative, minimum flows below Camanche would remain as they are now (Section 2.2-1 and Table 2.2-4). The current allocation of water to fish flows is 13 TAF (5 TAF during dry years) and there are no lower limits to the Camanche Reservoir pool elevation. The resulting minimum flows are shown in Figure 4.1-10.

Water Availability

Predicted releases from Camanche and reservoir storage volumes under the no action alternative are shown in Figure 4.1-11. Predicted Camanche releases do not match historical outflows, primarily because real-time operating decisions could not be replicated completely by our water balance modeling. The simulation results in Figure 4.1-11 should be used as a baseline for comparison with other alternatives. These results indicate that even under the no action alternative, significant drawdowns occur to both Camanche and Pardee reservoirs.

Fish Habitat

Under the no-action alternative, conditions similar to those now experienced will continue. The frequency of available habitat produced by this alternative is shown in Tables 4.1-1 and 4.1-2. Under the no-action alternative, conditions similar to those now experienced will continue. Overall chinook salmon production in the river would continue to be poor in most years, negligible in dry years, and approach target levels only when river flows are exceptionally high. These conditions, many of which can be linked to inadequate or inappropriate flows, can be summarized in the following sections.

Chinook Upstream Migration. The number of fall chinook entering the Lower Mokelumne River to spawn will depend on river flow more than on the river's recruitment. Fish from a common Delta pool of fish from the Sacramento and San Joaquin rivers and their tributaries will go to the river(s) with most attraction flow. This pool of adult salmon will enter the Delta without clear chemical cues to their natal stream. This is largely because most hatchery-raised fish will have been released (planted) in the Delta without having traversed the rivers between the hatchery and the Delta, and the general low survival rate of juvenile salmon that emigrate naturally. Adults that migrate into the Mokelumne River before temperatures have fallen to about 60°F (15.5°C) will be in poor shape and will have low probability of spawning successfully. Woodbridge Dam is a major obstacle with many details of fish passage that are not conducive to successful migration. A high percentage of migrants that arrive on the spawning grounds will be derived from Central Valley hatcheries.

Chinook Spawning. Fish will spawn relatively close to Camanche Dam in the remaining higher gradients. The no-action alternative of remaining with current conditions provides relatively low spawning acreage but high acreage for fry and juvenile rearing. It has widely fluctuating habitat acreage as flows fluctuate greatly. Staff believes this situation can be improved. Fish may spawn in relatively high water only to have redds exposed as water flows drop in late fall and winter and gravel bars become exposed. With gravels choked with fine sediment and biological detritus, the gravel quality is largely dependent on the amount of sediment reworking that the spawning salmon can accomplish. Some fish will be taken for spawning in the MRFF where water quality problems in dry years may limit egg incubation and fry production.

Chinook Egg Incubation. Intragravel flow in the river is poor because of biological growths and detritus in the stable streambed, and low DO causes poor embryonic survival during incubation.

Figure 4.1-10. Minimum flow regimes from Camanche Dam under the no action alternative (heavily shaded bars represent releases for fish resources and the lightly shaded bars represent other releases required to satisfy downstream water rights and conveyance losses). (Source: The staff.)

A. Camanche Outflow

B. Storage Volume

Figure 4.1-11. Predicted releases from Camanche Reservoir (A) and reservoir storage volumes (B) under the minimum flow regime of the no action alternative and normalized 1990 water demands. (Source: The staff.)

Chinook Fry Rearing. Conditions are suitable for rearing chinook salmon fry in the river through about April or May. Temperatures are good, and the river is productive of necessary food. The habitat is moderate quality and needs diversification from riffles, runs, and pools. The no-action alternative of remaining with current conditions provides relatively high acreage for fry and juvenile rearing. However, it has widely fluctuating habitat acreage as flows fluctuate greatly. Staff believes this situation can be improved.

There is insufficient riparian vegetation in places to provide shelter and to prevent solar heating.

Chinook Smolt Emigration. Emigration will lack the pulse of high water normally associated with initiation of outmigration of fall chinook salmon. Fry remaining in the river in late May, June and into July will be stressed by high temperatures in the river downstream of Woodbridge Dam. Woodbridge Dam and Lake Lodi will cause high mortalities from predation in the lake and diversion. High rate of mortality will continue as smolts pass through the lower river and into the Delta. Few manage to survive to the ocean.

Steelhead Upstream Migration. Adult steelhead will reach the Mokelumne River with the same constraints faced by chinook salmon. They will, however, continue to enter later in the winter. Most migrants will be hatchery-raised fish from throughout the Central Valley.

Steelhead Spawning. Nearly all steelhead will be taken at the MRFF for artificial spawning. Little spawning habitat remains in the river.

Steelhead Egg Incubation. Hatchery water quality will be a limiting factor in production of fry.

Steelhead Fry Rearing. Steelhead are reared through the summer at the MRFF and released as yearlings. This means that water quality problems in the hatchery water supply from Camanche Reservoir will continue to be acute during dry years.

Reservoir Fish Resources. There would be no change from present conditions if minimum flows are not changed.

Water Supply Deficiencies

The no action alternative does not require any need for additional water. However, this is based on the implementation of reduced demand scenario, which has an estimated cost of \$12.6 million annually.

Hydropower Production

The no action alternative results in a range of potential hydropower generation similar to the ranges due to other alternatives. The 10th percentile revenue is much, much lower than the median and 90th percentile values. As discussed for the other alternatives, the 10th percentile revenues are strongly affected by choice of flow/storage alternative. The no action alternative does not have stringent storage or Pardee release requirements. Therefore, hydropower revenues during dry years (10th percentile) are relatively low in comparison to alternatives with storage/release requirements (Table 4.1-10).

Table 4.1-10. Potential annual hydropower generated at Pardee and Camanche Dams under the no action alternative. (Source: The staff.)

	Annual hydropower generation (GWh)		
	Pardee Dam	Camanche Dam	Total
90th percentile	174.8	58.7	233.5
Median	119.1	40.8	159.9
10th percentile	0.5	7.6	8.1

4.2 MINIMUM CAMANCHE POOL ELEVATIONS

Mitigation alternatives involving new minimum pool elevations are designed to maintain a cold hypolimnion in Camanche Reservoir throughout the summer, ensuring colder water temperatures and improved water quality in Camanche releases and in the lower river. The effects of new minimum pool requirements are discussed in this section as they affect water availability, fish habitat, water supply deficiencies, and hydropower generation. Changes in water temperature and water quality are addressed under fish habitat for both the reservoirs and the lower river.

4.2.1 Assessment Methods

The effects of new minimum pool elevations on water temperatures, downstream fish resources, and LMRP operations were evaluated using two temperature simulation models, as described in this section. These results were then combined with the PHABSIM results to produce total habitat availability scores which were used to compare the various proposed alternatives.

Reservoir Modeling

Several operational scenarios for Camanche Reservoir have been suggested to improve the water quality in the Lower Mokelumne River. These consist of maintaining specified minimum flows from Pardee for dry, normal and wet years. These alternatives have been evaluated with the hydrodynamic and water quality model CE-QUAL-W2 described briefly in section 3.2.3 and in more detail in Appendix C. As described in Appendix C, CE-QUAL-W2 has been used to simulate the temperatures of releases from Camanche Reservoir for the proposed minimum releases while adjusting releases from Pardee Reservoir to maintain desired constant pool elevations in Camanche. The results of calibration of the numerical model show that computed release temperatures agree well with the EBMUD Hydrolab data, particularly in 1988. There are, however, some inaccuracies in the computed discharge temperatures. As explained in Appendix C, these differences are due to the limitations of the model and the accuracy of the available data. The principal value of the modeling effort is in predicting relative release temperatures produced by proposed reservoir operations. These results will give a reliable estimate of the direction and magnitude of change in release temperatures caused by each operational scenario modeled.

Stream Temperature Modeling

An instream water temperature model (SNTEMP) developed by the FWS (Theurer et al. 1984) was used to perform several analyses on the effects of Camanche Dam discharge flows and temperatures on instream

temperatures in the Lower Mokelumne River. Staff used various combinations of meteorological and hydrological data (both historical and hypothetical) to perform two types of analyses.

1) Analysis of thermally available habitat for life stages whose most critical habitat requirement is temperature (as opposed to other variables such as water velocity, substrate, and depth). These life stages include chinook smolt out-migrants, adult chinook in-migrants, and over-summering stocked steelhead trout. Various combinations of potential Camanche release temperatures and flows were used for this analysis.

2) Analysis of temperature-modified weighted usable area (tWUA) for life stages whose critical habitat requirements include temperature as well as other physical variables such as water velocity, substrate, and depth. These life stages include chinook spawning and incubation, chinook fry rearing, and chinook juvenile rearing. This analysis included a combination of the PHABSIM (WUA) analysis and SNTMP results.

The critical life stages considered by staff and the time of year in which they are most important are as follows:

January	chinook spawning/incubation
February	chinook spawning/incubation and fry rearing
March	chinook spawning/incubation and fry rearing
April	chinook juvenile rearing
May	chinook juvenile rearing and smolt out-migration
June	chinook juvenile rearing and smolt out-migration
July	stocked steelhead over-summering
August	stocked steelhead over-summering
September	stocked steelhead over-summering
October	chinook adult in-migration
November	chinook adult in-migration and spawning/incubation
December	chinook spawning/incubation

The results of these analyses were used in conjunction with other analyses to develop minimum flow and reservoir elevation criteria. These results were also used to calculate life-stage habitat scores (LHS) for each critical life stage for the various proposed alternatives. Details of the SNTMP modeling, the combined SNTMP/WUA analysis, and the LHS analysis are described in Appendix F.

4.2.2 CDFG Alternative for Minimum Pool Elevations

CDFG recommended that the temperature of releases from Camanche Reservoir be controlled by maintaining a minimum pool elevation of 210 ft as well as a minimum release of 250 cfs from Pardee Reservoir. Minimum releases proposed by CDFG are greater than 250 cfs except for 196.4 cfs in September and 248.1 cfs during October 15–31 during dry years. Since maintenance of a constant pool elevation in Camanche Reservoir requires Pardee releases at least as great as Camanche releases the minimum release of 250 cfs is redundant with a minimum pool elevation of 210 ft and has not been separately evaluated. The temperatures at the lower outlet from Camanche dam at elevation 110 ft computed under this scenario for dry and normal water years are shown in Figure 4-2.1. The predicted temperatures at the lower outlet from Camanche Dam were similar for dry and normal years with a maximum of 55°F (12.8°C) in a dry year and 56.4°F (13.6°C) in a normal year. The general result from this modeling is that a constant pool elevation of 210 ft yields acceptably low release temperatures for all proposed minimum releases.

Figure 4.2-1. Simulated water temperatures at Camanche Reservoir lower outlet for California Department of Fish and Game proposed minimum releases. (Source: The staff.)

Water Availability

The volume of Camanche Reservoir at 210 ft is approximately 238 TAF, or about one year's water supply to EBMUD at current demand levels. The result of imposing this new regulation on reservoir operations while also imposing CDFG's minimum flow recommendations would be to greatly increase the magnitude and frequency of drawdowns of both Pardee Reservoir and EBMUD's terminal reservoirs, especially during consecutive dry years. Minimum releases to the lower river would be essentially the same as described in Section 4.1.2 (Figure 4.1-3A). The LMRP reservoirs would no longer be a reliable source of water supply for EBMUD under the CDFG flow recommendations.

Fish Habitat

The CDFG alternative for a normal water year (Camanche minimum pool elevation 210 ft plus minimum release flows) provided adequate thermal habitat in the Lower Mokelumne River for adult migration, spawning/incubation, smolt migration, and stocked steelhead as indicated by LHSs of 97, 84, 100, and 98, respectively, out of a possible 100 (Figure 4.2-2, Table F-8). However, LHSs for fry rearing (4) and juvenile rearing (23) from mid-February through June were very low. These low scores were a result of a combination of too high flows (380-730 cfs) and too cold temperature (49.3–53.6°F; 9.6–12.0°C). The cold Camanche release temperatures are a result of the 210-foot minimum pool elevation requirement. LHSs for wet years were generally the same as for normal, but dry year scores were markedly lower, particularly for adult migration (75), smolt migration (61), and stocked steelhead (78).

Figure 4.2-2. Life-stage habitat scores (LHS) for three water year types and five proposed management alternatives. See Appendix F for details.
(Source: The staff.)

Pardee Reservoir Fisheries Under Severe Drawdown. Staff evaluated the effects on Pardee Reservoir cold-water fisheries (trout, kokanee) if water levels are lowered drastically to meet requirements of the CDFG Fisheries Management Plan (Myers 1992). There is significant risk that depletion of the hypolimnion and thermocline could occur with loss of suitable cool temperature habitat. This loss might occur through complete depletion of the volume of cool water by deep withdrawal or (more likely) by induction of early turnover in the reduced reservoir volume. Staff considers the potential loss of cool-water fish populations to be significantly adverse. Warmwater fishes would also lose habitat if Pardee Reservoir elevation were lowered significantly. Typically, loss of warm surface water is less severe for maintaining populations than is the more complete loss of coolwater habitat.

Maintaining a high water elevation in Camanche Reservoir would benefit reservoir fisheries. A larger volume of water would be available in the epilimnion (well-mixed surface volume) in summer for warm-water fishes such as largemouth bass. Part of this increase is attributable to the more extensive lateral spread of water into shallow embayments at high elevations. Concurrent with this increase in the epilimnion would be larger volumes of the hypolimnion and metalimnion (thermocline). These larger volumes would not only provide more volume of low-temperature water suitable for the cool-water and cold-water fishes, but would reduce the rate at which DO would decline from biological decomposition. More abundant DO would increase the utility of the habitat for cool- and cold-water fishes.

4.2.3 EBMUD Alternative for Minimum Pool Elevations

The minimum flow requirements proposed by EBMUD for dry and normal years have also been evaluated by simulating Camanche release temperature for the proposed discharges coupled with constant pool elevations of 170 ft, 190 ft, and 210 ft. The results of these simulations are shown in Figure 4.2-3 and indicate maximum outlet temperatures approaching 68°F (20°C) for 170 ft pool elevation for both dry and normal years, and maximum discharge temperatures of 53.9°F (12.3°C) for dry years and 56.1°F (13.4°C) for normal years at a constant pool elevation of 210 ft. For a constant pool elevation of 190 ft temperatures are in an acceptable range with maxima of 57.7°F (14.4°C) and 59.7°F (15.4°C) in dry and normal years respectively. Although EBMUD did not propose a specific pool elevation, they did propose that the pool elevation be maintained such that 20,000 to 28,000 ac-ft of water <61.5°F (16.4°C) be available at the end of October. Based on staff's simulations, the 170 ft constant pool elevation will not attain this, but 190 and 210 ft minimum pools will.

Water Availability

Water availability under the EBMUD flow recommendations would be essentially the same as described in Section 4.1.3. No water balance simulations were conducted for this EBMUD's minimum pool alternative, because the specific operating constraints are not clear. However, under current conditions (1990 normalized demand) and based on other simulation runs, we believe that there would be an insignificant change from the no action alternative.

Fish Habitat

The EBMUD alternative for a normal water year (Camanche minimum pool elevation 190 ft plus minimum release flows) provides less habitat than the CDFG, FWS, or staff alternatives for four of the six life stages, adult migration, spawning/incubation, smolt migration, and stocked steelhead. The LHSs for fry and juvenile rearing (33 for both) are low, but are higher or similar to the scores of CDFG and FWS. For all life stages, the relative differences among EBMUD and the other alternatives are a result of higher Camanche temperatures and lower flows. EBMUD wet year scores are the same, but scores for dry and critical dry years have several differences. Values for smolt migration and stocked steelhead decrease

Figure 4.2-3. Simulated water temperatures at Camanche Reservoir lower outlet for East Bay Municipal Utility District proposed minimum releases. (Source: The staff.)

substantially, while fry and juvenile rearing scores actually increase as a result of lower flows which provides more usable habitat and allows temperatures to attain levels more favorable to growth.

Low reservoir elevations in late summer and fall would reduce the volume of habitat available for both warm-water fishes in the epilimnion and cool-and cold-water fishes in the hypolimnion and thermocline. It is likely that low DO concentrations in the relatively small volume of deeper layers would severely restrict cool-and cold-water fishes as it does currently.

4.2.4 Staff Alternative for Minimum Pool Elevations

Simulations of the effects on Camanche discharge temperatures of minimum releases proposed by staff showed a similar pattern (Figure 4.2-4). Predicted release temperatures for constant pool elevations of 170 ft and 180 ft were high with the lowest predicted temperatures for 180 ft pool elevation for a dry year. The maximum predicted temperature for this case was 64°F (17.8°C) in October. For a constant pool elevation of 190 ft the predicted discharge temperatures were 59°F (15°C) or below throughout the year for both dry and normal years. Constant pool elevations of 200 ft and 210 ft produced lower predicted outflow temperatures for both water year types.

An additional staff alternative considered is the minimum proposed discharges described above with a Camanche pool elevation of 170 ft from February 23 through April 10. The pool elevation was then raised to 190 ft by June 29 by increasing the discharge from Pardee Reservoir. The elevation was maintained at 190 ft until September 27 when it was allowed to decrease by releasing no water from Pardee while maintaining the proposed Camanche discharges. The water surface elevations and the predicted discharge temperatures in the simulation of this management practice are shown in Figure 4.2-5. The predicted discharge temperatures of the staff alternatives of maintaining 190 ft pool elevation throughout the year and varying the pool elevation from 170 ft in the winter to 190 ft in the summer are compared with the simulation of 1988 historical management practices in Figure 4.2-6.

The predicted temperatures of Camanche releases for the variable pool elevation are seen to be less than 0.9°F (0.5°C) higher in October than the results of the simulation of a constant 190 ft pool elevation for a normal year. This result suggests that the late fall, winter and early spring pool elevation may be variable as long as the elevation is increased to 190 ft before the reservoir is strongly stratified.

The results of historical management practices in 1988 which are reported in Appendix C as the 1988 calibration run, are compared with the results instituting the minimum releases proposed by staff for a dry year and maintaining constant elevations of 170 ft to 210 ft in Table 4.2-1. The results of varying pool elevation from 170 ft in the winter to 190 ft in the summer are also reported.

The goal of EBMUD's management plan is to maintain a hypolimnion of at least 28 TAF below 61.5°F (16.4°C) in Camanche Reservoir (Biosystems 1992). The purpose of maintaining a minimum hypolimnion volume is to prevent premature reservoir destratification and to ensure a supply of cold water to release for fisheries downstream of Camanche. The volume of water colder than 61.5°F (16.4°C) for three dates was approximated for each of the operational scenarios simulated. The modeled elevation of the 61.5°F (16.4°C) isotherm in the most downstream segment of the model was determined and the volume of water below this isotherm was approximated from the elevation-storage relationship for Camanche Reservoir shown in Figure 3.2-10. The results of these calculations are given in Tables 4.2-2 and 4.2-3.

These data show that there is significantly more cold water available at a constant pool elevation of 190 ft than at 180 ft or lower, particularly in the summer and early fall. The alternative of maintaining a 190 ft

A. Camanche Outflow

B. Storage Volume

Figure 4.2-4. Predicted releases from Camanche Reservoir (A) and reservoir storage volumes (B) under the minimum flow regime of the staff's alternative with a minimum pool elevation of 190 ft MSL at Camanche Reservoir. (Source: The staff.)

(A) Dry Year **(B) Normal Year**

Figure 4.2-5. Simulated water temperatures at Camanche Reservoir lower outlet for minimum releases proposed by the staff. (Source: The staff.)

(A) Pool Elevation **(B) Discharge Temperature**

Figure 4.2-6. Results of simulation of variable water surface elevations. (Source: The staff.)

(A) Dry Year **(B) Normal Year**

Figure 4.2-7. Comparison of simulated discharge temperatures for 1988 historical management practices, a constant pool elevation of 190 ft, and a pool elevation varying from 170 to 190 ft. (Source: The staff.)

Table 4.2-1 Simulated decrease in temperature from historical management practices using staff proposed releases for a dry year. (Source: The staff)

Date	Constant elevation (ft) as indicated					Variable elevation
	170	180	190	200	210	
May 20, 1988	-0.4	0.3	0.7	0.9	1.3	-0.5
June 9, 1988	-0.5	0.2	0.9	1.5	2.0	-0.7
June 29, 1988	-1.4	0.2	1.0	2.0	2.6	-0.7
July 19, 1988	-1.2	2.0	3.5	4.6	5.0	1.4
Aug 8, 1988	1.1	5.6	7.9	9.0	9.5	5.5
Aug 28, 1988	2.5	6.8	10.3	11.5	12.1	7.8
Sept 17, 1988	1.0	4.8	8.6	10.2	10.7	6.6
Oct 7, 1988	-0.4	1.1	5.0	6.7	7.4	3.3
Oct 27, 1988	-1.2	-1.0	2.0	3.8	4.5	0.4

pool in the summer with a 170 ft pool the remainder of the year maintains a hypolimnion volume nearly as large as that for a constant pool elevation of 190 ft.

Based on the modeling results the temperature of Camanche releases may be managed by maintaining a minimum pool elevation throughout the year or by a rule curve which allows a lower pool elevation in the winter than in the summer. Maintaining a minimum pool elevation between 190 and 210 ft throughout the year while following the minimum release schedule proposed by staff would yield acceptable Camanche release temperatures while maintaining a constant pool elevation of 180 ft or less would not. A constant pool elevation between 180 and 190 ft might be appropriate for dry years since less water is being released from the reservoir and the hypolimnion would not be depleted as rapidly. An acceptable alternative management scenario is to maintain 170 ft pool elevation until early April; raise the pool elevation to 190 ft by the end of June; maintain 190 ft until the end of September and then allow the pool elevation to fall back to 170 ft. Simulation of this operational scenario resulted in maximum release temperatures of 50°F (15.5°C) in both dry and normal years and a hypolimnion volume in late summer and early fall nearly as large as that predicted for a constant pool elevation of 190 ft.

Water Availability

Figure 4.2-4 shows staff's prediction of what reservoir operation would have been over the past 25 years under the staff alternative with the minimum Camanche pool requirement and with current EBMUD demand. As with the other alternatives, minimum releases from Camanche would be maintained at much higher levels compared to historical performance. Releases from Camanche are essentially the same with and without the minimum pool elevation (Section 4.1-4), but there is an important difference in storage volumes during drought periods. In the second year of a drought sequence, such as the three-year upper bounding scenario used in this assessment to estimate need for water (see Section 4.1.1 and Appendix D), reservoir storage begins to be drawn down if our limit of 190 ft MSL is enforced. Through the first year of a drought, the reservoir operation performance is not distinguishable from that of the EBMUD or no

Table 4.2-2. Hypolimnion volume for dry year release scenarios. (Source: The staff.)

	Volume of hypolimnion in TAF for the constant water surface elevations and dry year release scenarios indicated					
	170	180	190	200	210	Variable elevation
May 30						
Staff	25.1	49.6	77.6	120.8	153.2	60.3
No action	26.3	50.3	77.8	121.1	153.1	
EBMUD	29.9		79.2		152.6	
CDFG					152.3	
July 29						
Staff	1.6	16.3	76.1	95.9	138.1	68.2
No action	1.7	21.0	76.0	99.1	136.9	
EBMUD	3.8		75.5		134.7	
CDFG					135.5	
Sept 27						
Staff	0.0	0.0	76.7	88.3	125.5	73.0
No action	0.0	15.0	76.1	94.6	121.9	
EBMUD	0.0		77.0		119.1	
CDFG					123.4	

action alternative. Impacts that begin in the second year of a drought can be minimized if a "deficit sharing" policy is implemented. For example, the reservoir volume between 190 ft and 175 ft elevations is approximately 50 TAF, or roughly equivalent to staff's dry year minimum flow requirement for fish. If this amount of water is released by relaxing the minimum pool elevation, then deficits decrease, and the reservoir performance returns to a pattern very similar to the EBMUD and no action alternatives. With the flexible minimum pool elevation, reservoir operation is essentially the same as shown in Figure 4.1-7.

Fish Habitat

The staff alternative for normal water years (Camanche minimum pool elevation 190 ft plus minimum release flows) provided adequate thermal habitat for adult migration, smolt migration, and stocked steelhead as indicated by LHSs of 84, 100, and 93, respectively (Figure 4.2-2, Table F-8). Although the score for fry rearing is low (33), it is same as EBMUD and greatly exceeds the scores of CDFG and FWS. Scores for juvenile rearing (52) were not as high as desired, but exceeded all other alternatives except for no action. Wet year scores were slightly higher for or the same for all life stages except for fry and juvenile rearing which actually decreased. Dry year scores showed just the opposite trend; fry and juvenile

Table 4.2-3. Hypolimnion volume for normal year release scenarios. (Source: The staff.)

	Volume of hypolimnion in TAF for the constant water surface elevations and normal year release scenarios indicated					
	170	180	190	200	210	Variable elevation
May 30						
Staff	45.0	38.3	77.0	121.3	152.2	60.9
No action	22.0	47.7	77.5	121.0	153.1	
EBMUD	31.3		61.5		152.5	
CDFG					151.9	
July 29						
Staff	1.6	1.6	76.9	96.3	134.2	75.6
No action	0.0	6.8	76.6	94.8	136.4	
EBMUD	0.0		73.7		137.0	
CDFG					136.5	
Sept 27						
Staff	0.0	0.0	78.5	92.2	121.2	77.4
No action	0.0	0.0	78.0	87.4	123.3	
EBMUD	0.0		77.0		119.1	
CDFG					118.7	

scores increased and the other scores decreased. Staff's dry year LHSs are the most consistent of the various alternatives.

Reservoir Fisheries. An intermediate pool elevation supported by staff would provide Camanche Reservoir fish habitat between the alternatives proposed by CDFG and EBMUD. It is likely that there would be a productive warm water fishery with some cool- and cold-water fishes able to maintain themselves through the summer period of low DO concentrations.

Water Supply Deficiencies

The need for additional water associated with staff's minimum flow and minimum pool alternatives are discussed in Section 4.1.1 and shown in Table 4.1-3. Under current demands, this deficit would be 36 TAF with staff's minimum pool requirement of 190 ft MSL and 1 TAF without this minimum pool requirement. With "deficit sharing" and a flexible minimum pool requirement, the deficit is expected to be much closer to 1 TAF.

Hydropower Production

Hydropower generation predicted under staff's minimum pool and minimum flow recommendations is discussed in Section 4.1-4 and shown in Table 4.1-7. There are only marginal differences that occur in dry years. In 1 out of 10 years, hydropower production would be increased from 16.9 GWh to 38.9 GWh due to greater releases from Pardee into Camanche and higher pools in Camanche Reservoirs. However, with "deficit sharing" and a flexible minimum pool requirement in the second year of a drought, this difference would be largely eliminated.

4.2.5 FWS Alternative for Minimum Pool Elevations

FWS has not proposed specific minimum pool requirements for Camanche Reservoir, so a minimum pool elevation of 190 feet was imposed for the purpose of evaluating the thermal quality of their proposed minimum flows. (Note: a 210-foot minimum pool elevation was also simulated and the differences were minor.) The FWS alternative provided adequate thermal habitat for adult migration, smolt migration, and stocked steelhead as indicated by LHSs of 93, 97, and 97 (Figure 4.2-2, Table F-8). However, scores for fry rearing (6) and juvenile rearing (42) from mid-February through June were low. These low scores were a result of a combination of too high flows (380-990 cfs) and too cold temperature (49.8–54.9°F; 9.9–12.7°C). Wet year scores were nearly the identical, and the primary differences during dry years were decreased habitat for smolt migration and stocked steelhead.

4.2.6 No Action Alternative for Minimum Pool Elevations

The minimum flow requirements under existing agreements were also evaluated for constant pool elevations of 170 ft through 210 ft at 10 ft intervals. The results of simulations are shown in Figure 4.2-8. Simulated release temperatures for both 170 ft and 180 ft were high in the late summer and early fall with maximum temperatures of 67.1°F (19.5°C) or higher for 170 ft pool elevation for both dry and normal years. For pool elevations of 180 ft the temperatures were lower but still reached a maximum in mid-October of 63.9°F (17.7°C) in a dry year and 64°F (17.8°C) in a normal year. Predicted release temperatures for a constant pool elevation of 190 ft were below 59°F (15°C) for both dry and normal years and pool elevations of 200 ft and 210 ft yielded predicted release temperatures below 55.4°F (13°C) throughout the year for all simulations.

Fish Habitat

Because the no action alternative provides no Camanche minimum pool elevations, staff assumed minimum pool elevations of 170 ft during dry water years and 190 ft during normal and wet years. Based on the LHSs, the no action plan provides the least amount of habitat of the various alternatives for adult migration, spawning/incubation, and smolt migration. The no action scores are higher than the other alternatives for fry and juvenile rearing, but these are at release flows which result in no flow below Woodbridge Dam from April through June—a condition which staff considers unacceptable. The only noticeable difference in wet year scores is a marked increase in the adult migration score, and the major differences during dry years is a decrease in spawning/incubation and stocked steelhead habitat.

Figure 4.2-8. Simulated water temperatures at Camanche Reservoir lower outlet for minimum releases required by existing agreements. (A) Dry year; and (B) normal year. (Source: The staff.)

4.3 OTHER FLOW ALTERNATIVES

4.3.1 Ramping Rates

Staff reviewed the CDFG analyses of Mokelumne River flows that could cause fish to be stranded on or in the dewatered substrate when river flows decrease rapidly (CDFG 1991). We also reviewed ramping rate recommendations by the State of Washington for waters with salmon and steelhead. It is difficult to select the best general regulatory measure of water level fluctuations to avoid stranding fish. The actual detrimental effect occurs on gravel bars and marginal pools where water elevation interacts with gravel topography to prevent fish from maintaining contact with open water as water level drops. This is a microhabitat feature that is inadequately expressed by general streamwide limits on either rate of change in water elevation or percentage change of flow. The importance of having a criterion also depends on the presence of vulnerable organisms (particularly salmon and trout fry and juveniles). Thus, the need depends on the time of year. A non-flow alternative to avoid stranding would be to eliminate places in a stream that could entrap fish, such as isolated potholes or backwaters. These physical features do not appear to be prevalent in the Lower Mokelumne River (Section 3.3).

CDFG Ramping Rate Alternative

To avoid loss of aquatic productivity and to prevent stranding from short-term daily flow fluctuations, CDFG recommended that daily flow fluctuations not exceed 10% of the average flow within any 24-hr period and weekly fluctuations not exceed 20% of the average flow within any 7-day period. These recommendations were to be applied whenever Camanche Reservoir releases were under control (not spilling), regardless of flow. A concurrent CDFG recommendation, applicable to just flow reductions, is that reductions be gradual and not exceed 30% of the existing initial flow during any 24-hr period. Again, this recommendation applies to all flows.

Because there is special concern for the October 1 through February 29 period of spawning and incubation, there were special recommendations for this time that would ensure steady flow and wetted redds. These recommendations stated that if the average flow for the preceding 7 days:

- 1) exceeds 500 cfs, the flow shall not be reduced below 400 cfs;
- 2) is 400-499 cfs, flows shall not be reduced below 350 cfs; or
- 3) is 300-399 cfs, flows shall not be reduced below 300 cfs;

and that controlled release flows should not be reduced by more than 300 cfs during any 6-day period. CDFG evaluated the importance of flow fluctuations on habitats of the river at various flows using quantitative instream flow modeling techniques and provided clear evidence that most losses in habitat area occurred as water flow declined at the lower flow rates, particularly below 300 cfs. Significant change also occurred between 400 and 300 cfs at two sites. Staff thus has difficulty justifying CDFG's restrictions on flow declines above 399 cfs (items 1 and 2 above). Similarly, restrictions on daily and weekly flow fluctuations above 400 cfs seem unjustified by the CDFG quantitative analysis.

In addition, CDFG's proposed ramping rates are in conflict with their proposed attraction and outmigration flows. These flows are proposed to be "slugs" of water introduced to the river rapidly, and then quickly down-ramped back to normal operational releases. The proposed CDFG ramping rates would require that increased flows start almost two months ahead of time in order to both abide by CDFG's proposed ramping rates, and have release flows at CDFG's proposed values by the specified dates. Similarly, for down-ramping at the end of the proposed "block flows", it would take over one month to return flows to normal. The effect upon water supply is that CDFG's proposed ramping rates require the

release of 12 to 24 TAF more from Camanche Dam than would be required if there were no ramping rates, depending upon water year type.

EBMUD Ramping Rate Alternative

EBMUD recommended restrictions on daily flow fluctuations, based upon the results of monitoring of salmon spawning activity (EDAW, Inc. 1992b). Streamflow fluctuations under the EBMUD alternative would not exceed 50 cfs/day or 10 cfs/hour during spawning and incubation periods (October to March). During other months, EBMUD would limit changes in streamflow to less than 100 cfs/day or 10 cfs/hour. The results of staff's analysis indicate that a flow-based ramping rate restriction of 100 cfs/day equates to a water level change of less than 1-inch per hour for the channel cross-section at the USGS gauge below Camanche Dam. Therefore, the EBMUD alternative ramping rates of either 50 or 100 cfs/day are more restrictive than staff's proposal, and would likely provide significantly more protection against fry stranding and redd dewatering than the no action alternative. However, staff's ramping rate is sufficient to protect fish resources in the Camanche tailwater. EBMUD's proposed ramping rates have a negligible effect upon required releases from Camanche Dam.

Staff Ramping Rate Alternative

The staff's proposed ramping rates restricting water level fluctuation to less than 2 inches per hr (Section 2.2.3) equate to an allowable flow fluctuation of approximately 400 cfs per day. This discharge was calculated using the 2 inches per hour figure, applied to the stream cross-sections at the streamflow gauge sites below the Camanche and Woodbridge dams. We assumed that these were typical stream cross-sections. The additional water that must be released to comply with staff's proposed ramping rates is negligible.

Based on the CDFG quantitative modeling of habitat change with change in streamflow, staff recommends that restrictions to change in flow not apply to the Mokelumne River above 400 cfs. Below 400 cfs, however, there is a real possibility of stranding fry and dewatering redds. However, if adult salmon and steelhead do not spawn on gravels that are covered only at high flows, there is no risk to eggs from dewatering below these high flows. A consistent flow near 300 cfs from October 1 through February 9 would seem most appropriate to keep spawning in areas that could reasonably be kept wetted throughout incubation. The CDFG recommendations for maximum daily and weekly fluctuations may be appropriate for these flows. Daily streamflow changes are not likely to affect incubating eggs and emerging chinook fry from October 1 through February 1. Research on Vernita Bar chinook salmon spawning beds on the Columbia River and related laboratory studies have shown that embryos and alevins in the gravel are resistant to several hours of dewatering so long as moisture-saturated conditions prevail. In winter, most gravel remains moist until river flows again inundate the redds during the high-flow part of the generating cycle.

After March 1, the presence of fry with a preference for shallow water would suggest the desirability of lowered flows with little fluctuation. The State of Washington recommends interim ramping rates for its anadromous salmonid rivers of 1-2 inches per hour (rates based on flow are very site-specific; the more generally applicable guideline is one based on change in water elevation). Olson and Metzgar (1987) found that ramping rates of 6 inches per hour definitely caused stranding of salmon and steelhead fry in Washington.

Staff recommends an interim limit for controlled flow fluctuations no greater than those that would cause a decrease in river elevation of 2 inches per hour as measured at the fish screen site from February 1 through June 15, when fry and smolts are expected to be present. It pertains to all streamflow reductions,

both daily and for more general flow changes. This interim limit may be modified based on further studies by CDFG and EBMUD. Staff would not restrict rates of change in water flow during the autumn period when abrupt spike flows may be desirable to stimulate upstream migration (see below).

FWS Alternative

The FWS has not proposed any specific ramping rates; therefore, staff was not able to analyze this aspect of their proposed instream flow regime.

No Action Alternative

Unrestricted flow fluctuations and rapid decreases in flow below 400 cfs could continue a risk of dewatered redds and stranding of fry as seems to have occurred in the past (e.g., Figure 3.3-10A). Although these effects are poorly quantified now, coordination of flows and fish needs would be more desirable than unplanned variability in flows.

4.3.2 Attraction Flows

We examined the available data for indications of the factors that attract fall chinook salmon and steelhead to the Mokelumne River. It is clear from escapement data for chinook salmon that years of exceptionally high flow in the Mokelumne River also had high escapement. However, statistical analyses do not show significantly positive relationships of escapement with flow across all of the years of record. The resource agencies are now conducting studies using coded wire tags and coordinated attraction flows on the Stanislaus, Merced, Tuolumne, and Mokelumne Rivers to evaluate the benefits of such flows. In 1987–1991, increased flows in the Mokelumne River attracted a large percentage of the total San Joaquin River chinook salmon run (Figure 3.3-5). In 1992, a dry water year, coordinated flow releases were provided from tributaries of the San Joaquin River to improve water quality conditions and attract salmon spawners into the system. Short-term attraction flow releases (600 cfs) from Camanche Dam, in conjunction with coordinated San Joaquin flows, favorably attracted salmon into the Mokelumne River that may not have entered the system otherwise, according to CDFG. However, the studies indicate that the Mokelumne River's gain is another river's loss.

Changes in flow or related factors, rather than steady high flow conditions, appear to cue adult salmon migration and might be used as a management tool. Data from the 1991 escapement study (EBMUD 1992g) illustrate the effect of environmental change on salmon migration. Adult fish movement did not begin in 1991 until the time when water temperatures dropped below about 63°F (17°C), in accord with results of other studies in the salmon literature. After this time, an increase in fish movement appears to have been triggered by a change in flow or a related condition. There were concurrent changes in flow and peaks in fish movement over Woodbridge Dam in late October, early November, and early December. There was a peak of fish movement in mid November that did not correlate with flow itself, but with precipitation that could have caused a flow-related change such as increased turbidity. Because there was precipitation each time flow and fish passage increased, there is support for a hypothesis that increase in turbidity, not flow itself, is the actual cue that stimulates fish movement. We have sought turbidity records for the Lower Mokelumne River in order to correlate them with escapement patterns. Neither turbidity nor migration data are sufficient for establishing a relationship.

If turbidity or another factor associated with a sharp pulse of flow were, indeed, the stimulus for adult salmon movement, considerable water could be conserved by reducing the magnitude of the fall attraction flow but retaining the initial pulse. Several pulses of higher flow followed by reduced flows spread through the fall might be more effective as an attractant than a prolonged high flow. It might even be

possible to induce a pulse of turbidity without increasing flow at all, and have both maximum water conservation and adult salmon migration (assuming flow is adequate for fish passage). Although these relationships are speculative now, they appear sufficiently promising to justify further study. Real-time monitoring of adult salmon in the Delta and timing of Lower Mokelumne River attraction flows to coincide with high fish concentrations is a possibility not fully explored by management agencies. Water could be conserved and the most fish attracted. The capabilities for such monitoring are not presently available but might be developed. Staff considers this option to be long-range and beyond the capability of current practice. As water conservation requirements become acute, the cost of such monitoring may become competitive with other measures.

CDFG Attraction Flow Alternative

The CDFG recommends high and sustained attraction flows in autumn amounting to 20 TAF during wet and normal years and 10 TAF in dry years, to be supplied between October 1 and November 15 (Figure 4.1-2). These flows, coupled with concurrent requirements for minimizing short-term daily streamflow fluctuations, would constitute a long period of gradually rising flows, sustained flows for a long period, and a period of gradually declining flows. Staff does not consider these flows to be justified when there is evidence that short spikes of high flow are effective attractants.

EBMUD Attraction Flow Alternative

We have not had a specific proposal from EBMUD.

Staff Attraction Flow Alternative

Staff proposes increased autumn flows in all years coincident with the lowering of Lake Lodi and after river temperatures have fallen below 60°F (15.6°C), generally between October 1 and November 15. Flows should be at least 300 cfs (weekly average) in normal and wet years, but may be reduced to 200 cfs in dry years. These flows can be allocated as short-term spikes within a weekly average. Discharges from Camanche Dam should be increased rapidly without ramping. Spike flows should be decreased slowly to avoid stranding of migrants. Staff also recommends studies by EBMUD, in collaboration with CDFG, to establish the amount and timing of flows and flow spikes that are effective in stimulating and maintaining adult upstream migrations. Flows above 300 cfs should be tested in wet or normal years when there is abundant water for experimental purposes. Staff recommends that enforcement of these limits be flexible and subject to coordinated determination by the agencies and EBMUD.

No Action

Adult migrations will be stimulated by the higher flows that occur when Lake Lodi is lowered. Migration past Woodbridge Dam will be stimulated by weather events that provide peak flows or flow-related changes, such as increased turbidity. Numbers of adults that return will be variable from year to year depending on unmanaged factors. There will be no special management action to encourage fish to return to the Mokelumne.

4.3.3 Spring/Summer Outmigrant Flows

The major outmigrations of salmon and steelhead smolts to the estuary and ocean throughout their ranges generally coincide with high flows associated with spring snowmelt. Although seasonal hydrology of watersheds has been altered markedly by dams and diversions, this trait of salmon and steelhead populations persists. There is general agreement among biologists that spring/summer outmigration has a

genetic basis cued by environment and that maintenance of elevated flows in late spring and early summer is important for preserving anadromous populations (Northwest Power Planning Council 1987). The higher flows both stimulate fish movement and facilitate rapid passage. Ongoing studies in the Central Valley using coded wire tags on the Stanislaus, Merced, Tuolumne, and Mokelumne Rivers by the CDFG and FWS are developing information to evaluate the benefits of coordinated pulse flow releases.

Staff evaluated alternative flow recommendations for their preservation of sufficient spring/summer flow in the Mokelumne River to stimulate and facilitate chinook salmon and steelhead outmigration. We reviewed the CDFG's calculations of water travel time from Camanche Dam to the Cosumnes River and from the Cosumnes River through the Sacramento-San Joaquin Delta (CDFG 1991). The assumptions behind this analysis were that faster water travel time would speed fish travel time and thus improve survival by minimizing exposure of the fish to high temperatures, predators, and diversions. We also reviewed EBMUD's estimation of habitat suitability during their proposed minimum flow regimes in spring and summer. The assumption behind the EBMUD approach was that suitable habitat for rearing and migration based on preference curves would be sufficient for emigration. Staff also recognized that flows in the reach from Camanche Dam to Woodbridge Dam would have to be large enough to provide for WID withdrawals.

Spring and early summer high flows are needed by species other than salmon and steelhead. Populations of all species in the Delta, including striped bass, American shad and Delta smolt, are adapted to higher flows at this time. The decline of these species appears to be related to loss of Delta inflow and resulting changes in salinity, temperature, and outflow. For the Delta ecosystem to be sustained, higher flows in spring seem essential.

CDFG Outmigrant Flow Alternative

CDFG proposed increased flows of short duration during April through June using 10 TAF during wet or normal years and 5,000 AF during dry years. They suggested the results of future studies would be needed to refine the timing, magnitude and duration of outmigrant flows (and that such flows would have to be coordinated with other releases and available water supplies).

CDFG used the COE HEC-2 computer program to calculate travel times between Camanche Dam and the Cosumnes River at several release flows. CDFG used appropriate methods, although channel profiles developed by the USGS (Simpson 1972) were more germane for higher flows than those of interest for the CDFG analysis and some updating of river cross sections was necessary. Travel times for the 40.2-mile reach ranged from 1.6 days at 1,000 cfs to 16 days at 25 cfs. Although travel time changed little at high flows, CDFG identified a marked increase in travel time at flows less than 200 to 300 cfs. Staff could not identify studies by CDFG or others that actually related water travel time to fish travel time or fish survival.

For the 4.2 miles of the Mokelumne River downstream of the Cosumnes River, CDFG compared travel times calculated with the use of current velocity data in the Delta computed by the DWR using a link-node tidal cycle computer model RMA-HYDRO at several Woodbridge Dam outflow rates (CDFG 1991). Staff was not able to analyze these calculations in detail, but believes them to be of questionable value, for the range of flows considered was not large and the results at low flows very disparate. Water travel times ranged from 0.2 day (4 hours) at 950 cfs to 12.7 day at 36 cfs, although at 4 flows between 28 and 52 cfs the estimates ranged from 0.5 to 12.7 days. CDFG acknowledged that correlation between flow and travel time of chinook salmon through the Delta has not yet been demonstrated.

EBMUD Outmigrant Flow Alternative

EBMUD proposes a pulse of water in the spring to accommodate juvenile outmigration (Table 2.2-2). This pulse would not be provided in critically dry years (presumably rare), but would amount to a rise from 100 cfs in mid-April to 400 cfs at the end of May in dry years and to 500 cfs at the end of June in normal and wet years. The basis for these flows is unclear, but staff has not been able to analyze the recent EBMUD material in detail. Based on the CDFG travel time calculations, these proposed flows would rise above the flow level at which travel times are especially long.

Staff Outmigrant Flow Alternative

Staff considers the general knowledge about salmon and steelhead outmigrations persuasive for some elevated flows at this time but finds the available information rather meager for establishing just what these flows should be in the Mokelumne River or how much water should be allocated for this purpose. The CDFG recommended water allocation might be appropriate but would depend greatly on how it was distributed. The EBMUD proposal seems responsive to CDFG's quantitative analysis of flows that critically affect travel time.

With meager evidence for defining specific recommendations, staff proposes that the studies suggested by CDFG to define timing, magnitude, and duration of outmigration flows to improve juvenile survival be implemented during years when water is available. Interim flows, including those proposed by EBMUD, would be agreed upon by all parties through the Mokelumne River Technical Advisory Committee in advance of the release year. Different flows would be selected for test years. Additional monitoring of juvenile travel time and survival would be implemented to evaluate the relative successes of the several interim flows. Staff anticipates that this experimental use of interim flows will take several years before the most suitable flows can be recommended.

Staff recommends 300 cfs (normal and wet years) and 200 cfs (dry years) as interim minimum flows for the month of May for Camanche Dam, not including obligations to WID and other water users. These flows would be in effect unless other coordinated actions were taken by the agencies and EBMUD.

No Action

Flows for juvenile salmon and trout outmigration will compete with reservoir filling and other objectives for the water volumes available. EBMUD may provide higher outflows from Camanche Dam in spring when water is available, but could be under no obligation to do so. Coordination of spring/summer flows through the Mokelumne River Technical Advisory Committee could come through debate of the matter, but without specific resolution or obligation.

4.3.4 Minimum Flows at Pardee Dam

In the summer of 1987 (a dry year) water was released from Pardee Reservoir at the rate of 230 to 450 cfs for 11 days beginning on June 22 when the Camanche Reservoir pool elevation was between 192 and 195 ft. Hydrolab temperature data collected in Camanche Reservoir between June 22 and July 16 were analyzed to determine whether this release significantly affected the temperature structure in Camanche. The analysis indicated no conclusive evidence of an effect on the temperature of water in Camanche Reservoir. The effect, if it existed, may well have been masked by the normal summer warming trend.

To test whether a cold water release from Pardee might lower release temperatures from Camanche Reservoir, the 1988 simulation of historical management practices in Camanche was modified to include a

20-day release of water from Pardee Reservoir between July 9 and July 29 beginning when the pool elevation was approximately 160 ft. Three simulations were run, with releases of 500 cfs, 1000 cfs, and 1500 cfs respectively. The model results presented in Figure 4.3-1 indicate that during periods of low pool elevation the temperature of releases from Camanche could be substantially lowered with such a strategy with a time lag of only a few days. The effects would last for several months due to the increase in pool elevation and volume of the hypolimnion. The simulations were run, however, without modeling the change in temperature as the releases flowed in the river channel from Pardee Dam to Camanche Reservoir. Before a strategy of such releases could be recommended, this possible temperature change would need to be simulated and a detailed analysis would be required to evaluate the effect on other water quality parameters of discharging at large flow rates into a shallow reservoir with contaminated sediments.

4.3.5 Reconsideration of Flood Control Operations

Based on the analyses that staff conducted for this FEIS, there appears to be room for improvement in the existing LMRP operational rules. For example, the flood storage requirements established in the agreement between EBMUD and the COE call for drawdown to begin in mid-September (Figure 2.1-4), before the initiation of upstream migrations of chinook salmon. The earliest that fall flood events have occurred in the Mokelumne River is mid-November (Figure 3.2-2). Therefore, the current operating rules force EBMUD to release water from Camanche before it can benefit fish resources. It may be possible to delay the fall drawdown of Camanche Reservoir by as much as a month, allowing flood control releases to benefit both fisheries and others. However, any revision of the LMRP upper rule curves would probably require a new system-wide study and the cooperation of the COE. Nevertheless, staff strongly encourages EBMUD and other interested parties to pursue this opportunity.

4.4 UPSTREAM FISH PASSAGE FACILITIES

Staff reviewed the CDFG assessment of adult fish passage in the Mokelumne River (Lower Mokelumne River Fisheries Management Plan; CDFG 1991) and EBMUD's evaluation (response to FERC questions) and conducted a site visit of Woodbridge Dam. Based on this information, a qualitative impression was obtained that is the basis for our recommendations. We considered riverine habitat for upstream migration and the fish passage facilities at Woodbridge Dam.

4.4.1 CDFG Upstream Passage Alternative

The CDFG identified three major barriers to upstream migration by adults, as follows:

- 1) instream passage barriers created by existing river channel conditions;
- 2) inadequate attraction flows from the Woodbridge Dam fishways; and
- 3) passage through the Woodbridge Dam fishways.

Instream Barriers. A potential low-flow instream migration barrier was identified by CDFG (1991) near Thornton just above the limit of tidal influence. CDFG conducted an instream flow analysis site at that point, with data collection and PHABSIM modeling. Although velocity was not a problem, water depth at low flows indicated that published criteria for minimum water depths for chinook salmon and steelhead (0.8 ft and 0.6 ft, respectively Thompson 1972) would not be met. CDFG also noted other published criteria that were somewhat more stringent (1 ft depth). The shallower depths more closely matched observed migrations through shallow reaches of the Mokelumne River at low flows. The agency concluded that flows at least 90 cfs were needed to maintain depths of about 1 ft. The specific

(A) Water Surface Elevations **(B) Discharge Temperatures**

Figure 4.3-1. Results of the simulation of Camanche Reservoir for historical 1988 management practices modifications consisting of increasing Pardee releases to 500, 1000, and 1500 cfs from July 9 to July 29. (Source: The staff.)

recommendation was to release 20 TAF during wet and normal years and 10 TAF during dry years from October 1 through November 15 to ensure adequate passage conditions.

Attraction Flows. CDFG analyzed adult fish movements into fish ladders under several conditions of water spillage and Lake Lodi elevations. In nearly all cases, fish had difficulty finding the fish ladders and were often attracted to zones (e.g., rocky base of Woodbridge Dam) where access to fish ladders was not possible. The agency concluded that access to the fish passage facilities by fish is obscure and hazardous for the fish. CDFG recommended that 1) attraction flows be improved both within the fishway and across the dam face leading to the fishway entrance; 2) a training fence be installed downstream of the dam to guide fish to the fishway and away from the dam; and 3) access from the river to the fishway be deepened.

Passage Through Fishways. There are two fishways at Woodbridge Dam, a concrete pool-and-weir fishway that is designed to operate when Lake Lodi is either filled or lowered (by adjusting the outlet) and a wooden Denil fishway that operates only when Lake Lodi is lowered. CDFG analyzed passage through these fishways in some detail for the Fisheries Management Plan (CDFG 1991) and found a number of deficiencies. On the basis of this analysis, the agency recommended 1) a new fishway be constructed on the east abutment of the dam; and 2) flows within fishways be maintained at design capacity.

4.4.2 EBMUD Upstream Passage Alternative

Staff received the EBMUD analysis and alternatives too late to conduct an analysis of them in this FEIS. We recognize that fish passage at Woodbridge Dam is primarily the responsibility of WID and CDFG and that EBMUD has no direct control over what is done at that location.

4.4.3 Staff Upstream Passage Alternative

Staff concurs with CDFG that habitat in the lower river can impede migrations, that attraction to the fish passage facilities at Woodbridge Dam would be confusing to fish, and that the adult fish passage facilities at Woodbridge Dam are inadequate and require modification if the full potential for adult escapement to the Mokelumne River is to be realized. Each situation requires EBMUD to work cooperatively with CDFG and WID to accomplish objectives that are beyond the scope of EBMUD's responsibility alone.

For conditions below Woodbridge Dam, staff recommends that EBMUD 1) formally participate with CDFG and WID to maintain the stream channel downstream of Woodbridge Dam (both close to the dam and fishways and at other locations downstream) to facilitate adult chinook salmon and steelhead migration and guidance to fish passage routes; and 2) provide flows adequate to cover shallow areas by a minimum of 1 ft. This work would entail studies adequate to judge the effectiveness of modifications and flows.

We believe the basic design of the weir-and-pool fishway is good with the exception of the use of the upstream exit as a control device for Lake Lodi water elevation. Partial closure of the gate at the fishway exit causes constriction that physically damages migrating fish. The Denil fishway appears to operate effectively during low Lake Lodi levels, but can be an obstacle at high levels. When Lake Lodi is high, spills can place water into the Denil fishway making it a blind channel for migrants. Staff recommends that EBMUD formalize a cooperative working relationship with CDFG and WID to modify the existing fishways and their entrances and to codify operational procedures to facilitate fish migration, including the conduct of studies to ensure that modifications are appropriate and successful. This effort would also include designing and installing an alternative method for controlling high-water releases from Lake Lodi

other than by the fish ladder gate. Staff does not concur with CDFG that an entirely new fishway is needed on the east abutment.

4.4.4 No Action for Upstream Passage

Without remedial measures to the adult fish passage capabilities in the lower river and facilities at Woodbridge Dam, there will continue to be adult migrants straying, delayed, or lost. Staff feels that the fish so affected are important to maintaining the populations of the Lower Mokelumne River. Because proposed remedial measures have a high likelihood of succeeding, the no-action alternative is not acceptable.

4.5 FISH SCREENS FOR DOWNSTREAM MIGRANTS

There may be less mortality of emigrating juvenile fall chinook salmon and steelhead trout if the effectiveness of screens and the fish bypass at the WID diversion from Lake Lodi is increased. Design of these facilities and their maintenance are the responsibility of CDFG under long-standing agreements with WID. There are some known problems, including loss of fish to the diversion through faulty rubber seals (a problem common to many rotating drum screens), obstructions for fish lateral movement at the screen supports, and low-attraction efficiency of the juvenile fish bypass that is partially caused by low-entrance velocity. Staff examined information on the screens provided by CDFG and EBMUD and concurs that the screens and the accessory fish bypass need improvement. Some of these improvements have been made as this EIS was in preparation.

Staff recognizes that timing of both fish migration and screen operation (water diversion) are important. WID does not begin to divert water until early April after some of the normal fry migration has already occurred. Full diversion of allocated water does not usually occur until after the smolt emigration in May and June. Nonetheless, significant numbers of fish pass Woodbridge when water is diverted, and effective screens and bypass are essential.

Importance of the fish screens for fish survival during downstream migration depends on the amount of river flow. At low flows, a larger percentage of the water at Woodbridge goes to the WID diversion than at high flows. With high enough flow passing through or over Woodbridge Dam, most fish will pass the diversion and any mortalities there would be of less significance to the population. Nevertheless, staff believes that the screen should be designed and maintained to minimize fish losses.

4.5.1 CDFG Fish Screening Alternatives

The CDFG recommends that the WID screens be upgraded to meet current statewide CDFG standards. They also recommend that the NSJWCD's diversion be screened. Because the maintenance of the WID screens is now a joint responsibility between WID and CDFG, staff feels that this work should be accomplished outside of this Commission proceeding.

4.5.2 EBMUD Fish Screening Alternatives

EBMUD planned to conduct a detailed evaluation study of the diversion screening and bypass. The study has been stalled by WID's desire to first perform maintenance on the seals under their agreement with CDFG (in which CDFG does the maintenance with 50% cost reimbursement by WID). EBMUD, however, wishes to evaluate current conditions.

4.5.3 Staff Fish Screening Alternatives

Staff considers improvement in the performance of the screens and bypass to be an important alternative for enhancement of survivorship of emigrating salmon and trout. This can be done only as a cooperative effort among the various parties. An evaluation of current performance seems essential. Refitting the drum screens with properly functioning seals is a maintenance item that should be attended to regularly. There are mechanisms for improving the attraction of a bypass at revolving drum screens that have been proven in other installations. At Three Mile Falls Dam on the Umatilla River in Oregon, drum screens did not injure juvenile fish and were 99.8% efficient in screening young chinook salmon from the canal. A minimum attraction flow of two ft/s has been shown to be needed in the entrance of such a bypass, and this can be supplied with a system that pumps water from the bypass back into the diversion canal, if necessary. A "sweep current" of at least 1 ft/s across the face of the screens is needed to move fish toward the bypass.

Staff encourages an immediate cooperative effort among CDFG, WID, and EBMUD to rectify the deficiencies in the design and performance of the WID screens. Although this action is important to fish passage and the sustainability of the Mokelumne River anadromous fish resources, the implementation of this action is outside this proceeding at this time.

4.5.4 No Action Fish Screening Alternatives

Many young trout and salmon will continue to be lost through inadequate screens if remedial measures (particularly routine maintenance) are not conducted. Inadequacies of the fish bypass will cause schools of migrating smolts to be delayed in Lake Lodi where they are vulnerable to predators and suffer physiological damage from high-water temperatures. These effects are known to adversely influence survival of a cohort of smolts.

4.6 OTHER NON-FLOW ALTERNATIVES

4.6.1 Spawning Gravel Rehabilitation

Staff conducted a qualitative assessment of the condition of the spawning gravel below Camanche Dam (based on its site visit and CDFG and EBMUD reports) and examined alternatives being conducted and proposed for its improvement.

River gravel below Camanche Dam, suitable for salmon spawning, is limited in abundance and rehabilitation is needed for the following reasons: new gravel supplies are no longer provided by bedload movement during flood events because of the dam and reservoir, infiltration of surface water into the groundwater has introduced fine sediments that have largely filled (cemented) the pore spaces, and biological materials (such as periphyton and rooted aquatic plants) flourish in the gravel bar areas and either plug interstices or cover the gravel. The high-water event of 1983, with its overflow of Camanche Reservoir and outwash of gravel at the spillway, demonstrated the value of gravel renewal for spawning salmon. EBMUD placed new gravel in the river in September 1990. The new gravel was not used in the 1990-1991 season, probably because fall chinook salmon are attracted to gravel that has been used the previous year. Enough tempering had apparently taken place by fall 1991 for the new gravel to be used for spawning. EBMUD studies also showed that spawning chinook in the Lower Mokelumne River prefer transition areas between spawning and non-spawning habitat types, especially berm areas.

Maps of redd locations in 1992 provided by EBMUD show heavy use of the artificial spawning gravels placed in 1990. This fact suggests that spawning gravels may be limiting and constitutes circumstantial evidence for the need for continued placement of gravels in the channel. An alternative explanation for the heavy use of gravels immediately downstream of the dam relates to the observation that fish commonly migrate upstream as far as they can, then concentrate spawning below the migration barrier. This behavioral pattern results in redd superposition and destruction of early-spawned eggs. Nonetheless, the artificial gravel emplacement appears sufficiently successful that it makes sense to expand these efforts. Additional gravels emplaced in October 1992 downstream in Van Assen Park were not heavily used by 1992 spawners, apparently reflecting a preference for gravels that have been "seasoned" by a year or more residence in the channel (Hartwell 1993).

Other steps to improve spawning habitat may require further study to justify. For example, if compaction (or immobility) of gravels below the dam can be documented, mechanical measures to loosen the gravels, such as "ripping" or use of hydraulic jets to loosen gravel and remove interstitial fine sediments may be justified. One of the difficulties in evaluating existing compaction problems and the success of any enhancement project is the lack of an accepted measure of compaction.

The reduced flood regime of the Lower Mokelumne River has had both positive and negative effects. It is not difficult to imagine that spawning gravels may have become relatively immobile given the reduction in shear stress and that this could lead to compaction and accumulation of interstitial fine sediment. However, this effect would also tend to limit losses of spawning gravels from the system. If flushing flow releases are proposed for the Lower Mokelumne River to cleanse the gravel, the objectives of these releases should be clearly stated and the success of the efforts should be evaluated. The potential for loss of spawning gravels from the channel is a constraint upon magnitude of optimal flushing flows. Flushing flows can be prescribed to entrain gravels, thereby liberating fine sediment and maintaining gravel looseness. However, to disrupt already impacted gravels by flow alone might require releases so large that once the pavement were disrupted, unacceptable gravel loss occurred. Moreover, such releases would be more costly in lost water and power revenues.

CDFG Spawning Gravel Rehabilitation Alternatives

CDFG (1991) recommended that gravel improvement projects be conducted, but did not specify details. The agency also proposed restrictions on gravel extraction operations in the reach below Camanche Dam by commercial gravel suppliers.

EBMUD Spawning Gravel Rehabilitation Alternative

Gravel additions by EBMUD are proposed to continue. A second placement of gravel was accomplished in August 1992. Three hundred cubic yards of gravel were placed in the spawning reach. There is also a planned five-year program of gravel additions cofunded by EBMUD and the California State Parks Department.

Based on the results of the 1991-92 spawning habitat preference survey, EBMUD is planning specific gravel improvement projects (Hanson Environmental 1992a). They plan to create gravel berms (found attractive to spawners) and to break up existing spawning gravels that have been affected by cementation (avoided by spawners).

Staff Spawning Gravel Rehabilitation Alternative

The gravel addition and rehabilitation programs appear to be useful and staff recommends that they proceed. There are other gravel rehabilitation techniques that may be more cost effective than adding new gravel supplies and these should be investigated. Mechanical gravel cleaning has been used effectively elsewhere for many years. Placement of boulder or "digger logs" in channels can stimulate existing river flows to rework streambed gravel and cleanse it of fine materials. If fish runs are increased, the spawning salmon provide an annual stirring of the gravel in the most productive spawning areas.

No Action Gravel Rehabilitation Alternative

Spawning gravel that is satisfactory for salmonid reproduction will remain restricted and could be the limiting factor for production of young fish in many years. Considering the demonstrated success of gravel rehabilitation, the no action alternative is not acceptable.

4.6.2 Mokelumne River Fish Facility (MRFF)

An important component of the existing Commission license is the requirement that EBMUD continue to mitigate losses of salmon and trout at Camanche Dam by operating the fish hatchery (MRFF). Some of the recent proposals for operation of the fish hatchery relate directly to instream conditions; for example, time of year for outplanting in the river below Camanche Dam (based on environmental conditions at the time) and stocks to be raised (that will affect the genetic makeup of fish that comprise the naturally spawning fish). Staff examined the fish hatchery operation in CDFG reports, minutes of the Mokelumne River Technical Committee, and EBMUD documents.

The MRFF has not lived up to expectations for sustaining chinook salmon and steelhead runs at the state's desired goals. Since completion of the hatchery, the chinook salmon run size in the Mokelumne has varied from a few hundred fish to nearly 16,000 with the goal of 15,000 fish reached only once (Figure 3.3-1). The hatchery processed only an average of 490 adult chinook per year (range 0–1,782) and 28 adult steelhead (0–215) over the period 1964–1988. Production of chinook salmon increased markedly in recent years, attaining plantings of 3.5–4 million juveniles. Steelhead production was generally greater in the early years of the hatchery although comparable production levels have been attained recently.

The hatchery has, however, been able to contribute to sustaining the Mokelumne River chinook salmon run at the sizes observed in the 19 years before Camanche Dam was closed. We compared the run sizes before and after Camanche closure (CDFG 1991; Figure 3.3-1) statistically and found no difference (Student's *t*; $P > 0.4$). How much of the run retention is attributable directly to the MRFF is not known.

During its history, the hatchery experienced several setbacks and changes in direction. The facility first began operation as a spawning channel facility built to provide semi-natural spawning habitat for adult salmon and trout from October to June. It failed to demonstrate successful production and was converted to a combination holding pond and waste treatment wetland. Use of the channels was believed poor; because of the facility's size, the adult usage and production of juvenile salmon and trout could not be well documented. A hatchery building was added with a capacity to incubate 320,000 eggs. With unused hatchery capacity, CDFG augmented mitigation activities at the facility with additional chinook salmon production to augment the stocks available to the ocean troll fishery. Costs of this production are supported by the troll fishermen and juvenile salmon produced at the Mokelumne hatchery are planted in the western Delta. Eggs of chinook and steelhead have also been transferred among the CDFG hatcheries in the Central Valley.

During low water years, especially since 1988, poor water quality in the forms of high temperatures, high hydrogen sulfide, low DO, low pH, and high metals content has plagued the hatchery water supply and apparently caused deaths of fish and poor growth. Despite installation of an aerator, a floating raft to obtain a selection of depths for the water supply, and water quality monitoring equipment, hatchery managers and EBMUD have been unable to develop a mutually satisfactory working arrangement for assuring good water quality and continually high fish production.

There is an inadequate system of accounting for fish raised at the MRFF to meet mitigation requirements of the Commission license. As has been observed by others (Hanson Environmental 1992b), there is no clear statement of specific mitigation obligations and an accounting system to document that mitigation obligations have been satisfied. EBMUD currently pays about half of the MRFF operating and maintenance costs each year. CDFG pays part of the cost for the hatchery manager's time, supporting staff time, and equipment from the Salmon Stamp Fund rather than from agency appropriations (of which none are used).

CDFG uses the EBMUD hatchery and rearing facilities in support of several nonmitigation programs. These include raising fish from other rivers and hatcheries in the Central Valley (e.g., American River and Feather River). For this use, CDFG "pays" EBMUD an allotment of 20,000 "rental fee" steelhead that are stocked in Pardee or Camanche reservoirs. For its part, EBMUD has chosen not to count fish raised under poor water quality conditions as part of the mitigation obligation, deferring such obligations to subsequent years when conditions are more satisfactory. Thus, the fish and the years that are for mitigation become muddled.

The ability to set and meet mitigation obligations is complicated by not having a clear, documented relationship between the 1961 agreement obligation (hatchery production equivalent to the production from 15 million salmon eggs, presumably natural production) and the number of chinook salmon fry, smolts, or yearlings that would be required to be released. This is not just an accounting and documentation problem. The yield of 15 million fall chinook salmon eggs, at whatever stage of development, is uncertain at best and highly variable in the natural environment that is being mitigated. Data to estimate the pre-1961 survivorship as a basis for agreement are not available. There may be relevant information for other Central Valley stocks but staff has not been able to locate it. Whether the obligation should be based on 1961 survivorship data or current survivorship is also not determined.

Survivorship has decreased markedly since 1961 as all studies of the Central Valley stocks have shown. Thus, the mitigation requirements for fry or other stages might have to be increased to accommodate the decline in natural survivorship to maintain the constant yield to adults anticipated in the license.

Staff feels that coordinated development of the MRFF is needed to maximize the management potential for the Lower Mokelumne River fishery resources. Development of the MRFF is proceeding independently and sometimes incompatibly by CDFG and EBMUD.

CDFG Hatchery Alternatives

The CDFG does not have a clear plan for operation of the MRFF that staff could examine.

EBMUD Hatchery Alternatives

EBMUD has prepared a master plan for the facility with Fish-Pro, a professional fish hatchery development firm, as contractor. The CDFG has been consulted in the planning process. Because of the upcoming master plan, the Mokelumne River Technical Committee has recommended that facilities

planned independently by CDFG (e.g., new rearing ponds) be deferred. The schedule for the master plan has been concurrent with preparation of this environmental impact statement. The plan would use the MRFF as an important part of the District's fisheries enhancement of the Lower Mokelumne River. Particularly, it would use the MRFF to sustain steelhead for which natural habitat in the Lower Mokelumne River is lacking (Section 3.3.2). Staff generally agrees with the plans for the fish facility by EBMUD. The focus of the EIS, however, is on flows and other in-river features on naturally spawning fish.

Staff Hatchery Alternatives

Staff concurs with development of a master plan for the MRFF including coordination with CDFG in its development and implementation. The plan should include evaluation of the effects of actions at the MRFF on the in-river fisheries. Staff recommends that brood stock for the MRFF be obtained from local migrants to reduce genetic mixture and perhaps attain a Mokelumne River stock (see Section 4.8.4).

No Action Hatchery Alternative

Maintaining the status quo at the MRFF will have marginal benefits to fisheries in the lower river.

4.6.3 Transportation

EBMUD's Fishery Management Plan has proposed a "trap and truck" operation to transport juvenile chinook salmon from the rearing areas above Woodbridge Dam to sites downstream of the Delta in dry and critically dry years when temperature conditions suitable for outmigration cannot be maintained. The apparent efficacy of releasing smolts from Central Valley hatcheries downstream of the Delta, based on adjusted ocean retrieval rates of coded wire tags as the index of success, was discussed in Section 3.3.1, *Factors Affecting Survival of Juvenile Chinook Salmon*.

Studies of fish transportation effectiveness in the Columbia River system, however, have noted a markedly diminished adult survival during the course of upriver migration of fish transported as juveniles compared to non-transported fish (AHTRG 1992). These studies question whether the long-range effectiveness of transportation for yielding more adults on the spawning grounds is as good as indicated by the Central Valley studies based on ocean catches or by earlier interpretations of the Columbia River data (e.g., Matthews et al. 1992). Some of the losses in upriver migration may be caused by straying by fish that have not been fully imprinted with the water chemistry of their migration route. The Columbia River studies demonstrated that fall chinook salmon groups emigrating later in the spring-summer season, when there is decreased flow and increased temperature, benefitted more from transportation than did the earlier migrants. The study expresses concern, however, over "the impression that the transportation program is a substitute for good migration conditions." "The overall trend in decreasing recovery rates...would suggest otherwise. If transportation is to be considered as a long-term mitigation measure, then it must be recognized as only part of the solution to the problem and more emphasis should be placed on when and how transportation as 'part' of a mitigation package is applied."

Staff evaluation of the situation on the Mokelumne does not yield a clear definition of the part transportation should play. There is no clear breakpoint separating conditions for which it is better to allow smolts to migrate downstream themselves and when human assistance becomes necessary, even though the value of each alternative is clear in the extreme.

CDFG Transportation Alternative

CDFG management plan includes continuation of the current practice of trapping and trucking fish from the WID screen bypass in June during dry years.

EBMUD Transportation Alternative

EBMUD proposes a permanent smolt trapping facility at the upstream end of Lake Lodi to intercept naturally spawned juvenile chinook salmon in June and July of dry and critically dry years when temperature criteria cannot be met in the Lower Mokelumne River below Woodbridge Dam.

Staff Transportation Alternative

With understanding of the limitations of transportation for homing, and the preference to maintain natural migrations as much as possible, staff feels that trapping of juvenile chinook salmon during their outmigration and trucking them downstream of the Delta for release, as an emergency measure in years of low flows and high temperatures, can be an effective part of salmon management in the Lower Mokelumne River. Staff recommends transportation only after imprinting in the river near the time of smoltification. The EBMUD plan for smolt capture before entering Lake Lodi appears superior to the use of the WID bypass because fish losses are likely to be high in Lake Lodi in June and July of the low-flow, high temperature years when trapping and trucking would occur. Staff recommends that a study plan be implemented in concert with the trapping and trucking operation to evaluate its effectiveness in relation to fish not trucked past the lower river.

No Action Transportation Alternative

With no action, CDFG will continue to trap late-run juveniles at Woodbridge Dam screen bypass and truck them to the lower Delta. No other action will be taken.

4.6.4 Manipulation of Fish Stocks

Yearling Fall Chinook Salmon Releases

Release of hatchery-raised chinook salmon yearlings in the fall seems to provide opportunity for enhanced survival. The CDFG conducted experimental releases of nominal yearlings (actually about 10 months old) of the Mokelumne River stock from the MRFF in the fall. Such releases have been tried because water temperatures in the Lower Mokelumne River and delta are high during the natural outmigration period for fall chinook salmon (March through June) and survival is presumed to be low (Section 3). These fall fish, held in the hatchery ponds through the summer to attain a larger size, are released when temperatures are falling in the river and delta and after the diversions to WID and the lower delta have ceased or decreased markedly. Thus, the relatively high risks associated with small size and poor environmental conditions are decreased.

There were 100,000 fish of the 1990 brood year released on November 1, 1991, during the fall attraction flow period. None of these fish were marked so the relative effectiveness of the fall planting cannot be evaluated when the adults return.

A group of 1991 brood year fish was marked with coded-wire tags and about 100,000 fish were released in November 1992. This group should be suitable for evaluating the fall-release program.

This fall planting of fall chinook salmon should be an effective way to increase survival of hatchery-raised fish in their emigration through the river-estuary environments. Use of the coded-wire tags should allow this advantage to be quantified when ocean catch and adult escapement are determined. Until such time, 4 to 5 years hence, the experimental releases should continue. For comparative purposes, however, there should be a comparable group of marked fish released each spring. Currently, this is being done, and it should continue.

However, a trade-off exists for increased survival during emigration. That trade-off involves maintaining adequate temperatures, water quality, and holding space at the MRFF through the summer for the underyearling chinook. In principle, this is being done with steelhead. Problems maintaining steelhead through this period, however, make the outlook for chinook somewhat problematical. If measures are taken to ensure temperature and water quality suitable for steelhead, then conditions may be suitable for chinook salmon (assuming physical space is available). We evaluated the relative holding requirements of steelhead trout and chinook salmon and found them generally comparable, although steelhead are somewhat more tolerant of temperatures near 68°F (20°C).

Use of Alternative Chinook Salmon Stocks for Hatchery Releases

Late-Run American River Stock. An alternative practice for conservation of chinook salmon stock is to use late-run fish for hatchery production of yearlings for fall release. Using these fish in this way has several theoretical advantages that might boost Lower Mokelumne River salmon production. Alternative management of late-arriving fish has been evaluated.

The reproductive success of late-arriving adult chinook salmon in the Lower Mokelumne River is likely to be negatively impacted by several factors. Although adult survival and egg condition are probably better in the cooler river temperatures of late November and December, spawning and incubation success can be problematic for several reasons. Suitable gravels below Camanche Dam are already used by fish arriving earlier. There is a documented tendency for later arrivals to construct redds at locations farther downstream where gradient is lower and gravel conditions are less suitable. This selection of poorer redd sites may reduce incubation success. If more upstream sites were selected, redd overlap could cause destruction of embryos from earlier spawns. Temperature in late stages of incubation is perhaps most critical. Because of late fertilization, the winter incubation period may extend into unsuitably warm temperatures in spring and fewer emergent fry may result. With later emergence, the time period for growth before arrival of unacceptably warm river temperatures is reduced and fully grown smolts may not be produced (or smoltification may occur in smaller fish that have less chance of survival). Although riverine rearing over the summer could theoretically take place, the evidence suggests that very few fish survive or remain in the Lower Mokelumne River to emigrate in the fall.

The late arrivals that could otherwise be wasted (their progeny not survive) or compete with earlier arrivals (redd overlap) could produce viable offspring with hatchery management. If collected at the Woodbridge fish ladder, these fish would be prevented from destroying redds of earlier arrivals. Hatchery propagation can be controlled to yield abundant fish for fall plantings. The benefit would be more fish for the system.

Conversely, there could be disadvantages for the population. If late arrival is a genetic trait, a higher percentage of late arrivals could be stimulated in the Lower Mokelumne River and the Central Valley system. More late arrivals attempting to spawn naturally would face the risks of high temperatures in the spring and generally poor survival. If late arriving chinook salmon were taken in the American River and transported to the MRFF, as has been suggested by CDFG, there could be a mixing of stocks to the detriment of any unique Mokelumne stock that remains.

Staff does not recommend the use of American River stock. However, propagation of later-run Mokelumne River fish as an experiment would have value and should be considered.

Spring Chinook Stocks. It has been suggested that spring-run chinook salmon stocks be introduced in the Lower Mokelumne River as a substitute or supplement to the fall run that now occurs and for which the Camanche Dam mitigation is designed (Hanson Environmental 1992a). Although spring chinook probably used the Mokelumne River before damming, mining, and overexploitation that began in the late 1800s, this run has not been present since record-keeping began. The justification for the proposal relies on information from coded wire tag studies of Sacramento River hatchery outplants that show greater survival and returns of this run. The difference is presumed to be because spring-run juveniles migrate from the Bay-delta system earlier in the spring when there are lower water temperatures and less water is being withdrawn. Another justification is the timing of adult returns, which occurs at the same time as the juveniles emigrate, thereby providing double use of water resources allocated for attraction and outmigration flows.

Staff evaluated this alternative and does not recommend it. The chinook salmon run that is mitigated in the Mokelumne River is the fall run and staff feels that this run should remain the focus of efforts. Also, conditions in the Lower Mokelumne River are not well suited for spring chinook. Water temperatures in late spring and summer are clearly not suitable for adult survival, egg incubation, and fry survival and growth. Thus, the run would need to be supported totally by hatchery operations. It is doubtful that the MRFF could provide suitable temperatures for adult holding or egg incubation in summer without mechanical chilling of water supplies. Supplementation of wild fall chinook salmon by hatchery spring stock has the potential for creating competition in the wild for available resources that could cause further losses of the fall stock. Although there is theoretical double use of water resources for adult attraction and smolt emigration, a fall attraction flow will still be needed for the fall-run chinook and steelhead.

Reestablishment of Native Mokelumne River Stock

In addition to goals for increasing self-sustaining runs of fall chinook salmon to the Lower Mokelumne River, there have been calls for reestablishment of a native stock. Premises of this proposal are that (1) there was a native stock particularly adapted to the conditions in the Lower Mokelumne River; (2) this genetic strain is still extant; and (3) the stock could be detected and selected for enhancement.

Staff does not find this proposal to have much chance of succeeding. Existence of a unique Mokelumne strain is problematic. Fall chinook salmon are known to stray naturally. If there was a unique genetic strain, this has probably been lost in recent years. High straying rates of spawning runs to Central Valley rivers in recent years documented in Section 3.3 ensure that stocks from various natal sources are now mixed. Hatchery transfers among rivers have also interchanged genetic materials. Even though there is casual evidence that some fish in the early years of this century were able to pass the unladdered Woodbridge dam, any native stocks would have been severely reduced by a combination of factors given in Section 3.3. Thus, any native genetic material is likely thinly dispersed with that of other Central Valley stocks. Detailed study of genetic material would be necessary to detect a unique Mokelumne strain. If characteristic Mokelumne River material is found, then a lengthy program of captive breeding would be necessary to "purify" the stock.

A less rigorous program could accomplish some of the objectives of those wanting a Mokelumne stock. By simply always taking brood stock from those fish ascending the Mokelumne and resisting overtures to move stocks between river basins, a locally adapted stock may develop. Straying during natural migration will remain a problem, but this can be minimized by not using excessive attraction flows in autumn. Staff therefore recommends that stock selection for future hatchery operations be limited to local migrants.

Reestablishment of Warmwater Game Fishes Below Woodbridge Dam

Reestablishment of warmwater game fishes below Woodbridge Dam has been proposed by CSM. This is not, to our understanding, a management objective of the CDFG. In contrast, expansion in numbers of these species would likely increase the rate of predation on juvenile salmonids as they migrate from the Lower Mokelumne River to the ocean. With passage in the lower river and Delta a major cause of salmonid losses, staff does not believe that such a program would be compatible with the salmonid enhancement program of CDFG, EBMUD, and others. Staff has discussed these species (Section 3.3) but purposely does not recommend actions on their behalf in the Lower Mokelumne River.

4.6.5 Water Quality Enhancement

Staff conducted a qualitative review of EBMUD plans for adding oxygen to the hypolimnion of Camanche Reservoir without altering thermal stratification. The objective of oxygenation is to improve the chemical quality (DO, hydrogen sulfide, metals) of water released in summer and fall to the MRFF and to the river via hydropower discharges and direct dam discharge, while maintaining low temperatures. Also examined were alternatives to the specific apparatus for hypolimnetic oxygenation and alternatives to in-lake oxygenation in the form of oxygenation at the hatchery. Installation of a selective withdrawal system to Camanche Dam was also considered as a means of controlling water quality in discharges from the reservoir.

CDFG Water Quality Enhancement Alternative

CDFG has not proposed oxygenation, although the hatchery uses aeration at point of use. The agency has suggested selective withdrawal as a possible solution to water quality problems (CDFG 1991).

EBMUD Water Quality Enhancement Alternative

EBMUD is developing plans for adding oxygen to the hypolimnion of Camanche Reservoir near the dam using a device called a "Speece Cone." This device dissolves gaseous oxygen in the water and mixes oxygenated water with the surrounding water without creating vertical mixing. The undesirable vertical mixing would disrupt thermal stratification and the ability of the reservoir to retain cool water for release to meet fish temperature requirements.

Hypolimnetic oxygenation is believed by EBMUD to be the most appropriate technique for simultaneously improving quality of all three potential discharge routes. It attacks the problem at the source. This source is the unmixed, deeper layers of Camanche Reservoir where an oxygen deficit in summer and early autumn causes oxygen depletion and adverse chemical reactions characteristic of anaerobic aquatic environments. By correcting the problem at the source, EBMUD has the option of water release from the dam using any discharge mode and it can supply the MRFF with good quality water. Use of oxygen rather than air ensures that the process is most efficient (oxygen is about 20% of atmospheric air; aeration would involve the costs of moving and dissolving the remaining 80%, mostly nitrogen). By using a Speece Cone, the oxygen is applied within the hypolimnion without mixing this cool layer with the warmer upper layers (epilimnion and thermocline). Mixing is undesirable because the hypolimnetic water would be warmed and the cool temperatures are needed for maintenance of salmon and steelhead at the MRFF and in the Lower Mokelumne River.

Staff's Water Quality Enhancement Alternatives

Staff also reviewed alternatives for improving water quality of Camanche Dam discharges. These alternatives include other methods for hypolimnetic oxygenation and oxygenation of the MRFF water supply, and selective withdrawal from Camanche Reservoir.

Hypolimnetic oxygenation. Staff finds hypolimnetic oxygenation desirable because it preserves and enhances the ability to generate hydroelectric power at Camanche Dam without degrading the water quality of the Lower Mokelumne River. The hydropower intake is located close to the bottom of Camanche Dam and it withdraws water from the hypolimnion in summer. This water is often of poor quality (particularly low DO and elevated hydrogen sulfide). EBMUD must now switch from valuable hydropower production to releases to the river through spray valves in summer when reservoir water quality deteriorates. Such suspension of hydropower production was begun in the summer of 1987. The aerating valves provide oxygen and remove hydrogen sulfide as the water enters the Lower Mokelumne River, but they provide no hydropower benefits.

There are other alternatives available for preserving hydropower and downstream water quality. Aeration of the hydropower releases themselves is possible through turbine venting and has been accomplished at several projects of the Tennessee Valley Authority (Bohac and Ruane 1991). However, this alternative would not help provide better water quality to the fish hatchery or reduce the liberation of metals from sediments that occurs in anoxic waters. In fact, it would promote the deposition of metals in river gravels thus contributing to undesirable cementation of spawning areas (a condition now prevalent). Aeration of the entire water column in the dam forebay can be successful, as has been demonstrated at the COE's Russell Dam on the Savannah River (Gallagher and Mauldin 1987). However, preservation of the cool hypolimnion temperatures needed for both the hatchery and the lower river is vitally important to the Lower Mokelumne River salmon and steelhead restoration program.

Staff does not consider hypolimnetic aeration to be an experimental technique, for it has been demonstrated over nearly 20 years at a number of locations (Lorenzen and Fast 1977; Pastorok et al. 1982). However, experience has shown that implementation at any particular site involves some degree of adaptive engineering that can be considered experimental until a satisfactory system is developed for the site. It has taken several years for the system at the Richard B. Russell Dam, for example, to be truly functional.

Other types of apparatus besides the Speece Cone are available for accomplishing hypolimnetic aeration. These systems include one described by Kortman et al. (1988). Performance of these alternatives is generally similar and all have demonstrated the same general advantages. Staff feels that the selection of the specific vendor should be EBMUD's prerogative.

Oxygenation of MRFF. Vendors supply highly efficient devices for adding oxygen to hatchery water supplies at the point of use. The configuration of the MRFF below Camanche Dam and its use of hypolimnetic water is not unique. Several techniques have been developed and are marketed for coping with such a situation. For example, oxygenation columns are used at the Lake Rathbun Hatchery below Lake Rathbun, Iowa, to augment DO in hatchery water supplies.

All devices such as Low Head Oxygenation System (Ziegler) and In-Line-Ox (VMG Industries) use the same principle of bubbling pure oxygen through diffusers in a form of containment (boxes, towers, etc.) through which the hatchery or raceway water is supplied. The advantage is highly efficient control of DO at the point of use and the enhanced capability to reuse (or extend the use of) water supplies. The efficiency of oxygen addition would surpass the aerators now in use at the MRFF that were installed in

1990. The disadvantages are related to high cost of a distributed system, not fully removing hydrogen sulfide or other contaminants derived from chemical reactions in the anoxic hypolimnion, and not treating all of the possible Camanche releases simultaneously.

Selective Withdrawal. At considerable expense for modifications of the water release structures of Camanche Dam, a method could be provided for allowing selective withdrawal of water from alternative depths in the reservoir. This form of release is common in many reservoirs and it successfully provides adequate water quality in discharges during annual changes in stratified conditions and degraded reservoir water quality (Bohan and Grace 1969; Imberger 1980). Staff does not consider a reworking of Camanche Dam to be feasible or cost effective at this time, however. Alternatives to major dam restructuring to accomplish similar benefits include the use of flexible curtains upstream of the dam as barriers to control release temperature and water quality (Johnson 1991; Johnson et al. 1993). The U.S. Bureau of Reclamation has experimented with such curtain barriers at Shasta and Lewiston Dams in California (Johnson et al. 1993). Staff does not consider these tests to be sufficiently conclusive to warrant recommendation of this method at Camanche Dam.

Although seemingly attractive, the development of selective withdrawal at Camanche Dam for water quality and temperature control includes high expense and considerable uncertainty. For these reasons, staff does not recommend this alternative.

In summary, for water quality enhancement staff supports EBMUD's experimental use of hypolimnetic oxygenation as an appropriate solution to water quality problems in Camanche Reservoir, Camanche discharges, and the water supply for the fish hatchery. The emphasis must be on the term "experimental" at this stage for although similar techniques have been used elsewhere, satisfactory performance at Camanche Reservoir is not assured and must be demonstrated. Staff does not recommend the point-of-use alternatives as an overall solution although they may still be useful for additional DO augmentation within the hatchery (such as for water reuse if there must be mechanical chilling).

No Action Water Quality Alternative

No action will require extensive aeration of water releases to both river and hatchery to meet oxygen requirements. Chemical quality will remain poor in years when reservoir elevation is low, with hydrogen sulfide and dissolved metals being the main problems. Chemical treatment of hatchery water supplies for H₂S removal will continue to be necessary in late summer and early autumn. It is this situation that most parties agree is unsatisfactory.

Staff reviewed the sequence of water quality conditions in Camanche Reservoir, river discharge, and MRFF water supply from 1989 through the present as described by Bowen (1992). The steps taken by EBMUD were reasonable and responsive to the poor water quality situation as it developed and was understood. The current solution, hypolimnetic oxygenation without destratification, is the state-of-the-art treatment for such a situation and staff concludes that it is appropriate.

4.6.6 Restriction of Angling in Salmon and Steelhead Spawning Areas

It was reported to staff that anglers seeking trout in the reach of river below Camanche Dam have been trampling redds and thus perhaps damaging embryos. Use of the fishery resource may thus be inadvertently detrimental to it. This is a possibility but neither damage nor lack thereof has been demonstrated. The alternative for protection of salmonid resources would be to restrict angling in the reach during October to May when eggs of either chinook salmon or steelhead would be incubating.

Staff has little information on which to evaluate this option and make a recommendation. The situation is only marginally related to the hydropower license at Camanche Dam. As CDFG is the enforcer of angling regulations, staff feels that it is the CDFG responsibility to adequately regulate the fishery to protect the resource. Staff does not recommend action related to the Commission's responsibilities.

4.6.7 Rearing Habitat Improvements for Chinook Salmon and Steelhead

Staff analyzed the habitat requirements for rearing of chinook salmon and steelhead juveniles (Sections 3.3.1 and 3.3.2) and compared these requirements to available habitat in the Lower Mokelumne River to see if physical improvements could be made. In general, juvenile chinook salmon would be favored by an increase in small pool habitats; steelhead would be favored by an increase in rocky, bouldery riffles and runs.

For chinook salmon, the critical component of habitat is the availability of pools in close proximity to upstream riffles and runs. A second necessary component is adequate riparian cover for the non-dominant juveniles that occur in open pools and along pool margins. This information is not provided by IFIM studies at the fish screen, spillway, Bruella Road, and pasture sites that were conducted in fixed transects even though they are presumably representative of the rest of the river. Staff has been unable to find a quantitative study of pool habitats in the Lower Mokelumne River.

For steelhead there are essentially no rocky, bouldery riffles or runs in the Lower Mokelumne River. Existing riffles and runs are composed of small gravel, even in the tailwater section. Riffles and runs are also the habitats that are most dewatered at low flows often prevalent below Camanche Dam. Thus, habitat for juvenile steelhead is deficient, and perhaps one reason why steelhead have not developed a self-sustaining population in the Lower Mokelumne River after Camanche Dam (the river in the reach flooded by Camanche Dam is reported to have had much more rocky, bouldery substrate). Higher flows in the Lower Mokelumne River would likely improve the suitability of riffles and runs for steelhead, at least in terms of water depth. Flow increases would be unlikely to affect the availability of rocks and boulders as shelter and cover, however. Therefore, staff concludes that flow alternatives alone will be unable to provide suitable habitat for juvenile steelhead in the Lower Mokelumne River.

CDFG Rearing Habitat Improvement Alternative

CDFG has not proposed specific non-flow alternatives for improving rearing habitat for chinook salmon and steelhead juveniles.

EBMUD Rearing Habitat Improvement Alternative

EBMUD has not proposed specific non-flow alternatives for improving rearing habitat for chinook salmon and steelhead juveniles.

Staff Rearing Habitat Improvement Alternative

Staff recommends habitat improvement to increase the relative abundance of small pools with velocities <0.15 m/sec. and interconnecting channels to augment chinook salmon rearing. Such a pool and channel system might be developed through use of abandoned gravel dredging sites along the river without major increases in river flow. These gravel pit areas extend from about one mile downstream of McIntire Road (the access to the MRFF) to about 3 miles downstream of Mackville Road near Clements, all adjacent to the main spawning and rearing areas of the Lower Mokelumne River (Figure 4.6-1). Richards et al. (1992) showed that small (100-200 ft long), off-channel mining dredge ponds with interconnecting

channels markedly increased the chinook salmon rearing habitat of the Yankee Fork of the Salmon River, Idaho, when the abandoned ponds were connected to the river and each other and water flow through the ponds was controlled.

Staff's examination of US Geological survey maps and channel surveys of the area (Simpson 1972) suggests that much more chinook salmon rearing habitat could be created by management of the adjacent gravel pit ponds—interconnected and provided with Mokelumne River water—than could be attained in the existing river channel through flow manipulations. The most suitable location might be between the bridges of Highway 88 and Mackville Road, where existing gravel pit ponds are inside the 5,000 cfs floodplain and some are already connected to the river (Figure 4.6-1). A detailed survey of these gravel pit areas would be necessary for a more thorough evaluation of this alternative, and, if built, there should be careful monitoring to assess the results. The ponds would be useful in the March through May period before water temperatures would be warmed excessively. Riparian plantings along the ponds would be necessary to provide shading and pool-edge cover for the fish, as Richards et al. (1992) found cover to be one of the most important correlates with salmon abundance. With careful design and management, using guidelines for evaluating stream habitats, the recommended pools and channels could simulate important aspects of natural rivers. These features would include the riparian community flooding and natural backwater areas that naturally occurred during high unimpaired flows during the critical April through May period of chinook salmon rearing. These are areas where juvenile chinook salmon naturally would have fed on abundant terrestrial insects. The ponds could receive hatchery-produced fry for imprinting and adjustment to the wild as well as wild fry that enter with river water. Hatchery fish often require months to lose their affinity for high densities and flume-like conditions (Richards and Cernera 1989). Smolts could be flushed from these pools by appropriate water management at the time of increased outmigration flows in the river.

These pools would be a different habitat type than exists in Lake Lodi under current conditions. Lake Lodi is principally a large overbank shallow zone with a submerged central, sinuous channel. The most upstream end of the lake probably provides a pool habitat preferred by chinook salmon juveniles, and it may also be suitable for enhancement. However, the lake's long channel does not match the many head-of-pool locations for dominant juveniles that would be found in a series of small pools, and the shallow, exposed overbank wetlands do not match the shaded pool-edge habitat used by schools of subdominants. Shallow overbank habitat in Lake Lodi is rapidly warmed to temperatures exceeding those to which chinook salmon are adapted (<20°C; 68°F) and the shallows are also frequented by bird predators.

Staff also recommends habitat improvement for steelhead by installation of coarse substrate of boulders and large woody debris in selected high-gradient riffles and runs not used for chinook salmon or steelhead spawning. Such streambed modification would simulate the normal rearing habitat of steelhead juveniles in more upriver locations now submerged or inaccessible.

No Action for Rearing Habitat Improvement

The no action alternative does not include any physical improvement of rearing habitat other than that obtained through minimum flow restrictions. Staff is concerned that minimum flow restrictions alone are not enough to provide adequate habitat for rearing salmonids. The creation of a more heterogeneous environment (i.e., a better mix of pool and riffle habitat) may be necessary to achieve the full benefits of limited flow in the Lower Mokelumne River.

Figure 4.6-1. Mokelumne River floodplain between Mackville Road (left) and highway 88 (right) proposed by staff for development of off-channel pool and riffle habitats for rearing juvenile chinook salmon (upper panel; numbered lines are topographic transects; stippled=Mokelumne River channel; hatched=off-channel, gravel-mining ponds; dashed line=flood plain inundated at 5,000 cfs). Elevation profiles for transects 112 and 113 are shown in lower panel (dashed line=water elevation at 1,420 cfs; circle-and-line symbol= water elevation at about 5,000 cfs). [Source: Adapted by staff from Simpson (1972).]

4.6.8 Riparian Vegetation

Staff generally evaluated the importance of riparian vegetation on salmonid ecology and water temperatures and examined existing vegetation along the river on the site visit and in aerial photographs provided by CDFG. Studies by CDFG (1991) were discussed in Section 3.4.2. Riparian vegetation is, without

question, important for salmonid habitat. Major stream rehabilitation programs in the West have focused on reestablishing riparian vegetation where it has been lost (often from cattle grazing).

Riparian vegetation is found as a thin corridor along most of both banks of the Lower Mokelumne River from New Hope Landing to Camanche Dam. According to CDFG, about 68% of this cover is classified as moderate to dense cover and useful for fish through leaf and insect drop as well as shade and submerged cover. Staff examination of the aerial photographs confirmed this in a general way. The reach with the most obvious deficiency in riparian vegetation is at Lake Lodi. Here, there are large areas of shallow water without riparian vegetation. Elsewhere, occasional pastures extend to the water's edge. Both Lake Lodi and the pasture lands could benefit from reestablishment of riparian vegetation.

The riparian corridor is generally only one or two trees wide. The biggest impact on the riparian vegetation has probably been riparian clearing for agriculture, and to a lesser extent, housing. These land uses have doubtless been encouraged by flood protection afforded by Camanche Dam. Thus, while Camanche Dam has encouraged vegetation encroachment into the formerly active channel, this has been accompanied by clearing formerly vegetated areas for other uses.

The greatest potential for riparian restoration would lie in two areas: expansion of the vegetated corridor on the bank tops and establishment of active riparian vegetation on lower surfaces. Land or conservation easements could be purchased along the bank top to create a wider riparian corridor for wildlife. Because these banks are no longer flooded, riparian restoration here would require active planting and management. It would be effectively a riparian garden, but one with habitat benefits. The few spots with degraded banks could be targeted as well to eliminate these as sources of sediment, unshaded areas, and eyesores.

In addition, on lower alluvial surfaces that are still inundated in the present flood regime every two or three years (at flows of 2,000 to 3,000 cfs), establishment of a more natural, flood-dependent riparian community could be attempted. In a similar vein, slightly higher surfaces could be planted and periodically inundated with releases from the reservoir. The idea would be to inundate the surface every few years. Releases could be made during wet years only. A restoration project of this kind should be regarded as experimental, in that there is little experience in coordinating riparian restoration with reservoir releases. The project should be carefully monitored to insure that lessons learned from the project can be applied elsewhere.

The Nature Conservancy has ambitious riparian restoration projects underway on the Sacramento River near Stony Creek and on the Lower Consumnes River about 15 miles northwest of the Lower Mokelumne River. The Consumnes River was chosen because it is essentially unregulated and still experiences natural floods, thus offering greater potential for restoration of a natural riparian system. If riparian enhancement or restoration were to be undertaken along the Lower Mokelumne River, the Nature Conservancy would be a logical cooperating organization to undertake design, supervise work, and monitor success or at the very least, to review plans for enhancement projects.

CDFG Riparian Vegetation Alternative

CDFG stated that programs for restoration, improvement, and acquisition of riparian habitat should be implemented. No detailed plans were proposed. If this work were implemented, it would aid salmonid fish populations.

EBMUD Riparian Vegetation Alternative

EBMUD has not proposed specific programs for riparian vegetation.

Staff Riparian Vegetation Alternative

Staff recommends that CDFG and EBMUD establish a program with riparian landowners for restoration and improvement of the riparian corridor. The program should begin with a careful inventory of the riparian lands and a prioritization of zones for attention. Shading would reduce solar warming in the critical late spring period, submerged vegetation would provide needed cover, and insect fall would provide useful food for rearing salmon and trout. If off-stream gravel pit ponds are developed for salmon rearing, the riparian zone of these area should be revegetated.

No Action Riparian Vegetation Alternative

Lack of riparian vegetation is probably not the limiting factor in success of salmon and trout populations in the Lower Mokelumne River. However, the current condition allows substantial warming by solar radiation, especially in Lake Lodi, and warm water in the river and delta is a major constraint for spring migrants. Retaining the current condition is not desirable.

4.6.9 Hydraulic Improvements to Lake Lodi and Woodbridge Dam

Outmigration flows from Camanche Dam in spring and early summer are determined by the necessity of both maintaining cool temperatures in the Lower Mokelumne River below Woodbridge Dam and effectively passing fish downstream. Lake Lodi both warms the water and presents an obstacle to migration. The WID has worked with the CDFG for many years to improve upstream passage, diversion screens, and to coordinate filling and draining of Lake Lodi with fishery needs. However, problems with temperatures and downstream passage remain. The upper reaches of Lake Lodi are probably suitable habitat for chinook salmon rearing in spring as long as temperatures are in the acceptable range. In May through July, however, the large expanse of shallow water open to solar warming is probably conducive to salmon rearing or successful migration, even though existing data are inconclusive. Therefore, staff considered three concepts for hydraulic modifications to water flow through the Lake Lodi-Woodbridge Dam-WID diversion system. These concepts are intended to lower temperatures in the Mokelumne River in late spring and summer and more effectively pass outmigrating chinook salmon and steelhead with river flow (Figures 4.6-2 and 4.6-3). Staff recommends further study of them for temperature control, fish passage benefits, unforeseen side effects (e.g., effects on wetland), and cost effectiveness.

The current configuration of Lake Lodi, Woodbridge Dam, and the WID diversion appears to favor high temperatures in the Lower Mokelumne River below the dam during the season of salmon smolt outmigration. High temperatures recorded at the dam after May 1 are known to be detrimental to smolt survival. Changes in configuration may be possible that would lower these temperatures in a critical period and enhance smolt bypass of the diversion screens.

Under current conditions, staff believes the following scenario of flows and temperature changes occurs. Cool water is first released in spring from the winter storage in Camanche Reservoir. This water warms slowly but steadily as it moves downstream in the river to Lake Lodi. After early April when Lake Lodi is filled, the water velocity slows and water spreads into shallow flats as well as moving downstream in the channel to Woodbridge Dam. Solar heating creates a vertical and horizontal thermal gradient in Lake Lodi, with warmer water at the surface and in embayments. BioSystems' studies (Walsh et al. 1992) confirm that Lake Lodi stratifies. Woodbridge Dam releases the warmest water to the lower river, because

Figure 4.6-2. Three staff alternative hydraulic improvements to Lake Lodi to improve fish passage and to reduce late spring and summer temperatures below Woodbridge Dam. A. Sill(s) in front of the WID diversion screens to guide cool water and fish toward a deep discharge in the dam (see Figure 4.6-3). Either an arc sill at the screens or two sills with a new dredged channel might be required, depending on a hydraulic study; B. Fish diversion screen at the head of Lake Lodi and bypass channel to below Woodbridge Dam; C. Shortened river channel dredged through Lake Lodi with a deep discharge in the dam. (Source: The staff.)

Figure 4.6-3. Diagrammatic view of Woodbridge Dam and Diversion from upstream (Lake Lodi) showing potential modifications (in bold: sill, deep discharge, and fish attraction pump) to selectively divert density underflows of cool water in late spring and summer to the Lower Mokelumne River below the dam and pump cool water to the screen bypass as an attraction flow. The inset shows a schematic plan view of the sill. Two alternative deep discharges are shown, one replacing some existing dam boards and another newly constructed deeper in the earth fill dam. Emigrating smolts would likely remain in cool water and pass through a deep discharge; those entering the screen forebay would be attracted to the bypass by the cool attraction flow. (Source: The staff.)

it has only a surface discharge, either surface overflow over the boards or as a surface release through the gated fish ladder exit (which serves as the main flow regulator for the dam). Cooler water can be selected for withdrawal by the WID diversion because it withdraws water from all depths. Maintenance dredging in front of the diversion screens ensures that the deepest and coolest water passes into the diversion. As cooler water from the river enters Lake Lodi and moves as a density underflow to the diversion, there is no comparable deep discharge at the dam to channel any of this cool underflow to the lower river. The smolt bypass at the diversion screens is less effective than it might be because it bypasses warmer surface water; fish must rise from deeper and cooler water to a warm surface flow at a time when the warm temperatures may actually be repelling them.

Staff Alternative for Improvements to Lake Lodi and Woodbridge Dam

Stratification Sills and Deep Discharge. Relatively modest modifications to the dam and diversion could effectively segregate water of different temperatures so that 1) more cool water is routed to the downstream river, and more of the warm water to the irrigation diversion; and 2) cooler water guides outmigrant chinook salmon and steelhead away from the diversion and through the dam. The temperature of irrigation water is not important, whereas cool temperature in the Lower Mokelumne River

is vital for downstream emigrating salmon smolts. Salmonids' natural preference for cool water would be used to guide fish downstream. Juvenile chinook salmon are known to avoid temperatures above approximately 68–72°F (20–22°C), and to seek the bottoms of "cold pools" of natural streams in summer (Baltz et al. 1987). Thermal differences may also be used to increase the efficiency of the screen bypass.

Three additions to the dam-diversion system could accomplish these objectives (Figure 4.6-3). One addition would be a submerged sill in front of the WID diversion. This sill would extend in an arc to within a few feet of the lake surface (Figure 4.6-3). It would allow only the warmest, less dense water to pass over the top while retaining the cooler, denser water behind it. Such a submerged dam is used at the Kingston Steam Plant, a Tennessee Valley Authority (TVA) fossil-fueled electric power station on the Clinch River, Tennessee. It selectively passes warm, surface water downstream while directing cool, deepwater to a cooling-water intake. Space limitations immediately in front of the screens may require that the submerged sills be placed out at the two points where water leaves the main channel for the diversion (Figure 4.6-2A).

The second addition would be a gated, deep discharge at the dam. This gate would both regulate flows (not done very effectively now) and capture the deeper strata of cooler water for release downstream. A totally new gated discharge might be constructed in the earth fill of the dam or a new gatebox could replace one set of boards in the existing pier/flashboard structure. A new gate in the earth dam could be located deeper, thus attracting cooler water than one in the existing flashboard facility. In either case, a suitable tailwater for the deep discharge would be required to avoid damaging smolts on the rock fill at the downstream base of the dam. Juvenile emigrants would likely use either deep-dam release route in preference to the warm surface water flow at the diversion, especially when surface temperatures exceed about 68–72°F (20–22°C). Reliance on a deep discharge at the dam to pass fish to the lower river could preclude collecting fish from the bypass for either monitoring or trucking to below the Delta unless the deep discharge were fitted with a collection device.

The third addition would be a cool-water attraction flow at the fish screen bypass. Water pumped from deep in the river channel side of the proposed stratification sill would be released in front of the fish bypass. With proper placement of intake and outflow, a thermally attractive body of water could lead fish from the forebay of the screen to the bypass and fill the bypass with cool water more conducive to smolt survival.

Ability to sustain a density underflow in Lake Lodi is not entirely certain at this point. Stable stratification occurs only when the volume of flow entering Lake Lodi is small enough to avoid vertical mixing. The existing convoluted channel may induce sufficient lateral movement at higher flows that turbulence will prevent stratification. The Lake Lodi thermal model of BioSystems regularly overpredicted stratification at the Woodbridge Dam forebay (their Figure 2-1), although they did not report the flow rates used. Contrary to the proposals of CDFG and EBMUD, lower flows in May through June with this modification concept may be more beneficial to sustaining lower river temperatures for outmigrants than would high flows. The benefits to the system from lower spring flows would be retention of more of the winter pool of cold water for use later in the year. The disadvantage would be less volume of water in May and June for cooling the Central Delta. Resolution of these possibilities would require more detailed modeling of Lake Lodi and the Lower Mokelumne River below Woodbridge Dam, especially for the flows of 400–500 cfs currently recommended by EBMUD.

This concept should have no detrimental side-effects, particularly if the stratification sill can be constructed in the WID diversion forebay. Such a layout is possible if steel pilings are used for the sill, because steel pilings take up much less area than a rockfill dike. The stratification sill shown in Figure 4.6-3 is a typical rockfill dike. If it is not possible to construct a sill in the forebay, then two sills will be required

somewhere along the side channels leading from the main channel of Lake Lodi to the diversion forebay (Figure 4.6-2A). The two-sill configuration is the basis for staff's cost estimate of \$120,000 for this alternative. Staff considers this a conservative cost estimate, because construction of a single, steel piling sill in the diversion forebay would probably be less expensive.

Bypass Canal and Fish Screen. Currently, Lake Lodi appears to account for about 70% mortality of chinook salmon smolts emigrating from the spawning area below Camanche Dam (EBMUD 1992) although this figure is disputed. This number is clearly excessive for sustaining the population, whether it is accurate or just in the general range. One solution for this high level of mortality is to have emigrating salmon avoid Lake Lodi altogether. Staff examined another alternative (in addition to the aforementioned) for reducing this level of mortality, that is, provision of a screening structure for the whole river and a bypass canal that would operate during smolt outmigration. We provide only a general concept and rough cost estimate.

Staff suggests an alternative for study that would consist of two parts: 1) a set of angled, rotating drum screens at the point where the Mokelumne River widens to form Lake Lodi when the lake is filled; and 2) diversion canal about 2 miles long, to carry cold river water to below Woodbridge Dam (Figure 4.6-2B). The screens might be located near MRM 41.8 where the channel becomes winding and associated with shallow flats and side channels. The diversion canal would follow the edge of the flood plain (much like an irrigation ditch) or be cut into somewhat higher elevations. Water not warmed in Lake Lodi would be shunted to below Woodbridge Dam to provide cooler temperatures in the river below the dam. Salmon smolts would be screened from the river flow and diverted through the bypass canal long before they reached the hazardous WID irrigation diversion screens. If only part of the river near MRM 41.8 were to be screened (e.g., along the north shoreline), the successful bypass of this part of the emigrating fish population might exceed the numbers of current survivors passing Lake Lodi.

A detrimental side effect of this concept would be disruption of about two miles of wetland and riparian vegetation, an effect that would have to be evaluated further. Staff estimated that such a system might be installed for approximately \$960,000 (Table 4.6-1). It is less desirable from the perspectives of biological results, undesirable side effects, and overall cost-effectiveness than installation of stratification sills and a deep discharge.

Channel Excavation and Deep Discharge. A third staff alternative for hydraulic modifications to Lake Lodi to protect emigrating salmon is to dredge a new deep channel about two miles long in Lake Lodi to move cool water and fish in nearly a straight line between the start of slack water near MRM 41.8 and Woodbridge Dam and provide a deep discharge in the dam for the cool water (similar to that shown in Figure 4.6-3). This new channel (Figure 4.6-2C) would avoid solar heating of water in the shallows and sinuous channel of the current Lake Lodi, providing cooler temperatures at the dam. A deep discharge would allow this cooler water to be discharged to the lower river while the warmer water (that has been exposed to the shallow lake) can be withdrawn by the WID canal. Emigrating salmon smolts would presumably follow the cooler water down the shortened channel and exit Lake Lodi through the deep discharge. This alternative would also have the disadvantage of disrupting about two miles of wetland and riparian vegetation, an effect that would require evaluation in more detail. Staff estimated that this alternative could cost approximately \$720,000 (Table 4.6-1). It, too, is less desirable from the perspective of fish passage benefits, side effects, and overall cost effectiveness than the sill and deep discharge concept.

Lake Lodi Filling. Staff acknowledges a high level of cooperation among the parties (CDFG, WID, and EBMUD) in the filling of Lake Lodi in the spring of 1992. As reported in the minutes of the May 12, 1992, Mokelumne River Technical Advisory Committee, approximately 140 cfs average daily flow was maintained in the Lower Mokelumne River between March 29 and April 6 as boards were placed in

Table 4.6-1. Estimated costs of Lake Lodi improvements. (Source: The staff)

I. Bypass canal and diversion / screening structure	
Canal (cy = cubic yards, sy = square yards)	
excavate 21,000 cy @ \$4/cy	\$ 84,000
concrete lining 39,200 sy @ \$11/sy	430,000
dewatering 14 days x 5 pumps @ \$500	35,000
mobilize/demobilize contractor	25,000
purchase land 10 acres @ \$2,000/acre	20,000
Subtotal	594,000
Diversion structure/screen (lump sum)	200,000
Design & contingencies @ 20% of construction	160,000
Total (rounded)	\$960,000
II. Dredge/excavate new channel, add deep discharge structure @ Woodbridge Dam	
Dredge 24,000 cy @ \$9/cy	\$216,000
Excavate 36,000 cy @ \$5/cy	180,000
Deep discharge structure	50,000
Mobilize and demobilize contractor	25,000
Design and contingencies @ 20% of construction	100,000
Subtotal (rounded)	575,000
Maintenance dredging	150,000
(present value of dredging at year 10 and year 20, with interest rate = 8%)	
Total (rounded)	\$720,000
III. Stratification sills, deep discharge structure @ Woodbridge Dam	
Stratification sills (2 required)	
100 x 6 x 6/27 cy per cubic foot = 130 cy/sill	
130 cy/sill x 2 sills = 260 cy x \$100/cy	\$26,000
Deep discharge structure	50,000
Mobilize and demobilize contractor	25,000
Design and contingencies @ 20% of construction	20,000
Total (rounded)	\$120,000

*The reference for all construction costs, except diversion structures, discharge structures, and screens, is Means 1992 *Building Construction Cost Data*. Best estimates based upon scale and complexity of construction were used for the diversion structures, discharge structures, and screens.

Woodbridge Dam to raise water level for WID irrigation diversions. EBMUD flow monitoring was used to closely match changes in elevation of the dam to flows released at Camanche. Staff believes that such cooperation is essential to future management to the fishery resources of the Lower Mokelumne River.

Staff's proposals of minimum Camanche pool elevation and hypolimnetic oxygenation should minimize the occurrence of those conditions which favor the resuspension of heavy metals in Camanche Reservoir. In addition, staff recommends a monitoring program for both Camanche Reservoir and the Mokelumne River which will characterize both the transport and fate of contaminants and identify possible ecological impacts. A monitoring program should be implemented which includes the following:

- Continued monitoring of water and sediment for heavy metals in Camanche Reservoir to document any changes in concentrations which might occur as a result of remediation activities at Penn Mine and natural remediation within the reservoir.
- Sampling of early life stages of resident fishes in the reservoir to evaluate the geographic extent of the impact of Penn Mine. This sampling might include larval net tows and beach seining at several sites of varying distance from Penn Mine.
- Increased monitoring of water and sediment for heavy metals in the Lower Mokelumne River to document any changes in concentrations which might occur as a result of remediation activities at Penn Mine, natural remediation within the reservoir, and changes in the operation of Camanche Reservoir releases. This monitoring should be extended below the immediate tailwaters of Camanche Dam.
- Measurement of hatching rates within chinook redds in the river. This study might also include the placement of hatchery-fertilized eggs into artificial redds in the river to provide a comparison of hatchery conditions to river conditions.
- Examination of chinook larvae collected from the redds to identify possible developmental abnormalities.
- Chemical analysis of 6–10 naturally-produced chinook smolts (and possibly some resident species) for the presence of contaminants. More sampling and analysis would be necessary if the initial sampling produces contaminant levels of concern.
- Standard acute and chronic toxicity testing of Camanche release water and Mokelumne River sediment pore water.

4.7 CUMULATIVE ENVIRONMENTAL IMPACTS

In this section we describe the key interactions among the LMRP and factors outside the immediate scope of this proceeding that could have a cumulative effect on water quantity, water quality, fisheries, and related socioeconomic matters in the region. We identify how the recommended actions in this EIS are related to anticipated actions of this agency and of other agencies. We also comment on other issues raised in the scoping process, such as recreation, that were considered beyond the scope of this proceeding under Articles 12 and 15 of the License.

The Commission's consideration of changes to the LMRP is taking place concurrent with other water developments in the Mokelumne basin and with several different regulatory actions designed to correct the multitude of factors affecting water quantity, water quality, fisheries resources, and socioeconomics in the northern Central Valley and San Francisco Bay area. In the process of scoping this EIS (Section 1.2), it became clear that the issues important to the LMRP were part of the larger, cumulative issues of water resources management and fisheries conservation of the region. Many of these broader matters are still

under active debate, negotiation, and rule-making by other bodies with defined administrative authority (Section 3.1.4). The staff, in the scoping process for this EIS, attempted to delineate those issues that could be clearly confined to the project within the mandate of Articles 12 and 15 of the License. Those issues were presented in Section 1.2. Nonetheless, evaluation of nearly every issue in this FEIS has involved, to some degree, a consideration of the broader perspective.

4.7.1 Upper Mokelumne Basin Development

The Mokelumne River basin above Pardee Reservoir is already developed for hydropower and additional development is proposed (Section 3.1.2; FERC 1993c). These developments may eventually affect water availability for the LMRP and potentially have cumulative effects with the LMRP. However, to our knowledge, no changes have been proposed to the Lodi Decrees, the third-party agreements among EBMUD, PG&E, and the City of Lodi, that dictate inflows to Pardee Reservoir. A FERC proceeding is now underway for the Mokelumne and Devil's Nose/Cross Country projects (FERC Project Nos. 137 and 8144/8759, respectively). Proposals for these projects have been delayed by proposed application amendments from both applicants. In order to have an orderly NEPA process, the LMRP has been evaluated under the existing water flow regimes entering Pardee Reservoir, thus accounting for cumulative effects of existing hydropower and water diversions. The proposed projects are being evaluated in a separate NEPA document that will tier on this one. The proposed projects are described briefly below.

The Mokelumne River Project owned and operated by PG&E consists of 19 dams at 7 storage reservoirs, 7 diversion facilities, 3 regulating reservoirs, 2 forebays, 1 conduit, 6 conduit feeders, 5 tunnels and penstocks, 4 powerhouses, and associated transmission lines and other appurtenances in the North Fork of the Mokelumne River. The Project has been developed gradually since the late 1800s. In relicensing, PG&E originally proposed to raise the maximum water surface elevation at one storage reservoir (Lower Bear River Reservoir) and one diversion facility (Cole Creek Diversion Dam), increase the Tiger Creek Conduit and Electra Tunnel flow capacities, add generating units at the Salt Springs and West Point facilities, and add two new powerhouses (Doaks Ridge and Mokelumne). In July of this year, PG&E notified the Commission of its intent to withdraw these proposed upgrades (PG&E 1993). The proposed action in this relicensing will be unclear until an amended license application is received by the Commission.

The Devil's Nose/Cross Country Project (FERC Project Nos. 8144 and 8749) is proposed for the North Fork and mainstem of the Mokelumne River below PG&E's Salt Springs Reservoir. Amador County proposes a new 470-ft high dam and reservoir (Devil's Nose), 3 powerhouses, 3 tunnels, and related facilities. The Devil's Creek Dam, part of the project, would be located at the upper reach of the existing PG&E Tiger Creek Reservoir on the North Fork. The Cross Country portion of the project includes an inlet structure on the existing Tiger Creek Reservoir, the Cross Country Tunnel and penstock, and a powerhouse on the mainstem. On completion, there would be an intermingling of water development and diversions between the Mokelumne and Devil's Nose/Cross Country projects. However, at a recent meeting with the Commission's staff, Amador County stated that the project was not economically feasible at this time, but that it is their hope that it may become feasible by the time licensing is complete (FERC 1993c).

The main interaction of these upper basin projects with the LMRP involves the amount and seasonality of water that is released into Pardee Reservoir. Because the existing and proposed water developments primarily shunt water around in the upper Mokelumne basin, the impact may not be significant for water quantity in the lower river; further consideration will come in the EIS for the projects proposed in the upper basin. There are valuable resident fisheries in the area rivers and reservoirs, but no anadromous fishes (e.g., chinook salmon or steelhead) pass upstream of Camanche Dam.

Additional water for municipal uses will eventually be needed in the upstream counties in the basin (Amador and Calaveras counties) if current population trends continue. However, the source and method by which these additional demands will be met is not readily apparent, nor can they be readily be anticipated, therefore they are beyond the scope of this Commission proceeding.

4.7.2 Management of Delta Flows

The fishery resources of the Lower Mokelumne River are intimately related to the physical and biological features of the Sacramento-San Joaquin Delta through which anadromous chinook salmon and steelhead must pass. These interactions were described in detail in Section 3 where survival of juvenile outmigrants was shown to be strongly related to Delta temperatures, flows, and salinities. These features are, in turn, related to management decisions regarding water withdrawals at state and federal water diversions in the southern part of the Delta (State Water Project and Central Valley Project, respectively) and water releases from storage reservoirs on the Sacramento and San Joaquin rivers and their tributaries.

Management decisions regarding the Delta flows can have larger impacts on Lower Mokelumne River fishery resources than management of the Lower Mokelumne River can have on Delta conditions. The Mokelumne River accounts of less than 2% (approximately 400 TAF) of the annual average inflow to the Delta inflow, compared to the Sacramento and the San Joaquin rivers, which supply about 82% and 13% of the inflows, respectively. Management of southern Delta withdrawals (about 5,000 TAF) and consumptive uses in the Delta itself (1,600 TAF) overshadow flows in the Mokelumne. In addition, part of the flow from the Sacramento River is shunted through the Cross Channel Canal into the Mokelumne as it enters the Delta so that flows there reflect more the management of the canal than it does water provided by the Lower Mokelumne River itself.

Current state and federal proceedings in other arenas are modifying the conditions mandated for the Delta (Section 3.1.4). The Commission is not directly involved in those Delta decisions that will contribute in large measure to cumulative effects on Lower Mokelumne River resources. The combined result of those other actions and the fisheries-protective recommendations in this proceeding should be conducive to protection and enhancement of the Lower Mokelumne River's fisheries resources.

4.7.3 Endangered Species Act Restrictions

There are actions under the federal Endangered Species Act in waters contiguous with the Lower Mokelumne River. The LMRP could, in theory, have cumulative effects on these species. In the Delta, the resident Delta smelt is listed as endangered (Section 3.3.5) and there are petitions to list the resident Sacramento splittail and longfin smelt. Both species have been heavily affected by water withdrawals from the Delta and the consequent changes in flow patterns, temperature, and salinity. In the Sacramento River, the winter chinook salmon has been listed as threatened, and other runs have been considered (Section 3.3.1). The Lower Mokelumne River is not included in the critical habitat designation for this species (NMFS 1992)

Because of the small contribution of the Lower Mokelumne River to the Delta flow, staff does not consider the LMRP to have much real potential for altering the status of the resident species there. Because the staff's proposed action will increase flows in the Lower Mokelumne River from existing conditions, any change would likely be a contribution toward better habitat conditions. Similarly, although the salmonids in the Sacramento River are unlikely to perceive the small flow in the Lower Mokelumne River, an increase in Lower Mokelumne River flow recommended in this EIS would likely have a small cumulative benefit to water quality conditions in the Delta.

4.7.4 Recreation

Recreation can be considered part of the cumulative impact of the LMRP even though it is not within the scope of Articles 12 and 15 of the LMRP license. The LMRP affects recreation primarily through the fishery resources sought by anglers in the river below Camanche Dam and in Camanche and Pardee reservoirs. Related recreational concerns include access to waters of the Lower Mokelumne River, boating access to the reservoirs, and aesthetics of a nearly full reservoir (as opposed to major drawdowns) for shoreline residents and picnickers.

Staff believes that the cumulative effects of actions it recommends will be generally positive to recreation. Generally higher flows in the river below Camanche Dam will provide more salmon and trout for anglers both in the river and in the coastal and estuarine waters fished. It will also provide more suitable and reliable water in the river for canoeing or rafting, should these sports become of interest. Water quality improvements will allow better fish production in the fish hatchery. The major public access point to the river in EBMUD's developed park below the dam will remain. Non-flow improvements recommended should enhance habitat for both fish and angler. Stabilization of reservoir elevations should allow more reliable development and use of recreation areas and boat launch ramps, as well as improved aesthetics. Some desirable management actions for benefit of recreation, such as development of new recreation areas or access points, cannot be mandated by this proceeding, but may result from the cooperation between parties that develops as a result of staff's recommendations on other topics.

4.7.5 Woodbridge Dam and Irrigation Diversions

Lake Lodi and the structures associated with the Woodbridge Irrigation District's facilities are discussed extensively in the main body of this EIS as part of the habitat for chinook salmon and steelhead. These facilities are not part of the LMRP. Effects there are, in the strict sense, part of the cumulative effects of all water resource development in the lower river. As noted in Section 2.3.2, staff considers the adverse impacts associated with Woodbridge Dam and Lake Lodi to be serious enough that they could negate any gains made from actions taken at the LMRP. Staff chose to integrate its analysis of Woodbridge facilities with features more directly under EBMUD's control because of the intimate association of the Woodbridge facilities with both upstream and downstream migration of salmon and trout (and monitoring of them). We anticipate close cooperation between EBMUD, the Woodbridge Irrigation District, and CDFG in resolving habitat questions at the dam and diversion that are important to cumulative impacts on salmon and trout population success in the Lower Mokelumne River.

4.7.6 EBMUD's Water Supply Options

There could be cumulative impacts to water and fisheries resources in the upper Central Valley region if EBMUD chooses to develop new water supplies to satisfy its need for water. Alternative mitigation actions proposed by staff, CDFG, and FWS would result in some water supply deficits in the Mokelumne River system (Figure 2.4-3). There has already been a protracted proceeding in the courts related to EBMUD's assertion of water rights to the American River via the Folsom South Canal. In that instance, strong efforts were made by environmental groups and Sacramento County to restrict withdrawals in order to protect flows required for maintaining suitable temperatures for chinook salmon and steelhead in the lower American River in summer. The compromise outcome affirmed the water right but imposed restrictions on water use under conditions when that withdrawal would likely be detrimental to salmon and trout. As population grows in the East Bay region, EBMUD will likely require more water supplies, regardless of the staff's recommendations regarding the LMRP. The instream flows recommended in this EIS are a small addition to the cumulative need. Staff recognizes that additional options are available,

such as further exploration of water conservation and reuse in the District's territory. EBMUD's long-range water supply planning is the subject of an on-going process (Section 3.1.4).

4.7.7 Summary of Cumulative Impacts

In summary, staff believes that the cumulative effects of its recommended actions for the LMRP will be positive for the environment, taken in concert with other influences in the region. Additional actions by FERC in the upper Mokelumne River basin will be rippled from this EIS and include its features as part of the cumulative impacts of the new action(s). Major thrusts for protection of the regional fisheries resources by other agencies in the San Francisco Bay-Delta area will likely interact positively with the staff's recommendations for the LMRP. The staff has been mindful of EBMUD's obligation for regional municipal water supply, but does not feel that its recommendations will have a cumulative negative effect.

4.8 UNAVOIDABLE ADVERSE IMPACTS

There would be no unavoidable adverse impacts to fish in the Lower Mokelumne River under the action alternatives considered in the FEIS, because these actions are designed as beneficial mitigation. The adverse impacts that could occur from the flow-related actions considered would be to EBMUD's water supply system. During all but the driest water years, EBMUD could continue to rely on water from the Mokelumne River under staff's recommended flow alternatives. During extreme drought conditions, such as in the 1976 and 1977 period, supply reservoirs would be drawn down and EBMUD would have to implement water conservation programs. The frequency and magnitude of these impacts to the EBMUD water supply system are difficult to measure, because the impacts depend on actions well beyond the scope of this proceeding (e.g., the implementation of future demand- or supply-side programs by EBMUD). Nevertheless, staff's assessment indicates that relative impacts can be assigned to the alternatives considered in the FEIS. The flow-related recommendations included in the CDFG alternative would have drastic implications, effectively removing the Mokelumne River as a reliable water supply for EBMUD. On the other hand, lesser but significant water supply deficits are likely to occur under EBMUD's alternative and even under the no action alternative. Staff's flow-related actions would cause water supply deficits that are slightly higher than the EBMUD alternative, but would also provide significantly greater benefits (e.g., more natural spawning habitat) than either the EBMUD or the CDFG alternatives. During a worst-case, three-year drought of the magnitude experienced in 1976-1977 and current water demands, staff estimates annual water supply deficits of 1 TAF, 123 TAF, and 160 TAF for the staff, CDFG, and FWS flow alternatives, respectively. Under the same low-flow scenario and our reduced 2020 demand for water, we estimate annual water supply deficits could increase to 27 TAF, 197 TAF, and 235 TAF for the staff, CDFG, and FWS flow alternatives, respectively. Although staff's analyses do not indicate a significant need for water for EBMUD under either EBMUD's flow alternative or no action, EBMUD is preparing to obtain significant new water supplies, as indicated by their updated WSMP reports (EDAW, Inc. 1993a).

4.9 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The actions considered in the FEIS do not involve any irreversible or irretrievable commitments of any of the natural resources of the Mokelumne River. All the alternatives that have been evaluated, except the no action alternative, would provide benefits to the anadromous salmonids and other aquatic biota in the river. Riparian habitat would also benefit from the higher flow regimes of the action alternatives. The main question is what combination of mitigation measures can maximize the benefits to fish resources without causing unacceptable impacts to EBMUD's water supply system.

4.10 RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM BENEFITS

Hydropower production, water supply, and anadromous fisheries are all long-term uses of the Mokelumne River system that can be made more compatible by modifications to the existing LMRP license. Current LMRP reservoir operations are optimized for water supply benefits. Although EBMUD's reservoir operations are not the only factor putting pressure on chinook salmon and steelhead trout resources in the lower river, they are one of the more important influences that are limiting the recovery of these fishery resources. For example, the short-term fluctuations of streamflow that occurred over the past decade have undoubtedly had a negative effect on salmon and trout recruitment. The low minimum flows allowed under the existing license are used by EBMUD to maximize short-term storage in their reservoirs and benefit water supply system, but these low flows are also a limitation to natural salmon and trout production. Staff's recommended alternative provides the most balanced combination of flow and non-flow mitigation actions that will increase the sustainability of fish resources in the lower river without conflicting with existing water rights or water supply operations. Water supply deficits during drought periods are predicted to occur at EBMUD's system under all the alternatives considered, even the no action alternative. Staff's alternative would result in significant benefits to anadromous fish without causing excessive costs to the EBMUD water supply system. This outcome would allow the long-term uses of water supply, hydropower, and fisheries to co-exist in the lower river.

5. STAFF CONCLUSIONS

This section contains staff's conclusions regarding the impacts of modifying the existing hydropower license for the Lower Mokelumne River Project (LMRP). Staff has determined that some of the proposed modifications described in Sections 2 and 4 are acceptable and necessary for the conservation and development of anadromous fish resources in the lower Mokelumne River. Other proposals would involve unacceptable adverse impacts and are therefore not recommended. Staff's evaluation of the alternative resource management plans is presented in the first part of this section. The significant impacts of these alternatives are presented in Section 5.2. Staff's recommendations for implementing our preferred alternative are presented in Section 5.3.

5.1 EVALUATION OF RESOURCE MANAGEMENT PLANS

There are three relevant plans for managing the fisheries resources in the Lower Mokelumne River. We considered all three approaches in the development of staff's final recommendations. The State of California passed the Salmon, Steelhead Trout, and Anadromous Fisheries Program Act in 1988 to help restore declining fish resources. The goal of this legislation is to increase natural reproduction of anadromous salmon and trout in the streams of the state, with a strong preference for restoring natural habitat as opposed to a reliance on artificial means (e.g., hatcheries). The CDFG issued a management plan consistent with this legislation and specific for the Lower Mokelumne in early 1992 (CDFG 1991). The EBMUD developed its own plan for managing fisheries in the Lower Mokelumne River and published it as part of EBMUD's updated WSMP (EDAW, Inc. 1992a). The CDFG plan is especially important to this proceeding, because its recommendations were used initially as the proposed action evaluated in this assessment.

The Mokelumne River fisheries management plans of both CDFG and the licensee, EBMUD, address the spirit of the state legislation, but propose different ways of accomplishing the mandated goals. In general, the EBMUD plan relies more on hatchery production and artificial transportation of outmigrating, juvenile fish than does the CDFG plan. The CDFG plan emphasizes higher minimum flows to support natural processes. Staff's recommendations are also consistent with the goals of the state legislation in terms of emphasizing restoration of natural processes and habitat conditions.

The following discussion presents more detail on our evaluation of these alternative management plans and identifies the underlying assumptions behind staff's final recommendations.

5.1.1 Underlying Assumptions in Staff's Analysis

Staff concurs that the lower Mokelumne River between Camanche Dam and its confluence with the Sacramento-San Joaquin Delta is a reach of considerable importance for maintenance and restoration of chinook salmon and, to a lesser degree, steelhead trout. However, staff analysis shows that the importance of the Lower Mokelumne River is small relative to other streams in the Central Valley, particularly the Sacramento River and its tributaries (e.g., the Feather and American rivers). The salmonid stocks of the Mokelumne are not unique; rather they form part of the highly mobile Central Valley stocks (due partly to many years of interchange of stocks by hatchery operations). Management of a genetically discrete stock within the Lower Mokelumne River, even after tight controls to limit interchange of hatchery stocks, does not seem possible with current levels of straying of fish among Central Valley rivers. However, in view of the declining stocks of salmon throughout the northwestern U.S. (Nehlsen et al. 1991), even a relatively small and non-unique run is valuable and worthy of increased conservation efforts.

Fish Population Declines. Staff sees no statistical difference in chinook salmon run sizes before and after Camanche Dam was built that would conclusively show that the run is in particular danger now compared to pre-dam conditions. The assertion that salmon populations "have failed to achieve (higher) population levels believed possible following completion of Camanche Dam in 1963" may be due to unrealistic expectations in setting of goals. Steelhead, on the other hand, have essentially lost the naturally spawning population since 1963. Although this decline in steelhead should be of major concern, habitat limitations downstream of Camanche Dam will make any recovery difficult, if not impossible. The decision to construct Camanche Dam and thus eliminate suitable habitat for steelhead pre-dated hydropower licensing for this project.

Although statistical evidence is inconclusive with regard to Mokelumne River salmon run sizes, we believe concern about run declines is justified. This concern is supported by continued poor return runs of 1991 and 1992 (not included in CDFG's Lower Mokelumne River Fisheries Management Plan), the high percentage of precocious males (jacks) in the run, the failure of artificial fish propagation since 1964 to significantly increase Mokelumne River escapement, the chronic problem of adult salmon straying to other rivers, increased water demands and diversions upstream from Camanche Dam and increased incidence of water quality degradation.

Causes. Water resource developments and other human activities have had significant adverse impacts on fish and wildlife resources of the Mokelumne River over the historical period. However, we must also recognize that some of the effects of these developments have been beneficial. Reservoirs have maintained streamflows that would have been reduced even more severely in years of drought. The annual hydrograph has been shifted such that peak flows are markedly reduced and low summer flows have been augmented. Temperatures are maintained sufficiently low to remain suitable for salmonids in summer by deep reservoir discharges. A clear comparison of the suitability of the habitats for salmon and steelhead before and after European colonization has not been developed. We concur that water quality decreased because of agricultural activities early in the 1900s, runoff from Penn Mine, and late summer-autumn water quality problems from hypolimnetic discharges from Camanche Dam, but there should also be recognition that conditions have improved markedly since the 1950s. Clearly, impoundments have covered significant amounts of previously suitable habitat for chinook salmon and steelhead trout and dams have blocked upstream spawning migrations to headwater tributaries, leading to the extirpation of some salmonid runs. However, as stated above, the construction of these dams pre-dated Commission involvement with the LMRP license.

Salmon Primacy. Staff agrees with the importance of chinook salmon for the Lower Mokelumne River, but does not agree that environmental requirements of steelhead are so similar that recommendations developed primarily to protect salmon will necessarily benefit steelhead. Chinook salmon have been able, with management actions, to sustain an escapement comparable to that documented before Camanche Dam. Steelhead have not. However, staff recognizes that the type of habitat needed to rear juvenile steelhead no longer exists in the Lower Mokelumne River and a major rehabilitation of a naturally spawning and rearing steelhead run is unlikely. Some modest habitat improvements (non-flow) may allow some wild stock steelhead production. A management plan of action that addresses both species on their own terms and makes tradeoffs necessary to adequately protect and enhance both species will be necessary.

Studies. Staff agrees that resolution of controversies and development of a management plan that most successfully accommodates all users, including fish and wildlife, will come, in part, from studies of the multiple-use environment.

5.1.2 Staff Findings

Based on the information and analyses presented in the FEIS, staff comes to the following conclusions regarding the issues raised in the management plans for the lower river:

Streamflow and Temperature. Recommended streamflows are generally higher than necessary and may well be counterproductive in terms of providing optimal habitats for all life stages, especially in the critical stream segments between Camanche Dam and Lake Lodi. Although CDFG has not presented its rationale for selecting its flow recommendations, CDFG does not seem to have accounted for conveyance releases that are necessary from Camanche Dam to satisfy the downstream water rights of WID and the NSJWCD. Temperature goals are reasonable from the standpoint of biological productivity, but it is unlikely they could be satisfied throughout the year with the high flows recommended by CDFG without deleting the cool, hypolimnetic water in EBMUD's reservoirs. We developed our recommendations based on a model that we feel will accommodate more of the desirable fish and wildlife values under a broader range of conditions than either CDFG or EBMUD recommendations.

Short-Term Daily Streamflow Fluctuation and Streamflow Reduction. Rapid changes in stream flow can have adverse effects if they lead to stranding of young fish or exposure of redds. The lack of any ramping rates at Camanche Dam has allowed such impacts to occur in the past during hydropower operations (Section 3.3). Although staff recognizes the environmental risks involved with fry stranding in shallows when flows decline rapidly, staff also understands that flow changes are often essential cues to stimulate both upstream migration of adults and emigration of fry and smolts. Thus, blanket recommendations to minimize daily and weekly flow fluctuations can be counterproductive without designation of exceptions during seasons of migration. Imposition of rigid controls to minimize fluctuations will frustrate efforts to manage flow changes to assist migrations. Staff does not support the blanket recommendations without further analysis of the importance of flow changes to stimulate migrations.

Attraction Pulse Flows. Staff agrees that attraction flows of some sort are important cues for initiating and sustaining upstream migration of adults. There is little evidence, however, that large, sustained flows recommended by CDFG are needed. In fact, available data for the Mokelumne are contradictory: high numbers of salmon return during years with high flows but detailed fish passage numbers at Woodbridge support the importance of brief spikes of flow or turbidity for stimulating migrations. Staff agrees with the need for future studies to refine the timing, magnitude, and duration of attraction flows and the benefits of coordinating the release with the lowering of Woodbridge Dam. We do not concur with the CDFG recommendations, preferring instead spike flows (without ramping) at several time intervals after river temperatures below Woodbridge Dam have declined below 60°F (15.6°C). Staff proposes an

interim minimum weekly average flow of 300 cfs (wet and normal years) or 200 cfs (dry years) that can be allocated experimentally as spikes. Staff recommends additional experiments at weekly average flows greater than 300 cfs, combined with appropriate fish monitoring, but only in wet or normal years when there is abundant water available.

Outmigrant Pulse Flows. As with attraction flows for adults, staff agrees with the general need for an outmigrant flow and more studies to define what the flows should be. The CDFG recommendations for water allocations seem premature without more study and adequate system planning. Staff recommends interim, experimental flows with monitoring to better define the desirable timing, magnitude, duration, and need for outmigrant flows. As a baseline, staff recommends a minimum of 300 cfs (normal or wet years) and 200 cfs (dry years) during the month of May unless there is coordinated action otherwise by agencies and EBMUD.

Habitat Protection and Improvement. Staff concurs with the recommendation for stream gravel improvements for providing adequate spawning substrate for chinook salmon and steelhead. Staff also agrees with limitations in gravel extraction from the Lower Mokelumne River except as this activity may be used by the agencies (CDFG/FWS) in a planned manner for improving stream gravels for fish uses. Because there is some risk that disturbance of stream sediments below Camanche Dam may unlock deposited metals, staff recommends chemical monitoring of suspended solids and dissolved metals in river water as stream gravels are reworked. We have highlighted other opportunities for habitat improvement, including modifications to Lake Lodi and Woodbridge Dam to facilitate downstream passage and temperature control, and opportunities to use abandoned gravel pit ponds present in the floodplain of the lower river for additional salmon rearing habitat. Additions of large gravels may also improve rearing habitat for salmon and steelhead juveniles.

Water Quality and Contaminants. Staff agrees that, in general, the recommended values for water quality variables should be met (both state and EPA). However, we also understand that to meet more important characteristics at any particular time (such as flow and temperature), compromises on chemical quality may need to be made. For example, it may be technically difficult or impossible to maintain 7 ppm DO throughout the summer and fall. To the extent possible, staff recommends actions that improve water quality be taken such as preventing slug flows from Penn Mine into Camanche Reservoir, maintaining Camanche Reservoir elevation such that there is sufficient hypolimnetic volume to sustain biological decomposition without major anoxia, and hypolimnetic oxygenation of Camanche Reservoir near the dam without destratification. Staff made its own recommendations regarding Camanche Reservoir minimum elevation and Pardee Reservoir minimum releases. Staff is uncertain of the possible impact of the concentrations of heavy metals in the Camanche releases and the Mokelumne River sediments and therefore recommends an expanded monitoring program be implemented to better characterize the transport and fate of contaminants in the system and potential ecological effects.

Escapement Goals. Staff found that chinook salmon escapement did not vary significantly between years before and after Camanche Dam (acknowledging imprecise estimates in some, the average is 3,300). Thus we conclude that the higher natural escapement goals by CDFG of 5,000 salmon not of hatchery origin are probably unrealistic under the past or current conditions (see above). The total run has exceeded this goal for fish of non-hatchery origin in only eight years since 1940. To the degree that habitat improvements in the river (including flows and temperatures) can make a more suitable habitat and stimulate more wild fish, the escapement goal of 5,000 may be more attainable. The improvements should not be considered a failure if a long-term average escapement of adults of non-hatchery origin does not reach 5,000.

For steelhead, the situation is different. The steelhead population has declined markedly to the point that there is essentially no self-sustaining steelhead run in the Lower Mokelumne River. Mitigating steelhead habitat losses from Camanche Dam has essentially failed for natural spawners. We believe that the reason is near absence of suitable habitat for juvenile steelhead in the lower river below Camanche Dam and that CDFG and EBMUD should conduct some habitat improvement for steelhead rearing that would allow CDFG to establish modest escapement goals for a small natural steelhead run.

The hatchery provides a valuable addition to natural production and it is worthwhile to continue its use (evaluation of the hatchery was not the objective of the staff analysis). The salmon and steelhead runs in the Mokelumne River can be supplemented by hatchery production, but staff believes the hatchery should not be considered a suitable substitute for the natural chinook salmon population, as it has recently for steelhead. To foster any indigenous stock remaining in the Lower Mokelumne River, we suggest that brood fish for juveniles that will eventually be stocked in the Mokelumne River be limited to migrants that return to the Mokelumne River.

Water Diversion and Fish Screens. Staff concurs that water diversions should be screened with state-of-the-art screening devices. It could be fruitless to enhance salmon and steelhead spawning, incubation, and rearing habitats below Camanche Dam when the emigrating juveniles are diverted to irrigation canals or other avenues not connecting with the ocean. Although not the responsibility of EBMUD under its FERC license, staff recommends collaboration among all parties to ensure adequate screening. Staff suggested alterations at Woodbridge Dam and diversion that may provide enhanced screening and fish bypass.

Fish Passage. Staff recognizes that upstream passage of adult salmon and steelhead at Woodbridge Dam can be a problem for attaining escapement goals below Camanche Dam. The CDFG recommendations for passage improvements at Woodbridge seem reasonable. Although not the responsibility of EBMUD under its FERC license, staff recommends collaboration among all parties to ensure adequate adult fish passage.

Riparian Habitat Maintenance and Protection. Staff agrees with CDFG that riparian habitat is important for salmon and steelhead in the Lower Mokelumne River. More riparian vegetation should be encouraged and removal carefully controlled to ensure that the stream's physical habitat and shading from direct sunlight (to minimize summer warming) are protected. Staff feels that this protection is EBMUD's responsibility on its property downstream of Camanche Dam. Elsewhere, EBMUD's participation in collaborative management is desirable. We suggest that use of abandoned gravel pit ponds for salmon rearing may also necessitate addition of riparian vegetation.

Public Access for Recreation. Staff recognizes conflicting desires regarding recreation. On the one hand, more access to the river for a multitude of legitimate, environmentally compatible uses (picnicking, birdwatching, fishing, hiking, etc.) is desirable. On the other hand, enhanced access during the migration and spawning seasons for salmon and trout can mean overharvest and trampling of redds with loss of important breeding stocks and embryos. Such illegal harvest occurs now at Woodbridge Dam and has not been effectively controlled. Redd destruction from trampling also occurs in the river below Camanche Dam. Providing more access is not directly EBMUD's responsibility under the FERC license, especially since the main access now is on EBMUD's Van Assen Park area. Staff recommends that EBMUD work collaboratively with CDFG and other parties to provide appropriate public access during times and at locations where adult salmon are not particularly vulnerable to additional fishing pressure or redd destruction.

Transportation. The staff concurs conditionally with proposals by EBMUD for increased collection and transportation of juvenile chinook salmon as they migrate downstream past Lake Lodi and Woodbridge Dam on their way to the Delta. However, this option is not our preferred option for mitigation of downstream migration, and therefore should only be used in dry water years when water supplies are low. Although artificial methods such as this are not preferred over natural migration, the high degree of conflicting demands for water in the basin dictate their limited use.

Fish Hatchery and Rearing Facility. Staff generally agrees with EBMUD's proposals for an improved hatchery operation at the MRFF. We did not, however, evaluate the hatchery plans in detail, for the thrust of this assessment was on natural fish production as it is affected by LMRP operations.

Additional Studies. Staff agrees with the CDFG recommendation that additional modeling studies, beyond those available to CDFG for the Management Plan, be conducted to evaluate Pardee and Camanche reservoirs for their capability to manage water temperature and water availability and to establish operational procedures and criteria. To some extent, such studies have been made by EBMUD and results provided to staff. The EBMUD results suggest extreme difficulty in meeting all the CDFG

recommendations. Staff conducted its own modeling studies, the results of which are contained herein, and recommend alternative flow and reservoir management conditions.

5.2 SIGNIFICANT IMPACTS

The action alternatives evaluated in the FEIS included flow and non-flow mitigation actions based on proposals or recommendations from CDFG, EBMUD, and staff (Section 2 and Table 2.4-1). Significant environmental and economic impacts of these alternatives have been identified and discussed in Section 4. This section summarizes these impact determinations and compares the impacts to the target resources emphasized in the FEIS: 1) naturally reproducing chinook salmon and steelhead trout; 2) EBMUD's water supply system; and 3) hydropower production. Both positive and negative impacts are discussed.

5.2.1 Flow Alternatives

Physical habitat and water quality conditions for salmon and trout in the lower river can be significantly improved by implementing higher minimum flows from Camanche Dam and minimum pool elevation requirements in Camanche Reservoir. These physical improvements in the Lower Mokelumne River are the best way to assure the sustainability of chinook salmon runs in this watershed. However, these positive impacts could be accompanied by significant negative impacts to the EBMUD water supply system and to some fish life stages if minimum flows are set too high. Table 5.2-1 presents our predictions of the positive and negative impacts of the alternative minimum flow regimes considered in the FEIS.

Chinook spawning habitat would be increased most by the CDFG, FWS, and staff alternatives. Median habitat available for chinook spawning (e.g., that area expected five out of ten years) would be increased to about seven acres, an increase of about 49% over what would be expected under the no action alternative. The EBMUD flow regime would increase spawning habitat to a lesser degree, in the range of 36%. Chinook fry habitat would be higher under the EBMUD alternative, but would also increase under staff's minimum flow regime. Median habitat for chinook juveniles would be marginally improved by all of the alternatives. The most important tradeoff among these habitat relationships is between chinook spawning, favored by the higher flows in the CDFG, FWS, and staff alternatives, and chinook fry habitat, favored by the lower flows in the EBMUD alternative. Staff recommends that spawning habitat is biologically more important to improvements in the chinook salmon reproductive cycle. Management of riparian habitat, Lake Lodi, and possible use of gravel pit ponds can increase the amount of fry habitat for chinook salmon if evidence becomes available that this life stage is limiting production.

The water supply deficits caused by higher minimum flows are shown in Table 5.2-1. In a worst-case, three-year drought sequence using staff's reduced 2020 municipal demand for water, the net deficits over the no action alternative range from a low of 0 TAF/yr for EBMUD's alternative to a high of 182 TAF for the FWS alternative. The water supply deficit caused by Staff's alternative lies between these extremes, but produces benefits to fish habitat comparable to the CDFG and FWS alternatives. The cost to EBMUD of replacing these worst-case deficits ranges from \$13 to \$24 million/yr, the latter for the FWS alternative (also see Appendices D and E). The annualized cost of implementing staff's alternative is between \$13 and \$18 million with our reduced 2020 municipal water demand. Under current (1990) supplies and demands, the cost of implementing staff's alternative, as well as EBMUD's, is negligible, but the cost of CDFG's and FWS's minimum flows is still significant even with current demand.

Hydropower production would show little change among the alternatives with net increases occurring only in infrequent dry years (Table 5.2-1). In one out of 10 years, the CDFG alternative could result in as

Table 5.2-1. Comparison of major environmental and socioeconomic benefits and costs of minimum flow regimes under the four action alternatives considered in the Final Environmental Impact Statement and no action. (Source: The staff.)

Resource impacted	Alternative flow regime				No Action
	CDFG	EBMUD	Staff	FWS	
Median physical habitat available					
Chinook spawning (acres)	7.1	6.4	7.0	7.0	4.7
Chinook fry (acres)	15.3	21.4	18.2	15.3	17.8
Chinook juveniles (acres)	8.5	7.2	7.6	7.6	6.9
Integrated habitat score (includes temperature effects)					
Chinook upstream migration	95	75	89	92	63
Chinook spawning/incubation	85	64	74	80	37
Chinook fry and juvenile rearing	14	36	40	24	60
Water supply deficits					
1990 normalized demand (TAF)	123	0	1	160	0
2020 reduced demand (TAF)	145	0	10	182	0
Annualized cost (\$M/yr)	20	13 ^a	13-18 ^b	24	13 ^a
Hydropower production					
90th percentile (GWh/yr)	233	233	231	230	234
Median (GWh/yr)	149	158	156	153	160
10th percentile (GWh/yr)	34	14	39	42	8

^a Cost of proposed conservation measures.

^b Conservation plus additional cost dependent on EBMUD's mode of deficit replacement.

much as 26 GWh additional hydropower generation by EBMUD, because more water would be moving downstream through hydroelectric turbines than under the no action alternative.

The positive and negative impacts of new pool elevation requirements in Camanche Reservoir are harder to quantify due to limited data. Temperatures downstream of Camanche Dam could be maintained at lower levels throughout the summer months of hot, dry years, but the exact magnitude and biological response cannot be predicted with confidence by existing models. The costs to EBMUD's water supply system would occur mostly in the second and third dry years in a drought sequence, because EBMUD's carryover storage would not be exhausted in one dry year. By relaxing minimum pool elevations in these extended droughts, the costs of minimum pool requirements can be minimized, and effects of droughts can be shared between fisheries and water users. The minimum pool requirement should not, however, be relaxed completely during droughts, because it provides an important buffer to potential water quality problems of the type that initiated this proceeding.

The benefits and costs of other flow-related actions are even more difficult to specify. There is little disagreement over the need for ramping rates, but the biological response to this mitigation is poorly understood anywhere in the country. Evidence for a biological response to attraction flows is also lacking. Therefore, staff recommends further studies before any final decisions are made.

5.2.2 Non-Flow Alternatives

The biggest advantage to non-flow mitigation actions is that they do not incur direct effects on the operation of EBMUD's water supply system. The overall cost of these actions can be high, however. Staff has not estimated the cost of all the non-flow alternatives in the FEIS because of lack of time and specific design information. Nevertheless, staff believes the most important non-flow actions that could be taken are: 1) to clean or otherwise improve spawning gravels; 2) to improve both the upstream and downstream passage at Woodbridge Dam; and 3) to improve the hydraulics of Lake Lodi, as discussed in Section 4.5. Staff recommends that EBMUD participate in a cooperative effort to resolve the fish passage problems at Woodbridge Dam and Lake Lodi. If improvements cannot be made in this area, the recommendations in the FEIS may have to be reconsidered.

5.2.3 No Action Alternative

The no action alternative would perpetuate the problems that are now threatening the sustainability of salmon and trout resources in the lower river. It also appears from EBMUD's planning studies for its updated WSMP that water development will be necessary to the LMRP to meet future water needs, regardless of any actions taken in this proceeding. Therefore, the costs of any modifications to the LMRP license will be marginal costs to be added to whatever action EBMUD takes on its own.

5.3 SUMMARY OF FINDINGS AND RECOMMENDATIONS

Staff's final recommendations for preferred actions are presented below. They include a combination of flow options, non-flow options, and monitoring designed to conserve and develop the naturally reproducing chinook salmon populations in the Lower Mokelumne River. In general, Staff's recommendations are intermediate between the proposals that have been made by CDFG and EBMUD. Our independent analyses have identified alternatives that provide an equivalent level of protection compared to those recommended by the resource management agencies but that have significantly less impact to water supplies. Because of the significant uncertainties surrounding water use in the Mokelumne River, and the rest of California's Central Valley, staff recommends that all the requirements generated from this proceeding be subject to review as additional information becomes available.

Flow-Related Mitigation Requirements

Based on our independent analyses and the best available information, staff recommends that four specific flow-related actions be taken:

- 1) Incorporate staff's minimum flow requirements into the LMRP license articles, requiring releases of 51, 108, and 160 TAF in dry, below-normal, and above-normal water years, respectively, as defined in Section 2.2.1 (Table 2.2-3). Water year types are to be based on a combination of CDWR estimates of unimpaired runoff into Pardee Reservoir and total system storage in EBMUD storage reservoirs, as defined under staff's alternative in Section 2.2.1. With the exception of dry water years, to facilitate upstream and downstream salmon migration, the point of compliance for minimum flow requirements

is below Woodbridge Dam during salmon migration periods (October 15 through December 31 and May 1 through June 30).

- 2) Require that a minimum pool elevation in Camanche Reservoir of 190 ft MSL be maintained from July 1 to the end of September in all water years except during extended droughts. In the second or third consecutive dry year, the minimum pool elevation in Camanche would be reduced to 175 ft MSL. This reduction in pool elevations would, in part, mean that fish resources would share water deficits with EBMUD's water supply system.
- 3) Institute ramping rates to stabilize short-term flow fluctuations in the Camanche Dam tailwaters. The rate of change of discharges from Camanche Dam would be no greater than that which would change stage elevation two inches per hour, based on the actual river-stage-to-flow relationships measured at the USGS gaging station below Camanche Dam. This operational constraint is to be effective at streamflows less than 400 cfs from February 1 through May 31.
- 4) Require, in addition to the minimum flows in Table 2.2-3, experimental studies of higher flows of short duration (pulse flows) in the spring and the fall of above-normal years only. A monitoring program shall be established by EBMUD to measure success of these pulse flows in attracting adults in the fall and aiding outmigrant survival in the spring. The effects of pulse flows for attraction and out-migration shall be evaluated by the parties after ten years with recommendations to the Commission.

Non-Flow Mitigation Requirements

In addition to the flow-related requirements, staff also recommends several non-flow actions:

- 5) In dry water years, when the lowest minimum flows would be required, trapping and trucking operations shall be required to move downstream migrating salmon from above Lake Lodi into the Delta. The licensee should establish a cooperative agreement with CDFG for approval by the Commission to implement this action.
- 6) A formal instream habitat enhancement program shall be implemented that focuses on spawning gravel rehabilitation and maintenance of the stream channel downstream of Woodbridge Dam for upstream passage during Camanche Dam fall flows. The licensee should establish a cooperative agreement with CDFG for approval by the Commission to implement this action.
- 7) The hypolimnetic oxygenation project shall continue, coupled with a strong monitoring program and annual progress reports to the Commission. The option of alternative selective withdrawal structures or curtains will be considered only if other mitigation requirements listed above have been successfully implemented and monitoring indicates that further improvements in DO or stream temperature are needed to protect fish and wildlife resources.

Required Monitoring and Studies

Staff concludes that currently available information is insufficient to define some of the mitigation needs for salmon and trout in the lower river and that additional studies are needed to fully define these needs. Therefore, staff recommends the following monitoring program be established, with the approval of the Commission and under the direction of the existing interagency Mokelumne River Technical Advisory Committee (MRTAC). Unless otherwise stated, we recommend that study results be compiled by the MRTAC at the conclusion of ten years of study, with recommendations to the Commission.

Chinook Salmon Biology. Continue the monitoring program that EBMUD has implemented for study of chinook spawning, incubation, rearing, and outmigration. The objective of this program should be to determine reproduction success, growth rates, and survival rates in the major segments of the lower river. This information would be used to develop a better understanding of the cumulative effects of water development projects in the lower river and to establish the need to modify any of the flow and non-flow requirements recommended by staff.

Temperature and Water Quality Monitoring. A formal monitoring program should be implemented by EBMUD to establish a long-term (e.g., five-year continuous record) data set of representative temperature and DO profiles (longitudinal in the river and vertical in the reservoirs, including Lake Lodi). This information would be used to understand cumulative impacts in the lower river and may be used as a basis to identify more efficient means of achieving the recommended mitigation in the future.

Contaminants Monitoring. An enhanced monitoring program should be implemented to better characterize the transport and fate of contaminants in the system and potential ecological effects. This program should include a characterization of the heavy metal contamination in the water, sediment, and fish in the Lower Mokelumne River and Camanche Reservoir. Particularly sensitive life stages (eggs and larvae) should be monitored for possible negative responses to contamination, such as poor survival or developmental abnormalities. These studies should include measurements of hatching success, sediment toxicity tests using hatchery eggs exposed to river sediments, and *in situ* toxicity tests with artificially propagated eggs placed into artificial redds in the river.

Attraction Flows. Monitor the effects of pulse flows of different magnitudes (amplitude and duration) on stimulation of adult migrations past Woodbridge Dam. A formal program should be established to ensure accurate escapement counts above and below Woodbridge Dam. This information would be used to establish an appropriate spike flow for autumn attraction flows.

Hypolimnetic Oxygenation. Study the effectiveness of hypolimnetic oxygenation in improving water quality of Camanche Dam releases. This information would be used to determine if this alternative is an effective means of maintaining DO levels in the reservoir and releases.

Additional Recommendations

In addition to the requirements listed above, staff recommends that the licensee consider implementing several additional actions to resolve the outstanding uncertainties associated with the condition of salmon and steelhead in the Lower Mokelumne River and to identify other ways in which their management and conservation can be improved. It is possible that through implementation of these recommended actions, new information will become available bearing on the effectiveness of the project modifications that result from this proceeding. Alternatively, through cooperative agreements, more efficient means of conservation may be identified. If at any time, new information relevant to project operations becomes available, the licensee is encouraged to share it with the Commission for consideration.

- **Ramping Rates.** EBMUD should monitor the effects of interim ramping rates of no more than two inches/hr below 400 cfs on fish stranding. This information would be used to adjust, if necessary, the ramping rate limits.
- **Turbidity (Attraction).** EBMUD should monitor the river turbidity downstream of Woodbridge Dam in relation to adult fish migrating past the dam. This information would be used to establish whether turbidity rather than flow is a cue for attraction.

- **Improve Riparian Conditions.** EBMUD should facilitate a cooperative program with CDFG and riparian landowners for restoration and improvement of the riparian corridor between Camanche Dam and Lake Lodi.
- **Improve fish screens.** EBMUD should participate in planning improvements in fish screens at Lake Lodi water diversion (WID intake). These improvements would directly benefit the production of chinook salmon in the river, and therefore would be in the interest of all users of the river.
- **Reconsider flood control operations.** The flood control agreement between EBMUD and the COE is an important limitation on operations of Camanche and Pardee dams. For example, the current agreement requires EBMUD to begin drawing down Camanche Reservoir in early September, before the initiation of upstream runs of chinook salmon. If Camanche drawdown could be delayed a few weeks and coordinated with the salmon runs to some degree, then Camanche releases would be more efficient and valuable, providing both flood control and fishery benefits.
- **Off-Stream Rearing Habitat.** EBMUD should carry out an exploratory study with cooperation of CDFG to evaluate the use of riparian gravel mining ponds as additional rearing habitat for juvenile chinook salmon. Even though the raceways at the MRFF did not workout as originally intended, artificial rearing closer to the natural channel still may be a viable option for augmenting available habitat in the lower river without the need for higher flows.
- **Steelhead Trout Biology.** Although staff is skeptical about the possibilities of restoring naturally reproducing steelhead to the Mokelumne River, EBMUD could clarify this issue by monitoring more carefully than in the past the steelhead spawning, incubation, rearing and outmigration in the river. This information would be used to determine why the steelhead natural spawners essentially had no production in recent years and why the steelhead reintroduction has not been successful. The staff conclusion that rearing habitat is nil should be tested. A final determination should be made by the MRTAC as to the viability of a naturally reproducing steelhead population in the lower river; if management of naturally reproducing steelhead is an unrealistic objective given the degree of water resources development on the river, it should be dropped from the management goals.
- **Demand Forecasting.** EBMUD should develop a more rigorous approach to demand forecasting that explicitly accounts for permanent structural changes with regard to water use. An improved approach would strengthen their position on need for water.
- **New Sources of Water Supply.** Unless they have already done so, EBMUD should undertake a detailed engineering cost study of new water withdrawal and treatment facilities below Camanche Dam, including, but not limited to, the Delta area. EBMUD should also continue to investigate the acquisition of dry-year water options from existing water rights holders.
- **Gravel Enhancements.** EBMUD should monitor the effectiveness of stream gravel placements and rehabilitation measures by measuring the spawning utilization of these sites. A screening survey of metals concentrations should be conducted in the Tailwater Segment of the river to determine if resuspension of contaminants could be a problem. This information would be used to evaluate whether this is effective and to establish needs for a continuing program of spawning gravel replenishment.
- **Lake Lodi Improvements.** EBMUD should facilitate and participate in a cooperative study of Lodi Lake/Woodbridge Dam improvements, focusing specifically on hydraulic options, such as diversion ditches, skimmer walls, and underflow releases, that would route downstream migrants away from the

Woodbridge Canal entrance. This action should investigate modifications that do not rely on improved screening that may or may not be implemented by others. If proven effective, these non-flow alternatives could replace the need for higher stream flows to protect downstream migrants.

- **Improve Fishery Management.** EBMUD should continue to work with CDFG in operation of the MRFF to emphasize the use of indigenous stocks for production in order to preserve any residual genetic resources of the salmonid runs in the Mokelumne River and to avoid introduction of other stocks and species to the river. This action would not take the place of restoration of natural production as intended by staff's required mitigation, but would be an additional mitigation measure to compensate for the loss of habitat above Camanche Dam. However, actions such as these will increase the likelihood of maintaining sustainable salmon runs in the Lower Mokelumne River, and thereby, possibly head off future actions that might be required under the Endangered Species Act.

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APPENDIX A. LICENSE TERMS AND CONDITIONS

APPENDIX A. LICENSE TERMS AND CONDITIONS

The following articles are incorporated into the existing license for the Lower Mokelumne River Project (FERC Project No. 2916) that was issued by the Federal Energy Regulatory Commission on March 10, 1981, to East Bay Municipal Utility District.

Article 12. The operations of the Licensee, so far as they affect the use, storage and discharge from storage of waters affected by the license, shall at all times be controlled by such reasonable rules and regulations as the Commission may prescribe for the protection of life, health, and property, and in the interest of the fullest practicable conservation and utilization of such waters for power purposes and for other beneficial public uses, including recreational purposes, and the Licensee shall release water from the project reservoir at such rate in cubic feet per second, or such volume in acre-feet per specified period of time, as the Commission may prescribe for the purposes hereintofores mentioned.

Article 15. The Licensee shall, for the conservation and development of fish and wildlife resources, construct, maintain, and operate, or arrange for the construction, maintenance, and operation of such reasonable facilities, and comply with such reasonable modifications of the project structures and operation, as may be ordered by the Commission upon its own motion or upon the recommendation of the Secretary of the Interior or the fish and wildlife agency or agencies of any state in which the project or a part thereof is located, after notice and opportunity for hearing.

APPENDIX B. WATER BALANCE MODELING

APPENDIX B. WATER BALANCE MODELING

MODEL DESCRIPTION

The water budget model used to perform predictive simulations is essentially an accounting model which tracks all of the hydrologic components of the Pardee-Camanche system. The modeled watershed is the 77-square-mile local area upstream of Camanche Dam (drainage area 621 square miles) and downstream of the United States Geological Survey's (USGS) stream gage on the Mokelumne River near Mokelumne Hill (gage no. 11319500; drainage area 544 square miles). The schematic diagram, shown in Figure B-1, includes all of the hydrologic parameters simulated in the water budget model.

The model operates on a daily time step. Storage allocation in Pardee, Camanche, and the terminal reservoirs is driven primarily by prioritized operating constraints, which are discussed in a subsequent section. No allowance for transferable space is made in the water budget model. In addition, the model has no forecasting component to predict annual snowmelt volumes.

The model is capable of simulating any portion of the historic period from January 1, 1921 through December 31, 1990. Only 1966-1970 were simulated, due to limited data availability prior to 1966. Alternative simulations are performed by varying the minimum discharge and pool elevations for Camanche Reservoir, and by deciding whether or not pumping is allowed from Pardee Reservoir to the East Bay Municipal Utility District (EBMUD) aqueducts.

Figure B-1. Schematic diagram of the Pardee and Camanche Reservoir system. (Source: The staff.)

Description of Water Budget Model Input Terms

The terms shown in Figure B-1 are defined as follows:

3195	Pardee inflow measured at USGS gage 11319500 (Mokelumne Hill)
PRAIN	Precipitation falling on Pardee Reservoir
PRO	That portion of the runoff and groundwater seepage term apportioned to Pardee Reservoir
PEVAP	Evaporation from the Pardee Reservoir surface
EBWD	EBMUD aqueduct withdrawals from Pardee Reservoir
JVID	Diversions for the Jackson Valley Irrigation District
POUT	Pardee outflow
TROUT	Terminal Reservoir outflow
CRAIN	Precipitation falling on Camanche Reservoir
CRO	That portion of the runoff and groundwater seepage term apportioned to Camanche Reservoir
CEVAP	Evaporation from the Camanche Reservoir surface
COUT	Camanche outflow

The precipitation input terms "PRAIN" and "CRAIN" are based on data from meteorological stations at Lodi and Camp Pardee, and from data supplied by EBMUD. These terms are the depths of rain falling directly on the surface of the respective reservoirs. The evaporation terms "PEVAP" and "CEVAP" are the volumes of water lost by evaporation from the respective reservoirs; they are based on data from the same sources as for the precipitation. The model computes the daily average surface area of Pardee and Camanche, and calculates the corresponding rainfall and evaporation volumes in the water budget equation by multiplying the daily depth of precipitation (or evaporation) by the average surface areas for that day.

EBMUD and Jackson Valley Irrigation District (JVID) diversions from Pardee are based on data supplied by EBMUD (1992). The outflow terms in the model include "POUT", "TROUT", and "COUT"; these terms are computed based on the model operating constraints and input data.

All the hydrologic terms described above are either known, or can be estimated with some confidence. The remaining terms are the runoff terms, "PRO" and "CRO". These terms, more properly called "net local inflow" or surface runoff plus groundwater seepage, represent the remaining elements of the hydrologic water balance equation. The method used to compute these terms is discussed in the next section.

Computation of Net Local Inflow Term Used in Water Budget Model

The hydrologic water balance equation for the Pardee-Camanche system can be written in its simplest form as:

$$\Delta S_t = \Delta S_p + \Delta S_c = (\text{SUM OF INFLOW TERMS}) - (\text{SUM OF OUTFLOW TERMS})$$

where:

ΔS_t = Total storage change in Pardee and Camanche system

ΔS_p = Storage change in Pardee Reservoir

ΔS_c = Storage change in Camanche Reservoir

and letting Σ stand for "sum of":

$$\Sigma \text{ INFLOW TERMS} = 3195 + \text{PRAIN} + \text{CRAIN} + \text{NETLOCINF}$$

$$\Sigma \text{ OUTFLOW TERMS} = \text{PEVAP} + \text{JVID} + \text{EBWD} + \text{CEVAP} + \text{COUT}$$

The COUT term, which represents Camanche outflows, can be obtained for any period after Camanche closure in 1963 from the USGS Mokelumne River below Camanche Dam stream gage (gage no. 11323500, drainage area 627 square miles). Therefore, the unknown term in the above equations is "NETLOCINF" (net local inflow). The equation can be rewritten as follows, allowing direct computation of this term:

$$\text{NETLOCINF} = \Delta S_p + \Delta S_c + \text{PEVAP} + \text{JVID} + \text{EBWD} + \text{CEVAP} + \text{COUT} - 3195 - \text{PRAIN} - \text{CRAIN}$$

The "NETLOCINF" term is the remaining component in the hydrologic water balance, and represents the sum of the surface water runoff term, the groundwater seepage term, and all of the errors associated with estimation of the other terms. While the surface water runoff term can be only zero or a positive number, both the groundwater seepage and error terms can be either positive or negative. The "NETLOCINF" term was computed directly from available data for the period January 1, 1966 through December 31, 1990 using the equation shown above. The monthly values of the "NETLOCINF" term for this period are shown in Figure B-2.

Figure B-2. Monthly net local inflow term, "NETLOCINF". (Source: The staff.)

The corresponding terms used in the water budget model are PRO and CRO. Based on the sizes of the drainage areas for both Pardee and Camanche, these terms were defined as follows:

$$\begin{aligned}\text{PRO} &= \text{NETLOCINF} * 0.41 \\ \text{CRO} &= \text{NETLOCINF} * 0.52\end{aligned}$$

That portion of the "NETLOCINF" term representing the area between Camanche Dam and the USGS gage below Camanche was not included in the water budget model, as it does not contribute to the water balance of the Pardee-Camanche system. Therefore, the sum of PRO and CRO is not equal to NETLOCINF, but rather, their sum is slightly less ($0.93 * \text{NETLOCINF}$).

MODEL OPERATING CONSTRAINTS

Model simulations were performed under a series of prioritized operating constraints. Those constraints are discussed next in order of decreasing importance.

Priority 1

Satisfy the Camanche minimum release requirement, and reduce terminal reservoir withdrawals by a specified fraction when the storage in Pardee and Camanche is low. The amount of the reduction as a function of combined storage in Pardee and Camanche is defined by the user prior to each simulation. The demand reduction function used was the same for all simulation runs. For total storage greater than 500 TAF, there is no demand reduction. For total storage between 500 TAF and 450 TAF, the demand reduction is a linear function of total storage, increasing to 15% when the total storage is 450 TAF. For total storage between 450 TAF and 300 TAF the demand reduction is a linear function of total storage, increasing to 25% at a total storage of 300 TAF. For total storage less than 300 TAF, the demand reduction percentage is 25%. The model checked total storage daily and adjusted accordingly.

Priority 2

Follow the terminal reservoir seasonal guide curve. Simulations were performed using the 10-year average terminal reservoir storage (provided by EBMUD) as the seasonal guide curve. This curve is shown in Figure B-3.

The model computes the desired value of terminal reservoir storage on a daily basis, and compares it to the actual volume of water stored in the terminal reservoir system. If the system has more storage in it than desired, aqueduct withdrawals from Pardee Reservoir are decreased by an amount equal to the excess storage in the terminal reservoirs, or shut off entirely, as required. If the system has less storage in it than desired, aqueduct withdrawals from Pardee Reservoir are increased by an amount equal to the lesser of 1) the additional storage required in the terminal reservoirs system; or 2) the maximum capacity that can be withdrawn given the current Pardee elevation.

Priority 3

Provide flood storage reservation as dictated by the agreement with the U.S. Army Corps of Engineers (COE). Figure B-4 shows the flood storage reservation guide curve used for model simulations. The model computes the value of required storage space (the sum of the storage space in Pardee and Camanche) on a daily basis, and compares this value to the actual storage space in Pardee and Camanche. If additional flood storage reservation is required, and the maximum allowable aqueduct withdrawals dictated by

Figure B-3. Seasonal guide curve for terminal reservoir storage. (Source: The staff.)

Figure B-4. Simplified flood storage rule curve. (Source: The staff.)

Priority 2 are not sufficient to evacuate enough additional water for the COE flood control requirement to be satisfied, then Camanche outflows are increased to the lesser of 1) the maximum turbine capacity; or 2) the rate required to discharge enough additional water to satisfy the COE storage requirement.

Priority 4

Satisfy the Pardee minimum storage requirement. Pardee minimum storages are defined by the user for each simulation and can be varied by month. The model computes the value of desired minimum Pardee storage on a daily basis and compares it to the actual computed value of Pardee storage. If the value of computed storage in Pardee is less than the desired minimum value, Pardee outflows are reduced (to zero if required) to preserve Pardee storage. No adjustments are made to withdrawals to the EBMUD aqueduct or to the JVID. If the value of computed storage in Pardee is greater than the desired minimum value, no adjustments are made.

Pardee outflows are reduced as required to satisfy the user-defined minimum storage requirement. Reductions in Pardee outflow required to preserve Pardee storage thus have a higher priority than satisfying the user-defined Pardee minimum discharge.

Priority 5

Satisfy the user-defined Pardee minimum outflow requirement. The minimum allowable release is specified by the user; for most simulations the minimum value was zero cubic feet per second (cfs).

Priority 6

Satisfy the Camanche minimum storage requirement. Camanche minimum storages are defined by the user for each simulation and can be varied by month. The model computes the value of desired minimum Camanche storage on a daily basis and compares it to the actual computed value of Camanche storage. If the value of computed storage in Camanche is less than the desired minimum value, Pardee outflows are increased to augment Camanche storage. If the value of computed storage in Camanche is greater than the desired minimum value, no adjustments are made.

Priority 7

Follow the Pardee guide curve. The guide curve used for all simulations is based on information provided by EBMUD, and is shown in Figure B-5. The model computes the value of desired Pardee elevation on a daily basis, and compares it to the actual computed value of Pardee elevation. If the computed Pardee elevation is above the guide curve, Pardee Dam outflows are increased as required to lower the reservoir pool elevation. The maximum allowable release without spillway discharge, is assumed to be 5200 cfs, from data provided by EBMUD. If the computed Pardee elevation is below the guide curve, Pardee Dam outflows are decreased as required to increase the reservoir pool elevation.

Other Model Features

The terminal reservoir system is treated as a simple, single reservoir in the water budget model. No provision is made to simulate rainfall, watershed runoff, or evaporation from this system. The water budget model simply tracks inflows to the system via the EBMUD aqueduct, and outflows from the system from a generalized demand function developed from observed aqueduct withdrawals.

Figure B-5. Target pool elevations for Pardee Reservoir. (Source: The staff.)

Aqueduct withdrawals can be made either by gravity flow alone or by gravity and pumping. The user specifies the desired option for a given simulation; that option is used throughout the entire simulation. If the pumping option is selected, the resulting, additional withdrawal capacity is utilized whenever gravity flow alone cannot move enough water to the terminal reservoir system.

Pardee outflows are checked to make sure they are not greater than maximum turbine capacity and not less than the user specified minimum value. Pardee outflows less than the minimum value are allowed only when there is insufficient storage volume in Pardee to satisfy the minimum flow requirement. Pardee outflows greater than maximum turbine capacity are allowed only when the computed value of Pardee pool elevation is above the spillway crest. For this condition, Pardee discharges are increased to include uncontrolled spillway discharges.

MODEL VALIDATION

The water budget model was used to perform a 5-year simulation from January 1, 1986 to December 31, 1990 in order to test the validity of the model. Observed data were used for all the model parameters. The model constraints outlined above were turned off for the validation simulation, as they would have forced simulated reservoir operation to vary from the observed operation. The results of the validation simulation are shown in Figures B-6 through B-8. Figure B-6 shows observed versus computed storages for Pardee, Figure B-7 for Camanche, and Figure B-8 for the total system storage in both reservoirs.

Figure B-6. Computed versus observed storages in Pardee Reservoir. (Source: The staff.)

Figure B-7. Computed versus observed storages in Camanche Reservoir. (Source: The staff.)

Figure B-8. Computed versus observed combined storages in Pardee and Camanche Reservoirs. (Source: The staff.)

WATER BUDGET MODEL SIMULATIONS

The water budget model was used for two kinds of simulations. The first involved daily computations for the 25-year historic period from 1966-1990, using observed values for rainfall, evaporation, Pardee inflow, net local inflow, EBMUD aqueduct withdrawal, and JVID diversions. The second involved daily computations for a 3 year drought period. The first two years of the drought sequence were based on observed data from 1976 and 1977. The third year of the drought sequence is a hypothetical year. Reservoir inflows for the third year were based on the 1977 data, adjusted so that the total annual Mokelumne river discharge into Pardee was 185,000 ac-ft.

Staff specified both the water year type and the associated minimum Camanche releases for each simulated. The water year types for each set of alternatives are shown in Table B-1. Tables B-2 through B-7 list the minimum required releases from Camanche Reservoir for each of the alternatives investigated.

CALCULATION OF REQUIRED CAMANCHE OUTFLOWS

Tables B-2 through B-7 are taken from the Microsoft Excel spreadsheets that staff used to calculate the releases required from Camanche Reservoir. The tables include alternative instream flow requirements (IFRs) proposed by California Department of Fish and Game (Tables B-2 and B-3), EBMUD (Table B-4), Staff (Table B-5), and the U.S. Fish and Wildlife Service (FWS) (Table B-7). Table B-6 lists the factors making up required releases under existing conditions (the no-action alternative).

Table B-1. Water year types for water budget model simulations. (Source: The staff.)

Year	True natural flow	Alternative water year classifications				
	[thousand acre-feet (TAF)] ^a	CDFG	EBMUD	ORNL	FWS	No action
1966	466	N	D	B	N	N
1967	1,152	W	N	A	W	W
1968	410	N	D	B	N	N
1969	1,339	W	N	A	W	W
1970	913	W	N	A	W	W
1971	780	N	N	A	W	N
1972	529	N	N	B	N	N
1973	795	N	N	A	W	W
1974	1,002	W	N	A	W	W
1975	779	N	N	A	W	N
1976	246	D	D	D	D	D
1977	129	D	CD	D	D	D
1978	959	W	N	A	W	W
1979	690	N	N	B	N	N
1980	1,136	W	N	A	W	W
1981	370	N	N	D	D	N
1982	1,554	W	N	A	W	W
1983	1,820	W	N	A	W	W
1984	1,080	W	N	A	W	W
1985	484	N	N	B	N	N
1986	1,232	W	N	A	W	W
1987	263	D	D	D	D	D
1988	253	D	D	D	D	D
1989	563	N	D	B	N	N
1990	344	D	D	D	D	D

W = wet year; N = normal year; D = dry year; CD = critically dry year; A = above normal year;
B = below normal year

^aTrue natural flow at the Mokelumne Hill gage (EBMUD 1992).

Table B-2. Calculation of necessary releases from Camanche Dam under instream flow requirements proposed by the California Department of Fish and Game for various water year types.
(All units are cfs except for the bottom row which is TAF/yr.)
 (Source: The staff.)

	WID			NSJWCD			Senior appropriators			CDFG fish flows			Carriage loss			Required release		
	Dry	Normal	Wet	Dry	Normal	Wet	Dry	Normal	Wet	Dry	Normal	Wet	Dry	Normal	Wet	Dry	Normal	Wet
Oct 1-14	48	73	73	0	6	11	3	3	3	130	470	520	75	86	88	255	638	695
Oct 15-31	31	47	47	0	6	11	3	3	3	130	520	570	74	87	89	237	663	720
Nov 1-15	2	4	4	0	1	3	1	2	2	310	520	570	79	86	87	393	612	665
Nov 16-30	2	4	4	0	1	3	1	2	2	200	300	350	76	79	81	279	386	439
Dec	0	1	1	0	0	0	2	3	3	200	300	350	76	79	81	278	382	434
Jan	0	0	0	0	0	0	0	1	1	200	300	350	76	79	80	276	380	431
Feb	0	0	0	0	0	0	0	1	1	200	300	350	76	79	80	276	379	431
Mar	12	18	18	0	1	3	2	2	2	200	350	400	76	81	83	290	452	505
Apr 1-14	35	53	53	0	10	19	5	7	7	200	400	450	77	84	86	317	553	615
Apr 15-30	63	97	97	0	10	19	5	7	7	250	400	450	79	85	87	397	598	660
May	95	146	146	0	26	53	12	16	16	300	450	450	82	89	90	490	728	755
June	121	185	185	0	35	69	18	24	24	20	400	300	73	89	87	232	733	665
July	128	196	196	0	39	77	17	23	23	20	150	300	74	82	88	240	491	685
Aug	120	184	184	0	30	61	11	15	15	20	100	300	72	80	87	230	417	655
Sep	78	119	119	0	17	33	6	8	8	20	100	300	63	77	84	172	328	551
Totals (TAF)	39	60	60	0	10	20	5	6	6	108	227	276	54	60	62	207	364	425

Note: Totals for fish flows and required releases do not include effects of ramping rates.

Table B-3. Calculation of necessary releases from Camanche Dam under instream flow requirements proposed by the California Department of Fish and Game without spike flows for various water year types. (All units are cfs except for the bottom row which is TAF/yr.)

(Source: The staff.)

	WID			NSJWCD			Senior appropriators			CDFG fish flows			Carriage loss			Required release		
	Dry	Normal	Wet	Dry	Normal	Wet	Dry	Normal	Wet	Dry	Normal	Wet	Dry	Normal	Wet	Dry	Normal	Wet
Oct 1-14	48	73	73	0	6	11	3	3	3	20	250	300	56	80	82	126	412	469
Oct 15-31	31	47	47	0	6	11	3	3	3	20	300	350	53	81	82	106	436	494
Nov 1-15	2	4	4	0	1	3	1	2	2	200	300	350	76	79	81	279	386	439
Nov 16-30	2	4	4	0	1	3	1	2	2	200	300	350	76	79	81	279	386	439
Dec	0	1	1	0	0	0	2	3	3	200	300	350	76	79	81	278	382	434
Jan	0	0	0	0	0	0	0	1	1	200	300	350	76	79	80	276	380	431
Feb	0	0	0	0	0	0	0	1	1	200	300	350	76	79	80	276	379	431
Mar	12	18	18	0	1	3	2	2	2	200	350	400	76	81	83	290	452	505
Apr 1-14	35	53	53	0	10	19	5	7	7	200	400	450	77	84	86	317	553	615
Apr 15-30	63	97	97	0	10	19	5	7	7	250	400	450	79	85	87	397	598	660
May	95	146	146	0	26	53	12	16	16	300	450	450	82	89	90	490	728	755
June	121	185	185	0	35	69	18	24	24	20	400	400	73	89	90	232	733	768
July	128	196	196	0	39	77	17	23	23	20	150	300	74	82	88	239	490	684
Aug	120	184	184	0	30	61	11	15	15	20	100	300	71	80	87	223	409	647
Sep	78	119	119	0	17	33	6	8	8	20	100	300	62	77	84	165	321	544
Totals (TAF)	39	60	60	0	10	20	5	6	6	98	207	262	53	59	61	195	343	409

Note: Totals for fish flows and required releases do not include effects of ramping rates.

Table B-4. Calculation of necessary releases from Camanche Dam under instream flow requirements proposed by East Bay Municipal Utility District for various water year types.
(All units are cfs except for the bottom row which is TAF/yr.)

(Source: The staff.)

	WID			NSJWCD			Senior appropriators			EBMUD fish flows			Carriage loss				Required release			
	Dry	Normal	Wet	Dry	Normal	Wet	Dry	Normal	Wet	Crit. Dry	Dry	Normal/Wet	Crit. Dry	Dry	Normal	Wet	Crit. Dry	Dry	Normal	Wet
Oct 1-15	48	73	73	0	6	11	3	3	3	20	20	20	56	56	62	63	126	126	164	170
Oct 16-31	31	47	47	0	6	11	3	3	3	20	100	200	53	68	78	78	106	201	333	339
Nov	2	4	4	0	1	3	1	2	2	100	200	300	62	76	79	79	166	279	386	387
Dec 1-15	0	1	1	0	0	0	2	3	3	100	200	300	62	76	79	79	165	278	382	382
Dec 16-31	0	1	1	0	0	0	2	3	3	50	100	100	52	62	62	62	105	165	166	166
Jan	0	0	0	0	0	0	0	1	1	50	100	100	52	62	62	62	102	162	162	162
Feb	0	0	0	0	0	0	0	1	1	50	100	100	52	62	62	62	103	162	162	162
Mar	12	18	18	0	1	3	2	2	2	50	100	100	54	64	66	66	118	177	187	189
Apr 1-15	35	53	53	0	10	19	5	7	7	20	100	100	54	69	75	75	113	209	244	254
Apr 16-30	63	97	97	0	10	19	5	7	7	20	150	150	59	76	78	78	147	294	341	351
May 1-15	95	146	146	0	26	53	12	16	16	20	300	300	67	82	85	85	194	490	573	600
May 16-31	95	146	146	0	26	53	12	16	16	20	400	400	67	85	88	88	194	593	676	703
June	121	185	185	0	35	69	18	24	24	20	20	500	73	73	92	93	232	232	836	871
July	128	196	196	0	39	77	17	23	23	20	20	20	74	74	78	79	239	239	356	396
Aug	120	184	184	0	30	61	11	15	15	20	20	20	71	71	77	78	223	223	327	358
Sep	78	119	119	0	17	33	6	8	8	20	20	20	62	62	74	75	165	165	237	255
Totals (TAF)	39	60	60	0	10	20	5	6	6	28	77	118	44	50	54	54	116	171	248	258

Table B-5. Calculation of necessary releases from Camanche Dam under instream flow requirements proposed by staff for various water year types. (All units are cfs except for the bottom row which is TAF/yr.)

(Source: The staff.)

	WID			NSJWCD			Senior appropriators			Staff flows			Carriage loss			Required release		
	Dry	BN	AN	Dry	BN	AN	Dry	BN	AN	Dry	BN	AN	Dry	BN	AN	Dry	BN	AN
Oct 1-14	48	73	73	0	6	11	3	3	3	20	150	300	56	77	82	126	309	469
Oct 15-31	31	47	47	0	6	11	3	3	3	200	300	350	77	81	82	310	436	494
Nov	2	4	4	0	1	3	1	2	2	150	220	310	72	77	79	225	303	398
Dec	0	1	1	0	0	0	2	3	3	150	220	320	72	77	80	224	300	403
Jan	0	0	0	0	0	0	0	1	1	150	220	320	71	77	80	222	297	400
Feb	0	0	0	0	0	0	0	1	1	100	120	220	62	65	77	162	186	297
Mar	12	18	18	0	1	3	2	2	2	50	80	100	54	62	66	118	163	189
Apr 1-14	35	53	53	0	10	19	5	7	7	20	50	50	54	65	67	113	185	196
Apr 15-30	63	97	97	0	10	19	5	7	7	20	50	50	59	74	75	147	236	248
May	95	146	146	0	26	53	12	16	16	20	200	300	67	82	85	194	470	600
June	121	185	185	0	35	69	18	24	24	20	300	400	73	86	90	232	630	768
July	128	196	196	0	39	77	17	23	23	20	50	100	74	79	82	239	387	478
Aug	120	184	184	0	30	61	11	15	15	20	50	100	71	78	81	223	358	441
Sept	78	119	119	0	17	33	6	8	8	20	50	100	62	76	78	165	269	338
Totals (TAF)	39	60	60	0	10	20	5	6	6	51	108	160	49	55	58	143	240	304

BN = below normal; AN = above normal

Table B-6. Calculation of necessary releases from Camanche Dam under existing agreement between East Bay Municipal Utility District and the California Department of Fish and Game for various water year types.
(All units are cfs except for the bottom row which is TAF/yr.)

(Source: The staff.)

	WID			NSJWCD			Senior appropriators			Existing fish flows			Carriage loss			Required release		
	Dry	Normal	Wet	Dry	Normal	Wet	Dry	Normal	Wet	Dry	Normal	Wet	Dry	Normal	Wet	Dry	Normal	Wet
Oct 1-14	48	73	73	0	6	11	3	3	3	0	0	0	52	58	59	102	140	146
Oct 15-31	31	47	47	0	6	11	3	3	3	0	0	0	41	53	54	75	109	116
Nov	2	4	4	0	1	3	1	2	2	25	50	50	36	53	53	64	110	112
Dec	0	1	1	0	0	0	2	3	3	25	66	66	34	56	56	62	125	125
Jan	0	0	0	0	0	0	0	1	1	0	40	40	1	50	50	1	91	91
Feb	0	0	0	0	0	0	0	1	1	20	30	30	26	38	38	46	69	69
Mar	12	18	18	0	1	3	2	2	2	20	30	30	42	52	52	75	104	105
Apr 1-14	35	53	53	0	10	19	5	7	7	0	0	0	50	56	57	89	125	137
Apr 15-30	63	97	97	0	10	19	5	7	7	0	0	0	55	64	66	123	177	188
May	95	146	146	0	26	53	12	16	16	0	0	0	63	76	76	171	264	291
June	121	185	185	0	35	69	18	24	24	0	0	0	69	77	78	208	321	356
July	128	196	196	0	39	77	17	23	23	0	0	0	70	78	79	215	335	375
Aug	120	184	184	0	30	61	11	15	15	0	0	0	67	77	78	199	306	338
Sept	78	119	119	0	17	33	6	8	8	0	0	0	58	70	73	142	213	233
Totals (TAF)	39	60	60	0	10	20	5	6	6	5	13	13	34	45	46	83	134	145

Table B-7. Calculation of necessary releases from Camanche Dam under instream flow requirements proposed by U.S. Fish and Wildlife Service (FWS) for various water year types.

(All units are cfs except for the bottom row which is TAF/yr.)

(Source: The staff.)

	WID			NSJWCD			Senior appropriators			FWS fish flows			Carriage loss			Required release				
	Dry	Normal	Wet	Dry	Normal	Wet	Dry	Normal	Wet	Crit. Dry	Dry	Normal/Wet	Crit. Dry	Dry	Normal	Wet	Crit. Dry	Dry	Normal	Wet
Oct 1-5	48	73	73	0	6	11	3	3	3	200	200	200	77	77	78	79	327	327	360	366
Oct 6-11	48	73	73	0	6	11	3	3	3	200	200	450	77	77	86	86	327	327	618	623
Oct 12-17	39	60	60	0	6	11	3	3	3	200	200	450	77	77	86	86	319	319	604	610
Oct 18-31	31	47	47	0	6	11	3	3	3	200	200	300	77	77	81	81	310	310	436	442
Nov	2	4	4	0	1	3	1	2	2	200	200	300	76	76	79	79	279	279	386	387
Dec	0	1	1	0	0	0	2	3	3	200	200	300	76	76	79	79	278	278	382	382
Jan	0	0	0	0	0	0	0	1	1	200	200	300	76	76	79	79	276	276	380	380
Feb	0	0	0	0	0	0	0	1	1	200	200	300	76	76	79	79	276	276	379	379
Mar	12	18	18	0	1	3	2	2	2	200	200	300	76	76	80	80	290	290	401	402
Apr	50	76	76	0	10	19	5	7	7	200	200	300	78	78	82	82	332	332	474	484
May 1-10	95	146	146	0	26	53	12	16	16	300	300	400	82	82	88	88	490	490	676	703
May 11-20	95	146	146	0	26	53	12	16	16	400	400	550	85	85	92	93	593	593	831	858
May 21-31	95	146	146	0	26	53	12	16	16	500	500	700	88	88	97	97	696	696	985	1012
June 1-10	121	185	185	0	35	69	18	24	24	50	50	400	76	76	89	90	264	264	733	768
June 11-30	121	185	185	0	35	69	18	24	24	50	50	100	76	76	80	81	264	264	424	459
July	128	196	196	0	39	77	17	23	23	50	50	100	76	76	81	82	271	271	438	478
Aug	120	184	184	0	30	61	11	15	15	50	50	100	75	75	80	81	256	256	409	441
Sept	78	119	119	0	17	33	6	8	8	50	50	100	68	68	77	78	201	201	321	338
Totals (TAF)	39	60	60	0	10	20	5	6	6	121	121	193	55	55	59	59	220	220	328	338

Each table uses the minimum number of rows that could fully account for the variation of all the factors, demands, and proposed IFRs over the course of the year. The values in these rows are expressed as average flows for the periods, in cubic feet per second. The bottom row provides the annual sum of all the periods, converting the flows to a volume in thousands of ac-ft.

The leftmost sets of columns [Woodbridge Irrigation District (WID), North San Joaquin Water Conservation District (NSJWCD), and senior appropriator demands] in these tables show the water demands during the year for these three sets of users. These columns are the same for all tables. The "senior appropriator demands" include only the demands for these users below the USGS gauge at Woodbridge Dam. Demands for at least three water year types are included for each table. The definition of water year type is taken from the users' water rights or water use agreements. Staff assumed that water year definitions between the water users, and the agencies proposing IFRs were compatible. For example, this means that a "critically dry" water year as defined by EBMUD would result in corresponding "dry" year demands from WID, NSJWCD, and senior appropriators.

The next set of columns lists the proposed IFRs below Woodbridge Dam, with water year types as proposed by the agency providing that particular alternative. Due to averaging over some of the periods, the values expressed may not exactly match what is listed elsewhere in this document. However, the overall annual pattern and averages are preserved.

In displaying values for carriage loss and total required Camanche release, the tables use the minimum number of columns necessary to show the variation over different water year types. For example, the FWS alternative (Table B-7) has four water year types listed under both carriage loss and total Camanche release. This accounts for both (1) the downstream demand columns having "dry", "normal" and "wet" water year types, and (2) the IFR columns including an additional water year type, "critically dry". Therefore, a total of four columns under both carriage loss and total Camanche release ("critically dry", "dry", "normal" and "wet") are required to fully account for the possible number of water year types.

Carriage loss is calculated as a function of the required release from Camanche Reservoir, which is in turn a function of all the downstream demands and the carriage loss itself. It is important to note that, as discussed in Section 3.2.1, the carriage loss term includes riparian and senior appropriator usage in the reach between Woodbridge and Camanche, as these uses are not explicitly quantified anywhere. Expressed as an equation:

$$\text{WID} + \text{NSJ} + \text{SEN} + \text{IFR} + \text{CL} = \text{CAM} \quad (1)$$

where

WID	=	Woodbridge Irrigation District demand
NSJ	=	North San Joaquin Water Conservation District demand
SEN	=	Senior appropriator demand downstream of Woodbridge Dam
IFR	=	Instream flow requirement below Woodbridge Dam
CL	=	Carriage loss plus demands from senior appropriators between Camanche Dam and Woodbridge Dam
CAM	=	required release from Camanche Reservoir for the period

As discussed in Section 3.2.1, carriage loss (CL) is a function of release from Camanche dam. The following equations define staff's function describing carriage loss, as discussed in Section 3.2.1 and shown in Figure 3.2-6:

$$\text{CL} = 0.555 \cdot \text{CAM} \quad (\text{CAM} \leq 90 \text{ cfs}) \quad (2)$$

$$\text{CL} = 35.5 + 0.161 \cdot \text{CAM} \quad (90 < \text{CAM} \leq 245 \text{ cfs}) \quad (3)$$

$$CL = 67.8 + 0.029 \cdot CAM \quad (245 < CAM \leq 1097 \text{ cfs}) \quad (4)$$

$$CL = 61.4 + 0.035 \cdot CAM \quad (1097 < CAM \leq 1808 \text{ cfs}) \quad (5)$$

A simple rearrangement of equation (1) places all the known quantities on the left side of the equation,

$$WID + NSJ + SEN + IFR = CAM - CL \quad (6)$$

However, the value of the required Camanche release (CAM) is not known in advance. Therefore, the value of carriage loss cannot be calculated by using the above formulas. Instead, staff starts by assuming that CAM is less than or equal to 90 cfs ($CAM \leq 90 \text{ cfs}$). Then, substituting equation (2) for carriage loss (CL) in equation (6),

$$WID + NSJ + SEN + IFR = CAM - 0.555 \cdot CAM \quad (7)$$

or, simplifying the right-hand side of equation (7),

$$WID + NSJ + SEN + IFR = 0.444 \cdot CAM \quad (8)$$

Rearranging equation (8) staff arrives at

$$CAM = 2.25 \cdot (WID + NSJ + SEN + IFR) \quad (9)$$

Equation (9) gives us the required Camanche release solely as a function of the known data: WID, NSJ, SEN and IFR, for values of $CAM \leq 90 \text{ cfs}$. If the value of CAM calculated by equation (9) is less than 90 cfs, then carriage loss is given by applying equation (2) to equation (9):

$$CL = 0.555 \cdot CAM = 0.555 \cdot (2.25 \cdot (WID + NSJ + SEN + IFR))$$

or simplifying,

$$CL = 1.25 \cdot (WID + NSJ + SEN + IFR) \quad (10)$$

If the value of CAM calculated by using equation (9) is greater than 90 cfs, then staff assumes that the required release is between 90 and 245 cfs ($90 < CAM \leq 245 \text{ cfs}$). Using the same reasoning as staff used to develop equations (9) and (10) above:

$$CAM = 1.19 \cdot (WID + NSJ + SEN + IFR + 35.5) \quad (11)$$

and applying equation (3) to equation (11),

$$CL = 42.3 + 0.192 \cdot (WID + NSJ + SEN + IFR) \quad (12)$$

If the value of CAM calculated by using equation (11) is greater than 245 cfs, then staff assumes that the required release is between 245 and 1097 cfs ($245 < CAM \leq 1097$). Using the same reasoning as staff used to develop equations (9) and (10) above:

$$CAM = 1.03 \cdot (WID + NSJ + SEN + IFR + 67.8) \quad (13)$$

and applying equation (4) to equation (13),

$$CL = 69.8 + 0.03 \cdot (WID + NSJ + SEN + IFR). \quad (14)$$

If the value of CAM calculated by using equation (13) is greater than 1097 cfs, then staff assumes that the required release is between 1097 and 1808 cfs ($1097 < CAM \leq 1808$). Using the same reasoning as staff used to develop equations (9) and (10) above:

$$CAM = 1.036 \cdot (WID + NSJ + SEN + IFR + 61.4) \quad (15)$$

and applying equation (5) to equation (15),

$$CL = 63.6 + 0.036 \cdot (WID + NSJ + SEN + IFR). \quad (16)$$

Staff did not develop the equations for Camanche release for flows above 1808 cfs, because none of the calculations for required Camanche release involved flows in excess of 1808 cfs.

SELECTED SIMULATION RESULTS

A large number of simulation runs were conducted with the water balance model for the FEIS, evaluating the effects of alternative minimum flow regimes under current and future demands (see Appendix D) and different operational scenarios. Although not all of these runs can be reproduced here, we present in the following tables representative results under the 1990 normalized demand from EBMUD and the minimum flow recommendations of CDFG (Table B-8), EBMUD (Table B-9), staff (Tables B-10 and B-11), FWS (Table B-12), and no action (Table B-13). These model runs are the basis for assessment results presented in Sections 4.1 and 4.2 of the FEIS.

Table B.8. Simulation results from the water balance model under the minimum flow alternative of the California Department of Fish and Game, no minimum pool requirements, and normalized 1990 water demands (aqueduct pumping allowed; EOM=end of month).
(Source: The staff.)

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-66	40,203	188,149	597	13,580	132,816	147,736	379	380
Feb-66	22,625	188,674	69	19,308	138,856	131,946	379	379
Mar-66	41,401	197,272	249	17,442	140,941	119,262	452	452
Apr-66	50,628	201,716	522	14,358	138,985	114,830	575	577
May-66	45,247	206,638	387	15,530	134,873	92,635	728	728
Jun-66	26,134	199,680	294	14,798	128,833	66,528	733	733
Jul-66	31,985	206,204	127	15,813	122,796	43,376	490	490
Aug-66	32,289	201,450	331	15,170	116,841	37,506	409	409
Sep-66	35,062	196,968	354	17,341	115,811	38,433	321	321
Oct-66	32,233	191,763	324	16,775	116,966	31,613	425	425
Nov-66	39,350	188,299	418	18,256	121,947	33,678	386	386
Dec-66	70,941	183,733	957	17,370	126,002	69,803	382	382
Jan-67	67,123	188,809	741	20,176	132,903	93,566	431	431
Feb-67	53,935	192,428	576	18,346	138,901	101,683	431	431
Mar-67	95,339	197,461	1,198	17,429	140,854	145,663	505	505
Apr-67	108,595	202,282	1,529	16,513	138,821	204,606	637	639
May-67	161,693	209,083	2,229	18,993	134,634	233,962	1,763	755
Jun-67	249,402	200,390	4,045	19,059	128,522	244,484	3,893	768
Jul-67	127,525	206,773	1,601	21,038	122,444	291,998	776	684
Aug-67	39,146	201,784	377	20,656	116,476	273,901	647	647
Sep-67	37,317	197,171	337	22,384	115,474	261,468	544	544
Oct-67	38,489	192,463	376	21,188	116,678	256,081	482	482
Nov-67	38,926	188,276	367	22,094	121,695	248,745	515	439
Dec-67	39,148	183,585	381	20,879	125,788	246,571	434	434
Jan-68	38,251	188,042	196	23,344	132,715	238,356	379	380
Feb-68	45,072	192,372	363	21,323	138,738	239,754	379	379
Mar-68	44,648	196,946	342	19,764	140,793	234,303	452	452
Apr-68	36,655	200,944	260	16,713	138,821	214,495	575	577
May-68	28,818	205,866	66	18,993	134,634	172,669	728	728
Jun-68	36,653	201,828	345	18,689	128,626	147,825	733	733
Jul-68	29,671	205,915	90	18,290	122,700	121,485	490	490
Aug-68	30,353	201,343	274	16,500	116,756	111,789	409	409
Sep-68	31,194	196,806	273	18,465	115,739	107,892	321	321
Oct-68	31,547	192,368	291	17,680	116,907	99,329	425	425
Nov-68	39,059	188,197	413	19,050	121,695	101,685	386	386
Dec-68	43,587	183,701	501	17,949	125,973	110,013	382	382
Jan-69	161,379	188,355	2,251	21,247	132,715	226,384	431	431
Feb-69	102,823	193,700	1,470	20,589	138,531	248,482	1,210	431
Mar-69	96,496	199,608	1,182	19,971	140,793	242,765	1,322	505
Apr-69	147,907	204,196	2,164	16,713	138,821	238,536	2,281	639
May-69	281,633	203,704	4,279	18,993	134,634	270,512	3,740	755
Jun-69	219,193	200,390	3,333	19,059	128,522	242,772	3,795	768
Jul-69	70,288	206,605	671	21,038	122,444	238,956	684	684
Aug-69	48,420	201,667	516	20,656	116,476	228,965	647	647
Sep-69	45,291	197,304	461	22,384	115,474	223,633	544	544
Oct-69	47,254	192,632	509	21,188	116,678	225,951	482	482
Nov-69	38,594	188,060	364	22,094	121,695	222,544	439	439
Dec-69	53,780	183,783	623	20,879	125,788	236,347	434	434
Jan-70	161,389	189,594	2,203	23,344	132,715	252,590	2,030	431
Feb-70	83,643	193,448	1,089	20,589	138,531	248,735	1,191	431
Mar-70	98,777	198,029	1,228	19,971	140,793	244,344	1,330	505
Apr-70	66,613	202,488	751	16,713	138,821	240,244	802	639
May-70	114,399	199,622	1,569	18,993	134,634	243,423	1,472	755
Jun-70	118,929	200,303	1,609	19,059	128,522	242,678	1,544	768
Jul-70	44,138	205,966	250	21,038	122,444	212,760	684	684
Aug-70	33,864	201,466	266	20,656	116,476	187,261	647	647
Sep-70	32,618	197,027	239	21,922	115,564	167,632	544	544
Oct-70	35,195	192,409	322	19,633	116,807	157,189	482	482
Nov-70	51,277	188,433	577	20,426	121,785	164,162	439	439
Dec-70	73,256	183,795	972	20,390	125,788	201,033	434	434
Jan-71	63,872	188,235	586	23,344	132,715	213,933	379	380
Feb-71	60,327	192,375	640	20,589	138,531	228,315	379	379
Mar-71	76,219	198,480	841	19,971	140,793	243,787	633	452
Apr-71	72,020	202,475	857	16,713	138,821	240,134	908	577
May-71	65,417	207,612	662	18,993	134,634	233,192	764	728
Jun-71	127,636	207,024	1,815	19,059	128,522	236,069	1,736	733
Jul-71	58,195	206,779	592	21,038	122,444	240,493	490	490
Aug-71	52,762	201,773	575	20,656	116,476	247,721	409	409
Sep-71	39,953	197,072	356	22,384	115,474	247,842	321	321
Oct-71	42,940	192,456	426	21,188	116,678	247,272	425	425
Nov-71	32,037	187,440	256	22,094	121,695	240,154	386	386
Dec-71	40,378	183,643	402	20,879	125,788	244,592	382	382

Table B.8. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR EOM Storage (ac-ft)	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-72	35,552	187,926	129	23,344	132,715	229,388	379	380
Feb-72	28,691	192,415	62	21,323	138,738	212,266	379	379
Mar-72	56,140	197,304	501	19,764	140,793	214,128	452	452
Apr-72	47,931	202,058	442	16,713	138,821	205,909	575	577
May-72	38,337	207,500	216	18,993	134,634	173,500	728	728
Jun-72	70,022	206,408	850	19,059	128,522	178,452	733	733
Jul-72	36,704	206,367	228	20,912	122,499	160,146	490	490
Aug-72	32,644	201,620	275	19,067	116,636	150,254	409	409
Sep-72	32,489	197,005	273	19,853	115,665	146,301	321	321
Oct-72	36,212	192,463	349	18,458	116,871	140,524	425	425
Nov-72	38,461	188,200	394	19,553	121,860	141,751	386	386
Dec-72	44,882	183,715	500	18,535	125,922	149,124	382	382
Jan-73	75,449	188,118	842	22,120	132,715	182,256	379	380
Feb-73	77,970	192,334	1,020	20,589	138,531	223,562	379	379
Mar-73	78,030	197,814	894	19,971	140,793	244,453	615	452
Apr-73	76,108	202,991	900	16,713	138,821	239,618	960	577
May-73	136,592	205,934	1,833	18,993	134,634	237,058	1,826	728
Jun-73	100,907	203,380	1,407	19,059	128,522	234,496	1,428	733
Jul-73	45,302	206,266	330	21,038	122,444	222,859	490	490
Aug-73	33,062	201,181	263	20,656	116,476	211,815	409	409
Sep-73	33,279	196,747	240	22,384	115,474	205,464	321	321
Oct-73	37,377	192,264	336	21,188	116,678	200,506	425	425
Nov-73	53,659	188,185	622	22,094	121,695	217,016	386	386
Dec-73	74,410	185,144	957	20,879	125,788	256,830	382	382
Jan-74	89,732	188,722	1,060	23,344	132,715	253,463	1,171	431
Feb-74	62,360	192,910	677	20,589	138,531	249,272	755	431
Mar-74	116,727	200,103	1,488	19,971	140,793	242,270	1,656	505
Apr-74	113,435	203,026	1,599	16,713	138,821	239,706	1,677	639
May-74	139,200	200,187	1,998	18,993	134,634	242,859	1,936	755
Jun-74	139,670	202,225	1,981	19,059	128,522	239,241	2,022	768
Jul-74	61,137	206,868	550	21,038	122,444	228,923	684	684
Aug-74	55,148	202,056	605	20,656	116,476	223,238	647	647
Sep-74	43,543	196,872	421	22,384	115,474	213,835	544	544
Oct-74	34,867	192,103	294	21,188	116,678	201,716	482	482
Nov-74	29,893	187,440	213	22,095	121,699	188,584	439	439
Dec-74	32,047	183,219	263	20,512	125,826	178,728	434	434
Jan-75	27,546	184,010	63	22,576	132,789	158,941	379	380
Feb-75	36,549	191,518	198	19,637	138,589	151,392	379	379
Mar-75	74,307	197,222	836	19,434	140,793	178,569	452	452
Apr-75	72,684	202,308	859	16,713	138,821	195,983	575	577
May-75	108,000	208,247	1,337	18,993	134,634	232,024	728	728
Jun-75	177,243	203,008	2,721	19,059	128,522	240,085	2,546	733
Jul-75	66,575	206,845	645	21,038	122,444	246,601	490	490
Aug-75	54,629	201,855	617	20,656	116,476	257,736	409	409
Sep-75	51,907	197,307	556	22,384	115,474	269,655	321	321
Oct-75	44,943	192,644	458	21,188	116,678	271,606	425	425
Nov-75	40,901	188,150	388	22,094	121,695	249,808	751	386
Dec-75	38,259	183,719	352	20,879	125,788	247,763	382	382
Jan-76	27,574	183,204	78	23,344	132,715	235,576	276	276
Feb-76	12,863	175,109	0	21,323	138,738	220,302	276	276
Mar-76	15,576	170,910	0	19,764	140,793	202,255	290	290
Apr-76	16,185	170,387	0	16,666	138,854	180,634	357	360
May-76	17,607	170,166	0	17,136	134,837	148,593	490	490
Jun-76	15,951	170,036	0	15,252	128,793	132,750	232	232
Jul-76	16,177	168,623	0	16,436	122,756	115,760	239	239
Aug-76	16,949	169,260	0	15,747	116,805	101,000	223	223
Sep-76	16,381	167,308	0	17,773	115,788	90,222	165	165
Oct-76	11,504	161,478	0	17,045	116,948	82,598	115	115
Nov-76	11,558	154,715	0	18,405	121,947	66,097	279	279
Dec-76	8,471	146,035	0	17,045	126,044	48,863	278	278
Jan-77	10,532	137,293	0	19,401	132,978	32,031	276	276
Feb-77	5,574	126,068	0	16,899	138,795	16,815	276	276
Mar-77	7,049	116,936	12	15,565	141,079	0	290	290
Apr-77	13,140	97,517	345	12,067	139,132	0	357	360
May-77	17,812	72,401	483	13,261	135,007	0	490	490
Jun-77	15,570	61,701	223	12,812	128,941	0	232	232
Jul-77	16,280	49,154	232	14,277	122,881	0	239	239
Aug-77	15,820	37,223	220	13,992	116,905	0	223	223
Sep-77	16,990	28,201	160	16,498	115,864	0	165	165
Oct-77	559	13,913	113	7,873	108,749	0	115	115
Nov-77	2,257	0	273	0	95,941	0	273	279
Dec-77	23,086	12,525	178	0	83,351	0	185	278

Table B.8. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR EOM Storage (ac-ft)	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-78	71,766	42,198	382	21,206	92,244	0	431	431
Feb-78	65,262	61,965	402	24,598	105,762	0	431	431
Mar-78	96,561	101,919	477	28,972	121,453	0	505	505
Apr-78	113,375	151,927	605	29,280	136,720	0	637	639
May-78	112,701	205,291	720	15,835	134,970	0	755	755
Jun-78	190,195	206,818	2,905	14,712	128,713	126,943	768	768
Jul-78	66,448	206,839	754	18,197	122,657	129,387	684	684
Aug-78	52,118	202,028	635	16,971	116,737	127,851	647	647
Sep-78	39,903	197,067	437	18,742	115,724	121,472	544	544
Oct-78	36,143	192,167	373	17,879	116,894	114,405	482	482
Nov-78	33,580	188,044	319	19,182	121,890	107,958	439	439
Dec-78	30,972	183,636	284	17,950	125,980	98,794	434	434
Jan-79	48,645	188,100	408	20,496	132,893	102,628	379	380
Feb-79	48,766	192,238	533	18,176	138,693	115,476	379	379
Mar-79	80,965	197,308	959	17,954	140,845	148,048	452	452
Apr-79	85,726	202,411	1,071	16,452	138,821	176,786	575	577
May-79	117,878	207,721	1,506	18,993	134,634	223,214	728	728
Jun-79	91,099	203,712	1,259	19,059	128,522	234,960	1,025	733
Jul-79	38,392	206,118	214	21,038	122,444	215,305	490	490
Aug-79	34,965	201,102	292	20,656	116,476	206,144	409	409
Sep-79	31,135	196,887	203	22,384	115,474	197,503	321	321
Oct-79	33,898	192,309	282	21,186	116,686	188,755	425	425
Nov-79	38,186	188,187	353	21,954	121,703	188,011	386	386
Dec-79	47,681	183,785	516	20,853	125,788	197,172	382	382
Jan-80	166,986	188,700	2,291	23,402	132,711	253,486	1,440	431
Feb-80	153,382	194,612	2,250	21,327	138,738	247,571	2,437	431
Mar-80	113,574	198,274	1,467	19,764	140,793	244,099	1,520	505
Apr-80	86,539	203,215	1,079	16,713	138,821	239,517	1,136	639
May-80	132,377	207,982	1,754	18,993	134,634	235,063	1,805	755
Jun-80	170,023	200,390	2,643	19,059	128,522	242,772	2,479	768
Jul-80	77,740	206,612	795	21,038	122,444	247,337	684	684
Aug-80	35,639	201,446	305	20,656	116,476	224,055	647	647
Sep-80	33,513	196,900	252	22,384	115,474	205,333	544	544
Oct-80	34,584	192,217	290	21,186	116,678	192,865	482	482
Nov-80	32,684	188,092	248	21,941	121,725	181,098	439	439
Dec-80	37,365	183,606	358	20,346	125,831	177,233	434	434
Jan-81	41,290	188,086	254	22,732	132,738	172,187	379	380
Feb-81	34,247	192,088	185	20,274	138,554	161,755	379	379
Mar-81	34,070	196,992	185	19,223	140,842	147,653	452	452
Apr-81	40,719	202,269	332	15,492	138,919	132,919	575	577
May-81	31,099	205,934	161	16,206	134,869	96,777	728	728
Jun-81	31,184	201,894	311	14,855	128,827	70,258	733	733
Jul-81	33,287	206,152	187	15,944	122,787	51,101	490	490
Aug-81	27,644	201,403	260	15,248	116,836	41,333	409	409
Sep-81	29,296	196,860	260	17,358	115,812	37,211	321	321
Oct-81	34,326	192,214	359	16,756	116,964	33,229	425	425
Nov-81	44,374	188,184	526	18,305	121,939	42,745	386	386
Dec-81	82,879	183,942	1,168	17,404	125,986	93,649	382	382
Jan-82	109,111	188,220	1,434	21,078	132,777	161,243	431	431
Feb-82	165,917	194,238	2,558	20,334	138,531	247,945	1,063	431
Mar-82	156,079	201,483	2,169	19,971	140,793	240,890	2,398	505
Apr-82	244,800	206,875	3,786	16,713	138,821	235,857	3,934	639
May-82	286,671	200,154	4,455	18,993	134,634	242,892	4,321	755
Jun-82	181,071	209,782	2,554	19,059	128,522	233,381	2,700	768
Jul-82	77,841	206,904	934	21,038	122,444	245,562	684	684
Aug-82	54,063	201,994	585	20,656	116,476	238,357	647	647
Sep-82	42,099	197,056	389	22,384	115,474	227,447	544	544
Oct-82	46,800	192,824	514	21,186	116,678	232,127	482	482
Nov-82	82,887	192,610	1,061	22,094	121,695	249,630	832	439
Dec-82	121,507	185,027	1,819	20,879	125,788	257,175	1,785	434
Jan-83	118,651	190,390	1,538	23,344	132,715	251,765	1,747	431
Feb-83	150,486	196,295	2,302	20,589	138,531	245,887	2,511	431
Mar-83	242,896	200,061	3,681	19,971	140,793	242,312	3,918	505
Apr-83	139,755	205,790	2,003	16,713	138,821	236,942	2,136	639
May-83	209,931	204,252	3,152	18,993	134,634	251,345	2,930	755
Jun-83	371,484	200,130	5,946	19,059	128,522	303,406	5,000	768
Jul-83	208,046	207,739	2,887	21,038	122,444	353,432	2,016	684
Aug-83	68,682	202,396	855	20,656	116,476	363,741	647	647
Sep-83	56,473	197,574	651	22,384	115,474	368,914	544	544
Oct-83	55,234	193,032	639	21,186	116,678	272,922	2,209	482
Nov-83	115,543	189,487	1,675	22,094	121,695	252,753	2,101	439
Dec-83	178,909	196,045	2,516	20,879	125,788	257,161	2,537	434

Table B.8. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)	EOM Storage (ac-ft)	EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-84	113,970	189,134	1,800	23,344	132,715	253,050	1,683	431
Feb-84	87,729	193,386	1,097	21,323	138,738	248,796	1,201	431
Mar-84	95,881	198,212	1,185	19,764	140,793	244,161	1,243	505
Apr-84	79,517	202,740	967	16,713	138,821	239,992	1,011	639
May-84	144,496	205,960	1,966	18,993	134,634	237,085	1,972	755
Jun-84	108,496	208,659	1,428	19,059	128,522	233,669	1,439	768
Jul-84	57,318	208,431	603	21,038	122,444	226,508	684	684
Aug-84	48,488	201,530	518	20,656	116,476	216,999	647	647
Sep-84	34,128	197,091	274	22,384	115,474	200,442	544	544
Oct-84	38,251	192,541	352	21,188	116,678	192,553	482	482
Nov-84	45,687	188,267	488	22,094	121,695	197,614	439	439
Dec-84	42,543	183,663	438	20,879	125,788	198,924	434	434
Jan-85	23,893	184,106	8	23,297	132,734	176,647	379	380
Feb-85	34,816	191,537	132	20,238	138,553	163,060	379	379
Mar-85	50,703	197,220	420	19,672	140,794	162,010	452	452
Apr-85	61,363	202,000	650	16,711	138,821	164,634	575	577
May-85	31,662	205,934	139	18,118	134,772	127,124	728	728
Jun-85	29,371	202,489	263	15,680	128,796	97,844	733	733
Jul-85	30,129	206,244	135	16,414	122,759	74,972	490	490
Aug-85	33,352	201,489	340	15,733	116,804	69,851	409	409
Sep-85	33,110	196,019	329	17,855	115,779	69,394	321	321
Oct-85	36,307	192,339	327	17,147	116,941	60,054	425	425
Nov-85	38,910	188,223	416	18,588	121,925	62,225	386	386
Dec-85	39,003	183,706	425	17,504	126,005	64,998	382	382
Jan-86	52,326	188,328	461	20,101	132,918	67,730	431	431
Feb-86	265,908	194,486	4,468	18,768	138,531	247,696	1,405	431
Mar-86	191,940	199,405	2,839	19,971	140,793	242,968	3,086	505
Apr-86	124,522	204,822	1,705	16,713	138,821	237,910	1,767	639
May-86	193,408	205,934	2,806	18,993	134,634	237,111	2,795	755
Jun-86	132,139	203,063	1,633	19,059	128,522	239,939	1,856	768
Jul-86	44,509	208,356	301	21,038	122,444	214,039	684	684
Aug-86	37,261	201,491	322	20,656	116,476	191,702	647	647
Sep-86	36,167	197,036	297	22,232	115,523	176,467	544	544
Oct-86	37,053	192,508	335	20,146	116,772	166,094	482	482
Nov-86	36,861	188,118	329	20,668	121,803	158,090	439	439
Dec-86	32,435	183,656	289	19,029	125,922	149,100	434	434
Jan-87	24,962	184,514	50	21,259	132,863	135,659	276	276
Feb-87	17,276	184,360	0	18,394	138,693	121,697	276	276
Mar-87	24,720	193,016	0	17,237	140,972	105,560	290	290
Apr-87	21,582	199,908	0	13,697	139,031	83,190	357	360
May-87	16,794	200,592	0	14,890	134,918	52,382	490	490
Jun-87	21,126	205,751	0	14,160	128,860	37,732	232	232
Jul-87	32,160	206,142	228	15,530	122,805	36,054	239	239
Aug-87	31,194	201,245	308	15,105	116,838	40,189	223	223
Sep-87	27,594	196,280	234	17,412	115,806	43,489	165	165
Oct-87	14,180	189,032	66	16,836	116,961	40,064	115	115
Nov-87	12,910	183,515	0	18,231	121,957	23,168	279	279
Dec-87	17,540	182,950	21	16,931	126,047	7,325	278	278
Jan-88	21,322	176,492	149	19,378	132,973	0	276	276
Feb-88	13,946	157,635	269	17,550	139,002	0	276	276
Mar-88	16,312	141,143	284	15,358	141,079	0	290	290
Apr-88	18,311	126,600	352	12,067	139,132	0	357	360
May-88	22,562	104,771	494	13,261	135,007	0	490	490
Jun-88	26,581	103,646	235	12,812	128,941	0	232	232
Jul-88	27,802	103,236	224	14,277	122,881	0	239	239
Aug-88	23,141	98,201	220	13,992	116,905	0	223	223
Sep-88	20,067	91,231	167	16,498	115,864	0	165	165
Oct-88	13,357	81,097	115	16,124	117,001	0	115	115
Nov-88	12,494	59,159	281	17,787	121,979	0	279	279
Dec-88	12,908	38,319	279	16,669	126,059	0	278	278
Jan-89	12,825	13,815	377	14,250	127,996	0	379	380
Feb-89	14,162	6,907	379	0	116,916	0	379	379
Mar-89	60,434	25,822	452	13,832	117,467	0	452	452
Apr-89	80,364	45,967	585	24,721	128,175	0	575	577
May-89	105,640	82,429	725	24,218	135,007	0	728	728
Jun-89	69,707	94,511	737	12,812	128,941	0	733	733
Jul-89	34,217	84,039	485	14,277	122,881	0	490	490
Aug-89	30,912	75,767	404	13,992	116,905	0	409	409
Sep-89	32,705	72,167	326	16,498	115,864	0	321	321
Oct-89	23,129	52,461	430	16,124	117,001	0	425	425
Nov-89	35,929	46,760	394	17,787	121,979	0	386	386
Dec-89	34,592	40,377	389	16,669	126,059	0	382	382

Table B.8. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR EOM Storage (ac-ft)	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-90	32,602	37,028	275	19,234	132,980	0	276	276
Feb-90	22,205	28,701	260	16,895	138,795	0	276	276
Mar-90	32,549	28,337	285	15,565	141,079	0	290	290
Apr-90	23,373	19,190	348	12,067	139,132	0	357	360
May-90	32,220	16,200	491	4,954	126,700	0	490	490
Jun-90	33,646	17,058	224	16,693	127,516	0	232	232
Jul-90	32,029	20,183	223	15,703	122,881	0	239	239
Aug-90	28,558	21,533	217	13,992	116,905	0	223	223
Sep-90	27,957	23,943	156	16,498	115,864	0	165	165
Oct-90	31,509	32,390	113	16,124	117,001	0	115	115
Nov-90	8,527	12,454	279	11,851	116,043	0	279	279
Dec-90	11,462	6,938	277	0	103,454	0	278	278

Table B.9. Simulation results from the water balance model under the minimum flow alternative of East Bay Municipal Utility District, no minimum pool requirements, and normalized 1990 water demands (aqueduct pumping; EOM=end of month).
(Source: The staff.)

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR EOM Storage (ac-ft)	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camarache (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-66	40,203	187,759	599	13,853	132,776	161,211	162	162
Feb-66	22,625	188,034	59	20,093	138,781	156,971	162	162
Mar-66	41,401	196,777	220	19,069	140,807	159,357	177	177
Apr-66	50,628	201,582	476	16,685	138,821	171,276	252	246
May-66	45,247	206,508	331	18,982	134,641	156,479	543	543
Jun-66	26,134	208,721	77	18,559	128,601	146,349	232	232
Jul-66	31,985	206,066	219	19,279	122,590	143,148	239	239
Aug-66	32,289	201,340	282	18,151	116,668	144,316	223	223
Sep-66	35,062	196,866	313	19,750	115,645	151,062	166	165
Oct-66	32,233	191,602	286	19,138	116,811	157,156	165	167
Nov-66	39,350	188,082	382	20,445	121,788	164,055	280	279
Dec-66	70,941	183,311	910	20,480	125,788	208,108	220	220
Jan-67	67,123	188,276	691	23,344	132,715	246,824	162	162
Feb-67	53,935	192,392	523	20,788	138,731	249,257	430	162
Mar-67	95,339	198,262	1,146	19,771	140,793	243,480	1,272	187
Apr-67	108,595	202,768	1,531	16,713	138,821	239,331	1,708	286
May-67	161,693	209,029	2,238	18,993	134,634	233,860	2,337	626
Jun-67	249,402	200,390	4,044	19,059	128,522	244,619	3,888	836
Jul-67	127,525	206,547	1,605	21,038	122,444	309,075	504	356
Aug-67	39,146	201,566	377	20,656	116,476	310,403	327	327
Sep-67	37,317	196,962	337	22,384	115,474	315,969	237	237
Oct-67	38,489	192,352	375	21,188	116,678	273,284	1,085	257
Nov-67	38,926	188,181	367	22,094	121,695	251,259	762	386
Dec-67	39,148	183,452	382	20,879	125,788	258,219	286	270
Jan-68	38,251	188,005	194	23,344	132,715	253,646	319	162
Feb-68	45,072	192,565	359	21,323	138,738	249,084	479	162
Mar-68	44,648	196,840	347	19,764	140,793	244,883	437	177
Apr-68	36,655	201,102	256	16,713	138,821	238,295	348	246
May-68	28,818	205,866	69	18,993	134,634	207,812	543	543
Jun-68	36,653	202,596	326	19,059	128,522	211,182	232	232
Jul-68	29,671	205,883	58	21,038	122,444	197,569	239	239
Aug-68	30,353	201,182	209	20,656	116,476	194,696	223	223
Sep-68	31,194	196,658	207	22,384	115,474	195,552	166	165
Oct-68	31,547	192,203	234	21,188	116,678	199,327	165	167
Nov-68	39,059	187,982	363	22,094	121,695	205,514	280	279
Dec-68	43,587	183,290	456	20,879	125,788	221,541	220	220
Jan-69	161,379	189,723	2,188	23,344	132,715	251,928	1,784	162
Feb-69	102,823	193,514	1,498	20,589	138,531	248,135	1,705	162
Mar-69	96,496	199,388	1,183	19,971	140,793	242,355	1,323	187
Apr-69	147,907	203,974	2,164	16,713	138,821	238,125	2,281	286
May-69	281,633	203,650	4,276	18,993	134,634	270,207	3,736	626
Jun-69	219,193	200,390	3,382	19,059	128,522	242,907	3,787	836
Jul-69	70,288	206,380	674	21,038	122,444	259,385	356	356
Aug-69	48,420	201,665	512	20,656	116,476	268,574	327	327
Sep-69	45,291	197,168	463	22,384	115,474	281,359	237	237
Oct-69	47,254	192,553	508	21,188	116,678	273,084	652	257
Nov-69	38,594	188,050	363	22,094	121,695	249,717	774	386
Dec-69	53,780	183,842	622	20,879	125,788	257,829	527	270
Jan-70	161,389	189,408	2,207	23,344	132,715	252,243	2,390	162
Feb-70	83,643	193,261	1,089	20,589	138,531	248,388	1,191	162
Mar-70	98,777	197,808	1,229	19,971	140,793	243,934	1,332	187
Apr-70	66,613	202,267	751	16,713	138,821	239,832	802	286
May-70	114,399	209,881	1,399	18,993	134,634	233,007	1,465	626
Jun-70	118,929	200,303	1,782	19,059	128,522	242,543	1,543	836
Jul-70	44,138	205,902	251	21,038	122,444	232,761	356	356
Aug-70	33,864	201,404	266	20,656	116,476	226,683	327	327
Sep-70	32,618	196,927	232	22,384	115,474	224,604	237	237
Oct-70	35,195	192,320	296	21,188	116,678	226,613	252	257
Nov-70	51,277	188,344	549	22,094	121,695	234,723	386	386
Dec-70	73,256	184,209	956	20,879	125,788	257,462	655	270
Jan-71	63,872	188,614	587	23,344	132,715	253,037	662	162
Feb-71	60,327	192,674	642	20,589	138,531	248,975	712	162
Mar-71	76,219	198,296	850	19,971	140,793	243,446	983	187
Apr-71	72,020	202,297	857	16,713	138,821	239,802	908	286
May-71	65,417	207,576	660	18,993	134,634	234,570	734	626
Jun-71	127,636	207,024	1,814	19,059	128,522	236,273	1,755	836
Jul-71	58,195	206,687	594	21,038	122,444	248,995	356	356
Aug-71	52,762	201,717	574	20,656	116,476	261,134	327	327
Sep-71	39,953	197,015	356	22,384	115,474	266,164	237	237
Oct-71	42,940	192,446	425	21,188	116,678	273,191	299	257
Nov-71	32,037	187,440	256	22,094	121,695	243,783	761	386
Dec-71	40,378	183,255	408	20,879	125,788	255,504	271	270

Table B.9. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR EOM Storage (ac-ft)	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-72	35,552	187,827	125	23,344	132,715	253,367	162	162
Feb-72	28,691	192,617	57	21,323	138,738	248,467	162	162
Mar-72	56,140	197,128	508	19,764	140,793	244,614	550	187
Apr-72	47,931	201,947	441	16,713	138,821	240,153	510	286
May-72	38,337	207,415	216	18,993	134,634	213,716	626	626
Jun-72	70,022	208,414	814	19,059	128,522	210,144	836	836
Jul-72	36,704	206,318	260	21,038	122,444	201,636	356	356
Aug-72	32,644	201,532	250	20,656	116,476	194,870	327	327
Sep-72	32,489	196,903	231	22,384	115,474	193,239	237	237
Oct-72	36,212	192,356	305	21,188	116,678	195,212	252	257
Nov-72	38,461	188,183	349	22,094	121,695	194,092	386	386
Dec-72	44,882	183,318	468	20,879	125,788	206,513	271	270
Jan-73	75,449	188,668	807	23,344	132,715	251,344	162	162
Feb-73	77,970	193,569	1,008	20,589	138,531	248,080	1,176	162
Mar-73	78,030	197,630	917	19,971	140,793	244,112	1,043	187
Apr-73	76,108	202,813	900	16,713	138,821	239,286	959	286
May-73	136,592	205,934	1,830	18,993	134,634	236,954	1,820	626
Jun-73	100,907	203,380	1,408	19,059	128,522	231,641	1,474	836
Jul-73	45,302	206,239	330	21,038	122,444	228,260	356	356
Aug-73	33,062	201,165	263	20,656	116,476	222,185	327	327
Sep-73	33,279	196,731	240	22,384	115,474	220,782	237	237
Oct-73	37,377	192,243	336	21,188	116,678	226,492	252	257
Nov-73	53,659	188,181	622	22,094	121,695	243,103	386	386
Dec-73	74,410	184,994	960	20,879	125,788	256,677	810	270
Jan-74	59,732	188,535	1,061	23,344	132,715	253,116	1,178	162
Feb-74	62,360	192,724	677	20,589	138,531	248,925	755	162
Mar-74	116,727	199,883	1,489	19,971	140,793	241,860	1,657	187
Apr-74	113,435	202,804	1,599	16,713	138,821	239,295	1,677	286
May-74	139,200	200,132	1,995	18,993	134,634	242,757	1,928	626
Jun-74	139,670	202,225	1,980	19,059	128,522	238,567	2,030	836
Jul-74	61,137	206,763	552	21,038	122,444	248,463	356	356
Aug-74	55,148	201,956	605	20,656	116,476	262,211	327	327
Sep-74	43,543	196,871	419	22,384	115,474	270,721	237	237
Oct-74	34,867	192,182	293	21,188	116,678	272,564	252	257
Nov-74	29,893	187,440	214	22,094	121,695	242,646	723	386
Dec-74	32,047	183,149	258	20,879	125,788	242,619	271	270
Jan-75	27,546	183,554	56	23,344	132,715	235,854	162	162
Feb-75	36,549	191,489	173	20,589	138,531	239,337	162	162
Mar-75	74,307	197,728	819	19,971	140,793	244,014	808	187
Apr-75	72,684	202,644	862	16,713	138,821	239,455	947	286
May-75	108,000	208,211	1,343	18,993	134,634	234,677	1,395	626
Jun-75	177,243	207,547	2,645	19,059	128,522	235,750	2,586	836
Jul-75	66,575	206,753	720	21,038	122,444	255,102	356	356
Aug-75	54,629	201,799	616	20,656	116,476	271,176	327	327
Sep-75	51,907	197,249	556	22,384	115,474	288,006	237	237
Oct-75	44,943	192,573	458	21,188	116,678	273,064	699	257
Nov-75	40,901	188,150	387	22,094	121,695	249,808	774	386
Dec-75	38,259	183,334	358	20,879	125,788	255,003	271	270
Jan-76	27,574	183,438	68	23,344	132,715	249,201	162	162
Feb-76	12,863	175,343	0	21,323	138,738	240,496	162	162
Mar-76	15,576	171,142	0	19,764	140,793	229,361	177	177
Apr-76	16,185	170,572	0	16,713	138,821	213,957	252	246
May-76	17,607	168,684	0	18,805	134,709	178,394	543	543
Jun-76	15,951	166,887	0	16,932	128,730	162,234	232	232
Jul-76	16,177	164,924	0	17,004	122,726	144,890	239	239
Aug-76	16,949	165,125	0	16,194	116,776	129,942	223	223
Sep-76	16,381	162,801	0	18,158	115,762	118,921	166	165
Oct-76	11,504	156,664	0	17,362	116,930	108,155	165	167
Nov-76	11,558	149,664	0	18,642	121,931	91,586	280	279
Dec-76	8,471	140,752	0	17,280	126,027	77,867	220	220
Jan-77	10,532	131,700	0	19,709	132,954	71,791	102	102
Feb-77	5,574	120,174	0	17,198	138,777	66,263	102	103
Mar-77	7,049	111,583	0	15,786	141,069	59,160	118	118
Apr-77	13,140	112,551	0	12,175	139,129	51,256	130	127
May-77	17,812	117,050	0	13,267	135,007	39,235	194	194
Jun-77	15,570	119,286	0	12,812	128,941	24,984	232	232
Jul-77	16,280	120,519	0	14,277	122,881	9,971	239	239
Aug-77	15,820	117,888	60	13,992	116,905	0	223	223
Sep-77	16,990	108,510	161	16,498	115,864	0	166	165
Oct-77	559	85,723	113	16,124	117,001	0	115	115
Nov-77	2,257	60,458	165	17,787	121,979	0	166	166
Dec-77	23,086	59,760	127	16,669	126,059	0	134	134

Table B.9. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR EOM Storage (ac-ft)	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-78	71,766	108,303	113	19,234	132,980	0	162	162
Feb-78	65,262	150,859	133	16,895	138,795	0	162	162
Mar-78	96,561	196,930	595	15,882	141,032	26,928	187	187
Apr-78	113,375	201,962	1,629	13,251	139,011	108,984	292	286
May-78	112,701	207,525	1,466	17,043	134,634	160,959	626	626
Jun-78	190,195	202,347	2,945	19,059	128,522	240,950	1,572	836
Jul-78	66,448	206,684	638	21,038	122,444	255,228	356	356
Aug-78	52,118	201,840	575	20,656	116,476	268,612	327	327
Sep-78	39,903	196,914	375	22,384	115,474	276,269	237	237
Oct-78	36,143	192,163	317	21,188	116,678	273,474	345	257
Nov-78	33,580	187,945	272	22,094	121,695	246,092	749	386
Dec-78	30,972	183,299	240	20,879	125,788	244,378	271	270
Jan-79	48,645	188,005	358	23,344	132,715	253,646	253	162
Feb-79	48,766	192,602	481	20,589	138,531	249,047	661	162
Mar-79	80,965	197,863	924	19,971	140,793	243,879	1,028	187
Apr-79	85,726	203,072	1,064	16,713	138,821	239,027	1,128	286
May-79	117,878	239,282	1,492	18,993	134,634	233,607	1,551	626
Jun-79	91,099	203,712	1,286	19,059	128,522	232,106	1,274	836
Jul-79	38,392	206,091	214	21,038	122,444	220,706	356	356
Aug-79	34,965	201,102	292	20,656	116,476	216,500	327	327
Sep-79	31,135	196,871	204	22,384	115,474	212,791	237	237
Oct-79	33,898	192,286	282	21,188	116,678	214,637	252	257
Nov-79	38,186	188,184	350	22,094	121,695	213,800	386	386
Dec-79	47,681	183,398	522	20,879	125,788	230,219	271	270
Jan-80	166,986	188,513	2,288	23,402	132,711	253,139	1,982	162
Feb-80	153,382	194,425	2,250	21,327	138,738	247,224	2,437	162
Mar-80	113,574	198,053	1,468	19,764	140,793	243,689	1,522	187
Apr-80	86,539	202,993	1,079	16,713	138,821	239,106	1,136	286
May-80	132,377	207,927	1,751	18,993	134,634	234,962	1,798	626
Jun-80	170,023	209,687	2,486	19,059	128,522	233,610	2,474	836
Jul-80	77,740	206,386	950	21,038	122,444	267,794	356	356
Aug-80	35,639	201,507	300	20,656	116,476	263,674	327	327
Sep-80	33,513	196,884	253	22,384	115,474	263,025	237	237
Oct-80	34,584	192,267	289	21,188	116,678	264,420	252	257
Nov-80	32,684	188,068	247	22,094	121,695	243,163	595	386
Dec-80	37,365	183,284	355	20,879	125,788	249,157	271	270
Jan-81	41,290	188,075	239	23,344	132,715	253,576	217	162
Feb-81	34,247	191,983	181	20,589	138,531	249,666	257	162
Mar-81	34,070	196,828	174	19,971	140,793	244,914	295	187
Apr-81	40,719	202,223	310	16,713	138,821	239,876	383	286
May-81	31,099	205,934	115	18,993	134,634	206,258	626	626
Jun-81	31,184	201,293	251	19,059	128,522	168,688	836	836
Jul-81	33,287	206,020	108	20,312	122,544	151,663	356	356
Aug-81	27,644	201,318	209	18,347	116,678	142,673	327	327
Sep-81	29,296	196,792	226	19,330	115,693	140,617	237	237
Oct-81	34,326	192,144	332	18,440	116,853	145,472	252	257
Nov-81	44,374	188,149	500	19,872	121,817	154,375	386	386
Dec-81	82,879	183,532	1,136	19,708	125,788	210,761	271	270
Jan-82	109,111	188,933	1,379	23,344	132,715	252,718	801	162
Feb-82	165,917	194,051	2,570	20,589	138,531	247,598	2,731	162
Mar-82	156,079	201,262	2,170	19,971	140,793	240,480	2,399	187
Apr-82	244,800	206,654	3,786	16,713	138,821	235,446	3,934	286
May-82	286,671	200,156	4,451	18,993	134,634	242,733	4,314	626
Jun-82	181,071	205,543	2,625	19,059	128,522	237,755	2,695	836
Jul-82	77,841	206,678	869	21,038	122,444	266,009	356	356
Aug-82	54,063	201,775	585	20,656	116,476	278,254	327	327
Sep-82	42,099	196,997	387	22,384	115,474	285,384	237	237
Oct-82	46,800	193,524	502	21,188	116,678	272,113	763	257
Nov-82	82,887	192,573	1,073	22,094	121,695	249,562	1,518	386
Dec-82	121,507	184,841	1,821	20,879	125,788	256,830	1,792	270
Jan-83	118,651	190,203	1,538	23,344	132,715	251,448	1,747	162
Feb-83	150,486	196,109	2,302	20,589	138,531	245,540	2,511	162
Mar-83	242,896	199,840	3,681	19,971	140,793	241,902	3,919	187
Apr-83	139,755	205,569	2,003	16,713	138,821	236,530	2,136	286
May-83	209,931	204,198	3,149	18,993	134,634	251,243	2,922	626
Jun-83	371,484	200,130	5,945	19,059	128,522	303,251	5,000	836
Jul-83	208,046	207,512	2,891	21,038	122,444	366,639	1,802	356
Aug-83	68,682	202,176	855	20,656	116,476	366,460	327	327
Sep-83	56,473	197,362	651	22,384	115,474	369,785	740	237
Oct-83	55,234	192,921	637	21,188	116,678	272,716	2,550	257
Nov-83	115,543	189,450	1,674	22,094	121,695	252,684	2,098	386
Dec-83	178,909	195,859	2,519	20,879	125,788	256,814	2,544	270

Table B.9. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR EOM Storage (ac-ft)	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-84	113,970	188,947	1,600	23,344	132,715	252,704	1,683	162
Feb-84	87,729	193,200	1,097	21,323	138,738	248,449	1,201	162
Mar-84	95,881	197,991	1,166	19,764	140,793	243,751	1,244	187
Apr-84	79,517	202,519	967	16,713	138,821	239,580	1,011	286
May-84	144,496	205,960	1,962	18,993	134,634	236,928	1,964	626
Jun-84	108,496	208,706	1,427	19,059	128,522	233,082	1,445	836
Jul-84	57,318	208,449	604	21,038	122,444	248,033	356	356
Aug-84	48,488	201,562	517	20,656	116,476	255,956	327	327
Sep-84	34,128	197,014	276	22,384	115,474	257,452	237	237
Oct-84	38,251	192,493	352	21,188	116,678	263,619	252	257
Nov-84	45,687	188,380	485	22,064	121,695	253,754	692	386
Dec-84	42,543	183,508	443	20,679	125,788	258,163	389	270
Jan-85	23,893	184,095	5	23,344	132,715	249,091	162	162
Feb-85	34,816	191,909	118	20,589	138,531	246,804	162	162
Mar-85	50,703	197,231	421	19,971	140,793	244,511	475	187
Apr-85	61,363	201,908	652	16,713	138,821	240,191	687	286
May-85	31,662	205,934	123	18,993	134,634	207,373	626	626
Jun-85	29,371	201,236	227	19,059	128,522	169,139	836	836
Jul-85	30,129	206,129	54	20,208	122,559	148,852	356	356
Aug-85	33,352	201,411	295	18,432	116,662	145,365	327	327
Sep-85	33,110	195,893	298	19,764	115,660	147,639	237	237
Oct-85	36,307	192,278	300	18,666	116,847	147,088	252	257
Nov-85	38,910	188,206	395	19,836	121,838	148,400	386	386
Dec-85	39,003	183,306	408	18,922	125,898	157,266	271	270
Jan-86	52,326	187,828	428	22,217	132,734	174,895	162	162
Feb-86	265,908	194,291	4,430	20,589	138,531	307,805	2,235	162
Mar-86	191,940	199,184	2,840	19,971	140,793	242,558	4,072	187
Apr-86	124,522	204,601	1,705	16,713	138,821	237,498	1,767	286
May-86	193,408	205,934	2,802	18,993	134,634	236,954	2,787	626
Jun-86	132,139	203,063	1,933	19,059	128,522	239,804	1,856	836
Jul-86	44,509	206,396	301	21,038	122,444	233,949	356	356
Aug-86	37,261	201,429	323	20,656	116,476	231,174	327	327
Sep-86	36,167	196,953	294	22,384	115,474	234,052	237	237
Oct-86	37,053	192,435	318	21,188	116,678	236,559	252	257
Nov-86	36,861	188,060	305	22,094	121,695	230,146	386	386
Dec-86	32,485	183,308	264	20,679	125,788	229,726	271	270
Jan-87	24,962	182,785	39	23,344	132,715	222,720	162	162
Feb-87	17,276	180,434	0	20,589	138,531	215,264	162	162
Mar-87	24,720	186,350	0	19,971	140,793	206,314	177	177
Apr-87	21,582	190,250	0	16,713	138,821	189,554	252	246
May-87	16,794	187,227	0	18,643	134,732	154,486	543	543
Jun-87	21,126	189,956	0	16,654	128,736	138,627	232	232
Jul-87	32,160	202,691	0	17,255	122,709	121,774	239	239
Aug-87	31,194	201,207	229	16,547	116,747	120,101	223	223
Sep-87	27,594	196,117	215	18,651	115,725	121,580	166	165
Oct-87	14,180	188,348	58	17,873	116,897	114,367	165	167
Nov-87	12,910	181,990	0	19,072	121,902	97,488	280	279
Dec-87	17,540	181,892	0	17,752	125,992	84,148	220	220
Jan-88	21,322	183,740	0	20,238	132,915	75,208	162	162
Feb-88	13,946	179,487	0	18,413	138,942	66,158	162	162
Mar-88	16,312	179,437	0	16,311	141,021	55,307	177	177
Apr-88	18,311	184,882	0	12,942	139,078	40,538	252	246
May-88	22,562	192,376	0	14,029	134,973	6,388	543	543
Jun-88	26,581	196,373	199	13,312	128,913	0	232	232
Jul-88	27,802	194,148	224	14,675	122,861	0	239	239
Aug-88	23,141	187,730	220	14,199	116,900	0	223	223
Sep-88	20,067	180,004	168	16,527	115,864	0	166	165
Oct-88	13,357	166,582	164	16,124	117,001	0	165	167
Nov-88	12,494	144,714	282	17,787	121,979	0	280	279
Dec-88	12,908	127,543	221	16,669	126,059	0	220	220
Jan-89	12,825	111,343	160	19,234	132,980	0	162	162
Feb-89	14,162	99,615	162	16,895	138,795	0	162	162
Mar-89	60,434	133,974	176	15,565	141,079	0	177	177
Apr-89	80,364	185,504	262	12,122	139,113	0	252	246
May-89	105,640	207,211	1,112	14,041	134,932	34,687	543	543
Jun-89	69,707	206,446	904	14,403	128,820	73,045	232	232
Jul-89	34,217	206,175	262	16,173	122,762	72,949	239	239
Aug-89	30,912	200,873	307	15,753	116,796	77,024	223	223
Sep-89	32,705	196,475	306	18,022	115,763	84,648	166	165
Oct-89	23,129	192,236	156	17,359	116,921	83,715	165	167
Nov-89	35,929	188,018	352	18,877	121,906	87,557	280	279
Dec-89	34,592	183,310	343	17,790	125,984	94,541	220	220

Table B.9. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR EOM Storage (ac-ft)	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-90	32,602	187,712	136	20,417	132,899	93,790	162	162
Feb-90	22,205	191,537	23	18,029	138,712	87,330	162	162
Mar-90	32,549	195,817	183	17,005	140,984	87,628	177	177
Apr-90	23,373	200,474	78	13,566	139,035	76,944	252	246
May-90	32,220	205,934	173	14,868	134,913	53,535	543	543
Jun-90	33,646	203,800	331	14,372	128,839	58,515	232	232
Jul-90	32,029	206,140	198	15,858	122,783	55,475	239	239
Aug-90	28,558	201,523	262	15,422	116,819	56,969	223	223
Sep-90	27,957	196,765	238	17,671	115,788	60,781	166	165
Oct-90	31,509	192,207	300	17,139	116,934	68,519	165	167
Nov-90	8,527	180,418	26	18,588	121,937	53,192	280	279
Dec-90	11,462	174,711	0	17,210	126,029	39,709	220	220

Table B.10. Simulation results from the water balance model under the staff's minimum flow alternative, no minimum pool requirements, and normalized 1990 water demands (aqueduct pumping allowed; EOM=end of month). (Source: The staff.)

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-66	40,203	188,002	597	13,683	132,801	152,828	297	297
Feb-66	22,625	188,286	66	19,717	138,809	147,608	186	186
Mar-66	41,401	196,752	232	18,619	140,834	151,599	163	163
Apr-66	50,628	201,564	479	16,516	138,821	166,149	211	212
May-66	45,247	206,486	332	18,903	134,644	155,960	470	470
Jun-66	26,134	209,201	81	17,788	128,714	122,552	630	630
Jul-66	31,985	206,150	259	17,246	122,715	112,970	387	387
Aug-66	32,289	201,407	310	16,411	116,760	107,976	358	358
Sep-66	35,062	196,926	335	18,454	115,736	110,190	269	269
Oct-66	32,233	191,700	308	17,761	116,903	104,995	374	379
Nov-66	39,350	188,137	405	19,119	121,888	111,613	304	303
Dec-66	70,941	183,566	942	18,321	125,914	152,414	300	300
Jan-67	67,123	188,720	713	21,808	132,742	177,302	400	400
Feb-67	53,935	192,181	536	20,760	138,731	190,583	297	297
Mar-67	95,339	198,264	1,143	19,771	140,793	243,482	312	189
Apr-67	108,595	202,703	1,532	16,713	138,821	239,211	1,711	224
May-67	161,893	208,976	2,237	18,993	134,634	233,762	2,336	600
Jun-67	249,402	200,390	4,043	19,059	128,522	244,486	3,888	768
Jul-67	127,525	206,831	1,604	21,038	122,444	302,725	603	478
Aug-67	39,146	201,644	377	20,656	116,476	297,139	441	441
Sep-67	37,317	197,031	337	22,384	115,474	296,796	338	338
Oct-67	38,489	192,463	374	21,188	116,678	273,491	770	482
Nov-67	38,926	188,201	368	22,094	121,695	250,737	776	398
Dec-67	39,148	183,579	380	20,879	125,788	250,408	403	403
Jan-68	38,251	187,894	198	23,344	132,715	247,409	297	297
Feb-68	45,072	192,581	357	21,323	138,738	249,115	368	186
Mar-68	44,648	196,830	347	19,764	140,793	244,865	438	163
Apr-68	36,655	201,100	255	16,713	138,821	239,448	328	212
May-68	28,818	205,866	69	18,993	134,634	213,445	470	470
Jun-68	36,653	201,664	342	19,059	128,522	194,119	630	630
Jul-68	29,671	205,883	43	21,038	122,444	170,687	387	387
Aug-68	30,353	201,257	221	19,814	116,584	160,487	358	358
Sep-68	31,194	196,741	238	20,552	115,615	157,239	269	269
Oct-68	31,547	192,335	268	19,109	116,834	150,227	374	379
Nov-68	39,059	188,037	397	20,157	121,810	156,780	304	303
Dec-68	43,587	183,541	477	19,389	125,859	168,992	300	300
Jan-69	161,379	189,888	2,199	22,757	132,715	252,235	928	400
Feb-69	102,823	193,607	1,499	20,589	138,531	248,309	1,709	297
Mar-69	96,496	199,389	1,184	19,971	140,793	242,357	1,327	189
Apr-69	147,907	203,910	2,165	16,713	138,821	238,005	2,284	224
May-69	281,633	203,597	4,276	18,993	134,634	270,313	3,732	600
Jun-69	219,193	200,390	3,381	19,059	128,522	242,774	3,790	768
Jul-69	70,288	206,464	673	21,038	122,444	251,705	478	478
Aug-69	48,420	201,743	512	20,656	116,476	253,991	441	441
Sep-69	45,291	197,236	463	22,384	115,474	260,878	338	338
Oct-69	47,254	192,664	507	21,188	116,678	263,059	482	482
Nov-69	38,594	188,052	365	22,094	121,695	249,235	616	398
Dec-69	53,780	184,007	619	20,879	125,788	258,134	512	403
Jan-70	161,389	189,573	2,207	23,344	132,715	252,550	2,390	400
Feb-70	83,643	193,355	1,090	20,589	138,531	248,562	1,194	297
Mar-70	98,777	197,810	1,230	19,971	140,793	243,937	1,337	189
Apr-70	66,613	202,202	752	16,713	138,821	239,712	805	224
May-70	114,399	209,829	1,399	18,993	134,634	232,909	1,464	600
Jun-70	118,929	200,303	1,781	19,059	128,522	242,676	1,539	768
Jul-70	44,138	205,926	251	21,038	122,444	225,404	478	478
Aug-70	33,864	201,426	266	20,656	116,476	212,410	441	441
Sep-70	32,618	196,946	232	22,384	115,474	204,429	338	338
Oct-70	35,195	192,352	296	21,188	116,678	192,333	482	482
Nov-70	51,277	188,359	549	22,094	121,695	199,977	397	398
Dec-70	73,256	183,733	964	20,879	125,788	238,482	403	403
Jan-71	63,872	188,271	585	23,344	132,715	250,035	400	400
Feb-71	60,327	192,768	634	20,589	138,531	249,149	647	297
Mar-71	76,219	198,298	851	19,971	140,793	243,448	987	189
Apr-71	72,020	202,232	858	16,713	138,821	239,682	911	224
May-71	65,417	207,523	660	18,993	134,634	235,215	721	600
Jun-71	127,636	207,024	1,813	19,059	128,522	236,140	1,768	768
Jul-71	58,195	206,771	592	21,038	122,444	241,306	478	478
Aug-71	52,762	201,795	574	20,656	116,476	246,538	441	441
Sep-71	39,953	197,084	357	22,384	115,474	245,667	338	338
Oct-71	42,940	192,467	426	21,188	116,678	241,573	482	482
Nov-71	32,037	187,440	256	22,094	121,695	233,803	397	398
Dec-71	40,378	183,682	401	20,879	125,788	236,859	403	403

Table B.10. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)	EOM Storage (ac-ft)	EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-72	35,552	187,910	130	23,344	132,715	226,747	297	297
Feb-72	28,691	192,070	68	21,323	138,738	221,059	186	186
Mar-72	56,140	196,814	504	19,764	140,793	240,794	163	163
Apr-72	47,931	201,874	437	16,713	138,821	240,017	444	212
May-72	38,337	207,049	220	18,993	134,634	223,451	470	470
Jun-72	70,022	208,442	808	19,059	128,522	227,077	707	630
Jul-72	36,704	206,324	260	21,038	122,444	216,532	357	387
Aug-72	32,644	201,539	250	20,656	116,476	207,744	358	358
Sep-72	32,489	196,910	231	22,384	115,474	204,169	269	269
Oct-72	36,212	192,376	305	21,188	116,678	198,589	374	379
Nov-72	38,461	188,036	352	22,094	121,695	202,545	304	303
Dec-72	44,882	183,557	461	20,879	125,788	212,792	300	300
Jan-73	75,449	188,140	820	23,344	132,715	243,749	400	400
Feb-73	77,970	193,663	997	20,589	138,531	248,254	1,025	297
Mar-73	78,030	197,632	919	19,971	140,793	244,114	1,047	189
Apr-73	76,108	202,748	901	16,713	138,821	239,167	962	224
May-73	136,592	205,934	1,829	18,993	134,634	236,804	1,819	600
Jun-73	100,907	203,380	1,408	19,059	128,522	233,498	1,440	768
Jul-73	45,302	206,263	330	21,038	122,444	222,607	478	478
Aug-73	33,062	201,187	263	20,656	116,476	209,596	441	441
Sep-73	33,279	196,750	240	22,384	115,474	202,248	338	338
Oct-73	37,377	192,275	336	21,188	116,678	193,734	482	482
Nov-73	53,659	188,206	622	22,094	121,695	209,548	397	398
Dec-73	74,410	183,848	979	20,879	125,788	249,131	403	403
Jan-74	89,732	188,700	1,040	23,344	132,715	253,423	1,029	400
Feb-74	62,360	192,817	679	20,589	138,531	249,099	759	297
Mar-74	116,727	199,884	1,490	19,971	140,793	241,862	1,661	189
Apr-74	113,435	202,740	1,600	16,713	138,821	239,175	1,681	224
May-74	139,200	200,079	1,995	18,993	134,634	242,659	1,928	600
Jun-74	139,670	202,226	1,979	19,059	128,522	239,231	2,017	738
Jul-74	61,137	206,847	550	21,038	122,444	241,560	478	478
Aug-74	55,148	202,034	605	20,656	116,476	248,389	441	441
Sep-74	43,543	196,940	419	22,384	115,474	250,988	338	338
Oct-74	34,667	192,103	295	21,188	116,678	238,874	482	482
Nov-74	29,893	187,440	213	22,094	121,695	228,265	397	398
Dec-74	32,047	183,196	257	20,879	125,788	220,023	403	403
Jan-75	27,546	183,554	57	23,344	132,715	198,646	400	400
Feb-75	36,549	191,489	173	20,589	138,531	194,453	297	297
Mar-75	74,307	196,743	835	19,971	140,793	237,993	189	189
Apr-75	72,684	202,579	846	16,713	138,821	239,336	833	224
May-75	108,000	208,159	1,343	18,993	134,634	234,579	1,395	600
Jun-75	177,243	207,547	2,644	19,059	128,522	235,617	2,585	768
Jul-75	66,575	206,837	719	21,038	122,444	247,417	478	478
Aug-75	54,629	201,877	616	20,656	116,476	256,555	441	441
Sep-75	51,907	197,318	556	22,384	115,474	267,482	338	338
Oct-75	44,943	192,684	457	21,188	116,678	265,867	482	482
Nov-75	40,901	188,153	389	22,094	121,695	249,437	361	398
Dec-75	38,259	183,757	352	20,879	125,788	246,065	403	403
Jan-76	27,574	183,204	79	23,344	132,715	237,237	222	222
Feb-76	12,863	175,109	0	21,323	138,738	228,523	162	162
Mar-76	15,576	170,910	0	19,764	140,793	221,032	118	118
Apr-76	16,185	170,341	0	16,713	138,821	212,868	130	131
May-76	17,607	168,265	0	18,993	134,634	198,708	194	194
Jun-76	15,951	165,058	0	18,347	128,638	182,357	232	232
Jul-76	16,177	162,060	0	18,053	122,706	164,809	239	239
Aug-76	16,949	161,970	0	16,494	116,757	149,737	223	223
Sep-76	16,381	159,396	0	18,416	115,745	138,590	166	165
Oct-76	11,504	153,057	0	17,571	116,919	124,280	221	227
Nov-76	11,558	145,899	0	18,801	121,919	110,977	225	225
Dec-76	8,471	136,806	0	17,463	126,016	96,996	224	224
Jan-77	10,532	127,620	0	19,841	132,948	83,563	222	222
Feb-77	5,574	116,031	0	17,260	138,774	74,707	162	162
Mar-77	7,049	107,393	0	15,836	141,066	67,593	118	118
Apr-77	13,140	108,323	0	12,227	139,126	59,608	130	131
May-77	17,812	112,816	0	13,283	135,007	47,523	194	194
Jun-77	15,570	115,077	0	12,812	128,941	33,100	232	232
Jul-77	16,280	116,337	0	14,277	122,881	17,866	239	239
Aug-77	15,820	117,450	0	13,992	116,905	3,918	223	223
Sep-77	16,990	111,951	96	16,498	115,864	0	166	165
Oct-77	559	82,686	219	16,124	117,001	0	221	227
Nov-77	2,257	53,907	224	17,787	121,979	0	225	225
Dec-77	23,086	47,837	217	16,669	126,059	0	224	224

Table B.10. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-78	71,766	81,439	351	19,234	132,980	0	400	400
Feb-78	65,262	116,445	268	16,895	138,795	0	297	297
Mar-78	96,561	189,388	161	15,621	141,058	0	189	189
Apr-78	113,375	201,801	1,511	12,842	139,036	79,017	222	224
May-78	112,701	207,388	1,489	15,575	134,752	134,295	600	600
Jun-78	190,195	202,347	2,948	18,767	128,522	240,817	1,131	768
Jul-78	66,448	206,768	636	21,038	122,444	247,546	478	478
Aug-78	52,118	201,918	575	20,656	116,476	254,013	441	441
Sep-78	39,903	196,983	375	22,384	115,474	255,731	338	338
Oct-78	38,143	192,072	319	21,188	116,678	244,811	482	482
Nov-78	33,580	187,947	270	22,094	121,695	238,257	397	398
Dec-78	30,972	183,543	236	20,879	125,788	228,150	403	403
Jan-79	48,645	187,925	363	23,344	132,715	234,946	297	297
Feb-79	48,766	192,619	479	20,589	138,531	249,078	321	186
Mar-79	80,965	197,846	924	19,971	140,793	243,848	1,029	163
Apr-79	85,726	203,000	1,065	16,713	138,821	238,891	1,131	212
May-79	117,878	209,139	1,493	18,993	134,634	233,341	1,555	470
Jun-79	91,099	203,712	1,283	19,059	128,522	236,891	1,186	630
Jul-79	38,392	206,097	214	21,038	122,444	223,543	387	387
Aug-79	34,965	201,102	292	20,656	116,476	217,422	358	358
Sep-79	31,135	196,877	203	22,384	115,474	211,803	269	269
Oct-79	33,898	192,306	281	21,188	116,678	206,120	374	379
Nov-79	38,186	188,038	353	22,094	121,695	210,312	304	303
Dec-79	47,681	183,637	516	20,879	125,788	224,528	300	300
Jan-80	166,986	188,679	2,289	23,402	132,711	253,446	1,885	400
Feb-80	153,382	194,519	2,251	21,327	138,738	247,398	2,440	297
Mar-80	113,574	198,054	1,469	19,764	140,793	243,692	1,526	189
Apr-80	86,539	202,929	1,080	16,713	138,821	238,986	1,139	224
May-80	132,377	207,874	1,751	18,993	134,634	234,864	1,797	600
Jun-80	170,023	200,390	2,641	19,059	128,522	242,774	2,474	768
Jul-80	77,740	206,470	797	21,038	122,444	260,103	478	478
Aug-80	35,639	201,585	300	20,656	116,476	249,063	441	441
Sep-80	33,513	196,860	255	22,384	115,474	242,604	338	338
Oct-80	34,584	192,218	289	21,188	116,678	229,969	482	482
Nov-80	32,684	188,070	246	22,094	121,695	220,505	397	398
Dec-80	37,365	183,580	350	20,879	125,788	218,043	403	403
Jan-81	41,290	187,767	249	23,344	132,715	222,540	222	222
Feb-81	34,247	191,868	178	20,589	138,531	223,763	162	162
Mar-81	34,070	196,514	177	19,971	140,793	230,005	118	118
Apr-81	40,719	202,088	307	16,713	138,821	239,626	135	131
May-81	31,099	206,400	105	18,993	134,634	230,685	214	194
Jun-81	31,184	201,293	258	19,059	128,522	229,075	232	232
Jul-81	33,287	205,954	98	21,038	122,444	217,976	239	239
Aug-81	27,644	201,209	172	20,656	116,476	212,569	223	223
Sep-81	29,296	196,682	175	22,384	115,474	211,227	166	165
Oct-81	34,326	192,061	287	21,188	116,678	215,156	221	227
Nov-81	44,374	187,842	466	22,094	121,695	232,087	225	225
Dec-81	82,879	185,543	1,080	20,879	125,788	256,242	743	224
Jan-82	109,111	189,099	1,409	23,344	132,715	253,024	1,565	400
Feb-82	165,917	194,145	2,571	20,589	138,531	247,772	2,735	297
Mar-82	156,079	201,263	2,171	19,971	140,793	240,483	2,403	189
Apr-82	244,800	206,589	3,787	16,713	138,821	235,326	3,938	224
May-82	286,671	200,158	4,450	18,993	134,634	242,580	4,313	600
Jun-82	181,071	209,782	2,554	19,059	128,522	233,383	2,695	768
Jul-82	77,841	206,762	937	21,038	122,444	258,322	478	478
Aug-82	54,063	201,853	585	20,656	116,476	263,644	441	441
Sep-82	42,099	197,067	387	22,384	115,474	264,797	338	338
Oct-82	46,800	193,635	501	21,188	116,678	268,749	482	482
Nov-82	82,887	192,581	1,075	22,094	121,695	249,576	1,463	398
Dec-82	121,507	185,006	1,819	20,879	125,788	257,135	1,785	403
Jan-83	118,651	190,368	1,538	23,344	132,715	251,755	1,747	400
Feb-83	150,486	196,202	2,304	20,589	138,531	245,714	2,515	297
Mar-83	242,896	199,841	3,683	19,971	140,793	241,905	3,924	189
Apr-83	139,755	205,504	2,004	16,713	138,821	236,410	2,140	224
May-83	209,931	204,145	3,149	18,993	134,634	251,145	2,922	600
Jun-83	371,484	200,130	5,944	19,059	128,522	303,102	5,000	768
Jul-83	208,046	207,596	2,889	21,038	122,444	361,727	1,878	478
Aug-83	68,682	202,255	855	20,656	116,476	384,601	441	441
Sep-83	56,473	197,432	651	22,384	115,474	389,916	540	338
Oct-83	55,234	193,032	637	21,188	116,678	272,922	2,548	482
Nov-83	115,543	189,458	1,676	22,094	121,695	252,699	2,103	398
Dec-83	178,909	196,023	2,516	20,879	125,788	257,121	2,537	403

Table B.10. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)	EOM Storage (ac-ft)	EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-84	113,970	189,113	1,600	23,344	132,715	253,010	1,683	400
Feb-84	87,729	193,293	1,099	21,323	138,738	248,623	1,204	297
Mar-84	95,881	197,993	1,167	19,764	140,793	243,753	1,248	189
Apr-84	79,517	202,454	968	18,713	138,821	239,480	1,014	224
May-84	144,496	205,960	1,961	18,993	134,634	236,778	1,964	600
Jun-84	108,496	208,660	1,428	19,059	128,522	233,660	1,434	768
Jul-84	57,318	206,533	602	21,038	122,444	239,008	478	478
Aug-84	48,488	201,640	517	20,656	116,476	242,009	441	441
Sep-84	34,128	197,051	276	22,384	115,474	237,651	338	338
Oct-84	38,251	192,542	352	21,188	116,678	229,682	482	482
Nov-84	45,687	188,186	489	22,094	121,695	237,499	397	398
Dec-84	42,543	183,657	437	20,879	125,788	240,891	403	403
Jan-85	23,893	184,043	8	23,344	132,715	223,502	297	297
Feb-85	34,816	191,952	116	20,589	138,531	219,793	186	186
Mar-85	50,703	196,701	431	19,971	140,793	237,250	163	163
Apr-85	61,363	201,835	644	16,713	138,821	240,056	559	212
May-85	31,662	205,934	122	18,993	134,634	216,663	471	470
Jun-85	29,371	201,236	227	19,059	128,522	190,564	630	630
Jul-85	30,129	206,092	42	21,027	122,462	167,426	387	387
Aug-85	33,352	201,382	273	19,792	116,584	160,531	358	358
Sep-85	33,110	195,835	282	20,741	115,603	159,890	269	269
Oct-85	36,307	192,290	291	19,179	116,830	151,212	374	379
Nov-85	38,910	188,057	392	20,149	121,806	157,282	304	303
Dec-85	39,003	183,544	394	19,396	125,876	163,499	300	300
Jan-86	52,326	188,254	425	22,230	132,759	166,289	400	400
Feb-86	265,908	194,387	4,438	20,475	138,531	295,219	2,313	297
Mar-86	191,940	199,185	2,841	19,971	140,793	242,561	3,868	189
Apr-86	124,522	204,536	1,707	16,713	138,821	237,379	1,770	224
May-86	193,408	205,934	2,801	18,993	134,634	236,804	2,787	600
Jun-86	132,139	203,063	1,933	19,059	128,522	239,937	1,851	768
Jul-86	44,509	206,316	302	21,038	122,444	226,691	478	478
Aug-86	37,261	201,451	322	20,656	116,476	216,883	441	441
Sep-86	36,167	196,973	295	22,384	115,474	213,761	338	338
Oct-86	37,053	192,467	318	21,188	116,678	202,201	482	482
Nov-86	36,861	188,062	306	22,094	121,695	195,222	397	398
Dec-86	32,485	183,596	260	20,813	125,801	186,397	403	403
Jan-87	24,962	183,124	41	23,122	132,740	175,806	222	222
Feb-87	17,276	181,201	0	20,161	138,568	168,266	162	162
Mar-87	24,720	187,687	0	19,401	140,823	162,843	118	118
Apr-87	21,582	192,277	0	16,019	138,879	153,539	130	131
May-87	16,794	190,577	0	17,309	134,785	140,154	194	194
Jun-87	21,126	194,075	0	15,869	128,776	124,443	232	232
Jul-87	32,180	206,107	18	16,864	122,721	108,805	239	239
Aug-87	31,194	201,211	287	16,379	116,757	110,803	223	223
Sep-87	27,594	196,136	217	18,507	115,735	112,474	166	165
Oct-87	14,180	188,437	59	17,743	116,908	101,890	221	227
Nov-87	12,910	182,205	0	18,946	121,909	88,275	225	225
Dec-87	17,540	182,199	0	17,660	125,999	74,681	224	224
Jan-88	21,322	184,165	0	20,121	132,924	62,000	222	222
Feb-88	13,946	180,041	0	18,283	138,951	52,966	162	162
Mar-88	16,312	180,120	0	16,181	141,027	45,782	118	118
Apr-88	18,311	185,641	0	12,866	139,080	38,253	130	131
May-88	22,562	193,029	0	14,133	134,954	25,457	194	194
Jun-88	26,581	204,365	0	13,633	128,892	10,880	232	232
Jul-88	27,802	205,883	157	15,009	122,840	6,369	239	239
Aug-88	23,141	201,497	181	14,515	116,880	3,695	223	223
Sep-88	20,067	196,475	117	16,789	115,850	569	166	165
Oct-88	13,357	179,964	211	16,247	117,001	0	221	227
Nov-88	12,494	161,389	227	17,787	121,979	0	225	225
Dec-88	12,908	144,000	225	16,669	126,059	0	224	224
Jan-89	12,825	119,494	295	19,234	132,980	0	297	297
Feb-89	14,162	106,435	186	16,895	138,795	0	186	186
Mar-89	60,434	141,669	162	15,565	141,079	0	163	163
Apr-89	80,364	195,660	220	12,170	139,105	0	211	212
May-89	105,640	206,998	1,276	14,209	134,918	49,104	470	470
Jun-89	69,707	202,530	965	14,471	128,830	67,361	630	630
Jul-89	34,217	206,213	202	15,935	122,783	54,655	387	387
Aug-89	30,912	200,940	313	15,372	116,825	51,047	358	358
Sep-89	32,705	196,498	314	17,580	115,795	53,117	269	269
Oct-89	23,129	192,617	158	16,870	116,959	39,460	374	379
Nov-89	35,929	188,063	366	18,369	121,939	42,696	304	303
Dec-89	34,592	183,467	349	17,276	126,019	45,209	300	300

Table B.10. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR EOM Storage (ac-ft)	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-90	32,602	187,830	146	19,863	132,936	41,051	222	222
Feb-90	22,205	191,537	35	17,512	138,749	35,066	162	162
Mar-90	32,549	195,914	191	16,413	141,020	39,642	118	118
Apr-90	23,373	200,510	89	13,011	139,068	37,153	130	131
May-90	32,220	206,365	175	14,394	134,931	35,520	194	194
Jun-90	33,646	203,874	341	14,083	128,858	41,461	232	232
Jul-90	32,029	206,148	204	15,557	122,802	39,117	239	239
Aug-90	28,558	201,530	267	15,136	116,837	41,161	223	223
Sep-90	27,957	196,772	243	17,426	115,804	45,407	166	165
Oct-90	31,509	192,265	302	16,925	116,950	49,974	221	227
Nov-90	6,527	180,583	27	18,393	121,948	38,051	225	225
Dec-90	11,482	175,035	0	17,052	126,040	24,334	224	224

Table B.11. Simulation results from the water balance model under the staff's minimum flows plus minimum pool requirements and normalized 1990 water demands (aqueduct pumping allowed; EOM=end of month). (Source: The staff.)

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR EOM Storage (ac-ft)	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-66	40,203	188,002	597	13,683	132,801	152,828	297	297
Feb-66	22,625	188,286	66	19,717	138,809	147,608	186	186
Mar-66	41,401	196,752	232	18,619	140,834	151,599	163	163
Apr-66	50,828	201,564	479	18,516	138,821	166,149	211	212
May-66	45,247	206,486	332	18,903	134,644	155,960	470	470
Jun-66	26,134	184,231	501	17,788	128,714	147,513	630	630
Jul-66	31,985	166,741	504	17,244	122,715	152,600	387	387
Aug-66	32,289	156,974	399	16,415	116,760	152,600	358	358
Sep-66	35,062	171,949	10	18,456	115,736	135,201	269	269
Oct-66	32,233	185,710	0	17,762	116,903	110,972	374	379
Nov-66	39,350	188,137	305	19,119	121,888	111,603	304	303
Dec-66	70,941	183,566	942	18,320	125,914	152,404	300	300
Jan-67	67,123	188,720	713	21,807	132,742	177,293	400	400
Feb-67	53,935	192,181	536	20,759	138,731	190,574	297	297
Mar-67	95,339	198,264	1,143	19,771	140,793	243,482	312	189
Apr-67	108,595	202,703	1,532	16,713	138,821	239,211	1,711	224
May-67	161,693	208,976	2,237	18,993	134,634	233,762	2,336	600
Jun-67	249,402	200,390	4,043	19,059	128,522	244,486	3,888	768
Jul-67	127,525	206,631	1,604	21,038	122,444	302,725	603	478
Aug-67	39,146	201,644	377	20,656	116,476	297,139	441	441
Sep-67	37,317	197,031	337	22,384	115,474	296,796	338	338
Oct-67	38,489	192,483	374	21,188	116,678	273,491	770	482
Nov-67	38,926	188,201	368	22,094	121,695	250,737	776	398
Dec-67	39,148	183,579	380	20,879	125,788	250,408	403	403
Jan-68	38,251	187,894	198	23,344	132,715	247,409	297	297
Feb-68	45,072	192,581	357	21,323	138,738	249,115	368	186
Mar-68	44,648	196,830	347	19,764	140,793	244,865	438	163
Apr-68	36,655	201,100	255	18,713	138,821	239,448	328	212
May-68	28,818	205,866	69	18,993	134,634	213,445	470	470
Jun-68	36,653	201,664	342	19,059	128,522	194,119	630	630
Jul-68	29,671	205,883	43	21,038	122,444	170,687	387	387
Aug-68	30,353	201,257	221	19,814	116,584	160,487	358	358
Sep-68	31,194	196,741	238	20,552	115,615	157,239	269	269
Oct-68	31,547	192,335	268	19,109	116,834	150,227	374	379
Nov-68	39,059	188,037	397	20,157	121,810	156,780	304	303
Dec-68	43,587	183,541	477	19,389	125,859	168,992	300	300
Jan-69	161,379	189,888	2,199	22,757	132,715	252,235	928	400
Feb-69	102,823	193,607	1,499	20,589	138,531	248,309	1,709	297
Mar-69	96,496	199,389	1,184	19,971	140,793	242,357	1,327	189
Apr-69	147,907	203,910	2,165	16,713	138,821	238,005	2,284	224
May-69	281,633	203,597	4,276	18,993	134,634	270,313	3,732	600
Jun-69	219,193	200,390	3,381	19,059	128,522	242,774	3,790	768
Jul-69	70,288	206,464	673	21,038	122,444	251,705	478	478
Aug-69	48,420	201,743	512	20,656	116,476	253,991	441	441
Sep-69	45,291	197,236	463	22,384	115,474	260,878	338	338
Oct-69	47,254	192,664	507	21,188	116,678	263,059	482	482
Nov-69	38,594	188,052	365	22,094	121,695	249,235	616	398
Dec-69	53,780	184,007	619	20,879	125,788	258,134	512	403
Jan-70	161,389	189,573	2,207	23,344	132,715	252,550	2,390	400
Feb-70	83,643	193,355	1,090	20,589	138,531	248,562	1,194	297
Mar-70	98,777	197,810	1,230	19,971	140,793	243,937	1,337	189
Apr-70	66,613	202,202	752	16,713	138,821	239,712	805	224
May-70	114,399	209,829	1,399	18,993	134,634	232,909	1,464	600
Jun-70	118,929	200,303	1,781	19,059	128,522	242,676	1,539	768
Jul-70	44,138	205,926	251	21,038	122,444	225,404	478	478
Aug-70	33,864	201,426	266	20,656	116,476	212,410	441	441
Sep-70	32,618	196,946	232	22,384	115,474	204,429	338	338
Oct-70	35,195	192,352	296	21,188	116,678	192,333	482	482
Nov-70	51,277	188,359	549	22,094	121,695	199,977	397	398
Dec-70	73,256	183,733	964	20,879	125,788	238,482	403	403
Jan-71	63,872	188,271	585	23,344	132,715	250,035	400	400
Feb-71	60,327	192,768	634	20,589	138,531	249,149	647	297
Mar-71	76,219	198,298	851	19,971	140,793	243,448	987	189
Apr-71	72,020	202,232	858	16,713	138,821	239,682	911	224
May-71	65,417	207,523	660	18,993	134,634	235,215	721	600
Jun-71	127,636	207,024	1,813	19,059	128,522	236,140	1,768	768
Jul-71	58,195	206,771	592	21,038	122,444	241,306	478	478
Aug-71	52,762	201,795	574	20,656	116,476	246,538	441	441
Sep-71	39,953	197,084	357	22,384	115,474	245,667	338	338
Oct-71	42,940	192,467	426	21,188	116,678	241,573	482	482
Nov-71	32,037	187,440	256	22,094	121,695	233,803	397	398
Dec-71	40,378	183,682	401	20,879	125,788	236,859	403	403

Table B.11. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-72	35,552	187,910	130	23,344	132,715	226,747	297	297
Feb-72	28,691	192,070	68	21,323	138,738	221,059	186	186
Mar-72	56,140	196,814	504	19,764	140,793	240,794	163	163
Apr-72	47,931	201,874	437	16,713	138,821	240,017	444	212
May-72	38,337	207,049	220	18,993	134,634	223,451	470	470
Jun-72	70,022	208,442	808	19,059	128,522	227,077	707	630
Jul-72	36,704	206,324	260	21,038	122,444	216,532	387	387
Aug-72	32,644	201,539	250	20,656	116,476	207,744	358	358
Sep-72	32,489	198,910	231	22,384	115,474	204,169	269	269
Oct-72	36,212	192,376	305	21,188	116,678	198,589	374	379
Nov-72	38,461	188,036	352	22,094	121,695	202,545	304	303
Dec-72	44,882	183,557	461	20,879	125,788	212,792	300	300
Jan-73	75,449	188,140	820	23,344	132,715	243,749	400	400
Feb-73	77,970	193,663	997	20,589	138,531	248,254	1,025	297
Mar-73	78,030	197,632	919	19,971	140,793	244,114	1,047	189
Apr-73	76,108	202,748	901	16,713	138,821	239,167	962	224
May-73	136,592	205,934	1,829	18,993	134,634	236,804	1,819	600
Jun-73	100,907	203,380	1,408	19,059	128,522	233,498	1,440	768
Jul-73	45,302	206,263	330	21,038	122,444	222,607	478	478
Aug-73	33,062	201,187	263	20,656	116,476	209,596	441	441
Sep-73	33,279	196,750	240	22,384	115,474	202,248	338	338
Oct-73	37,377	192,275	336	21,188	116,678	193,734	482	482
Nov-73	53,659	188,206	622	22,094	121,695	209,548	397	398
Dec-73	74,410	183,848	979	20,879	125,788	249,131	403	403
Jan-74	89,732	188,700	1,040	23,344	132,715	253,423	1,029	400
Feb-74	62,360	192,817	679	20,589	138,531	249,099	759	297
Mar-74	116,727	199,884	1,490	19,971	140,793	241,862	1,661	189
Apr-74	113,435	202,740	1,600	16,713	138,821	239,175	1,681	224
May-74	139,200	200,079	1,995	18,993	134,634	242,659	1,928	600
Jun-74	139,670	202,226	1,979	19,059	128,522	239,231	2,017	768
Jul-74	61,137	206,847	550	21,038	122,444	241,560	478	478
Aug-74	55,148	202,034	605	20,656	116,476	248,389	441	441
Sep-74	43,543	196,940	419	22,384	115,474	250,988	338	338
Oct-74	34,867	192,103	295	21,188	116,678	238,874	482	482
Nov-74	29,893	187,440	213	22,094	121,695	228,265	397	398
Dec-74	32,047	183,196	257	20,879	125,788	220,023	403	403
Jan-75	27,546	183,554	57	23,344	132,715	198,646	400	400
Feb-75	36,549	191,489	173	20,589	138,531	194,453	297	297
Mar-75	74,307	196,743	835	19,971	140,793	237,993	189	189
Apr-75	72,684	202,579	846	16,713	138,821	239,336	833	224
May-75	108,000	208,159	1,343	18,993	134,634	234,579	1,395	600
Jun-75	177,243	207,547	2,644	19,059	128,522	238,617	2,585	768
Jul-75	66,575	206,837	719	21,038	122,444	247,417	478	478
Aug-75	54,629	201,877	616	20,656	116,476	256,555	441	441
Sep-75	51,907	197,318	556	22,384	115,474	267,482	338	338
Oct-75	44,943	192,684	457	21,188	116,678	265,867	482	482
Nov-75	40,901	188,153	389	22,094	121,695	249,437	661	398
Dec-75	38,259	183,757	352	20,879	125,788	246,065	403	403
Jan-76	27,574	183,204	79	23,344	132,715	237,237	222	222
Feb-76	12,863	175,109	0	21,323	138,738	228,523	162	162
Mar-76	15,576	170,910	0	19,764	140,793	221,032	118	118
Apr-76	16,185	170,341	0	16,713	138,821	212,868	130	131
May-76	17,607	168,265	0	18,993	134,634	198,708	194	194
Jun-76	15,951	165,058	0	18,347	128,638	182,357	232	232
Jul-76	16,177	162,060	0	18,053	122,706	164,809	239	239
Aug-76	16,949	159,106	46	16,494	116,757	152,900	223	223
Sep-76	16,381	156,168	6	18,416	115,745	141,805	166	165
Oct-76	11,504	149,836	0	17,571	116,919	127,481	221	227
Nov-76	11,558	142,679	0	18,801	121,919	114,178	225	225
Dec-76	8,471	133,588	0	17,463	126,016	100,193	224	224
Jan-77	10,532	124,400	0	19,841	132,948	86,763	222	222
Feb-77	5,574	112,811	0	17,260	138,774	77,908	162	162
Mar-77	7,049	104,175	0	15,836	141,066	70,790	118	118
Apr-77	13,140	105,117	0	12,227	139,126	62,776	130	131
May-77	17,812	109,618	0	13,283	135,007	50,669	194	194
Jun-77	15,570	1,595	1,880	11,524	127,654	147,513	232	232
Jul-77	16,280	0	296	0	107,317	148,473	239	239
Aug-77	15,820	0	260	0	87,349	148,550	223	223
Sep-77	16,990	16,598	10	0	69,810	138,198	166	165
Oct-77	559	16,425	0	756	55,578	123,779	221	227
Nov-77	2,257	16,468	0	2,268	45,038	110,602	225	225
Dec-77	23,086	25,438	0	14,591	47,039	98,483	224	224

Table B.11. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-78	71,766	73,243	0	26,724	61,451	78,459	400	400
Feb-78	65,262	113,512	0	26,507	76,878	64,083	297	297
Mar-78	96,561	181,353	0	30,639	94,160	54,937	189	189
Apr-78	113,375	201,797	1,091	29,840	109,133	109,242	222	224
May-78	112,701	207,392	1,241	30,834	120,102	149,059	600	600
Jun-78	190,195	205,452	2,709	29,840	124,943	237,712	1,192	768
Jul-78	66,448	206,767	829	24,617	122,444	243,994	478	478
Aug-78	52,118	201,918	575	20,656	116,476	250,490	441	441
Sep-78	39,903	196,983	375	22,384	115,474	252,220	338	338
Oct-78	36,143	192,072	319	21,188	116,678	241,314	482	482
Nov-78	33,580	187,947	270	22,094	121,695	234,752	397	398
Dec-78	30,972	183,543	236	20,879	125,788	224,643	403	403
Jan-79	48,645	187,925	363	23,344	132,715	231,422	297	297
Feb-79	48,766	192,619	479	20,589	138,531	249,078	257	186
Mar-79	80,965	197,846	924	19,971	140,793	243,848	1,029	163
Apr-79	85,726	203,000	1,065	16,713	138,821	238,891	1,131	212
May-79	117,878	209,139	1,493	18,993	134,634	233,341	1,555	470
Jun-79	91,099	203,712	1,283	19,059	128,522	236,891	1,186	630
Jul-79	38,392	206,097	214	21,038	122,444	223,543	387	387
Aug-79	34,965	201,102	292	20,656	116,476	217,422	358	358
Sep-79	31,135	196,877	203	22,384	115,474	211,803	269	269
Oct-79	33,898	192,308	281	21,188	116,678	206,120	374	379
Nov-79	38,186	188,038	353	22,094	121,695	210,312	304	303
Dec-79	47,681	183,637	516	20,879	125,788	224,528	300	300
Jan-80	166,986	188,679	2,289	23,402	132,711	253,446	1,885	400
Feb-80	153,382	194,519	2,251	21,327	138,738	247,396	2,440	297
Mar-80	113,574	198,054	1,469	19,764	140,793	243,692	1,526	189
Apr-80	86,539	202,929	1,080	16,713	138,821	238,986	1,139	224
May-80	132,377	207,874	1,751	18,993	134,634	234,864	1,797	600
Jun-80	170,023	200,390	2,841	19,059	128,522	242,774	2,474	768
Jul-80	77,740	206,470	797	21,038	122,444	260,103	478	478
Aug-80	35,639	201,585	300	20,656	116,476	249,063	441	441
Sep-80	33,513	196,860	255	22,384	115,474	242,604	338	338
Oct-80	34,584	192,218	289	21,188	116,678	229,969	482	482
Nov-80	32,684	188,070	246	22,094	121,695	220,505	397	398
Dec-80	37,365	183,580	350	20,879	125,788	218,043	403	403
Jan-81	41,290	187,797	249	23,344	132,715	222,540	222	222
Feb-81	34,247	191,868	178	20,589	138,531	223,783	162	162
Mar-81	34,070	196,514	177	19,971	140,793	230,005	118	118
Apr-81	40,719	202,088	307	16,713	138,821	239,626	135	131
May-81	31,099	206,400	105	18,993	134,634	230,685	214	194
Jun-81	31,184	201,293	258	19,059	128,522	229,075	232	232
Jul-81	33,287	205,954	98	21,038	122,444	217,974	239	239
Aug-81	27,644	201,209	172	20,656	116,476	212,569	223	223
Sep-81	29,296	196,682	175	22,384	115,474	211,227	166	166
Oct-81	34,326	192,061	287	21,188	116,678	215,156	221	227
Nov-81	44,374	187,842	466	22,094	121,695	232,067	225	225
Dec-81	82,879	185,543	1,080	20,879	125,788	256,242	743	224
Jan-82	109,111	189,099	1,409	23,344	132,715	253,024	1,565	400
Feb-82	165,917	194,145	2,571	20,589	138,531	247,772	2,735	297
Mar-82	156,079	201,263	2,171	19,971	140,793	240,483	2,403	189
Apr-82	244,800	206,589	3,787	16,713	138,821	235,326	3,938	224
May-82	286,671	200,158	4,450	18,993	134,634	242,580	4,313	600
Jun-82	181,071	209,782	2,554	19,059	128,522	233,383	2,695	768
Jul-82	77,841	206,762	937	21,038	122,444	258,322	478	478
Aug-82	54,063	201,853	585	20,656	116,476	263,644	441	441
Sep-82	42,099	197,087	387	22,384	115,474	264,797	338	338
Oct-82	46,800	193,635	501	21,188	116,678	268,749	482	482
Nov-82	82,887	192,581	1,075	22,094	121,695	249,576	1,463	398
Dec-82	121,507	185,006	1,819	20,879	125,788	257,135	1,785	403
Jan-83	118,651	190,368	1,538	23,344	132,715	251,755	1,747	400
Feb-83	150,486	196,202	2,304	20,589	138,531	245,714	2,515	297
Mar-83	242,896	199,841	3,683	19,971	140,793	241,905	3,924	189
Apr-83	139,755	205,504	2,004	16,713	138,821	236,410	2,140	224
May-83	209,931	204,145	3,149	18,993	134,634	251,145	2,922	600
Jun-83	371,484	200,130	5,944	19,059	128,522	303,102	5,000	768
Jul-83	208,046	207,596	2,889	21,038	122,444	361,727	1,878	478
Aug-83	68,682	202,255	855	20,656	116,476	384,601	441	441
Sep-83	56,473	197,432	651	22,384	115,474	389,916	540	338
Oct-83	55,234	193,032	637	21,188	116,678	272,922	2,548	482
Nov-83	115,543	189,458	1,676	22,094	121,695	252,699	2,103	398
Dec-83	178,909	196,023	2,516	20,879	125,788	257,121	2,537	403

Table B.11. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR EOM Storage (ac-ft)	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-84	113,970	189,113	1,600	23,344	132,715	253,010	1,683	400
Feb-84	87,729	193,293	1,099	21,323	138,738	248,623	1,204	297
Mar-84	95,881	197,993	1,167	19,764	140,793	243,753	1,248	189
Apr-84	79,517	202,454	968	16,713	138,821	239,460	1,014	224
May-84	144,496	205,960	1,961	18,993	134,634	236,778	1,964	600
Jun-84	108,496	208,660	1,428	19,059	128,522	233,660	1,434	768
Jul-84	57,318	206,533	602	21,038	122,444	239,008	478	478
Aug-84	48,488	201,640	517	20,656	116,476	242,009	441	441
Sep-84	34,128	197,051	276	22,384	115,474	237,651	338	338
Oct-84	38,251	192,542	352	21,188	116,678	229,682	482	482
Nov-84	45,687	188,186	489	22,094	121,695	237,499	397	398
Dec-84	42,543	183,657	437	20,879	125,788	240,691	403	403
Jan-85	23,893	184,043	8	23,344	132,715	223,502	297	297
Feb-85	34,816	191,952	116	20,589	138,531	219,793	186	186
Mar-85	50,703	196,701	431	19,971	140,793	237,250	163	163
Apr-85	61,363	201,835	644	16,713	138,821	240,056	559	212
May-85	31,662	205,934	122	18,993	134,634	216,663	471	470
Jun-85	29,371	201,236	227	19,059	128,522	190,564	630	630
Jul-85	30,129	206,092	42	21,027	122,462	167,426	387	387
Aug-85	33,352	201,382	273	19,792	116,584	160,531	358	358
Sep-85	33,110	195,835	282	20,741	115,603	159,890	269	269
Oct-85	36,307	192,290	291	19,179	116,830	151,212	374	379
Nov-85	38,910	188,057	392	20,149	121,808	157,282	304	303
Dec-85	39,003	183,544	394	19,366	125,876	163,499	300	300
Jan-86	52,326	188,254	425	22,230	132,759	160,289	400	400
Feb-86	265,908	194,387	4,438	20,475	138,531	295,219	2,313	297
Mar-86	191,940	199,185	2,841	19,971	140,793	242,561	3,868	189
Apr-86	124,522	204,536	1,707	16,713	138,821	237,379	1,770	224
May-86	193,408	205,934	2,801	18,993	134,634	236,804	2,787	600
Jun-86	32,139	203,063	1,933	19,059	128,522	239,937	1,851	768
Jul-86	44,509	206,316	302	21,038	122,444	226,691	478	478
Aug-86	37,261	201,451	322	20,656	116,476	216,883	441	441
Sep-86	36,167	196,973	295	22,384	115,474	213,761	338	338
Oct-86	37,053	192,467	318	21,188	116,678	202,201	482	482
Nov-86	36,861	188,062	306	22,094	121,695	195,222	397	398
Dec-86	32,485	183,596	260	20,813	125,801	186,397	403	403
Jan-87	24,962	183,124	41	23,122	132,740	175,806	222	222
Feb-87	17,276	181,201	0	20,161	138,568	168,266	162	162
Mar-87	24,720	187,687	0	19,401	140,823	162,843	118	118
Apr-87	21,582	192,277	0	16,019	138,879	153,539	130	131
May-87	16,794	190,577	0	17,309	134,785	140,154	194	194
Jun-87	21,126	170,997	388	15,869	128,776	147,513	232	232
Jul-87	32,160	163,018	360	16,869	122,720	152,600	239	239
Aug-87	31,194	160,608	262	16,395	116,756	152,600	223	223
Sep-87	27,594	168,511	7	18,527	115,733	141,492	166	165
Oct-87	14,180	164,562	0	17,762	116,906	127,218	221	227
Nov-87	12,910	158,305	0	18,963	121,908	113,622	225	225
Dec-87	17,540	158,262	0	17,676	125,998	100,080	224	224
Jan-88	21,322	160,173	0	20,137	132,923	87,505	222	222
Feb-88	13,946	156,044	0	18,299	138,950	78,442	162	162
Mar-88	16,312	156,192	0	16,199	141,026	71,176	118	118
Apr-88	18,311	161,763	0	12,885	139,078	63,613	130	131
May-88	22,562	169,209	0	14,154	134,953	50,496	194	194
Jun-88	26,581	68,479	1,892	13,651	128,891	147,513	232	232
Jul-88	27,802	59,813	351	15,018	122,839	152,600	239	239
Aug-88	23,141	52,122	259	14,514	116,880	152,600	223	223
Sep-88	20,067	54,590	7	16,777	115,851	141,349	166	165
Oct-88	13,357	51,526	0	16,231	117,001	126,847	221	227
Nov-88	12,494	46,268	0	17,787	121,979	113,932	225	225
Dec-88	12,908	42,564	0	16,669	126,059	100,544	224	224
Jan-89	12,825	38,230	0	19,234	132,980	82,268	297	297
Feb-89	14,162	33,498	0	16,895	138,795	71,977	186	186
Mar-89	60,434	78,569	0	15,565	141,079	62,557	163	163
Apr-89	80,364	145,846	0	12,164	139,106	48,703	211	212
May-89	105,640	206,999	477	14,193	134,918	48,344	470	470
Jun-89	69,707	121,734	2,329	14,459	128,830	147,513	630	630
Jul-89	34,217	107,841	511	15,925	122,784	152,600	387	387
Aug-89	30,912	99,136	387	15,366	116,825	152,600	358	358
Sep-89	32,705	113,270	10	17,577	115,796	136,315	269	269
Oct-89	23,129	119,238	0	16,871	116,959	112,912	374	379
Nov-89	35,929	136,445	0	18,370	121,939	94,413	304	303
Dec-89	34,592	153,341	0	17,277	126,019	75,404	300	300

Table B.11. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR EOM Storage (ac-ft)	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-90	32,802	166,588	0	19,864	132,936	62,477	222	222
Feb-90	22,205	172,217	0	17,514	138,749	54,646	162	162
Mar-90	32,549	188,366	0	16,416	141,020	47,458	118	118
Apr-90	23,373	198,243	0	13,014	139,068	39,641	130	131
May-90	32,220	206,365	138	14,397	134,931	35,728	194	194
Jun-90	33,646	98,031	2,129	14,086	128,858	147,513	232	232
Jul-90	32,029	92,834	351	15,561	122,802	152,600	239	239
Aug-90	28,558	90,221	255	15,138	116,837	152,600	223	223
Sep-90	27,957	100,244	6	17,426	115,804	141,881	166	165
Oct-90	31,509	114,552	0	16,922	116,950	127,317	221	227
Nov-90	8,527	104,567	0	18,388	121,948	113,609	225	225
Dec-90	11,462	99,027	0	17,046	126,040	99,853	224	224

Table B.12. Simulation results from the water balance model under the U.S. Fish and Wildlife Service's minimum flow alternative, no minimum pool requirements, and normalized water demands (aqueduct pumping allowed; EOM=end of month). (Source: The staff.)

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-66	40,203	188,151	597	13,578	132,816	147,674	380	380
Feb-66	22,625	188,676	69	19,306	138,857	131,886	379	379
Mar-66	41,401	197,180	249	17,508	140,931	122,363	401	401
Apr-66	50,628	201,677	516	14,642	138,983	123,605	474	474
May-66	45,247	205,934	393	15,836	134,671	95,075	836	836
Jun-66	26,134	199,628	282	14,888	128,819	80,399	527	527
Jul-66	31,985	206,186	122	16,082	122,777	59,891	438	438
Aug-66	32,289	201,443	326	15,459	116,823	53,419	409	409
Sep-66	35,062	196,961	350	17,588	115,795	53,900	321	321
Oct-66	32,233	191,753	321	16,949	116,956	42,677	492	492
Nov-66	39,350	188,296	416	18,383	121,939	44,696	386	386
Dec-66	70,941	183,730	955	17,493	125,994	80,798	382	382
Jan-67	67,123	188,713	740	20,311	132,894	107,821	380	380
Feb-67	53,935	192,335	574	18,497	138,889	118,668	379	379
Mar-67	95,339	197,271	1,189	18,109	140,793	138,503	402	402
Apr-67	108,595	201,961	1,528	16,713	138,821	236,701	484	484
May-67	161,993	209,191	2,222	18,993	134,634	234,162	2,273	863
Jun-67	249,402	200,390	4,047	19,059	128,522	243,872	3,909	562
Jul-67	127,525	208,631	1,604	21,038	122,444	302,725	594	478
Aug-67	39,146	201,644	377	20,656	116,476	297,139	441	441
Sep-67	37,317	197,031	337	22,384	115,474	296,796	338	338
Oct-67	38,489	192,442	374	21,188	116,678	273,451	771	497
Nov-67	38,926	188,183	368	22,094	121,695	251,212	767	387
Dec-67	39,148	183,575	380	20,879	125,788	252,162	382	382
Jan-68	38,251	188,043	196	23,344	132,715	243,903	380	380
Feb-68	45,072	192,372	363	21,323	138,738	245,314	379	379
Mar-68	44,648	196,995	341	19,764	140,793	242,960	401	401
Apr-68	36,655	200,944	261	16,713	138,821	229,195	474	474
May-68	28,818	205,866	66	18,993	134,634	180,657	836	836
Jun-68	36,853	202,632	326	19,060	128,530	166,776	527	527
Jul-68	29,671	205,883	77	19,928	122,591	142,569	438	438
Aug-68	30,353	201,332	257	17,555	116,731	131,643	409	409
Sep-68	31,194	196,797	268	18,775	115,718	127,298	321	321
Oct-68	31,547	192,366	287	17,907	116,894	114,356	492	492
Nov-68	39,059	188,194	410	19,223	121,883	116,625	386	386
Dec-68	43,587	183,698	498	18,116	125,962	124,861	382	382
Jan-69	161,379	188,259	2,249	21,464	132,715	244,431	380	380
Feb-69	102,823	193,664	1,469	20,589	138,531	248,415	1,536	379
Mar-69	96,496	199,537	1,183	19,971	140,793	242,632	1,323	402
Apr-69	147,907	204,074	2,164	16,713	138,821	238,309	2,283	484
May-69	281,633	203,812	4,275	18,993	134,634	270,405	3,735	863
Jun-69	219,193	200,390	3,384	19,059	128,522	242,159	3,806	562
Jul-69	70,288	206,464	673	21,038	122,444	251,066	478	478
Aug-69	48,420	201,743	512	20,656	116,476	253,387	441	441
Sep-69	45,291	197,236	463	22,384	115,474	260,276	338	338
Oct-69	47,254	192,642	508	21,188	116,678	261,532	497	497
Nov-69	38,594	188,050	365	22,094	121,695	249,673	582	387
Dec-69	53,780	183,992	619	20,879	125,788	258,107	520	382
Jan-70	161,389	189,559	2,207	23,344	132,715	252,524	2,390	380
Feb-70	83,643	193,412	1,089	20,589	138,531	248,668	1,191	379
Mar-70	98,777	197,957	1,229	19,971	140,793	244,211	1,332	402
Apr-70	66,613	202,366	752	16,713	138,821	240,017	804	484
May-70	114,399	199,730	1,565	18,993	134,634	243,623	1,462	863
Jun-70	118,929	202,840	1,568	19,059	128,522	239,709	1,556	562
Jul-70	44,138	205,926	291	21,038	122,444	224,984	478	478
Aug-70	33,864	201,426	266	20,656	116,476	211,994	441	441
Sep-70	32,618	196,946	232	22,384	115,474	204,015	338	338
Oct-70	35,195	192,346	296	21,188	116,678	199,978	497	497
Nov-70	51,277	188,341	549	22,086	121,695	199,242	387	387
Dec-70	73,256	183,696	964	20,879	125,788	239,058	382	382
Jan-71	63,872	188,765	576	23,344	132,715	251,310	380	380
Feb-71	60,327	192,825	642	20,589	138,531	249,255	676	379
Mar-71	76,219	198,446	850	19,971	140,793	243,723	983	402
Apr-71	72,020	202,396	858	16,713	138,821	239,987	911	484
May-71	65,417	207,730	659	18,993	134,634	227,357	854	863
Jun-71	127,636	207,024	1,817	19,059	128,522	235,526	1,650	562
Jul-71	58,195	206,771	592	21,038	122,444	240,697	478	478
Aug-71	52,762	201,795	574	20,656	116,476	245,934	441	441
Sep-71	39,953	197,084	357	22,384	115,474	245,067	338	338
Oct-71	42,940	192,461	426	21,188	116,678	240,034	497	497
Nov-71	32,037	187,440	256	22,094	121,695	232,851	387	387
Dec-71	40,378	183,644	402	20,879	125,788	237,233	382	382

Table B.12. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR EOM Storage (ac-ft)	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-72	35,552	187,926	129	23,344	132,715	221,962	380	380
Feb-72	28,691	192,415	62	21,323	138,738	204,830	379	379
Mar-72	56,140	197,236	503	19,764	140,793	209,910	401	401
Apr-72	47,931	202,034	441	16,713	138,821	207,692	474	474
May-72	38,337	207,872	210	18,993	134,634	168,252	836	836
Jun-72	70,022	206,331	857	19,059	128,522	185,915	527	527
Jul-72	36,704	206,333	225	21,039	122,445	170,553	438	438
Aug-72	32,644	201,598	262	19,862	116,587	159,766	409	409
Sep-72	32,489	196,987	262	20,500	115,624	155,125	321	321
Oct-72	36,212	192,459	343	18,833	116,855	144,822	492	492
Nov-72	38,481	188,199	390	19,769	121,846	145,858	386	386
Dec-72	44,882	183,714	497	18,738	125,910	153,041	382	382
Jan-73	75,449	188,119	839	22,300	132,715	185,965	380	380
Feb-73	77,970	192,333	1,020	20,589	138,531	227,301	379	379
Mar-73	78,030	197,780	894	19,971	140,793	244,389	677	402
Apr-73	76,108	202,912	901	16,713	138,821	239,471	962	484
May-73	136,592	205,934	1,832	18,993	134,634	237,419	1,816	863
Jun-73	100,907	203,380	1,407	19,059	128,522	238,849	1,360	562
Jul-73	45,302	206,263	330	21,038	122,444	227,911	478	478
Aug-73	33,062	201,187	263	20,656	116,476	214,857	441	441
Sep-73	33,279	196,751	240	22,384	115,474	207,488	338	338
Oct-73	37,377	192,269	336	21,188	116,678	198,039	497	497
Nov-73	53,659	188,187	622	22,094	121,695	214,482	387	387
Dec-73	74,410	183,810	979	20,879	125,788	255,415	382	382
Jan-74	89,732	188,666	1,039	23,344	132,715	253,397	1,131	380
Feb-74	62,360	192,874	677	20,589	138,531	249,205	755	379
Mar-74	116,727	200,032	1,489	19,971	140,793	242,137	1,657	402
Apr-74	113,435	202,903	1,600	16,713	138,821	239,479	1,680	484
May-74	139,200	200,294	1,994	18,993	134,634	243,059	1,926	863
Jun-74	139,670	202,225	1,983	19,059	128,522	240,324	2,009	562
Jul-74	61,137	206,847	550	21,038	122,444	242,646	478	478
Aug-74	55,148	202,034	605	20,656	116,476	249,466	441	441
Sep-74	43,543	196,940	419	22,384	115,474	252,059	338	338
Oct-74	34,867	192,097	295	21,188	116,678	239,001	497	497
Nov-74	29,893	187,440	213	22,094	121,695	228,981	387	387
Dec-74	32,047	183,192	257	20,879	125,788	222,037	382	382
Jan-75	27,546	183,554	57	23,344	132,715	201,887	380	380
Feb-75	36,549	191,489	173	20,589	138,531	193,145	379	379
Mar-75	74,307	197,126	829	19,971	140,793	223,163	402	402
Apr-75	72,684	202,743	850	16,713	138,821	239,640	582	484
May-75	108,000	208,374	1,342	18,993	134,634	234,979	1,392	863
Jun-75	177,243	203,008	2,723	19,059	128,522	239,542	2,607	562
Jul-75	66,575	206,837	645	21,038	122,444	246,805	478	478
Aug-75	54,629	201,877	616	20,656	116,476	255,947	441	441
Sep-75	51,907	197,318	556	22,384	115,474	266,877	338	338
Oct-75	44,943	192,663	458	21,188	116,678	264,333	497	497
Nov-75	40,901	188,151	389	22,094	121,695	249,778	629	387
Dec-75	38,259	183,719	352	20,879	125,788	247,733	382	382
Jan-76	27,574	183,204	78	23,344	132,715	235,546	276	276
Feb-76	12,863	175,109	0	21,323	138,738	220,272	276	276
Mar-76	15,576	170,910	0	19,764	140,793	202,225	290	290
Apr-76	16,185	170,379	0	16,675	138,849	182,092	332	332
May-76	17,607	170,177	0	17,116	134,858	143,524	596	596
Jun-76	15,951	170,178	0	15,121	128,801	125,847	264	264
Jul-76	16,177	168,899	0	16,301	122,766	106,985	271	271
Aug-76	16,949	169,699	0	15,583	116,816	90,259	256	256
Sep-76	16,381	167,920	0	17,599	115,800	77,415	201	201
Oct-76	11,504	162,320	0	16,813	116,969	57,499	318	318
Nov-76	11,558	155,834	0	18,128	121,965	40,978	279	279
Dec-76	8,471	147,420	0	16,778	126,059	23,798	278	278
Jan-77	10,532	138,846	0	19,234	132,980	6,908	276	276
Feb-77	5,574	119,295	150	16,895	138,795	0	276	276
Mar-77	7,049	93,390	285	15,565	141,079	0	290	290
Apr-77	13,140	75,548	320	12,067	139,132	0	332	332
May-77	17,812	43,967	589	13,261	135,007	0	596	596
Jun-77	15,570	31,604	255	12,812	128,941	0	264	264
Jul-77	16,280	17,424	264	14,277	122,881	0	271	271
Aug-77	15,820	16,332	253	1,376	104,289	0	256	256
Sep-77	16,990	14,932	197	6,820	93,570	0	201	201
Oct-77	559	0	253	0	78,582	0	255	318
Nov-77	2,257	0	39	0	65,774	0	39	279
Dec-77	23,086	12,525	178	0	53,184	0	185	278

Table B.12. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR EOM Storage (ac-ft)	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-78	71,766	44,491	331	22,057	62,928	0	380	380
Feb-78	65,262	66,945	350	24,807	76,655	0	379	379
Mar-78	96,561	112,904	375	29,327	92,700	0	402	402
Apr-78	113,375	171,829	452	29,530	108,217	0	484	484
May-78	112,701	205,228	800	30,834	121,572	0	835	863
Jun-78	190,195	205,787	2,700	27,923	128,721	126,998	562	562
Jul-78	66,448	206,773	733	18,541	122,600	140,739	478	478
Aug-78	52,118	201,942	615	18,231	116,635	150,463	441	441
Sep-78	39,903	196,982	411	20,253	115,626	154,705	338	338
Oct-78	36,143	192,143	356	18,841	116,852	145,513	497	497
Nov-78	33,580	188,020	311	19,695	121,859	141,734	387	387
Dec-78	30,972	183,613	277	18,360	125,954	135,382	382	382
Jan-79	48,645	188,093	399	21,037	132,844	138,815	380	380
Feb-79	48,766	192,223	517	19,083	138,592	151,071	379	379
Mar-79	80,965	197,215	933	19,646	140,793	185,125	401	401
Apr-79	85,726	202,195	1,068	16,713	138,821	219,601	474	474
May-79	117,878	209,463	1,475	18,993	134,634	233,943	1,214	836
Jun-79	91,099	207,626	1,223	19,059	128,522	234,600	1,174	527
Jul-79	38,392	206,108	277	21,038	122,444	222,012	438	438
Aug-79	34,965	201,102	292	20,656	116,476	212,789	409	409
Sep-79	31,135	196,887	277	22,384	115,474	204,105	321	321
Oct-79	33,898	192,310	282	21,188	116,678	191,231	492	492
Nov-79	38,186	188,186	351	22,075	121,695	190,374	386	386
Dec-79	47,681	183,785	516	20,879	125,788	199,512	382	382
Jan-80	166,986	188,665	2,292	23,402	132,711	253,421	1,480	380
Feb-80	153,382	194,576	2,250	21,327	138,738	247,504	2,437	379
Mar-80	113,574	198,202	1,468	19,764	140,793	243,966	1,522	402
Apr-80	86,539	203,092	1,080	16,713	138,821	239,290	1,138	484
May-80	132,377	208,090	1,750	18,993	134,634	235,263	1,795	863
Jun-80	170,023	200,390	2,645	19,059	128,522	242,159	2,495	562
Jul-80	77,740	206,470	797	21,038	122,444	259,493	478	478
Aug-80	35,639	201,585	300	20,656	116,476	248,457	441	441
Sep-80	33,513	196,860	255	22,384	115,474	242,002	338	338
Oct-80	34,584	192,211	289	21,188	116,678	228,429	497	497
Nov-80	32,684	188,068	246	22,094	121,695	219,558	387	387
Dec-80	37,365	183,576	350	20,879	125,788	218,389	382	382
Jan-81	41,290	187,894	247	23,344	132,715	219,458	276	276
Feb-81	34,247	192,057	176	20,589	138,531	214,258	276	276
Mar-81	34,070	196,824	175	19,971	140,793	209,745	290	290
Apr-81	40,719	201,799	317	16,713	138,821	208,307	332	332
May-81	31,099	205,934	108	18,993	134,634	176,336	596	596
Jun-81	31,184	201,293	251	19,059	128,522	172,943	264	264
Jul-81	33,287	205,983	102	20,769	122,498	160,659	271	271
Aug-81	27,644	201,276	196	19,177	116,613	155,110	256	256
Sep-81	29,296	196,757	211	20,235	115,630	154,183	201	201
Oct-81	34,326	192,124	322	19,055	116,819	154,340	318	318
Nov-81	44,374	187,653	493	20,454	121,768	169,286	279	279
Dec-81	82,879	183,731	1,120	20,310	125,788	224,275	278	278
Jan-82	109,111	189,085	1,379	23,344	132,715	252,999	1,016	380
Feb-82	165,917	194,202	2,570	20,589	138,531	247,878	2,731	379
Mar-82	156,079	201,411	2,170	19,971	140,793	240,758	2,399	402
Apr-82	244,800	206,753	3,787	16,713	138,821	235,630	3,937	484
May-82	286,671	200,150	4,453	18,993	134,634	243,203	4,311	863
Jun-82	181,071	209,782	2,554	19,059	128,522	232,768	2,715	562
Jul-82	77,841	206,762	937	21,038	122,444	257,712	478	478
Aug-82	54,063	201,853	585	20,656	116,476	263,039	441	441
Sep-82	42,099	197,067	387	22,384	115,474	264,192	338	338
Oct-82	46,800	193,614	501	21,188	116,678	267,213	497	497
Nov-82	82,887	192,574	1,075	22,094	121,695	249,563	1,437	387
Dec-82	121,507	184,991	1,819	20,879	125,788	257,108	1,785	382
Jan-83	118,651	190,355	1,538	23,344	132,715	251,729	1,747	380
Feb-83	150,486	196,259	2,302	20,589	138,531	245,820	2,511	379
Mar-83	242,896	199,989	3,681	19,971	140,793	242,179	3,919	402
Apr-83	139,755	205,668	2,004	16,713	138,821	236,715	2,139	484
May-83	209,931	204,360	3,148	18,993	134,634	251,544	2,920	863
Jun-83	371,484	200,130	5,948	19,059	128,522	303,711	5,000	562
Jul-83	208,046	207,596	2,889	21,038	122,444	361,727	1,888	478
Aug-83	68,682	202,255	855	20,656	116,476	384,601	441	441
Sep-83	56,473	197,432	651	22,384	115,474	389,916	540	338
Oct-83	55,234	193,010	637	21,188	116,678	272,882	2,549	497
Nov-83	115,543	189,451	1,676	22,094	121,695	252,686	2,102	387
Dec-83	178,909	196,009	2,516	20,879	125,788	257,094	2,537	382

Table B.12. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR EOM Storage (ac-ft)	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-84	113,970	189,099	1,600	23,344	132,715	252,985	1,683	380
Feb-84	87,729	193,350	1,097	21,323	138,738	248,729	1,201	379
Mar-84	95,881	198,141	1,166	19,764	140,793	244,028	1,244	402
Apr-84	79,517	202,618	967	16,713	138,821	239,765	1,013	484
May-84	144,496	205,960	1,964	18,993	134,634	237,392	1,961	863
Jun-84	108,496	204,072	1,505	19,059	128,522	238,478	1,440	562
Jul-84	57,318	206,533	527	21,038	122,444	239,240	478	478
Aug-84	48,488	201,840	517	20,656	116,476	242,240	441	441
Sep-84	34,128	197,051	276	22,384	115,474	237,879	338	338
Oct-84	38,251	192,535	352	21,188	116,678	228,968	497	497
Nov-84	45,687	188,168	490	22,094	121,695	237,389	387	387
Dec-84	42,543	183,652	437	20,879	125,788	241,859	382	382
Jan-85	23,893	184,059	8	23,344	132,715	219,545	380	380
Feb-85	34,816	191,537	124	20,589	138,531	205,551	379	379
Mar-85	50,703	197,127	417	19,971	140,793	207,499	401	401
Apr-85	61,363	201,976	649	16,713	138,821	215,824	474	474
May-85	31,662	205,934	124	18,993	134,634	170,399	836	836
Jun-85	29,371	201,395	231	18,637	128,614	151,056	527	527
Jul-85	30,129	206,195	82	18,645	122,669	127,575	438	438
Aug-85	33,352	201,464	323	16,774	116,745	120,915	409	409
Sep-85	33,110	195,967	317	18,649	115,727	119,418	321	321
Oct-85	36,307	192,327	316	17,783	116,902	105,142	492	492
Nov-85	38,910	188,214	408	19,104	121,891	107,031	386	386
Dec-85	39,003	183,700	417	18,005	125,973	109,448	382	382
Jan-86	52,326	188,230	454	20,601	132,884	115,092	380	380
Feb-86	265,908	194,448	4,458	19,248	138,531	258,345	2,066	379
Mar-86	191,940	199,333	2,840	19,971	140,793	242,835	3,262	402
Apr-86	124,522	204,700	1,706	16,713	138,821	237,683	1,769	484
May-86	193,408	205,934	2,804	18,993	134,634	237,419	2,784	863
Jun-86	132,139	204,805	1,904	19,059	128,522	237,744	1,869	562
Jul-86	44,509	206,316	330	21,038	122,444	226,247	478	478
Aug-86	37,261	201,451	322	20,656	116,476	216,442	441	441
Sep-86	36,167	196,973	295	22,384	115,474	213,321	338	338
Oct-86	37,053	192,460	318	21,188	116,678	200,822	497	497
Nov-86	36,861	188,060	306	22,094	121,695	194,436	387	387
Dec-86	32,485	183,591	260	20,815	125,800	186,904	382	382
Jan-87	24,962	183,172	41	23,078	132,749	172,982	276	276
Feb-87	17,276	181,484	0	19,926	138,595	159,099	276	276
Mar-87	24,720	188,662	0	18,710	140,886	143,066	290	290
Apr-87	21,582	194,554	0	14,712	138,987	121,920	332	332
May-87	16,794	194,735	0	15,415	134,892	84,198	596	596
Jun-87	21,126	199,507	0	14,574	128,834	67,192	264	264
Jul-87	32,160	206,139	120	15,927	122,781	56,523	271	271
Aug-87	31,194	201,243	302	15,448	116,818	57,987	256	256
Sep-87	27,594	196,247	230	17,674	115,790	58,734	201	201
Oct-87	14,180	189,001	64	16,971	116,958	42,705	318	318
Nov-87	12,910	183,454	0	18,261	121,955	25,813	279	279
Dec-87	17,540	182,950	20	16,960	126,045	9,892	278	278
Jan-88	21,322	179,054	107	19,406	132,971	0	276	276
Feb-88	13,946	160,171	269	17,575	139,002	0	276	276
Mar-88	16,312	143,676	284	15,358	141,079	0	290	290
Apr-88	18,311	130,620	327	12,067	139,132	0	332	332
May-88	22,562	102,250	600	13,261	135,007	0	596	596
Jun-88	26,581	99,240	267	12,812	128,941	0	264	264
Jul-88	27,802	96,898	256	14,277	122,881	0	271	271
Aug-88	23,141	89,875	253	13,992	116,905	0	256	256
Sep-88	20,067	80,800	203	16,498	115,864	0	201	201
Oct-88	13,357	58,280	318	16,124	117,001	0	318	318
Nov-88	12,494	36,297	281	17,787	121,979	0	279	279
Dec-88	12,908	15,947	279	16,134	125,524	0	278	278
Jan-89	12,825	5,642	378	0	113,211	0	380	380
Feb-89	14,162	0	356	0	102,131	0	356	379
Mar-89	60,434	26,785	397	9,303	98,152	0	397	401
Apr-89	80,364	52,630	484	25,046	109,185	0	474	474
May-89	105,640	78,421	833	28,228	120,027	0	836	836
Jun-89	69,707	87,821	531	27,792	128,941	0	527	527
Jul-89	31,217	80,580	433	14,277	122,881	0	438	438
Aug-89	30,912	72,326	404	13,992	116,905	0	409	409
Sep-89	32,705	68,730	326	16,498	115,864	0	321	321
Oct-89	23,129	44,908	497	16,124	117,001	0	492	492
Nov-89	35,929	39,204	394	17,787	121,979	0	386	386
Dec-89	34,592	32,826	389	16,669	126,059	0	382	382

Table B.12. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR EOM Storage (ac-ft)	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-90	32,602	29,446	275	19,234	132,980	0	276	276
Feb-90	22,205	21,106	260	16,895	138,795	0	276	276
Mar-90	32,549	20,755	285	15,565	141,079	0	290	290
Apr-90	23,373	15,128	323	10,067	137,133	0	332	332
May-90	32,220	10,580	597	0	119,747	0	596	596
Jun-90	33,646	16,363	256	12,872	113,741	0	264	264
Jul-90	32,029	16,574	256	16,859	110,063	0	271	271
Aug-90	28,558	17,054	250	12,870	102,965	0	256	256
Sep-90	27,957	16,439	192	17,422	102,848	0	201	201
Oct-90	31,509	16,528	315	12,106	96,968	0	318	318
Nov-90	8,527	6,943	279	1,514	88,674	0	279	279
Dec-90	11,462	1,428	277	0	76,085	0	278	278

Table B.13. Simulation results from the water balance model under the no action alternative for minimum flows, no minimum pool requirements, and normalized 1990 water demands (aqueduct pumping allowed; EOM=end of month). (Source: The staff.)

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-66	40,203	187,631	599	13,942	132,763	165,620	91	91
Feb-66	22,625	187,654	58	20,372	138,752	166,529	69	69
Mar-66	41,401	196,646	208	19,577	140,793	172,626	104	104
Apr-66	50,628	201,462	476	16,713	138,821	190,422	151	153
May-66	45,247	206,441	330	18,993	134,634	192,544	264	264
Jun-66	26,134	208,376	73	19,059	128,522	176,584	321	321
Jul-66	31,985	206,033	187	20,986	122,474	165,187	335	335
Aug-66	32,289	201,322	257	19,671	116,589	159,518	306	306
Sep-66	35,062	196,851	297	20,702	115,592	162,358	214	213
Oct-66	32,233	191,554	276	19,818	116,761	170,259	124	123
Nov-66	39,350	187,773	372	21,317	121,713	186,724	110	110
Dec-66	70,941	183,235	900	20,848	125,788	236,159	125	125
Jan-67	67,123	192,453	622	23,344	132,715	249,057	517	91
Feb-67	53,935	192,327	600	20,788	138,731	249,137	598	69
Mar-67	95,339	198,206	1,146	19,771	140,793	243,374	1,271	105
Apr-67	108,595	202,662	1,532	16,713	138,821	239,134	1,710	164
May-67	161,693	208,761	2,240	18,993	134,634	233,364	2,344	291
Jun-67	249,402	200,390	4,040	19,059	128,522	243,668	3,892	356
Jul-67	127,525	206,560	1,605	21,038	122,444	308,086	504	375
Aug-67	39,146	201,573	377	20,656	116,476	308,755	338	338
Sep-67	37,317	196,959	337	22,384	115,474	314,578	233	233
Oct-67	38,489	192,201	377	21,188	116,678	273,003	1,069	130
Nov-67	38,926	188,130	365	22,094	121,695	253,461	719	112
Dec-67	39,148	183,424	381	20,879	125,788	258,166	323	125
Jan-68	38,251	187,956	195	23,344	132,715	253,554	320	91
Feb-68	45,072	192,500	360	21,323	138,738	248,964	480	69
Mar-68	44,648	196,789	347	19,784	140,793	244,789	436	104
Apr-68	36,655	201,100	255	16,713	138,821	239,960	318	153
May-68	28,818	205,866	69	18,993	134,634	226,584	264	264
Jun-68	36,653	202,614	326	19,059	128,522	224,491	321	321
Jul-68	29,671	205,883	58	21,038	122,444	204,892	335	335
Aug-68	30,353	201,198	208	20,656	116,476	196,867	306	306
Sep-68	31,194	196,667	207	22,384	115,474	194,869	214	213
Oct-68	31,547	192,039	237	21,188	116,678	201,321	124	123
Nov-68	39,059	187,677	366	22,094	121,695	217,796	110	110
Dec-68	43,587	183,217	453	20,879	125,788	239,506	125	125
Jan-69	161,379	189,673	2,187	23,344	132,715	251,837	2,079	91
Feb-69	102,823	193,449	1,498	20,589	138,531	248,015	1,706	69
Mar-69	96,496	199,331	1,183	19,971	140,793	242,249	1,323	105
Apr-69	147,907	203,868	2,164	16,713	138,821	237,928	2,283	164
May-69	281,633	203,382	4,279	18,993	134,634	269,916	3,740	264
Jun-69	219,193	200,390	3,377	19,059	128,522	241,955	3,794	356
Jul-69	70,288	206,393	674	21,038	122,444	257,267	375	375
Aug-69	48,420	201,672	512	20,656	116,476	265,807	338	338
Sep-69	45,291	197,165	463	22,384	115,474	278,856	233	233
Oct-69	47,254	192,401	510	21,188	116,678	272,803	619	130
Nov-69	38,594	187,893	363	22,094	121,695	253,699	703	112
Dec-69	53,780	183,814	620	20,879	125,788	257,776	591	125
Jan-70	161,389	189,358	2,208	23,344	132,715	252,152	2,391	91
Feb-70	83,643	193,196	1,089	20,589	138,531	248,268	1,192	69
Mar-70	98,777	197,751	1,228	19,971	140,793	243,828	1,332	105
Apr-70	66,613	202,161	752	16,713	138,821	239,635	804	164
May-70	114,399	209,614	1,401	18,993	134,634	232,511	1,472	291
Jun-70	118,929	205,547	1,689	19,059	128,522	236,798	1,539	356
Jul-70	44,138	205,905	336	21,038	122,444	231,106	375	375
Aug-70	33,864	201,408	266	20,656	116,476	224,370	338	338
Sep-70	32,618	196,926	232	22,384	115,474	222,546	233	233
Oct-70	35,195	192,065	300	21,188	116,678	232,263	131	130
Nov-70	51,277	188,626	539	22,094	121,695	252,965	164	112
Dec-70	73,256	184,180	961	20,879	125,788	257,409	957	125
Jan-71	63,872	188,565	587	23,344	132,715	252,945	663	91
Feb-71	60,327	192,609	642	20,589	138,531	248,855	713	69
Mar-71	76,219	198,239	849	19,971	140,793	243,339	983	104
Apr-71	72,020	202,183	858	16,713	138,821	239,591	911	153
May-71	65,417	207,290	662	18,993	134,634	234,781	730	264
Jun-71	127,636	202,185	1,891	19,059	128,522	240,090	1,772	321
Jul-71	58,195	206,672	515	21,038	122,444	249,279	335	335
Aug-71	52,762	201,703	574	20,656	116,476	262,702	306	306
Sep-71	39,953	196,999	357	22,384	115,474	269,089	214	213
Oct-71	42,940	192,290	428	21,188	116,678	272,901	353	123
Nov-71	32,037	187,811	247	22,094	121,695	253,776	579	110
Dec-71	40,378	183,684	407	20,879	125,788	257,905	394	125

Table B.13. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR EOM Storage (ac-ft)	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-72	35,552	187,778	132	23,344	132,715	253,732	203	91
Feb-72	28,691	192,553	57	21,323	138,738	248,912	161	69
Mar-72	56,140	197,071	507	19,764	140,793	244,507	559	104
Apr-72	47,931	201,833	442	16,713	138,821	239,941	513	153
May-72	38,337	207,566	211	18,993	134,634	233,355	298	264
Jun-72	70,022	206,275	853	19,059	128,522	235,039	784	321
Jul-72	36,704	206,314	224	21,038	122,444	225,478	335	335
Aug-72	32,644	201,529	250	20,656	116,476	219,800	306	306
Sep-72	32,489	196,899	231	22,384	115,474	219,452	214	213
Oct-72	36,212	192,075	309	21,188	116,678	229,483	124	123
Nov-72	38,461	187,683	353	22,094	121,695	245,214	110	110
Dec-72	44,882	183,558	456	20,879	125,788	258,032	255	125
Jan-73	75,449	188,619	812	23,344	132,715	252,891	984	91
Feb-73	77,970	193,505	1,008	20,589	138,531	247,960	1,206	69
Mar-73	78,030	197,574	917	19,971	140,793	244,006	1,042	105
Apr-73	76,108	202,706	901	16,713	138,821	239,089	962	164
May-73	136,592	200,782	1,912	18,993	134,634	241,343	1,827	291
Jun-73	100,907	200,847	1,363	19,059	128,522	241,382	1,340	356
Jul-73	45,302	206,366	287	21,038	122,444	234,110	375	375
Aug-73	33,062	201,167	265	20,656	116,476	227,439	338	338
Sep-73	33,279	196,730	240	22,384	115,474	226,266	233	233
Oct-73	37,377	192,020	340	21,188	116,678	239,660	131	130
Nov-73	53,659	188,339	616	22,094	121,695	253,253	432	112
Dec-73	74,410	184,966	963	20,879	125,788	256,624	979	125
Jan-74	89,732	188,486	1,061	23,344	132,715	253,024	1,179	91
Feb-74	62,360	192,659	678	20,589	138,531	248,805	756	69
Mar-74	116,727	199,826	1,489	19,971	140,793	241,754	1,657	105
Apr-74	113,435	202,698	1,600	16,713	138,821	239,098	1,680	164
May-74	139,200	199,864	1,998	18,993	134,634	242,261	1,936	291
Jun-74	139,670	202,225	1,976	19,059	128,522	240,120	1,991	356
Jul-74	61,137	206,776	551	21,038	122,444	248,827	375	375
Aug-74	55,148	201,964	605	20,656	116,476	261,904	338	338
Sep-74	43,543	196,868	419	22,384	115,474	270,664	233	233
Oct-74	34,867	192,031	295	21,188	116,678	273,173	244	130
Nov-74	29,893	187,440	211	22,094	121,695	253,036	556	112
Dec-74	32,047	183,150	258	20,879	125,788	258,275	185	125
Jan-75	27,546	183,554	56	23,344	132,715	253,433	131	91
Feb-75	36,549	191,489	173	20,589	138,531	249,975	288	69
Mar-75	74,307	197,670	820	19,971	140,793	243,907	984	104
Apr-75	72,684	202,530	863	16,713	138,821	239,244	950	153
May-75	108,000	207,925	1,346	18,993	134,634	234,146	1,403	264
Jun-75	177,243	203,008	2,716	19,059	128,522	239,268	2,589	321
Jul-75	66,575	206,739	647	21,038	122,444	255,387	335	335
Aug-75	54,629	201,785	616	20,656	116,476	272,747	306	306
Sep-75	51,907	197,234	556	22,384	115,474	290,934	214	213
Oct-75	44,943	192,417	460	21,188	116,678	272,774	754	123
Nov-75	40,901	187,976	387	22,094	121,695	253,611	705	110
Dec-75	38,259	183,565	352	20,879	125,788	258,025	277	125
Jan-76	27,574	183,204	76	23,344	132,715	255,793	111	1
Feb-76	12,863	175,109	0	21,323	138,738	253,768	46	46
Mar-76	15,576	170,910	0	19,764	140,793	248,880	75	75
Apr-76	16,185	170,341	0	16,713	138,821	242,086	106	107
May-76	17,607	168,265	0	18,993	134,634	229,170	170	171
Jun-76	15,951	164,347	0	19,059	128,522	213,954	208	208
Jul-76	16,177	159,004	0	20,408	122,550	197,569	215	215
Aug-76	16,949	157,157	0	18,263	116,689	183,800	199	199
Sep-76	16,381	153,990	0	19,024	115,714	173,889	142	142
Oct-76	11,504	147,237	0	17,996	116,887	167,625	88	87
Nov-76	11,558	139,607	0	19,274	121,884	163,889	64	64
Dec-76	8,471	129,951	0	18,030	125,975	159,798	62	62
Jan-77	10,532	120,089	0	20,513	132,900	160,033	1	1
Feb-77	5,574	107,797	0	17,962	138,721	157,646	46	46
Mar-77	7,049	98,277	0	16,721	141,008	153,087	75	75
Apr-77	13,140	98,300	0	13,172	139,063	145,884	106	107
May-77	17,812	101,671	0	14,432	134,936	134,821	170	171
Jun-77	15,570	102,961	0	13,853	128,883	120,824	208	208
Jul-77	16,280	103,531	0	15,052	122,844	105,299	215	215
Aug-77	15,820	104,294	0	14,412	116,890	91,393	199	199
Sep-77	16,990	104,416	0	16,631	115,861	82,241	142	142
Oct-77	559	88,614	0	16,130	117,001	76,270	88	87
Nov-77	2,257	73,178	0	17,787	121,979	72,637	64	64
Dec-77	23,086	80,335	0	16,669	126,059	70,243	62	62

Table B.13. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR EOM Storage (ac-ft)	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-78	71,766	135,854	0	19,341	132,954	69,007	91	91
Feb-78	65,262	185,248	0	17,495	138,732	67,279	69	69
Mar-78	96,561	196,753	1,137	17,146	140,903	133,511	105	105
Apr-78	113,375	201,666	1,580	16,272	138,821	220,951	162	164
May-78	112,701	208,659	1,411	18,993	134,634	233,466	1,201	291
Jun-78	190,195	202,347	2,964	19,059	128,522	239,998	2,824	356
Jul-78	66,448	206,697	637	21,038	122,444	253,109	375	375
Aug-78	52,118	201,847	575	20,656	116,476	265,842	338	338
Sep-78	39,903	196,911	375	22,384	115,474	273,757	233	233
Oct-78	36,143	192,012	319	21,188	116,678	273,193	312	130
Nov-78	33,580	187,817	271	22,094	121,695	253,774	615	112
Dec-78	30,972	183,406	236	20,879	125,788	258,184	167	125
Jan-79	48,645	187,956	361	23,344	132,715	253,554	482	91
Feb-79	48,766	192,538	481	20,589	138,531	248,927	661	69
Mar-79	80,965	197,805	924	19,971	140,793	243,772	1,027	104
Apr-79	85,726	202,959	1,065	16,713	138,821	238,815	1,131	153
May-79	117,878	208,996	1,495	18,993	134,634	233,076	1,559	264
Jun-79	91,099	201,782	1,313	19,059	128,522	240,443	1,152	321
Jul-79	38,392	206,087	183	21,038	122,444	228,340	335	335
Aug-79	34,965	201,102	292	20,656	116,476	225,357	306	306
Sep-79	31,135	196,866	204	22,384	115,474	222,959	214	213
Oct-79	33,898	192,028	286	21,188	116,678	232,898	124	123
Nov-79	38,186	187,689	354	22,094	121,695	248,792	110	110
Dec-79	47,681	184,193	501	20,879	125,788	257,397	378	125
Jan-80	166,986	188,464	2,301	23,402	132,711	253,048	2,440	91
Feb-80	153,382	194,360	2,250	21,327	138,738	247,104	2,437	69
Mar-80	113,574	197,996	1,467	19,764	140,793	243,583	1,522	105
Apr-80	86,539	202,887	1,080	16,713	138,821	238,909	1,138	164
May-80	132,377	207,660	1,754	18,993	134,634	234,465	1,805	291
Jun-80	170,023	200,390	2,638	19,059	128,522	241,955	2,477	356
Jul-80	77,740	206,399	799	21,038	122,444	265,672	375	375
Aug-80	35,639	201,515	300	20,656	116,476	260,899	338	338
Sep-80	33,513	196,881	253	22,384	115,474	260,513	233	233
Oct-80	34,584	192,116	291	21,188	116,678	269,512	131	130
Nov-80	32,634	187,921	247	22,094	121,695	253,671	504	112
Dec-80	37,365	183,427	350	20,879	125,788	258,163	290	125
Jan-81	41,290	188,025	242	23,344	132,715	253,485	368	91
Feb-81	34,247	191,918	181	20,589	138,531	249,546	258	69
Mar-81	34,070	196,771	174	19,971	140,793	244,807	295	104
Apr-81	40,719	202,109	311	16,713	138,821	239,665	386	153
May-81	31,099	205,934	113	18,993	134,634	227,275	278	264
Jun-81	31,184	201,293	251	19,059	128,522	219,972	321	321
Jul-81	33,287	205,973	97	21,038	122,444	203,065	335	335
Aug-81	27,644	201,225	172	20,656	116,476	192,691	306	306
Sep-81	29,296	196,691	175	22,384	115,474	188,631	214	213
Oct-81	34,326	192,006	288	21,188	116,678	198,598	124	123
Nov-81	44,374	187,638	468	22,094	121,695	222,443	110	110
Dec-81	82,879	185,475	1,077	20,879	125,788	256,115	585	125
Jan-82	109,111	188,884	1,411	23,344	132,715	252,626	1,572	91
Feb-82	165,917	193,987	2,570	20,589	138,531	247,478	2,732	69
Mar-82	156,079	201,205	2,170	19,971	140,793	240,375	2,399	105
Apr-82	244,800	206,547	3,787	16,713	138,821	235,248	3,937	164
May-82	286,671	200,166	4,449	18,993	134,634	241,959	4,321	291
Jun-82	181,071	209,782	2,554	19,059	128,522	232,563	2,668	356
Jul-82	77,841	206,691	938	21,038	122,444	263,889	375	375
Aug-82	54,063	201,782	585	20,656	116,476	275,481	338	338
Sep-82	42,099	196,994	387	22,384	115,474	282,863	233	233
Oct-82	46,800	193,372	504	21,188	116,678	271,832	730	130
Nov-82	82,887	192,383	1,074	22,094	121,695	249,209	1,520	112
Dec-82	121,507	184,813	1,819	20,879	125,788	256,777	1,785	125
Jan-83	118,651	190,154	1,539	23,344	132,715	251,356	1,748	91
Feb-83	150,486	196,044	2,302	20,589	138,531	245,420	2,512	69
Mar-83	242,896	199,783	3,681	19,971	140,793	241,796	3,919	105
Apr-83	139,755	205,463	2,004	16,713	138,821	236,333	2,139	164
May-83	209,931	203,930	3,152	18,993	134,634	250,747	2,930	291
Jun-83	371,484	200,130	5,941	19,059	128,522	302,493	5,000	356
Jul-83	208,046	207,525	2,891	21,038	122,444	365,874	1,802	375
Aug-83	68,682	202,184	855	20,656	116,476	395,032	338	338
Sep-83	56,473	197,359	652	22,384	115,474	389,780	716	233
Oct-83	55,234	192,769	640	21,188	116,678	272,435	2,557	130
Nov-83	115,543	189,260	1,675	22,094	121,695	252,331	2,099	112
Dec-83	178,909	195,830	2,516	20,879	125,788	256,762	2,537	125

Table B.13. Continued.

Month -Year	PARDEE RESERVOIR				TERMINAL RESERVOIR EOM Storage (ac-ft)	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-84	113,970	188,898	1,601	23,344	132,715	252,612	1,684	91
Feb-84	87,729	193,135	1,098	21,323	138,738	248,329	1,201	69
Mar-84	95,881	197,934	1,166	19,764	140,793	243,645	1,244	105
Apr-84	79,517	202,413	967	16,713	138,821	239,363	1,013	164
May-84	144,496	200,505	2,049	18,993	134,634	241,620	1,972	291
Jun-84	108,496	201,459	1,458	19,059	128,522	240,886	1,424	356
Jul-84	87,318	206,462	486	21,038	122,444	245,411	375	375
Aug-84	48,488	201,570	517	20,656	116,476	254,671	338	338
Sep-84	34,128	197,012	276	22,384	115,474	266,423	233	233
Oct-84	38,251	192,341	354	21,188	116,678	270,191	131	130
Nov-84	45,687	188,190	486	22,094	121,695	253,401	809	112
Dec-84	42,543	183,479	440	20,879	125,788	258,110	382	125
Jan-85	23,893	184,046	5	23,344	132,715	253,427	91	91
Feb-85	34,816	191,537	124	20,589	138,531	249,927	190	69
Mar-85	50,703	197,173	416	19,971	140,793	244,404	523	104
Apr-85	61,363	201,794	653	16,713	138,821	239,680	689	183
May-85	31,662	206,046	119	18,993	134,634	227,762	286	264
Jun-85	29,371	201,236	228	19,059	128,522	220,001	321	321
Jul-85	30,129	206,075	42	21,038	122,444	199,821	336	336
Aug-85	33,352	201,324	260	20,656	116,476	195,068	306	306
Sep-85	33,110	195,717	256	22,384	115,474	195,973	214	213
Oct-85	36,307	192,124	259	21,188	116,678	200,620	124	123
Nov-85	38,910	187,698	362	22,094	121,695	216,685	110	110
Dec-85	39,003	183,223	370	20,879	125,788	232,293	125	125
Jan-86	52,326	188,630	395	23,344	132,715	252,495	91	91
Feb-86	265,908	194,223	4,446	20,589	138,531	336,876	3,133	69
Mar-86	191,940	199,127	2,839	19,971	140,793	242,453	4,548	105
Apr-86	124,522	204,465	1,706	16,713	138,821	237,301	1,769	164
May-86	193,408	205,934	2,800	18,993	134,634	236,191	2,795	291
Jun-86	132,139	209,882	1,819	19,059	128,522	232,463	1,852	356
Jul-86	44,509	206,296	413	21,038	122,444	232,374	375	375
Aug-86	37,261	201,431	322	20,656	116,476	228,835	338	338
Sep-86	36,167	196,953	295	22,384	115,474	231,954	233	233
Oct-86	37,053	192,102	323	21,188	116,678	242,248	131	130
Nov-86	36,861	187,925	301	22,094	121,695	251,917	112	112
Dec-86	32,485	183,441	259	20,879	125,788	258,149	158	125
Jan-87	24,992	182,785	41	23,344	132,715	257,751	57	1
Feb-87	17,276	180,434	0	20,589	138,531	256,807	46	46
Mar-87	24,720	186,350	0	19,971	140,793	254,228	75	75
Apr-87	21,582	190,250	0	16,713	138,821	245,835	106	107
May-87	16,794	186,877	0	18,993	134,634	233,216	170	171
Jun-87	21,126	187,208	0	19,059	128,522	218,109	208	208
Jul-87	32,160	196,179	0	21,038	122,444	202,054	215	215
Aug-87	31,194	201,038	59	20,656	116,476	190,777	199	199
Sep-87	27,594	195,566	159	22,384	115,474	189,914	142	142
Oct-87	14,180	186,333	31	20,976	116,720	185,634	88	87
Nov-87	12,910	177,708	0	21,338	121,759	181,663	64	64
Dec-87	17,540	175,472	0	19,885	125,854	178,217	62	62
Jan-88	21,322	175,065	0	22,481	132,756	179,521	1	1
Feb-88	13,946	168,503	0	20,726	138,788	177,048	46	46
Mar-88	16,312	166,009	0	18,828	140,864	172,199	75	75
Apr-88	18,311	169,078	0	15,384	138,916	165,971	106	107
May-88	22,562	173,929	0	16,729	134,802	163,507	170	171
Jun-88	26,581	183,146	0	15,839	128,771	138,631	208	208
Jul-88	27,802	192,490	0	16,913	122,718	123,876	215	215
Aug-88	23,141	197,449	0	16,348	116,763	109,774	199	199
Sep-88	20,067	196,475	23	18,380	115,746	101,211	142	142
Oct-88	13,357	188,975	42	17,617	116,911	97,686	88	87
Nov-88	12,494	182,767	0	18,946	121,904	94,279	64	64
Dec-88	12,908	178,137	0	17,761	125,990	90,817	62	62
Jan-89	12,825	170,726	0	20,246	132,917	85,211	91	91
Feb-89	14,162	167,150	0	17,764	138,733	81,420	69	69
Mar-89	60,434	196,658	238	16,749	140,682	80,350	104	104
Apr-89	80,364	201,611	1,006	14,174	138,901	139,508	151	153
May-89	105,640	206,659	1,306	18,635	134,634	201,394	264	264
Jun-89	69,707	206,571	814	19,059	128,522	227,468	321	321
Jul-89	34,217	206,056	187	21,038	122,444	215,133	335	335
Aug-89	30,912	200,459	232	20,656	116,476	208,355	306	306
Sep-89	32,705	196,475	225	22,384	115,474	208,074	214	213
Oct-89	23,129	192,061	96	21,188	116,678	205,955	124	123
Nov-89	35,929	187,702	300	22,094	121,695	216,902	110	110
Dec-89	34,592	183,231	289	20,879	125,788	226,313	125	125

Table B.13. Continued.

Month - Year	PARDEE RESERVOIR				TERMINAL RESERVOIR EOM Storage (ac-ft)	CAMANCHE RESERVOIR		
	Total Inflow (ac-ft)	EOM Storage (ac-ft)	Avg. Rel. to Camanche (cfs)	Aqueduct Withdrawal (ac-ft)		EOM Storage (ac-ft)	Avg. Release (cfs)	Minimum Flow Requirement (cfs)
Jan-90	32,602	187,399	92	23,344	132,718	233,329	1	1
Feb-90	22,205	186,959	0	20,589	138,531	232,260	46	46
Mar-90	32,549	195,170	119	19,971	140,793	234,661	75	75
Apr-90	23,373	200,028	22	18,713	138,821	228,573	106	107
May-90	32,220	206,334	93	18,993	134,634	222,423	170	171
Jun-90	33,646	202,280	284	19,059	128,522	224,288	208	208
Jul-90	32,029	205,989	92	21,038	122,444	214,295	215	215
Aug-90	28,558	201,399	177	20,666	116,478	210,512	199	199
Sep-90	27,957	196,823	159	22,384	115,474	209,907	142	142
Oct-90	31,509	191,989	235	21,188	116,678	217,666	68	87
Nov-90	6,527	177,381	15	22,094	121,695	214,253	64	64
Dec-90	11,492	188,008	0	20,879	125,788	210,480	62	62

LITERATURE CITED

EBMUD (East Bay Municipal Utility District) 1992. EBMUDSIM Model Description Assumptions and Verifications. Hearing before the State Water Resources Control Board, EBMUD Exhibit No. 34, November.

APPENDIX C. MODELING OF HYDRODYNAMICS AND WATER TEMPERATURES

APPENDIX C. MODELING OF HYDRODYNAMICS AND WATER TEMPERATURES

MODEL DESCRIPTION

The staff used CE-QUAL-W2, a numerical, two-dimensional, laterally-averaged hydrodynamic and water quality model. The CE-QUAL-W2 model simulates the vertical and longitudinal distribution of thermal energy and water quality constituents in a water body through time (COE 1992). The primary model selection criterion was the need to define both the two-dimensional water temperature structure of Camanche Reservoir and the impact of reservoir operations on this structure, particularly the temperature of the reservoir discharge. As used in this study, the model calculates in-pool water volumes, water surface elevations, longitudinal and vertical velocities, and temperatures. The CE-QUAL-W2 model is also capable of simulating the dynamics and concentrations of up to 21 chemical constituents. The model simulates hydrodynamics (including temperature) independently from water quality components. Temperature is included in the hydrodynamic calculations due to its effect on water density.

MODEL ASSUMPTIONS

The numerical model used in this study assumes that flow in the reservoir is two-dimensional with the longitudinal axis oriented along the Lower Mokelumne River channel and the other principal axis oriented vertically downward. The two-dimensional structure of the model implies that lateral variations in flow, temperatures, or constituents are either negligible or can be adequately represented by an average value (Figure C-1). The governing model equations are averaged within each cell defined by the longitudinal segments and the vertical layers and are written in the conservative form with the Boussinesq and hydrostatic assumptions. Eddy coefficients are used to model the influence of turbulence.

Figure C-1. A two-dimensional geometric representation of a reservoir. (Source: Baca and Arnett 1976.)

The numerical basis of the model is finite-differencing of the governing equations. Upwind differencing is used for the advective momentum and constituent transport processes. The finite differences are computed on a grid consisting of longitudinal segments and vertical layers. The finite difference grid imposes limitations on model accuracy by assuming the complex morphology of a reservoir can be adequately represented by a simplified structure. The grid also serves to simulate a continuum using a number of discrete cells. Staff used a fine grid to obtain a high degree of resolution.

In applying the numerical model to the actual reservoir system, several assumptions were necessary (Table C-1). During simulations of historical data used to calibrate the model, measurements of temperature and water levels at approximately weekly intervals were used. Small time steps were employed in the model to avoid large water balance and temperature errors in the model computations. These errors are particularly important when simulating hydrodynamics and temperature changes during periods of very low water levels.

DATA REQUIREMENTS

The CE-QUAL-W2 model requires a data base that includes initial conditions, reservoir geometry, physical coefficients, hydrologic time series, meteorologic time series, and inflowing water temperature. Because a suitable data base of in-pool chemical concentrations was not available, chemical constituents were not considered in the simulations.

Reservoir Bathymetry

The initial task in applying CE-QUAL-W2 to Camanche Reservoir was assembling the necessary data. These data include geometric discretization, initial and boundary conditions, hydraulic properties, and calibration and confirmation data. Data required for the computational grid include bathymetric cross sections, a topographic plan, section-elevation view, and an elevation-area-volume table. The finite difference grid was carefully constructed so that it accurately represented the morphology and capacity of Camanche Reservoir.

The computational grid consisted of a series of vertical segments and horizontal layers, with the total number of cells equal to the number of segments times the number of layers (Figure C-2). The basic parameters used to define the grid are the longitudinal spacing (X , equal to 1000 meters), and the vertical spacing or cell height (H , equal to 7 ft). Each cell has a width which represents an average value at that particular water level and longitudinal position within the reservoir. The cell height of 7 ft (2.13 m) was small enough to adequately model temperature changes with a manageable computation size.

The longitudinal spacing of the segments was then selected such that the ratio of the cell height to cell width (H/X) approximated the overall reservoir bottom slope of 0.0015 to 0.0021. The model grid consisted of 17 segments and 22 layers. Only layers 2 through 21 and segments 2 through 16 were used in the model computations as indicated in Figure C-2. Attention was given to changes in cell width, depth, tributary storage volumes, and other factors that may result in velocity disturbances. If the size of a disturbance is less than the finite difference grid's cell size, the effects of the disturbance will be averaged over the cell. The widths specified for the model cells represent average values. They were determined by transforming digitized bathymetry data using the U.S. Army Corps of Engineers' (COE) computer program GEDA to produce reservoir widths as a function of elevation at regular intervals from cross sectional data for transects at irregular intervals of ΔX . The segmentation of Camanche Reservoir used in this modeling effort is presented in Figure C-3.

Table C-1. Summary of major assumptions used in applying the numerical model to Camanche Reservoir. (Source: The staff.)

Model assumptions	Actual conditions	Comments
Lateral variations in flow, temperatures, or constituents are negligible or can be represented by an average value.	Three-dimensional variations exist and may be significant at certain times of the year.	Model assumptions consistent with available data.
Tributary streams are intermittent and do not contribute water to main water body.	Tributary contributions may be significant during periods of high rainfall and runoff.	Model assumptions consistent with topographic maps and available data.
Reservoir inflows from upstream are averaged over a period of one month.	Inflows and outflows fluctuate over daily and hourly time scales.	Accuracy of specified hydrologic conditions limited to available data.
Wind speeds and directions over the reservoir water surface can be described by monthly averages.	Winds highly variable and individual storm effects may be important.	Accuracy of specified meteorological conditions is limited by available data.
Evaporation rates are computed from available meteorological data.	Evaporation rates are highly variable and depend on many factors.	Model results agreed closely with measured evaporation rates.
Temperatures of discharges into Camanche Reservoir are not known but may be approximated with temperatures which average about 56.3°F (13.5°C) and have little variation.	Inflow temperatures may vary considerably over small time scales and will be modified by warming or cooling of water as it flows through the stretch of Mokelumne River between Pardee and Camanche Reservoirs.	No inflow temperatures available and values were approximated using available data.
Complex reservoir bathymetry can be represented by a simplified finite-difference grid.	Reservoir morphology is complex, with numerous changes in bathymetry.	Limited by numerical solution and computational methods employed in model.

The CE-QUAL-W2 model automatically expands or contracts the computational grid of active cells to accommodate rising and falling water surfaces, so the grid was made large enough to contain the largest anticipated volume (corresponding to a maximum pool elevation of 235.5 ft). The model grid consists of both currently active and potentially active cells. Velocities and temperatures were computed only for active cells, the number of which varied with changes in water surface elevation.

Meteorological Data

Daily air temperatures were estimated from maximum and minimum values reported for the U.S. Meteorological Station at Lodi, California. Temperature data for 1988 were available only for August; missing values for the remaining portions of 1988 were estimated from the 1989 data.

CE-QUAL-W2 Model Grid

Figure C-2. Finite-difference grid structure used for Camanche Reservoir temperature model. (Source: The staff.)

Figure C-3. Plan view of Camanche Reservoir showing locations of segments used in creating finite-difference grid cells. (Source: The staff.)

Local measurements of dew point temperatures, cloud cover, wind speed, and wind direction were not available. Monthly values for these data were estimated from the long-term averages for Sacramento reported in the Climatic Atlas of the United States (U.S. Department of Commerce 1968.)

Hydrologic and Water Quality Data

Daily values of discharge into Camanche Reservoir were not available. Monthly Camanche reservoir inflows were assumed to equal the monthly releases from Pardee Reservoir reported by East Bay Municipal Utility District (EBMUD) to the Federal Energy Regulatory Commission (EBMUD 1989). Daily inflow rates were computed such that the total monthly inflow equaled the monthly Pardee releases. Temperatures of the Pardee releases as they flowed into Camanche Reservoir were not available. They were approximated by monthly average temperatures ranging from 54.5°F (12.5°C) in the winter to 58.1°F (14.5°C) in the summer with an annual average of 56.1°F (13.4°C). This annual average inflow temperature is only 0.2°F (0.1°C) less than the 10-year average temperature in Pardee afterbay reported by EBMUD (EBMUD 1993). The Pardee afterbay temperature was described as showing "...little annual variation..".

Daily outflows [cubic feet per second (cfs)] from Camanche Reservoir were estimated from the United States Geological Survey (USGS) measurements recorded at the hydrologic gaging station on Mokelumne River below Camanche Dam (Hydrologic Station No. 11323500) for 1988 and 1989. Water temperatures within the reservoir were available from Hydrolab surveys taken at four locations in the reservoir, with station CAMD at the dam spillway used for model calibration because of its length of record and sounding depths.

MODEL CALIBRATION

Before applying the model to predictive simulations, a calibration procedure was used to check the ability of the model to match observed field conditions. The calibration phase consisted of the following two steps:

1. The water balance component of the model was calibrated by adjusting evaporation parameters until the computed storage volumes and water surface elevations closely approximated the observed pool elevations. Reservoir bathymetry, inflows and outflows were constrained by the initial and boundary conditions specified in the model data files.
2. The temperature component of the model was calibrated by adjusting the wind-sheltering coefficients, longitudinal dispersion, and vertical diffusion coefficients until the computed temperatures closely approximated the observed values. Inflow temperatures and meteorological parameters were constrained by the observed data specified in the model data files.

Calibration and verification data were obtained for two different years (1988 and 1989), each covering different hydrologic conditions. The year 1988 is classified as a dry year (inflows were less than 50% of the long-term average), with total flow into Pardee Reservoir of 235 thousand acre-feet (TAF) and 1989 is classified as a normal year with 480 TAF inflow. The long-term average inflow to Pardee Reservoir is 730 TAF (CDFG 1991).

Calibration is an iterative process whereby model coefficients were adjusted until an adequate fit of observed data to computed values is obtained (Figure C-4). The sequence involved the collection and interpretation of available data, estimation of model parameters, preliminary model runs, and

interpretation of the results. The water budget was checked first and then the hydrodynamics and temperatures were calibrated.

Calibration Parameters

The following coefficients were used in calibrating the hydrodynamics and temperature components of the Camanche reservoir model:

a. Horizontal eddy viscosity	$[A_x]$
b. Horizontal eddy diffusivity	$[D_x]$
c. Minimum vertical momentum dispersion coefficient	$[A_z]$
d. Minimum vertical temperature/constituents dispersion coefficient	$[D_z]$
e. Chezy coefficient	$[C_r]$
f. Wind sheltering coefficient	$[C_{ws}]$
g. Solar radiation absorbed in surface layer	$[\beta]$

The horizontal eddy viscosity and diffusivity coefficients, Chezy coefficient, and wind-sheltering coefficient directly affect the hydrodynamics which affect the transport of heat. The solar radiation absorption coefficient affects the temperature of the surface layer which also affects the hydrodynamics.

Treatment of mixing processes in mathematical models of surface water bodies is generally achieved through the specification of eddy viscosity and eddy diffusivity terms (Bowie et al. 1985). Horizontal eddy viscosity coefficient $[A_x]$ and eddy diffusivity $[D_x]$ values of $10.0 \text{ m}^2 \text{ s}^{-1}$ were specified in the model control file. Horizontal diffusion coefficient values depend on the scale of the phenomena being modeled

Figure C-4. Iterative procedure of model application. (Source: The staff.)

(Okubo and Osmidov 1970); these values were selected based on the scale of model cells. The horizontal eddy viscosity specifies the dispersion of momentum in the X-direction. The horizontal eddy diffusivity specifies the dispersion of heat and constituents in the X-direction. In this model, these parameters are space and time invariant. The vertical dispersion coefficients for momentum [A_v] and temperature/constituents [D_v] vary in space and time and are computed by the model but are constrained by minimum values included in the control file. Minimum values of $1.4 \times 10^{-7} \text{ cm}^2 \text{ s}^{-1}$ corresponding to empirical coefficient values reported for stratified lakes (Bowie et al. 1985) produced acceptable results.

The Chezy coefficient [C_b] is used in the calculation of boundary friction which varies spatially as a function of exposed bottom area and temporally as a function of the flow field. A value of 70 was used in the final calibration run and in the simulations.

Computed Water Surface Elevations

The water budget was checked by comparing the predicted reservoir elevations with the observed elevations. Errors in the water budget may be caused by 1) incorrect bathymetry; 2) evaporation; 3) storm events; and 4) seepage losses. Incorrect bathymetric errors were minimized by checking the volume-area-elevation table produced by the model and ensuring that it closely matched values reported by the USGS for Camanche Reservoir. Because evaporation is significant in the region of Camanche Reservoir, evaporation was computed by the model using the meteorological data. Computed values compared favorably with pan evaporation measurements reported by EBMUD. Storm events and seepage losses may be significant in some areas of the reservoir at various times and would contribute to errors in the water budget.

Once the simulated water surface elevations agreed closely with the observed pool elevations, the water balance component of the model was considered calibrated and verified (Figure C-5).

Surface Boundary Conditions

CE-QUAL-W2 uses equilibrium temperatures for calculation of surface heat exchange. The model uses latitude and longitude, air temperature, dew point temperature, and cloud cover to calculate equilibrium temperature and the coefficient of surface heat exchange. Distribution of solar radiation in the water column is controlled by the fraction of solar radiation absorbed in the surface layer and the attenuation rate. Wind speed and direction were specified in the meteorological input file because wind stresses were included in the internal flow computations. In addition, a wind-sheltering coefficient ranging from 0.0 to 1.0 was specified which, when multiplied by the wind speed, adjusts for the effects of local topography and other roughness elements on wind shear on the water surface.

Computed Water Temperatures

The total heat budget for a water body includes the effects of inflows, outflows, heat generated by chemical-biological reactions (not considered in this study), heat exchange with the stream bed, and atmospheric heat exchange at the water surface. The dominant processes controlling the heat budget are atmospheric heat exchange and absorption of solar radiation. Temperature was used as the parameter for calibration since measured velocity data were not available. Once the simulated water temperatures at the reservoir outlet agreed closely with the observed temperatures, the model was considered calibrated (Figure C-6).

(A) 1988

(B) 1989

Figure C-5. Comparison between simulated and observed water surface elevations at Camanche Dam: (A) 1988 and (B) 1989. Observed water surface elevations from Hydrolab survey, CAMD station. (Source: The staff.)

(A) 1988

(B) 1989

Figure C-6. Comparison between simulated and observed water temperatures at lower level outlet, Camanche Reservoir: (A) 1988 and (B) 1989. Observed data from Hydrolab survey, CAMD station. (Source: The staff.)

Because of the higher average reservoir pool elevations in 1989 (usually above 180 ft), the water temperatures at the spillway outlet were much lower than in 1988, when water elevations were below 160 ft during the warmest months of the year. The computed temperatures in late summer and early fall, of particular interest in this study, were approximately 1°F (0.5°C) lower than the measured temperatures in 1988 and 3.6°F (2°C) higher in 1989. The historical record for 1989 is incomplete and only a partial comparison can be made, but the simulated and historical trends agree well. The greatest deviation in the trend of the computed temperature from the measured temperature occurred in April of 1989 [Figure C-6(B)]. The releases from Pardee were abruptly increased from approximately 270 cfs to 1100 cfs at this time and remained high for three months. It is probable that the water flowing into Camanche during this period was colder than the assumed temperature since there would have been much less warming of the flow in the riverine section between the two reservoirs at these high flow rates. The temperature trends agree well after this anomaly and the computed temperature is approaching the measured temperature by early fall. Average computed water temperatures agreed well with the average of the measured values (Table C-2). Therefore, the calibrated model successfully simulates relative trends and magnitude of changes in water temperatures at the lower outlet at Camanche Dam. It is important to note that the simulated absolute temperature values may be in error by several degrees.

MODEL RESULTS

The calibrated model was then used to evaluate the temperature patterns and water levels under various management scenarios. The model results are discussed in this section and in Section 4.1. Management practices that can be simulated in this model may involve changes in discharge into or out of the reservoir, outlet location, and maintenance of specific pool elevations.

As described in Section 2.2, staff evaluated five alternative plans for minimum releases from Camanche Reservoir. These minimum releases range from the no action alternative to those proposed by California Department of Fish and Game (CDFG) and U.S. Fish and Wildlife (FWS). Two other release schedules evaluated are EBMUD's latest proposal and recommendations developed by staff. Each of these alternatives specifies a minimum release schedule for dry, normal and wet years. The EBMUD alternative

Table C-2. Summary statistics of computed and measured water temperatures at the lower outlet at Camanche Dam, 1988 and 1989. (Source: The staff.)

	1988		1989	
	Computed	Measured	Computed	Measured
Maximum temperature (°F)	73.8	73.2	61.0	58.5
Minimum temperature (°F)	42.3	48.6	43.0	43.7
Average temperature (°F)	56.1	61.2	54.9	52.0
Standard deviation	40.8	39.6	38.5	36.7

also includes a critically dry year. The reservoir simulations reported here were performed for dry and normal years and for a series of pool elevations held constant throughout the year. An additional staff alternative imposed a rule curve in which the reservoir pool elevation was held at 190 ft for the summer and early fall.

Meteorological data from the 1988 calibration was used for each reservoir simulation. The initial temperature conditions were estimated from the EBMUD Hydrolab vertical water temperature soundings taken in March 23, 1988 and the inflow temperatures were as described earlier in this appendix. The simulation period was from February 23 through December 26 with results reported on March 1 and every 10 days thereafter. Outflows were those proposed in the minimum release schedules and inflows were adjusted to maintain a constant pool elevation. Simulated pool elevations in all cases remained within 0.5 ft of the target elevation.

Staff used the CE-QUAL-W2 model of Pardee Reservoir to estimate the drawdown in Pardee which would result from adjusting Pardee releases to maintain Camanche minimum pool elevations. Pardee inflows for this scenario were those measured at Mokelumne Hill in 1988. The results are given in Table C-3.

Alternative Release Scenarios

The CDFG proposed a management scenario requiring a minimum Camanche pool elevation of 210 ft. The initial pool elevation was set at 210 ft and Pardee releases were adjusted to maintain that elevation. The initial temperature profile was estimated from the EBMUD hydrolab data on February 23, 1988. The simulated temperatures of Camanche Reservoir releases were reported in Section 4.

The EBMUD proposed minimum Camanche Reservoir releases are described in Section 2.2 for dry and normal years. Simulation of these proposed releases were performed as described above and the results reported in Section 4.

Minimum Camanche Reservoir releases under currently existing agreements are described in Section 2.2 for dry and normal years. The temperatures at the lower outlet from Camanche Dam at elevation 110 ft computed under this scenario for dry and normal water years were simulated and are reported in Section 4.

Table C-3. Simulated pool elevations in Pardee Reservoir for releases to maintain Camanche Reservoir constant pool elevations. (Source: The staff.)

Date	Camanche constant pool elevation		
	160 ft	180 ft	200 ft
Mar 1	551.6	551.6	551.6
Apr 30	536.2	536.2	535.9
Jun 29	523.5	522.5	521.0
Aug 28	509.5	506.9	503.7
Oct 27	495.1	491.3	485.7

Proposed minimum Camanche Reservoir releases developed by staff are described in Section 2.2 for dry and normal years. The temperatures at the lower outlet from Camanche Dam at elevation 110 ft computed under this scenario for dry and normal water years are reported in Section 4.

The hydrolab data from 1989 and the simulations of releases of flows of 500, 1000, and 1500 cfs described in Section 4.3.4 suggest that Camanche Reservoir release temperature requirements may be satisfied by maintaining a high pool elevation only during the summer and early fall with a lower pool elevation allowed from late fall until early spring. An additional set of simulations was performed to test this idea. The pool elevation was held at 170 ft from February 23 through April 10. It was then raised to 190 ft by June 29, maintained at 190 ft until September 27 and then allowed to be lowered by releasing no water from Pardee for the remainder of the year. The simulated water surface elevations and the temperatures at the lower outlet from Camanche Dam at elevation 110 ft for dry and normal water years are reported in Section 4.

CONCLUSIONS AND RECOMMENDATIONS

The modeling efforts indicated the proposed changes in reservoir operations would lower discharge temperatures from Camanche Reservoir, particularly during dry years. The calibration simulations closely matched the observed temperatures, but differences of 1.8–3.6°F (1–2°C) in maximum absolute temperature have been noted. Trends in temperature and variations due to changing inflow and outflow conditions have been accurately reproduced. For these reason the predictions of absolute temperature should be interpreted as approximate with probable errors of a few degrees. The changes in discharge temperature due to changes in reservoir operations are considered much more accurate and may be used with confidence.

Although DO and toxics such as heavy metals from Penn Mine were not modeled in this study, adoption of modified operational practices for Camanche Reservoir could affect the concentrations of these constituents in Camanche releases. Metals including aluminum, copper, iron, manganese, and zinc are present in the sediments of Camanche Reservoir (EVS 1989) and their concentrations in Camanche releases are dependent on their solubility and the availability of energy to suspend the sediments. Energy for resuspension can be furnished by flow in the old river channel due to Pardee releases or from fall overturning of the reservoir. Sudden increases in Pardee releases would tend to increase the concentration of suspended metals, while maintaining a deep pool would keep overturning energy to a minimum at the reservoir bottom. On the other hand, low DO levels in the hypolimnion, typical of a deep reservoir, may chemically reduce iron and manganese and increase their solubility. A detailed study of the expected concentrations of suspended material and the solubility of metals of interest under the suggested management practices would be required to quantify these effects. DO in Camanche releases would normally be higher under low pool conditions than when the pool is maintained at a higher level.

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APPENDIX D. WORST-CASE NEED FOR WATER

APPENDIX D. WORST-CASE NEED FOR WATER

East Bay Municipal Utility District (EBMUD) has defined its "need for additional water" as the amount of water required to assure that shortages in supply do not necessitate imposing drought restrictions resulting in more than a 25% reduction from normal demand. This definition is also subject to providing sufficient flows from Camanche Reservoir to meet all downstream Mokelumne River obligations including fish flows. Demands by Amador and Calaveras Counties in the upper Mokelumne River basin may also increase over time, thus reducing water available to EBMUD.

EBMUD has assumed that the greatest need for additional water will come at the end of their study period (year 2020) when water demands and other downstream obligations are greatest. Under conditions of normal runoff, Mokelumne River flows are adequate to meet current and prospective needs. In periods of extended drought, Mokelumne River flow and EBMUD's storage capacity are insufficient to prevent the imposition of a drought management program. EBMUD has used their worst drought of record (runoff from 1976–77 period) with an additional critically dry water year (1978) to estimate its need for additional water.¹ These two years (1976–77) along with the hypothetical third year defines EBMUD's drought planning sequence. By imposing normalized 1990 and 2020 customers demands, its drought management program when system storage falls below 500 thousand acre feet (TAF), and the potential demand growth by other upstream and downstream water agencies, EBMUD is able to estimate its need for additional water under current and future levels of river basin development.

For this study, a similar approach was taken to estimate the need for additional water. The water balance model as described in Appendix B was used to simulate the Pardee and Camanche Reservoir system for each of the proposed fish flow alternatives under the above defined drought sequence. Water releases from Pardee included current dry year entitlements for Amador and Calaveras Counties as well as three levels of EBMUD aqueduct withdrawals—normalized 1990 customer demands [220 million gallons per day (MGD) or 247 TAF], normalized 2020 customer demands (250 MGD or 280 TAF), and year 2020 reduced customer demands (229 MGD or 257 TAF). The water balance model also included EBMUD's standard water deficiency rule. The deficiency rule requires that a drought management program be invoked anytime total system storage falls below 500 TAF. The model reduces demand by 0–15% when system storage falls between 500 and 450 TAF, 15–25% when system storage is between 450 and 300 TAF, and by a full 25% when total system storage is below 300 TAF. For Camanche Dam, the required releases account for Woodbridge Irrigation District, senior appropriators, fish flows for each of the proposed alternatives, and flow-related carriage losses. Finally, it was assumed that the level of all required releases from Pardee and Camanche for meeting the demands of upstream and downstream water agencies would be based on current dry-year use and not on speculations about future water use. For example, model runs do not account for Amador and Calaveras Counties taking full advantage of their water entitlements beyond current dry-year use (about 10 TAF and 2 TAF, respectively).

Figure D-1 displays the need for additional water under differing demand forecasts for each of the fish flow alternatives. The need for additional water is the difference in the available supply (primarily in the third year of the drought sequence) and EBMUD customer demand after the imposition of the standard deficiency rule calling for up to a 25% reduction in water use. The need for additional water also includes any shortages in meeting minimum Camanche Dam releases. Based on EBMUD's 1990 normalized demand (220 MGD or 247 TAF) staff estimate water needs ranging from 0 TAF for the no

¹In 1976 and 1977 runoff from precipitation was approximately 240 TAF and 130 TAF, respectively. Flows into Pardee were also supplemented by Pacific Gas and Electric with upstream releases of 50 TAF in 1976 and 27 TAF in 1977. Year 1978 hypothetical runoff (185 TAF) was defined as an average of the 1976–77 precipitation runoff. Actual runoff in 1978 was above normal (860 TAF) and allowed EBMUD's water supply system to recover rapidly.

Figure D-1. Need for additional water under the three year drought sequence (1976-77 and 1978 at 185 TAF) for the no action and each proposed fish flow alternative. (Source: The staff.)

action and EBMUD alternatives to 123 TAF and 160 TAF for the California Department of Fish and Game (CDFG) and U.S. Fish and Wildlife Service (FWS) alternatives, respectively. Staff's alternative water need is about 36 TAF assuming a minimum pool at Camanche. There is virtually no need for additional water for staff alternative under 1990 conditions if the minimum pool requirement is not imposed.

Water needs under EBMUD's 2020 normalized demand conditions (250 MGD or 280 TAF) increase for staff, CDFG, and FWS alternatives. Model results do not show a water need for the no action and EBMUD alternatives, although total system storage is nearly depleted by the end of the third drought sequence year. The need for water increases to about 107 TAF for staff's alternative with a minimum pool requirement (27 TAF without the Camanche minimum pool), 197 TAF for the CDFG alternative, and 230 TAF for the FWS alternative. As noted above, this scenario is based on EBMUD's 2020 planning level of demand taking into consideration existing and planned conservation and reclamation programs. It is an increase of 30 MGD over 1990 planning levels. If EBMUD's proposed additional conservation and reclamation programs are implemented, 2020 demands are reduced by 21 TAF to 229 MGD (257 TAF) before the imposition of drought deficiency rules. This reduced demand lowers the need for additional water for staff alternative by 50 TAF to 52 TAF, at the end of the third drought sequence year (10 TAF without the Camanche pool requirement). Similar reductions (about 50 TAF) in water needs are estimated for the CDFG and FWS alternatives.

This need for additional water occurs primarily toward the end of the third drought year. On an annual basis the need for water from supplemental supplies or additional conservation and/or reclamation projects would be approximately 20 TAF for staff alternative (assuming a Camanche minimum pool), 50 TAF for the CDFG alternative, and 60 TAF for the FWS proposal.²

In a separate analysis using their own water balance model EBMUD has estimated their need for additional water (EDAW, Inc. 1992) under three alternatives—1990 no action, 2020 no action, and imposition of the 2020 Lower Mokelumne River Management Plan (LMRMP).³ The estimated need for additional water runs from zero under the 1990 no action case to 130 TAF for the 2020 LMRMP alternative. No action in 2020 requires the need for an additional 113 TAF. Comparison of EBMUD's calculated water needs with those in Figure D-1 shows considerable differences. For example, staff have estimated that there is no need for additional water for the EBMUD alternative whereas EBMUD calculates a need for 130 TAF in the third year of the drought sequence. To be sure, total system storage for staff alternative is nearly depleted by the end of the third year of the drought sequence. The difference between estimated water needs can be explained by dissimilarities between water balance models and assumptions about factor inputs. One modeling dissimilarity is the treatment of channel or carriage losses. EBMUD's model uses a fixed channel loss whereas the staff water balance model calculates a flow dependent carriage loss. There is a difference of about 8 TAF during the last two years of the drought sequence. However, the most significant dissimilarity lies in assumptions about future demand growth of upstream and downstream water agencies. Staff have chosen to base their estimates on current levels of development within the basin. EBMUD has estimated their water needs based on other water agencies taking considerably more of their entitlements. The magnitude of this difference is about 34 TAF per year. Overall, about 114 TAF of the discrepancy between staff's and EBMUD's estimated water need (before accounting for the effects of evaporation, carriage losses, and timing of early deficiency rules) can be explained by assumptions about the future development of the Lower Mokelumne River Basin.

²The 1976–77 drought period was the worst on record in terms of lower than normal runoff. There were two successive critically dry water years. The addition of the third critically dry water year to the drought sequence would be an extremely unlikely event. Planning for future water needs on this basis is conservative and could possibly overestimate EBMUD's need for additional water. Eliminating the third drought year from the drought sequence would eliminate EBMUD's need for additional water for the Staff alternative and greatly reduce the water needs for alternative proposed by the CDFG and FWS.

³In more recent analyses, they have estimated water deficits for variations of these alternatives and other alternatives such as a proposal by the CDFG (EBMUD 1993).

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APPENDIX E. COSTS OF DEMAND AND SUPPLY ALTERNATIVES

APPENDIX E. COSTS OF DEMAND AND SUPPLY ALTERNATIVES

East Bay Municipal Utility District (EBMUD) has proposed six composite programs as part of their updated Water Supply Management Program (WSMP) (EDAW, Inc. 1992a). Each of these composite programs are made up of various component demand and supply interventions. These composite programs are designed to meet a prospective water supply deficit of 130 thousand acre feet (TAF). This need for additional water is based on their three year drought sequence under year 2020 planned demand levels (250 MGD or 280 TAF). EBMUD has also prepared exhibits for the State Water Resources Control Board (State Board) hearings. These exhibits outline in more detail EBMUD's position on using the Delta for meeting part or all of their future water needs (EBMUD 1992). EBMUD documents as well as other testimony presented at the State Board hearings provide the basis for estimating the economic impacts of alternative fish flow requirements. The next section discusses EBMUD's composite programs and provides more specific overviews of the individual demand and supply projects. The basis for estimating the least cost option for alleviating prospective water deficits is discussed in the final section.

EBMUD Composite Programs

Of the six composite programs presented as part of the updated WSMP, one relies entirely on demand-side activities, one relies solely on the development and use of groundwater, and four programs use a combination of demand and supply component projects. In addition, each of the composite programs contain measures to secure Mokelumne aqueducts. The demand components of the composite programs reflect water savings above existing and adopted programs. These programs have two levels of water conservation and three levels of reclamation activities. The supply components of the composite programs contain four additional water sources. One of the four sources involves the use of groundwater (indirect and/or direct use). Surface water supply sources include the use of the Delta, the diversion of American River water through the South Folsom Canal, and the raising of Pardee reservoir to accommodate additional storage. These programs are briefly outlined below (specifics of these programs can be found in EDAW, Inc. 1993, Technical Appendices C through G):

- **Program I.** This program emphasizes demand-side management activities. The components of the program include conservation, two water reclamation projects, and a drought management program that accomplishes a 33% demand reduction. The conservation and reclamation projects result in savings of 60 million gallons per day (MGD) (year 2020 planned demand is reduced from 250 MGD to 190 MGD).
- **Program II.** This program includes demand side activities and the development of groundwater storage. The conservation and reclamation projects reduce 2020 demand by about 21 MGD. Groundwater supplies about 42 TAF to help alleviate the water deficiency during the drought sequence.
- **Program III.** This program contains the same conservation and water reclamation activities as the previous program. Additional supplies are developed from the Delta. The Delta supply source is sized to provide 45 TAF during the drought sequence.
- **Program IV.** This program contains the same conservation and water reclamation activities as the previous program. However, additional water supplies come from the same groundwater projects as described in Program II plus the delivery of water from the American River via the Folsom South Canal. The Folsom South Canal is sized to take out 225 cubic feet per second (cfs) (145 MGD) when available.
- **Program V.** This program contains the same conservation and water reclamation activities as Program II. Additional supplies are developed by raising Pardee's storage capacity by 150 TAF.

■ **Program VI.** This program relies entirely on the development of groundwater supplies. No conservation or reclamation projects are implemented above existing and already adopted programs. This program uses the same groundwater project as described in Program II plus the development of direct groundwater pumping to EBMUD aqueducts for an additional 21 TAF of supply.

Demand Side Component Activities

The demand side components of the composite programs reflect water savings above existing and adopted programs that are reflected in planned 2020 normalized demand of 250 MGD (280 TAF). The demand side programs have two alternative water conservation components and three reclamation activities. The specifics of the conservation components are as follows:

■ **Conservation Level IV.** Implementation of this conservation program would be expected to save 35 MGD over and above existing and adopted conservation and reclamation programs (Table E-1). The program would include extensive residential audits (35% coverage); interior appliance rebate programs; mandatory use of ultra-low flush toilets (100% coverage); use of low-flow showerheads and faucets (95% coverage); landscape rebates (\$500) for drip irrigation or use of drought tolerant plants; and voluntary turf reduction. The program would also include non-residential interior (95% coverage) and exterior audits (81% coverage) with savings of approximately 15%.

■ **Conservation Level II.** Total water savings under this option would amount to 13 MGD above existing and adopted conservation activities (Table E-1). The program would include: residential audits (8% coverage), interior appliance rebate programs, emphasis on ultra-low flush toilets, low-flow showerheads and faucets (90% coverage), and landscape rebates (\$100) for drip irrigation or use of drought tolerant plants (20% coverage). Non-residential interior (95% coverage) and exterior audits (35% coverage) audits would expect save about 19% of current uses.

■ **Reclamation A1.** This component would more than double the existing EBMUD reclamation program. It would provide for tertiary treatment and provide non-potable water to large irrigators within 5 miles of reclaimed water sources. Water savings of 8 MGD are anticipated (Table E-1).

■ **Reclamation A2.** This component would expand upon Reclamation A1 by serving more remote users. It would also provide dual distribution systems for areas east of the Oakland/Berkeley Hills. The component would save an additional 13 MGD above Reclamation A1 program (Table E-1).

■ **Reclamation A6.** This component would provide de-mineralized water to industry via a separate distribution system. Specific projects have been identified that could save 8 MGD (Table E-1).

It should be noted that Conservation Level II (13 MGD savings) and Reclamation A1 (8 MGD), which are common to five of the six composite programs, define the reduced demand scenario presented in the need for additional water analysis in Appendix D.

Supply Side Component Activities

■ **Groundwater Storage and Conjunctive Use.** EBMUD has proposed three sources of groundwater storage -- two indirect themes (agricultural exchange and river substitution) and one direct use theme.

Under the indirect agricultural exchange option, irrigators would pump banked groundwater in dry and critically dry water years instead of diverting water from the Mokelumne River. Equivalent agricultural releases would be held as storage in Pardee Reservoir. This storage would then be used for EBMUD

Table E-1. Alternative conservation measures proposed by East Bay
Municipal Utility District. (Source: EDAW, Inc. 1992c.)

Conservation measures	Level II (MGD)	Level IV (MGD)
Interior measures		
Interior audits		
Residential	0.13	0.56
Non-residential	3.21	4.81
Plan review (non-residential)	1.36	1.36
Ultra-low flush toilets		
New residential	1.36	1.36
Existing residential	8.86	15.18
Low-flow showerheads	1.43	1.51
Low-flow faucets	0.43	0.45
Dishwashers	0.35	0.35
Washing machines	2.18	4.36
Total interior savings	19.31	29.94
Exterior measures		
Exterior audits		
Residential	0.47	2.05
Non-residential	0.37	0.86
Major irrigators	2.40	2.40
Rebates		
Residential	2.03	5.06
Non-residential	0.38	0.95
Irrigation upgrades	0.25	0.53
Efficiency incentives	0.28	0.53
Landscape standards		
Residential	2.82	2.82
Non-residential	0.61	0.61
Water waster prohibitions		
Residential	0.58	0.58
Non-residential	0.11	0.11
Turf area reductions	--	4.99
Normal replacement		
Residential	2.92	2.92
Non-residential	0.53	0.53
Total exterior savings	13.75	24.94
Total interior and exterior	33.10	54.90
Existing and adopted programs	19.84	19.84
Total net savings	13.26	35.06

customers and/or to meet downstream obligations. EBMUD has estimated the maximum dry year yield from this source at 30 TAF (i.e., limited to dry-year agricultural entitlements and instream flow requirements).

Under the river substitution option groundwater would substitute for part of the Camanche releases required under EBMUD's Mokelumne River management plan. These flows would be used to maintain instream flows in dry and critically dry water years. Water yield from this option is a function of water temperature extremes, and flows required for outmigration, spawning, and imprinting. Dry and critically dry year water yield is estimated by EBMUD at 22 and 13 TAF per year, respectively.

The direct groundwater use option would involve pumping banked water directly into the Mokelumne aqueducts. Yield under this option would be limited to the amount banked and by withdrawals of other groundwater users. EBMUD has estimated the annual yield of this option at 21 TAF.

■ **American River via Folsom South Canal.** This supply option would use EBMUD's existing fixed cost contract with the Bureau of Reclamation to divert up to 134 MGD (150 TAF) annually from the American River through South Folsom Canal to Mokelumne aqueducts. This option would consist of two pumping plants between the current terminus of the Folsom South Canal and the Mokelumne aqueducts. In addition, about 16 miles of new pipeline would need to be constructed. Since American River water is of high quality existing treatment and filtration facilities could be used. Use of this option would be subject to meeting certain flow requirements throughout the American River as a condition of delivery.

■ **Raise Pardee Reservoir Storage.** This supply option would increase Pardee Reservoir storage capacity from 210 TAF to 360 TAF. It would increase the high water level by 57 ft, inundate an additional 2.4 miles of the Mokelumne River, and increase reservoir surface area by 892 acres. The project would use existing facilities and water could be fed into Mokelumne aqueducts by gravity. The project would increase operating flexibility considerably.

■ **Delta Supply.** Water from the Delta is affected by municipal and industrial discharges, urban runoff, agricultural drainage, saltwater intrusion, and is lower in overall quality than that of Pardee Reservoir. The use of the Delta by EBMUD on a permanent basis for meeting part or all of its future water needs would require modifications of existing treatment plants or construction of a separate Delta treatment facility. EBMUD has stated a clear preference for treating Delta water before it enters their distribution system.

Of particular concern to EBMUD are levels of trihalomethanes (THMs).¹ According to Newkirk (1992), THM levels are on average about five times higher in Delta water than in water from Pardee Reservoir. The concern over THMs lies in the potential for increased incidence of cancer and the possibility that drinking water standards will be made more stringent for THMs. Currently, the United States Environmental Protection Agency is in the process of assessing and possibly revising their maximum concentration limit for THMs, which is currently set at 100 µg/L (Water Newsletter 1993). In addition,

¹EBMUD has also prepared exhibits for the State Board hearings that outline in much more detail their position on the use of the Delta (Newkirk 1992). In this testimony, EBMUD states that the high quality of the Pardee Reservoir source permits them to use direct filtration except for some additional processes that are required to handle special runoff problems at terminal reservoirs. These additional treatment processes include granular activated carbon, ozonation, and chloramines to minimize THM formation. EBMUD goes on to state that their upgraded treatment facilities are capacity limited and their system as a whole is not designed to use a Delta water source. EBMUD contends that use of the Delta would require full treatment before it is introduced into the distribution system.

EBMUD believes that the use of the Delta could possibly lower the overall aesthetic quality (e.g., taste and odors, turbidity, and dissolved solids) of their delivered water.

As described by EBMUD in their updated Water Supply Management Plan, the Delta supply component would consist of constructing withdrawal and treatment facilities (EDAW, Inc. 1992a; Newkirk 1992). Water would be pumped from the Delta, treated conventionally, desalinated using reverse osmosis, and pumped into their aqueducts. Facilities could be sized at any scale up to their maximum Mokelumne entitlement (325 MGD). The current capacity of EBMUD's Bixler pump station is 52 MGD (58 TAF) per year.

Of all the water supply options facing EBMUD the use of the Delta is the most contentious. On behalf of the Central Delta Water Agency (CDWA), testimony was presented at the State Board hearings regarding EBMUD's unwillingness to seriously consider using Delta water in their system. From this testimony, Greenberg concludes that Delta water can be treated to the same quality (primary and secondary standards) as that of Pardee. Further, he states that there would be insignificant differences in the risk to public health (CDWA 1992b). Greenberg basis his conclusions partly on the fact that there are numerous water suppliers who take their water from the Delta and meet all appropriate water quality standards. Often these users of the Delta do better than EBMUD in treating water for certain criteria pollutants. For example, in the case of the city of Pittsburg (Contra Costa Water District), average THM levels of 20 µg/L (range of 10 to 40 µg/L) were reported for 1991. By contrast, EBMUD reported higher THM levels of 44 µg/L (range of 24 to 56 µg/L) using their Pardee source. The conclusion drawn is that there exists treatment technology that can be used to deliver Delta water that is of very high quality. Greenberg also notes that EBMUD has the capability of using a Delta source and their current Pardee source conjunctively. That is, Delta water could be blended with Pardee water. The blend could be increased or decreased (not exceeding some specified ratio, such as a maximum of 20% or 25% Delta) depending on storage in Pardee and raw water quality in the Delta.

Testimony on behalf of the CDWA was also presented countering EBMUD's need for building an advanced treatment (reverse osmosis and activated carbon) plant. Baumann (CDWA 1992a) states that a relatively simple direct filtration plant could be used to treat Delta water and meet all applicable current and foreseeable drinking water standards. Baumann also concludes that EBMUD's cost estimates for treating water are greatly exaggerated especially when compared to costs currently being experienced by other users of the Delta.

Finally, the feasibility of upgrading existing EBMUD treatment facilities has also surfaced regarding the future use of the Delta. At a recent WSMP workshop, EBMUD presented information on upgrading existing treatment facilities to handle Delta water. This information provides contaminant and cancer risk data as well as cost estimates for various Delta water use options. One such option is the addition of pre- and post-chloramination to existing treatment plants. This upgrade option would allow EBMUD to mix Delta water (Indian Slough and Bixler Pumping Station) with Pardee water in a 1 to 4 blend and still meet all water quality standards (EBMUD 1991). To be sure, concentrations of certain criteria pollutants would increase, but they still would be below all current applicable standards.

Least Cost Options for Alleviating Water Deficits

EBMUD has estimated preliminary costs for each of the composite programs (EDAW, Inc. 1992d.) Capital, annual fixed operating, and variable operating costs are displayed in Table E-2. The fixed annual operating costs associated with the conservation programs include the costs of interior and exterior audits, toilet replacement and other water saving devices, irrigation upgrade incentives, public information and other related implementation type costs. For the two levels of conservation corresponding to annual water

Table E-2. Estimated water yield and costs of composite program components.

(Source: EDAW, Inc. 1992d; Newkirk, 1992)

Composite program component	Annual yield (TAF)	Capital cost (\$10 ⁶)	Fixed annual costs (\$10 ⁶ /yr)	Variable annual costs (\$10 ⁶ /yr)
Demand side components				
Conservation IV	39.2	0	16.5	0.0
Conservation II	14.8	0	3.9	0.0
Reclamation A1	7.8	74	2.1	0.0
Reclamation A2	20.3	273	4.3	0.0
Reclamation A6	9.0	83	6.6	0.0
Supply side components				
Indirect groundwater	50.6	47	0.9	1.7
Indirect and direct groundwater	71.3	78	1.4	3.9
South Folsom Canal	162.9	97	4.5	8.8
Raise Pardee	150.0	204	0.1	0.0
Delta alternatives ^a				
A1	67.2	97.0	0.0	25.0
A2	150.3	224.6	0.0	35.3
A3	364.6	382.0	0.0	130.0
B1	80.8	460.7	0.0	45.4
B2	179.5	829.6	0.0	97.6
B3	437.6	1454.8	0.0	230.1

^aThe cost data reported in Newkirk (1992) were projected to year 2000 based on a 3%/yr escalation rate. The costs reported above have been deflated to current year dollars at 3%/yr.

savings of 14.8 TAF and 39.2 TAF annual costs are estimated at \$3.9 to \$16.5 million, respectively. The other demand side programs are the water reclamation projects. These projects are relatively capital intensive as they require the construction of pipelines, tertiary treatment plants and pumping facilities for supplying non-potable water to large municipal irrigators and industry. The annual water yields from the three reclamation projects range from 7.8 TAF to over 20 TAF.

Table E-2 also shows EBMUD's estimates for the supply side components of their composite programs (EDAW, Inc. 1992d). The indirect groundwater components (switch surface water users to groundwater in dry years and put groundwater into the Mokelumne to supplement flow requirements) are estimated to cost about \$47 million and have annual operating costs of about \$2.5 million. Pumping groundwater directly into the Mokelumne aqueducts adds \$30 million to the capital cost and increases annual water yield by another 20 TAF.

Accessing EBMUD's entitlements to American River water through the construction of the South Folsom Canal is estimated to cost \$97 million with annual operating costs of over \$13 million if the full entitlement is taken. EBMUD estimates that the raising of Pardee Dam will cost about \$150 million to construct. However, once built this alternative will have essentially no associated operating costs.

In a report presented at the State Board hearings, EBMUD provides updated cost estimates for treating Delta water (Newkirk 1992). This report outlines two alternative levels of treatment configured at three capacities ranging from the approximate size of the Bixler Pump Station (60 MGD) to EBMUD's full Mokelumne entitlement (325 MGD). The facility types correspond to treatment to meet existing regulations and treatment to meet possible future regulations. EBMUD's estimated costs for these treatment plants are shown in Table E-2. The data show that the costs of advanced treatment (meeting possible future standards) plants (B1-B3) are about 4 times higher than treating to meet existing regulations (plants A1-A3). The primary difference in the advanced treatment processes and treating to existing standards is the inclusion of biologically activated carbon and desalination (reverse osmosis) processes.

Table E-3 shows the total levelized annual costs and unit (discounted average annual) water costs for each of the demand and supply side component projects, which are part of EBMUD's six composite programs. On the demand-side, levelized annual costs range from \$3.9 to \$16.5 for Level II and IV conservation, respectively. The reclamation projects have much higher levelized costs. Because the demand projects are likely to be operated at or near their maximum yield and offer aqueduct security benefits, unit water costs are a good basis for comparison among these alternatives. Unit water costs are lowest for the Conservation Level II project at \$264/ac-ft. EBMUD's maximum conservation project (Level IV) is about \$160/ac-ft higher, but reduces demand by an additional 24 TAF annually. In contrast, each of the proposed reclamation projects have unit water costs that easily exceed \$1000/ac-ft.

The low cost supply alternative on the basis of levelized annual cost is Groundwater AB (agricultural exchange and river substitution) at \$6.8 million. This option is followed by Groundwater ABC (addition of direct pumping to Mokelumne aqueducts) at \$12.2 million. If these groundwater projects are operated at their maximum yield, unit water costs would be about \$134/ac-ft and \$172/ac-ft, respectively. EBMUD's data tends to suggest that the raising of Pardee would have lower levelized annual costs than that of extending the South Folsom Canal. Raising Pardee would cost about \$18.2 annually and if fully

exploited would have unit water costs of only \$121/ac-ft. The South Folsom Canal would cost nearly \$22 million in amortized capital and operating expenses and provide water at \$135/ac-ft, if the full entitlement was taken.

As shown in Table E-3, the Delta alternatives (conventional and advanced treatment) greatly exceed all other options. For the conventional plants levelized costs range from \$34 to \$164 million annually depending the capacity of the plant. Annual levelized costs are much higher for the plants that employ advanced treatment technology, ranging from \$86.4 to \$360.2 million. Unit water costs are about double those for conventional treatment. As noted earlier, Baumann contends that EBMUD's estimates of Delta treatment facilities are inflated.²

²Similar exaggeration of Delta treatment costs can be found in a technical report by the State Board (State Board 1988). The lowest cost alternative, which was evaluated by Sacramento County, was to remove water from the Delta via Bixler pumps. Sacramento County estimated the cost of a Delta treatment plant at \$48 million (including conveyance) with unit water costs of \$77/ac-ft. In the same report, EBMUD's capital cost estimate is placed \$391 million with unit water costs of \$330/ac-ft. These estimates differ by a factor of four.

Table E-3. Levelized annual costs of demand and supply component projects.^a (Source: The staff.)

Component project	Levelized annual cost ^b (\$10 ⁶ /yr)	Maximum yield (TAF/yr)	Unit water cost (\$/ac-ft)
Demand side components			
Conservation II	3.90	14.8	264
Conservation IV	16.50	39.2	421
Reclamation A1	8.67	7.8	1112
Reclamation A2	28.55	20.3	1406
Reclamation A6	13.97	9.0	1553
Supply side components			
Groundwater AB	6.77	50.6	134
Groundwater ABC	12.23	71.3	172
Folsom South Canal	21.92	162.9	135
Raise Pardee	18.22	150.0	121
Delta alternatives			
A1	33.66	67.3	500.0
A2	55.24	150.3	367.4
A3	163.94	364.6	449.6
B1	86.37	80.8	1069.2
B2	171.34	179.5	954.5
B3	360.22	437.6	823.2

^aThese estimates are based on costs and annual yields from Table E-2.
^bCapital costs from Table E-2 were amortized at 8% for 25 years.

This contention is based partly on a comparison with the costs of a Los Angeles Aqueduct plant. This plant, which has a capacity of 600 MGD, was constructed at a cost of \$114 million (1986 dollars). The unit water costs of the Los Angeles plant are estimated to be about ten times less than what EBMUD is projecting for their 325 MGD direct filtration plant. Closer examination of EBMUD's Delta treatment plant cost data show that they are based on order of magnitude estimates without detailed engineering data. The estimates are claimed to be accurate within -30% to +50%. In addition, EBMUD cost estimates include a contingency of 25% plus another 32% added to cover engineering, legal, administration, and other services during construction. Baumann contends that these contingencies are fairly liberal considering that estimated costs may be as much as 50% high.

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APPENDIX F. MODELING PHYSICAL HABITAT FOR SALMON AND TROUT

APPENDIX F. MODELING PHYSICAL HABITAT FOR SALMON AND TROUT

The basis for modeling physical habitat availability for chinook salmon and steelhead trout in the Lower Mokelumne River in the Final Environmental Impact Statement (FEIS) was an instream flow study conducted for the California Department of Fish and Game (CDFG) by Envirosphere Company in 1986 and 1987 (CDFG 1988, 1991). This study used the Instream Flow Incremental Methodology (IFIM) and its Physical Habitat Simulation (PHABSIM) model developed by the U.S. Fish and Wildlife Service (Bovee 1982). In addition to PHABSIM modeling, the CDFG instream flow study included stream temperature modeling, riparian habitat evaluations, and other fisheries studies.

Staff obtained the original PHABSIM data from CDFG and evaluated the model application. We concluded that the study was well designed and well executed, and that it provided a good basis for evaluating the minimum flow regimes considered in the FEIS. Therefore, the recommendations in our DEIS and in the CDFG and the East Bay Municipal Utility District (EBMUD) fisheries plans used the same original IFIM data. There are, however, important differences in how these data were applied to impact assessment, as explained in this appendix.

Thermal considerations were included in the model by combining output from a stream temperature model (SNTMP) with the PHABSIM analysis. This analysis produced measures of stream area that met both thermal criteria and physical habitat requirements and measures of stream longitudinal distance which met thermal criteria alone when other physical requirements were of less importance.

Study Reaches

Four representative reaches in the Lower Mokelumne between Camanche Dam and Lake Lodi were modeled in the CDFG instream flow study: 1) Bruella Road at Mokelumne River Mile (MRM) 48.9; 2) MRM 62.3 called the "Pasture" site; 3) near Van Assen County Park at MRM 63.0 called the "Spillway" site; and 4) just below the fish diversion rake and the Camanche powerhouse discharge at MRM 62.3. The first site at Bruella Road is representative of the Rearing segment of the lower river which has a relatively lower gradient and little spawning utilization by salmon or trout. The other three sites are all representative of the Tailwater segment of the river where there is a higher gradient, larger substrate types, and the majority of spawning occurs. Staff grouped these upper three study reaches together to represent the Tailwater segment.

Habitat Suitability Indices

The habitat suitability indices used in the CDFG study were taken from a number of sources. The spawning curves for chinook salmon (Figure F-1A) were developed exclusively from site-specific observations of depth, velocity, and substrate at 98 redds in the Lower Mokelumne River (CDFG 1988). Chinook salmon spawning occurred only in gravel and cobble substrates (Table F-1). Suitability data for chinook fry (Figure F-1B) came from generic curves published by Raleigh (1986), but site-specific observations of fry habitat use were used to verify the Raleigh curves. Habitat suitability data for chinook juveniles (Figure F-1C) came from two sources: 1) a study of depth and velocity utilization by Beak (1987); and 2) data from Bovee (1978) for substrate utilization. The selected habitat suitability indices curves were approved by CDFG during the course of their instream flow study (CDFG 1991).

Because of the low numbers of steelhead trout in the Mokelumne River, no site-specific habitat suitability indices curves could be developed. The habitat suitability indices curves used for steelhead (Figure F-2) all came from previously published data by Bovee (1978). The substrate codes used in all habitat suitability indices sets are shown in Table F-1.

Figure F-1. Habitat suitability indices for chinook salmon in the Lower Mokelumne River: (A) spawning, (B) fry, and (C) juveniles (see Table F-1 for definition of substrate codes). (Source: CDFG 1988, 1991.)

Figure F-2. Habitat suitability indices for steelhead trout in the Lower Mokolune River:

(A) spawning, (B) fry, and (C) juveniles (see text for definition of substrate codes). (Source: CDFG 1988, 1991.)

Table F-1. Substrate codes used in habitat modeling. (Source: CDFG 1988, 1991.)

Substrate code	Substrate type
1	Organic debris
2	Mud/soft clay
3	Silt (< 0.002 inch)
4	Sand (0.002-0.25 inch)
5	Gravel (0.25-3.0 inches)
6	Cobble (3.0-9.0 inches)
7	Large cobble/boulder (>9.0 inches)
8	Bedrock

Habitat Response Curves

The relationship between habitat condition and streamflow was quantified with a standard IFIM application, including four separate hydraulic data sets at streamflows 61 and 862 cubic feet per second (cfs) (CDFG 1988, 1991). The IFG4 hydraulic simulation model was used in the CDFG study with at least one calibration data set at the highest and lowest flows observed at each study reach. This approach allows for a good estimate of habitat conditions over flows between 100 and 1000 cfs in the lower river.

To represent the Tailwater and Rearing segments of the lower river, we converted the normal Weighted Usable Area (WUA) indices produced by PHABSIM into total usable area values by multiplying WUA by the length of each reach and converting to acres. WUA values are in units of square feet per 1000 ft of stream, and the total usable area values used by staff in the FEIS are in units of acres. In the Tailwater segment, the three representative reach habitat response functions were aggregated as a weighted average based on the length of each study reach. The fish screen (FS) site composed roughly 33% of the area, the spillway site (S) 17%, and the pasture site (P) the remaining 50%. By using these weights, a combined weighted average WUA for the Tailwater segment was calculated in this formula :

$$.33(WUA(FS)) + .17(WUA(S)) + .50(WUA(P)) = WUA(COMB)$$

No such aggregation was needed to represent the Rearing segment because there was only one IFIM study site in that segment. The overall lengths of the two river segments were 14 miles for the Rearing segment (MRM 43 to 59) and 4.5 miles for the Tailwater segment (MRM 59 to 63.5). The habitat response curves for chinook and steelhead life stages that are used in the FEIS are shown in Tables F-2 and F-3 and Figure F-3.

Minimum Flow Determination

Staff's minimum flow requirements were determined through an iterative process of examining: 1) the shape of physical habitat response curves (total habitat available versus flow) for chinook salmon, 2) the requirements of conveyance releases from Camanche Dam to satisfy downstream water users and channel losses, and 3) the life-stage-specific water temperature requirements of chinook salmon. According to the

Table F-2. Habitat response curves (total usable area in acres versus streamflow in cfs) for chinook salmon in the Lower Mokelumne River.
(Source: Staff analysis of data from CDFG 1988, 1991.)

Flow (cfs)	Total usable habitat for chinook salmon (acres)				
	<i>Tailwater segment</i>			<i>Rearing segment</i>	
	Spawning	Fry	Juveniles	Fry	Juveniles
100	4.2	15.1	15.2	24.0	4.5
200	6.2	11.6	13.0	15.3	4.4
300	7.2	8.5	12.3	10.6	3.8
400	7.1	6.4	10.0	8.1	3.4
500	7.0	4.5	7.3	6.6	3.1
600	6.6	3.8	5.9	5.6	3.1
700	6.2	3.4	5.0	6.5	3.8
800	5.5	3.1	4.2	6.8	3.6
900	4.8	2.9	3.7	6.5	3.5
1000	4.1	2.8	3.2	6.2	3.4

instream flow studies conducted on the river, maximum spawning habitat for chinook salmon occurs around 300 cfs and decreases at higher flows (Table F-2). Maximum habitat conditions for fry and juveniles occurs around 100 cfs and decreases monotonically at higher flows. In months in which spawning, incubation, and rearing overlap (February-May), we subjectively selected 200 cfs as our target flow, assuming that the best habitat conditions in the river are those that do not excessively favor one life stage over another.

Minimum flow requirements were adjusted iteratively in a computerized spreadsheet format equivalent to Table B-5. In this format, minimum fish flows could be changed and conveyance releases were automatically adjusted until target flows were reached.

For all water years except Dry years (total unimpaired inflow to Pardee less than 350 TAF or end-of-September reservoir storage less than 300 TAF), we selected minimum flows that would maximize spawning habitat during the October-January period. There are little or no conveyance releases during this period. Increased flows during the beginning of the spawning period, in October, are for the benefit of upstream passage as well as for alleviation of water temperature stresses that can occur in early fall. In the transition period in the salmon life cycle after January, when eggs are incubating and fry are emerging from the gravel, we allow minimum flows to drop gradually and be supplemented by conveyance flows which pick up in March and April for irrigation withdrawals. During this transition period (February-April), salmon are limited in distribution to the river segments between Lake Lodi and Camanche Dam and they therefore benefit from all dam releases. Water temperatures are not limiting during the spring months, so flows are allowed to decrease gradually toward optimal rearing conditions until the outmigrant

Table F-3. Habitat response curves (total usable area in acres versus streamflow in cfs) for steelhead trout in the Lower Mokelumne River.
(Source: Staff analysis of data from CDFG 1988, 1991.)

Flow (cfs)	Total usable habitat for steelhead trout (acres)				
	<i>Tailwater segment</i>			<i>Rearing segment</i>	
	Spawning	Fry	Juveniles	Fry	Juveniles
100	2.7	9.7	14.9	1.2	13.2
200	4.0	6.4	13.1	0.6	11.1
300	3.8	5.9	13.3	0.4	8.4
400	3.8	4.8	11.0	0.3	6.0
500	4.4	3.1	8.9	0.2	4.2
600	4.0	2.1	7.0	0.2	2.6
700	3.6	1.4	5.3	0.1	1.4
800	3.1	0.9	4.2	0.1	1.2
900	2.4	0.6	3.3	0.1	1.3
1000	1.9	0.5	2.7	0.1	1.2

period is reached in May and June. After June when all chinook are assumed to have left the Lower Mokelumne system, minimum flows were set at the levels at or above those recommended by CDFG and EBMUD. The June-September period is assumed to be non-limiting to chinook for the purposes of this proceeding.

In Dry water years, target flows for spawning were reduced somewhat to 200 cfs and the increased flows for outmigration were eliminated. Based on staff's definition of dry years, these conditions are expected to occur less than once every five years. In these cases, trapping and trucking operations would be required.

Assessment Procedure

Weekly and monthly habitat values were calculated from the habitat response curves by using either observed or predicted streamflows at the United States Geological Survey gage below Camanche Dam. For the description of existing conditions (Section 3), observed daily flows were averaged to produce weekly average flows, and the habitat values associated with these streamflow values were then calculated by interpolation from the habitat response curves. For the assessment of impacts from alternative minimum flow regimes (Section 4), monthly average flows predicted from the water balance modeling (Appendix B) were used as the independent variable.

Figure F-3. Habitat response curves (Weighted Usable Area versus stream flow) for chinook salmon at four instream flow study reaches below Camanche Dam. (Source: CDFG 1991.)

Temperature Modeling

An instream water temperature model (SNTEMP) developed by the U.S. Fish and Wildlife Service (FWS) (Theurer et al. 1984) was used to perform several analyses on the effects of Camanche Dam discharge flows and temperatures on instream temperatures in the Lower Mokelumne River. Staff used various combinations of meteorological and hydrological data (both historical and hypothetical) to perform two types of analyses.

- 1) Analysis of thermal habitat availability for life stages whose primary habitat requirement is temperature (as opposed to other variables such as water velocity, substrate, and depth). Various combinations of potential Camanche release temperatures and flows were used for this analysis.
- 2) Analysis of habitat availability for life stages whose critical habitat requirements include temperature as well as other physical variables such as water velocity, substrate, and depth. This analysis included a combination of the PHABSIM (WUA) analysis and SNTEMP results.

Mean daily temperatures output once every two-week period from the SNTEMP model were used in the analyses of temperature acceptability. The results of these analyses were used in conjunction with other analyses to develop minimum flow and reservoir elevation criteria and to evaluate various management alternatives.

The input parameters used in the SNTEMP model to describe the stream geometry, hydrology, and meteorology were the same as those used by CDFG (CDFG 1991). The model does not account for stratification that occurs in Lake Lodi when flashboards are in place at Woodbridge Dam (approximately April through mid-October). A comparison of observed temperatures to predicted temperatures below Lake Lodi for six years shows an average underestimate of actual temperatures below Woodbridge Dam of about 1.8°F (1.0°C) during the months that Lake Lodi is present (Figures F-4 and F-5). Despite this overestimation, staff believes that this model alone without any calibration or accompanying reservoir model is sufficient for the intended analyses. The magnitude of the overestimation is relatively small, and staff doesn't feel that additional models or calibration would decrease the uncertainty of the predictions without adding other sources of modeling uncertainty. In addition, the only stages of the salmon life cycle that occur below Woodbridge Dam are outmigrating smolts (May through June) and inmigrating adult spawners (October through December). Both of these life stages require careful temperature analysis, and staff considered the shortcomings of the SNTEMP model as they developed their recommendations.

Temperature as the Primary Habitat Requirement

For some life stages of both chinook salmon and steelhead trout, the limiting habitat variable is temperature; other variables such as those typically used in the WUA analysis are less important. These life stages include: 1) the out-migration of chinook smolts; 2) the in-migration of adult chinook spawners; and 3) the over-summering of stocked steelhead trout (both juveniles and adults).

Out-migration of chinook smolts. Once smolts move below Woodbridge Dam and begin their out-migration from the Mokelumne River, the primary physical habitat variable of concern is temperature. Temperatures of 53.6–71.6°F (12–22°C) should be suitable to support chinook smolts during this time. These out-migrations appear to begin around the middle of May and may last until the end of June. Once the out-migration is begun, the time required to leave the flowing waters of the Mokelumne River and enter the tidal-influenced waters of the Delta is relatively short, on the order of a few days to a few

Figure F-4. Observed water temperatures (solid line) at the Woodbridge gage, predicted temperatures from SNTemp model (squares), and the difference between the two (predicted minus observed; dashed line) for six years of calibration data. (Source: The staff.)

Figure F-5. Observed versus predicted water temperatures at Woodbridge Dam gage for six years of calibration data. (Source: The staff.)

weeks. During this time, water released from Camanche Dam warms significantly from solar heating as it passes down river. In addition, temperature rise is greater at lower flows. Simulations were run from May through June for the reach from below Woodbridge Dam (MRM 38.7) to the confluence of the Cosumnes River (MRM 23.0, near the extent of the tidal influence). These simulations were performed with various combinations of flow and temperature at the Camanche Dam release. Flows at Camanche (194–630 cfs) were selected based on the resulting flow at Woodbridge Dam (20–300 cfs) so that a wide range of potential flows could be analyzed. The Camanche release temperatures that were included in the simulation were 50, 53.6, 57.2, and 60.8°F (10, 12, 14, and 16°C). Estimated temperatures were output at regular intervals within the reach so that the percentage of the reach that was within the acceptable temperature range 53.6–71.6°F (12–22°C) could be calculated for each flow/temperature combination. This value, which is a measure of the thermally acceptable habitat, ranges from 0–100. The results indicate that any of the flow/temperature combinations tested would provide adequate downstream temperatures in May (Table F-4). During June, flows greater than 527 cfs at Camanche (200 cfs at Woodbridge) are sufficient for all release temperatures.

In-migration of adult chinook spawners. Historically, adult chinook move through Woodbridge Dam during their upstream spawning migrations from October to December, with a majority of such activity occurring from October 16 to November 30 (CDFG 1991). Acceptable temperature (< 64.4°F; 18°C) in the lower reaches of Mokelumne River (i.e., below Woodbridge) is one criteria necessary to attract spawners from the delta into the river. Thermal considerations are particularly important during the early part of this time period when warming is more pronounced. Simulations were run from October through

Table F-4. Percentage of the Mokelumne River below Woodbridge Dam (MRM 23.0–38.7) that is within temperature criteria (i.e., thermally available habitat) for juvenile chinook salmon outmigration (53.6–71.6°F; 12–22°C) at different flows and temperatures of Camanche Dam releases, based on SNTMP model simulations averaged for each time period. Flows at Woodbridge that correspond to Camanche Dam outflows are shown in parentheses. Percentages above 90 (an acceptable range) are shaded. (Source: The staff.)

Time period	Camanche flow in cfs (Woodbridge flow)	Camanche release temperature (°F/°C)			
		50/10	53.6/12	57.2/14	60.8/16
May	194 (20)	100	100	100	100
	316 (50)	100	100	100	100
	367 (100)	100	100	100	100
	470 (200)	100	100	100	100
	573 (300)	100	100	100	100
June	232 (20)	21	21	14	14
	372 (50)	57	43	43	43
	424 (100)	86	86	86	71
	527 (200)	100	100	100	100
	630 (300)	100	100	100	100

November for the reach from below Woodbridge Dam (MRM 38.7) to the confluence of the Cosumnes River (MRM 23.0). These simulations were performed with various combinations of flow and temperature at the Camanche Dam release. Flows at Camanche (53–463 cfs) were selected based on the resulting flow at Woodbridge Dam (20–300 cfs) during each time period so that a wide range of potential flows could be analyzed. The Camanche release temperatures that were included in the simulation were 50, 53.6, 57.2, and 64.4°F (10, 12, 14, and 18°C). The proportion of the reach that was within the acceptable temperature range (50–64.4°F; 10–18°C) was calculated as above. The results indicate that during the first half of October, flows > 460 cfs at Camanche at release temperatures of 50–57.2°F (10–14°C) are sufficient to maintain < 64.4°F (18°C) in the lower river (Table F-5). Flows below 400 cfs or at > 57.2°F (14°C), result in unacceptably high temperatures in some or all of the reach downstream of Woodbridge Dam. During late October and November, any of the flow/temperature combinations tested would provide acceptable downstream temperatures.

Over-summering steelhead. Because staff feels that a viable self-sufficient steelhead trout population is not likely to become re-established in the Mokelumne River regardless of the modifications made to the river and the reservoir operations, we concentrated on ensuring that adequate habitat for stocked steelhead/rainbow is available during critical times. This primarily means providing acceptable temperature (53.6–68°F; 12–20°C) for the stocked fish to survive throughout the summer between Camanche Dam and Lake Lodi. Simulations were run for this reach (MRM 43.0–63.7) from July through September; adequate temperature for other months should be provided by the flows and temperatures proposed to meet chinook requirements. These simulations were performed with various combinations of Camanche

Table F-5. Percentage of the Mokelumne River below Woodbridge Dam (MRM 23.0–38.7) that is within temperature criteria (a.k.a. thermally available habitat) for the spawning migration of adult chinook salmon (50–64.4°F; 10–18°C) at different flows and temperatures of Camanche Dam releases, based on SNTMP model simulations averaged for each time period. Flows at Woodbridge that correspond to Camanche Dam outflows are shown in parentheses. Percentages above 90 (an acceptable range) are shaded. (Source: The staff.)

Time period	Camanche flow in cfs (Woodbridge flow)	Camanche release temperature (°F/°C)				
		50/10	53.6/12	57.2/14	60.8/16	64.4/18
October 1	126 (20)	0	0	0	0	0
	199 (50)	14	14	0	0	0
	257 (100)	43	29	14	14	0
	360 (200)	86	86	71	43	29
	463 (300)	100	100	100	86	43
October 16	106 (20)	100	100	100	100	100
	169 (50)	100	100	100	100	100
	228 (100)	100	100	100	100	100
	334 (200)	100	100	100	100	100
	436 (300)	100	100	100	100	100
November	53 (20)	100	100	100	100	100
	110 (50)	100	100	100	100	100
	170 (100)	100	100	100	100	100
	283 (200)	100	100	100	100	100
	386 (300)	100	100	100	100	100

release flows (100, 200, 300, 400, 600, 1000 cfs) and temperatures 53.6, 57.2, and 60.8°F (12, 14, and 16°C). The proportion of the reach that was within the acceptable temperature range (53.6–68°F; 12–20°C) was calculated as above. The results indicate that during July, flows greater than 300, 400, and 600 cfs at temperatures of no greater than 53.6, 57.2, and 60.8°F (12, 14, and 16°C), respectively, will maintain acceptable temperatures throughout the reach (Table F-6). During August, flows greater than 300 at 53.6–57.2°F (12–14°C) or flows greater than 400 cfs no more than 60.8°F (16°C), will maintain acceptable temperatures throughout the reach. During September, flows greater than 200, 300, and 400 cfs at temperatures not greater than 53.6, 57.2, and 60.8°F (12, 14, and 16°C), respectively, will maintain acceptable temperatures throughout the reach.

Table F-6. Percentage of the Mokelumne River between Camanche Dam and Lake Lodi (MRM 43.0–63.7) that is within temperature criteria for steelhead (53.6–68°F; 12–20°C) in summer at different flows and temperatures of Camanche Dam releases, based on SNTEMP model simulations averaged for each month. Flows at Woodbridge that correspond to Camanche Dam outflows are shown in parentheses (i = insufficient for any flow at Woodbridge). Percentages above 90 (an acceptable range) are shaded. (Source: The staff.)

Month	Camanche flow in cfs (Woodbridge flow)	Camanche release temperature (°F/°C)		
		53.6/12	57.2/14	60.8/16
July	100 (i)	42	33	29
	200 (i)	71	58	46
	300 (i)	92	83	71
	400 (63)	100	96	79
	600 (257)	100	100	100
	1000 (645)	100	100	100
August	100 (i)	38	38	29
	200 (i)	75	62	46
	300 (i)	100	92	67
	400 (91)	100	100	92
	600 (285)	100	100	100
	1000 (673)	100	100	100
September	100 (i)	62	54	46
	200 (i)	92	83	75
	300 (80)	100	100	88
	400 (177)	100	100	100
	600 (371)	100	100	100
	1000 (760)	100	100	100

Temperature as an Additional Habitat Requirement

In order to more fully evaluate the availability of acceptable habitat for chinook salmon in the Mokelumne River, the results of the WUA analysis were combined with output from the stream temperature model (SNTEMP), to produce a measure of habitat which meets both physical (depth, current, etc.) and thermal criteria. This method, which is a relatively simple and effective way to include temperature in the habitat analysis, was performed in the following steps.

- 1) WUA (acres) was calculated for spawning, fry, and juvenile life stages at various flows in two study reaches (MRM 43 to 59 and MRM 59 to 63.5) as described earlier in this appendix.
- 2) Stream temperatures were predicted with the SNTMP model for various combinations of flow (100, 200, 300, 400, 600, and 1000 cfs) and Camanche release temperature (42.8, 46.4, 50, 53.6, 57.2, and 60.8°F; 6, 8, 10, 12, 14, and 16°C) for each two-mile segment within the two stream reaches used for the WUA analysis. This analysis was performed for each two-week period to account for normal variation of meteorological conditions.
- 3) For each of the WUA reaches for each life stage, the proportion of the reach which met acceptable thermal criteria was calculated based on the following temperature criteria.

Spawning/incubation:	7.8-11.6°C (46.0-53.0°F)
Fry rearing:	11.0-17.0°C (51.8-62.6°F)
Juvenile rearing:	12.0-20.0°C (53.6-68.0°F)

- 4) The modified tWUA was calculated as a product of the original WUA (step 1) and the proportion of stream reach which met the temperature criteria (step 3) (Bovee 1982).

$$tWUA = WUA_i \times P_i$$

where WUA_i = weighted usable area (acres) for stream reach i , and
 P_i = proportion of stream reach i having acceptable temperature.

This method uses the temperature criteria in a binary fashion. That is, if the temperature criteria are met within a segment then the total WUA calculated for that segment is considered usable and tWUA equals WUA. However, if the thermal criteria are not met then tWUA is zero. A continuous function relating temperature to habitat suitability might be more appropriate for some types of habitat suitability analyses. However, in this case, the step function which was used is the appropriate way to convert the WUA acreage into an equivalent measure that includes temperature considerations. Calculations of HA were made for each month for each of the critical chinook life stages (spawning/incubation, November through March; fry rearing, mid-February through March; juvenile rearing, April through June). The results of the total habitat analysis for spawning/incubation, fry rearing, and juvenile rearing were expressed as acres of usable habitat within the total reach from Camanche Dam to just above Lake Lodi and are summarized below.

Spawning/incubation. In general, the amount of usable habitat for chinook spawning and incubation is maximized when flows in the spawning reach are from 250–600 cfs and temperatures are between 46.4–53.6°F (8–12°C) (Table F-7).

Fry rearing. In general, fry rearing habitat is maximized when flows in the reach are less than 150 cfs and temperatures are 53.6–60.8°F (12–16°C) (Table F-8).

Juvenile rearing. In general, juvenile rearing habitat is maximized when flows in the reach are less than 100 cfs and temperatures are 53.6–60.8°F (12–16°C) although flows up to 300 cfs produce similar results (Table F-9).

Table F-7. Temperature-modified Weighted Usable Area (tWUA) (acres) for chinook spawning and egg incubation in the Lower Mokelumne River (MRM 59-63.5) calculated as the product of the WUA at each Camanche release flow and the proportion of the stream reach which met acceptable temperature criteria of 46–52.9°F (7.8–11.6°C) based on the SNTMP model.

Corresponding Woodbridge flows are included in parentheses. Values above 90% of the maximum WUA (i.e., 7.2 acres) are shaded. (Source: The staff.)

	Camanche flow (cfs)	WUA (ac)	42.8/6	46.4/8	50/10	53.6/12	57.2/14	60.8/16
Nov	100 (42)	4.2	1.1	4.2	4.2	2.6	0.0	0.0
	200 (125)	6.2	0.0	6.2	6.2	3.9	0.0	0.0
	300 (217)	7.2	0.0	7.2	7.2	4.5	0.0	0.0
	400 (314)	7.1	0.0	7.1	7.1	4.4	0.0	0.0
	600 (508)	6.6	0.0	6.6	6.6	4.1	0.0	0.0
	1000 (896)	4.1	0.0	4.1	4.1	2.6	0.0	0.0
Dec	100 (45)	4.2	0.0	3.2	4.2	4.2	0.5	0.0
	200 (129)	6.2	0.0	6.2	6.2	6.2	0.0	0.0
	300 (220)	7.2	0.0	7.2	7.2	7.2	0.0	0.0
	400 (317)	7.1	0.0	7.1	7.1	7.1	0.0	0.0
	600 (511)	6.6	0.0	6.6	6.6	6.6	0.0	0.0
	1000 (900)	4.1	0.0	4.1	4.1	4.1	0.0	0.0
Jan	100 (48)	4.2	0.0	3.2	4.2	4.2	0.5	0.0
	200 (132)	6.2	0.0	5.4	6.2	6.2	0.0	0.0
	300 (223)	7.2	0.0	7.2	7.2	7.2	0.0	0.0
	400 (320)	7.1	0.0	7.1	7.1	7.1	0.0	0.0
	600 (514)	6.6	0.0	6.6	6.6	6.6	0.0	0.0
	1000 (902)	4.1	0.0	4.1	4.1	4.1	0.0	0.0
Feb	100 (48)	4.2	1.1	4.2	4.2	4.2	0.0	0.0
	200 (132)	6.2	0.0	6.2	6.2	6.2	0.0	0.0
	300 (223)	7.2	0.0	7.2	7.2	7.2	0.0	0.0
	400 (320)	7.1	0.0	7.1	7.1	7.1	0.0	0.0
	600 (514)	6.6	0.0	6.6	6.6	6.6	0.0	0.0
	1000 (902)	4.1	0.0	4.1	4.1	4.1	0.0	0.0
Mar	100 (27)	4.2	2.1	4.2	3.7	1.1	0.0	0.0
	200 (111)	6.2	0.8	6.2	6.2	1.6	0.0	0.0
	300 (202)	7.2	0.0	7.2	7.2	1.8	0.0	0.0
	400 (299)	7.1	0.0	7.1	7.1	1.8	0.0	0.0
	600 (493)	6.6	0.0	6.6	6.6	1.7	0.0	0.0
	1000 (882)	4.1	0.0	4.1	4.1	1.0	0.0	0.0

Table F-8. Total usable habitat (HA) values (acres) for chinook fry rearing in the Lower Mokelumne River (MRM 43-63.5) calculated as the product of the Weighted Usable Area (WUA) at each Camanche release flow and the proportion of the stream reach which met acceptable temperature criteria of 51.8–62.6°F (11.0–17.0°C) based on the SNTMP model. Corresponding Woodbridge flows are included in parentheses. Values above 90% of the maximum WUA (i.e., 39.1 acres) are shaded. (Source: The staff.)

	Camanche flow (cfs)	WUA (ac)	42.8/6	46.4/8	50/10	53.6/12	57.2/1	60.8/16
Feb	100 (48)	39.1	0.0	8.0	18.7	39.1	39.1	39.1
	200 (132)	26.9	0.0	0.0	3.4	26.9	26.9	26.9
	300 (223)	19.1	0.0	0.0	0.0	19.1	19.1	19.1
	400 (320)	14.5	0.0	0.0	0.0	14.5	14.5	14.5
	600 (514)	9.4	0.0	0.0	0.0	9.4	9.4	9.4
	1000 (902)	9.0	0.0	0.0	0.0	9.0	9.0	9.0
Mar	100 (27)	39.1	16.0	20.0	29.7	39.1	39.1	39.1
	200 (111)	26.9	3.4	6.8	15.1	26.9	26.9	26.9
	300 (202)	19.1	0.0	2.4	7.1	19.1	19.1	19.1
	400 (299)	14.5	0.0	0.5	5.0	14.5	14.5	14.5
	600 (493)	9.4	0.0	0.0	1.9	9.4	9.4	9.4
	1000 (882)	9.0	0.0	0.0	0.7	9.0	9.0	9.0

Comparison of Total Available Habitat Under Different Management Alternatives

Staff used the results of the foregoing analyses of thermal acceptability of the Lower Mokelumne River to produce total available habitat scores for the purpose of comparing the various management alternatives. This analysis was performed for several of the management alternatives being considered (four from staff, i.e., constant Camanche elevations of 170, 180, 190, and 210 ft and one each from CDFG, FWS, EBMUD, and no-action). The sequence of this analysis follows, and an example of the results is shown in Table F-10.

- 1) An average Camanche release temperature was estimated from the CE-QUAL-W2 reservoir modeling for each month for both dry and normal water years for the alternative being considered.
- 2) Each temperature from above was paired with a corresponding proposed flow for that month. In some cases months were subdivided into smaller periods.
- 3) The most critical life stages for each month were identified as follows:

January	spawning/incubation
February	spawning/incubation, fry rearing
March	fry rearing, spawning/incubation

Table F-9. Total usable habitat (HA) values (acres) for chinook juvenile rearing in the Lower Mokelumne River (MRM 43-63.5) calculated as the product of the Weighted Usable Area (WUA) at each Camanche release flow and the proportion of the stream reach which met acceptable temperature criteria of 53.6–68°F (12–20°C) based on the SNTMP model. Corresponding Woodbridge flows are included in parentheses (i = insufficient for any flow below Woodbridge). Values above 90% of the maximum WUA (i.e., 19.7 acres) are shaded. (Source: The staff.)

	Camanche flow (cfs)	WUA (ac)	42.8/6	46.4/8	50/10	53.6/12	57.2/14	60.8/16
Apr	100 (i)	19.7	3.8	5.4	10.2	19.7	19.7	19.7
	200 (41)	17.4	2.2	3.2	3.9	17.4	17.4	17.4
	300 (132)	16.1	0.2	1.7	2.7	16.1	16.1	16.1
	400 (230)	13.4	0.0	0.4	2.1	13.4	13.4	13.4
	600 (424)	9.0	0.0	0.0	1.0	9.0	9.0	9.0
	1000 (812)	6.6	0.0	0.0	0.0	6.6	6.6	6.6
May	100 (i)	19.7	7.8	11.1	14.7	18.0	17.5	17.0
	200 (i)	17.4	3.4	3.9	9.3	17.4	17.4	17.4
	300 (35)	16.1	2.1	3.0	6.9	16.1	16.1	16.1
	400 (132)	13.4	1.3	2.0	3.0	13.4	13.4	13.4
	600 (326)	9.0	0.0	0.9	2.2	9.0	9.0	9.0
	1000 (714)	6.6	0.0	0.0	0.6	6.6	6.6	6.6
June	100 (i)	19.7	7.5	9.1	12.7	16.2	16.0	13.6
	200 (i)	17.4	3.9	7.4	10.2	15.9	15.2	14.5
	300 (i)	16.1	2.7	3.4	6.9	16.1	15.7	14.8
	400 (77)	13.4	1.9	2.6	5.9	13.4	13.4	13.0
	600 (271)	9.0	0.5	1.6	2.6	9.0	9.0	9.0
	1000 (659)	6.6	0.0	0.0	1.3	6.6	6.6	6.6

April	juvenile rearing
May	juvenile rearing, smolt migration
June	juvenile rearing, smolt migration
July	stocked steelhead
August	stocked steelhead
September	stocked steelhead
October	adult migration
November	adult migration, spawning/incubation
December	spawning/incubation

Table F-10. An example of an analysis of life-stage habitat scores (LHS) using staff's proposal for a normal water year with a minimum Camanche pool elevation of 190 feet. (Source: The staff.)

Period	Camanche flow (cfs)	Woodbridge flow (cfs)	Camanche temperature (°C)	TAH ¹	tWUA ²	Normalized score	LHS
Adult migration							84
Oct 1	308	150	15.0	36	--	36	
Oct 16	436	300	15.0	100	--	100	
Nov	304	220	13.6	100	--	100	
Spawning/incubation							72
Nov	304	220	13.6	--	0.0	0	
Dec	300	220	10.8	--	7.2	100	
Jan	297	220	9.5	--	7.2	100	
Feb	186	120	9.9	--	6.2	86	
Mar	163	80	10.1	--	5.2	72	
Fry rearing							33
Feb	186	120	9.9	--	3.4	9	
Mar	163	80	10.1	--	22.4	57	
Juvenile rearing							52
Apr 1	185	50	10.6	--	10.7	54	
Apr 16	236	50	10.6	--	10.0	51	
May	470	200	11.7	--	11.2	57	
June	630	300	12.7	--	9.0	46	
Smolt migration							100
May	470	200	11.7	100	--	100	
June	630	300	12.7	100	--	100	
Stocked steelhead							93
July	387	50	13.2	98	--	98	
Aug	358	50	14.2	96	--	96	
Sept	269	50	14.8	86	--	86	

¹Thermally Available Habitat score derived from Tables F-4 (smolt migration), F-5 (adult migration), and F-6 (stocked steelhead).

²Temperature-modified Weighted Usable Area derived from Tables F-7 (spawning/incubation), F-8 (fry rearing), and F-9 (juvenile rearing).

- 4a) For each life stage that depends primarily on adequate temperature (i.e., adult migration, smolt migration, and steelhead overwintering), a total available habitat value was determined from Tables F-4, F-5, and F-6 based on the corresponding monthly Camanche release temperature (step 1) and flow (step 2). For example, the staff's normal water year/190-ft pool elevation proposal would produce a Camanche release flow in June of 630 cfs and a temperature of 54.9°F (12.7°C). For smolt migration the total available habitat (i.e., acceptable proportion of stream reach) for the reach below Woodbridge is 100 (Table F-4).
- 4b) Likewise, for each life stage that is dependent on both adequate temperature and other physical habitat qualities (i.e., spawning/ incubation, fry rearing, and juvenile rearing) a temperature-modified WUA value was determined from Tables F-7, F-8, and F-9 based on the corresponding monthly Camanche release temperature (step 1) and flow (step 2). For the June example from above, the tWUA for juvenile rearing was approximated as 9.0 acres (Table F-9).
- 5a) For the purpose of summarizing results within a life stage or within a month, it is desirable to have all the scores on the same relative scale (0–100). Total available habitat values required no modifications to achieve this.
- 5b) Temperature-modified WUA values were normalized to 100 by dividing by the maximum WUA (sum of tailwater and rearing segments if applicable) achieved with optimal flow for each life stage. These values were 7.2, 39.1, and 19.7 acres for spawning/incubation, fry rearing, and juvenile rearing, respectively (Table F-2). For the June example in Step 4b, the normalized score is 46 $[(9+19.7) \times 100]$.
- 6) For comparing the alternatives by life stages, the total available habitat and the normalized tWUA values were averaged across months to provide a life-stage habitat score (LHS) for each life stage for each water year type. The results of this analysis for four minimum pool elevations considered as possible staff alternatives are summarized in Table F-11. The analysis of the primary management alternatives presented by CDFG, FWS, EBMUD, staff, and no-action are summarized in Table F-12. The LHS generally represents the temporal and spatial availability of acceptable habitat as compared to the maximum amount of habitat available over the duration of that life stage. Interpretation of these results should be made with caution as the biological meaning of the LHS score may not be obvious. For example, a LHS of 50 could mean that 50% of the potentially usable habitat is available 100% of the time or that 100% of the potentially usable habitat is available 50% of the time or something in between.
- 7) These scores were then combined across water year types into a long-term (e.g., 25-year) average by multiplying each score times the percent occurrence of the corresponding water year based on each proposal's water year type definition (Table F-13 from Table B-1) and then summing these three (or four) products for each life stage. For example the combined LHS for adult migration for staff's (190-ft pool elevation) alternative was calculated as follows:

$$(75 \times 0.2) + (84 \times 0.3) + (98 \times 0.5) = 89$$

As with most indices, an accurate interpretation of the LHS scores requires more than just the final value. There is information produced at each step of the process that contributes to a knowledgeable interpretation of the scores. On the other hand, the scores by themselves can be used for a general comparison of the various proposed alternatives, as long as one considers that small differences between alternatives may be biologically meaningless. The combined LHS for the various alternatives evaluated are presented in Tables F-11 and F-12 and summarized below.

Table F-11. Average monthly habitat scores by year type and for year types combined for each life stage for staff's minimum pool elevations of 170, 180, 190, 210 ft. (Source: The staff.)

	Pool elevation (ft)			
	170	180	190	210
Dry year				
Adult migration	75	75	75	75
Spawning/incubation	59	59	70	72
Fry rearing	52	52	52	52
Juvenile rearing	80	64	64	58
Smolt migration	61	61	61	61
Stocked steelhead	39	61	66	80
Normal				
Adult migration	79	79	84	88
Spawning/incubation	66	71	72	77
Fry rearing	40	33	33	33
Juvenile rearing	63	52	52	28
Smolt migration	100	100	100	100
Stocked steelhead	70	71	93	99
Wet year				
Adult migration	86	86	98	100
Spawning/incubation	70	77	77	83
Fry rearing	27	19	19	19
Juvenile rearing	57	46	46	18
Smolt migration	100	100	100	100
Stocked steelhead	87	92	99	100
Combined life-stage habitat score ¹				
Adult migration	81	81	89	91
Spawning/incubation	67	72	74	79
Fry rearing	36	30	30	30
Juvenile rearing	64	51	51	29
Smolt migration	92	92	92	92
Stocked steelhead	72	79	90	96

¹ Uses percent occurrence of various water-year types shown in Table F-13.

Table F-12. Average monthly habitat scores by year type and for year types combined for each life stage for proposed alternatives of staff, California Department of Fish and Game (CDFG), U.S. Fish and Wildlife Service (FWS), East Bay Municipal Utility District (EBMUD), and no action. (Source: The staff.)

	Staff	CDFG	EBMUD	FWS	No action
Critical dry year					
Adult migration			75		
Spawning/incubation			51		
Fry rearing			62		
Juvenile rearing			51		
Smolt migration			61		
Stocked steelhead			74		
Dry year					
Adult migration	75	75	75	93	50
Spawning/incubation	70	93	69	93	22
Fry rearing	52	9	33	9	62
Juvenile rearing	64	37	49	35	69
Smolt migration	61	61	59	75	0
Stocked steelhead	66	78	69	95	35
Normal year					
Adult migration	84	97	75	95	50
Spawning/incubation	72	84	63	85	43
Fry rearing	33	4	33	6	62
Juvenile rearing	52	23	33	28	60
Smolt migration	100	100	100	97	0
Stocked steelhead	93	98	85	99	90
Wet year					
Adult migration	98	100	75	95	50
Spawning/incubation	77	84	63	85	39
Fry rearing	19	4	33	6	62
Juvenile rearing	46	20	33	26	72
Smolt migration	100	100	100	97	0
Stocked steelhead	99	100	85	100	90
Combined life-stage habitat score ¹					
Adult migration	89	95	75	95	50
Spawning/incubation	74	85	64	86	37
Fry rearing	30	5	35	7	62
Juvenile rearing	51	24	38	29	68
Smolt migration	92	94	88	92	0
Stocked steelhead	90	96	81	99	79

¹ Uses percent occurrence of various water-year types shown in Table F-13.

Table F-13. Percent occurrence of water year types used to calculate combined life-stage habitat scores shown in Tables F-11 and F-12. (Source: The staff.)

Year type	Staff	CDFG	EBMUD	FWS	No action
Critically dry	0	0	5	0	0
Dry	20	15	25	20	20
Normal	30	35	70	30	30
Wet	50	50	0	50	50

Adult migration. Staff (89), CDFG (95), and FWS (92) scores were relatively high. EBMUD (75) score was lower due to low flows and relatively high (>59°F; 15°C) release temperatures in the first half of October which combined to produce unacceptably high temperatures downstream. No action alternative produced a very low score (63) because no flow is required below Woodbridge during October.

Spawning/incubation. CDFG (85) and FWS (80) scores were highest. Staff score (74) was somewhat lower, primarily due to a high release temperature (>56.3°F; 13.5°C) in November. EBMUD score (64) was even lower due to both low flows throughout the winter and a high release temperature in November. No action score (37) was very low, primarily due to very low flows.

Fry rearing. WUA analysis for fry rearing habitat suggests that flows < 100 cfs are optimal. Staff has some reservations about these results and believes the results of the habitat score analysis should be viewed cautiously. The no-action alternative (62) had the highest habitat score because of extremely low flow requirements. EBMUD (35) and staff (30) had the next highest scores. And CDFG (5) and FWS (7) had the lowest scores due to higher flows and low temperatures. Low Camanche release temperatures contributed to the low scores for all the alternatives. Although the temperatures were below the targeted range of 51.8–62.6°F (11–17°C), these temperatures would not be lethal or unduly stressful as would temperatures that were higher than the acceptable range. However, such low temperatures could have a significantly negative effect on growth which could be crucial to the fry's ultimate survival.

Juvenile rearing. No-action (68) and staff (51) had the highest scores followed by FWS (41), EBMUD (38), and CDFG (24). All the plans shared the common problem of release temperatures from 50–55.4°F (10–13°C), which is several degrees below the optimal juvenile rearing temperature of 57.2–59°F (14–15°C). High flows compound this problem by preventing the water from warming as it moves downstream.

Smolt migration. Except for the no-action alternative, all plans had similarly high scores for the out-migration of smolts. This analysis did not include any short-term spike flows which are being proposed by some. However, such flows would most likely lower temperatures below Woodbridge Dam, which would be more desirable.

Stocked steelhead. FWS, CDFG, and staff alternatives should provide adequate habitat for resident steelhead during July to September as all had scores above 90. EBMUD (81) and no-action (79) alternatives are slightly less due to somewhat lower flows and higher release temperatures.

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APPENDIX G. WATER RIGHTS IN THE MOKELUMNE RIVER BASIN

APPENDIX G. WATER RIGHTS IN THE MOKELUMNE RIVER BASIN

The first half of this appendix contains a summary of current water rights on the Mokelumne River. Table G-1 displays the active water rights in the basin. The information was derived from each respective permit/license and associated orders, except where additional sources are cited in parentheses. The second half of the appendix addresses the evolving markets for water rights transfers.

Summary of California Water Rights Law

California uses a system of water rights which recognizes both prior appropriation rights and riparian rights. Appropriative rights are based on physical control and use of the water and on the concept of first in time means first in right. Prior to 1914, water rights were acquired simply by posting a claim and putting the water to "beneficial use". Since the 1914 adoption of the Water Commission Act, potential water users must file an application with the State to appropriate water, and may be issued a permit allowing water diversion and use. When the largest amount of water allowed by the permit has been developed, the permittee applies for a license. An application establishes the priority date of the water right; a permit allows the potential user to develop the water right; and the issuance of a license confirms the water right.

Riparian rights are based, not on prior use, but on ownership of land which physically touches a river, stream, pond or lake. Riparian rights are attached to the land and are normally not forfeited if not used. Water use is restricted to the watershed of the sources from which the water is taken. Riparians rights generally have priority over appropriative rights. In California, riparian water rights are correlative, meaning that a common water source (and corresponding shortages) must be shared between all riparians. Since 1928, California's dual water rights system has been subject to a common standard that the use must be both "reasonable and beneficial". While common, acceptable uses of riparian water are well established in California law, the "reasonable and beneficial" concept is not well defined or fixed in law. (Water Education Foundation 1986).

Woodbridge Irrigation District

The Woodbridge Irrigation District (WID) holds two active water rights licenses. The licenses involve the same point of diversion: north 37°N 14 minutes east 2,983 ft from S 1/4 corner of Section 34, Township (T) 4N, Range (R) 6E, Mount Diablo (MD) Base and Meridian (B&M), within NE 1/4 of SE 1/4 of Section 34, and benefit the same area: 19,370.3 acres within a gross area of 40,435.72 acres within the boundaries of WID and Woodbridge Water Users Conservation District (WWUCD) and within T2N, T3N, T4N, and T5N, and R5E, R6E, and R7E, MDB&M (points refer to the map on file with the State).

The first Woodbridge license (*application 5807, permit 3890, license 5945*) is for irrigation and incidental domestic use. The priority date is January 20, 1928. The license was issued February 8, 1960. The licensee is entitled to the direct diversion of 300 cubic feet per second (cfs) from February 1 through October 31 of each year. A 30-day flow may be diverted in a shorter time if it does not interfere with other vested rights.

The second Woodbridge license (*application 10240, permit 6930, license 8214*) is for irrigation, stockwatering, and incidental domestic use. The priority date is July 17, 1941. The license was issued September 7, 1967. The licensee is entitled to the direct diversion of 114.4 cfs from May 1 through August 31 and from November 1 through January 31. The equivalent of a 30-day flow allowance can be

Table G-1. Active water rights on the Mokelumne River as of July 1992.

(Source: Computer listing provided by the State Board, June 1992.)

Current Owner Name	Application No.	License/Permit No.	County
Reclamation Dist 756	002948	L-001405	San Joaquin
Solari, Andrew P. et al.	003213A	L-003679A	San Joaquin
Solari, James J. et al.			
Solari, Kathleen A. et al.			
Solari, Lorraine M. et al.			
Queirolo, Gertrude	003213B	L-003679B	San Joaquin
Biglieri, Steven J. & Petre J.	003213C	L-003679C	San Joaquin
Gauntt, Gilbert C. & Lucille C.	003453	L-001700	San Joaquin
Harris Vineyards	003617	L-000663	San Joaquin
Hoffman, Robert M. & Joanne A.	003811	L-000644	San Joaquin
Van Galder, Robert A.	003821	L-000920	San Joaquin
Clagg, Richard et al.	003830	L-000682	San Joaquin
Elkins, Carl & Phyllis et al.			
Kirschenmann, Leon A. et al.			
Preszler, Leonard et al.			
Vanderheiden, Bert et al.			
McCormack Williamson Co.	003914	L-001320	Sacramento
Blossom, Robert Ditz et al.	003990	L-005453	San Joaquin
McGurk, Annlee Blossom et al.			
McGurk, Mary Karen et al.			
Steinbrecher, Elaine Emily et al.			
Bonaire Motors, Inc.	003996	L-001726	San Joaquin
Botts, Arthur R et al.	004215	L-001226	San Joaquin
Cipolla, Gilbert R. & Sharon E. et al.			
Equitable Life Assurance Society et al.			
Lipelt, Randolph et al.			
Mehlehoff, Ray et al.			
Stepelberg, Don J. & Frances A. et al.			
East Bay Municipal Utility District	004228	L-011109	Amador

Table G-1. Active water rights on the Mokelumne River as of July 1992 (continued).

Current Owner Name	Application No.	License/Permit No.	County
Henry, Jerrold & Ruth J.	004405	L-004412	San Joaquin
East Bay Municipal Utility District	004768	L-001388	Amador
East Bay Municipal Utility District	005128	L-006062	Amador
State Water Resources Control Board	005647		Amador
State Water Resources Control Board	005648		Calaveras
Jackson Valley Irrigation District	005648B	P-012167	Amador
Woodbridge Irrigation District et al. Woodbridge Water Users Conservation District et al.	005807	L-005945	San Joaquin
Beldt, Homer C. and E. J.	005957	L-001455	San Joaquin
Den Hartog, Arie et al. Den Hartog, Peter et al. Holthouse, Mark Vernon Jr.	006145	L-002729	San Joaquin
Dinelli, Elmer et al. Dinelli, Tony et al. Dinelli, William et al.	008406	L-002262	San Joaquin
Davis, Hugh S. & Bernice S.	008871	L-002288	San Joaquin
Cranston Farms	009796	L-002546	San Joaquin
Woodbridge Irrigation District et al. Woodbridge Water Users Conservation District et al.	010240	L-008214	San Joaquin
Fry, Marian Mohr	010531	L-002999	Sacramento
Hoffman, Robert M. and Joanne A.	010553	L-002937	San Joaquin
Sutter, Robert E.	011977	L-005299	San Joaquin
George R. Beggs, Inc.	012539	L-010703	San Joaquin

Table G-1. Active water rights on the Mokelumne River as of July 1992 (continued).

Current Owner Name	Application No.	License/Permit No.	County
North San Joaquin Water Conservation District	012842	P-010477	Amador
East Bay Municipal Utility District	013156	P-010478	San Joaquin
East Bay Municipal Utility District	015201	P-010479	Amador
Ferdun, Charles F., Trustee	015202	L-006966	San Joaquin
A. Steffan Ranch	015250	L-009929	San Joaquin
Carey, Pamela June et al.	015698	L-005523	Sacramento
Ceccarini, Anthony L. et al.	015698	L-005523	Sacramento
Ceccarini, Frances E. et al.			
Ceccarini, Livio et al.			
Kirkam, Dianne Irene et al.			
Krau, Gerhard et al.			
Kraus, Karl A. et al.			
Kraus, Michael et al.			
Machado, Frank G. and M. Grace et al.			
Robert Cecchini, Inc. et al.			
Rose, Emily Irene et al.			
Sims, George E. and Carla J. et al.			
Stockton Production Credit Association E			
Yih, Shou Chen et al.			
Zau, Tommy et al.			
Sutter, Robert E.	017954	L-007049	Sacramento
Schulz, Frank J. H. Jr. et al.	020318	L-009784	Amador
Vaccarello, Dale	020535	L-009811	Amador
Piazza, James A and Norma L.	021578	L-009327	Amador
Teichert & Son, Inc.	022103	L-010590	San Joaquin
Ceres Farm Company	024386	L-011728	San Joaquin
Vaccarello, Dale et al.	025049	L-011720	Amador
Vaccarello, Diane et al.			
Vaccarello, Sam et al.			

Table G-1. Active water rights on the Mokelumne River as of July 1992 (continued).

Current Owner Name	Application No.	License/Permit No.	County
Vaccarello, Dale et al. Vaccarello, Diane et al. Vaccarello, Sam et al.	025050	L-011721	Amador
East Bay Municipal Utility District	025056	P-017378	San Joaquin
Pereira, Mabel	025059	L-011272	Calaveras
Hesseltine, Howard L. and Leah B.	027322	L-012514	Amador
Vaccarello, Dale et al. Vaccarello, Diane et al. Vaccarello, Sam et al.	027946	L-012767	Amador
Vaccarello, Dale et al. Vaccarello, Diane et al. Vaccarello, Sam et al.	027947	L-012768	Amador
Forster, Jerome F. and Rosemary	028216	P-019467	San Joaquin
Delta Wetlands, A California Corporation	029061		San Joaquin
Mokelumne River Water and Power Authority	029835		Amador
Mokelumne River Water and Power Authority	029855		Amador

diverted in a shorter time if it does not interfere with other vested rights. Diversion is subject to the terms of the July 21, 1965 agreement between WID, East Bay Municipal Utility District (EBMUD), and WWUCD.

The simultaneous diversion under license 5945 and license 8214 and under the appropriate right acquired from the Stockton and Mokelumne Canal Company cannot exceed 414.4 cfs.

East Bay Municipal Utility District

EBMUD holds six active water rights. The first (*application 4228, permit 2459, license 11109*) is for municipal use within the EBMUD [as defined by the 1980 map on file with the State Water Resources Control Board (State Board)] and for recreational purposes at Pardee Reservoir. The priority date is September 22, 1924. The license was issued April 3, 1981.

From the point of diversion at Pardee Dam - 18°S 10 minutes east, 3,420 ft from NW corner of Section 26, T5N, R10E, MDB&M, within NW 1/4 of SW 1/4 of Section 26 - the licensee is entitled to 310 cfs from January 1 through December 31 by direct diversion, and 209,950 ac-ft per annum from October 1 through July 15 of the succeeding year, by storage. The combined direct diversion and withdrawal from storage cannot exceed 310 cfs or 200 mgd (City of Lodi Decree). The total amount taken from the source (combined direct diversion and collection to storage) cannot exceed 316,250 ac-ft/annum. The total amount of water to be placed to beneficial use (direct diversion plus withdrawal from storage) cannot exceed 224,037 ac-ft/annum.

The combined total collection to storage under this license, license 1388 and license 6062, cannot exceed 209,950 ac-ft/annum.

The license is subject to the express condition that in the event of a water shortage during the irrigation season, the State Board can regulate use.

The second (*application 4768, permit 2529, license 1388*) is for power. Its priority date is September 11, 1925. The license was issued December 12, 1933. From the point of diversion at Pardee Dam - 18°S 10 minutes east, 3,420 ft from NW corner of Section 26, T5N, R10E, MDB&M within NW 1/4 of SW 1/4 of Section 26 (per Order Correcting Point of Diversion 4/14/52) - the licensee is entitled to 375 cfs from January 1 through December 31 by direct diversion, and 198,965 ac-ft/annum from January 1 through July 31 by storage. The water will be put to beneficial use where it is returned to the Mokelumne River at NW 1/4 of SW 1/4 of Section 26, T5N, R10E, MDB&M.

The license is subject to the express recognition that the rights to power use will not interfere with future appropriations for agricultural or municipal purposes. In addition, the parties recognize that in the event of water shortage during the irrigation season, the State Board can regulate use.

The simultaneous use by this license and license 6062 cannot exceed 750 cfs (by both direct diversion and storage). The combined total collection to storage under this license, license 11109, and license 6062 cannot exceed 209,950 ac-ft/annum (license 11109 - 4/3/81).

The third (*application 5128, permit 5587, license 6062*) is for power. Its priority date is July 27, 1926. The license was issued on August 2, 1960. From the point of diversion at Pardee Dam - 18°S 10 minutes east, 3,420 ft from NW corner of Section 26, T5N, R10E, MDB&M within NW 1/4 of SW 1/4 of Section 26 - the licensee is entitled to 375 cfs from January 1 through December 31 by direct diversion, and 28,702 ac-ft/annum from October 1 through December 31 by storage. The water is used at the Pardee Power Plant within SW 1/4 of SW 1/4 of Section 26, T5N, R10E, MDB&M.

The simultaneous use by this license and license 1388 cannot exceed 750 cfs (by both direct diversion and storage). The combined total collection to storage under this license, license 1388, and license 11109 cannot exceed 209,950 ac-ft/annum (license 11109 - 4/3/81).

This license is subject to the express recognition that use for power will not interfere with future appropriations for agriculture and municipal purposes.

The fourth (*application 13156, permit 10478*) is for municipal uses and potential flood control. The priority date is June 16, 1949. The permit was issued July 3, 1956. There are two points of diversion: 1) Camanche Dam - 41°S 33 minutes west, 1,824 ft from east quarter corner Section 6, within SE 1/4 of SE 1/4 of Section 6, T4N, R9E, MDB&M in San Joaquin County; and 2) Pardee Dam - 18°S 10

minutes east, 3,420 ft from NW corner Section 26, within NW 1/4 of SW 1/4 of Section 26, T5N, R10E, MDB&M in Amador and Calaveras counties (Order changing point of diversion 7/29/60).

The permit rights are used within the EBMUD service area covering 360 square miles and includes the cities of Alameda, Albany, Berkeley, El Cerrito, Emeryville, Oakland, Piedmont, Richmond, San Leandro, San Pablo, and Brentwood and unincorporated areas in Alameda and Contra Costa Counties, and generally located within Tps. 1,2,3,4 S and 1 and 2 N, 1,2,3,4 and 5 W and 2 E, MDB&M (as shown on maps on file with the State Board) (Order changing place 1/26/83).

The permittee is entitled to 194 cfs from December 1 through July 1 of the succeeding year by direct diversion, and 140,000 ac-ft/annum from December 1 through July 1 by storage (Release From Priority). From March through October (inclusive), if the mean flow released downstream from the enlarged Pardee Reservoir or Camanche Reservoir is less than 400 cfs, the mean daily flow cannot be less than 75% of the average monthly flow rate (Decision 858). The permittee must maintain a 5 cfs bypass or natural flow (when flow is less than 5 cfs) at Railroad Flat Dam for fish protection (Decision 858).

The fifth (*application 15201, permit 10479*) is for power and incidental domestic purposes. The priority date is February 16, 1953. The permit was issued July 3, 1956.

From the point of diversion at Pardee Dam - 18°S 10 minutes east, 3,420 ft from NW corner of Section 26 within the NW 1/4 of SW 1/4 of Section 26, T5N, R10E, MDB&M (Order to change point of diversion, purpose, intent, and amount - 8/6/62), the permittee is entitled to 1800 cfs from January 1 through December 31 by direct diversion, and to 353,000 ac-ft/annum from December 1 through July 1 by storage. Per Order 10/19/81, paragraph 14, this quantity of water is subject to modification by the State Board according to water quality and waste discharge analyses.

From March through October (inclusive), if the mean flow released downstream from the enlarged Pardee Reservoir or Camanche Reservoir is less than 400 cfs, the mean daily cannot be less than 75% of the average monthly flow rate (Decision 858). The permittee must maintain a 5 cfs bypass or natural flow (when flow is less than 5 cfs) at Railroad Flat Dam for fish protection (Decision 858). Diversion under permit 10479 cannot interfere with prior or subsequent higher uses (Decision 858).

Per the Release From Priority (March 5, 1959), the combined quantity diverted under applications 13156 and 15201 cannot exceed 194 cfs or 140,000 ac-ft/annum (direct diversion or diversion by storage). In addition, two reservations for use remain in effect based on Applications Nos 5647 and 5648: 1) Amador County may use the amount of water required for a safe yield to a maximum of 20,000 ac-ft/annum and 2) Calaveras County may use the amount of water required for a safe yield to a maximum of 27,000 ac-ft/annum. (Release From Priority - 3/5/59; Agreement between EBMUD and Calaveras Public Utility District (CPUD) - 5/8/40.

The sixth (*application 25056, permit 17378*) is for power. The priority date is April 29, 1976. The permit was issued June 22, 1978.

From the point of diversion - 41°S 33 minutes west, 1,824 ft from E1/4 corner of Section 6; SE 1/4 of SE 1/4 Section 6, T6N, R9E, MDB&M -the permittee is entitled to 1200 cfs from October 1 through July 31 by direct diversion and to 353,000 ac-ft/annum from December 1 through July 1 by storage. The total amount taken from the source cannot exceed 853,000 ac-ft/annum between October 1 and September 30. Per Order 7/11/84, this permit allows use for power but no additional storage over what is defined in permit 10478 (353,000 ac-ft/annum). The place of beneficial use is NW 1/4 of SE 1/4; Section 6, T4N, R9E, MDB&M.

From March through October (inclusive), if the mean flow released downstream from the enlarged Pardee Reservoir or Camanche Reservoir is less than 400 cfs, the mean daily flow cannot be less than 75% of the average monthly flow rate (Decision 858).

North San Joaquin Water Conservation District

The North San Joaquin Water Conservation District (NSJWCD) holds one active water right permit. Application 12842, permit 10477 is for irrigation and incidental domestic, municipal, recreational and industrial uses. The priority date is December 2, 1948. The permit was issued July 3, 1956. It was issued in accordance with Water Code 1462 for temporary appropriation of the excess from EBMUD application 13156 (Decision 858).

Points of diversion for permit 10477 are:

1. (Camanche): 41°S 33 minutes west, 1,824 ft from E 1/4 corner of Section 6, T4N, R9E, MDB&M within the SE 1/4 of SE 1/4 of Section 6 in San Joaquin County.
2. (Pardee): 18°S 10 minutes east, 3,420 ft from the NW corner of Section 26, T5N, R10E, MDB&M within the NW 1/4 of SW 1/4 of Section 26 in Amador and Calaveras counties.
3. 4°N east, 2,753 ft from center of Section 14, T4N, R8E, MDB&M, within SW 1/4 of SE 1/4 of Section 11, T4N, R8E, MDB&M.
4. 16°S east, 5,000 ft from NW corner of Section 24, T4N, R7E, MDB&M within SW 1/4 of SW 1/4 of Section 24.
5. 75°S ft and east 850 ft from W1/4 corner of Section 35, T4N, R7E, MDB&M within NW 1/4 of SW 1/4 of Section 35.

(Order changing point of diversion - 5/21/64)

Per the Stipulated Agreement of June 30, 1992, the permittee is allowed a time extension on water rights (through December 31, 2000) as long as the combined total (diversion and storage) does not exceed 20,000 ac-ft/annum (December 1 through July 1 of the succeeding year) and the maximum rate of direct diversion at two existing pumping facilities does not exceed a combined total of 80 cfs (no more than 40 cfs at each facility) (December 1 through July 1 of the succeeding year). In addition, further diversion is not permitted until NSJWCD reaches agreements with the California Department of Fish and Game (CDFG) regarding fish screens and flow bypass.

Use under permit 10477 is to benefit the 45,000 acre net area within a gross area of 52,000 acres within the boundaries of the NSJWCD within T3N, R6, 7, and 8 east; T4N, R6, 7, and 8 east, MDB&M (as described on map filed with the State Board).

Amador and Calaveras Counties

In 1927 the State of California filed two applications for unappropriated water of the Mokelumne River and its tributaries on behalf of Amador and Calaveras Counties - *applications 5647 and 5648*. These applications were made under Division 6, Part 2, of the Water Code of the State of California which allows the state to file application for any water which is required for the development and completion of a coordinated water resources plan. The priority date for these applications is July 30, 1927.

These rights were quantified and limited in the March 5, 1959 "Release from Priority" issued by the California Department of Water Resources. Agreements in 1958 between EBMUD and Amador and Calaveras Counties jointly requested the Department take such action. The Release corresponded with the issuance of permits 10478 and 10479 allowing EBMUD to divert 140,000 ft-ft per annum. It found that permit 10478 and 10479 were in furtherance of a coordinated plan looking toward the development of water resources in the state, and would not deprive the county of origin (Calaveras and Amador) from water which would be necessary to its development. The Release from Priority also reserved up to 20,000 ac-ft per year for direct diversion to beneficial use and diversion to storage for use in Amador County. Similarly, 27,000 ac-ft per year were reserved for diversion for use in Calaveras County. This 20,000 ac-ft reserved for Amador County included the water diverted through the Amador Canal. The Amador Canal water right is owned by Pacific Gas and Electric (PG&E) but is contracted in perpetuity to Amador County. Amador has applied for a permit to develop use of the remaining 5,000 ac-ft of water reserved under application 5647 and has filed for additional water through applications 028740 and 028741.

The 27,000 ac-ft reserved right in Calaveras County included the existing rights of CPUD to diversions of water from the South Fork of the Mokelumne as set forth in the May 8, 1940 agreement between CPUD and EBMUD.

The vast majority of these water rights have not yet been exercised. Regardless, they are viable, with a relatively early priority date, and remain a potential source of future water demands from the Mokelumne.

Evolving Water Market, Water Banks, and Transfers of Water Rights

Table G-2 shows a summary of the major flows and diversions in the Lower Mokelumne River. The first column shows entitlements for water on the river. The next three columns show the number of ac-ft per year that user agent diverted from the river in 1979, an average withdrawal, and the historic range of these diversions. The final column shows the maximum entitlement of each right holder on the river. As can be seen, the largest single user is EBMUD with an average usage of 196,500 ac-ft per year. This represents 95% of EBMUD's total water usage. All other right holders are either irrigation districts who use the water for their agricultural customers, or individual riparian or senior right holders. The City of Lodi is a special case discussed below. As noted by the asterisks by some of the downstream right holders, the water that flows to them provides instream flow (until the water is diverted or lost in the form of channel losses). As discussed below, this amount is in addition to releases for the fish hatchery below the Camanche Reservoir.

In more technical detail, EBMUD has the legal right to divert up to 325 MGD. This amount has been defined and limited by the interrelationships between EBMUD and the other entitlement holders on the river. EBMUD received its original appropriation pursuant to its Water Rights Application of 1926 under permit 2459. The allocation consisted of 200 MGD for diversion to EBMUD's service area and the right to divert up to 217,000 ac-ft per year into storage at the Pardee Reservoir. In 1981 license 11109 was issued establishing that full use of the water provided under the 1926 permit had been demonstrated.

EBMUD filed a second Water Rights Application in 1949. This was for the right to divert an additional 125 MGD to direct use for the Mokelumne River and another 353,000 ac-ft per year of river water for storage in the Camanche Reservoir. These rights, as with those prior, were needed for the construction of the Reservoir's dam. In 1956 the State approved EBMUD's application, and issued Water Right Permit 10478. Later, EBMUD sought partial reassignment or release from priority of certain upstream water rights. In 1959 the State granted the release sought by EBMUD, but reserved 47,000 ac-ft per year for eventual upstream use by Amador and Calaveras Counties. These rights are, and will remain, superior to EBMUD and other downstream users.

Table G-2. Mokelumne River flow downstream of Pardee Reservoir (ac-ft per year).
 (Source: EDAW, Inc. 1992.)

	Water year 1979	Average	Range	Maximum entitlement
Mokelumne Hill Gage	678,3000	735,500	150,300– 1,738,090	364,00
Jackson Valley Irrigation District	3,000	1,500	0–3,800	5,000
EBMUD Aqueduct Draft	187,100 (167 MGD)	196,500 (175 MGD) (20 years)	130,600– 245,700 (117 MGD– 219 MGD) (Last 20 years)	364,000 (325 MGD)
Fish Hatchery Releases	16,200	18,300	5,900–23,300	13,000
Intermediate Inflow	7,100	6,600	80–13,900	-----
North San Joaquin Water Conservation District	7,400	7,400 (without 1976 and 1977)	4,600–9,500 (0 in 1976 & 1977)	20,000
Woodbridge Irrigation District	76,200	95,100	51,400– 121,700	116,700 (60,000 Permanent Regulated + 56,700 Interim)
Riparians and Senior Appropriators	14,600	13,700	10,100– 18,200	20,618
Channel Losses	56,700	80,000	32,700– 108,700	-----
City of Lodi	0	0	0	3,500 (if triggered by Lodi Decree)
Woodbridge Gage	341,700	453,800	15,800– 1,559,600	-----

The waters of the Mokelumne also have senior downstream users that must have their entitlement met before EBMUD may use or store this water. Many individual riparian landowners have claim to the river's natural flow that are superior to EBMUD's right. WID and other individuals have appropriative water rights that in some instances predate those of EBMUD (and thus are senior). The city of Lodi, while utilizing groundwater for its needs, depends on the Mokelumne River for recharging the water table. Lodi's claim is superior to EBMUD right under a 1938 court decision.

EBMUD has also negotiated agreements with certain irrigation districts which establish how EBMUD will provide them with water from the river to which they (the irrigation district) have a State-granted right. For example, NSJWCD has a Temporary Water Right Permit to divert and store water that is not used by EBMUD pursuant to its Water Right Permit 10478. Because NSJWCD knows that its Permit is only temporary, it did not invest in a storage facility. Instead, it entered into an agreement whereby EBMUD would store water for it but EBMUD was also permitted to determine when it had water available for NSJWCD.

The Jackson Valley Irrigation District (JVID) has a Water Right Permit to transfer water from the river to its storage reservoir. As outlined in an agreement between JVID and EBMUD, water is provided to JVID through a creek, by gravity flow, located at the upper end of Pardee Reservoir where EBMUD operates an outlet valve. If the level of Pardee drops below an elevation of 550 ft, the diversion under gravity flow is not possible. Currently, JVID does not have a pumping facility that would enable it to obtain water when the elevation falls below 550 ft. With the low level of Pardee Reservoir in recent years, JVID has been warned it may not receive any of its allocation (JVID, 1992).

To meet the needs of downstream water users, EBMUD must release sufficient water not only to offset the amounts of water the senior right holders will divert, but also to provide carriage water to assure that the senior right holders receive their entitlement. Carriage water is the amount of water needed to make sure that everyone gets their due after channel losses such as evaporation and groundwater recharge. In addition to these waters, EBMUD's Water Right Permit 10478 requires EBMUD to reach agreement with the CDFG regarding release for the protection of fish in the Lower Mokelumne River. Thus, in 1961 EBMUD entered into an agreement with CDFG which required EBMUD to build a fish hatchery at Camanche Dam and to release up to 13,000 ac-ft per year from Camanche for fishery protection. This amount is over and above water required for carriage water and senior users.

LITERATURE CITED

EDAW, Inc. 1992. *Draft EIS/EIR for the Updated Water Supply Management Program*. Volume One.
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Water Education Foundation 1986. *Layperson's Guide to Water Rights Law*.

**APPENDIX H. RESPONSE TO COMMENTS ON THE
DRAFT ENVIRONMENTAL IMPACT STATEMENT**

APPENDIX H. Response to Comments on the Draft Environmental Impact Statement

The Notice of Availability of the Draft Environmental Impact Statement (DEIS) on the Lower Mokelumne River Project (LMRP) was published in the Federal Register on October 30, 1992. The DEIS was mailed to federal, state, and local agencies, as well as other interested parties, with a 60-day comment period. This comment period was subsequently extended to March 1, 1993, at the request of several parties. Section 8 of the Final Environmental Impact Statement (FEIS) identifies those agencies and individuals that were sent copies of the DEIS and the FEIS. A public meeting on the DEIS was conducted on November 30, 1992, in Livermore, California, to allow participants to express their views on the DEIS.

All timely letters of comment on the DEIS were reviewed by Commission staff during preparation of the FEIS. Suggestions for correcting text or data and requests for expanded discussion of a subject have been considered. Those editorial changes and suggestions which were practicable and reasonable, and which improved the quality of the FEIS, were incorporated herein.

Constructive criticism presenting a major environmental point of view or one in opposition to staff's position, when persuasively supported, is treated by making revisions in the appropriate part of the FEIS. When the major point of view is not persuasive, reasons are given why the staff did not change its point of view.

Staff's response to comments are presented in this appendix to the right of each comment letter. The sections or pages of the FEIS that have been modified are identified where appropriate. A response of "no response is required" is given to comments that are statements that raised no questions concerning treatment of subject matter in the DEIS. A response of "your comment is noted" is given to comments that are considered to be statements of opinion.

The commentors on the DEIS and the page on which their letters of comment occur are as follows:

<u>Name of Commentor</u>	<u>Page</u>
1. Jackson Valley Irrigation District	H-3
2. California State Department of Fish and Game	H-8
3. U.S. Environmental Protection Agency	H-22
4. Amador County	H-29
5. San Joaquin County	H-38

6.	Committee to Save the Mokelumne and California Sportfishing Protection Alliance	H-41
7.	Woodbridge Irrigation District	H-52
8.	California State Water Resources Control Board	H-65
9.	City and County of San Francisco	H-74
10.	East Bay Municipal Utility District	H-95
11.	U.S. Fish and Wildlife Service	H-215
12.	Mr. Felix E. Smith	H-229

Jackson Valley
Irrigation District
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FEDERAL ENERGY
REGULATORY COMMISSION

5751 Buena Vista Road
Ione, California 95640
709-274-7037

January 26, 1993

Ms. Lois D. Cashell
Federal Energy Regulatory Commission
825 North Capitol Street, N.E.
Washington, D.C. 20426

RE: Lower Mokelumne River Project
FERC Project No. 2916-004

Dear Ms. Cashell:

Following are the comments from the Jackson Valley Irrigation District regarding the Draft Environmental Impact Statement - Proposed Modifications to the Lower Mokelumne River Project - California.

1. The undersigned has reviewed the DEIS and attended the November 30, 1992 review session held by FERC at Livermore, California.
2. Droughts and salt intrusions into, and through, the Delta were a regular event before reservoirs, yet the fish and plant populations declined and increased without fanfare.
3. During the Lower Mokelumne River Hearings before the State Water Resources Control Board (November, 1992), Dr. Charles H. Hanson, in ERMED Exhibit No. 27, starting at page 3-8, testified as follows:

"Based upon the analyses of the potential effects of changes in Delta hydrology associated with operation of the Delta Cross-Channel, water management practices, and diversions from the South Delta it can be concluded that:" (emphasis mine)

- "o A high degree of uncertainty exists in the relationship between Mokelumne River Fall attraction flows and either adult salmon or adult steelhead escapement;

- 1-1 Staff has reviewed all testimony and exhibits submitted for the California State Water Resources Control Board's (State Board's) Mokelumne River Water Rights hearings and considers this information part of the administrative record for this Commission proceeding.
- 1-2 The DEIS summarized on p. 5-7 the uncertainty referred to and stated that attraction flows should be implemented on an interim basis in normal and wet years with a monitoring program to measure the success of these pulse flows. This recommendation has remained in the FEIS. In addition, the FEIS includes interim attraction flows of at least 300 cubic feet per second (cfs) in normal and wet years and 200 cfs in dry years.

- o Modifications to Delta hydrology during the fall contribute to high straying rates of adults and difficulties in maintenance of a Mokelumne River - specific steelhead and chinook salmon stock;
- o High mortality of downstream migrating juveniles within the Delta negatively impacts the effectiveness of improved flow conditions on the lower Mokelumne River;
- o High juvenile mortality rates within the Delta support management decisions to release hatchery-reared juvenile chinook salmon and steelhead downstream of the Delta in an effort to improve survival rates and the contribution of hatchery production to the ocean fishery and adult stock;
- o High juvenile mortality within the Delta, particularly during low-flow periods when percentage diversion associated with SFP and CVP operations is high, supports a management plan decision to trap juvenile chinook salmon and steelhead emigrating from the lower Mokelumne River and truck the juvenile fish to release locations downstream of the Delta, and the release of yearlings into the Mokelumne River during the fall when water temperatures and diversion are reduced, in an effort to improve juvenile survival and the contribution of production from the lower Mokelumne River to ocean stocks and adult escapement."

SUMMARY:

- A. The Jackson Valley Irrigation District is already short of water during the current dry years. Conservation measures have not and cannot make up for the shortfall because growth continues to increase demand.
- B. It seems quite clear that trying to maintain primitivism for the State of California is not a realistic or practical goal. We do not expect beef, lamb, turkey, chicken or pork to be raised in a primeval setting, so why do we expect fish to propagate without the help of "man". (At JVID's Lake Amador we support two trout raising facilities, both successfully operated by private enterprise. Even during the 1992 drought, over 80,000 lbs of trout were raised in spite of about 50% loss due to hydrogen sulfide (H₂S).) It is time to privatize salmon and other fish raising activities just as we do with other farm products. The price of (legal) salmon in a food market would suggest the money is there, but it is not being applied to fish raising.
- C. "POACHING" was a word used often during the various Hearings regarding the Delta. It would seem the time has come to rearrange some of the priorities and enforce the laws already in existence to correct this problem. It would also seem prudent for the State and Federal agencies to apply real honest pressure on the United States Congress to establish a 200 mile, off shore fishing boundary for our (legal) fishermen. Why should we raise fish for the ocean just to find that foreign interests have more rights and protection than do our citizens to catch these fish.

1-3

1-4

1-5

1-6

1-7

1-8

1-9

1-3 The DEIS discussed straying of upstream migrating chinook salmon on p. 3-39. The FEIS included additional comment on the likelihood that modifications to delta hydrology contribute to high straying rates.

1-4 The DEIS discussed high mortality of downstream migrating juveniles in the Delta on p. 3-42. The FEIS has an additional sentence relating this fact to the effectiveness of improved flows in the Lower Mokelumne River.

1-5 The DEIS discussed on p. 3-42 the high mortality of downstream migrating juveniles in the Delta and the benefit of releasing juveniles beyond the Delta to increase survival. However, such release increases straying by adults on their return.

1-6 The DEIS discussed on p. 3-42 the high mortality of downstream migrating juveniles in the Delta and the benefit of releasing juveniles beyond the Delta. The FEIS supports the East Bay Municipal Utility District (EBMUD) plan to trap and truck juveniles to sites beyond the Delta in the driest water years.

1-7 Your comment is noted; Jackson Valley Irrigation District (JVID) is recognized as one of the water users in the Mokelumne River basin in Section 3 and Appendix G of the DEIS and the FEIS.

1-8 The important role of fish hatcheries in maintaining salmonid fisheries in the Central Valley has been discussed in Sections 3 and 5 of the DEIS and the FEIS.

1-9 The DEIS discussed on p. 3-39 the high mortality of adult salmon in the ocean fishery and its negative effects on the results from improving environmental conditions and the restoration program. The FEIS includes a new section (p. 3-62 of FEIS) on limiting factors, of which ocean harvest is listed as the most important for limiting the population.

D. The Delta Cross Channel, referred to by Dr. Charles H. Hanson, has been operated for some years and obviously the drought has aggravated the fish migrating problem through this jet stream. It is hard to believe the planners and designers of this cross channel; a) could not have foreseen the affect a large flow of water would have on small fish trying to cross it; b) would continue to ignore or avoid facing the real cause of the problem; c) now come forth with the proposed "Water Rights Decision 1630" which will force northern California water users to pay for a "no plan" solution and contribute large quantities of water to enhance the Delta, and; d) presented little factual data at the Delta Hearings to support the concept that a lot more water will increase fish populations.

1-10

1-10 Staff appreciates how complicated water management in the Delta has become. Although factors affecting salmon survival in the Delta are important determinants of the success of remediation efforts in the Lower Mokelumne River, a joint effort by state and federal entities is needed to address these basin-wide problems. This proceeding is an essential part of the required effort.

E. Frequently, throughout the State hearing process for the Delta, the advocates demanding more water for the Delta tried to instill the idea that, because some agencies must use Delta water as the source for drinking water, that others should release their "clean" water into the Delta Estuary and then reclaim it for drinking water. It seems to this writer, that mixing good water with contaminated water, when it is not necessary, and then reclaim it for drinking water, borders on or is, in fact, a criminal act.

1-11

1-11 Your comment is noted.

Following are comments on the Section 5, STAFF CONCLUSIONS of the subject DEIS:

5.1 CONSISTANCY WITH EXISTING RESOURCE PLANS

The intent of the State is admirable, but ill advised. The quantity of fish of all species needed for todays consumption was obviously not considered. The cost to achieve the goal was either of no concern, or simply ignored.

1-12

1-12 Within the limitations of the Commission's authority, the EIS has attempted a thorough exploration of the feasibility and cost-effectiveness of enhancing the fisheries resource within the hydropower license issued to EBMUD.

5.1.1 UNDERLYING ASSUMPTIONS

The undersigned agrees with FERC Staff.

FISH POPULATION DECLINE

The undersigned agrees with FERC Staff.

CAUSES

The undersigned agrees with FERC Staff, and, lets not forget, the vast and significant fish populations propagated and maintained in the "man made" reservoirs.

1-13

1-13 Your comments are noted.

STUDIES

The undersigned cautiously agrees. Lately studies generate more studies, are frequently used to stop projects by increasing the cost and rarely produce production or product.

Ms. Lois D. Cashell
FERC

January 26, 1993
Page 4

5.1.2 STAFF FINDINGS

STREAM FLOW AND TEMPERATURE

The undersigned agrees with the first part of the paragraph, but has not analyzed the Staff proposal.

SHORT TERM DAILY STREAMFLOW FLUCTUATION AND STREAMFLOW REDUCTION

The undersigned does not believe any solutions can be effective unless and until the "CROSS CHANNEL" problem is fixed with filter levees or some other method to allow small fish to pass into the Delta even while the Cross Channel water continues to flow to the pumps.

ATTRACTION FLOWS

The undersigned offers the same comment as above for this action.

OUT MIGRANT FLOWS

The undersigned agrees this might help, but only if the Cross Channel is fixed.

HABITAT PROTECTION AND IMPROVEMENT

The undersigned agrees.

WATER QUALITY

The undersigned believes "minimum pool" may be idealistic considering the drought and flood extremes.

ESCAPEMENT GOALS

The undersigned generally agrees with the first paragraph if corrective action is taken to get the fish past the Cross Channel. The total fish raising activity should be transferred to private fish farm operators. The idea that enough fish can be raised by natural process is as obsolete as expecting the population to become hunters and gatherers again.

WATER DIVERSION AND FISH SCREENS

The undersigned agrees.

FISH PASSAGE

The undersigned agrees.

RIPARIAN HABITAT MAINTENANCE PROTECTION

Idealistic.

PUBLIC ACCESS FOR RECREATION

The undersigned mostly disagrees. The idea is good if "people"

1-14

1-14 Operation of the California Department of Water Resource's (CDWR) Cross Channel diversion is outside the scope of this proceeding. Nevertheless, this issue was discussed briefly in cumulative impacts section (Section 4.7) of the FEIS.

1-15

1-15 Your comment is noted.

1-16

1-16 Fish farming has become more popular as it is recognized that wild stocks cannot sustain the demands for seafood seen in the marketplace. Farming of salmon is expanding in the U.S. However, this option is not considered a viable means to maintain fish and wildlife resources in the Mokelumne River. Recent emphasis on Public Trust values is leading to protection and rehabilitation of the salmon and steelhead resources of the Lower Mokelumne River for purposes other than as a source of food.

1-17

1-17 Your comments are noted.

1-18

1-18 This resource management issue is outside the scope of this compliance proceeding, as explained in Section 1 of the FEIS.

Ms. Lois D. Cashell
FERC

January 26, 1993
Page 5

could be left out. Areas opened for public access turn into dumps unless constantly patrolled. Pacific Gas & Electric Co. tried to maintain a small campground at Electra on the Mokelumne River just east of State Highway 49. When overnigheters were allowed, the grounds, tables and outhouses were regularly destroyed. Now the area must be vacated at night and frequent daily patrols are required by the Sheriff. A rest stop on Highway 88, about 6 miles west of the town of Jackson, was so regularly destroyed, the State finally bulldozed it out of existence. Sure, it is only a few who destroy it for munny, but society continues to protect this human debris, so lets not create more places for them to destroy on public or private property.

1-18
(cont.)

ADDITIONAL STUDIES

The undersigned believes additional studies should include the affect the Amador County Devil's Nose Project would have in contributing some cold water to the stream system. We must not forget that before reservoirs were constructed on the Mokelumne, there were many dry periods which severely affected the fish and wildlife anlong its length. This is not to say we should not make the best effort possible to enhance wildlife along the River's length; we should just be aware that things are not perfect, with or without "man".

1-19

1-19 The status of the Devil's Nose Project and its relationship to EBMUD's Lower Mokelumne River Project was discussed in Section 3.1.2 of the FEIS.

APPENDIX G - WATER RIGHTS (Page 6-10)

The last paragraph refers to the Jackson Valley Irrigation District water permit on the Mokelumne River. Even during the current extended drought, we have received water four years, including the 1992 water year. To date, we have received no "warning" from anyone that our Mokelumne River water would be confiscated. In fact, the DEIS failed to consider water rights, water right contracts, County of Origin water rights or related Court decisions; therefore, your report is seriously flawed.

1-20

1-20 The FEIS has been revised to reflect the status of JVID's water rights. These rights were considered in our assessment, including the frequency of Pardee Reservoir pool elevations under different alternatives and how these might affect delivery of JVID water. However, the delivery of JVID water is essentially a third-party agreement between EBMUD and JVID in which the Commission has limited, if any, involvement.

Thank you for the opportunity to respond to your environmental Document.

Very truly yours,

JACKSON VALLEY IRRIGATION DISTRICT

Henry Willy
Henry Willy
Secretary-Manager

STATE OF CALIFORNIA—THE RESOURCE AGENCY

DEPARTMENT OF FISH AND GAME

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FEDERAL ENERGY REGULATORY COMMISSION

February 1, 1993

Ms. Lois Cashell, Secretary
Federal Energy Regulatory Commission
825 North Capitol Street, N.E.
Washington, D.C. 20426

Dear Ms. Cashell:

Lower Mokelumne River Project, Project No. 2916-004

This responds to the October, 1992 Draft Environmental Impact Statement (DEIS) prepared by the Federal Energy Regulatory Commission (FERC) staff and consultants in connection with a proceeding to consider modifications of facilities and operation of the Lower Mokelumne River Project (FERC No. 2916-004) in Amador and San Joaquin counties. We understand that the proposed modifications are for the specific purpose of conserving anadromous fisheries in the lower Mokelumne River. The California Department of Fish and Game (CDFG) has reviewed the DEIS and we have the following comments.

In general, the FERC staff and consultants have done an excellent job in preparing the DEIS for the lower Mokelumne River. Rather than address every detail of the DEIS, we will focus our comments on the following general topics that we consider to be very important: (1) streamflow and water temperature; (2) short-term daily streamflow fluctuation and streamflow reduction; (3) attraction flows; (4) outmigrant flows; (5) habitat protection and improvement; (6) water quality; (7) escapement goals; (8) water diversion and fish screens; (9) fish passage; (10) riparian habitat maintenance and protection; (11) public access for recreation; and (12) additional studies. To facilitate FERC staff's review of our comments we will use a format similar to Section 5.3 (Summary of Findings and Recommendations) of the DEIS.

Ms. Lois Cashell
February 1, 1993
Page Two

Minimum Flow Recommendations

The CDFG continues to recommend that the following streamflows and temperatures be maintained in the lower Mokelumne River:

Time period	Minimum streamflow (ft ³ /s) at:		Mean daily temperature (°C) at:		
	Highway 99	Woodbridge	Elliott Road	Cosumnes River	Highway 99
Normal water years:					
Oct 15 - Feb 29	300*	300	13.3		
Mar 1 - Mar 31	350	350	13.3		
Apr 1 - Apr 30	400+	400		15.6	
May 1 - May 31	450	450		15.6	
Jun 1 - Jun 30	400	400			18.3
Jul 1 - Jul 31	150	150			18.3
Aug 1 - Sep 30	100	100			18.3
Oct 1 - Oct 14	250	250			18.3
Dry water years:					
Nov 1 - Mar 31	200	200	13.3		
Apr 1 - Apr 14	200	200		18.3	
Apr 15 - Apr 30	250	250		18.3	
May 1 - May 31	300	300		18.3	
Jun 1 - Sep 30	200	20			18.3
Oct 1 - Oct 31	100	20			18.3
Wet water years:					
Oct 15 - Feb 29	350	350	13.3		
Mar 1 - Mar 31	400	400	13.3		
Apr 1 - May 31	450	450		15.6	
Jun 1 - Jun 30	400	400			
Jul 1 - Oct 14	300	300			18.3

*Attraction flow in addition 10/1-11/15 to be 20,000 acre-feet (AF) below Camanche Dam and Woodbridge Dam during wet and normal water years, 10,000 acre-feet (AF) during dry years.

+Outmigration flow in addition 4/1-6/30 to be 10,000 AF below Camanche Dam and Woodbridge Dam during wet and normal water years and 5,000 AF during dry water years.

2-1

2-1 These revised instream flow recommendations have been fully evaluated as the proposed alternative in the FEIS.

Ms. Lois Cashell
February 1, 1993
Page Three

The above recommendations are similar to those on page xv of CDFG's Lower Mokelumne River Fisheries Management Plan (Plan) and those on page 2-11 of PERC's DEIS, with a minor revision to the June 1 - June 30 flows during a wet water year. In addition to the Instream Flow and Management Recommendations discussion beginning on page 169 of CDFG Plan, we offer further rationale for our flow recommendations.

2-1
(cont.)

When evaluating instream needs and formulating flow regimes, CDFG considered a variety of factors and competing species life-stage needs. Water temperature characteristics, the relationship between physical habitat availability and streamflow, water quality, food availability, channel stability, spawning gravel, migration barriers, fish entrainment, riparian vegetation, and effects of water project operations on flow and temperature were among the factors which CDFG considered and integrated when developing flow recommendations.

Our flow recommendations are consistent with the Instream Flow Incremental Methodology (IFIM) which is intended to account for as much variability as possible. IFIM integrates the multitude of components and associated variables important to evaluating potential impacts to streams. It is more than a simple consideration of depth, velocity, substrate, and the physical habitat simulation output (PHABSIM). The output from PHABSIM depicts the weighted usable area (WUA) vs. discharge relationship. Consequently, WUA is simply an index of the suitable stream habitat and provides a relative index as to how aquatic habitat changes with changes in stream discharge. It does not include other habitat variables, such as: (1) water temperature; (2) water quality; (3) escape cover; (4) predation; (5) competition; (6) food availability; (7) hydrology; (8) fish migration; (9) riparian habitat; etc. These other variables are extremely important when considering flow regimes for fry and juvenile life stages of salmon and steelhead.

2-2

2-2 These additional factors were considered by staff in the DEIS and the FEIS in formulating our recommendations. Staff must note, however, that neither the California Department of Fish and Game (CDFG) nor any other interested party has provided substantial, quantitative evidence regarding how factors such as escape cover, predation, competition, food availability, or riparian habitat are affected by stream flows in the Lower Mokelumne River.

Considering only the microhabitat changes (i.e., depths and velocities) would result in low velocities and shallow depths throughout the channel and reaches of the Mokelumne River. In effect, the whole river becomes suitable fry habitat and in addition becomes desirable and suitable habitat for predators such as smallmouth bass and Sacramento squawfish. This approach provides an index to microhabitat, however, we must also consider the macrohabitat (river reaches) and the overall river ecosystem. In a flat gradient valley stream, such as the Mokelumne River, there is fry and juvenile habitat along the edges of the stream.

2-3

2-3 Your comment is noted. These factors have been considered and discussed in the FEIS.

Ms. Lois Casbell
February 1, 1993
Page Four

As flow discharge increases, there are still low velocities and shallow depths along the edges where organic debris is also present. This is important because the chinook salmon fry in the lower Mokelumne River exhibited a high preference for organic debris (p. 59 of CDFG Plan).

2-3
(cont.)

Finally, steelhead are present in the river spawning during January through March so flows must be maintained (p. 104 of CDFG Plan) to provide suitable spawning conditions. We agree with FERC staff that the steelhead resource must be protected and enhanced.

2-4

2-4 Your comment is noted. Staff's recommendations in the FEIS de-emphasized the feasibility of promoting natural reproduction of steelhead via flow-related mitigation because of habitat limitations.

We disagree with the conclusion on page 5-2 that CDFG has not accounted for conveyance releases that are necessary from Camanche Dam to satisfy the downstream water rights of Woodbridge Irrigation District (WID) and the North San Joaquin Water Conservation District (NSJWCD). We recognize that our flow recommendations of 400, 450, and 400 cubic feet per second (cfs) during April, May, and June respectively, may result in actual releases from Camanche Dam closer to 600 or 700 cfs. However, during that time of year most of the chinook salmon juveniles are rearing in habitat represented by the Bruella Road study site (p. 99 of CDFG Plan). Based on our review of the aquatic habitat and stream discharge relationship for the Bruella Road site, WUA for juvenile salmon gradually declines as flow increases from 100 to 600 cfs, and then increases at 700 cfs (p. 104 of CDFG Plan). Even though the increase may not appear to be significant, the Bruella Road site represents a large number of miles of lower Mokelumne River habitat, characterized by low gradient, slow-run pool habitat, moderate-to-thick riparian vegetation, and riparian debris accumulations in the channel providing significant rearing areas for juvenile chinook salmon and steelhead.

2-5

2-5 Your comment is noted, and the data to which you refer have been incorporated into our analyses (see Sect. 4.1 and Appendix F). In our final recommendations, this relatively small benefit in habitat values was balanced against its adverse effect on municipal water supplies.

The steelhead trout habitat suitability criteria (p. 64 and 65 of CDFG Plan) indicate that steelhead fry and juveniles utilize water depths ranging from 0.1 to 4 feet deep with the highest use from 0.2 to 2 feet deep and water velocities ranging from 0 to 3 feet per second (fps) with the highest use from 0.28 to 1.5 fps. In our opinion, even though there may be less WUA for steelhead fry and juveniles at CDFG's recommended flows, it won't be significantly less than WUA at FERC staff's recommended flows or East Bay Municipal Utility District (EBMUD's) recommended flows. As discussed above for fry and juvenile chinook salmon, a flat gradient stream, such as the lower Mokelumne River, provides fry and juvenile steelhead trout habitat along the edges of the stream.

2-6

2-6 Staff concurs with CDFG's habitat suitability criteria for steelhead, but concludes in the FEIS that the overall lack of suitable habitat for steelhead juveniles is a critical limiting factor below Camanche Dam. Because of the lack of this habitat in the Camanche tailwater, recovery of naturally reproducing steelhead is unlikely in this stream.

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The February through June period is also when the juvenile salmon and yearling steelhead need higher flows for emigration (page 3-36 of the DEIS). The chinook salmon and steelhead trout juveniles have evolved in the Mokelumne River with relatively high flows during the February through June period (Fig. 53, p. 173 of CDFG Plan). When salmon and steelhead are ready to emigrate from the Mokelumne River to the ocean, these higher flows help to convey them downstream improving survival past Woodbridge Dam and through the Delta.

2-7

2-7 Your comment is noted. This issue was discussed in Section 3.3 and elsewhere in the FEIS.

In summary, CDFG recommends our minimum flow schedule as the best of the four alternatives considered in the DEIS, for the maintenance of the lower Mokelumne River fisheries and acceptable water temperatures during normal, wet, and dry water years. We agree with the conclusion in Section 5.2.1 that physical habitat and water quality conditions for salmon and steelhead trout in the lower Mokelumne River can be significantly improved by implementing higher minimum flows from Camanche Dam and minimum pool elevation requirements in Camanche Reservoir. However, the analysis in Table 5.2-1 should be used with caution. It addresses fish habitat values based on depth and velocity variables only, and doesn't adequately consider the other habitat variables discussed above. Furthermore, it centers on the fish habitat values for the tailwater segment only, even though the Bruesella site, downstream, is representative of a large number of miles of lower Mokelumne River habitat which are rearing areas for chinook salmon and steelhead trout.

2-8

2-8 Table 5.2-1 is a summary presentation intended for comparison purposes only. Physical habitat data were not the only consideration in setting staff's recommendations.

2-9 Your comment is noted.

In addition to the benefits to the lower Mokelumne River fishery, the CDFG recommended flows would provide increased hydropower generation and revenues at both Pardee and Camanche powerhouses. We agree with the conclusion on page 4-13 that a required increase in pool elevation or discharge would increase hydropower generation.

2-9

2-10 Staff agrees with the CDFG that the Delta is a technically viable source of water for EBMUD. However, EBMUD treatment facilities are currently designed to handle a relatively clean water source. During the 1976-77 drought, EBMUD mixed Delta water with its existing supplies in a 10% blend. According to EBMUD data, trihalomethane (THM) levels rose considerably after mixing and required about 5 years for THM levels to decline to preblend levels. The controversy regarding the future use of the Delta lies in EBMUD's claim to changing EPA standards and the cost of building a treatment facility at Bixler.

In our opinion, the water supply deficit analysis is not complete. The conclusion that the CDFG flow alternative results in greater water supply deficits during two-year and three-year droughts does not consider the alternative of supplementing water supplies with the transfer of water from the Delta, which the DEIS recognizes as a viable option (p. 4-4) and EBMUD has done during the 1976-77 drought and was prepared to do in 1989, using the Bixler pumping station. The DEIS indicates that about a third of total water consumption is used outside (p. 3-67) and that 42 percent of indoor water use is for toilet flushing. Consequently, the use of Delta water during extended drought or when small amounts of supplemental supplies are required should be completely considered and investigated as a viable option.

2-10

CDFG's comment about the proportion of outdoor and toilet flushing water is unclear. Without dual distribution systems all water must be treated to potable standards. The FEIS recognizes that much of this non-consumptive water is used inefficiently and that the water supply deficit analysis includes conservation and reclamation activities as well as the imposition of a drought management program that requires residential consumers to reduce consumption by about 35%. EBMUD has revised its 2020 planning demand downward to 229 MGD. This planning demand in combination with a drought management program would lower 2020 drought sequence demands to 172 MGD.

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Finally, the CDFG wet, normal, and dry water year criteria use the California Department of Water Resources May 1, Report of Water Conditions in California, which is an objective report of the unimpaired runoff in the Mokelumne River for any given water year. This is also consistent with wet, normal, and dry year determinations on other river systems in California. PERC staff's alternative, (described on p. 2-13) appears to be acceptable. However, the observed inflow to Pardee Reservoir, as measured at the U. S. Geological Survey (USGS) stream gauge, is not usually available for several months after the fact. The EBNOD alternative, described on p. 2-11 and 2-12, is unacceptable. We are not aware of any definition of water year type in California that results in dry or critically dry years 50 percent of the time as EBNOD's alternative does.

Minimum Pool Elevation

The information presented in the DEIS supports CDFG's recommendation of a minimum pool elevation in Camanche Reservoir of 210-feet above mean sea level (MSL). It does not support the recommendation of a minimum pool elevation in Camanche Reservoir of 180-feet MSL. Figures 4.2-1 and 4.2-2 demonstrate clearly that maintenance of 210-feet MSL provides suitable water temperatures downstream of Camanche Reservoir for salmon and steelhead. According to p. 4-43, interpolating these results indicates that a minimum pool elevation of 180 feet MSL would provide acceptable water temperatures. Rather than depending on interpolation, we recommend that the Final EIS include a comparative analysis of maintaining a minimum pool elevation of 180-feet MSL, 190-feet MSL, 200-feet MSL, and 210-feet MSL.

The conclusion on p. 5-2 is premature that temperature goals are reasonable, but their attainability is unrealistic for the flows recommended. The minimum pool elevation analysis indicates that the temperature goals are attainable. We also disagree that the minimum release from Pardee is redundant with the minimum pool requirement in Camanche Reservoir (p. 2-10). Their purposes are similar in helping to maintain a cold hypolimnion in Camanche Reservoir, thus improving the water quality and temperature of downstream releases. However, the minimum release from Pardee serves an additional purpose of maintaining the stream between Pardee and Camanche reservoirs. It would not be appropriate to reduce Pardee releases to zero whenever the minimum pool elevation in Camanche Reservoir exceeds 210-feet MSL. Consequently, until additional studies are completed CDFG continues to recommend an interim Camanche Reservoir minimum-surface elevation not less than 210-feet MSL with an interim minimum inflow from Pardee Reservoir of 250 cfs at all times (page xviii of CDFG Plan).

2-11

2-11 The definition of Water Year types in staff's alternative has been revised in the FEIS in response to comments on the DEIS (see Section 2.2.1).

2-12

2-12 The comparative analysis requested has been presented in the FEIS (Appendix C) using the best available data and hydrodynamic modeling.

2-13

2-13 In the DEIS, staff may have underestimated the importance of the Pardee Reservoir tailrace as utilized fisheries and as a contributor to the Camanche Reservoir fish population success. However, the Pardee releases necessary to satisfy minimum pool elevations in Camanche Reservoir will be adequate to protect any fishery values in the Pardee tailwater.

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Finally, CDFG's minimum pool elevation recommendation of 210-feet MSL in Camanche Reservoir will inundate the existing upper-level outlet structure at 201-feet MSL in addition to the lower-level outlet structure at 105-feet MSL. This would allow the selective withdrawal of water from upper reservoir levels, thus storing colder, denser water in the bottom of the reservoir for release at a later time in the year, while utilizing surface or mid-depth waters that meet water quality standards. It would also allow the use of the small floating pumping plant which can withdraw selectively from depths between 30 and 50 feet below the water surface and may help improve water quality at the Mokelumne River Fish Hatchery (MRFH).

Short-Term Daily Streamflow Fluctuation and Streamflow Reduction

FERC staff recognizes the need for instituting ramping rates that would limit changes in river elevation (p. 5-7). However, changes that are limited to less than two inches per hour are difficult to measure for compliance. Based on discussions with the USGS, we now recommend ramping rates based on a percentage of the flow. Additionally, ramping rate criteria from February 1 - May 31, do not protect incubating eggs and emerging chinook fry that may be dewatered or stranded from October 1 through February 1.

To avoid loss of aquatic productivity and to prevent stranding from short-term daily flow fluctuations (defined as changes in flow that occur on a regular daily basis generally associated with daily operations of hydroelectric power generation and deliveries to offstream diverters), CDFG continues to recommend that at all times while Mokelumne River releases from Camanche Reservoir are under control (i.e., no unregulated spills are occurring) daily flow fluctuations should not exceed 10 percent of the average flow within any 24-hour period and weekly flow fluctuations should not exceed 20 percent of the average flow within any 7-day period (p. xvi of CDFG Plan).

Streamflow reductions are defined as planned reductions. Such reductions are generally associated with, but not limited to, the specified monthly flow schedule(s) above, reservoir flood reservation requirements, deliveries to offstream diverters, water transfers and sales, and downstream salinity intrusion control. To prevent fish stranding during all such flow reductions, including those specified in the monthly flow schedule(s) above, ramping should be gradual and not exceeding 30 percent existing initial flow during any 24-hour period.

2-14 Your comment is noted. See the revised hydrodynamic and water temperature modeling presented in the FEIS.

2-15 It is difficult to select the best general regulatory measure of water level fluctuations to avoid stranding fish. The actual detrimental effect occurs on gravel bars and marginal pools where water elevation interacts with gravel topography to prevent fish from maintaining contact with open water as water level drops. This is a microhabitat feature that is inadequately expressed by general streamwide limits on either rate of change in water elevation or percentage change of flow. The FEIS includes these points in Section 4.3.1 of the FEIS as well as retaining the staff's interim limit that was in the DEIS.

Daily streamflow changes are not likely to affect incubating eggs and emerging chinook fry from October 1 through February 1. Research on Vernita Bar chinook salmon spawning beds on the Columbia River and related laboratory studies have shown that embryos and alevins in the gravel are resistant to several hours of dewatering so long as moisture-saturated conditions prevail. In the winter most gravel remains moist until river flows again inundate the redds during the high-flow part of the generating cycle. This discussion has been added to Section 4.3.1 of the FEIS.

2-16 Staff accepts this recommendation for daily flow fluctuations as the CDFG alternative. Please refer to our response to the previous comment.

2-17 Staff accepts this recommendation for streamflow fluctuations as the CDFG alternative. Staff agrees that planned streamflow reductions (that go beyond the daily fluctuation flows of the hydropower cycle) should be gradual. We have clarified our staff recommendation in Section 4.3.1 of the FEIS to specifically include daily fluctuations and more general streamflow reductions. As noted in the response to comment No. 2-15, the functional problem of fish stranding associated with streamflow decreases lies at the microhabitat scale. Any general streamwide criterion is likely to be inadequate. The importance of having a criterion also depends on the presence of vulnerable organisms (particularly salmon fry). Thus, the need depends on the time of year. A blanket criterion of no more than 30% of existing initial flow in any 24-hr-period at any time of year does not seem justified.

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To further minimize the impacts from flow reduction during the period October 1 through February 29, while Mokelumne River releases from Camanche Reservoir are under control (i.e., no unregulated spills are occurring), the following schedule shall prevail to reduce negative impacts on salmon and steelhead spawning behavior, desaturating of redds, net loss of spawning gravels, and loss of juveniles to stranding:

- 1) If the average flow for the preceding 7-day (d) average flow exceeds 500 ft³/s, the flow shall not be reduced below 400 ft³/s.
- 2) If the average flow for the preceding 7-d average flow is 400-499 ft³/s, flows shall not be reduced below 350 ft³/s.
- 3) If the average flow for the preceding 7-d average flow is 300-399 ft³/s, flows shall not be reduced below 300 ft³/s.
- 4) Controlled release flows should not be reduced by more than 300 ft³/s during any 6-d period.

Attraction Flows

In reviewing and comparing the October/November flows to the adult returns for the same year, in general higher flows resulted in a greater number of salmon returning to the Mokelumne River to spawn (p. 17 and p. 199 of CDFG Plan). The Mokelumne River salmon escapement from 1977-1992 was approximately 18 percent of the total San Joaquin and Mokelumne River escapement (ranged from 2 percent to 47 percent). The data suggests there is value in attraction flows for chinook salmon. For example:

- 1987 - 4 percent of escapement (Oct/Nov flows at Woodbridge approximately 64/48 cfs)
- 1988 - 2 percent of escapement (Oct/Nov flows at Woodbridge approximately 48/36 cfs)
- 1989 - 5 percent of escapement (Oct/Nov flows at Woodbridge approximately 34/126 cfs)- attraction flows of approximately 463 cfs from 11/3-11/6
- 1990 - 21 percent of escapement (Oct/Nov flows at Woodbridge approximately 173/158 cfs) - attraction flows of approximately 475 cfs from 10/26-10/29

2-18

- 2-18 Staff recognized the flow schedule outlined in the comment as the CDFG alternative in the DEIS. It further considered this alternative in the FEIS.

2-19

- 2-19 Staff emphasized on p. 4-46 in the DEIS the apparent importance of autumn flows in the Lower Mokelumne River for stimulating and sustaining upstream migration of adult chinook salmon. It was discussed in Section 3.3 (the description of the status of chinook salmon stocks) that because many of the Sacramento-San Joaquin fall chinook salmon are derived from hatchery plantings beyond the Delta, homing is difficult. Returning adults appear to enter those streams with the largest flows at the time. The additional data provided by the CDFG in its comment was useful for documenting this phenomenon and was incorporated into the FEIS as a new figure and paragraph in Section 3.3 and in Section 4.3.2 on attraction flows.

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1991 - 29 percent of escapement (Oct/Nov flows at Woodbridge approximately 100/200 cfs) - attraction flows of approximately 500 cfs from 11/1-11/10

1992 - attraction flows of approximately 700 cfs from 10/26-10/31, resulted in more than 300 salmon counted at Woodbridge that week. The count is now greater than 1500 salmon past Woodbridge.

2-19
(cont.)

In conclusion, the evidence suggests there is value in attraction flows for chinook salmon in the Mokelumne River. We agree with the DEIS that results of future studies should be used to refine the timing, magnitude, and duration of the attraction flows and the benefits of coordinating the release with the lowering of Woodbridge Dam (p.5-2). However, attraction flows may be extremely important during dry years, because the lower minimum flow releases make it more difficult for spawning salmon to successfully return to the lower Mokelumne River. Consequently, CDFG continues to recommend that attraction flows in addition to the minimum proposed flow schedule necessary to induce chinook salmon and steelhead trout into the lower Mokelumne River should be provided below Camanche Dam and Woodbridge Dam during the period October 1 through November 15 in the amount of 20,000 AF during wet and normal water years and 10,000 AF during dry water years (p. xvii of CDFG Plan).

2-20

2-20 Although there is great value in having attraction flows in autumn, as discussed in the DEIS and stressed in the comment, staff feels there is insufficient basis for selecting exact values for the timing, magnitude, and duration of that flow in years of different water availability. The quantitative relationships will become understood with additional experience and monitoring. Staff recognizes the numerical values for the water volumes to be reserved for this purpose that are recommended in the comment as the CDFG alternative.

Outmigrant Flows

The chinook salmon, steelhead trout and other aquatic resources have evolved in the Mokelumne River with relatively high flows during February through June. When salmon are ready to migrate (smolt) from the Mokelumne River to the ocean, these higher flows help to convey them downstream and through the Delta. There is evidence that a significant relationship exists between high-spring flows and adult salmon escapement 2-3 years later on the Tuolumne and Stanislaus Rivers. A review of the Mokelumne River data by CDFG indicates a similar relationship between winter and spring flows and the resultant year class production (p. 17 and p. 199 of CDFG Plan).

2-21

2-21 Staff recognized in the DEIS the value of higher flows in spring for assisting smolt emigration. Staff is grateful to the CDFG for pointing out relevant information from the Stanislaus and Tuolumne rivers and the additional information from the Mokelumne. This information has been considered in the FEIS.

Spring pulse flows have been used on the Sacramento and San Joaquin River systems to increase the survival of downstream migrating salmon. It is important to provide adequate winter and spring flows to ensure the survival of salmon in the Mokelumne River.

2-22

2-22 See response to Comment No. 2-21.

We agree with the DEIS that results of future studies should be used to refine the timing, magnitude, and duration of the outmigrant flows (p. 5-3). These flows should be coordinated

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with other similar releases and limits on Delta water exports. However, the FERC staff does not recommend a specific interim flow amount to be evaluated. Consequently, CDFG continues to recommend that increased spring flows of short duration during April through June be provided to increase survival of young chinook salmon and steelhead trout during downstream migration with 10,000 AF set aside for this purpose during wet and normal water years and 5,000 AF during dry water years (p. xvii of CDFG Plan).

Habitat Protection and Improvement

The DEIS recommends an instream habitat enhancement program that focuses on spawning gravel rehabilitation and maintenance of the stream channel and generally concurs with CDFG recommendations (p. xvii of CDFG Plan). CDFG concurs with the DEIS (p. 5-3) that chemical monitoring of suspended solids and dissolved metals in river water be conducted as stream gravels are reworked. During the State Water Resources Control Board hearing, testimony was presented that there are heavy metals being found in the Mokelumne River, downstream of Camanche Dam, and occasionally their concentrations exceed the Environmental Protection Agency (EPA) standards (p. xviii of CDFG Plan).

Water Quality

Evaluation of the water quality of the Mokelumne River indicates that selected parameters do not meet standards that promote long-term maintenance and growth of aquatic life. This is a result of long-term pollution associated with such sources as Penn Mine, drought, and project operation of Pardee and Camanche reservoirs. To ensure the long-term maintenance and viability of aquatic resources of the lower Mokelumne River, CDFG continues to recommend the following water quality parameters for the river and the MRFR (p. xviii of CDFG Plan):

- 1) Dissolved oxygen levels of not less than 7.0 mg/l.
- 2) The pH not exceeding the range of 6.5-8.5.
- 3) Heavy metal and other constituents should not exceed those recommended by the EPA (1986) for maintenance of fresh water aquatic life and should not cause chronic or acute toxicity to any life stage of aquatic life. Ambient water concentrations for copper, cadmium, and zinc should not exceed those objectives developed by the CDFG for the Upper Sacramento River. The CDFG used an application factor of $0.1 \times K_{LC50}$ (where: K_{LC50} = 96-hr LC50 developed from CDFG

2-23

2-23 Staff did not recommend specific interim flow amounts for spring pulses to benefit emigrating smolts because of a lack of suitable information. Further study was recommended. However, interim flows of 300 cfs (200 cfs in dry years) have been recommended pending additional study.

2-24

2-24 Staff has provided a review of recent water quality data (primarily heavy metal concentrations) in the FEIS. In addition to monitoring metal concentrations in the water as stream gravels are reworked, staff has also recommended that possible biological effects also be monitored.

2-25

2-25 Staff agrees with CDFG's proposed pH criteria. Staff also agrees that the presence of heavy metals and other contaminants at concentrations that cause acute or chronic effects to aquatic life is also unacceptable. Because the methods for controlling the concentrations of contaminants in the Lower Mokelumne River are very limited and there has been no evidence of either acute or chronic effects of contaminants in recent years, staff is opposed to establishing strict water quality criteria which may be impossible to meet. Staff does support efforts to stop releases from the original source (Penn Mine) to Camanche Reservoir. Staff has proposed a mode of operation for Camanche Dam which staff feels will minimize the release of heavy metals associated with resuspended sediments during fall turnover and minimize the resuspension of sediments due to prolonged exposure of large expanses of lake bottom.

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studies) together with the hardness relationship of the EPA to develop the following recommendations:

Hardness (mg/l)	Copper (ug/l)	Cadmium (ug/l)	Zinc (ug/l)
20	3	0.10	9
30	5	0.16	13
40	7	0.22	16
50	8	0.29	19
60	10	0.36	22
70	11	0.43	25
80	13	0.50	28
90	14	0.57	31
100	16	0.65	34

2-25
(cont.)

CDFG agrees with FERC staff's recommendations to improve water quality by preventing high flows from Penn Mine into Camanche Reservoir and maintaining Camanche Reservoir elevation such that there is sufficient hypolimnetic volume to sustain biological decomposition without major anoxia (p. 5-3). However, we emphasize that even though it may be technically difficult to maintain 7 mg/l dissolved oxygen throughout the summer and fall, it is important that minimum water quality standards be enforced. Maintaining the Camanche Reservoir minimum surface elevation not less than 210 feet MSL with an interim minimum inflow from Pardee Reservoir of 250 cfs at all times, may ensure that dissolved oxygen levels are maintained at 7 mg/l throughout the summer and fall. We concur with the recommendation that a formal monitoring program should be implemented to establish a long-term data set of representative temperature and dissolved oxygen profiles (p. 5-8).

2-26

Should the maintenance of Camanche Reservoir minimum surface elevation (not less than 210-feet MSL) prove successful in maintaining satisfactory dissolved oxygen levels, then the experimental hypolimnetic oxygenation pilot study would become unnecessary. We agree with FERC staff that hypolimnetic oxygenation is experimental and satisfactory performance is not assured (p. 4-61). If the pilot study is implemented it should be coupled with a strong monitoring program (p. 5-7) and close coordination with the resource agencies. Even if hypolimnetic oxygenation is successful in maintaining adequate dissolved oxygen levels and reducing hydrogen sulfide levels, it will not likely solve the problems of heavy metals in the reservoir and the lower Mokelumne River.

2-27

2-26 Your comment is noted, but staff disagrees. The minimum pool level in Camanche will not, in itself, ensure that CDFG's DO objective will be satisfied in the releases from Camanche Dam. Furthermore, in our final recommendations, staff finds that CDFG's minimum pool requirements would incur excessive costs to the licensee and would not provide justified, incremental benefits to the anadromous fishery in the Camanche tailwater. The management of Camanche Reservoir may require elevated pool levels, however, it is the quality and quantity of the releases from Camanche Reservoir that will affect the fish and wildlife resources in the downstream Mokelumne River.

2-27 As EBMUD has correctly stated, the hypolimnetic oxygenation proposal would have benefits beyond improving tailwater dissolved oxygen (i.e., in stabilizing hypolimnetic water quality). Staff believes that this is worth exploring.

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Consequently, we recommend that the feasibility and possible benefits of selective withdrawal alternatives need to be explored (p. 2-21). We concur that considerable water quality management in the lower Mokelumne River may be possible if both Pardes and Camanche dams had multiple outlet structures for the downstream releases, including those used for hydropower. This type of management might allow cool water from Pardes Reservoir to be used to flush the deeper waters of Camanche Reservoir in a density underflow, thus minimizing the buildup of toxic materials and maintaining cool temperatures in the Camanche discharge.

Escapement Goals

Establishment of escapement goals is a responsibility and under the sole authority of the State as the Constitutional agency responsible for fish and wildlife management within the State of California. FERC shall revise the DEIS to recognize this fact and include the State's escapement goals.

Furthermore, we disagree with FERC staff's unsubstantiated conclusion that the natural escapement goal of 5,000 salmon is probably unrealistic (p.5-3). A review of the estimated chinook salmon runs in the lower Mokelumne River shows a range of 100 to 15,900 salmon returning to spawn. We believe that implementation of CDFG's flow recommendation will provide suitable conditions for a greater number of spawning salmon on a consistent basis. We also consider this goal and the 10,000 chinook salmon goal for the hatchery as ESHUD's mitigation responsibility. During the 26-year period, since completion of Camanche Dam, the escapement goals of 15,000 chinook salmon and 2,000 steelhead trout adult spawners annually have not been met. We recommend that this now be included as a mitigation obligation under the FERC license.

Most of the steelhead trout habitat has been eliminated in the lower Mokelumne River due to the construction of Camanche and Pardes dams. Consequently, we did not recommend an escapement goal for a natural steelhead run. CDFG anticipates that our flow, temperature, and water quality recommendations will provide increased steelhead habitat, thus increasing the numbers of naturally reproduced steelhead. The focus on restoring natural runs of chinook salmon and steelhead trout is appropriate. We agree with FERC staff that steelhead spawning, incubation, rearing, and outmigration should be carefully monitored; hatchery production should supplement it and not substitute for the natural population (p. 5-3 and p. 5-8).

2-28 Your comment is noted.

2-29 The FEIS includes presentation and discussion of the CDFG escapement goals. It does not question the state's responsibility and authority to set such goals. However, the Commission is obligated under law to conduct an independent analysis. Staff's independent analysis of the historical record supports the view that a goal of 5,000 adults not of hatchery origin has probably been unrealistic under the past and current conditions, as stated in Section 5.1.1 of the FEIS. The total run has exceeded this goal in only 8 years since 1940. The goal may be more realistic as a sustainable average with restoration efforts proposed in the EIS. These points were expanded in Section 5.1 of the FEIS.

2-30 See response to comment No. 2-29. The staff's review of the salmon runs to the Mokelumne River and the relationship of natural to hatchery-produced fish supports the conclusion that a goal of an average of 5,000 naturally produced adult fish in the highly developed Lower Mokelumne River is probably unrealistic. The fact that this escapement goal has not been consistently met by the entire run (including hatchery-derived stock) for 26 years suggests that it may be overly optimistic and not an appropriate basis for mitigation obligation. Further discussion has been presented in Section 3.3.1 of the FEIS.

2-31 Your comment is noted.

2-28

2-29

2-30

2-31

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Water Diversion and Fish Screens

We note that FERC staff concurs with CDFG that water diversions should be screened with current state-of-the-art screening devices (p. 5-3). We recognize that KENUD does not have the responsibility under its FERC license to screen the downstream diversions on the lower Mokelumne River. CDFG is willing to work with the other parties (including KENUD, WID, and NAWTCD) to ensure adequate screening and meet the goals of our Plan (p. xix of CDFG Plan).

2-32

2-32 Your comment is noted.

Fish Passage

We note that FERC staff concurs with CDFG that fish passage improvements at Woodbridge Dam seem reasonable (p. 5-4). We recognize that KENUD does not have the responsibility under its FERC license to make modifications at Woodbridge Dam to improve fish passage for upstream migrating adult salmon and downstream migrating juvenile salmon. CDFG is willing to work with the other parties (including KENUD and WID) to ensure adequate fish passage and meet the goals of our Plan (p. xix of CDFG Plan).

2-33

2-33 Your comment is noted.

Riparian Habitat Maintenance and Protection

We note that FERC staff concurs with CDFG that riparian habitat is important for salmon and steelhead in the lower Mokelumne River (p. 5-4). We recognize that KENUD's responsibility under the FERC license is limited to its property downstream of Camanche Dam. CDFG is willing to work with the other parties (including KENUD and WID) to implement programs for protection, restoration, improvement, and acquisition of riparian habitat to meet the goals of our Plan (p. xx of CDFG Plan).

2-34

2-34 Your comment is noted. The Commission encourages such third-party agreements as long as they do not conflict with existing license conditions.

Public Access for Recreation

FERC staff recommends that KENUD work collaboratively with CDFG and other parties to provide appropriate public access during times and at locations where adult salmon are not particularly vulnerable to additional fishing pressure in the lower Mokelumne River (p. 5-4). We recognize that KENUD's responsibility under the FERC license is limited to its property downstream of Camanche Dam in the Van Arsen Park area. CDFG is willing to work with the other parties (including KENUD and WID) to provide and improve access at additional sites on the lower Mokelumne River to provide for a wide base of recreational activities and to meet the goals of our Plan (p. xx of CDFG Plan).

2-35

2-35 See previous response.

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Additional Studies

We note that FERC staff concurs with CDFG that additional modeling studies should be conducted to evaluate Pardee and Camanche reservoirs for their capability to manage water temperature, water availability, and to establish operational procedures and criteria (p. 5-4). FERC staff also recommends that monitoring programs and additional studies be conducted to fully define the mitigation needs for the lower Mokelumne River Project (p. 5-8). Based on the CDFG Plan and review of FERC's DEIS, we recommend that additional studies include, but not be limited to: (1) prediction of the effects of altered project operations on water temperatures downstream of Camanche Dam; (2) characterization of the reservoir elevations drawn upon by the intake structures at Pardee and Camanche reservoirs; (3) characterization of the water temperature regime and volume of cold water present in these reservoirs available to the intake structures; (4) evaluation of selective withdrawal structures or curtains for water quality management; (5) studies to refine the timing, magnitude, and duration of the attraction flows; (6) studies to refine the timing, magnitude, and duration of emigration flows; (7) monitoring chinook salmon and steelhead spawning, incubation, rearing, and outmigration in the river; (8) temperature and water quality monitoring to establish long-term temperature, dissolved oxygen, and pH profiles in addition to monitoring concentrations of heavy metals in the reservoir and the lower Mokelumne River; and (9) studies to evaluate fish losses at several diversions, and should evidence show need, those diversions should be screened or existing screens upgraded to meet current CDFG criteria.

2-36

2-36 Your comment is noted. See Section 5 of the FEIS for staff's final recommendations.

Thank you for the opportunity to comment on the lower Mokelumne River Project (FERC No. 2916). If you have any questions regarding our comments please contact Mr. Jerry Mensch, Environmental Services Supervisor, California Department of Fish and Game, 1701 Nimbus Road, Rancho Cordova, California 95670, telephone (916) 355-7030; or Ms. Cindy Chadwick, Environmental Services Division Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814, telephone (916) 653-9743.

Sincerely,

John L. Turner, Chief
Environmental Services Division

cc: See Attached List

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IX

75 Hawthorne Street
San Francisco, Ca. 94106

February 23, 1993

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Return Receipt Requested

Ms. Lois D. Cashell, Secretary
Federal Energy Regulatory Commission
925 North Capitol Street, NE
Washington, DC 20426

Re: Draft Environmental Impact Statement
Lower Mokelumne River Project
FERC Project Number 2916-004

Dear Ms. Cashell:

The U. S. Environmental Protection Agency (EPA) has reviewed the Draft Environmental Impact Statement (DEIS) for Proposed Modifications to the Lower Mokelumne River project, California. We provide our comments pursuant to the National Environmental Policy Act (NEPA), Section 309 of the Clean Air Act and the Council on Environmental Quality's (CEQ) Regulations for implementing NEPA.

The proposed action considers possible modifications to the operation of the Lower Mokelumne River Project and other non-flow mitigation measures to improve fisheries in the Lower Mokelumne River. The project sponsor is considering these modifications based on requests to investigate and correct fishery impacts in the Lower Mokelumne River.

The DEIS discusses three potential action alternatives and a no action alternative. The proposed action, recommended by FERC staff, attempts to strike a balance between the other two action alternatives which are plans proposed by California Department of Fish & Game and the licensee, East Bay Municipal Utilities District.

Based on our review of the Draft EIS we have classified this document as Category EC-2, Environmental Concerns - Insufficient Information (See enclosed "Summary of Rating Definitions and Follow-up Action"). The DEIS is rated "EC", Environmental Concerns, because of the potential cumulative impacts to flows from upfield developments and how they may affect the project sponsor's ability to achieve the project goals. This DEIS is rated "2", Insufficient Information because it does not discuss the means by which the project sponsors will measure the success of the project and it does not fully discuss the potential minimum flow and pool impacts, particularly temperature effects. The Final EIS should expand its discussion of these subjects.

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3-1

3-1 It is the Commission that is considering the need for project modification in this proceeding. However, EBMUD has parallel deliberations on-going, as explained in Sections 1 and 2 of the FEIS.

3-2

3-2 The discussion of cumulative impacts has been expanded in the FEIS, but it remains limited to the scope of this proceeding, as explained in Section 1. Additional details are provided in the FEIS on monitoring programs that will determine the success of recommended mitigation measures. Further analyses of temperature effects have also been added to the FEIS in Sections 3 and 4.

We are enclosing Attachment 1 which contains our detailed comments and which is hereby incorporated into our comment letter.

We appreciate the opportunity to review and provide comments on this Draft EIS. Please send two copies of the Final EIS to this office at the same time it is officially filed with our Washington, DC office. Please send one copy of the Record of Decision to this office when it is signed. If you have any questions, please feel free to contact me at (415) 744-1015, or Kathryn Mazaika of the Office of Federal Activities at (415) 744-1575.

3-3

3-3 All commentors on the DEIS have been added to the distribution list for the FEIS.

Sincerely,

Deanna M. Wieman, Director
Office of External Affairs

Enclosures: (1) Attachment 1-Four pages of comments
(2) Summary of Rating Definitions & Follow-Up Action

NI# 001585: FERC2916.DEI

cc: John Schnagl, Federal Energy Regulatory Commission
Tom Richardson, U.S. Fish & Wildlife Service-Sacramento
Jerry Mensch, California Department of Fish & Game
Mike Meins, State Water Quality Control Board
Regional Water Quality Control Board-Central Valley Region
John Lampe, East Bay Municipal Utility District

NEPA COMMENTS

Attachment 1

Cumulative Impacts

The DEIS states that the cumulative impacts of future development in the upper Mokelumne River basin are beyond the scope of this EIS, but that this issue may be taken up in future Commission proceedings or licensing actions (page 1-4). Proposed hydropower development in the upper basin includes the Devil's Nose/Cross County Project (FERC Project Nos. 8759 and 8144) (a new dam) and the revision to the existing Pacific Gas & Electric (PG&E) Mokelumne Project (FERC Project No. 137) (increase height of two dams, increase diversion capacity and build several new powerhouses) (page 3-4).

We appreciate the fact that cumulative impacts may be discussed in future hearings, but are concerned that the impacts of building and operating these upper basin projects may directly affect the goals of the proposed action. Although the project sponsor asserts that development in the upper basin is beyond the scope of this document, we believe the EIS should nevertheless discuss the cumulative impacts of these hydropower projects if they are reasonably foreseeable. The CEQ Regulations for implementing NEPA define "scope" and "cumulative impact" at Sections 1508.25 and 1508.7, respectively. For example, we believe that the EIS should discuss how building these projects may affect the flows embodied in this proposal given the fact that these developments would impound waters upfield of the project area.

PROPOSED FLOW- AND NONFLOW-RELATED ACTIONS

Flow-Related Mitigation Actions (page 5-7)

1) The staff's minimum flow requirements are based mainly on physical habitat simulation (PHABSIM) analysis and temperature modeling of flow alternatives with the assumption of certain minimum pool elevations. While these are two major factors in providing anadromous fish with adequate habitat, there are other important factors used in an instream flow incremental methodology (IFIM) analysis, such as food and cover, which can vary with flow and temperature. These other factors should be taken into account when analyzing the relative merits of the alternative actions, as was done in the CDFG "Lower Mokelumne River Fisheries Management Plan."

2) Although the DEIS mentions that episodic releases during fall turnover has caused water quality problems and fish kills, there is not enough analysis of the likelihood of this event and its consequences for the river resources at the three alternative

3-4 The scope of the compliance proceeding that is the subject of this assessment was described in Section 1 of the FEIS.

3-5 As explained in the FEIS, upper basin projects will be bound by the Lodi Decrees, third party agreements that regulate inflows to Pardee Reservoir. Also see the expanded discussion of cumulative impacts in Section 4.7 of the FEIS.

3-6 These issues were considered in the DEIS and were the subject of additional discussion in the FEIS.

3-7 This discussion of risks has been added to the FEIS.

pool elevations. The risk of this event and its consequences must be clearly included in the discussion of the alternatives, and taken into account in the recommendation. The recommended measures must result in meeting all water quality standards in the river.

3-7
(cont.)

3) The analysis of methods to improve temperature in the Mokelumne River uses predicted temperature at four specific sites "representative of areas where important life history stages occur" (page 4-28). These sites are then used to define temperature conditions for different life stages under various alternatives and weather conditions. The goal should be to optimize the river distance available to each life stage (especially spawning), not, as in this analysis, to meet certain temperatures at those specific sites. This is possible using temperature criteria for different distances downstream of the dam, based on water year type (as defined by the SWRCB), such as has been done below Shasta Dam. The analysis should be aimed at this goal.

3-8

4) Spike flows may be most important, and their success most obvious during dry and critical years. The pulse flows recommended by CDFG should be instituted and monitored to be sure that they are providing the expected benefit. If it can be demonstrated that they are not, then this requirement can be changed.

3-9

Non-Flow Mitigation Actions

Steelhead Trout Biology

The DEIS states that despite years of stocking, no natural population of steelhead is developing in the river (page 4-12). We support the staff's proposal to monitor steelhead trout, but recommend that the FEIS discuss thresholds that will be used to measure improvement and, alternatively, to determine whether management of naturally reproducing steelhead is an unrealistic objective. We recommend working with California Department of Fish & Game and the U.S. Fish & Wildlife Service in developing these thresholds.

3-10

ANALYSIS OF MINIMUM FLOW REQUIREMENTS

Water Supply Deficiencies (page 4-2)

The assumptions behind the 2020 normal demand figure should be clearly identified and supported, since the DEIS uses this demand to estimate economic impacts of the alternatives, and discusses the difficulty in meeting this demand under the CDFG alternative (page 4-12). Other demand scenarios should be

3-11

3-8 Staff does not agree that optimizing river distance for a particular life-stage temperature requirement is any better a strategy than trying to achieve a target temperature at a representative site for that life stage. In the spring, when life stages for which critical temperature requirements are being evaluated occur, the difference in estimated temperature throughout the rearing reach is minimal [i.e., > 35.6°F (2°C)] under normal flow and meteorological conditions. Even under hot and dry conditions staff still feels that a single point in the reservoir adequately represents a 5- to 10-mile river reach. In addition, the representative sites are in the middle or lower half of the reach in question (e.g., spawning or rearing). If the temperatures are adequate at that point, we can be assured that they are adequate in the upstream portion of the reach as well.

3-9 Your comment is noted.

3-10 Your comment is noted. The FEIS concludes that reestablishment of a naturally reproducing run of steelhead is probably not realistic in the tailwaters of Camanche Dam because of habitat limitations (see Sections 3.3.2 and 5.1 of the FEIS).

3-11 The section on forecasting demand has been expanded with more discussion of how EBMUD arrived at their 2020 planning demand (e.g., Appendix D). The FEIS also includes sensitivity analysis on the demand-side. See comment No. 2-10.

included, especially current water delivery as a baseline, and minimal increase of deliveries to current delivery areas. These other demands should more clearly define the cost in current terms, and should also define the cost when fishery and wildlife resource needs are assumed to require as much protection as water supplies to KSMUD customers. Alternative supplies from the Delta at the Bixler pumping station should also be considered in the water supply analysis.

3-11
(cont.)

WATERS OF THE U.S.

The project sponsor contemplates a number of hydraulic modifications to lower temperatures in the Mokelumne River in late spring and summer, among them improvements at Woodbridge Dam and Lake Lodi. The DEIS mentions the option of excavating and dredging a 6,000 foot channel in Lake Lodi and constructing a submerged sill across the present channel (page 2-20). It also mentions the possibility of using submerged dams and channelization near the Woodbridge Irrigation District diversion (page 2-17). Measures which involve construction or placement of instream structures in waters of the U.S. must comply with the 404(b)(1) Guidelines (40 C.F.R. Part 30) promulgated pursuant to Section 404 of the Clean Water Act. The EIS should:

a. demonstrate that the project sponsors have selected the least damaging practicable alternative based on costs, logistics and existing technology with respect to waters of the United States, including special aquatic sites. [40 C.F.R. § 230.10(a)]

b. describe how the project sponsors will avoid, minimize and mitigate the potential impacts of implementing each of the alternatives.

c. demonstrate that implementing the action will not jeopardize the continued existence of species listed as endangered or threatened under the Endangered Species Act of 1973 or result in the destruction or adverse modification of a habitat which is critical habitat under the Endangered Species Act of 1973.

d. discuss how the impacts of the proposed action may contribute to cumulative losses of special aquatic sites, including wetlands, in the area.

e. discuss whether the project will cause or contribute to significant degradation of the waters of the United States.

3-12

3-12 Staff's recommendations were not intended to imply that 404 permits would be required.

WATER QUALITY RELATED TO PENN MINE

The Final EIS should reflect that EPA recently issued CERCLA Section 104 notice to East Bay Municipal Utilities District to avert the release and threatened release of hazardous substances, pollutants or contaminants from the Mine Run Dam Reservoir at the Penn Mine Site. Since the activities requested to respond to the release or threatened release include monitoring and reporting requirements, we recommend that the Final EIS include the results of sampling obtained to characterize nearfield and background water quality in Camanche Reservoir.

3-13

- 3-13 The specific information referred to has been included and any other related information available to the Commission at the time of the issuance of the FEIS has been included in Section 3.1.3 of the FEIS.

SUMMARY OF RATING DEFINITIONS AND FOLLOW-UP ACTION

Environmental Impact of the Action

LO-Lack of Objections

The EPA review has not identified any potential environmental impacts requiring substantive changes to the proposal. The review may have disclosed opportunities for application of mitigation measures that could be accomplished with no more than minor changes to the proposal.

EC-Environmental Concerns

The EPA review has identified environmental impacts that should be avoided in order to fully protect the environment. Corrective measures may require changes to the preferred alternative or application of mitigation measures that can reduce the environmental impact. EPA would like to work with the lead agency to reduce these impacts.

EO-Environmental Objections

The EPA review has identified significant environmental impacts that must be avoided in order to provide adequate protection for the environment. Corrective measures may require substantial changes to the preferred alternative or consideration of some other project alternative (including the no action alternative or a new alternative). EPA intends to work with the lead agency to reduce these impacts.

EI-Environmentally Inadequate

The EPA review has identified adverse environmental impacts that are of sufficient magnitude that they are unsatisfactory from the standpoint of environmental quality, public health or welfare. EPA intends to work with the lead agency to reduce these impacts. If the potential unsatisfactory impacts are not corrected at the final EIS stage, this proposal will be recommended for referral to the Council on Environmental Quality (CEQ).

Adequacy of the Impact Statement

Category 1-Adequate

EPA believes the draft EIS adequately sets forth the environmental impact(s) of the preferred alternative and those of the alternatives reasonably available to the project or action. No further analysis or data collection is necessary, but the reviewer may suggest the addition of clarifying language or information.

Category 2-Insufficient Information

The draft EIS does not contain sufficient information for EPA to fully assess environmental impacts that should be avoided in order to fully protect the environment, or the EPA reviewer has identified new reasonably available alternatives that are within the spectrum of alternatives analyzed in the draft EIS, which could reduce the environmental impacts of the action. The identified additional information, data, analysis, or discussion should be included in the final EIS.

Category 3-Inadequate

EPA does not believe that the draft EIS adequately assesses potentially significant environmental impacts of the action, or the EPA reviewer has identified new, reasonably available alternatives that are outside of the spectrum of alternatives analyzed in the draft EIS, which should be analyzed in order to reduce the potentially significant environmental impacts. EPA believes that the identified additional information, data, analysis, or discussion are of such a magnitude that they should have full public review at a draft stage. EPA does not believe that the draft EIS is adequate for the purposes of the NEPA and/or Section 309 review, and thus should be formally revised and made available for public comment in a supplemental or revised draft EIS. On the basis of the potential significant impacts involved, this proposal could be a candidate for referral to the CEQ.

^aFrom: EPA Manual 1648, "Policy and Procedures for the Review of Federal Actions Impacting the Environment."

WATER RESOURCES

WATER RESOURCES DIVISION • WASHINGTON, D.C. • PHONE (202) 833-2400
FAX: (202) 833-2400 • ADDRESS: 1200 K STREET, N.W.

COPY

February 24, 1993

50 FEB 26 1993

REGULATORY COMMISSION

Ms. Lois D. Casbell, Secretary
Federal Energy Regulatory Commission
825 North Capitol Street, N.E.
Washington, D.C. 20426

SUBJECT: REVIEW AND COMMENTS ON FERC/REGIS-0047 PROPOSED
IDENTIFICATIONS TO THE LOWER MISSISSIPPI RIVER PROJECT,
CALIFORNIA (FERC PROJECT NO. 2916-004)

Dear Ms. Casbell:

Please find enclosed an original plus eight (8) copies of Amador County's comments, with attachments, on the subject Draft Environmental Impact Statement.

Also included as attachments relative to Amador County's water needs are the following:

- o EXHIBIT IDENTIFICATION INDEX
- o 10 EXHIBITS PER EXHIBIT IDENTIFICATION INDEX
- o EXHIBIT "A" - Issues of Proposed FERC License Plan Release on Water Available to Amador County, by R.W. Beck and Associates, dated January 1993

If you have any questions concerning this document or its attachments, please contact me at (209) 223-6394.

Very truly yours,

Roderick E. Schaler
Roderick E. Schaler, P.E.
Director

RES:mb

Attachments

cc: See Attached List

REVIEW AND COMMENTS ON FERC/DEIS-0067
 PROPOSED MODIFICATIONS TO THE
 LOWER MOKELUMNE RIVER PROJECT, CALIFORNIA¹
 (FERC PROJECT NO. 2916-004)

I. Introduction and Summary

This document contains comments of the County of Amador, California, regarding the referenced Draft Environmental Impact Statement prepared by the FERC staff regarding proposed modifications to the Lower Mokelumne River Project in California.

Much of Amador County is within the drainage basin of the Mokelumne River, and the river forms the southerly boundary of the county for a distance of some 65 miles. The Mokelumne is present major source of water supply for municipal and domestic purposes within Amador County and is expected to provide additional supplies for the county in the future upon completion of a proposed water supply and hydroelectric project. Therefore, the allocation of the waters of Mokelumne River to instream uses, for export to the East Bay Area, and to adjacent counties and water districts, is a major concern to Amador County.

Any additional instream flow releases will adversely impact Amador County as pointed out further in this document and supported by the attached Model Study shown as EXHIBIT "A", titled "Impacts of Proposed FERC Instream Flow Releases on Water Availability to Amador", by R.W. Beck and Associates, dated January 1993.

A review of the draft EIS reveals that the document totally ignores water demands and water uses in the counties of origin, such as the river reach and basin upstream from Pardee Reservoir. Although comments regarding the EIS scoping process were filed with the FERC in April 1992 regarding potential impacts of the proposed FERC action on Amador County, no response, analysis or consideration in regard to such comments is contained within the document. Since receipt of the draft EIS, Amador County has

4-1

- 4-1 Potential effects of increased fish flows below Camanche Dam on future water users in the basin are discussed in the FEIS, Sections 4.1, 4.7, and 5.2.1.

4-2

- 4-2 These potential impacts are discussed in the FEIS. However, it must be noted that the Devil's Nose Project and the new potential water right associated with it are in the application stage and are subject to revision or possible rejection in the process of federal and state regulatory proceedings. These potential projects have applications but no active water rights. Therefore, impacts to these potential rights are not given the same weight in the FEIS as existing projects with actual water rights.

¹ Draft Environmental Impact Statement, FERC Project Number 2916-004, Federal Energy Regulatory Commission, Office of Hydropower Licensing, October 1992.

undertaken additional impact analyses using information from the DEIS to demonstrate that very significant adverse impacts would occur to the water supply yield of the County's proposed Devil's Nose Project if the proposed minimum instream flows as recommended by the FERC staff were implemented. An Application for License for the Devil's Nose/Cross County Water-Power Project, FERC Project No. 8144-003, is currently pending before the Commission. Descriptions of the impacts on Project yield and the methodology used in assessing such impacts are presented in Section III of this document. At an East Bay Municipal Utility District (EBMUD) water demand of 250 mgd, the FERC staff proposal would reduce the projected water-supply yield of the Devil's Nose Project by over 35% from 17,800 acre feet per year ("afa") to 11,200 afa.

4-2
(cont.)

Also, we have enclosed for FERC's information Amador County's testimony, Exhibit Amador 2, presented to the California State Water Resources Control Board during the November and December 1992 Water Right Hearings on the Lower Mokelumne River. This testimony includes analysis of potential impact to Amador County's water supplies from the Mokelumne River under both California Department of Fish and Game (CDFG) and EBMUD proposed fish release programs. At the same time EBMUD water demand of 250 mgd, CDFG's proposal would reduce the projected Devil's Nose yield by over 55%, from 17,800 afa to 7,600 afa; EBMUD's proposal would reduce this yield by about 13% from 17,800 afa to 15,400 afa.

4-3

4-3 Your comment and supporting information have been noted.

In summary, the draft EIS ignores impacts of changed instream flow releases on upstream water availability, water use and water rights, and does not explain the water rights from which the additional instream water would be taken, or the relative level in the hierarchy of water rights at which the new instream flows would be placed. Under the FPA and the ECPA, FERC must consider all beneficial public uses, including these critical needs in Amador County.

4-4

4-4 Staff has addressed these impacts in both the DEIS and the FEIS (e.g., Section 3.2.1 and Appendix G). However, as evidenced by State Board comments on Amador County's modeling and application for future water rights (e.g., letter from Katherine Mrowka, California Water Resources Control Board staff, to Roderick E. Schuler, County of Amador, July 2, 1993), the exact hierarchy of water rights is by no means clear. It is not the intention of this proceeding to sort out state water rights, nor is a basin-level analysis within the scope of this assessment.

II. Comments on Specific Sections of the Draft EIS

1. Executive Summary. (page xxiii).

The third paragraph indicates the FERC evaluation is limited to the costs each action would impose on EBMUD's water supply only and does not include water-supply costs

4-5

4-5 Staff concluded that there would not be any appreciable water supply impacts or costs to other parties. If there are any impacts they would only occur under an extremely unlikely drought event. Moreover, these potential impacts (if any) must be weighed relative to the gains from increased fish populations.

- to other parties. Because significant water costs to Amador County would result from the proposed action, such costs should be documented. 4-5 (cont.)
2. Executive Summary. (page xxiv).
In the first full paragraph, again, the identified impacts to water supply are limited to those on the EBMUD system. This paragraph also assumes that other water rights in the Lower Mokelumne River must be accounted for and protected and satisfied in addition to releases for fish resources, but no mention is made of upstream water rights or future water needs in Amador and Calaveras Counties. 4-6
3. Scoping of DEIS. (page 1-3).
The comments filed by Amador County with regard to the scoping process were not considered in drafting the EIS. Only water supply impacts to EBMUD are analyzed. Primary issues are stated to include water quantity and quality and socioeconomic issues related to water supply and demand. However, no mention is made of Amador County in this regard. Such issues being addressed are those limited to EBMUD. 4-7
4. Middle paragraph. (page 1-4).
Although new Mokelumne River development in the upper basin may be taken up under other FERC licensing proceedings in the future, if the current proceeding results in reallocation of water to fishery resources to the detriment of Amador County's water rights, then Amador County's proposed project may become infeasible and the future proceeding may be moot. 4-8
5. No-Action Alternative. (page 2-14).
The 1961 agreement between CDPG and EBMUD does distinguish between wet and dry years and provides distinctly different instream flows depending on the classification of each year. 4-9
- 4-6 This concern was addressed in the FEIS. Also, see response to comment No. 4-2.
- 4-7 All comments filed during scoping were considered. Any direct impacts associated with the proposed action were discussed in the DEIS. The impacts that you postulated were considered too speculative for inclusion in the FEIS. This proceeding was not designed to be a basin-level analysis of all foreseeable or unforeseeable water uses.
- 4-8 Your comment is noted.
- 4-9 This statement has been corrected in the FEIS.

<p>6. <u>First paragraph. (page 2-24).</u>
The estimated costs of additional fish releases apparently <u>do not</u> include costs to Amador County or to any entity other than EBMUD.</p>	4-10	4-10 The costs presented in the DEIS pertain only to EBMUD. See comment No. 4-9.
<p>7. <u>Bottom paragraph. (page 3-4).</u>
The description of the Devil's Nose Project does not include the Devil's Nose Powerhouse, nor does it indicate the installed generating capacity proposed for the Project. Further, there is no mention of the water supply for Amador County as being the primary project purpose. The discussion is limited to hydropower only, and interactions between development in the upper and lower basins to be addressed in future proceedings is apparently limited to hydropower only.</p>	4-11	4-11 The description of the Devil's Nose-Cross County Project has been updated in the FEIS.
<p>8. <u>Amador and Calaveras Counties. (page 3-14).</u>
The second sentence in the first paragraph should list the present annual diversions of 9,000 acre feet at the Amador Canal.

The last line in the second paragraph indicates that data are not available for documenting actual water use by these counties. This statement ignores the report issued by the California Department of Water Resources in March 1990 titled, <u>Mountain Counties. Water Management Studies. Amador County.</u> Also, this paragraph does not indicate that the existing Amador County entitlement to 20,000 acre/ft of Mokelumne River water will not be sufficient to meet future needs in the County.</p> | 4-12 | <p>4-12 The FEIS has been revised to reflect your comment.</p> |
| <p>9. <u>East Bay Municipal Utility District (EBMUD). (pages 3-14 and 3-15).</u>
The discussion of EBMUD's water usage includes no mention of forecasts of future water demands by this district or upstream counties.</p> | 4-13 | <p>4-13 See previous response.</p> |
| <p>10. <u>Socio-Economic Resources. Section 3.5 (page 3-61).</u>
Because the section headed "San Joaquin County" actually discusses San Joaquin, Amador, and Sacramento Counties, the heading should be changed to list all three counties.</p> | 4-14 | <p>4-14 Forecasts of future water needs for Amador County are presented in Section 3.2.1 of the FEIS. However, the water balance model used in the analysis does account for demand growth of upstream and downstream users as established by water rights.</p> |
| | 4-15 | <p>4-15 The FEIS has been revised to reflect your comment.</p> |

11. Water Demand and Supply Issues, Section 3.6 (pages 3-67 to 3-79).

This section discusses EBMUD's water-supply issues in detail and correctly states that modifications to facilities or project operation would affect EBMUD's ability to meet its water demand. However, similar effects on other water users, such as those in Amador County, are not discussed. The FERC staff and CDFG proposals would have serious water-supply impacts in Amador County. These impacts should be discussed.

4-16

4-16 It was concluded that there would not be any immediate water supply impacts to Amador County. Any potential impacts would be minor relative to the gains from increased fish populations. Longer term impacts to water supply is unpredictable because of water management uncertainties in the state.

12. Minimum Flow Requirements, Section 4.1 (pages 4-1 to 4-27).

Losses to "other" water users are mentioned, but apparently only in regard to users located downstream of Camanche Dam. Again, upstream users are ignored in this analysis. To be complete, the analysis must also consider and discuss upstream impacts, including the impacts on Amador County water supplies.

4-17

4-17 The FEIS has been revised to discuss staff's understanding of upstream, future water users in Section 3.2.1, 4.1, and Appendix G.

13. Assessment Method, Section 4.1.1 (page 4-1).

A water balance model used by the FERC considers minimum flow requirements for fish and all downstream water rights, and deficits in water supply to EBMUD. Upstream rights and deficits to other entities are not included in the model, thus making it inadequate for assessing impacts of the proposed action.

4-18

4-18 The meaning of this comment is unclear. Existing upstream water rights and uses are accounted for in the water balance model in terms of historical inflows to Pardee Reservoir. Future uses that may modify this historical flow regime were considered too speculative to include in this assessment.

14. Flow Alternatives, Section 5.2.1 (pages 5-4 to 5-6).

While negative impacts to the EBMUD water supply and hydro-power production are discussed in some detail, negative impacts to other existing water supply systems and to other proposed projects, like those in Amador County, are not. The EIS needs to discuss and consider these other impacts.

4-19

4-19 Other water supply systems and future projects were discussed in this section of the FEIS.

15. Appendix B. Hydrologic Water Budget Model.

a. Model Description and Operating Constraints (pages B-1 to B-6):

It is not clear whether this model operates within the constraints contained in EBMUD's water rights, but the implication is that such constraints are not considered. Because these constraints place some limitations on EBMUD's ability to divert water under the District's rights, they must be included in the model. The model also should consider the upstream impacts of the various instream-flow proposals, and not simply use the historical flows at USGS gage 11319500.

4-20

4-20 Staff's water balance model is designed to account for EBMUD's water rights as well as other existing downstream water users in the basin.

The 25-year historical period used in the model simulations is not adequate to provide accurate assessments of impacts of operating alternatives because it excludes the severe drought of the 1930's. As a minimum, the historical period should run from 1928 through 1990. Recent model studies by Amador County and by EBMUD have typically used the 70-year period 1921 through 1990. The model should also consider the effects of forecast future upstream diversions from the Mokelumne River.

4-21

4-21 The 25-year period used in staff's analysis includes the drought of record (1976-77) as well as the most recent protracted low-flow period. This period is sufficient for understanding water supply deficits to EBMUD as these costs relate to proposed mitigation alternatives.

b. Water Budget Model Simulations (pages B-8 to B-9):

- o The assumed levels of EBMUD aqueduct diversion (water demand) used in the simulations should be stated.

4-22

4-22 These data have been presented in the FEIS in Appendix B.

- o Tables B-2 through B-5 referenced on page B-8 are not included in the DEIS, and therefore, we are unable to provide comments at this time.

4-23

4-23 These tables were sent out as part of an errata update to all parties receiving the original DEIS, including Amador County. This error has been corrected in the FEIS.

16. Appendix G. (page G-4).

This discussion should be expanded to discuss the facts that Amador County has applied for an assignment of the remainder of Application 5647, and has filed new Applications 28740 and 28741, for the Devil's Nose Project.

4-24

4-24 These applications have been discussed in the FEIS.

17. Appendix G, Table G-1 (pages G-5 to G-9).

The listing of water rights should be edited to include Amador County's Applications Number 28740 and 28741 for the Devil's Nose Project.

4-25

4-25 These applications have been included in Table G-1 in the FEIS.

18. Appendix G, (pages G-11 through G-13).

The discussion of water market, water banks and transfer of water rights should be expanded to indicate that water transfers from rivers besides the Mokelumne are potential alternate sources of supply for EBMUD that could reduce impacts on upstream Mokelumne River users like those in Amador County.

4-26

4-26 The DEIS did not specifically investigate the potential of water transfers other than providing background information on EBMUD's participation in such transactions. Staff concluded that EBMUD had sufficient demand-side as well as supply-side (Delta, American River, groundwater exchange) options to exploit.

III. Impacts of Proposed FERC Instream Flow Releases on Water Availability to Amador County

Amador County has performed detailed computer modeling of river flows and reservoir operations, considering the water rights hierarchy, to analyze and evaluate impacts of the FERC's proposed instream flow requirements on the availability of Mokelumne River water supply to the County. A description of the modeling performed and the findings and conclusions reached are presented in the enclosed Exhibit A.

The key findings are summarized as follows:

1. The firm annual water-supply yield of Amador County's proposed 'Devil's Nose/Cross County Water-Power Project would be reduced by about 37% under the FERC proposed instream releases (at the EBMUD demand level of 250 mgd) and by about 40% at the EBMUD 229 demand level.
2. Under the FERC proposal, reductions would occur in the ability of the Jackson Valley Irrigation District to divert water from Pardee reservoir under existing conditions. The number of months in which diversions could be made would be reduced by about 15% to this District that already suffers a water shortage.

4-27

4-27 Your comment is noted, and reference to these studies has been included in the FEIS.

The impacts presented in Exhibit A should be carefully considered by the FERC in reaching a decision regarding proposed increases in instream flow requirements.

cc: See Attached Lists

cc: Amador County B.O.S.
Congressman Doolittle
Assemblyman Knowles
Senator Leslie
F. Springer (FERC)
J. Canaday (SWRCB)
J. Alverson (R.W. Beck and Associates)
S. Kronick (Bartkiewicz, Kronick & Shanahan)
C. Williams
Amador Water Agency
Water Resources Advisory Committee
Water Committee of the B.O.S.
J. Hahn (County Counsel)
J. Pulver (San Joaquin County Dept. of Public Works)
Attached Service List

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February 25, 1993

Secretary, Federal Energy
Regulatory Commission
325 North Capitol Street, NE
Washington, DC 20426

SUBJECT: LOWER MOKELUMNE RIVER PROJECT, PROJECT NO. 2916-004

Dear Secretary:

San Joaquin County submits the following comments upon the Draft Environmental Impact Statement (DEIS) prepared by the Federal Energy Regulatory Commission (FERC) for the Proposed Modifications to the Lower Mokelumne River Project, California (FERC Project No. 2916-004).

San Joaquin County is very much concerned with the conservation and restoration of fish and wildlife resources on the Mokelumne. The County is also very concerned with the conservation and development of these waters for agricultural, municipal and industrial use in the County. Our County is in great need of additional surface water supplies due to the extensive groundwater overdraft condition existing in the eastern portion of the County. While fish and wildlife need protection, the County also needs water to meet its existing demands.

Given the above, the County is particularly concerned with the virtual absence of any analysis in the DEIS of the impacts of the proposed modifications upon the groundwater basin underlying the eastern portion of the County. The Eastern San Joaquin County Groundwater Basin has been identified by the California Department of Water Resources in Bulletin 118-80 as a groundwater basin subject to critical conditions of overdraft. The staff's recommendations to alter diversion methods by the Woodbridge Irrigation District and the North San Joaquin Water Conservation District, besides being beyond the scope of FERC jurisdiction, must include an analysis of the impacts these recommendations may have upon the groundwater basin. The DEIS also must consider the impacts of changes in water releases from Camanche and Pardee Reservoirs upon the groundwater basin.

5-1

5-1 Your comment is noted. Staff attempted to present a balanced discussion of these competing needs in the DEIS and in the FEIS.

5-2

5-2 The implementation of additional flow-related mitigation measures below Camanche Dam would have a beneficial impact on groundwater resources in the immediate vicinity of the river because this area is a losing reach. Neither the DEIS nor the FEIS included recommendations that would alter diversion methods by Woodbridge Irrigation District (WID) or North San Joaquin Water Conservation District (NSJWCD) as the comment claims.

The DEIS is unclear as to whether the groundwater storage options identified on page 4-3 include the full restoration of the groundwater basin before its use by the East Bay Municipal Utility District (EBMUD). The full restoration of the basin is a condition precedent which San Joaquin County has placed upon any use by EBMUD of this aquifer. The DEIS should also more fully consider a Delta diversion point for EBMUD and a Folsom South Canal connection.

5-3

5-3 These groundwater storage options are those identified in EBMUD's Updated Water Supply Management Plan and associated analyses, as indicated. The Delta diversion point and Folsom South Canal are considered in the FEIS among options available to EBMUD as they are defined in EBMUD's long-term planning.

The County is also concerned that the DEIS has failed to consider the impacts of the proposed modifications upon the County's Middle Bar Project. As you know, the County, through the Mokelumne River Water and Power Authority, has recently been issued a preliminary permit to begin investigation into this project (Project No. 11171-000). While there are certainly financial, environmental and other hurdles to construction and operation of the Middle Bar Project, these hurdles are no different than those confronted by any other project. Concluding this project is "too uncertain to be evaluated" and characterizing the steps necessary to implement the project as "serious problems," the DEIS fails to consider the importance of this project to the County in meeting its existing water supply needs. The County is seriously committed to the Middle Bar Project and hopes that no steps would be taken in this proceeding which would jeopardize a future consideration and construction of this important facility. In order to ensure the future consideration and construction of the facility, the impacts of the proposed modification upon the Middle Bar Project must be examined in the DEIS.

5-4

5-4 Preliminary permits are not considered in the Commission's NEPA assessments, because they are too speculative to be "foreseeable." The fact that a preliminary permit has been issued for the Middle Bar Project is mentioned in the FEIS

The County continues to be concerned with the Commission's interest in the diversion practices of the Woodbridge Irrigation District (WID), the North San Joaquin Water Conservation District (NSJWCD) and the other appropriators and riparians along the Lower Mokelumne. FERC has no authority over either the diversion practices or water rights of these water users. We caution the Commission not to overreach its jurisdiction by seeking to alter the water rights or diversion methods of interest in San Joaquin County. Additionally, the Commission must ensure that the water rights of WID, NSJWCD and other appropriators and riparians along the Lower Mokelumne are not harmed by the proposed modifications. The Commission must more closely examine the impacts upon the water supply of water users in San Joaquin County and elsewhere when deficiencies are imposed upon EBMUD through flow releases for fish.

5-5

5.5 Your comment is noted. The FEIS discusses downstream water users as a critical part of the existing environment of the Lower Mokelumne River.

The County is also very concerned by the apparent lack of independent analysis in the DEIS; its reliance on data provided by EBMUD and the California Department of Fish and Game, particularly as it relates to the diversion practices of WID and NSJWCD. FERC staff and consultants should closely examine the testimony presented by WID and NSJWCD

5-6

5-6 This testimony has been incorporated and considered in this proceeding.

Secretary, Federal Energy
Regulatory Commission
February 25, 1993
Page 3

at the recent State Water Resources Control Board hearings on the Lower Mokelumne to obtain a more balanced understanding of the impacts of WID and NSJWCD diversion practices upon fish.

5-6
(cont.)

We appreciate the opportunity to comment upon the DEIS and look forward to your response.

Very truly yours,

WILLIAM N. SOUSA, Chairman
Board of Supervisors
San Joaquin County

WNS:CW:to
c:\FARC\LEADERV.EIS

c: Henry M. Hirata
Director of Public Works

H-40

Response to Comments

**Committee to Save the Mokelumne
California Sportfishing Protection Alliance**

26 February 1993

Ms. Lois Cashell, Secretary
Federal Energy Regulatory Commission
825 North Capitol Street, N.E.
Washington, D.C. 20426

Dear Ms. Cashell:

Lower Mokelumne River Project, Project No. 2916-004

This responds to the October, 1992 Draft Environmental Impact Statement (DEIS) prepared by the Federal Energy Regulatory Commission (FERC) staff and consultants in connection with the proceeding to consider modifications of facilities and operation of the Lower Mokelumne River Project (FERC No. 2916-004) in Amador and San Joaquin Counties. The Committee to Save the Mokelumne (Committee) and the California Sportfishing Protection Alliance (CSPA) have reviewed the DEIS and have the following comments. Both the Committee and the CSPA appreciate the time and effort on the part of FERC staff and consultants in preparing this generally excellent DEIS for the lower Mokelumne River.

The DEIS states that all pertinent information developed at the State Water Resource Control Board (State Board) hearing regarding the diversion and use of water from the Mokelumne River will be incorporated into the final impact statement (page 3-11). We would urge the FERC staff and consultants to closely examine the written and oral testimony presented by CSPA and Committee fisheries scientists Felix Smith, William Kier, and Dr. Don Chapman. We also believe that the written and oral testimony by Dr. Robert Baumann and Dr. Alvin J. Greenberg on behalf of the Central Delta Water Agency regarding the ability of East Bay Municipal Utility District (EBMUD) to safely and economically use water from the Sacramento - San Joaquin Delta (Delta) will help staff to better understand the range of options that EBMUD has for providing water to its service area.

We would also urge staff and consultants to review the soon-to-be-released Camanche Reservoir study being conducted under a Clean Lakes Program grant by the University of California at Davis and the University of California at Santa Barbara for the Central Valley Regional Water Quality Control Board. That study is scheduled to be released in April

6-1

6-1 Your comment is noted. The testimony and exhibits from the State Water Board's hearing have been reviewed by staff in the preparation of the FEIS

6-2

6-2 All information available to the Commission from this source at the time of the FEIS release was reported in the FEIS. Please refer to our response to EPA's comment No. 3-13.

1993 and we believe it will further document the extent of toxic sediments in Camanche Reservoir and the need for a high minimum pool level in the Reservoir to prevent re-mobilization of those sediments. We suggest that staff consult with Dr. Darrell Slotten of the University of California at Davis (916) 752-0353.

6-2
(cont.)

Since release of the DEIS, the State Board has issued draft decision 1630 regarding the protection of aquatic resources in the Delta. The effects of D1630 or possible project modifications should be evaluated in the final EIS. For example the closing of the Delta Cross Channel may make attraction and outmigrant water flows for Mokelumne salmon and steelhead critical important. D1630's mandated "pulse" flows for the Mokelumne should be incorporated in any FERC decision. The comments of the United States Environmental Protection Agency (EPA) on D1630 should be evaluated because of the likelihood that the agency will promulgate additional water quality standards under the federal Clean Water Act that will require additional Delta outflow. The Mokelumne River may have to contribute some of this additional flow.

6-3

6-3 The State Board's Interim Decision was withdrawn in April 1993, at the direction of Governor Wilson. Although the background information leading to this decision was considered by staff in the development of the FEIS, this state plan is no longer likely to be implemented in the near future.

A brief summary of our concerns are:

1) The Committee and the CSPA believe that the use of weighted usable area (WUA) to estimate needed instream flows should be approached with caution. WUA is simply an index of the suitable stream habitat at various flows. It does not consider temperature, water quality, cover, and numerous other factors that should be evaluated in any flow recommendation. For example try require access to instream cover as debris and brush therefore suitable flows for this purpose will likely tend to put the stream edge into vegetation on the stream banks.

6-4

6-4 Physical habitat considerations are only one of several limiting factors to fish populations that were used in determining staff's final recommendations for instream flows (e.g., see Section 3.3 of the FEIS). Weighted usable area (WUA) results stand out in the report, as well as most other instream flow analyses across the country, because they provide the most quantitative method for examining the incremental benefits of stream flows. Better quantitative methods have not been identified and recommended by anyone in this proceeding.

At the recent State Board hearing, Committee and CSPA fisheries scientists Felix Smith, William Kier, and Dr. Don Chapman generally supported the flow recommendations of the California Department of Fish and Game. Certainly, the DFG minimum flow schedule is far superior to the other alternatives evaluated in the DEIR. William Kier provided testimony regarding the positive correlation between outflow and returning year classes on the Mokelumne. We believe there is biological justification for outmigrant flows. Available evidence suggests that there is value in attraction flows for chinook salmon in the Mokelumne and we strongly support such flows especially in dry years. The Committee and the CSPA do not believe there is any biological basis for establishing reduced dry year flows.

6-5

6-5 Your comment is noted.

We believe all of the escapement goals considered in the DEIS are inadequate. There is no data in the DEIS to support the FERC staffs conclusion that the natural escapement goal of 5,000 is probably unrealistic. Spawning habitat in the lower Mokelumne River has been

6-6

6-6 See staff response to CDFG comments No. 2-29 and No. 2-30 regarding salmon escapement goals. See response to EPA comment No. 3-10 regarding steelhead. It is unlikely that habitat criteria for juvenile steelhead can be met in the Lower Mokelumne River without habitat alterations beyond the capacity of the Lower Mokelumne River. Staff feels it is premature to set steelhead escapement goals without additional study and habitat planning.

permitted to deteriorate for many years in violation of the 1983 mitigation agreement for the construction of Camanche Dam. We believe rehabilitation, maintenance, and enhancement of spawning habitat in the river (and implementation of DFG's flow recommendations) would provide suitable conditions for more than 5,000 spawning salmon on a consistent basis. Since construction of Camanche Dam destroyed all remaining steelhead spawning habitat, we believe that staff should investigate the possibility of an instream enhancement program to create suitable steelhead spawning habitat. Hatchery production should not be a substitute for natural propagation. We believe that escapement goals should be included as a mitigation obligation under EBMUD's FERC license.

6-6
(cont.)

Given the history of streamflow fluctuations in the lower Mokelumne we strongly support DFG's proposed ramping rates.

6-7

We support FERC staff and DFG recommendations for additional studies on the Mokelumne River and believe an important additional study would be an evaluation of the effects to salmon and steelhead from chronic exposure to heavy metals.

6-8

2) The DEIS characterizes the California Department of Fish and Game alternative as relying on the enforcement of water quality standards to eliminate any potential effects of Camanche Dam Releases on water quality in the lower river and the Mokelumne River Fish Installation (Hatchery). These water quality standards are federal and state laws designed to protect water quality and should be incorporated into any modification of EBMUD's FERC license.

6-9

We question the FERC staff and consultants reliance on experimental technical fixes. Technical fixes (such as EBMUD's hypolimnetic oxygenation scheme) as an alternative to flow should be approached with caution. All too frequently technical fixes have failed to operate as anticipated. Testimony at the State Board's Mokelumne River hearing emphasized that "Spence Cones" are experimental and have never been successfully used on a reservoir as large as Camanche Reservoir. Technical solutions should be proven in situ before they are permitted to operate in lieu of minimum flow or minimum pool requirements.

6-10

The DEIS acknowledges that concentrations of H_2S exceeding EPA recommended levels have contributed to fish kills in the Mokelumne River Fish Installation (page 3-32). We believe that chemical treatment of hatchery water supplies for H_2S removal is, at best, an unsatisfactory solution that does not deal with H_2S discharged to the river.

6-11

At the State Board hearing Committee and CSPA expert witness Dr. Don Chapman recommended the diversion of EBMUD aqueduct (Pardoe) water to the base of

6-12

6-7 After reviewing available information, staff disagrees. There is insufficient data to provide a substantial justification for CDFG's ramping rate.

6-8 Your comment is noted.

6-9 The Ambient Water Quality Criteria established by EPA are only guidelines. Similarly, the criteria proposed by CDFG based on EPA criteria are, at this time, recommendations. Because of the nature of the situation, achieving these recommendations could be very difficult and maybe impossible at present. There is no direct evidence that the fish and invertebrate communities in the Lower Mokelumne River are being impacted by the presence of heavy metals at the present concentrations (Section 3.2.5). Therefore, staff believes the best strategy for dealing with this problem is to (1) minimize additional input of contaminants into the system, particularly from Penn Mine; (2) minimize the occurrence of those activities and processes that result in a resuspension of contaminated sediments in Camanche Reservoir; and (3) monitor for any biological response to contaminants in the river and hatchery below Camanche Dam, such as egg viability, larval survival and growth, etc.

6-10 Your comment is noted.

6-11 Staff agrees that treatment with potassium permanganate is not the best alternative. The DEIS includes reservoir operational controls which will help to minimize the chance of high H_2S releases from Camanche Dam. At the same time, staff recognizes that an operational treatment system is a reasonable backup and support its continued use.

6-12 Your comment is noted.

Camanche Dam to eliminate or reduce water quality problems resulting from poor water quality in Camanche Reservoir. We believe that this solution should be fully considered in the final EIS.

6-12
(cont.)

3) We believe that the DEIS insufficiently considers adverse impacts to fisheries and other public trust resources in the Lower Mokelumne between Woodbridge Dam and the Delta. The water rights of Woodbridge Irrigation District and riparian appropriators are senior to EBMUD's water rights. Prior to construction of the Mokelumne River Project and excessive diversion of water around the lower seventy-five miles of the Mokelumne there was sufficient flow available to protect fisheries in this lower segment of the river. It is EBMUD's FERC licensed Mokelumne River Project that has devastated public trust resources and values below Woodbridge dam. Therefore we believe it appropriate that there be modifications in the FERC licensed project to protect and restore these resources and values.

6-13

4) The Committee and the CSPA do not understand the reasoning behind FERC staff and consultants decision to avoid recommendations to alleviate the major source of the mass loading of toxic pollutants into the Mokelumne River. This source was acquired as part of the EBMUD's Mokelumne River Project and has been cited by the EPA and been judged in federal court to be operated in violation of the Federal Clean Water Act. Because of the continuing mass loading of contaminants from Penn Mine into the Mokelumne, Camanche Reservoir water releases exceed EPA aquatic life criteria 30 to 50% of the time according to the United States Fish and Wildlife Service (USFWS).

6-14

The DEIS characterization of Penn Mine is misleading. It states that there are no groundwater discharges from the mine shafts at Penn Mine (page 3-6). In fact there are discharges from the shafts into Hinchey Run Creek which flows into Mine Run Dam Reservoir. We would suggest that staff consult with Dr. Charlie Alpers of the United States Geological Survey (USGS) office in Sacramento California (916-978-4548, ext. 356). The DEIS implies that Mine Run Dam prevents discharge of groundwater acid mine drainage (AMD) under the dam (page 3-6). The USGS is conducting an extensive groundwater investigation at Penn Mine and has established that a contaminated groundwater plume originating from EBMUD's Mine Run Dam Reservoir is reaching Camanche Reservoir. Analysis of that plume reveal that it exceeds California criteria for hazardous wastes. Features through which the contaminated groundwater enters Camanche have been discovered.

6-15

The DEIS inaccurately describes the short-term Penn Mine remedial measures (page 3-7). The installation of an impervious cover over the Shoreline waste rock pile was not funded and the construction of a gravity drainage system in the upper Mine Run Creek was excluded from the remedial project. Even with implementation of the other measures

6-16

6-13 Your comment is noted. Fish resources and the effect of various water project operations to this stretch of the Lower Mokelumne River have been discussed and considered in the FEIS. Available evidence indicates that numerous stresses, including the LMRP operations predating the FERC license, affected the Mokelumne below Woodbridge Dam.

6-14 Although staff has deferred any final Penn Mine recommendations until other ongoing regulatory actions are resolved (see Section 3.1.3 of the FEIS), we do suggest that Shaft No. 4 at Penn Mine be sealed to eliminate groundwater discharge to Hinkley Creek and its holding ponds. Staff also is suggesting feasibility studies of a groundwater pump-back system to Mine Run Reservoir or, alternatively, lining the floor of this reservoir to reduce discharge through the groundwater pathway. Although placement of a cap on the Shoreline waste pile would be beneficial, staff believes it is a lower priority project than either the sealing of Shaft No. 4 or reducing groundwater discharge beneath Mine Run Reservoir.

Staff is also proposing construction of a ditch to divert uncontaminated water from upper Mine Run Creek into Oregon Gulch, pending the determination of metals loading to Camanche Reservoir via the existing berm. Metals loading from this source and background are currently unknown. Construction of the diversion ditch would only be recommended if metals loading from the existing berm to Oregon Gulch is significantly higher than that from background metals loading from upper Mine Run Creek. If construction of the diversion ditch to Oregon Gulch is demonstrated to be necessary, such remedial action would be compared with other remedial action proposals in terms of cost-benefit before proceeding.

6-15 As discussed in Section 3.1.3 of the FEIS, available data indicate that discharge from Shaft No. 4 is a significant contributor to Mine Run Reservoir when the water table is seasonally high. Elimination of this source of Mine Run Reservoir water would reduce the volume of uncontrolled releases over the Mine Run Dam spillway. As a result, staff suggests that Shaft No. 4 be sealed (see previous comment).

The FEIS states that the Mine Run Dam's core wall impedes the flow of groundwater under the dam. The word "prevents," as appeared in the DEIS, was replaced with the word "impedes" in the FEIS.

6-16 The DEIS accurately stated the proposed remedial measures at the time of writing. Subsequently, funds were diverted from the Shoreline project for higher priority construction and the diversion ditch project was canceled.

(including raising the spillway two feet) an overflow discharge began 21 February 1993. At the urging of the United States Environmental Protection Agency (EPA)¹, EBMUD added over 150 tons of lime in a frantic last minute effort to reduce the acidity of the discharge. On February 23 EPA's Region 9 Emergency Response Section ordered EBMUD to begin pumping several million gallons in an effort to gain freeboard in Mine Run Reservoir. EPA also requested installation of an in-line treatment system (ILS) as soon as possible. It should be noted that this system was proposed as an interim measure and according to preliminary testing will not treat Mine Run Reservoir waste waters to meet applicable water quality standards.

6-16
(cont.)

It is clear that the authors of the DEIS did not contact geochemist Dr. Ann Meier (303-636-1620), Dr. Steve Onyiah (916-544-2789), or Dr. Fiona Doyle (415-642-2846) who have testified in hearings and affidavits that the impoundment and re-circulation of waste waters at the Penn Mine site² has accelerated the formation and increased the concentration of AMD.

6-17

The DEIS describes the Committee and CSPA appeal of the exemption of Penn Mine from provisions of the TPCA but does not mention that a lawsuit has been filed in Sacramento Superior Court for violations of the TPCA and the Porter Cologne Water Quality Control Act and that the Committee has filed a lawsuit against EBMUD and the Regional Board for violations of the Federal Clean Water Act. In May 1992 United States District Court Judge Lawrence K. Kerton granted the Committee's motion for summary judgment against EBMUD, holding the water district liable for discharging pollutants into the Mokelumne River without an NPDES permit.

6-18

The result of historical and continuing mass-loading of heavy metals into Camanche Reservoir from Penn Mine is abundantly clear. During the course of the Mokelumne River hearings before the State Board, EBMUD testified that Camanche Dam water releases occasionally exceed EPA criteria for protection of aquatic life. Following this testimony, Hearing Officer Marc Del Piero requested that EBMUD provide the District's water quality monitoring data on Camanche releases to all parties to the proceeding. In rebuttal testimony Ms. Judy Selchick, a contaminant control specialist with the United States Fish and Wildlife Service (916-978-4886) stated that analysis of the EBMUD data revealed exceedences of EPA aquatic life criteria for one or more dissolved metals (adjusted for pH) 36% to 50% of the time over the last three years.

6-19

6-17 Staff acknowledges that the recirculation of waste water at Penn Mine was inadequately discussed in the DEIS. This was an unintended oversight. The creation of additional acid mine draining (AMD) is the downside if the creation of additional surface area for evaporation of water. The unintended production of AMD by recirculation of water from Mine Run Reservoir is addressed in the FEIS, Section 3.1.3.

6-18 The FEIS incorporates this information.

6-19 Staff has reviewed this data and Camanche releases do exceed EPA water quality criteria at times. See response to comment No. 6-9.

¹ In a General Notice Letter pursuant to Section 104 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended, 42 U.S.C. 9604 ("CERCLA")

² A facility constructed in 1978 by EBMUD and the Central Valley Regional Water Control Board.

DFG reports submitted to FERC reveal that diversion of water into the Mokelumne aqueduct from EBMUD's FERC licensed Pades Dam reduced river flows that had previously diluted Penn Mine waste discharges. Those reports also establish the existence of a heavy metal sink in Camanche Reservoir because EBMUD's FERC licensed Camanche Dam prevents Penn Mine toxic wastes from being flushed to the sea. Impoundment of waste waters behind EBMUD's Mine Run Dam has increased the contamination of groundwater which subsequently discharges into Camanche Reservoir. Mine Run Dam Reservoir overflows every non-drought year. Since EBMUD acquired 187 acres of the Penn Mine site containing slag heaps, sediment dumps and the former site of the milling and processing structures as part of its Mokelumne River Project, we believe that FERC has a responsibility to require that EBMUD eliminate the principal source of heavy metals to Camanche Reservoir and the Mokelumne River.

6-19
(cont.)

We note that according to T. 2.2.1 (page 2-2) of the DEIS Penn Mine remediation was considered as a mitigation measure for the conservation and development of natural reproducing salmon and steelhead in the Lower Mokelumne River for all salmonoid life stages. Why was this mitigation measure dropped?

6-20

6-20 This measure was not dropped. See Section 3.1.3 and staff's final recommendations in the FEIS.

5) We question the statement on page 1-4 of the DEIS that proposals for the Commission to specifically require EBMUD to move its point of water withdrawal from Pades Reservoir are not an appropriate part of this proceeding. If potential alternative diversion points are excluded from consideration by FERC staff and consultants we believe that it is inappropriate to consider the impacts on EBMUD's water supply from proposed project modifications. Failure to consider EBMUD's refusal to use its water rights on the American River or the ability and safety with which the District can divert and treat Delta water make any water supply deficit analysis seriously flawed. NEPA requires evaluation of alternatives to the project. The DEIS fails to evaluate the reasonable alternative whereby the Commission could approve the DFG Lower Mokelumne Fisheries Management Plan and at the same time assure EBMUD of a secure, safe, and ample water supply via Delta diversion. We believe that the Federal Power Act requires the Commission to give equal consideration to fish and wildlife resources in conjunction with evaluating FERC licensed project purposes (hydro-electric, municipal supply).

6-21

6-21 The alternatives evaluated in the FEIS are those that the Commission has authority to require of the licensee. The range of alternatives that EBMUD has available to meet future water supply needs are discussed in the FEIS.

6-22 It was only in 1990 that the Superior Court confirmed EBMUD's right to take American River water subject to diversion restrictions (i.e., minimum flow requirements). Future use of the American River by EBMUD will require finalization of flow requirements and construction of conveyance facilities from the point of take out to Mokelumne aqueducts. This alternative is described as one option to meeting water deficiency in Appendix E of the FEIS.

6-22

Information presented by all sides regarding the use of the Delta is conflicting. Estimates of facility costs to treat Delta water before entering the distribution system are especially divergent. The FEIS has attempted to balance these different points of view. FEIS also includes information on installing pre- and post-chloramination to existing EBMUD facilities.

EBMUD has water rights to almost half of the average unimpaired runoff of the Mokelumne watershed. EBMUD has additional water rights on the American river that it has historically refused to use. EBMUD has a Delta pumping facility that it used during 1976-77 and was prepared to use in 1989. At a EBMUD sponsored workshop on the District's updated Water Supply Management Plan, EBMUD presented information revealing that the addition of Pre and Post Chloramination to existing treatment plants would enable the

District to meet all applicable water quality standards for a blend of Purdee and Delta water (EBMUD supplied FERC this information). Indeed, cancer rates attributable to Bromate and THM's from a Delta blend would be the same as the cancer rates from Bromate and THM's in the District's current source of water from Purdee Reservoir. The cost of adding Pre and Post Chloramination was estimated by EBMUD at 1.2 million dollars per year.

6-22
(cont.)

In written and direct testimony during the State Board hearing, Dr. Robert Baumann and Dr. Alvin J. Greenberg stated that EBMUD could reliably, economically, and safely use treated Delta Water or a blend of Purdee and Delta water. They also said that: the use of such water would reduce rather than add to health risks; the city of Pittsburg California treats Delta water to lower THM levels than reported by EBMUD; there have been major advances in water treatment since the late 1970's; the majority of Californians drink treated Delta water; and that EBMUD's costs estimates for treating Delta water were seriously exaggerated.

6-23

6-23 The testimony presented by the Central Delta Water Agency is compelling and tends to refute the estimates of treatment facility costs presented by EBMUD. A range of Delta alternatives and cost estimates is presented in the FEIS.

Since the State Board hearing, the State Board has announced Draft Decision 1630 which will significantly improve the quality of Delta water. Also since the State Board hearing, the EPA in a letter to the State Board concerning the inadequacy of D1630 indicated that EPA would issue additional water quality standards that would further improve the quality of Delta water. It is likely that the future quality of Delta water will be better than current conditions and the final EIS should reflect this likely improvement.

6-24

6-24 Your comment is noted. Since the State of California has withdrawn Interim Decision 1630 and EPA has not acted, it is impossible for staff to predict the future benefits of unknown regulatory actions on the water quality of the Delta.

The use of Delta water by EBMUD would: further improve Delta water conditions; provide sufficient Mokelumne River flows to restore the river's ecosystem and public trust values; increase hydroelectric revenues; and permit the District to use its American River water which would likely increase the total amount of water readily available to the East Bay service area. The benefits deriving from a Delta diversion are so great that we believe the final EIS will be seriously deficient if it fails to reasonably consider this alternative.

6-25

6-25 EBMUD will determine how it will meet its future water supply needs. Your comment has been noted.

6) We agree with staff that minimum pool requirements are needed in Camanche Reservoir to ensure that water releases meet minimum water quality standards. We believe it essential that any staff stream flow or minimum pool recommendation be sufficient to meet Regional Board Basin Plan and State Board Inland Surface Waterways Plan standards for water quality. The recommendations contained in East Bay Municipal Utility District's (EBMUD) Management Plan will not meet relevant water quality standards for temperature, dissolved oxygen, pH, or metals. It is questionable whether FERC staff recommendations will meet those standards. We support the DFG minimum pool recommendations and believe that all relevant water quality standards should be incorporated into EBMUD's operating license.

6-26

6-26 Your comment has been noted.

7) Page 3-33 of the DEIS states that runs for the 19 year period of record before Camanche Reservoir was impounded averaged 3,300 spawners. It further states that run sizes before and after Camanche Dam was built are comparable. These statements are based on an inaccurate and misleading chart from DFG (Figure 3.3-1 on page 3-35). That chart indicates that the estimated run size was 5,000 in 1940 and approximately 12,000 in 1941 and 1942.

More accurate data on the fish counts between 1939-1958 can be found in Table 2, page 11 of the November 1959 DFG study titled The Influence Of Proposed Water projects On The Fisheries Resources Of The Lower Mokelumne River, Amador, Calaveras, And San Joaquin Counties. FERC has a copy of this study. The 1940 count at Woodbridge Dam was stopped on November 4 and at that time the run exceeded the runs of 1941 and 1942. The 1941 count was also incomplete with the count stopping on November 23. The 1942 count was stopped on November 19 with fish going over the Dam in quantity when the count stopped. There were 2,758 fish recorded in the last week of the count. In 1943 Perrin Mine was reopened during WW II and according to DFG reports heavy toxic conditions existed in the river. The old inadequate fish ladder was replaced in 1948 but the new ladder washed out in 1980 leaving another partial count. There was no fish ladder until 1954 and counts comprised estimates of fish that jumped the dam. Pre-Camanche runs were also adversely impacted by cannery and winery waste dumping. These practices were largely eliminated by the time Camanche Dam was constructed.

There is no accurate justification for comparing the average pre-Camanche runs with the runs following construction of the Dam. What can be said is that when DFG began fish counts on the Mokelumne fish runs were probably above 15,000. The reopening of Perrin Mine devastated fisheries and the loss of the fish ladder prevented the runs from rebounding. In 1972 DFG changed the method of counting from actual counts to carcass surveys (except for the counts of 1982 and 1983 which were calculated runs based on the hatchery run). Actual counts resumed in 1989. Estimates of the effects of Camanche Dam on the rivers fisheries based on average counts before and after Camanche Dam was constructed are likely to be highly inaccurate. We believe the final EIS should reflect this fact.

8) We unfortunately tend to agree with the comments on page 3-38 of the DEIS that suggest that returning chinook salmon in the Mokelumne River are opportunistic members of a single Central Valley stock. The DEIS is probably wrong in stating that the original runs of spawning chinook salmon and steelhead trout were lost at Woodbridge because of the lack of a fish ladder (page 3-32). The Mokelumne River Alliance played a 1929 home movie at the State Board hearing that showed salmon jumping Woodbridge Dam. "Old timer" accounts also indicate that prior to the construction of Pardes Dam Autumn storms frequently enabled returning salmon to navigate past Woodbridge. It is likely that Pardes Dam and the diversion of water into the Mokelumne aqueduct led to the

6-27

6-27 Staff used data on sizes of salmon runs to the Lower Mokelumne River provided by CDFG and used by the agency in its Management Plan as the basis for numerical comparisons in the DEIS of run sizes before and after the Camanche Project. Staff appreciates the comments that the early data may be unreliable and have added this qualifier to the FEIS.

6-28

6-28 See staff response to the previous comment.

6-29

6-29 This additional information was included in a new FEIS discussion of possible reintroduction of the native salmon stock (Section 4.6.4).

demise of historic fisheries. The Committee and the CSPA strongly believe that any Mokelumne Project modifications should include provisions for reestablishing a native Mokelumne River stock. We refer staff to the comments made by Committee fishery's scientist Dr. Don Chapman at the State Board hearing on the reestablishment of a native stock.

6-29
(cont.)

The construction of Camanche Dam has adversely affected warm water fisheries below Woodbridge Dam. The November 1969 DFG study titled *The Influences Of Proposed Water projects On The Fisheries Resources Of The Lower Mokelumne River*; Amador, Calaveras, And San Joaquin Counties states that "the sports fishery for striped bass, shad, and the other warmwater game fishes in the section of the Mokelumne River below Woodbridge is surprisingly large." Since Mokelumne Project operations led to the demise of these fisheries, we believe that The FERC has an obligation to require modifications in the Project license to mitigate for these impacts. The DEIS includes no recommendations for the restoration or mitigation for the loss of the striped bass, shad, and other warmwater gametish.

6-30

6-30 Reestablishment of warmwater game fishes below Woodbridge Dam is not, to our understanding, a management objective of the CDFG. In contrast, expansion in numbers of these species would likely increase the rate of predation on juvenile salmonids. The DEIS discussed these species but purposely did not recommend actions to increase their number. This point was expanded in the FEIS, Section 3.3.4.

9) The DEIS on page 4-56 states that Lake Lodi appears to account for about 70% of chinook salmon smolts emigrating from the spawning area below Camanche Dam and attributes this information to EBMUD 1992. We refer staff to the comments made by Steven Cramer on behalf of Woodbridge Irrigation District and Committee fishery's scientist Dr. Don Chapman on the inadequacies and inaccuracies of EBMUD's study and conclusions regarding salmon smolt mortality in Lake Lodi.

6-31

6-31 See staff response to comment No. 7-10.

EBMUD has attempted to blame Woodbridge Dam and diversion for the decline of the Mokelumne fisheries. Certainly there are serious passage problems at Woodbridge Dam but these problems are proportional to bypass flows. Woodbridge Dam and diversion existed long before EBMUD constructed Pardee and Camanche Dams. It is EBMUD's FERC project that has principally devastated Mokelumne fisheries. We question whether FERC has authority over Woodbridge Irrigation District. FERC, however, has direct responsibility over EBMUD and the release of flows from Camanche Dam sufficient to minimize passage problems at Woodbridge Dam. Before EBMUD constructed its Mokelumne River Project there were frequent spills from Woodbridge Dam that benefited fish. Subsequent to Project construction spills have become rare.

6-32

6-32 Impacts to fisheries in the Mokelumne River have been the result of multiple water projects, one of which is the Commission-licensed hydroelectric facilities at Camanche and Pardee dams. Although the Commission has no authority over WID, third-party agreements between EBMUD and WID are encouraged in the FEIS. Spill flows at Woodbridge Dam can be enforced by having a point of compliance below that dam when this measure is appropriate; the FEIS recommends this approach for months in which spills are important to migrating salmon.

We agree that the fish screen at Woodbridge diversion should be upgraded to meet current DFG statewide standards. However, testimony by a number of fishery experts at the State Board hearing established that the problems related to the fish screens become more serious as bypass flows are reduced. Screen problems are exacerbated by

6-33

6-33 A discussion of the effects of river flow on the performance of the WID diversion screens and fish bypass (Section 4.5) was included in the FEIS.

EBMUD's excessive diversion of water around the lower 75 miles of the Mokelumne River.

6-33
(cont.)

FERC staff and consultant's alternative proposal for hydraulic improvements to Lake Lodi and Woodbridge Dam are interesting and merit serious consideration, but since the FERC has no authority over Woodbridge Irrigation District we wonder how these improvements will be financed. We reiterate that the passage and screen problems at Woodbridge Dam are magnified by operation of EBMUD's Mokelumne Project. We believe that the Commission has the responsibility to require EBMUD to mitigate for these adverse impacts.

6-34

6-34 Your comment is noted. The Commission may require off-site mitigation where it is justified; therefore, these improvements at Lake Lodi were considered in the DEIS and the FEIS.

10) The Committee and the CSPA believe that the DEIS insufficiently considers the cumulative adverse impacts to water quantity and water quality in the Lower Mokelumne River below Woodbridge Dam, to the DFG Fisheries Management Plan, and to the Bay-Delta Estuary from operation of EBMUD's Mokelumne River Project, Pacific Gas and Electric's (PG&E) FERC licensed project on the North Fork of the Mokelumne, Amador County's proposed Devils Nose Dam, and San Joaquin County's proposed Middle Bar Dam. We believe that the FERC has a duty under NEPA to evaluate the cumulative impacts of these projects. Unfortunately, cumulative environmental impacts rate only one paragraph on page 4-88 of the DEIS. Since anadromous fish from the Mokelumne must navigate the Sacramento - San Francisco - San Joaquin Bay-Delta, we believe that the FERC has a duty under NEPA to evaluate the cumulative impacts from all FERC licensed California projects to the Bay-Delta Estuary. Based on legal arguments submitted to the State Board Draft Decision 1630, it appears to us that the FERC and the EPA have the authority over water quality and water quantity in the Bay-Delta.

6-35

6-35 Staff's discussion of cumulative impacts has been expanded in the FEIS in Section 4.7, and the scope of this proceeding has been explained in Section 1 of the FEIS.

11) The Committee and the CSPA note with astonishment the complete lack of reference to the Public Trust and Public Trust resources in the DEIS. From the dawn of western civilization, "running waters, like the air and the sea, were *res communes*—things common to all and property of none." This doctrine of the "Public Trust" passed to us by way of the Civil Law of Spain and English Common Law. U.S. Supreme Court decisions establish that wild fish and game within a state belong to the people in their collective sovereign capacity; the public trust is inalienable and can not be given away; and the state can not abdicate its trusteeship responsibilities. The California Supreme Court has ruled that water rights are subject to limitations protecting the public trust; the state as a sovereign has the authority and duty "to protect the people's common heritage of streams, lakes, marshlands, and tidelands," and "the right of property in water is usufructuary, and consists not so much of the fluid itself as the advantage of its use." The American Heritage Dictionary defines usufruct as "the right to utilize and enjoy the profits and advantage of something belonging to another so long as the property is not damaged or altered in any way."

6-36

6-36 Although these exact words are not used, similar interests and concerns are a part of the federal legislation that establishes the Commission's authority and responsibilities. The Federal Power Act also requires balancing of power and non-power resources. Staff agrees that the development of EBMUD's LMRP has altered the environmental resources of the lower river, as explained in Sections 2 and 3 of the FEIS. However, hydropower development is only one of the many types of water development in the basin.

It is a basic and incontrovertible fact that historically the Mokelumne River provided flows that met the biological, physical, and chemical parameters necessary to support renewable fishery resources. It is an unrefutable fact that current instream flows do not meet those necessary parameters. The public trust resources of the Lower Mokelumne (including the reach below Woodbridge Dam) have been grievously altered and damaged by EBMUD's Mokelumne River Project.

6-36
(cont.)

The Committee and the CSPA believe that the FERC has a responsibility to enforce and implement not only the Federal Power Act but also the Public Trust on behalf of the people of California and the people of the United States.

In the final analysis, there is probably insufficient runoff in the Mokelumne Watershed to maintain all life stages for all species of aquatic organisms in all years and, at the same time, fully provide for existing water entitlements if EBMUD continues to divert almost a third of average annual basin runoff around the lower seventy-five miles of the Mokelumne and the Delta. For too long EBMUD's Mokelumne River Project has been subsidized by the degradation of Public Trust assets owned in common by the people of this nation. We ask that the DER incorporate and elaborate the FERC's obligations under Public Trust law.

We request that the testimony and evidence submitted to the State Board hearing by the Committee, the CSPA, the Central Delta Water Agency, and the Mokelumne River Alliance be incorporated by reference into these comments on the DEIS.

6-37

6-37 The exhibits and testimony from the State Board's water rights hearing on the Lower Mokelumne River were reviewed by staff in development of the FEIS and are referenced where appropriate.

Thank you for the opportunity to comment on the Draft Environmental Impact Statement for the lower Mokelumne River Project (FERC No. 2916-004). If you have any questions regarding our comments please contact Mr. William Jennings, Chairman of the Committee to Save the Mokelumne and the California Sportfishing Protection Alliance, 5637 North Pershing Avenue, Suite A-2A, Stockton, CA 95207, Telephone (209) 474-3177 or Mr. Bob Baiocchi, Executive Director, California Sportfishing Protection Alliance, P.O. Box 357, Quincy, CA 95971, Telephone (916) 253-3757. Please send a copy of the final Environmental Impact Statement to the above addresses.

Respectfully Submitted,

William Jennings, Chairman

Committee to Save the Mokelumne
California Sportfishing Protection Alliance

cc: All parties as required

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Ms. Lois D. Casshell, Secretary
FEDERAL ENERGY REGULATORY COMMISSION
825 North Capitol Street NE
Washington, D.C. 20426

RE: Comments to Draft Environmental Impact Statement, FERC
Project Number 2916-004

Dear Ms. Casshell:

Enclosed you will find the original and fourteen copies of the comments by Woodbridge Irrigation District to the Draft Environmental Impact Statement for FERC Project Number 2916-004, the Lower Mokelumne River Project in California.

We would ask that these documents be filed and that the enclosed copy of this letter be file marked and sent back to us as evidence of the filing of our comments. We have enclosed a self-addressed, stamped envelope for that purpose.

It is my understanding that the exhibits from the Lower Mokelumne River Hearing before the State Water Resources Control Board in California have been obtained by the staff of the Federal Energy Regulatory Commission. As a result, we have attached only particular key exhibits that were referred to in several portions of our comments.

We appreciate your attention to this matter and ask that you call the undersigned should there be any questions.

Very truly yours,

Joseph H. Fagundes

JOSEPH H. FAGUNDES

JHF:ds

Enclosures

cc: Anders Christensen
WOODBRIDGE IRRIGATION DISTRICT

7.1

7-1 Your understanding is correct.

COMMENTS OF THE
WOODBIDGE IRRIGATION DISTRICT
TO THE
DRAFT ENVIRONMENTAL IMPACT STATEMENT
BY THE
FEDERAL ENERGY REGULATORY COMMISSION
OFFICE OF HYDROPOWER LICENSING
PERC PROJECT NO. 2916-004

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INDEX OF ATTACHED EXHIBITS

<u>LARD-422</u> Review Comments Prepared by Steven P. Cramer	
<u>LARD-416</u> Exhibit 1:	Testimony of Anders Christensen, General Manager for the Woodbridge Irrigation District
<u>LARD-417</u> Exhibit 3:	Testimony of James C. Hanson, Consulting Engineer
<u>LARD-418</u> Exhibit 5:	Testimony of Steven P. Cramer, Fisheries Biologist
<u>LARD-419</u> Exhibit 7:	Testimony of William J. Mitchell, Fisheries Biologist
<u>LARD-420</u> Exhibit 32:	Canal Diversions, 1940-1990
<u>LARD-421</u> Exhibit 40:	Rebuttal Testimony of Steve P. Cramer, Fisheries Biologist

I. WOODBRIDGE IRRIGATION DISTRICT IS A SENIOR APPROPRIATOR ON THE MOKELUMNE RIVER AND HAS PUT SURFACE WATER TO BENEFICIAL USE FOR OVER 100 YEARS.

The Woodbridge Irrigation District¹ (hereinafter referred to as "WID") appreciates this opportunity to comment upon the draft Environmental Impact Statement (hereinafter referred to as "draft EIS") of the Federal Energy Regulatory Commission (hereinafter referred to as "FERC"). Although WID approves the fact that the FERC "staff does not intend to recommend any alternative that would adversely affect any existing water rights in the river" (draft EIS, p. 2-10), WID still feels it is necessary to respond to some misconceptions about WID operations and the effects of WID diversions on fisheries in the Mokelumne River.

WID understands that the exhibits and testimony presented before the State Water Resources Control Board (hereinafter referred to as SWRCB) and the water rights hearing on the Lower Mokelumne will be incorporated along with the comments to the draft EIS in preparing a final Environmental Impact Statement for this proceeding.² (Draft EIS, p. xxv.) WID feels this is-

¹This also refers to the Woodbridge Water Users Conservation District (hereinafter referred to as WWUCD) which has cross-assigned water rights with WID and is served by the same irrigation facilities. WWUCD does not have any irrigation facilities of its own.

²WID also has attached hereto key exhibits referred to as well as the comments of Steven P. Cramer, an expert fish biologist.

7-2

7-2 Staff attempted to represent WID's water rights as accurately as possible in the DEIS and the FEIS.

7-3

7-3 This understanding is correct, as explained in Section 1 of the FEIS.

essential to a complete understanding of the uses and benefits derived from the diversions of surface water by WID and the lack of any significant detrimental effect to the fisheries in the Mokelumne River by WID operations.

7-3
(cont.)

WID holds the most senior rights on the Mokelumne River behind only some riparian rights as has been noted by FERC staff. (Draft EIS, p. 3-18; Exhibits 1, 3 attached hereto; see also WID Exhibits 10-16.)³ Historically, WID diverted in excess of 100,000 acre feet from the Mokelumne until the mid-1970s when that amount steadily dropped, eventually reaching the base amount of 60,000 acre feet per contracts with East Bay Municipal Utilities District (hereinafter referred to as "EBMUD"), with only 39,000 acre feet being diverted in dry years when inflow into Pardee Reservoir is less than 375,000 acre feet. (WID Exhibit 32.) This latter circumstance has occurred in each of the last two years, 1991 and 1992. The licenses from the SWRCB allow diversions of over 400 cfs by WID which would give it well over 100,000 acre feet annually.

7-4

7-4 Your comment is noted. Updated information on WID's water use was incorporated into the FEIS, Section 3.2.1.

Contrary to the statement at page 3-17 of the EIS, WID has not "historically exceeded the maximum entitlement of 60 TAF." The maximum entitlement has been well over 100,000 acre feet but WID and EBMUD have entered into contracts which gave WID a base

7-5

7-5 This statement has been reworded in the FEIS.

³The reference to exhibits will be the same numbering as was used for the WID exhibits in the hearing before the SWRCB on the Lower Mokelumne.

amount of 60,000 acre feet in wet years with interim agreements for an additional 56,700 acre feet. (See WID Exhibits 1, 17, 19, 20, and 21.) Therefore, WID never exceeded its entitlements.

7-5
(cont.)

Rather, as other purveyors of water on the Mokelumne began using more water, WID was cut down to its base amount which is derived from the seniority of its rights. The additional amounts that had been diverted by WID were based on licenses from the SWRCB but did not have the seniority afforded to the 60,000 acre feet.

This water diverted by WID has been put to beneficial use since the late 19th century in the irrigation of eastern San Joaquin County. Over 40,000 acres is included in the combined districts of WID and MWCD (WID Exhibits 1 and 3) as opposed to the 20,000 acres of farmland referred to in the draft EIS at page 3-15. It would be requested this correction be made.

7-6

7-6 This information has been incorporated into the FEIS, Section 3.2.1 and 3.6.3.

The eastern San Joaquin Basin is accurately described by the draft EIS at page 3-20 as being subject to critical conditions of groundwater storage depletion. WID diversions are the only significant source of recharge for that area according to engineering testimony provided by James Hanson (WID Exhibit 3) and by Don Kienlen. (See San Joaquin County Exhibit 13.)

7-7

7-7 Channel losses from the mainstem of the Mokelumne River below Camanche Dam also contribute to groundwater recharge. Information from these references have been considered and incorporated into the FEIS.

Most important to note is that no substantial evidence was presented to the SWRCB that WID operations had any significant detrimental effect on fisheries in the Mokelumne River. Rather, the substantial changes in WID operations over the years have only served to mitigate any detrimental effects on fisheries. First of all, there is the declining amount of diversions made by

7-8

7-8 Staff recognizes that WID has cooperated with the resource agencies for several years to minimize the effects of its operations on salmon and steelhead in the Lower Mokelumne River. This recognition may not have been clear in the DEIS, but is clear in the FEIS at the beginning of the section on hydraulic improvements to Lake Lodi and Woodbridge Dam. Nonetheless, there is ample evidence for fisheries problems at WID facilities. Staff has specifically clarified the responsibility for the fish screen as being with CDFG in the FEIS in Section 4.7.

WID. Second, fish ladders have been improved over time by the Department of Fish & Game which has the responsibility for the fish ladders by agreement with WID. (WID Exhibit 26.) Third, the fish screen put in place by the Department of Fish & Game in 1968 is the responsibility of the Department, both by statute and agreement. (Fish and Game Code §5989; WID Exhibit 27.) The screen functions quite adequately according to fish biologists (WID Exhibit 5, the testimony of Steven P. Cramer; WID Exhibit 7, the testimony of William Mitchell) and the testimony of Department of Fish & Game officials themselves during the proceedings on the Lower Mokelumne River before the SNECB.

7-8
(cont.)

Because no evidence was presented in the lengthy and detailed proceedings before the SNECB that WID had any significant impact on fisheries, one can only conclude that the draft EIS is incorrect in stating that the hydraulics of Lodi Lake are "the most important non-flow action that could be taken . . ." (Draft EIS, p. XXV.) Contrary to comments at pages 2-17 and 4-26 of the draft EIS there have been no proven adverse impacts by Lodi Lake or WID diversions. To undertake the expense of the hundreds of thousands of dollars that any of the three staff alternatives would cost would be ill advised.

7-9

In fact, strong evidence was presented at the Lower Mokelumne River hearings at Lodi Lake was a key rearing area on the Mokelumne River.

7-10

7-9 Staff does not agree with the premise or the conclusion stated here.

7-10 Staff has reviewed this evidence for Lake Lodi being a key rearing area for chinook salmon on the Lower Mokelumne River. The habitat preferences of chinook salmon juveniles for pool areas downstream of riffles (given in Section 3.3.1) would suggest that the upper reaches of Lake Lodi would be suitable habitat, as long as temperatures are suitable in early spring. The large expanse of shallow water open to solar warming would not appear to be suitable in May-July and is the part of the lake that staff suggests be avoided. The likely positive effects are discussed in the FEIS at the beginning of the section on hydraulic improvements to Lake Lodi and Woodbridge Dam.

II. LODI LAKE MAY BE A REARING AREA FOR JUVENILE SALMON.

A. Affirmative Testimony Was Presented By Steven P. Cramer And Donald Chapman That Lodi Lake Was A Potential Rearing Area For Juvenile Salmon In The Mokelumne River.

Steve Cramer, who is a respected and well-known fish biologist, reviewed available information and the circumstances on the Mokelumne River for over one year before giving his testimony before the SMRCB during the Lower Mokelumne River hearings. He believed that Lodi Lake did not present any peculiar temperature problems for juvenile salmon and, based on his research and experience with other similar river systems, concluded that Lodi Lake may very well be a prime source of juvenile rearing area for the Mokelumne River. (WID Exhibit 5, pp. 30-31.) He based this on several factors including the size of the fish who migrate past the screen and dam in the late spring and early summer period. (WID Exhibit 5, p. 30.) These fish are quite large and reared in the river for quite some time before beginning their migration to the sea.

The Committee to Save the Mokelumne River called Don - Chapman, Ph.D., as a witness in the Lower Mokelumne River proceedings and he substantiated Mr. Cramer's opinion based on his long years of experience and expertise. Dr. Chapman testified on November 12, 1992, and gave this testimony in his oral comments at that time.

Additionally, Charles Hanson, a fish biologist on behalf of EDWID, testified that the most limiting factors to the salmon

7-11

7-11 See response to comment No. 7-10.

7-12

7-12 See response to comment No. 7-10.

7-13

7-13 See response to comment No. 7-10. The DEIS and FEIS also placed strong emphasis on the effects of fish mortalities in the Delta and in the ocean fishery. A limiting factors analysis has been added for chinook salmon and steelhead (Sections 3.3.1, 3.3.2) that emphasizes the importance of these locations for fish mortalities.

fisheries are Delta mortality and ocean harvesting. Conditions on the Lower Mokelumne and, specifically, in the Lodi Lake area were not the significant limiting factors in fish survival.

This testimony was contrary to the conclusions reached by Bio Systems in performing a limited mortality study on behalf of EBMUD which the draft EIS places heavy emphasis upon.

7-13
(cont.)

B. The Mortality Study In Lodi Lake Was Admittedly Flawed And Cannot Be Relied Upon To Support The Hypothesis That Mortality Takes Place In Lodi Lake.

The 30% survival number or 70% mortality number used in the draft EIS at pages 2-19 and 4-55 are based upon the mortality study performed by Bio Systems on behalf of EBMUD. This mortality study focused on the Lodi Lake area and used only three samples in a short period of time. Steve Cramer was quite critical of the study and pointed out many of its flaws, both in his direct testimony (WID Exhibit 5, pp. 32-33) and in his rebuttal testimony. (WID Exhibit 40, pp. 5-6.) Mr. Cramer concludes that survival of juvenile chinook migrating through Lodi Lake may be near 100%. (See Review Comments Prepared by Steven P. Cramer attached hereto.)

7-14

7-14 See response to comment No. 7-10.

Charles Hanson also agreed that the mortality study would be flawed if Bio Systems had not compared day versus night captures, flows at the time of the study, a survey of the river, and efficiency of the trapping downstream.

Bio Systems witnesses John Garcia and Ed Bianchi also agreed these were important criteria. Mr. Ed Bianchi, who supervised

7-15

7-15 See response to comment No. 7-10.

the mortality study, admitted that they did not sample the river, they did not sample below the dam, they did not evaluate the screen, and they did not determine delayed mortality.

John Garcia then made the admission that a longer mortality study would be needed over a period of years to make any definitive conclusions and that Lodi Lake was not one of the prime limiting factors in salmon mortality. He believed the most significant limiting factors were the conditions in the Delta and ocean harvesting.

7-15
(cont.)

Therefore, the mortality study upon which the draft EIS places all its emphasis in suggesting the non-flow alternatives, is flawed and there is no basis upon which to support any of the non-flow alternatives, the costs of which are summarized on page 4-56 as \$960,000.00, \$720,000.00 and \$120,000.00, respectively.

7-16

As Steve Cramer points out neither temperature (WID Exhibit 5, pp. 31-32) nor any evidence of significant predatory activity has been noted to be a problem in the Lake Lodi area. (WID Exhibit 5, p. 33.) Charles Hanson and Bio Systems also agreed that neither of those factors had been qualified as having any significant effect on salmon passing through Lake Lodi.

7-17

III. THE FISH SCREENS OPERATE ADEQUATELY AND PROTECT JUVENILE SALMON FROM BEING DIVERTED INTO THE WID CANAL SYSTEM.

The testimony of Steve Cramer and Bill Mitchell, two qualified fish biologists (WID Exhibits 6 and 8), substantiate that the fish screens are not a significant source of mortality for juvenile salmon.

7-16 The non-flow alternatives were offered in the DEIS for the objective of increasing the production and survival of fall chinook salmon and steelhead in the Lower Mokelumne River based on the staff's general knowledge of salmon and trout environmental requirements, not just on EBMUD's fish mortality study for Lake Lodi. Staff recommended that EBMUD, as part of its hydropower license, participate in further evaluation of these alternatives. This point was strengthened in the FEIS at the introduction to the first non-flow alternative.

7-17 See response to comment No. 7-10.

The small fry move downstream in the early spring before any irrigation diversions and are not impacted by WID operations at all. By the time diversions start picking up in May and June the mean length of the smolts exceeds 100 mm and they are very strong swimmers who have no trouble avoiding the flow into the screen and do not suffer any impingement. (WID Exhibit 5, pp. 18-25.) Furthermore, the screen maintenance by the Department of Fish & Game has been improved and new seals have been put on the screen to protect against entrainment. DFG did this last spring. (Review Comments of Steven P. Cramer attached hereto.)

7-18

7-18 WID correctly points out that some migration of young salmon and trout occurs in early spring before any irrigation diversions. These fish avoid interactions with the screens. Larger fish migrate in May and June and may be better able to avoid damages at the screens than smaller fish. Additional screen maintenance since the DEIS was prepared may have reduced the potential for detrimental effects. These points are provided in the FEIS at the introduction to the section on fish screens (Section 4.5).

Mr. Cramer also has summarized his thoughts and conclusions with regard to the specific proposals by the draft EIS in a new exhibit which is attached to these comments and submitted to the Federal Emergency Regulatory Commission for its review and consideration. (See Review Comments of Steven P. Cramer attached hereto.)

7-19

7-19 Staff has reviewed Mr. Cramer's evidence and has included it in the FEIS along with additional discussion of the effects, both positive and negative, of Lake Lodi and other WID operations on salmon and trout. See response to comment No. 7-10.

The Department of Fish & Game officials who testified in the Lower Mokelumne River proceedings also agreed that the screens were operating effectively and were not in need of replacement at this time. If they were in need of any replacement or repair that would be the legal and financial responsibility of the Department of Fish & Game.

7-20

7-20 Staff has reviewed the testimony on the current effectiveness of the fish screens. Staff recognizes that maintenance has been done on the screens during the time the EIS was prepared. This information has been added to the FEIS (Section 4.5). Staff has also clarified that the screens are the responsibility of CDFG.

IV. RECOMMENDED CHANGES TO THE DRAFT EIS.

Several comments have been noted above regarding references to specific pages and comments in the draft EIS. Similar comments occur elsewhere in the draft EIS. WID would ask that

7-21

7-21 See staff response to comment No. 7-10. Staff agrees that the study by BioSystems of fish mortality in Lake Lodi is not conclusive. However, conditions in Lake Lodi in late spring and early summer do not appear conducive to salmon and trout either there or in the river below the dam. Modifications to Woodbridge Dam to enhance the passage of cooler water would benefit fish passage and downstream water temperatures. The most modest proposal would also likely have the most benefit.

the PERC staff rethink the whole issue of the hydraulics of Lodi Lake in light of the evidence presented to the SWRCB which indicated that Lodi Lake was not a problem. The mortality study performed by Bio Systems was seriously flawed and limited sampling was only done on three occasions during one season. No far reaching conclusions can be made from this study even according to the Bio Systems personnel. More importantly, because of the flaws, Steve Cramer concludes that the survival rate through Lodi Lake is extremely high and both he and Dr. Chapman agree that Lodi Lake may be a prime rearing area on the Mokelumne River.

7-21
(cont.)

All of the parties involved in the Lower Mokelumne River proceedings agreed that the real limiting factors to fish survival were Delta conditions and several of the leading fish biologists felt that ocean harvest was the other most limiting factor. No one testified that WID operations or Lodi Lake had any proven adverse impacts as described in the draft EIS at pages 2-17 and 4-26. Before any recommendation is made of spending hundreds of thousands of dollars in Lodi Lake it is recommended that the evidence referred to in these comments be reviewed and considered.

7-22

7-22 See staff response to comments No. 7-10 and No. 7-21.

WID appreciates the opportunity to address the Federal Energy Regulatory Commission on these issues and would be happy

to provide any further information or answer any questions that
FERC staff may have.

DIEHL, STEINHEIMER, RIGGIO,
HAYDEL & MORDAUNT

Joseph H. Fagundes

DATED: February 26, 1993

By: Joseph H. Fagundes
Attorneys for WOODBRIDGE
IRRIGATION DISTRICT

STATE OF CALIFORNIA - CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
 STATE WATER RESOURCES CONTROL BOARD
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 801 P STREET
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 SACRAMENTO, CALIFORNIA 95812-0100

PETE WILSON, Governor

(916) 657-0941

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MAR -1 1993

Mr. Martin L. Allday, Chairman
 Federal Energy Regulatory Commission
 825 North Capitol Street N.E.
 Washington, D.C. 20426

Dear Mr. Allday:

Lower Mokelumne River Project, Project No. 2916-004

The State Water Resources Control Board (State Water Board) has reviewed the October, 1992 Draft Environmental Impact Statement (DEIS) prepared by the Federal Energy Regulatory Commission (FERC) regarding the proceeding to consider modifications of facilities and operation of the Lower Mokelumne Project (FERC NO. 2916-004). The State Water Board's comments on this document are attached.

The State Water Board supports your efforts to assure that both the State Water Board's water right proceedings and FERC's proceeding do not result in competing requirements to be met by East Bay Municipal Utility District.

The State Water Board held eight days of formal hearing involving thirteen parties and received expert testimony by seventy seven witnesses regarding measures needed to protect the fishery resources on the Lower Mokelumne River. (A copy of the transcripts and exhibits received to date for this hearing have been sent to Michael J. Sale of Oak Ridge National Laboratory for consideration in the preparation of the final EIS). The hearing record is being held open for submission of additional hydrological model studies, comments on impacts to the Lower Mokelumne river by the proposed Bay/Delta Decision 1630, written closing arguments, and written legal briefs. As discussed in the attached comment letter, all of this information as well as the FERC DEIS will be evaluated by the State Water Board technical staff and will be discussed in the staff analysis of the hearing.

8-1

8-1 Staff received this information and fully considered it in the development of the FEIS. Staff appreciates the cooperation and timeliness of the State Board's staff in providing this information.

The staff analysis will provide a discussion of the alternatives and will propose specific flow, temperature, and water quality measures as well as other measures required for the protection of the fishery resources of the Lower Mokelumne River including improvements to the Mokelumne River Fish Hatchery, diversion and operation of Woodbridge Irrigation District facilities, and operation of North San Joaquin Water Conservation District facilities. We anticipate that the staff analysis and the accompanying order will be completed in July 1993. The staff analysis should provide additional, significant information that would be useful to FERC in completing the final EIS. Accordingly, the State Water Board suggests that FERC delay completion of the final EIS until after the State Water Board completes the staff analysis and draft order.

8-2

8-2 The schedule for the release of the State Board's staff analysis has been delayed so that it will follow the scheduled completion of the FEIS. Opinions of the State Board's staff analysis was considered extensively in the FEIS. Staff considered the Board's decision, and the Commission's actions and the Board's actions were complementary.

Mr. Martin L. Allday

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MAR - 1 1993

If you have any questions regarding the above request, please contact me at (916) 657-0941 or Ed Otto at (916) 657-2048.

Sincerely,

Walt Pettit
Executive Director

cc: Mr. John Schnegle
Federal Energy Regulatory Commission
825 North Capitol Street N.E.
Washington, D.C. 20426

STATE OF CALIFORNIA

STATE WATER RESOURCES CONTROL BOARD

THE PAUL R. BENDERSON BUILDING
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Ms. Lois Cashell, Secretary
Federal Energy Regulatory Commission
825 North Capitol Street, N.E.
Washington, D.C. 20426

Dear Ms. Cashell:

Comments on the Draft Environmental Impact Report, Lower
Mokelumne River Project, Project No. 2916-004

This is in response to the October, 1992 Draft Environmental
Impact Statement (DEIS) prepared by the Federal Energy
Regulatory Commission (FERC) Staff and Oak Ridge National
Laboratory Staff regarding the proceeding to consider
modifications of facilities and operation of the Lower
Mokelumne River Project (FERC No. 2916-004). The State Water
Resources Control Board (State Water Board) has reviewed the
DEIS and offers the following general and specific comments.

GENERAL COMMENTS:

The State Water Board has received substantial information as
a result of our hearing regarding the Lower Mokelumne River.
A copy of the transcripts and exhibits for this hearing have
been forwarded to Michael J. Sale of Oak Ridge National
Laboratories for consideration in the preparation of the
final EIS. The hearing record for the Lower Mokelumne river
hearing is being held open for submission of additional
hydrological model studies, comments on the anticipated
impacts of the Delta Decision (D-1630) to the Lower Mokelumne
River, written closing arguments, and written legal briefs.
Although the submission due date for this additional
information falls after the final date for comments on FERC's
DEIS, we recommend that this information be considered by
FERC prior to preparing the final EIS.

The additional model studies will provide information
regarding the effects of alternative flow criteria,
alternative water year types, alternative design drought
sequence, and alternative ramping criteria. Attachment 1
provides a description of the twelve additional studies that
are being conducted by East Bay Municipal Utility District
(EBMUD) at the request of the State Water Board. We believe
that these studies will provide substantial information that
will be essential to the analysis of the appropriate fish
flow standards as well as the overall allocation/management

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93 MAR -1 PM 4:23

8-3

8-3 See the response to comment No. 8-1.

8-4

8-4 The additional modeling studies by EBMUD for the State Board have been
considered in development of the FEIS and have been helpful. However, this
additional information is not definitive, for the purposes of the Commission's
decision-making, because it did not evaluate alternative instream flow releases for
fish resources. EBMUD's modeling studies have concentrated on either their own
proposed releases or on CDFG's. There are intermediate flow regimes that have
increased benefits and reduced costs, as staff has shown in our assessment. Staff
redefined its water year types in the FEIS, in part due to additional information
and modeling studies such as those referred to here.

Ms. Lois Cashell

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of the water resources of the Lower Mokelumne River. The importance of this information is highlighted in Section 2.2.1 of the DEIS which states the magnitude of the streamflow, the definition of water year type and specific minimum flow criteria have "a strong influence on the benefits and costs of each alternative".

8-4

The Delta decision (D-1630) and comments regarding the impact of D-1630 on the Lower Mokelumne River will provide additional information on the issue of how to best coordinate releases from Pardee/Camanche for the benefit of the fishery resources in both the Lower Mokelumne River and the Delta.

8-5

8-5 The Interim Delta decision was withdrawn by the state in April. It is mentioned in the FEIS, but since it had been withdrawn, it cannot be considered by the Commission as an impending action or condition on EBMUD's project.

Written closing arguments will provide a summation of the most important concerns of each party in the State Water Board hearing. Written legal briefs have been requested in response to the following questions:

1) Who is legally obligated to pay the cost of improving fish screens or fish bypass structures operated by Woodbridge Irrigation District or North San Joaquin Water Conservation District, these agencies or the Department of Fish and Game?

8-6

8-6 Staff appreciates all the efforts by the State Board's staff; these efforts were extremely helpful in the preparation of the FEIS. EBMUD's closing brief was received and considered in the development of the FEIS.

2) What water quality standards are applicable to the release of water from Camanche Reservoir into the Mokelumne River?

In addition, the State Water Board took "Administrative Notice" of the FERC DEIS at the hearing. State Water Board staff will consider the information contained in the DEIS.

All of the above information will be utilized by State Water Board staff in the preparation of its staff analysis and draft order. The State Water Board is anticipating that the staff analysis and draft order will be completed by July 1993. The DEIS outlined many issues as being critical to the success of any effort to restore the fishery resources of the Lower Mokelumne River; specifically, Lake Lodi, the Mokelumne River Fish Hatchery, other non-flow related actions, and additional studies. The importance of these measures are emphasized in the DEIS which states the adverse impacts of Woodbridge Dam and Lake Lodi are "so serious that they could negate any benefits that could be gained from other actions taken on the river" (DEIS Section 2.3.2) although these measures are "not the responsibility of EBMUD under its FERC license..." (DEIS Section 5.1.2)

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SPECIFIC COMMENTS:

Flow Requirements: The FERC alternative fish flow requirements are based on the same information as EBMUD's and California Department of Fish and Game's (CDFG) recommended flows. On the surface, the minimum flows proposed by FERC staff (p. 2-13) appear to be a compromise between those of CDFG and EBMUD. It is stated on page 2-12 that the methods used to design the FERC fish flow alternatives are described in Appendix B. That section describes an input/output hydrological model, however, it is not clear how flow recommendations for fish, which are essentially biological in nature, are derived from the model.

The DEIS states that the CDFG IFIM study was well designed and executed, yet evaluation of the data, using the same habitat suitability indexes, results in quite different flow recommendations by CDFG, EBMUD, and FERC staff. On page F-1 the DEIS states that this results from "important differences in how these data are applied to impact assessment, as explained in appendix F"; however, the only significant difference appears to result from the aggregation of the three upstream reaches into the "Tailwater Segment." On page 3-47 the DEIS refers to Appendix H for further details on habitat suitability indexes; however, Appendix H is not included in any of the DEIS copies received by the State Water Board.

Model Studies: We believe that the Oak Ridge Technical staff has made an extraordinary effort to develop a computer hydrology model; however, insufficient information is provided to evaluate the model and various alternative hydrology runs. We would suggest that the actual output of the FERC model runs be included in the appendix so that closer comparisons could be made between each model run. We believe that the EBMUD model provides a better replication of the operation of the facilities on the Mokelumne River and the hydrology for various flow scenarios. We recommend that you use the results of the hydrology studies being conducted by EBMUD. In the alternative, we would recommend that FERC conduct additional hydrology studies and include that information in the DEIS as described below.

In order to compare FERC's and DFG's proposed fishery releases, a model run should be conducted and presented using DFG's proposed releases without DFG's proposed "minimum pool" at Camanche. Similarly in order to compare FERC staff's, DFG's, and EBMUD's water year

8-7

8-7 The explanation of staff's flow recommendations and how these flows were identified were expanded in the FEIS, Appendix F and elsewhere. The instream flows recommended by staff were not simply a compromise but also were the result of a thorough examination of available data and resources requirements.

8-8

8-8 The Instream Flow Incremental Methodology (IFIM) is a suite of assessment methods designed to generate quantitative information relating incremental changes in stream flow to changes in physicochemical habitat quality. There is no single, well-defined way in which IFIM information is used to generate flow recommendations. Although staff used the same IFIM information describing stream flow to habitat relationships, we interpreted it differently in arriving at our flow recommendation. Staff's analytical approach is consistent with guidelines for IFIM studies. The reference to Appendix H in the DEIS was incorrect. The explanation of staff's instream flow analyses was presented in Appendix F in the FEIS in an expanded form.

8-9

8-9 Staff developed a new water balance model for this assessment, because EBMUD did not provide full access to their simulation model. Although EBMUD has made a large number of different modeling analyses on the LMRP system, to staff's knowledge there have not been sufficient studies of alternative flow regimes by EBMUD on which to base staff's recommendations (e.g., EBMUD runs focus on the extremes of CDFG or EBMUD alternatives and too little in between). Additional modeling details and results have been presented in the FEIS as requested.

8-10

8-10 These requests have been answered with new modeling runs presented in the FEIS.

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definition, model runs should be conducted using DFG's fishery releases without minimum pool on Camanche, and with EBMUD's water year definition.

Consideration should also be given to conducting additional studies varying the breakpoints for water year types using EBMUD's and DFG's methodology. One example would be to set breakpoints separating water year types such that the breakpoint for Wet/Normal years is set at an average annual unimpaired flow which is exceeded 33% of the time, and the Normal/Dry breakpoint is set at an average annual unimpaired flow which is exceeded 67% of the time.

8-10
(cont.)

It is not clear whether the FERC model incorporated ramping in its determination of the expected operation under each alternative. Different ramping criteria may have significant effects on the quantity of water released for fishery of the Lower Mokelumne River.

Water Year Types: FERC's staff propose a water year type based on observed inflows to Pardee Reservoir as measured at the USGS stream gage station at Mokelumne Hill. No mention is made as to how or when the determination of the water year type would be made. Typical requirements by SWRCB have been to require a yearly determination on or about April 1st of each year.

The State Water Board anticipates several difficulties with FERC's proposed definition of year type:

- A yearly determination based on observed inflow to Pardee Reservoir would cause the reduction of downstream fishery releases to lag one year behind the occurrence of a drought.
- Upstream reservoirs may hold water over from one year to another. This would result in the observed flow being artificially diminished and result in diminished supply to both the fishery bypass and off stream diversions.
- Upstream consumptive uses are expected to increase in the future. This may require that the dry/normal and normal/wet breakpoints of 500 cfs and 1100 cfs be continuously modified in the future.
- Imposing restrictions on fishery and downstream diversions based on observed average annual inflow to Pardee in effect causes upstream right holders to gain a higher priority.

8-11

- 8-11 Staff's definition of water year type has been refined in the FEIS in response to these and other comments on the DEIS. See Section 2.2.1 of the FEIS.

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FERC's methodology results in three years out of 25 being different from DFG's methodology. It is unclear what is gained by FERC's methodology over DFG's methodology.

8-11
(cont.)

It does not appear to the State Board that water year types based on observed inflow would allow for an equal sharing of dry year deficiencies among all off-stream diverters and the fishery resources of the Lower Mokelumne River.

In the EBMUD alternative, the fishery releases downstream of Camanche and deficiencies to EBMUD customers are determined for the year based on the projected end of October combined storage in all EBMUD reservoirs. This projected end of October combined storage is determined by using the predicted unimpaired runoff as of April 1st of each year combined with available storage as of this date and subtracting out of the stream demands. The effect of this type of index in the first year of drought is to provide greater water to both the fishery and EBMUD customers due to the benefit of storage to meet all demands. However, in a multi-year drought the amount of storage combined with runoff available to both the fishery and out-of-system demands would diminish. It appears that EBMUD methodology of using anticipated runoff and storage to determine year type places the water deficiency to both fish releases and EBMUD customers into later years in a multi-year drought sequence as compared to using DFG's methodology of using anticipated unimpaired runoff.

8-12

8-12 See response to previous comment. EBMUD's additional studies for the State Board did help, but they left new questions about the best water year definition

The hydrology studies requested by the State Water Board should provide specific data that will allow comparison of the different water year classifications.

Improvements at Lake Lodi and Woodbridge Dam: Significant testimony was received during the State Water Board water rights hearing regarding improvements to Lake Lodi and Woodbridge Dam. Additionally, all of the alternative improvements to Woodbridge Dam and Lake Lodi would involve construction in significant wetlands habitat. Consideration should be given to mitigation of these impacts and the relative impacts to wetlands habitat for each alternative.

8-13

8-13 The staff has included a discussion of the possible effects on wetlands of the staff's conceptual proposals for improving fish passage through Lake Lodi, recognizing that enhancement of one resource may entail a balancing with effects to another resource.

Spring/Summer Outmigration Flows: State Water Board draft decision D-1630 proposes outmigration flows for the benefit of the Sacramento/San Joaquin River Delta. Discussion should be included in the EIS regarding coordination of D-1630 outmigration flows with the alternatives considered on the Lower Mokelumne River.

8-14

8-14 See response to comment No. 8-6.

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Public Access for Recreation: Recently, EBMUD expressed concern regarding the trampling of redds by wading fishermen. Discussion of management of fishing restrictions on the Lower Mokelumne River should be included which could include efforts to reduce the effects of trampling of redds or restriction of fishing to bank angling when redds are present.

8-15

8-15 The issue of trampling of salmon redds by wading trout anglers was discussed in the FEIS in relation to embryo survival and possible management restrictions (Section 4.6.6).

Water Quality: Additional information and testimony was received in the State Water Board hearing regarding water quality affecting the Lower Mokelumne River. Copies of this testimony and exhibits have been provided to Oak Ridge National Laboratory.

8-16

8-16 This information was reviewed by staff and was used to revise the EIS where appropriate.

Fish Screens: Additional information and testimony was received in the State Water Board hearing regarding fish screens. Copies of this testimony and exhibits have been provided to Oak Ridge National Laboratory.

8-17

8-17 See staff responses to comment No. 7-10

References: Many of the graphs and charts produced by FERC staff were compilations of information obtained from various parties. It would be helpful if the source or sources of this information is identified.

8-18

8-18 Additional source references have been included in the FEIS to address your comment.

Sincerely,

Edward C. Anton, Chief
Division of Water Rights

Attachment

SWRCB Model Studies

Summary of SWRCB Model Studies

Assumptions Common to all Twelve Studies: <ul style="list-style-type: none"> Revised Early Deficiency rules to obtain 12.9%, 30%, and 35% customer rationing programs in the first, second, and third year of the design drought. 	
Assumptions Common to Studies 1, 3, 5, 7, 9, and 11: <ul style="list-style-type: none"> Current Drought Planning Sequence equal to 1976-1977-1985 TAF. 	Assumptions Common to Studies 2, 4, 6, 8, 10, and 12: <ul style="list-style-type: none"> Revised Drought Planning Sequence equal to 1976-1977-785 TAF (in g.)
Study Number 1: Fish Release based on combined runoff/storage Critical year = LMRMP critical year flow Dry year = LMRMP dry year flow (decreased frequency) Wet/Norm = LMRMP wet year flow (increased frequency)	Study Number 2: Fish Release based on combined runoff/storage Critical year = LMRMP critical year flow Dry year = LMRMP dry year flow (increased frequency) Wet/Norm = LMRMP wet year flow (increased frequency)
Study Number 3: Fish Release based on combined runoff/storage Critical year = LMRMP critical year flow Dry year = LMRMP dry year flow Wet/Norm = LMRMP wet year flow	Study Number 4: Fish Release based on combined runoff/storage Critical year = LMRMP critical year flow Dry year = LMRMP dry year flow Wet/Norm = LMRMP wet year flow
Study Number 5: Fish Release based on combined runoff/storage Critical year = LMRMP dry year flow Dry year = LMRMP dry year flow Wet/Norm = LMRMP wet year flow	Study Number 6: Fish Release based on combined runoff/storage Critical year = LMRMP dry year flow Dry year = LMRMP dry year flow Wet/Norm = LMRMP wet year flow
Study Number 7: Modify the DF&C Plan requirements to have EBMUD ramping and temperature operations. DF&C attraction/outmigration included.	Study Number 8: Modify the DF&C Plan requirements to have EBMUD ramping and temperature operations. DF&C attraction/outmigration included.
Study Number 9: Fish Release Based on TNF Critical year = LMRMP critical year flow Dry year = LMRMP dry year flow Wet/Norm = LMRMP wet year flow Same frequencies as Study Number 1	Study Number 10: Fish Release Based on TNF Critical year = LMRMP critical year flow Dry year = LMRMP dry year flow Wet/Norm = LMRMP wet year flow Same frequencies as Study Number 1
Study Number 11: Same as Study Number 7 except DF&C attraction/outmigration not included.	Study Number 12: Same as Study Number 8 except DF&C attraction/outmigration not included.

ELLIS & PRIOLEAU

ATTORNEYS AT LAW

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GWENDOLYN D. PRIOLEAU, DC, MD BAR

March 1, 1993

Ms. Lois D. Cashell
Secretary
Federal Energy Regulatory Commission
825 North Capitol Street, NE
Washington, DC 20426RE: FERC Project No. 2916-004 - Proposed Modifications
to the Lower Mokelumne River Project, California

Dear Ms. Cashell:

Enclosed are the comments of the City and County of San Francisco to the Draft Environmental Impact Statement, issued October 23, 1992 in the above-referenced proceeding. San Francisco is an intervenor in these proceedings and submits these comments in accordance with the procedural schedule established in this docket.

Sincerely,

GWENDOLYN D. PRIOLEAU

Enclosure

GDP/ctg

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Lower Mokelumne River Project

Project No. 2916-004

COMMENTS OF
THE CITY AND COUNTY OF SAN FRANCISCO
ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

Intervenor City and County of San Francisco ("San Francisco" or "City and County") respectfully submits the following comments to the Draft Environmental Impact Statement ("DEIS") issued in this proceeding pursuant to the National Environmental Policy Act ("NEPA"), and dated October 1992.

INTRODUCTION

San Francisco previously intervened in this proceeding by motion filed October 23, 1992. In that Motion to Intervene, the City and County stated that its interest in these proceedings "is in assuring that the Commission takes into account the regional nature of California's water resources and the importance of maintaining high quality water supplies for municipal and industrial purposes." (Motion of the City and County of San Francisco to Intervene Out of Time at 4). San Francisco also emphasized the fact that the ongoing drought, at that time six (6) years in duration, had forced San Francisco, East Bay Municipal Utility District ("EBMUD"), and other water agencies to engage in stringent programs of water rationing.

The DEIS issued in this proceeding could result in the imposition of many of the adverse effects described by San | 9-1

9-1 Your comment is noted.

Francisco in its Motion to Intervene. Those effects include water quality concerns, a foreseeable strain on existing water resources, economic effects on municipal and industrial water uses, and a direct and immediate decline in regional reliability of pooled water resources. The mandates of both NEPA and the Federal Power Act require the Commission to balance all of these factors. Further, the recommendations reflected in the DEIS will not resolve the fish problems identified as existing on the Mokelumne River.

Among the stated purposes of NEPA are the encouragement of productive and enjoyable harmony between man and his environment, and the promotion of "efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man..." 42 U.S.C. §4321. Each of these stated purposes requires a delicate balancing between biospheric environmental concerns and the human environment. This required balance is not evident in the DEIS issued in this proceeding. Accordingly, the following comments are submitted on behalf of the Public Utilities Commission of the City and County of San Francisco concerning the DEIS for the proposed modifications to the lower Mokelumne River Project, California, FERC Project No. 2916-004, operated by EBMUD.

9-1
(cont.)

The following is a section-by-section analysis of the DEIS.

I.

Section 1.2. Included within major socio-economic issues which should be discussed are the effects which reduced water supply availability in the EBMUD service area will have on adjacent

9-2

- 9-2 Clearly, any transfers of water to EBMUD in times of drought could impact other suppliers such as CCSF, but the specifics of these impacts depends on the nature of these unforeseeable transfers among third parties. The FEIS discusses briefly the issue of water transfers; however, it was concluded that the impact of these potential additional transfers would have a minor impact on other water agencies. The impact would be minimal because it would only affect other water suppliers under a prolonged drought sequence.

water suppliers. This issue should be discussed in light of increased water transfers which will become necessary as a result of the projected shortages of water available to EBMUD from the Mokelumne River.

9-2
(cont.)

Section 1.3 - Assessment Approach. The DEIS analysis focused on "the trade-offs between anadromous fisheries and water supply economics." DEIS at 1-4. Rather than limiting the analysis to water supply economics, other aspects of water supply should be taken into account, including but not limited to water supply availability, impacts on water quality, impacts on the Delta due to additional diversions, the availability of water transfers to make up for lost supplies,¹ and impacts on adjacent water suppliers resulting from additional competition for water transfers.

9-3

9-3 See previous comment. The impacts regarding the use of the Delta could be mitigated by EBMUD through conjunctive use with their Pardee water source.

Section 2.1. This section describes the project facilities for EBMUD. It would also be appropriate to describe the end uses of the water, including municipal and industrial uses for San Francisco and the Bay Area residents.

9-4

9-4 Water uses were discussed in Sections 3.2 and 3.6 of the DEIS and the FEIS. A cross reference from Section 2.1 to these Existing Environment sections were added to the FEIS.

Section 2.2 - Flow Alternatives. The introductory language indicates that staff does not intend to recommend an alternative that would affect existing water rights, but notes that "some of the options considered may affect the amount of water available to EBMUD to divert for municipal water supply." DEIS at 2-10.

¹The issue of water transfers is now particularly important because of the actions taken by the State Water Resources Control Board in issuing the draft Interim Water Rights Decision 1630 ("D-1630"). Under the stringent flow restrictions imposed by D-1630, water transfers will occur less frequently, be more unreliable, require large amounts of carriage water and be more expensive.

Any flow alternative which would reduce the supply available to EBMUD would obviously affect their water rights. The DEIS does not reconcile the loss of water to EBMUD through fish flows with the non-impact standard which is recommended. Further, it should be noted that a change in point of diversion is a change in a water right, even if the amount of water taken by EBMUD does not change. Finally, the DEIS fails to discuss the actual ability of EBMUD to recover the additional flows downstream. (See n. 1, supra.)

9-5

9-5 Your comment is noted. Additional text was added to the FEIS in several places to discuss this issue. Staff and the Commission recognize that there are multiple regulatory actions underway in California that may affect water rights. However, there is significant uncertainty as to the final resolution of all these actions, including the Bay-Delta proceedings. These uncertainties were discussed in the FEIS, including EBMUD's ability to recover additional flows downstream. Actions that will allow EBMUD to comply with its hydropower license obligations in spite of these uncertainties were recommended.

Section 2.2.1 - Minimum Flow Requirements. The DEIS is silent as to those studies and actions which are the basis for the "new recommendations developed independently by staff." This data is required for a full consideration of the recommendations and possible impacts of the recommendations in the DEIS.

9-6

9-6 The NEPA process and the analyses presented in the FEIS constitute the studies and actions referred to here.

Staff's Alternative. The recommendations for minimum flows by CDPC and EBMUD are based upon their extensive studies. On what basis did staff develop its flow regime? The discussion in the text at pages 2-12 and 2-13 provides no explanation of staff's development of the 65, 135, and 169 TAF flow release proposal.

9-7

9-7 See previous response.

No-Action Alternative. Considerable water must be released to satisfy the water rights of downstream users. There is no discussion of the benefits of the no-action alternative which result from existing downstream releases.

9-8

9-8 Additional discussion of benefits have been added to the FEIS in Section 4 and elsewhere to clarify staff's position on this point.

Further, there is no discussion of any flow regime offered by the United States Fish and Wildlife Service. Has USFWS offered any flow regimes or participated in any of the studies? To what extent are their recommendations included in the DEIS?

9-9

9-9 The U.S. Fish and Wildlife Service (FWS) alternative flow regime was provided as a comment on the DEIS and is included as a separate flow alternative in the FEIS.

Section 2.3 - Non-Flow Alternatives. The DEIS fails to reconcile alternative means of protecting the fish resources. For example, if non-flow alternatives can be shown to have the same beneficial impacts to fisheries as would flow alternatives, would FERC accept the non-flow alternatives in-lieu of flow alternatives? Does FERC favor flow or non-flow alternatives? These questions assume that some level of flow is absolutely necessary for the fishery, but they also emphasize the need to consider issues of management versus flow-based fishery protection.

Page 2-24 discusses the cost impacts of each of the alternatives. However, the basis of these costs is unstated.

Section 3.3.2 - Steelhead Trout. In the discussions concerning Chinook salmon, the DEIS quantified salmon runs before and after the construction of Camanche Dam and noted that they were roughly equivalent. No similar comparison is made for steelhead trout. A CDFG study in 1991 estimates present production at 200 fish per year. It is not clear whether better information is available concerning the history of steelhead trout populations in the Mokelumne River.

CDFG estimated that the river was capable of sustaining 2,000 spawning adult steelheads. How does this number compare with actual average runs? If the average annual runs are significantly lower than 2,000 spawners, is the CDFG estimate still reasonable? These concerns also arise in the context of the CDFG estimates for salmon in light of the consistent production of approximately 3,300

9-10

9-10 The final staff recommendations in the FEIS are a combination of flow and non-flow actions that staff believes are the best, balanced approach to conserving sustainable anadromous salmon in the Lower Mokelumne River. The entire FEIS is an attempt to reconcile these alternatives.

9-11

9-11 The FEIS contains more discussion of the basis of the cost estimates.

9-12

9-12 Staff added more information in the FEIS on steelhead habitat and populations in the Lower Mokelumne River and a limiting factor analysis that suggested that attempts to rehabilitate steelhead in the Lower Mokelumne River are not worthwhile (Section 3.3.2).

9-13

9-13 Please refer to staff responses to comments No. 6-12, No. 2-31, and No. 3-10.

salmon both before and after the construction of Camanche Dam versus the CDFG estimate of 15,000 potential spawners.

9-13
(cont.)

Section 3.6.1 - Municipal Water Demand and Consumption. At page 3-74 a study of the conservation potential of Best Management Practices is cited (Vickers, 1991) which calculated estimated annual household savings from a retrofit of toilets, shower heads and faucets. Has any sensitivity analysis been done as to the applicability of the Vickers study to the EBMUD service area or other service areas?

9-14

9-14 Staff is not aware of any specific studies that document household water savings in the EBMUD service area. However, an EBMUD-sponsored study shows that water conserving landscaping can save up to 42% of water when compared to traditional landscaping (Water Newsletter, Nov. 15, 1992).

Section 3.6.2 - Water Quality Considerations. Is there a cost estimate for treating Delta water to Mokelumne River standards?

9-15

9-15 The cost estimates provided in the DEIS for treating Delta water are intended to bring that water source up to Mokelumne standards. Additional information is included in the FEIS for upgrading existing treatment facilities to accommodate a 4:1 mixture of Mokelumne and Delta water.

Section 3.6.3 - Agricultural Water Supply. No analysis is made of the potential benefits of agricultural water conservation. The DEIS spent several pages discussing the benefits of EBMUD's urban water conservation program. Agricultural water conservation could make water available to the Mokelumne River system to benefit fisheries, or perhaps additional supplies for EBMUD, and should be taken into consideration in the recommendations as a potential source of water supply.

9-16

9-16 More discussion of agricultural water supply is included especially as it relates to the possibility of dry season water transfers and the storing of groundwater in exchange for Mokelumne water during drought conditions.

Section 4.1.1 - Assessment Method. Staff outlined its assessment methods to determine water supply deficiencies. At pages 4-2 and 4-3, an analysis of water supply deficiencies is made based upon hydrology similar to 1976-77 plus an additional drought year where run-off was assumed to be 185 TAF. The DEIS then comments that a third year may be an overly conservative assumption.

Caution should be used in assuming that a third consecutive drought year is unlikely. California has just ended a drought cycle of six consecutive years. This drought has defined a new critical water period for California. Even if no two-year sequence approximates the exact conditions experienced in 1976-77, the cumulative impact of successive dry years could prove even more devastating. An analysis should be included which takes into account the current dry cycle followed by a year where inflow is 185 TAF.²

At page 4-4 the DEIS states that an alternative low-cost supply option available to EBMUD is the purchase of water from other agencies or the State Emergency Drought Water Bank (Emergency Water Bank). This option causes at least three problems, each of which should be analyzed.

1. Competition for water from the Emergency Water Bank for municipal uses is significant. The 1992 Emergency Water Bank allocated 45% of the available water to M&I users, 45% to agricultural, and 10% for fisheries. The 45% available for M&I supplies has generally been fully subscribed. EBMUD has not been a participant in the Emergency Water Bank, and if shortages are

²For the record, it should be noted that San Francisco uses a more conservative design drought. While San Francisco's design drought is in part a product of its status as a junior appropriator, there is also a need for a margin of safety which protects against the possibility of extreme water shortage to an urban area. As contrasted with agricultural water use, it is not possible to "fallow" businesses or people. Rationing at levels in excess of 25% have devastating and permanent impacts on businesses, and in turn, the local environment.

9-17

9-17 This type of upper-bounding drought sequence was considered as part of the FEIS.

9-18

9-18 EBMUD has participated in short-term water transfers in the past and has attempted to purchase and exchange groundwater with holders of senior surface water rights. It was felt that any impact to other water suppliers would be minimal given the potential fish population benefits and the extreme circumstances in which this option would be pursued.

9-19

9-19 See previous comment regarding the impact of any water transfers. With regard to the second point, the FEIS contains more discussion of water quality as it relates the use of the Delta by EBMUD. With regard to the third point, the availability of the Delta to EBMUD is an open question which cannot be resolved in the scope of this proceeding. EBMUD, in their evaluation of Delta as one of their composite programs, noted that water would be available for the District to purchase although a specific source had not been identified. The FEIS assumes that, for the Delta and any other water source, EBMUD can take appropriate actions to secure the necessary rights and permits.

imposed on EBMUD then competition for these limited supplies would increase, resulting in additional shortfalls to other agencies.

2. If EBMUD takes Delta water into its system, even in small amounts over an extended drought period, it will eventually contaminate the entire system. In such a case, far more expensive filtration would be required, since the entire water supply would have to be treated.

3. The availability of the Delta to either the Emergency Water Bank or other water transfers is decreasing. Fishery and other environmental impacts are reducing the window of opportunity for water transfers. Putting additional burdens into the Delta must be taken into account and analyzed in terms of the reasonably available alternative. The recent SWRCB decision, D-1630, exacerbates water reliability problems by reducing the availability of water transfers.

9-19
(cont.)

Section 4.1.4 - Staff's Alternative. At page 4-22 staff discusses water supply deficiencies which would result from its proposal. Staff assumes that EBMUD will be able to purchase 16 TAF of Delta water whenever necessary for water supply purposes. No documentation is provided to support this assumption. Refer to above comments concerning reliance on the Delta supply, which are incorporated herein by reference.

9-20

9-20 Again, it is assumed that EBMUD can secure additional rights and permits to alternative supplies and withdrawal points. See previous responses to comments Nos. 9-18 and 9-19.

Staff also comments on the design drought and suggests the possibility of a reduced deficiency under a two-year sequence. The prior comments concerning reliance upon the 1976-77 drought versus

the current drought are also relevant, and are incorporated herein by reference.

Section 4.2 - Minimum Pool Elevations. Maintaining flow levels for sustained periods of time is not an efficient fishery management program. Rather than viewing flow levels and temperature ranges on a constant basis, fishery management with coordinated flows on a real-time basis to encourage migration and spawning will conserve substantial quantities of water. This real-time management may be used both for flow levels and temperature. As noted in Section 4.2.3, temperature and flow during "biologically critical periods" should be the relevant consideration. Flows and temperatures at other times may affect native species, but the species are adapted to significant temperature and flow variations under natural conditions. Since the native species do not require the flow regime necessary for salmon, there does not seem to be a basis for requiring flows to protect those species.

9-21

9-21 Your comment is noted. Staff's final recommendations allow for considerable flexibility in project operation.

The minimum pool elevation of 180 feet, as set forth under the staff recommendation in Section 4.2.4, is based upon a desired Camanche release temperature of 62.6 degrees Fahrenheit during the period May through November. This six-month period is characterized as "critical", but critical needs during this six-month period are not identified. Further, the number of oversummering stock have not been identified as being significant to the Mokelumne River fishery. It seems unreasonable to maintain low temperatures for oversummering stock when compared to the

9-22

9-22 The critical time periods and variable temperature and flow requirements are identified in the FEIS (e.g., Section 4.1 and Appendix F). The critical needs from May through November with regard to temperature requirements are those of juvenile steelhead trout that may rear in the river for one to four years and for adult steelhead/rainbow trout that reside in the river. The minimum pool requirement also assures that a bank of cold water is maintained in Camanche for use as attraction flows in October.

significant water cost. Conservation of flows and timing of releases to maximize the fishery are more reasonable than expending large amounts of water to benefit a relatively small number of fish overwintering in the Mokelumne.

9-22
(cont.)

Section 4.2.5 - No action. On what basis did staff conclude that unacceptable release temperatures existed in 1987 given that "temperature data are not available for 1987 . . .?"

If acceptable release temperatures are available in all but the driest years, this should suggest that no modification should be made to the project concerning temperature in any year other than the most dry years. Further, since dry years are a naturally occurring condition, consideration should be given as to whether there should be mitigation at all based on temperatures which would have naturally occurred at higher levels under no-project conditions.

9-23

9-23 Water of acceptable temperatures may be available for release from Camanche in most years under the no action alternative, but not necessarily in the amount or of the quality required to meet staff's objectives. A dry year is indeed a naturally occurring condition, but the affect of a dry year on the system now with its multiple impoundments and diversions is far from the affect on the system in its natural state. Furthermore, the affected fishery (particularly the California coastal chinook stocks) is more sensitive and less resilient to additional stresses now than when it was unimpacted.

Section 4.3 - Other Flow Alternatives Considered.

Section 4.3.1 - Ramping Rates. Staff is concerned about stranding fry and dewatering redds. It does not appear that non-flow alternatives have been considered as a means of resolving this problem.

9-24

9-24 Stranding of fry and dewatering of redds is a problem of flow fluctuations. As flow declines, water levels drop and fish and redds can be left exposed. A non-flow alternative is to eliminate backwater pools that can become isolated by retreating water level and physical prevention of spawning in zones that could later be dewatered. These alternatives are discussed in more detail in the FEIS (Sections 3.3 and 4.3).

Section 4.3.2 - Attraction Flows. Attraction flows could be conserved if they were timed to coincide with salmon and steelhead migration. Rather than scheduling pulse flows for a 45-day period running from approximately October 1st to November 15th, real-time monitoring of fish migration would be the most efficient use of water.

9-25

9-25 Staff agrees, in principle, with the desirability of real-time monitoring of adult salmon in the delta and provision of attraction flows when fish are ready to move upstream. Water could be conserved thereby, and the most fish might be attracted. However, the ability to conduct such monitoring is limited at present. Perhaps the cost savings of reduced water use could be applied to developing such a monitoring program. This possibility is discussed in the FEIS (Section 4.3.2).

Real-time monitoring would require biologists and other fishery experts to coordinate their activities and monitor conditions in the Delta and its tributaries. At such time as fall run salmon and steelhead are migrating upstream, pulse flows would be released to attract the fish. Flows would be timed to start and stop on an as-needed basis rather than covering a large period of time which may or may not coincide with fish migration.

9-25
(cont.)

Section 4.2 - Cumulative Environmental Impacts. This section fails to consider several impacts which will result from an increase in flow releases from EBMUD's facilities. Among the cumulative impacts which should be considered are the need for increased water transfers to the EBMUD service area; the impact of reduced water supplies to the EBMUD service area; loss of hydropower generation; loss of local vegetation in the EBMUD service area as a result of increased water rationing; impacts in the Bay-Delta Estuary resulting from increased pumping to accommodate EBMUD's water transfers; increased competition among water users for the limited pumping capacity in the Delta which will now be reduced because of EBMUD's need for Delta transfers; adverse impacts on water quality within EBMUD's service area due to the introduction of Delta water; socio-economic impacts resulting from reduced reliability of both quantity and quality of water within the EBMUD service area. In short, the environmental impacts which must be considered under NEPA go far beyond the change in flows on the Mokelumne River and impacts on fisheries. Users of the water must also be considered in this analysis.

9-26

- 9-26 Your comment is noted. The FEIS discusses the most direct of these cumulative effects, but a quantitative, predictive analysis of many of the issues listed here is beyond the scope of this proceeding and, in fact, beyond the capabilities of current water management and science.

Section 4.10 - Unavoidable Adverse Impacts. See comments to

Section 4.9, which are incorporated herein by reference.

In addition, in San Francisco's view, the frequency and magnitude of the impacts of water shortages is not beyond the scope of this proceeding, as indicated by the discussion in this section. To the contrary, FERC's responsibility to undertake a balancing of the public interest and the creation of a comprehensive plan for the Mokelumne River dictate that it consider all of the impacts of this significant change in flow requirements. The DEIS indicates that as a result of a change in flow, "EBMUD will have to confront significant new water supply cost under any of these alternatives." (DEIS, at 4-66, emphasis added). These "significant" costs must be considered even if only as socio-economic impacts. However, it is likely that the water supply cost will include decreases in quantity and quality of supply and the other impacts identified in the comments under Section 4.9.

Section 4.11 - Irreversible and Irrecoverable Commitment of Resources. The DEIS fails to consider that release of flows for fishery purposes represents an irreversible and irretrievable commitment of resources. Once this water is released from EBMUD's system it is degraded in quantity and quality as water supply for EBMUD. Even if a portion of this water is retrievable at the Delta, it is in a substantially degraded condition. Further, reliability of water transfers is tenuous, and increased treatment cost are substantial. Filtration does not represent an adequate

9-27

9-27 Impacts that must be discussed are those that would result from the proposed action. As indicated in the DEIS, EBMUD may face water supply shortages regardless of any proposed action. Staff believes that it has addressed the socioeconomic costs that this comment requests in as foreseeable a manner as possible in the FEIS and has balanced these costs in its final recommendations

9-28

9-28 Your comment is noted.

replacement of high quality source supplies. Each of these impacts should be considered in the final analysis. 9-28 (cont.)

General Comment: Fishery resources on the Mokelumne River are affected in large part by activities outside of EBMUD's control. Delta pumping and reverse flows caused by the operation of the Central Valley Project and State Water Project significantly impact salmon and steelhead migration and survival. Further, ocean harvesting is one of the major impacts on salmon populations. It is unrealistic to expect that increases in fishery protection measures on the Mokelumne River will result in a one-to-one benefit to the fishery. Rather, these improvements will only have limited beneficial impacts until such time as a totally coordinated effort is undertaken to limit Delta water impacts and ocean harvesting. 9-29

The State Water Resources Control Board has issued a draft water rights Decision in D-1630 as part of the Interim Water Rights hearings in the Bay-Delta proceedings. The flow impacts and other measures mandated by D-1630 should be considered in the context of this proceeding. 9-30

II.

The issues and comments set forth above are an indication that the DEIS has not fully considered the facts as they exist on the Mokelumne River and EBMUD's system. Those issues and comments also highlight the regional interrelationship between the numerous water districts that rely upon the same scarce water supplies in California.

9-29 Staff agrees that there are many different influences affecting anadromous salmon stocks in the Central Valley, only one of which is hydroelectric project operations. In the FEIS, staff has attempted to distinguish among these effects and to separate those for which hydropower is responsible.

9-30 This Interim Decision has since been withdrawn by the State. It is mentioned in the FEIS, but its specifics are not now likely to be implemented in the near future.

The Mokelumne River, like the Tuolumne River, is part of the Bay Delta Estuary. The Hetch Hetchy system on the Tuolumne River provides most of the water supply for San Francisco and the thirty cities and water agencies that comprise the San Francisco Bay Area Water Users Association. In addition to Hetch Hetchy, both San Francisco and the Bay Area cities and agencies that rely on the Tuolumne River for water must also obtain water from other sources. Thus, far from being self-sufficient, eight of the nine counties in the metropolitan area rely on water stored far from the region and imported by way of aqueducts, canals and other conveyances. The Bay Area relies upon the State Water Project ("SWP"), which serves Sonoma, Napa and Solano Counties, the Federal Central Valley Project ("CVP") which serves Contra Costa and Santa Clara Counties,³ and, most important to this proceeding, the East Bay Municipal Utility District, which brings water to Contra Costa and Alameda Counties from the Mokelumne River. Taken together, these interrelated systems comprise the municipal water supply base for much of the region, including San Francisco and the Bay Area cities it serves.

In failing to give adequate attention to those relationships, the DEIS has failed to give appropriate consideration to municipal and urban water requirements. Consequently, the DEIS reaches an unbalanced result wherein the recommended flows will not resolve

³San Francisco's Hetch Hetchy system serves the needs of the Bay Area customers to varying degrees. Those customers who do not receive 100% of their needs from Hetch Hetchy or local watersheds receive water directly or indirectly from SWP or CVP contractors.

9-31

- 9-31 Your comment is noted and is consistent with staff's description in the FEIS. However, the contributions of the Mokelumne River and EBMUD's system are negligible compared to this larger Bay-Delta system.

9-32

- 9-32 Staff disagrees. The DEIS considers all resources and proposes a reasonable allocation. The inconveniences described by the City are small compared to the balanced resource benefits described herein.

the fish population issues, and will negatively impact water transfers, water rights, and municipal and urban water resources to areas such as San Francisco. Further, the Bay-Delta water system will be negatively affected by the recommendations in the DEIS, since the effects of D-1630, if implemented, will place increased strains on this water supply independently of the DEIS recommendations.⁴ San Francisco's ability to continue wheeling water through an already constrained Delta system will certainly be negatively affected by implementation of the recommendations in the DEIS.

9-32
(cont.)

III.

As stated above, there are numerous factual issues that are set forth in the DEIS, but which appear to have been discounted in the recommendations. For example, the DEIS notes that a drought management program is initiated by EBMUD whenever storage is projected to be less than 500 TAF, acknowledging that "[t]he severity of the drought management program depends on the level of projected storage" at September 30 of each year. DEIS at 3-69. EBMUD is also recognized as initiating drought management and planning actions in addition to mandatory or voluntary water reduction goals. The DEIS also sets forth the types of water use restrictions initiated by EBMUD as part of its drought management and planning. Those water use restrictions include "prohibitions on the washing of cars without shutoff nozzles, filling of

9-33

9-33 The FEIS includes an expanded discussion of demand-side activities as well as pricing (see Section 3.6 and Appendices D and E).

⁴The State Water Resources Control Board has stated that its decision in D-1630 is exempt from the California Environmental Qualities Act, and that no environmental review is required.

decorative ponds and fountains, washing sidewalks, and landscape watering that results in excessive runoff." *Id.* at 3-70, n. 2. Further, the DEIS footnote acknowledges that EBMUD established regulations that govern its water service, that are set forth in Sections 28 and 29 of EBMUD's Water Service Regulations. *Id.*

These water conservation considerations should be given greater consideration in the final recommendations in this proceeding. Similarly, the facts regarding water quality considerations and their impact on water pricing for EBMUD should be given greater consideration in the final analysis.

There is evidence in the record that the water in the Mokelumne River is of a higher quality than the water obtained from the Delta. Further, the DEIS notes the effect of the lower quality Delta water on EBMUD's aqueduct system. In this regard, the DEIS acknowledges that EBMUD's existing facilities are not adequate for treating Delta water. As a result, EBMUD would be required to incur the additional costs of separate treatment facilities to improve the quality of Delta water and would also increase the cost of delivered water. These costs, in turn, affect revenues to EBMUD from water sales.

Water pricing issues are an extremely important factor in determining the reasonableness of the analysis and findings set forth in this DEIS. As set forth above, the cost of treating Delta water to Mokelumne River standards will substantially exceed the cost of treating water under existing regulations. This is no small matter, since the DEIS acknowledges that approximately two-

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(cont.)

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9-34 The costs of upgrading facilities to treat and mix Delta water are included in the FEIS. The FEIS also includes expanded discussion of the likely impacts to EBMUD customers. However, this is only a generalized assessment since the likely costs to be borne by EBMUD customers depend on a host of assumptions regarding project implementation and scheduling, system capacity charges, and project financing.

9-35

9-35 Specific water rate impacts on EBMUD customers are difficult to estimate. These impacts depend on assumptions about how to allocate system capacity charges for providing services between existing and new customers, capital financing assumptions, and water rate structures. EBMUD in their Updated Water Supply Management Program estimated rate impacts ranging from a low 3% to 26% above their no-action alternative (existing fish flows). For their Composite Program III (advanced treatment facilities for Delta supplies), a 30% water rate increase was projected in year 2000 declining to about 16% in year 2020 over the no-action alternative. Although it is difficult to estimate required changes in water rates, the FEIS contains expanded discussion of likely impacts.

thirds of total EBMUD system revenues are derived from sales of water. *Id.* at 3-72.

These facts should be given greater consideration by the Commission in the final analysis because the current recommendations create significant negative impacts to the EBMUD water supply system, which are set forth in Table 5.2.1 to the DEIS. In water supply deficits alone, the various proposals produce the following shortfall:

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(cont.)

(1) 2-year drought shortfall - 76 TAF at a cost of \$12.3 M (CDFG proposal), 38 TAF at a cost of \$6.7 M (EBMUD proposal), and 53 TAF at a cost of \$7.2 M (Staff proposal); and

(2) 3-year drought shortfall (TAF) - 123 TAF at a cost of \$21.2 M (CDFG proposal); 71 TAF at a cost of \$11.9 M (EBMUD proposal); and 95 TAF at a cost of \$15.1 M (Staff proposal).

Id. at 5-5. Further, the costs reflected here are exclusive of treatment costs.

The above impacts on EBMUD are foreseeable under the scenario presented in the DEIS, since the Staff recommended that its minimum flow requirements be incorporated into the LMRP license articles. Under the Staff's proposal, releases would be required in the following amounts: 65 TAF (dry water year), 135 TAF (normal water year) and 169 TAF (wet water year).⁵ *Id.* at 5-7.

⁵Staff's definition of the water year is based on observed inflows to Pardee Reservoir at the USGS stream gauge at Mokelumne Hill. According to Staff's definition, the "upper thresholds defining dry and normal years are 500 cfs (approximately 50% of the average annual flow) and 1100 cfs (approximately 110% of the average annual flow), respectively." *Id.* at 2-13.

Staff also recommended a minimum pool elevation in Camanche Reservoir of 180 MSL, to be maintained in all water years except dry years. *Id.* at 5-7. In dry water years, Staff recommends that the fish resources share water deficits with EBMUD's water supply system. *Id.* However, Staff acknowledges that its proposal requires a separate mechanism to implement the deficit sharing proposal. *Id.* Staff states further that both positive and negative impacts of its new minimum pool elevation requirements are difficult to quantify because the data upon which it relies is limited.

These factual considerations are important because the DEIS recognizes that the flow-related recommendations incorporated into the DEIS will have a significant impact on the Mokelumne River as a reliable water supply system for EBMUD. This fact is no small matter, considered in the context of the interrelationship between the regional nature of water supply needs of EBMUD, San Francisco and others. Further, when each of these factors is considered along with reasonably verifiable impacts on the fish population, the impacts to municipal and industrial needs are disproportionately large. This occurs because the DEIS recognizes that even if every recommendation contained therein is implemented, all of the benefits to the fish would be offset by factors over which the Commission has little or no control. These factors include the elimination of "seasonal barriers to migration" that exist in the vicinity of Lake Lodi." DEIS Executive Summary at xxiv. The DEIS states elsewhere that Woodbridge Dam is a "major bottleneck in

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9-36 Your comment is noted.

movement of anadromous fish into and out of the lower Mokelumne River....Woodbridge Dam that forms Lake Lodi poses a significant barrier to both upstream and downstream migrants." Id. at 2-17.

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(cont.)

IV.

The comments in Section I above and the analysis in Sections II and III above support further analysis of the enhanced water supply burden recommended in the DEIS. San Francisco respectfully requests that the Commission allow the record to be supplemented with reasonable, updated information that reflects, among other things set forth in Section I above, the effects of the recommendations under current drought conditions and under a drought sequence that is greater than the two-year "conservative" sequence reflected in the DEIS.

Respectfully submitted,

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ATTORNEYS FOR CITY AND COUNTY
OF SAN FRANCISCO

Dated: March 1, 1993

CERTIFICATE OF SERVICE

I hereby certify that the foregoing instrument is being served
upon each person designated on the official service list compiled
by the Secretary in this proceeding.

Dated at Washington, D.C., this 1st day of March, 1993.

GWENDOLYN D. PRIOLEAU

March 1, 1993

Hon. Lois D. Cashell, Secretary
Federal Energy Regulatory Commission
825 North Capitol Street, N.E.
Washington, D.C. 20426

**SUBJECT: Lower Mokelumne River Project,
California. Project No. 2916-004**

Dear Secretary Cashell:

Enclosed on behalf of East Bay Municipal Utility District ("EBMUD" or the "District") is an original and fourteen copies of the Comments of EBMUD on the Draft Environmental Impact Statement ("DEIS") for proposed modifications to the Lower Mokelumne River Project (the "Project").

EBMUD, which relies on the Project's storage capacity as the principal source of water to fulfill its statutory obligation to provide a reliable supply of high-quality water to meet the needs of its 1.2 million customers, is committed to operating the Project in an environmentally responsible manner. Toward that end, EBMUD has devoted substantial resources to developing the base of scientific knowledge necessary to understand the conditions that affect fish populations in the Mokelumne River and to formulate the most effective means of improving those conditions, while still meeting its obligations to its customers and to other holders of water rights on the Mokelumne River. The District welcomes the DEIS as a contribution to that process.

Although EBMUD supports the objective of enhancing fish resources in the Mokelumne River, EBMUD has identified numerous shortcomings in the analyses presented in the DEIS, which are detailed in the enclosed Comments. Fundamentally, the enclosed Comments explain that the DEIS does not support its ultimate conclusion: that certain modifications in the operations of the Project recommended by the Commission Staff would, if implemented, promote the anadromous fish resources in the lower Mokelumne River in a manner that appropriately balances the other demands on the water in the River. The DEIS presents no analysis of the factors limiting anadromous fish populations in the river and, as a consequence of this and other failings, endorses a program of modifications that fails to meet the most critical needs of the fish resources.

The DEIS also significantly understates the impact that implementation of its preferred alternative would have on the District's water supply system. In the first instance, the DEIS proposes to reduce significantly the amount of water available to

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10-1

10-1 Your comment is noted. Additional information and discussion has been added to Sections 3 and 4 of the FEIS on the subject of limiting factors (e.g., see Sections 3.3.1 and 3.3.2).

10-2

10-2 This is the balancing issue - cost of additional water versus the value of fish. Impacts on EBMUD have been reevaluated in the FEIS, given new modeling runs, and some sensitivity analyses on the demand side.

Hon. Lois D. Cashell
March 1, 1993
Page 2

the District for municipal supply purposes without giving any serious consideration to the question of whether the District can in fact make up that shortfall. Second, even if it is assumed that there are means by which the District could make up that shortfall, the District has conservatively estimated the cost of securing the additional water supplies that would be required if Staff's preferred program were implemented could easily reach \$1.5 billion. The District submits that these costs are out of proportion to the small increase in spawning habitat for anadromous fish that the DEIS calculates would be provided under its preferred alternative. There can be no dispute that these costs far exceed the costs and value of the hydroelectric expansion that was the subject of the Project's initial licensing by the Commission in 1981. EBMUD does not believe that the drastic change in Project operations recommended in the DEIS as a modification to the Project license is permissible under the license and the Federal Power Act.

10-2
(cont.)

In addition, the enclosed Comments explain that the DEIS does not consider all of the environmental and socio-economic consequences of the alternatives considered by Staff. As an example, the DEIS does not consider the impact that implementation of its preferred alternative would have on wetlands, wildlife or botanical resources in the lower Mokelumne River or on the cold-water fisheries in Pardee Reservoir. For this and other reasons discussed in its Comments, the District believes the DEIS does not satisfy the Commission's obligations under the National Environmental Policy Act and its own implementing regulations.

10-3

10-3 Your comment is noted. The FEIS does examine all relevant environmental and socioeconomic consequences of the proposed action within the scope of this proceeding. More discussion of wetlands, wildlife/botanical resources, and cold-water fisheries in Pardee Reservoir have been added to the FEIS Sections 3 and 4.

The District has endeavored in the enclosed Comments to address the most critical portions of the DEIS. The District's ability to provide complete comments has been limited by the refusal of the Commission Staff to make available all of the data that were used in the analyses in the DEIS, the intermediate results of those analyses, or statistical measures of the reliability of those analyses. Moreover, the DEIS is incomplete or ambiguous regarding key aspects of Staff's recommendation, such as the manner in which the classification of a water year, which determines the quantity and timing of releases of water from Project facilities, would be predicted in advance. This further restricts EBMUD's ability to analyze and comment upon the impacts of the proposed action that is endorsed in the DEIS.

10-4

10-4 Your comment is noted. Staff believes that EBMUD had adequate opportunity to review the DEIS and to interact with staff during the NEPA process.

Finally, although the DEIS concludes that Staff's alternative is preferable to the Lower Mokelumne River Management Plan ("LMRMP") developed by the District -- based upon over two years of scientific analysis and field work -- to balance EBMUD's water

Hon. Lois D. Cashell
March 1, 1993
Page 3

supply needs with the needs of in-river resources in a feasible, efficient and environmentally responsible manner, the DEIS acknowledges that Staff did not have time to fully evaluate the LMRMP or the underlying scientific support. Indeed, as the enclosed Comments point out, the DEIS reflects erroneous assumptions about key aspects of the District's LMRMP.

EBMUD has endeavored in the enclosed Comments to correct these errors and to assist the Staff's consideration of the LMRMP in the DEIS'. EBMUD hopes that, as a result of its Comments, the Staff will be in a position to give the LMRMP full and fair consideration as an alternative to the recommendation endorsed in the DEIS. We believe that, following such consideration, the Staff will agree with the District that the LMRMP constitutes a scientifically-grounded approach to enhancing the natural resources of the lower Mokelumne River in a balanced, effective and feasible manner. It should also be noted that the California State Water Resources Control Board (SWRCB) is conducting a Water Rights hearing covering the same issues as covered by the DEIS. The SWRCB has developed a body of information including the LMRMP as a major portion of the material to be considered. The PERC DEIS was accorded "administrative notice" in this process and is not considered equivalent to the other testimonies provided, such as the LMRMP. If the Staff requires additional information or has any questions regarding the LMRMP or these Comments, the District would be pleased to provide it.

Sincerely,

Jorge Carrasco
Jorge Carrasco
General Manager

JC:er
Enclosure

c: J. Mark Robinson, OHL
John Schnagl, OHL
Cynthia A. Harlette, OGC
jmc397

¹ The District notes that, because the LMRMP can be implemented consistent with the current requirements of the Project license, it has not sought an amendment to the Project license to implement the LMRMP.

10-5

10-5 Your comment is noted. EBMUD's Lower Mokelumne River Management Plan (LMRMP), its DEIS/Report for its Updated Water Supply Management Plan (UWSMP), and the testimony and exhibits of the State Board's Water Rights Hearing on the Mokelumne River have become part of the administrative record of this proceeding and have been fully considered by staff in the development of the FEIS.

10-6

10-6 The Commission should be notified of any substantive changes in project facilities or operation. After a review of any proposed change, the Commission will determine if an amendment of the project license is necessary.

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UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Lower Mokelumne River Project)
) Project No. 2916-004
) California

COMMENTS OF EAST BAY MUNICIPAL UTILITY DISTRICT
ON DRAFT ENVIRONMENTAL IMPACT STATEMENT

I. Introduction and Summary

East Bay Municipal Utility District ("EBMUD" or the "District") presents its comments on the Draft Environmental Impact Statement ("DEIS") for proposed modifications to the Lower Mokelumne River Project, FERC Project No. 2916-004 (the "Project"), dated October 23, 1992. EBMUD is the Project licensee, having received a fifty-year license on March 10, 1981, in connection with the expansion of the hydroelectric power facilities at two existing dams. The District relies on the Project's storage capacity as the principal source of municipal drinking water supplies for its 1.2 million customers.

The District is committed to operating the Project in a manner that serves the needs of its customers while also protecting and enhancing environmental values. In particular, the District is dedicated to taking effective steps to maintain and augment the fish populations in the Mokelumne River. EBMUD has devoted substantial resources to developing the base of scientific knowledge necessary to understand the conditions that limit fish populations and to formulate the most effective means of improving those conditions, while still meeting its water

10-7

10-7 See response to comment No. 10-5.

- 2 -

supply obligations to its customers and to other holders of water rights on the Mokelumne River. Based on numerous studies and analyses conducted over a period exceeding two years undertaken as part of its ongoing Water Supply Management Program^{1/}, the District has prepared a Lower Mokelumne River Management Plan ("LMRMP") to balance EBMUD's water supply needs with those in-river needs in a feasible, efficient and environmentally responsible manner.^{2/} The California Department of Fish and Game ("DFG"), which operates the Mokelumne River Fish Facility ("MRFF"), the hatchery located at Camanche Dam, has also prepared a plan that is intended to improve fishery conditions in the Lower Mokelumne River.

10-7

EBMUD welcomes the DEIS as a contribution to the process of analysis and consideration of the needs of the various interests

^{1/} The District plans to adopt an Updated Water Supply Management Program ("Updated WSMP") that includes new conservation and reclamation measures and other improvements to its water supply system intended to allow the District to meet the growing demands of its customers, to meet the growing demands of other Mokelumne River water users, to improve the Mokelumne River fishery resources, and to meet shortages during droughts. The District has recently completed its draft Environmental Impact Report/Environmental Impact Statement for the Updated WSMP ("Draft EIR/EIS"). The six volumes of the Draft EIR/EIS are appended to these Comments as Attachment A.

^{2/} A draft of the LMRMP was provided to FERC Staff on September 17, 1992. The final version of the LMRMP was provided to FERC Staff on October 5, 1992. The LMRMP was also submitted as EBMUD Exhibit 32 (and summarized in EBMUD Exhibit 25) in the proceedings before the California State Water Resources Control Board ("SWRCB") referred to as the Mokelumne River Hearing. These Comments will often refer to exhibits submitted in that proceeding, which were filed with the Commission on October 5, 1992 (and earlier, in draft form, in some cases), citing them as follows: "MRH, EBMUD Ex. ___."

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that rely upon the Mokelumne River. The District shares the objective of the DEIS: to determine, based on a comprehensive review of all environmental and economic impacts of each alternative and on the best scientific evidence, how to improve conditions for natural resources in the Mokelumne River while preserving the ability of EBNUD to rely on the storage capacity of the Project as the primary source of water for its customers. The District also agrees with FERC Staff that enhancement of the chinook salmon fishery in the Mokelumne is an important natural resource objective (although the chinook salmon population is not the only natural resource that would be affected by changes in Project operation). Further, EBNUD is in agreement with many of the findings in the DEIS, including the following:

- The DEIS correctly finds that runs of chinook salmon to the Mokelumne River "have not changed in size since the beginning of record-keeping in 1940" and "variations in run size and general periodicity are comparable before and after Camanche Dam was built." (DEIS, p. 3-33.)
- The DEIS is correct in noting that recent declines in the runs of salmon to the Mokelumne River are not unprecedented and, moreover, are mirrored in declines of salmon runs on other rivers in the San Joaquin system. (Id., pp. 3-33, 3-34.)
- The DEIS correctly recognizes that the ability of anadromous fish to return to the Mokelumne River to spawn is affected by numerous factors other than the operation of the Project, including ocean harvest, high mortality during outmigration of juvenile fish through the Sacramento-San Joaquin Delta, and "straying" due to the planting of hatchery production beyond the Delta to avoid these hazards. (Id., pp. 3-39 to 3-45.)
- The District agrees with the statement in the DEIS that, "It is not likely that the natural reproduction of chinook salmon can be improved in the lower river without eliminating the serious barriers to migration

- 4 -

that exist in the vicinity of Lake Lodi." (Id., p. xxiv.)

- The DEIS correctly finds that the impacts of the DFG proposal on operation of the Project "would essentially eliminate it as a reliable source of water for EBNUD." (DEIS, p. 4-7.) This finding is supported both by the DEIS's analysis and by other evidence in the record. The District agrees with the conclusion of the DEIS that the DFG proposal would have an undue and unnecessary impact on the District's municipal use of water from the Mokelumne River.^{1/}

Despite the District's agreement with the objective of the DEIS and with many of the findings in the DEIS, the District disagrees strongly with other aspects of the DEIS, including its ultimate conclusion. EBNUD does not concur that the FERC Staff recommendation, which is preferred in the DEIS, has been shown to promote the objective -- which the District shares -- of "improv[ing] the natural reproduction of chinook salmon within the natural stream channel of the Mokelumne River below Camanche Dam"^{2/} or to balance that objective appropriately against the socio-economic and environmental costs of implementing the Staff recommendation.

First, as these Comments demonstrate, the DEIS fails to meet the requirements for an environmental impact statement as established by the National Environmental Policy Act ("NEPA") and the Commission's own implementing regulations in several fundamental respects: (a) the DEIS fails to consider all

10-8

10-8 Your comment is noted. Reasonably foreseeable impacts have been considered in the FEIS consistent with the scope of this proceeding (see Sections 1 and 2 of the FEIS). The discussion of the no action alternative has been expanded somewhat in the FEIS.

^{1/} Because it agrees with this conclusion, the District has not focused in these Comments on the DEIS's analysis of the DFG proposal. EBNUD's analysis of the DFG proposal may be found principally in EBN, EBNUD Exs. 29, 32, and 35.

^{2/} Letter from J.E. Robinson to J.A. Myers, February 11, 1993.

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reasonably foreseeable direct and indirect environmental and socio-economic impacts of the alternatives considered; (b) the DEIS fails to discuss and evaluate reasonably foreseeable cumulative impacts of the alternatives considered; (c) the DEIS fails to discuss and evaluate fully the "no action" alternative; and (d) the DEIS focuses on unreasonable -- that is, legally unattainable -- alternatives. As a result of these deficiencies, the DEIS is wholly inadequate to meet the Commission's obligations under the NEPA and its own regulations.

10-8
(cont.)

Second, as the District will show in these Comments, even if the analyses in the DEIS were accepted at face value, they would not support the DEIS's endorsement of the Staff recommendation. The DEIS simply fails to support its finding that the Staff's preferred alternative would benefit the anadromous fishery resources of the Mokelumne River. Moreover, any such benefits come at an enormous and disproportionate cost to the District's municipal water supply. In addition, as these Comments show, the DEIS fails to consider numerous other significant costs and environmental consequences that would result from implementation of the Staff alternative.

Third, as these Comments will establish, the DEIS, in fact, is rife with significant factual and methodological errors that go to the heart of the analyses presented and conclusions reached in the DEIS. The District is unable to identify all such deficiencies because of the refusal of FERC Staff to identify the inputs utilized in those analyses, to provide the intermediate

10-9

10-9 Your comment is noted, but we disagree. The options considered in the DEIS and in the FEIS are adequately documented. Based on these documents, EBMUD should be able to evaluate the impact of any of the proposed options and to provide comments if it believes that any of the conclusions are inaccurate.

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results produced by the models utilized in the DEIS, or to furnish the District with correlation coefficients for the resulting equations (see n. 4, above). While the absence of this critical information has severely limited EBMUD's ability to provide complete comments on the DEIS, we have nevertheless identified numerous significant shortcomings. For example, the DEIS fails to consider adequately the factors limiting the development of anadromous fish populations in the Mokelumne River, employs incorrect methodologies and factual assumptions in its analyses of the effects of alternative minimum flow regimes on fish habitat, and relies on erroneous assumptions regarding the steelhead trout fishery. In addition, the analysis in the DEIS of instream temperature and Mokelumne River water balance and hydrology issues are factually and analytically flawed. As a result of these shortcomings, the DEIS cannot be relied upon as an accurate assessment of the environmental impacts sufficient to support a choice among the alternatives for Project operation considered in the DEIS.

Fourth, these Comments demonstrate that the fishery management alternative preferred in the the DEIS does not maximize the benefits to anadromous fish populations. To the contrary, across the hydrologic record, the preferred Staff alternative provides only a slightly greater improvement in spawning conditions than would be provided by the LMRMP alternative, while providing poorer conditions for fry rearing and smolt outmigration. Moreover, compared to the no-action

10-9
(cont.)

10-10

10-10 Your comment is noted. Additional details on the assessment methods used in the FEIS were presented in Section 4 and appendices of the FEIS.

10-11

10-11 Your comment is noted. There is substantial disagreement about the appropriate management emphasis for the anadromous fishery in the Mokelumne River, not only between EBMUD and the Commission's staff, but also between the state and federal fishery management agencies. Staff also notes, for example, that the U.S. Fish and Wildlife Service (FWS) supports our emphasis on spawning habitat rather than EBMUD's emphasis on fry habitat (see comment No. 11-15). Staff has conducted its own independent analysis of the best available information and documented its findings and recommendations in the FEIS.

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alternative, the changes in minimum flows and in the operation of Camanche Reservoir recommended by Staff would not enhance either the natural production of chinook salmon in the river -- which the Staff has identified as the principal objective of its proposal (see n. 4, above) -- or returns of spawning salmon to the river. In contrast, the LMRMP's integrated program of increased flows, combined operation of Pardee and Camanche Reservoir, and modifications to hatchery operations, fishing regulation and assistance to migrating fish in dry conditions, would substantially improve both natural reproduction of chinook salmon and spawning returns.

10-11
(cont.)

Fifth, the DEIS ignores the potential adverse environmental consequences of the Staff recommendation and grossly understates the impacts of the Staff alternative and that of the DFG on the District's municipal water supply. In fact, as these Comments show, the DFG and Staff proposals would effectively eliminate the District's ability to rely on the Project as a reliable source of water supply for its 1.2 million customers. Implementation of the Staff alternative would require the District to incur 30-year gross costs of between \$369 million and \$1.09 billion over and above the costs that the District would incur to implement the LMRMP alternative. The costs of meeting the water supply deficiency that the Staff proposal would cause are three to six times greater than the DEIS indicates. These costs, the District believes, are wholly out of proportion to the incremental benefits to anadromous fish populations in the Mokelumne River

10-12

10-12 Staff believes that EBMUD over estimates the potential impact. See response to comment No. 9-2. Cost estimates in the DEIS are for comparison among alternatives and are not intended to represent likely EBMUD costs of implementation. The actual cost to EBMUD depends on when and how each alternative is implemented.

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that the DEIS claims will result from implementation of the Staff's proposal.

10-12
(cont.)

Finally, the DEIS indicates (p. 5-1) that, because of insufficient time, it does not reflect a complete understanding and analysis of the LMRNP. EBNOD assumes that the tentative preference of the DEIS for the Staff recommendation is subject to reconsideration upon completion of Staff's review of the LMRNP. EBNOD hopes that the following Comments will assist FERC Staff in its further review of the LMRNP and the other alternatives and that, upon consideration of all the evidence, Staff will concur that the LMRNP best serves the objectives shared by Staff and the District.

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10-13 See response to comment No. 10-5.

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II. The DEIS Presents an Unduly Constrained and Improperly Focused Analysis That Fails To Fulfill the Commission's Obligations Under NEPA.

A fundamental purpose of an environmental impact statement ("EIS") is to provide a comprehensive discussion of the significant environmental impacts of a proposed federal action and to inform decision-makers and the public of the reasonable alternatives which would avoid or minimize the adverse impacts to or enhance the quality of the human environment. To satisfy the requirements of the NEPA, at a minimum, an EIS must:

(1) evaluate all reasonably foreseeable direct and indirect impacts of the proposed action; (2) evaluate cumulative impacts; (3) give adequate attention to the "no-action" alternative; and (4) focus on legally permissible alternatives. In addition to the numerous and substantial factual and analytical deficiencies discussed below, the DEIS fails even to touch upon, and in some instances expressly declines to address, these fundamental requirements.

10-14

10-14 Your comment is noted. See response to comment No. 10-8.

A. The DEIS Fails To Consider Reasonably Foreseeable Direct and Indirect Effects of the Actions Under Consideration.

The alternatives considered in the DEIS were: "1) to require flow-related modifications to the project facility and operation; 2) require non-flow-related modifications; and/or 3) make no modifications." (DEIS, p. 2-1.) The DEIS foresees that, as a result of implementing Staff's preferred recommendations, the District will suffer a water supply

10-15

10-15 Staff recognizes that EBMUD has a number of different ways in which it can meet future water supply shortfalls, consistent with EBMUD's own updated WSMP. Staff does not presume to make the selection of the preferred solution among these supply alternatives, but rather examine a range of options and attempt to identify a least-cost solution.

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shortfall and analyzes the cost of meeting this shortfall by assuming that the District could withdraw water from the Delta. (DEIS, p. 4-22.) The DEIS, however, fails to consider numerous direct and indirect effects of the various flow-related and non-flow-related modifications considered in the DEIS and of the suggestion that the District supplement its water supply with water from the Delta. For example, the DEIS fails to consider the following reasonably foreseeable environmental impacts of the alternative flow regimes on the lower Mokelumne River:

Wetlands. Four types of wetlands do or may occur along the lower Mokelumne River corridor. Freshwater marshes/shrub swamps are scattered, and riparian/forested wetlands are almost continuous, along the river corridor. Springs and seeps may occur along the river banks; and coastal/brackish wetlands may occur along tidal sloughs at the western end of the corridor. The DEIS does not consider the potential for adverse effects on these various wetlands from changes in flow in the Mokelumne River or the potential for loss and disturbance of wetlands from construction of various facilities contemplated in the DEIS.

Wildlife. The lower Mokelumne River corridor between Pardee Dam and the Delta provides habitat for at least nine, and perhaps two other, "Listed Species"^{3/} as well as twenty-five species of "Special Concern."^{4/} The DEIS gives no consideration to the possible impact on these various species from vegetative changes from changes in flow regimes in the river or from loss, damage or alteration of habitat from facility construction.

10-15
(cont.)

10-16

10-16 Because no alternative would involve releasing less water than presently released to the river, it was assumed that wetlands in the river corridor would either not be affected or would benefit from proposed project modifications.

10-17

10-17 Staff does not expect changes in vegetation communities to occur as a result of flow changes on a scale that would affect wildlife.

^{3/} Listed species are species listed by the U.S. Fish & Wildlife Service as Endangered, Threatened, Proposed Endangered or Candidate Category 1; or listed by the CDFG as Endangered or Threatened.

^{4/} "Species of Special Concern" include species petitioned for federal listing, are listed by USFWS as Candidate Category 2, are recommended for Candidate Category 1 status by USFWS or are listed by CDFG as species of special concern or protected.

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Botanical Resources. Seven Sensitive Plant Communities, one Listed Plant Species^{1/} and four Plant Species of Special Concern^{2/} occur in the lower Mokelumne River corridor. The DEIS does not consider the impacts of modified flow regimes in the Mokelumne River on these plant communities and species.

10-18

10-18 Staff does not expect that proposed changes in flow regime would adversely affect sensitive plant species or communities.

In addition, as discussed in Section III.B.3 of these Comments, the DEIS does not discuss the substantial damage that adoption of Staff's preferred alternative would do to the valuable fishery resources in Pardee Reservoir, or the implications of the loss of fry and juvenile habitat for chinook salmon and steelhead trout that would occur under that alternative for the fishery resources of the lower Mokelumne River.

10-19

10-19 The DEIS briefly discussed the fishery effects of severe drawdown of Pardee Reservoir in Section 4.1.2. this discussion has been expanded for the FEIS. The DEIS also discussed the change in habitat for fry and juvenile chinook salmon with the staff's alternative in relation to the CDFG and EBMUD alternatives (Section 4.1.4). Staff believes that no additional discussion is needed.

Similarly, the DEIS fails to consider the reasonably foreseeable environmental impacts of a Delta water withdrawal described in Section III.B.3 of these Comments, as well as the following:

10-20

10-20 A water withdrawal from the Delta to make up water supply deficits could have adverse impacts on plant and animal resources in the Delta. However, this is only one of the options available to EBMUD to respond to changing supply or demand.

Wetlands. Three types of wetlands do or may occur in the Bixler area or between Bixler and Pittsburg-Antioch, extending to the shore of Suisun Bay: Freshwater marshes/shrubs swamps occur along waterways, alkali wetlands may occur in fallow fields and there are extensive coastal/brackish wetlands along the shoreline of Suisun Bay. The DEIS does not consider the potential for loss and disturbance of wetlands from construction of various facilities contemplated in the DEIS.

^{1/} "Listed Plant Species" includes species listed by the U.S. Fish and Wildlife Service as Endangered, Threatened, or Candidate Category C1, or by the California Department of Fish & Game as Endangered, Threatened or Rare.

^{2/} "Plant Species of Special Concern" includes species listed by the U.S. Fish and Wildlife Service as Candidate Category C2, or by the California Native Plant Society on List 1 or List 2.

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Wildlife Resources. The Delta area near Bixler and/or between Bixler and Pittsburg-Antioch contains at least nine Listed Species and twenty-eight species of Special Concern. The DEIS gives no consideration to the possible impact on these various species from loss, damage or alteration of habitat from brine overflow.

Botanical Resources. Eight Sensitive Plant Communities, three Listed Plant Species, and four species of Special Concern occur in the Delta area near Bixler. The DEIS does not consider the potential impacts to the plant communities and species resulting from construction of desalination facilities or the brine disposal pipeline.

10-20
(cont.)

B. The DEIS Fails To Consider Cumulative Impacts.

The DEIS asserts that issues such as cumulative impacts are "beyond the scope of this proceeding." (DEIS, p. 1-4.) The failure to discuss and to evaluate the cumulative impacts of the alternatives considered in this DEIS in conjunction with other proposed projects and actions, precludes meaningful analysis by decision-makers and the public of the environmental and socio-economic implications of these contemplated actions. Addressing "[a]ny cumulative effects and interaction between hydropower development in the upper and lower [Mokelumne] basins" in a "new proceeding" (DEIS, p. 3-4 - 3-5) subverts the fundamental purpose of an environmental impact statement, which is to ensure that all environmental consequences are considered before a federal action is taken. Further, the suggestion that the cumulative impacts analysis should be limited to hydropower developments fails to recognize that other actions under consideration by federal, state and local agencies can also have effects on the environment which are cumulative with those of the actions considered in this DEIS.

10-21

10-21 Your comment is noted. See Section 1 and 2 of the FEIS for an expanded discussion of the scope of this proceeding.

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Currently, the DEIS presents an incomplete and unduly limited discussion and evaluation of the significant environmental impacts of the alternatives considered. Yet, there are numerous other federal, state and local projects and actions under consideration which, in conjunction with the actions considered in this DEIS, may have cumulative or synergistic environmental impacts upon the Mokelumne River basin and elsewhere which have not been discussed and evaluated in this DEIS. These other projects and actions include the following.

Devils Nose/Cross County Project - FERC No. 8144. The Devils Nose project is a proposed 140 TAF reservoir located on the North Fork of the Mokelumne River below Salt Springs Reservoir and upstream of Pardee Reservoir. The proposed reservoir would cause a long-term net decrease in inflow to Pardee Reservoir and may alter the temperature of that inflow. The reduction of inflow could lead to a reduction of the water that is currently released from Pardee for flood control purposes. The DEIS does not discuss the possible cumulative impact of this action in conjunction with the modified flow regimes analyzed by FERC Staff in this DEIS on the wetlands, wildlife, or botanical resources of Pardee Reservoir or the lower Mokelumne River.

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10-22 A original license application has been accepted by the Commission from Amador County for the Devil's Nose Project (Commission No. 8144). See Section 3.1.2 of the FEIS for an expanded discussion of this project.

Mokelumne River Project - FERC No. 137. PG&E has filed a FERC application to enlarge the Lower Bear River Reservoir from 52 TAF to 78 TAF to increase the operational flexibility of PG&E's hydroelectric facilities and potentially to develop an additional water supply for use within Amador County. The reservoir is located on the Bear River, a tributary of the North Fork of the Mokelumne River above Pardee Reservoir. If the project is constructed, it may impact the timing and volume of water entering Pardee Reservoir. Again, the possible cumulative impacts of this action in conjunction with the alternatives considered in this DEIS are not discussed.

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10-23 Pacific Gas and Electric Company's (PG&E's) Mokelumne Project (Commission No. 137) is discussed in Section 3.1.2 of the DEIS and the FEIS. The operation of this project is currently constrained by the Lodi Decrees, a third party agreement, and is expected to remain so in the foreseeable future.

The North Delta Water Management Plan. The North Delta Plan (NDP) is a program developed by the Department of Water Resources (DWR) and contains alternatives for improvements of through-Delta water transfers. The preferred NDP

environmental impact report alternative includes: (1) dredging the main stem and South Fork of the Mokelumne River; (2) enlarging the main stem and North Fork of the Mokelumne River with levee setbacks and channel dredging; (3) enlarging the Delta Cross Channel gate structure; and (4) test mitigation river collector wells and fish screens. Implementation of the NDP will result in increased Sacramento River flows through the Delta Cross Channel, and the wider and deeper channels in the plan will increase flows southward toward the State Water Project and Central Valley Project pumps. These actions could further reduce the survival rate of salmon migrating to and from the Mokelumne River. The DEIS must evaluate these impacts in conjunction with each of the alternatives considered.

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10-24 The level of discussion of these projects in the FEIS is appropriate considering the scope of this proceeding.

The West Delta Water Management Program. The DWR West Delta Management Program is primarily a land use management program to control subsidence and soil erosion on Sherman Island and Twitchell Island in the Delta while also providing significant amounts of wildlife and waterfowl habitat. This project could have a significant impact on water quality for water supply diversions from the Delta and thus its impact must be considered in terms of the impact of the DEIS suggestion that the District supplement its water supply through Delta withdrawals which will also impact the Delta environment.

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10-25 See No. 10-24.

The State Water Resources Control Board Bay-Delta Proceeding. In April 1992, Governor Wilson directed the SWRCB to establish interim standards to protect the public trust resources of the Bay-Delta Estuary. The SWRCB draft Bay-Delta Decision (D-1630) requires water projects in the Bay-Delta watershed, including the District's Camanche and Pardee projects, to contribute water to help meet new Bay-Delta standards for salinity, flow, temperature and pollutants. The incremental and cumulative environmental impacts of releases required by the Bay-Delta Decision must be discussed and evaluated in the DEIS in terms of the flow regimes contemplated by FERC Staff.

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10-26 In April 1993, Governor Wilson ordered the withdrawal of Interim Decision 1630 from consideration. Therefore, the D-1630 proceeding was not discussed in detail in the FEIS.

The Los Vaqueros Project. The Los Vaqueros Project has been initiated by the Contra Costa Water District (CCWD) and the U.S. Bureau of Reclamation to improve the drinking water quality and reliability of water service for CCWD customers. Construction is scheduled to start in Spring 1994 and to be completed in early 1997. This CCWD project could affect the environmental implications of the Delta supply alternative identified in the DEIS in that increased diversions from the Delta would affect Delta fisheries, water quality and potentially reduce the availability of Delta water to the District thus requiring reliance on other alternatives, each with discrete environmental impacts.

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10-27 See No. 10-24

C. The DEIS Fails Adequately To Discuss and Evaluate the "No Action" Alternative.

The DEIS fails to describe and evaluate the environmental implications posed by the "no action" alternative. Consequently, the DEIS fails to define the issues sharply and to provide a clear basis for choice among options by the decision-makers and the public. The DEIS reaches several conclusions which are significant for purposes of a rigorous exploration and objective evaluation of the "no action" alternative.

- The DEIS concludes that the importance of the lower Mokelumne River for purposes of the restoration and maintenance of chinook salmon and steelhead trout "is small relative to other streams in the Central Valley" (DEIS, p. 5-1.)
- The DEIS concludes that there is "no statistical difference in chinook salmon run sizes before and after Camanche Dam was built that would suggest that the run is in particular danger now compared to pre-dam conditions." (Id.)
- The DEIS concludes that it "cannot agree with the generalization that water flows have reduced substantially and temperature and water quality have deteriorated from conditions that occurred naturally [in the Mokelumne River]." (Id.)
- And, the DEIS concludes that "[t]o the degree that habitat improvement in the river (including flows and temperature), can make a more suitable habitat and stimulate more fish ... [t]his [result] should be considered an enhancement by EBMUD,... not a mitigation obligation under the FERC license." (DEIS, p. 5-3.)

Thus, on one side of the equation, the "no action" alternative does not perpetuate an environmental "harm" but merely forgoes an environmental benefit -- albeit one that the District, too, seeks to achieve. However, the Staff recommendation endorsed in the DEIS seeks to achieve this

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10-28 Your comment is noted. The FEIS provides additional discussion of the no-action alternative and its implications to the sustainability of anadromous salmon runs in the Lower Mokelumne River.

10-29 Your comment is noted.

10-30 Your comment is noted. However, other commentors have noted the unreliability of the early data on run sizes. Staff has expanded its discussion of this issue in the FEIS.

10-31 Staff believes this statement to be generally true. However, this does not mean that we believe that past and present water developments and other human activities have not had significant adverse impacts. Though temperature and flow are within the ranges of pre-development conditions, these and other critical habitat components rarely occur in the necessary temporal and spatial harmony in the Lower Mokelumne River to support a "natural" chinook population as it was prior to the impact of human activities. It is not our intent to reestablish pre-project conditions, but rather to ensure the sustainability of anadromous salmon in the Mokelumne.

10-32 This statement has been clarified in the FEIS. Staff believes that habitat improvement is an essential part of ensuring the sustainability of anadromous salmon runs in the Lower Mokelumne River, and we interpret EBMUD's LMRP as a similar commitment. The FEIS clearly states our recommendation that hydropower projects, such as the LMRP, are obligated to bear their fair share of the cost of maintaining sustainable salmon runs.

10-33 Your comment is noted. An expanded discussion of the no-action alternative has been presented in the FEIS to clarify comparisons.

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enhancement (assuming, for the moment, that it would be effective in doing so) at the cost of numerous substantial adverse impacts. Absent a complete consideration of the "no action" alternative in the DEIS, the ability of decision-makers to act and the public to comment on a complete exposition of the relevant environmental impacts and trade-offs will be frustrated.^{2/}

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(cont.)

D. The DEIS Fails To Discuss and Evaluate All Relevant Information Provided To Staff.

A draft EIS must fulfill and satisfy to the fullest extent possible the requirements of a final EIS. The DEIS fails in this regard in that it readily concedes that substantial and relevant information provided to FERC Staff by the District has not been fully reviewed, digested, and included in the DEIS. Thus, in effect, the DEIS does not fully consider the alternatives which it purports to discuss and evaluate.

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10-34 The timing of EBMUD's release of numerous studies supporting their UWSMP coincided with the release of the DEIS. Some, but not all of these studies were available and considered in the DEIS. All available studies have been considered in the FEIS; see the response to comment No. 10-5.

The DEIS "acknowledges that EBMUD is preparing its own resource management plan for the lower river, but the full details of that plan were not available in time to be discussed in the DEIS." (DEIS, p. 5-1.) In fact, the District provided a virtually completed final draft of its plan to FERC more than a month in advance of the release of the DEIS; the final LMRMP was provided as soon as it was available. Further, in response to Scoping Document I, which the District received in March 1992,

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10-35 See the response to comment No. 10-5.

^{2/} Notably, the LMRMP developed by the District achieves each of the objectives of the DEIS while avoiding or minimizing each of the harms caused by Staff's "preferred alternative."

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the District advised Staff that the proposed schedule for the DEIS was unrealistic and, in effect, would ensure that the analysis of environmental impacts in the DEIS would not have the benefit of many of the critical environmental studies which were then under way.^{10/} Nevertheless, Staff declined to modify its schedule for the DEIS.^{11/} Thus, FERC Staff has not made every effort to discuss and evaluate all relevant information, but rather has proceeded on a schedule that has virtually ensured that it would not.

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10-36 Your comment is noted. The Commission cannot defer its compliance proceedings indefinitely. The DEIS used the best available information to describe alternatives and impacts in a manner sufficient for EBMUD to comment. See the response to comment No. 10-5.

E. The DEIS Inappropriately Focuses on Unreasonable Alternatives.

The District has indicated on several occasions that it cannot, consistent with its statutory obligations to its customers, accede to any modification to the Project license that affects the fundamental balance of uses of Mokelumne River water established in the license. The DFG and Staff proposed flow regimes for the Project would have just such an affect and should, therefore, be eliminated from further consideration.

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10-37 The EBMUD's statutory responsibilities must be determined by the EBMUD and the State of California. The EBMUD's obligations under its Commission license will be determined by the Commission.

The Federal Power Act ("FPA") expressly prohibits the modification of a previously issued hydroelectric license without

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10-38 The proposed action is authorized pursuant to Articles 12 and 15 of EBMUD's Commission license (see Appendix A of the FEIS).

^{10/} Comments of East Bay Municipal Utility District and Submission of Information in Response to Proposed Modifications to Project Facilities and operations at The Lower Mokelumne River Project, California, FERC Project No. 2916-004, Scoping Document I, May 15, 1992, at p. 7.

^{11/} Letter of Fred E. Springer to Jorge Carrasco, dated June 3, 1992.

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the agreement of the licensee.^{12/} The proscription in Section 6 against unilateral alteration of a license is an integral part of a statutory scheme that was designed to assure a licensee that the terms governing the use of a project would be made clear at the outset, in order to encourage the commitment of private capital to hydropower development. Section 6 is buttressed by the requirement in Section 10(a) that all substantive considerations regarding a project be made before a license is issued.

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(cont.)

The continued reliance on Articles 12 and 15 of the District's FERC license for the Lower Mokelumne River Project to justify this proceeding is misplaced. EBMUD's acceptance of a license that included certain standard, open-ended reservations clauses does not constitute "agreement" to any changes in the operation of the Project that FERC might choose to require in the future, negating the restriction in Section 6. The courts have squarely rejected attempts to avoid the force of Section 6's limitation on the FERC's authority through the device of broad "reopener" clauses:

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10-39 The authority for the Commission to act in this matter is provided in the Federal Power Act.

Notwithstanding a reopener clause, FERC may not "amend" a license in a modification proceeding without the licensee's consent. 16 U.S.C. § 799. Plainly, therefore, the Commission's discretion is curtailed in a modification proceeding.

^{12/} Section 6 of the FPA provides, in relevant part, that "Licenses . . . may be altered or surrendered only upon mutual agreement between the licensee and the Commission after thirty days' public notice." 16 U.S.C. § 799 (1985) (emphasis supplied).

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Confederated Tribes and Bands of the Yakima Indian Nation v. FERC, 746 F.2d 466, 473 (9th Cir. 1984). Yakima is an illustration of the general rule that FERC cannot do indirectly, through its conditioning power, what it is forbidden by Congress from doing directly. See e.g., New York State Electric & Gas Corp. v. FERC, 638 F.2d 388 (2d Cir. 1980); Public Service Commission of the State of New York v. FERC, 866 F.2d 467 (D.C. Cir. 1989).

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(cont.)

Further, FERC Staff cannot reasonably suggest that the changes in project operation and facilities are de minimus and thus not proscribed by Section 6. See Pacific Gas and Electric Company v. FERC, 720 F.2d 78 (D.C. Cir. 1983). As we show in greater detail below, the costs of the modifications proposed by FERC Staff are monumental and dwarf the investment and benefits that the District sought by obtaining its FERC license in 1981.

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10-40 Your comment is noted, but it argues to the merits of *any* Commission action. This argument is premature until a final Commission action is taken.

Therefore, the express limitation contained in Section 6 of the FPA on the FERC's authority to modify the terms on which the District's hydropower license was granted precludes the imposition of Staff's preferred alternative and that proposed by DFG as well. FERC Staff should cease any further consideration of these alternatives and refrain from imposing on the District the costs of analyzing and commenting on alternatives that are clearly beyond the authority of FERC to require.

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10-41 Any Commission action will be predicated by a determination that the Commission has the authority to take the action. The purpose of the DEIS is to examine the need for project modifications and to present feasible alternatives to provide adequate protection to the fish and wildlife resources of the Lower Mokelumne River.

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III. The Analyses Presented in the DEIS Do Not Support the Conclusion Reached.

Both FERC Staff, in the DEIS, and the District, in the LMRMP, endeavor to assess alternatives for modifications in Project operation (and, other factors, as well) by balancing the expected benefits to anadromous fish resources in the lower Mokelumne River and the expected impacts on EBMUD's water supply system. (DEIS, p. xxiii.) The DEIS concludes that Staff's recommendation, which it describes as a "compromise between the proposals that have been made by CDFG and EBMUD" (DEIS, p. 5-7), achieves the best balance between those objectives.

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In Part IV of these Comments, the District will show that the analytical and factual flaws in the analyses presented in the DEIS vitiate that conclusion. Even if these flaws were not present and the results of the analyses in the DEIS were accepted at face value, however, those results simply do not support the conclusion that the Staff's preliminary recommendation appropriately balances benefits to fishery resources and the impacts on the District's water supply resources. To the contrary, even on its own terms, the DEIS does not support its finding that adoption of the Staff recommendation would benefit anadromous fish populations, grossly understates the burdens that the Staff recommendation would impose on the District's water supply system, and ignores adverse environmental impacts that are likely to follow if Staff's recommendation were adopted.

10-42 The use of the term "compromise" in the DEIS was somewhat misleading and has been clarified in the FEIS. Staff's recommendations are intermediate in terms of water needs between EBMUD and the CDFG. However, these recommendations were not arrived at simply by splitting the difference. Staff's recommendations are derived from our independent analysis of available data and the resource needs in the Lower Mokelumne River, as explained in the FEIS.

A. The Analyses in the DEIS Do Not Support the Conclusion That the Staff's Recommendation Will Produce the Claimed Benefits to Fishery Resources.

FERC Staff has described "the fisheries management objective" of the DEIS as "improv[ing] the natural reproduction of chinook salmon within the natural stream channel of the Mokelumne River below Camanche Dam" (see n. 4, above).^{12/} The heart of Staff's approach to achieving that objective is a schedule of minimum flows from Camanche Dam. The DEIS prefers the Staff recommendation based on a comparison of the acreage of habitat that each of the minimum flow regimes would provide for different life-stages of chinook salmon and steelhead trout in the lower Mokelumne River. (DEIS, p. 5-5.) In Section IV(A) of these Comments, the District shows that the assumed linkage between fish populations and habitat acreage between Camanche Dam and Lake Lodi cannot be supported and that the analysis in the DEIS of the habitat abundance that would result from each alternative is critically deficient. Moreover, the DEIS fails to recognize that the severe drawdowns of Pardee Reservoir required to implement the Staff recommended minimum flows would exhaust the supply of cold water, adversely affecting the anadromous fisheries in the river.

^{12/} Staff fails to recognize the importance of MRFF operations to achieving its objective. Notably, as the District demonstrates in the LMRFP, even if conditions in the river were close to optimal, returns to the river could not be sustained in the long run without production from the MRFF because of excessive losses in Lake Lodi and the Delta and because of high ocean harvest rates. (MRH, ERMUD Ex. 32, p. 5-3.)

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10-43 Staff recognizes the difficulties of relating fish populations quantitatively to areas of habitat for various life stages. This is an active area of research and analysis nationwide, not only for chinook salmon and steelhead but for other fish species. Nonetheless, general linkages are apparent and because of this there is active use of standardized instream flow analyses in environmental impact assessment. The FEIS makes use of these standard analytical techniques.

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10-44 Your comment is noted; this issue was addressed in the FEIS.

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10-45 The Mokelumne River Fish Facility (MRFF) was acknowledged in the DEIS as an important component of the fish populations in the Lower Mokelumne River (Section 4.6.2). The DEIS commented on the MRFF, its history, and its operational problems. The Master Plan for the MRFF was not available to staff at the time of preparation of the DEIS. The focus of the EIS, however, is on flows from Camanche Dam and their effects on naturally spawning fish. Staff elaborates on the MRFF and its importance in the FEIS, but does not conduct a detailed analysis of the Master Plan.

Even on its own terms, however, using the total usable acres of habitat derived from the DFG instream flow incremental methodology ("IFIM") study as an indication of benefits to the anadromous fishery resources,^{15/} the DEIS fails to support its conclusion that the Staff alternative maximizes the benefits to those resources. Indeed, the DEIS analyses show that, while the Staff's recommendation provides more habitat for chinook spawning than the LMRMP alternative -- the principal benefit that the DEIS claims for the Staff proposal (DEIS, p. 2-24) -- this increase comes at the cost of a reduction in the habitat for chinook fry of exactly the same amount. (See Table III.1, which is based on DEIS, Table 5.2-1.) Similarly, Staff's recommendation would provide slightly more habitat for steelhead spawning than would the LMRMP or the "no-action" alternative, but would decrease the habitat available for steelhead fry and juveniles by substantially greater amounts. (Id.) Staff's recommended minimum flows thus do not provide more habitat than the LMRMP alternative. Rather, the DEIS shows that Staff's recommendation would provide different habitat, increasing habitat for spawning while reducing habitat for fry (and steelhead juveniles) by equal or greater amounts.

^{15/} As discussed in Section IV.B.2 below, this use of IFIM data is inappropriate.

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10-46 There is a tradeoff between habitat available for spawning chinook salmon adults and rearing juveniles according to the standard IFIM interpretations. This is discussed in the FEIS Section 3.3.1, the limiting factor analysis. However, a shallow river having water no deeper than that considered best habitat for chinook juveniles is not the best interpretation when more water is also needed for downstream temperature control, passage in the river below Woodbridge, etc. Staff has also proposed evaluation of off-channel rearing ponds and channels in abandoned gravel pit areas as habitat enhancements for rearing juveniles when there is adequate or surplus spawning and incubation (Section 4.6.7).

10-47 See staff's response to comment No. 10-46; the same applies to steelhead although rearing habitat for steelhead in the Lower Mokelumne is nearly nonexistent.

10-48 Your comment is noted. Our position is based on what staff thinks is the most limiting factor. This is an alternative that was not fully evaluated in EBMUD's LMRMP. Also, see response to comment No. 10-46.

TABLE III.1
DEIS ANALYSIS OF CHANGE IN HABITAT ABUNDANCE
UNDER STAFF AND LMRNP FLOW REGIMES,
COMPARED TO NO-ACTION ALTERNATIVE
(IN TOTAL USABLE ACRES)

Median Habitat Available	Alternative Flow Regimes		Habitat Gain (Loss) From Staff Proposal Over LMRNP
	LMRNP	Staff	
Chinook spawning	0.9	2.4	1.5
Chinook fry	2.1	0.6	(1.5)
Chinook juveniles	0.1	0.3	0.2
Steelhead spawning	0.5	1.2	0.7
Steelhead fry	(0.1)	(1.2)	(1.1)
Steelhead juveniles	(0.2)	(2.1)	(1.9)

Source: DEIS, Table 5.2-1.

The preference in the DEIS for Staff's alternative violates the DEIS's stated criterion for selecting among flow regimes. The DEIS states that "it seems best to select a flow regime that avoids extreme advantages" for one life stage over another (spawning or fry and juveniles), "while providing reasonably abundant habitat for both." (DEIS, p. 2-22.) Staff's proposal, fails this test, enhancing spawning habitat at the expense of fry habitat. Over the hydrologic record, Staff's alternative provides 88% of optimum spawning conditions for chinook salmon (only 5% more than the LMRNP alternative) at the expense of relatively poor fry rearing conditions (42% of optimum) and for

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10-49 Staff appreciates having the quantitative differences in habitat availability among the alternatives pointed out by EBMUD. Reference to previous Commission analyses is helpful.

outmigration below Woodbridge Dam (43% of optimum). See Exhibit 1, discussed in Section IV.E of these Comments.¹³

The DEIS's finding that the results of its habitat abundance analyses support the superiority of Staff's recommendation is premised upon an apparent belief that trading spawning habitat for fry habitat (and, in the case of steelhead, juvenile habitat as well) results in a net gain to the chinook and steelhead fisheries. Although the DEIS thus views the availability of spawning habitat as the key constraint on the populations of anadromous fish in the lower Mokelumne River, it provides no analysis to support this critical premise.¹⁴ Absent evidence to support this belief, the DEIS's preference for the Staff recommendation cannot stand.

In fact, the available evidence indicates that spawning habitat is not the principal factor limiting anadromous fish populations on the lower Mokelumne River.¹⁵ The assumption to

¹³ In other cases, in the absence of evidence that one life-stage was limiting a fish population, the Commission has looked to the average percentage of optimum habitat that would be provided for all life-stages by different flow alternatives. See Thomas Hodgson & Sons, Inc., 60 FERC ¶ 62,071 at 63,147, 63,171 (OHL 1992). The DEIS presents no such analysis.

¹⁴ The DEIS offers only Staff's unexplained and unsupported "recommendation that spawning habitat is biologically more important to improvements in the chinook salmon reproductive cycle." (DEIS, p. 5-6.)

¹⁵ Further, evidence suggests that the additional fish brought into the run as a result of increased flow during the in-migration period would be strays. Since the goal adopted by Staff (and the District) is to establish a Mokelumne River run based on fish of Mokelumne origin, flows that attract large numbers of strays are not desirable. (MRH, EBMUD Ex. 32, p. 5-5.)

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10-50 The quantitative relationships between either spawning habitat or rearing habitat and population numbers are not well established by any of the work conducted in the Lower Mokelumne River. However, spawning habitat provides an ultimate limit to the reproductive success of a species. If there is no spawn, no amount of habitat for the subsequent stages will be effective. On the other hand, rearing of juveniles can often compensate for an abundant spawn by expanding to somewhat less suitable habitat within the normal rearing area or by displacement of juveniles farther downstream. Available quantitative data for the Lower Mokelumne River does not indicate that juvenile chinook salmon have saturated the available rearing habitats of the Lower Mokelumne River in the spring months following emergence. The presence of a fairly strong fry emigration at Woodbridge in March shortly after emergence would suggest such saturation, but most of these fry appear to come from the Bruella Road segment and not the upper reaches, according to recent fry trapping studies. It is not known whether this is really saturation or a natural tendency of some fry to move downstream right away. Therefore, the numbers of fish produced in the normal spawning and rearing area above Lake Lodi are more likely to be limited by the numbers of fish spawning. This rationale for the staff's position has been included in the FEIS in the limiting factor analysis (Section 3.3.1).

10-51 See response to comment No. 10-50. Factors outside the project area are clearly affecting salmon survival as was discussed in the DEIS and expanded in a limiting factor analysis of the FEIS (Section 3.3.1). Suitable conditions for outmigration, as noted in the comment, are a major factor. Limitations at this point in the life cycle become evident only when there are sufficient numbers of smolts produced by spawning and rearing in the Lower Mokelumne River. Staff's use of CDFG data on historic run sizes before and after Camanche Dam was closed has been challenged by other parties, and this analysis has been qualified by reference to the questionable nature of the early data. Recognition of the importance of outmigration led to conceptual proposals for improved fish passage in Lake Lodi. Staff has augmented its analysis of flow alternatives to include flow to assist outmigrants.

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the contrary in the DEIS is belied by the data showing that the construction of Camanche Dam, which is thought to have inundated much of the available salmon spawning habitat (NRN, EBMUD Ex. 32, p. 1-13), has not appreciably diminished salmon runs to the Mokelumne (DEIS, p. 3-33). Further, the LMRMP, which contains the only in-depth analyses of the factors affecting fishery resources in the river indicate that the main limiting factor is the suitability of conditions for outmigration. (NRN, EBMUD Ex. 32, ch. 3, App. A, D.) While outmigration success is affected largely by factors external to the Project (see Section IV.A, below), the scientific evidence indicates that, if any life-stage is to be stressed in evaluating proposed changes in Project operation, it should be outmigration, not spawning. (Id.)

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(cont.)

The Staff alternative provides substantially poorer conditions for outmigration than does the District's proposal, for any type of water year. See Exhibit 1, discussed in Section IV.E, below. By sacrificing conditions for outmigration to increase spawning habitat, the Staff's recommended flow regime makes precisely the wrong trade-off.

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10-52 Staff has reexamined its analysis in light of the additional information provided by the EBMUD on the relationships between conditions for spawning and outmigration. Given the uncertain nature and likely annual variability of true limiting factors, staff has also proposed off-channel habitat for fry rearing in the form of pools and channels in old gravel pit ponds (Section 4.6.7).

Even if Staff's recommended flows were successful in increasing the number of salmon spawning in the Mokelumne, the DEIS does not consider whether the diminished fry and juvenile habitat that would be available under the Staff proposal will be adequate to support the number of spawners that the proponents hope to attract, or whether the fry that might result from an increase in spawning habitat could successfully rear and migrate

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10-53 See responses to comments No. 10-50 through 10-52.

downriver. The Staff's recommendation provides so little outmigration flows that it would provide only about 80% of the natural outmigration that would be obtained under the LMRMP alternative. See Exhibit 2. Staff's alternative would also provide significantly lower bypass flows at Woodbridge Dam than the LMRMP and would therefore be expected to result in lower survival of outmigrating smolts. See Id. The Staff alternative thus appears to focus on an exercise that the DEIS describes (p. 5-3) as "fruitless": enhancing conditions in the Mokelumne for spawning, without making corresponding improvements in conditions for outmigration.

In sum, because it includes no analysis to identify the factors constraining the target fishery resources, and ignores the analysis of those factors that EBMUD provided to Staff, the DEIS fails to recognize that adoption of the Staff recommendation would be far less beneficial than other alternatives because it fails to provide water when the fish need it most.

B. Even if the Staff Alternative Would Achieve the Fishery Benefits Claimed for It, They Would Come at Enormous and Unprecedented Cost.

The DEIS concludes that Staff's recommendation would not impose unreasonable costs on EBMUD's water supply system, although it quantifies only the costs associated with Staff's recommended minimum flow regime. The costs to the District related to this preferred flow regime are substantial by any measure.

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(cont.)

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10-54 Your comment is noted. See the response to comment No. 10-11.

10-55 Your comment is noted. See the response to comment No. 10-41 on the purpose of this EIS and this proceeding. Staff has quantified the socio-economic costs of alternative project modifications in the FEIS. It is important to note that EBMUD is recommending a significant cost in its LMRMP.

The DEIS finds that implementation of Staff's recommended minimum flow requirements would increase the District's water supply costs by \$15.1 million annually, levelized over 30 years, or \$3.2 million per year more than its estimate of the water supply cost of providing the LMRP's recommended minimum flows.^{18/}

The DEIS implicitly finds that the incremental costs of the Staff's recommended minimum flow requirements are outweighed by the incremental fishery benefits that would be produced. The basis for this conclusion is unstated and, EBMUD believes, insupportable. We show in Section IV.F of these Comments that the analysis in the DEIS of the impact of Staff's recommendation on the District is unrealistic and erroneous in critical respects. The costs to the District's water supply system of implementing the Staff proposal will, in fact, be three to six times higher than the DEIS estimates -- totalling \$753 million to \$1.47 billion over thirty years.^{19/} Even assuming, for the sake of argument, that the DEIS accurately measured the impact of

^{18/} DEIS, p. 5-5. The cited figure is based on the three-year drought sequence used by the District in its long-range water supply planning. The DEIS suggests that this planning contingency might be unduly conservative (DEIS, p. 4-2) and also includes lower cost figures for a two-year drought sequence, although it nowhere indicates which figures form the basis for its conclusions. We show in Section IV.F of these Comments that the District's use of a three-year drought sequence in its planning conforms with accepted water supply planning practices and is not unduly conservative.

^{19/} There is simply no valid basis for the assertion in the DEIS (p. 2-24) that the water supply costs of the Staff proposal are "comparable" to those contemplated by the District's Updated WSMP.

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10-56 Your comment is noted, but we disagree on many of these points. See staff's findings and recommendations in Section 5.

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10-57 Your comment is noted. The FEIS focuses primarily on EBMUD's worst-case, three-year drought in estimating impacts to municipal water supplies.

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Staff's proposal on the District's water supply and that increasing spawning habitat benefits the anadromous fishery in the lower Mokelumne, those benefits would come at a prohibitive cost, even as calculated by the DEIS.

1. The Costs of Staff's Proposal Far Exceed Both the Claimed Fishery Benefits and the Costs and Benefits of the Power Generated by the Project.

(a) The costs of Staff's proposal vs. expected fishery benefits. The DEIS bases its preference for the Staff proposal on analyses showing that it would yield 1.5 acres of chinook spawning habitat more than the LMRMP at an annual incremental cost (as calculated in the DEIS) of \$3.2 million levelized over 30 years, or over \$2 million ~~per acre~~ each year. The incremental cost of steelhead spawning habitat is even higher: over \$4.5 million per acre per year for the 0.7 acres gained. (DEIS, p. 5-5.) The District is unaware of any licensing decision in which the FERC has imposed costs of this magnitude on a project devoted principally to municipal water supply in order to achieve such modest gains in spawning habitat.^{24/}

A recent survey of mitigation costs imposed on hydroelectric projects indicates that requiring a project to bear total costs

^{24/} The Commission has recently restated its policy, when licensing projects that use "an existing state- or municipally-owned dam and reservoir whose primary function is municipal water supply," to acknowledge "the primary importance of water supply in such cases" and to protect water supply operations in determining the necessary license conditions. Appomattox River Water Authority, 60 FERC ¶ 61,083 at 61,265 (1992). See also City of Fort Smith, Arkansas, 42 FERC ¶ 61,362 (1988); City of Cortland, Oregon, 6 FERC ¶ 61,257 (1979).

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10-58 Your comment is noted. Staff's recommendation is based on the relative differences among alternatives rather than the absolute costs and benefits of individual alternatives. The status and need for protection of the fishery resource is also a major consideration. Our approach to examining tradeoffs has been explained more fully in Sections 2 and 5 of the FEIS.

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10-59 The Commission considers many resources, including municipal water supply, irrigation, fish and wildlife, and hydropower, when determining whether to issue a license for a hydroelectric facility. See the numerous fish and wildlife protection measures required at each of the cited projects. Also, see the mitigation costs for hydropower development presented in Sale et al. (1991, DOE/ID-10360), which you reference elsewhere in your comments.

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of this magnitude for the provision of instream flows as mitigation is unprecedented.^{41/} The DEIS offers no support for its conclusion that the limited gains in spawning habitat that it finds the Staff's recommended minimum flow regime would provide justify the monumental costs (as calculated in the DEIS) required to achieve them, especially in light of the following factors:

- As the DEIS acknowledges, in the absence of evidence that salmon runs to the Mokelumne are significantly different before and after the construction of Camanche Dam in 1964, habitat improvements in the river, including minimum flows, should be considered an enhancement, rather than a mitigation obligation (DEIS, p. 5-3).^{42/}
- The numerous considerations cited in the DEIS, including conditions in Lake Lodi, unscreened diversions, conditions in the Delta, and ocean harvest could render it "fruitless to enhance salmon and steelhead spawning, incubation, and rearing habitats below Camanche Dam" (DEIS, p. 5-3).^{42/}
- The difference between the spawning habitat under the Staff's preferred alternative and the District's LMRMP is quite small. As shown in Section IV.E of these comments, the District's proposal would provide 83% of optimum spawning conditions across the hydrologic record. Exhibit 1. While this is less than the Staff recommendation, which provides 88% of optimum spawning habitat (id.), it is substantial and the difference is relatively small in view of the lack of precision in the IFIM data underlying these analyses.

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10-60 Your comment is noted.

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10-61 This statement has been clarified in the FEIS.

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10-62 The FEIS recommendations (Section 5) emphasize project modifications that do not rely on actions by others to increase protection of chinook salmon runs in the lower river.

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10-63 Although the absolute amount of spawning habitat may seem small in terms of acreage, on a percentage basis it is quite significant. Staff's recommendations in the FEIS, which are supported by the FWS (e.g., see comment No. 11-15), find that this increase in spawning habitat is necessary and sufficient to result in a substantial increase in the sustainability of natural, instream production of salmon in the Lower Mokelumne River.

^{41/} M.J. Sale, et al., Environmental Mitigation at Hydroelectric Projects, DOE/ID-10360, DE92-009744 (U.S.D.O.E. 1991) ("DOE Environmental Mitigation Survey").

^{42/} While correct on its own terms, this statement implies that Staff's recommended flow regime would improve conditions for fry and juveniles, as well as spawning. As the discussion in Section III.A, makes clear, however, this is not so.

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(b) The costs of Staff's proposal vs. the costs and benefits of the Project's hydroelectric capacity. The costs of providing the additional flows required under Staff's recommendation (as estimated by the DEIS) are also disproportionate to the amount invested in expanding the Project's generating capacity -- which was the subject of the license issued by the Commission in 1981 -- and to the value of the power that could be produced by the Project after the expansion.^{22/} In its March 20, 1980 license application, the District explained that, while the primary purpose of the Project would remain the supply of EBMUD's municipal water needs, it planned to invest \$23.8 million to add 20.6 megawatts of capacity (approximately doubling the Project's installed generating capacity).^{23/} The \$15.1 million annual water supply costs of providing Staff's recommended flows would thus exceed the total amount invested in about 1.6 years.

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10-64 Your comment is noted. Recent federal and state legislation, including but not limited to the Electric Consumers Protection Act of 1986 and the Energy Policy Act of 1992, make it very clear that hydroelectric developers must bear the cost of environmental protection and mitigation. The Federal Power Act provides the authority to the Commission to ensure licensing conditions are set and enforced.

The cost of providing Staff's recommended flows would also exceed the benefit of the hydroelectric power that the Project generates. The DEIS estimates that the gross potential hydropower revenues that could be generated under the Staff

^{22/} Before the District applied in 1980 for a license for the expansion of the Project's generating capacity, the District was authorized to operate the Project without a license under Public Law No. 177 (48 Stat. 642) (1934).

^{23/} Application, Ex. B, p. 12; Ex. C, pp. 25-26. The actual amount invested was slightly under this estimate. The original cost of the land, water rights and existing facilities at Pardee and Camanche Dams totalled \$46.7 million. Application, Ex. C, pp. 23-24.

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proposal would be approximately \$6 million per year. (DEIS, p. 4-23.) The DEIS estimate of the cost of providing Staff's recommended flows is 2.5 times greater than the expected gross hydropower revenues -- with no deduction for the fixed and variable generating costs. In its 1980 application, the District provided projections of the net revenues that it anticipated receiving from the Project generation.^{23/} Although the expected value of Project generation was sensitive to a number of assumptions, the District's base case projections were equivalent to a levelized stream of net revenues of approximately \$5.6 million per year -- less than 40% of the DEIS's estimate of the cost of providing the Staff-recommended minimum flows.

Both of the preceding estimates of Project hydropower revenues, moreover, include the energy generated both by the new turbines and by the turbines at the Pardee powerhouse, which could have continued to operate without a FERC license. Since the new turbines were expected to provide less than one-half of the Project's hydropower generation (Application, Ex. B, p. 12), the DEIS's estimate of the cost of providing the Staff's recommended minimum flows is at least five times greater than the estimated benefits of the generation covered by the 1980 application.^{24/}

^{23/} Application, Ex. C, pp. 34-45. In practice, the District's net hydropower revenues have proven to be less than had been projected in 1980.

^{24/} Even the DEIS's estimate of the incremental costs of providing the flows required under the Staff proposal over the
(continued...)

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10-65 The issue of the value of hydropower production versus the cost for providing additional flows is less relevant in the context of this EIS because the LMRP is principally a water supply project.

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10-66 The licensed project includes the Pardee and Camanche power houses. Existing project operation considers these facilities to be integral.

Had Staff's recommended minimum flow requirements been required at the time of licensing, they would plainly have rendered the expansion project uneconomic.^{2/} Certainly, the District would not have gone forward with the generation expansion project under those conditions. (See Application, Ex. B, p. 16.) Even under the analysis in the DEIS (ignoring for the time being the flaws in the analysis), Staff's recommendation therefore would impose costs on the District that are wholly disproportionate to the costs and benefits of the construction that brought the Project within the Commission's licensing jurisdiction. A post-licensing modification of the restrictions on a project's operation that so drastically transforms the project's economics cannot be considered a "reasonable" modification permissible under Article 15 of the Project's license and Section 6 of the Federal Power Act.

2. The Estimates in the DEIS of the Costs to the District Omit Important Costs Associated With Staff's Recommendation.

Even accepting the assumptions in the DEIS regarding the costs the District would incur to make up the water supply shortfall resulting from the Staff's recommendations, the DEIS

^{2/}(...continued)

flows called for by the LMRMP (\$3.2 million per year on a levelized basis) exceeds the estimated value of the hydropower revenues associated with the generation expansion that brought the Project under the Commission's jurisdiction.

^{2/} FERC, Office of Hydropower Licensing, Evaluating the Economics of Hydroelectric Projects at the Federal Energy Regulatory Commission, Paper No. DPR-1 (1989).

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10-67 This argument is premature until a final Commission action is taken. However, the same argument concerning the effect of instream flows on project economics probably applies to EBMUD's alternative, the LMRMP. The FEIS displays the economic costs of the alternatives considered for Commission decision-making.

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understates the costs of Staff's alternative by omitting costs in a number of areas.

(a) The costs of Staff's minimum pool recommendation. The DEIS acknowledges that accommodating Staff's recommended minimum pool requirement for Camanche Reservoir would impose substantial additional costs on the District's water supply. (DEIS, p. 5-6.) The DEIS fails, however, to quantify either the costs or the benefits of this part of Staff's recommendation. (Id.) The DEIS contains no analysis showing that this measure is justified by hoped-for temperature benefits "the exact magnitude [of which] and biological response [to which] cannot be predicted with confidence." (DEIS, p. 5-6.)

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10-68 The DEIS did present separate modeling runs for staff's minimum pool requirement and staff's minimum flow requirement. Nevertheless, the FEIS explains the separate benefits of these requirements more completely (see Section 4).

(b) Increased treatment costs and the costs of increased health risks to the District's customers. In estimating the impact of the Staff recommendation on the District, the DEIS assumes that the District could meet the shortfall in its water supplies by adding water withdrawn from the Delta. (DEIS, p. 4-22.) In Section IV.F of these Comments, we show that this assumption is unfounded. Even if it were supportable, however, the DEIS fails to reflect all of the costs associated with adding water from the Delta to the District's supplies.

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10-69 Cost of treating Delta water, health risks associated with its use, and whether it would be available during a prolonged drought are key issues. Claims made by EBMUD regarding the cost of treatment and potential health risks are disputed by testimony (Central Delta Water Agency) given at the State Board hearings held November 1992. This new information has been incorporated into the FEIS, and both sides of the controversy are presented in the FEIS.

The DEIS downplays the health concerns associated with the use of Delta supplies for drinking water. (DEIS, p. 4-4.) In fact, major concerns with the quality and safety of the use of water from the Delta for drinking have been documented in numerous studies -- none of which are cited or considered in the

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10-70 See comment 10-69.

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DEIS. (MRH, EBMUD Exs. 31, pp. 6-10; 32, App. A-1 - A-5.)

Unlike water from the District's project on the Mokelumne River, the quality of water in the Delta is influenced by municipal and industrial waste discharged to the Sacramento and San Joaquin Rivers, urban runoff, agricultural drainage into the rivers and the Delta, and seawater intrusion from San Francisco Bay. (Draft EIR/EIS, vol. six, p. G1-120.) Treatment of Delta water supplies to address these contaminants produces elevated levels of bromates and trihalomethane ("THM"), which has been identified as a potential carcinogen. Current state and federal regulations may preclude available options for controlling high THM levels (MRH, EBMUD Ex. 31, p. 10), and regulatory proposals currently under consideration could reduce the availability of current treatment technologies and increase the cost of treating low-quality water supplies. (Id. pp. 12-16.)

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(cont.)

These problems are not merely theoretical, but are borne out by the District's experience in the drought of 1976-1977, when limited amounts of Delta water were mixed with existing supplies on an emergency basis. Sea water intrusion caused high levels of sodium, chloride, bromide and total dissolved solids in the water supply. (Draft EIR/EIS, vol. six, p. G1-121.) Even though Delta water was limited to 10% of the total supply at the direct filtration plants (as is also contemplated under the Staff proposal), THM levels more than doubled, on average, and peaked at even higher levels, and remained at elevated levels long after Delta supplies were eliminated. (MRH, EBMUD Ex. 31, pp. 10-11.)

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10-71 See comment 10-69.

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The quality of water in the Delta has deteriorated markedly since 1977, so the water quality impacts of using water in the future are likely to far worse. Certainly, there is no basis for the assumption in the DEIS that, because the District used Delta water for 10% of its total needs during emergency conditions in the 1970's, doing so in the future would raise no water quality concerns.

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(cont.)

In Section IV.F of these Comments, we show that the environmental and water quality concerns associated with Delta withdrawals makes reliance on the Delta as a potential source of supplemental supplies highly problematic. Even assuming, as the DEIS does, that it is realistic to plan to use Delta water to supplement the District's supplies from the Mokelumne, it must be recognized that there are significant costs associated with lower quality water -- costs that are ignored in the DEIS.

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10-72 See comment 10-69. EBMUD also raises the issue of significant costs associated with using Delta water. These costs (consumers purchasing bottled water, home treatment devices, etc.) were pointed out in the DEIS and recognized that they exist. Whether these are significant is another matter. We note that hundreds of thousands of people currently obtain their drinking water from the Delta. Therefore, we conclude that the Delta is a feasible alternative water supply for EBMUD.

A plan to rely on the introduction of Delta water into the District's system during times of shortage would require major upgrades to the District's treatment facilities. The District has estimated that the cost of a treatment facility for Delta water, sized at the capacity of the existing Bixler pumping station, would be between \$119 million and \$567 million in capital costs, and would have operating costs between \$31 million and \$56 million per year. (MRH, EBMUD Exs. 31, p. 18; App. A-6.) In addition, using Delta water, even for only 10% of the District's total supplies, would lead to increased concentration of contaminants and, in particular, THMs, which present a small,

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10-73 See comment 10-69. EBMUD's estimates of the cost of treating Delta water are considered by staff to be over estimated.

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but measurable increase in the cancer risk to the District's customers.^{24/} If the DEIS is to compare the cost of alternative proposals to modify Project operations based on the assumption that Delta water can be used to make up for water supply deficiencies, then it must assess and quantify the costs of the increased health risks associated with that supply option.^{25/}

(c) The value of Pardee Reservoir recreational use.

Adoption of Staff's preferred alternative will result in significant drawdowns of Pardee Reservoir. A low Pardee Reservoir level will render the existing marina and boat launch ramps inoperative. Notably, the main boat launch is reduced to two lanes at elevation 540 feet, and the two-lane low-level boat launch ramp is not functional below 525 feet. In addition, lower reservoir elevations make it far more difficult for anglers to get to fishing areas. The impact on recreational opportunities is potentially significant and demonstrable.^{26/} For example,

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10-74 In the FEIS, staff looked at the differences in lake elevations among CDFG, EBMUD, and staff alternatives and considered the implications of elevation changes to reservoir-based recreation (see Sect. 4.2). Going beyond the direct recreational values to impute indirect economic values is beyond the scope of the EIS (cumulative impacts).

^{24/} As shown in Section IV.C of these Comments, the DEIS underestimates the water supply deficiency that would result if the Staff recommendation were adopted. The District therefore would have to use Delta supplies for more than 10% of its water supplies, if it were to rely on this source to make up that shortfall.

^{25/} See EBMUD May 15, 1992 Comments, Attachment F. That risk would fall disproportionately on lower-income families, for whom bottled water is not an option.

^{26/} Despite the clear and direct implications of Staff's preferred alternative for recreational opportunities, the DEIS inexplicably concludes that "recreational issues, such as fishing and boating access at both Camanche and Pardee reservoirs and in the lower Mokelumne River, are not appropriate for consideration under the limitations of Article 15 unless they are directly related to the modifications recommended to protect the

(continued...)

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between 1990 and 1991, due to the low reservoir conditions in Pardee resulting from an unprecident fifth year of drought, total visitor usage at Pardee dropped from 139,965 to 88,490. This reduction in recreational opportunities creates an economic "ripple" effect on the surrounding communities which derive a commercial benefit from the visitors to the District's Mokelumne recreational facilities.

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(cont.)

3. The DEIS Fails To Assess Environmental Impacts of the Staff Recommendation.

(a) The DEIS fails to consider the environmental costs of withdrawing water supplies from the Delta. The DEIS also ignores the environmental impacts that would be associated with withdrawing water from the Delta to obtain the supplemental supplies necessary to meet the shortfall in the District's water supplies that would result if Staff's recommendation were adopted. Federal and State agencies, including U.S. EPA, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, the U.S. Bureau of Reclamation, and DFG, as well as the California Sportfishing Protection Alliance, have all expressed concern about the impacts of Delta diversions on the survival of the Delta smelt (which is a candidate for listing as a threatened species under the Endangered Species Act), longfin smelt,

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10-75 The comments from CDFG and the Committee to Save the Mokelumne seem to indicate that Delta water use is preferable to upstream withdrawals. With regards to availability, EBMUD states in their Composite Program III that water will be available for the EBMUD to purchase although a specific source has not been identified.

²² (...continued)
anadromous fisheries in the lower river." (DEIS, p. 1-4.) The fact that the Commission could not order changes in recreational facilities under Article 15 does not, however, excuse Staff from considering in an EIS the impact on recreational opportunities of modifications in Project operations that are under consideration.

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Sacramento splittail, salmon, striped bass and other resident Delta fish populations. (NRE, ERMUD Ex. 30, pp. 16-17.) Although the stresses on populations of these species result from a variety of biological and environmental factors, entrainment losses at Delta diversions have been identified as a major contributing factor. (Id., pp. 17-20.) The concerns with the cumulative impact of Delta diversions are greatest during low-flow years and periods of prolonged drought (id. at 20), precisely when the DEIS assumes that ERMUD would rely on Delta supplies. Studies show that a significant diversion from the Delta by the District during low-flow periods would contribute directly to existing cumulative impacts that are stressing the Delta fisheries populations. (Id. at 25.)

By omitting the environmental impacts of the "least-cost" solution that the DEIS identifies to rectify the diminution in ERMUD's water supplies resulting from Staff's proposal, the DEIS understates the true cost of that proposal. To fulfill the Commission's obligations under the NEPA, if the DEIS bases its assessment of the costs of Staff's proposal on an assumption that Delta withdrawals will be used to make up supply deficits, it must evaluate both whether the environmental concerns regarding additional Delta withdrawals make it realistic to treat the Delta as a supply source that will be available to the District (an issue discussed in Section IV.F) and the environmental impacts of such diversions if they are permitted.

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10-76 Similar to responses to comments No. 10-75 and No. 10-69.

(b) The DEIS fails to consider the value of the Pardee Reservoir fishery resources. The DEIS also fails to take into account the damage that adoption of Staff's recommendation would do to the valuable fishery resources in Pardee Reservoir. The cold-water fishery in Pardee Reservoir is an extremely valuable natural resource that is highly valued by anglers. (NRH, ERMUD Exs. 29, pp. 24-43; 32, App. F.)

The DEIS acknowledges that the Staff proposal would cause Pardee Reservoir to be drawn down to "dead storage" even in water years that the DEIS would classify as "normal." (DEIS, pp. 4-20, 8-9.) The DEIS also recognizes correctly that the drastic reductions of water levels in Pardee Reservoir that would occur under the DFG proposal could adversely affect the significant cold-water fishery in Pardee and that "the potential loss of cool-water fish populations [would] be significantly adverse." (Id., p. 4-12.) Indeed, when water levels in Pardee Reservoir were reduced drastically during the drought of 1976-1977, the damage suffered by the fishery was severe and long-lasting.

The DEIS fails to recognize, however, that its own analyses show that the Staff proposal would lead to drawdowns in Pardee Reservoir as severe (albeit somewhat less frequent) as those that would occur under the DFG proposal. (Id., pp. 4-8, 4-20.)^{21/} Severe reductions in Pardee Reservoir water levels could be especially damaging, due to the narrow littoral zone in the

^{21/} In Section IV.C of these Comments, we show that the DEIS underestimates the frequency with which the Staff's proposal would cause severe drawdowns of Pardee Reservoir.

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10-77 See response to comment No. 10-56. Pardee's loss in terms of recreation and fisheries could be Camanche's gain. The stabilization of Camanche surface elevation should produce the necessary conditions for the development of a successful coldwater fishery as well as provide better conditions for other recreational activities.

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10-78 See response to comment No. 10-74.

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10-79 Staff has expanded its evaluation of each alternative flow regime to include effects on reservoir fishes. Warmwater fishes are capable of tolerating drawdowns. Elimination of cold water salmonids in Pardee Reservoir is highly unlikely, especially with the normal stocking program continuing.

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steep-sided reservoir. (EBMUD Ems. 29, p. 43; 32, App. F.) Fish would be denied access to this productive zone, which would reduce normal spawning activities and cause nests to become inaccessible and/or easy prey for predators. The result would be smaller fish populations, with age-classes of fish limited and cold water salmonids potentially eliminated. (Id.)

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(cont.)

The DEIS contains no analysis of the impact that Staff's recommendation would have on the fishery and recreation resources in Pardee Reservoir. The DEIS therefore fails to provide a complete assessment of the environmental impacts of that proposal.

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10-80 The FEIS examined this issue more fully in Section 4.

(c) The DEIS fails to consider the value of the salmon and steelhead habitat lost under Staff's recommendation. Finally, the analysis in the DEIS shows that adoption of the Staff's recommended minimum flow regime would lead to a loss of fry and juvenile habitat. Unless it can be shown that the loss of this habitat causes no harm at all to the anadromous fishery resources -- a showing that is not made or attempted in the DEIS -- a consideration of the costs and benefits of Staff's proposal must weigh the environmental impacts of the loss of this habitat, together with the other costs of Staff's proposal, against the small gain in spawning habitat that may result. In fact, the analysis described in Section IV(E) of these Comments demonstrates that the flows proposed by Staff would not increase the natural reproduction of anadromous fish in the Mokelumne

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10-81 Staff reexamined its analysis in light of the additional information provided by the EBMUD on the relationships between conditions for spawning and rearing. Providing less water so that rearing habitat can be optimized below Camanche Dam is not acceptable when this water is needed for passage and temperature control in the river below Woodbridge. See response to No. 10-46.

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River, indicating that the reduction of habitat for rearing is not cost-free.

* * * * *

In sum, even if the analyses in the DEIS were accepted at face value, those analyses do not support the conclusion that Staff's recommendation appropriately balances the benefits to fisheries and the adverse impacts on EBMUD's water supply system. To the contrary, the DEIS ignores significant costs and environmental impacts that would result if Staff's proposal were adopted and inappropriately focuses on increasing spawning habitat when the available evidence shows that the principal factor limiting the populations of anadromous fish in the lower Mokelumne is not the amount of spawning habitat, but the suitability of conditions for outmigration. Staff's recommendation is demonstrably less favorable for outmigration than the LMRMP. Moreover, adoption of the Staff's recommendation would impose unprecedented and unwarranted costs on the District, for only a modest gain in spawning habitat for anadromous fish, which has not been shown to provide a significant benefit to fish populations.

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10-82 Your comment is noted. Additional information provided by EBMUD, comments by others on the DEIS, and the exhibits and testimony before the State Board have been incorporated into the FEIS to better explain the costs and benefits of potential project modifications for use in the Commission's decision-making.

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IV. The Analyses in the DEIS Are Analytically and Factually Flawed in a Number of Critical and Fundamental Respects, Rendering the DEIS Inadequate as an Evaluation of the Environmental Impact of the Alternatives.

In the preceding sections of these Comments, ERMUD has shown that the analyses presented in the DEIS, even taken at face value, do not support the conclusion that the Staff recommendation provides substantial benefits to anadromous fisheries, while having only a reasonable impact on ERMUD's water supply system. In the following sections, the District shows that the analyses in the DEIS contain numerous significant factual errors and analytical flaws. These shortcomings render the DEIS unreliable as an assessment of the environmental consequences of the Staff recommendation and other alternatives considered.

A. The DEIS's Analysis of the Impact of the Alternative Minimum Flow Regimes on Anadromous Fisheries and Habitat Requirements Is Severely Flawed.

As noted previously, the basic premise of the DEIS fishery analysis is that populations of chinook salmon will benefit if Project operations were modified to increase the acreage of potential habitat -- in particular, potential spawning habitat -- below Camanche Dam. Applying this criterion, the DEIS finds that the flow regimes recommended by Staff and DFG will be more beneficial to anadromous fisheries than the LNMMP alternative. However, flaws in the DEIS's methodology and factual assumptions infect the analyses of the alternative minimum flow recommendations and fatally undercut the conclusion reached. The

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DEIS simply does not present an accurate or reliable assessment of the impact of the alternative minimum flow regimes on habitat availability or fish populations. In this section of these comments, the District will address some of the most significant errors in the DEIS's analysis of minimum flows and fisheries benefits.

1. The DEIS Fails To Assess the Staff Recommendation in Light of Other Factors Acknowledged To Affect Chinook Salmon Populations in the Mokelumne River.

The DEIS fails to provide any support for its assumption that increasing the availability of habitat, especially habitat for spawning chinook salmon, will increase the populations of anadromous fish in the lower Mokelumne River. It is generally recognized that a direct relationship between habitat acreage and fish populations cannot be assumed. One recent survey provides the following summary:

Under current theory, the amount of WUA in a stream should have a strong effect on fish populations during (and only during) times when physical habitat limits population size.... During other times populations may be controlled by factors other than physical habitat, such as food availability, fishing mortality, and predation. Therefore, relations between WUA and fish populations are frequently complex and difficult to identify.^{23'}

The DEIS ignores this accepted principle, and instead assumes, without analysis, that the anadromous fish populations in the Mokelumne River are constrained by the amount of spawning habitat

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10-83 See responses to comments No. 10-50 through 10-52.

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10-84 Your comment is noted. Staff did not ignore the presence of limiting factors in either the DEIS or the FEIS (e.g., see Sections 3.3.1 and 3.3.2). Staff believes, and is supported by FWS, that improvements in spawning habitat conditions will have direct benefits in terms of the sustainability of natural, instream production of chinook salmon in the lower river.

^{23'} DOE Environmental Mitigation Survey, pp. 5-3 to 5-4 (emphasis added; footnotes omitted).

available between Camanche Dam and Lake Lodi. This assumption, unwarranted as a general rule, is especially problematic in this case.^{12/}

Abundant evidence establishes that anadromous fish populations in the lower Mokelumne are affected by numerous factors other than the amount of habitat in the stretch of the river that is the focus of the DEIS. Modifying the operation of the Project to increase the amount of spawning habitat in the Camanche reach will not affect those factors. Long before the construction of Camanche Dam, salmon runs in the Mokelumne were affected by periodic drought, by pollution from wineries, the canning industry and mining operations, and by inadequate fish passage facilities at Woodbridge Dam. (MRH, EBMUD Exs. 27, 32, pp. 1-8 - 1-11.) Indeed, the DEIS recognizes that there is no statistical difference between the size of salmon runs before and after the construction of Camanche Dam (DEIS, p. 3-33) and that "it is not likely that the natural reproduction of chinook salmon can be improved in the lower river without eliminating the serious barriers to migration that exist in the vicinity of Lake Lodi" (id., p. xxiv). The facilities and operations of Woodbridge Dam, which forms Lake Lodi, are beyond the control both of the District and of the FERC. Studies indicate, however,

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^{12/} In Section III.A of these Comments, the District shows that the focus of the Staff alternative on modifying Project flows to increase spawning habitat ignores evidence showing that conditions for outmigration, not abundance of spawning habitat, is the major factor affected by Project operation limiting anadromous fish populations.

10-85 The EBMUD correctly summarizes the multiple factors that influence salmon production and survival in the Lower Mokelumne River. Staff has included this information in a limiting factor discussion in the FEIS (Section 3.3.1). However, it is incumbent on the Commission to ensure the best conditions possible within its control. The foremost of these is local spawning and rearing areas. The major feature affecting downstream survival in all reaches of the Lower Mokelumne River and Delta that can be influenced by the Commission's area of responsibility is flow. Therefore, staff has reexamined the use of increased flows (as volume of flow and as water temperature) to enhance outmigration success in areas of Lake Lodi, the river and Delta downstream of the immediate spawning and rearing areas.

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that even if increased spawning habitat above Lake Lodi were to attract more spawners and were to lead to the emergence of more fry, as much as 70-80% of juvenile salmon migrating through the lower Mokelumne will continue to be lost during passage through Lake Lodi. (MRH, EBMUD Exs. 27, p. 1-4; 32, pp. 15-1 - 15-13.)

Nor is Lake Lodi the only factor adversely affecting anadromous fisheries on the Mokelumne. Adult chinook and steelhead returning to the lower Mokelumne River to spawn are caught and harvested by recreational anglers and poachers.^{25/} Migrating fish are also impacted by the hundreds of municipal and agricultural diversion facilities, many of them unscreened, which exist throughout the Delta and in the lower Mokelumne. (MRH, EBMUD Exs. 27, pp. 4-1 - 4-7; 32, pp. 1-16 - 1-23.) Most agricultural diversions, including the Woodbridge Irrigation District Canal, operate at high levels during the peak outmigration period for salmon smolts. (MRH, Ex. 32, pp. 1-20 - 1-21.)

Major diversion facilities in the Delta, such as the export pumps of the Central Valley Project and the State Water Project, also impede downstream passage of juvenile salmonids. (MRH, EBMUD Exs. 27, pp. 3-1 - 3-9; 32, p. 1-23.) Those fish encounter

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10-86 See staff response to comment No. 8-15 regarding wading anglers and salmon redds. The FEIS urges screening of all diversions.

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10-87 The staff discusses mortalities in the Delta and transporting fish from hatcheries to areas beyond the Delta in the FEIS (Section 3.3.1).

^{25/} MRH, Ex. 27, p. 2-7. Recently, fishermen using river access operated by DFG have been observed disturbing salmon redds in the Mokelumne River, activity that has also been observed in the past. (MRH, EBMUD Ex. 32.) This activity, which is beyond the ability of EBMUD to control, threatens to negate the numerous steps taken over the last few years to enhance conditions for salmon in the Mokelumne, steps that the District has funded at substantial cost.

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reverse flow conditions, predation, entrainment and high temperatures, leading to losses estimated to reach 85 percent. (MRH, EBMUD Ex. 32, p. 3-58.) To reduce Delta mortalities, DFG has transported Mokelumne salmon around the Delta. While these efforts increase juvenile survival rates, they contribute to "straying" by returning adults. (MRH, EBMUD Exs. 27, p. 3-4; 32, pp. 3-19 - 3-20.) It is estimated that 90% of Mokelumne River salmon planted below the Delta return to other river systems, thereby further reducing returns to the Mokelumne River. (MRH, EBMUD Ex. 32, p. E-14.)

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(cont.)

Finally, salmon populations are also reduced by the impact of commercial harvest during the period of ocean residence. Ocean harvest of adult salmon averages approximately 65% annually, and ranges as high as 80 percent. (MRH, EBMUD Ex. pp. 5-1 - 5-4, Fig. 5-1.)

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10-88 The staff discussed the ocean fishery in Section 3.3.1 of the FEIS.

Taken together, these factors raise substantial doubts about whether a small increase in spawning habitat acreage in a portion of the lower Mokelumne River, attained by the dramatic increases in flows from the Project called for in Staff's recommendation, can provide significant benefits to anadromous fisheries in the river. The DEIS takes note of this problem, identifying the obstacles to anadromous fish that are presented by conditions external to the Project and recognizing that these factors could cause any efforts to increase spawning habitat below Camanche Dam to be for naught. The DEIS nevertheless recommends adoption of a Staff proposal that focuses exclusively on "natural" means of

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10-89 See response to comment No. 10-85.

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promoting anadromous fish by increasing flows, even though it acknowledges that the hoped-for benefits could be thwarted by conditions beyond the control of the licensee and of the Commission. The DEIS is fatally flawed because of the absence of any analysis of how proposed changes in Project facilities and operation will impact the objective of promoting the anadromous fish populations in the lower Mokelumne in light of the external factors it identifies. As the analyses in Section IV.E of these Comments demonstrate, the flow enhancements proposed by Staff would result in virtually no improvements in natural salmon smolt production or in salmon returns to the Mokelumne River. See Exhibit 2.

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10-90 See response to comment No. 10-85.

The LMRMP, in contrast, is based on precisely such an analysis. It is designed specifically to sustain and enhance the chinook salmon and steelhead trout resources in the river, taking into account current conditions downstream. To the extent that conditions are improved in Lake Lodi, at downstream diversions and in the Delta, the LMRMP will have even greater success, but it does not depend upon the amelioration of conditions that are beyond the District's power to control. Unlike the Staff proposal, the LMRMP recognizes that an exclusive focus on natural reproduction and migration of anadromous fish is doomed to failure in light of the high mortality rates suffered by outmigrating smolts in Lake Lodi and the Delta, the variability of runoff, the competing demands for water in dry periods, temperature conditions in Lake Lodi and below Woodbridge Dam, and

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10-91 Staff fully considered EBMUD's LMRMP and incorporated it into our FEIS recommendations where appropriate. The differences between EBMUD's and staff's alternatives were displayed in Section 5 of the FEIS.

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the other factors discussed above and in the DEIS. To address these conditions, the LMRMP combines its proposed regime of increased minimum flows, modifications to the operation of Pardee and Camanche Reservoirs to maintain downstream temperature, and flows to assist natural outmigration, with proposals for improvements and modifications in MRFF operations^{22/} and in DFG's fishing regulation,^{24/} and for trapping and trucking of smolts around Lake Lodi and the Delta during critically dry and parts of dry years. (MRH, EBMUD Ex. 32, pp. 5-1 - 5-45.) Unlike the Staff proposal, the integrated LMRMP is projected to increase the natural reproduction of salmon in the Mokelumne River -- the

^{22/} The failure of the DEIS to take into account the role that the MRFF must play in advancing the objective of promoting natural runs of anadromous fish to the lower Mokelumne River is insupportable, especially since the DEIS acknowledges (p. 1-1) that the genesis of this proceeding lies in reports of losses of steelhead fingerlings in the MRFF. Unlike the DEIS, the LMRMP recognizes that improved hatchery facilities and operations -- especially the raising of yearling chinook salmon and steelhead trout -- will have a direct and immediate impact on anadromous fish runs, permitting a more rapid and complete utilization of improved habitat conditions in the river. (MRH, EBMUD Ex. 32, pp. 5-9 to 5-27.) For steelhead, these practices can be enhanced by selecting for the hatchery only those steelhead exhibiting true anadromous qualities (determined by reading fish scales) are selected for broodstock. Improvements in the MRFF are thus entirely consistent with and, in fact, a essential component of any strategy the goal of which is to enhance the natural reproduction of chinook and steelhead in the natural channel of the lower Mokelumne River.

^{24/} Under the LMRMP, DFG's current steelhead management would be altered to develop a successful anadromous steelhead fishery and to protect the chinook fishery. This would be accomplished by changes in stocking hatchery practices and changes in fishing regulations to protect salmon redds and to provide for the release of steelhead caught in the river. (MRH, EBMUD Ex. 32, pp. 5-3 - 5-4 and 5-36 - 5-39.)

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10-92 Although the DEIS mentions the MRFF and provides some evaluation of it and its history, a detailed analysis of the MRFF was not considered to be appropriate in the EIS. This position continues for the FEIS. The staff considers the MRFF important for the EBMUD's management plan (see Section 4.6.2 of the FEIS).

10-93

10-93 Staff appreciates the EBMUD's suggestions for enhancing steelhead in the Lower Mokelumne River. Staff has considered them in the FEIS.

DEIS's primary fishery management objective -- and salmon runs to the river. See Exhibit 2.

The DEIS does not present an accurate and reliable assessment of the environmental impacts of alternative modifications in Project facilities and operations because it fails to analyze the degree to which recognized external conditions will prevent a proposal from achieving the promised fishery benefits. This failing goes to the heart of the DEIS's analysis of the environmental impacts and benefits of alternatives and its conclusion that the Staff recommendation is superior to the other alternatives considered.

2. Methodological Shortcomings in the DEIS Analysis of Minimum Flows.

(a) The DEIS misuses the IFIM methodology. The DEIS compares the minimum flow proposals by converting weighted usable area ("WUA"), produced by DFG's instream flow incremental methodology ("IFIM") study, to acres of potential habitat for each life stage. This is not a valid use of the DFG data. WUA is an index of habitat suitability; it can only be converted to areal extent of habitat with additional data not collected in the DFG study.^{22/} The results of an IFIM study can be used to compare different proposed flow regimes by measuring the percentage of optimum habitat for each species and life stage provided by each alternative. Even such an analysis must

^{22/} Personal communication, C. Stalnaker, Instream Flow Group, Fort Collins, CO (Feb. 24, 1993).

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10-94 Your comment is noted. The FEIS discusses factors outside of the Lower Mokelumne River and the influence of EBMUD's project that affect fisheries. Furthermore, the FEIS recommendations are designed to minimize the likelihood of benefits not being realized due to the inaction, or actions, of others.

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10-95 Staff disagrees with EBMUD's interpretation of IFIM procedures. The conversion of weighted usable area (WUA), measured as area per unit length of stream at a representative reach, to total area in a homogeneous stream segment is an established IFIM analysis procedure, documented in the publications of Clair Stalnaker and Ken Bovee of the U.S. Fish and Wildlife Service (e.g., Instream Flow Information Paper No. 12, FWS/OBS-82/26, 1982, p. 75-76). The FEIS explains staff's IFIM analysis in more detail and provides references supporting our procedure (see Appendix F of the FEIS).

11-1-88

Response to Comments

recognize that the data underlying an IFIM study is seldom precise enough to give significance to small differences in WUA scores. WUA scores are only meaningful to identify large differences in the impact of a flow alternative on the abundance of potential habitat, relative to other flow alternatives evaluated in the same IFIM study. WUA scores alone cannot, however, properly be used to determine the actual acreage of potential habitat that would be available under each proposal.

In Section IV.E of these Comments, EBMUD provides a more appropriate analysis of the WUA data. As we will show, these data do not support the DEIS's preference for the Staff's recommended minimum flows. Rather, the analyses described in Section IV.E show that the LMRMP would maximize benefits to the anadromous fisheries of the Lower Mokelumne River.

(b) The IFIM methodology relied upon in the DEIS erroneously predicts spawning habitat. Both scientific literature and field observations on the Mokelumne River indicate that the IFIM methodology provides erroneous estimates of spawning habitats. Numerous studies indicate that spawning salmon are selective; they do not use all potentially suitable spawning habitat, but prefer transition areas between spawning and non-spawning habitat types or naturally formed gravel "berm" areas, results that are confirmed by fieldwork on the Mokelumne River in 1991-1992.²⁴ (MRH, EBMUD Ex. 32, pp. 11-2 - 11-3.)

²⁴ The LMRMP includes programs to enhance the suitability of spawning gravel and to create more berm areas in the river. (MRH, EBMUD Ex. 32, pp. 5-35 - 5-37.)

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10-96 See previous response.

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10-97 Your comment is noted.

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10-98 The IFIM approach to defining suitable spawning habitat is not complete, as the comment suggests. There are other factors besides depth, velocity, and substrate that are involved in spawning site selection by a female salmon. When these other factors are known, they can be included in the analysis. Staff had reported in the DEIS (Section 4.4.1) the observation of the use of berms by spawning chinook salmon in the Lower Mokelumne River noted in the comment and the plans in the EBMUD's management plan for enhancing this type of habitat. The FEIS has been revised accordingly.

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The failure to incorporate this tendency into IFIM models has led some scientists to conclude that IFIM studies, such as those relied on in the DEIS, erroneously predict chinook spawning habitat.^{22/} (Id.)

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(cont.)

(c) Transect data were improperly weighted. The DEIS weights the transect data from the DFG IFIM study based on the length of each study reach. This procedure is not justified by the way the DFG study was conducted. DFG selected transects that it believed to be representative of habitat conditions in a reach of the river, but did not measure the extent of different habitat types.^{23/} In the absence of such measurements, it is impossible to say how much of the total reach is represented by conditions at any transect and the only legitimate way to treat these data -- in contrast to the manner in which it is used in the DEIS -- is to give each transect equal weighting.

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10-99 Your comment is noted. However, the type of weighing used in the DEIS has not changed the optimum flows recommended in staff's alternative. See Appendix F in the FEIS for the IFIM procedures used in the FEIS.

^{22/} These studies suggest that greater attention should be given to the availability and enhancement of preferred habitat rather than simply the depth and velocity of flows. For example, the District has documented that over 50 of the 335 salmon redds constructed during the 1992 spawning run in the Mokelumne River were constructed in the 1990 gravel enhancement site. Notably, the gravel enhancement site is just a small fraction of the total river habitat. Further, the DEIS's undue emphasis on flow to enhance spawning may, in fact, frustrate the DEIS's espoused objective of enhancing a distinct Mokelumne River run of chinook salmon. See n. 17, above.

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10-100 Your comment is noted and was considered in the methods used in the FEIS (Appendix F).

^{23/} Personal communication, S. Wilcox, EBASCO Environmental (Feb. 24, 1993).

3. Factual Errors or Ambiguities in the DEIS Analysis of Fishery Issues and Flow Requirements.

(a) The assumptions in the DEIS regarding the location of habitat for rearing and spawning are incorrect. The DEIS uses data collected by DFG for the Bruella Road study reach to represent rearing conditions for chinook salmon and steelhead trout. (DEIS, pp. 3-48.) This is a serious error. Studies indicate that most rearing of anadromous fish takes place in the "Tailwater" segment of the river -- that is, the section of the river from Camanche Dam downstream about 4.5 miles. Seining data indicate that most of the salmon rearing occurs above Elliot Road (which is above Bruella Road) and, in fact, that the vast majority of the rearing occurs above Mackville Road which is even further upstream. (NRH, ERMUD Ex. 32, App. A.) Fry trapping shows relatively little downstream movement by fry out of the reach above Bruella Road. (Id.) Unlike the Tailwater segment, the Bruella Road segment lacks the mixture of riffles and runs and the cobble and gravel substrate that characterize optimal rearing habitat. (Id., pp. 4-1 - 4-3.) Moreover, the Bruella segment is the least responsive to changes in flow. Measuring the impact of the alternative flow regimes at Bruella Road, rather than at the Tailwater sites, therefore understates the reduction in fry and juvenile habitat that occurs with the DFG and Staff proposals. This error also affects the DEIS analysis of stream temperatures, which use temperatures at the Bruella Road site to determine whether temperatures suitable for juvenile

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10-101 Rearing habitat was evaluated at the Bruella Road study reach, used to represent staff's "Rearing Segment," and in the "Tailwater Segment." Staff agrees that rearing occurs in both areas, and it was accounted for in the DEIS and in the FEIS.

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10-102 Staff appreciates the information on the relative use of the tailwater and Bruella segments of the Lower Mokelumne River for salmon rearing. Fry emigration is a good indicator of the saturation level of the habitat for rearing. Fry emigration from the Bruella Road segment indicates that this reach may be saturated. As the comment indicates, this reach lacks the mixture of riffles and pools that form good rearing habitat. That there is little fry movement out of the reach above Bruella Road suggests that there is available rearing habitat there and that spawning habitat may be limiting in this reach.

rearing result from different minimum pool elevation requirements. (DEIS, p. 4-28.)

Conversely, while the DEIS states that spawning habitat exists only in the Tailwater segment of the river, spawning surveys document good spawning habitat downstream as far as River Mile 56 (below Mackville Road). In 1991, almost half of the salmon redds observed were constructed below Mackville Road. (MRH, EBMUD Ex. 32, App. A.) The incorrect portrayal of existing spawning habitat casts further serious doubt on the accuracy of the DEIS's analysis of the impact of different flow regimes on the abundance of habitat for that life-stage.

(b) Flows measured below Woodbridge Dam may differ from flows in Camanche reach. The DEIS also appears to base all habitat analyses on flows measured below Woodbridge Dam. (DEIS, pp. 4-6, 4-13; Table 2.2-2.) This approach could lead to serious errors in the estimation of habitat conditions in the Camanche reach, since the gradients are steeper in the Camanche reach above Woodbridge Dam (see Exhibit 3) and the flows greater in the Camanche reach than those shown in DEIS Table 2.2-2 (presumably the basis for the analyses in the DEIS) because of the need to have sufficient water to meet agricultural diversion at Woodbridge.

(c) Errors in life-stage assumptions. The DEIS commits several errors regarding the timing of chinook life-stages in the Mokelumne River. First, the DEIS states (p. 3-34) that chinook fry emergence usually continues until June. Most fry emergence,

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10-103 The DEIS properly reports that spawning has been observed "upside of the Tailwater Segment," but there is no quantitative habitat response data (e.g., WUA versus stream flow) for spawning sites below Mackville Road. Rather than require EBMUD to do a new IFIM study on the river, staff can best use the best available habitat data, which was the study done for CDEC.

10-104 Habitat analysis presented in the DEIS and the FEIS used flows released from Camanche Dam as input to all spawning, fry, and juvenile habitat analyses.

10-105 The comment correctly notes that it is fry emergence that is generally complete by late March or early April and that juveniles rear in the general area of the spawning sites and immediately downstream (the tailwater reach) until May or June. The DEIS contained some imprecise wording that has been corrected in the FEIS.

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however, is complete by April. (NRH, ERMUD Ex. 32, ch. 3.) At the same time, the DEIS states that most juvenile chinook have left the spawning areas by late March, though field work in the past few years demonstrates that most chinook juveniles remain in the spawning areas until May or June. (Id.) These errors may have caused the DEIS to give incorrect weight to conditions for different life-stages during the late Spring and early Summer.

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(cont.)

(d) The treatment of life-stage timing issues is unclear. The analysis in the DEIS does not make clear what was assumed regarding the timing of life history stages or how conflicts between overlapping life-stages were evaluated. For example, were flows during March evaluated for their impact on spawning habitat, since incubation is still proceeding, or for their impact on fry rearing? If both life stages were considered, what weight was given to each? In the analyses presented in the LMRNP and in Section IV(E) of these Comments, life-stage timing and weighting are clearly defined. (NRH, Ex. 32, Table D-5.)

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10-106 A clearer definition of life-stage timing is important, as the comment indicates. Staff has clarified what was done.

(e) The DEIS presents oversimplified assumptions regarding flow benefits. The DEIS states that low flows favor older life stages of salmon, while higher flows favor spawning. This is an over-simplification of a more complex phenomenon that has important implications for the validity of the conclusions reached in the DEIS. High flows favor chinook spawning only up to about 350 cfs.^{11/} While lower flows are beneficial to fry

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10-107 Contrary to this comment, the habitat response curves presented in the DEIS and the FEIS clearly show that spawning benefits decrease at higher flows.

^{11/} NRH, ERMUD Ex. 32, Figure D-2. The LMRNP recognizes the need to improve high-flow spawning conditions, especially since
(continued...)

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and juvenile rearing, outmigration requires much higher flows to maintain suitable temperatures. (MRH, EBMUD Ex. 32.) The failure of the DEIS to analyze the limiting life-stage for salmon in the Mokelumne leads to a failure to recognize the importance of providing adequate flows for outmigration.

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10-108 See responses to comments No. 10-80 through 10-82

(f) Components of Staff's flow recommendations are unexplained. Staff's recommendation would provide minimum flows of 100 cfs below Woodbridge Dam during July-September during normal water years. The DEIS provides no explanation of the purpose to be served by these flows. Nor is a purpose readily apparent, since chinook or steelhead have not been shown to inhabit this reach at this time of year.

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10-109 See Section 2, 4, and Appendix F in the FEIS for an expanded explanation of staff's minimum flow alternative

(g) The effectiveness of pulse flows. The DEIS suggests that short-term pulse flows may be effective to attract adult salmon or to initiate the outmigration of juveniles. (DEIS, pp. 4-26, 4-46.) This suggestion is unsupported and, indeed, is contradicted by data assembled in the LMRMP. (MRH, EBMUD Ex. 32, ch. 3.) Contrary to the suggestion in the DEIS, natural conditions during outmigration are not characterized by a pulse of high water, but by a gradually increasing pattern of high flow over several weeks, with peak flows occurring near the end of the outmigration period. (Id.) The District's smolt outmigration monitoring at Woodbridge Dam clearly shows that salmon will leave when they reach a minimum threshold size. (MRH, Ex. 32, p. 3-46,

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10-110 Pulse flows are being considered as a management tool in several river basins as a means of stimulating salmon migration in spring and autumn with the least amount of water, also an objective in the Lower Mokelumne River. Clearly, the natural pattern was for more sustained high flows over the migration periods, especially in spring. At least in the autumn, migratory patterns can be stimulated and sustained by relatively short-term pulses of water not much larger than the base flow. Data from the Lower Mokelumne River showed upstream movement of adults stimulated by small peaks of flow (Section 4.3.2). These pulses occur naturally as freshets. There is also ample evidence in many river systems for outmigrations of juvenile fall chinook salmon in freshets. Earlier spring emigration that entails higher risk of predation on small fish must be balanced against later migration at larger size that entails increased susceptibility to high temperatures. As the DEIS indicates, the value of brief, small pulses (as an alternative to other flow regimes that usually require releasing more water) and the most appropriate timing, magnitude, and duration of these pulse flows must be established with more study. Staff notes that the sustained flows recommended by the EBMUD in its management plan requires much greater water use than the staff-proposed pulse flows.

21 (...continued)
spawning escapement is usually highest during wet years, when flow are also high. (Id., p. 5-37.)

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App. A.) In fact, pulse flows may cause premature migration and higher losses due to the greater susceptibility of small fish to predation.⁵ Notably, the LMRMP does not incorporate a pulse of water in the Spring to encourage outmigration (DEIS, p. 4-48), but rather by a gradual increase in flows, with a peak at the end.

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(cont.)

(b) EBMUD's outmigration flows. The DEIS states that, in reviewing the LMRMP's proposed flows to assist outmigration, it proceeded on the understanding that LMRMP's approach assumed that suitable habitat for rearing and migration would be sufficient to assist emigration. (DEIS, p. 4-47.) This reflects a basic misunderstanding of the approach of the LMRMP. The LMRMP flows are premised on assuring adequate temperature conditions for outmigrating smolts throughout the lower reaches of the river. (MRH, EBMUD Ex. 32.) The level of flows required for this purpose exceeded that required for spawning. Temperature analysis presented in the LMRMP indicates that the level of flow in the Staff proposal is insufficient to assure adequate temperature conditions. (MRH, EBMUD Ex. 32, Appendix C.)

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10-111 Contrary to the conclusions of EBMUD, staff found that the flows proposed by staff when considered in conjunction with the Camanche outfall temperatures provided by the minimum Camanche elevation criteria are sufficient to assure adequate temperature conditions for the various Chinook life stages during years with normal meteorological conditions. The results of this analysis have been included in the FEIS.

⁵ See, Kjelson, M.A., P.F. Raquel, and F.W. Fisher, "Life History of Fall-Run Juvenile Chinook Salmon, *Oncorhynchus tshawytscha*, in the Sacramento-San Joaquin Estuary, California" published in *Estuarine Comparisons*, V.S. Kennedy (ed.), Academic Press, New York, 1982, at pp. 393-411; DPG Ex. 15, State Water Resources Control Board Bay/Delta Hearing Phase I: Determination of Beneficial Uses and Determination of Reasonable Levels of Protection, July 1987; Brown, R.L. and S. Greene, "Biological Assessment Effects of Central Valley Project and State Water Project Delta Operations On Winter-Run Chinook Salmon," California Department of Fish and Game, October 1992; 1990 Annual Report, Interagency Ecological Studies Program for the Sacramento - San Joaquin Estuary, December 1991.

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Further, unlike the Staff proposal, the LMRMP recognizes that there are times when it becomes impossible to reduce temperature with flows. When these circumstances occur -- that is, when flows cannot control temperature -- the LMRMP cuts back flows so as to not waste water and provides for trapping and trucking to assist smolt emigration and to save production.

(i) What flows are considered in the DEIS analysis?

Finally, it is unclear whether the DEIS's habitat analysis was based only on the flows provided under each proposed minimum flow regime or whether the analysis took into account all releases that would occur, including for flood control, downstream users, fishery protection, and channel losses. Plainly, all flows present in the river must be taken into account when performing a habitat analysis. However, as discussed in Section IV(C) of these Comments, the DEIS's water budget analysis does not include all releases required from Camanche Dam for downstream rights holders. Any analysis of habitat below Camanche Dam that relies on an erroneous estimate of flows from Camanche is necessarily highly suspect.

4. The DEIS's Treatment of the Steelhead Trout Fishery Is Based on Incorrect Assumptions and Flawed Analyses.

Although the fishery management objective that is the focus of the DEIS concerns chinook salmon (see n. 4, above), the DEIS states that the steelhead rainbow trout "was the most important fish in the lower Mokelumne River" before the construction of

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10-112 See the response to comment No. 10-104. The instream flow analyses in the DEIS and the FEIS accounted for all releases to the lower river (see Appendices B and F).

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10-113 The comment correctly characterizes the discussion about steelhead in the DEIS. The DEIS noted that the steelhead resource in the Lower Mokelumne River has suffered proportionately more than the chinook salmon by having its sustainable, natural population essentially eliminated. Nonetheless, management of chinook salmon is the higher priority of the CDFG, with steelhead management relegated to put-and-take hatchery planting without a sustainable natural population being derived from the continual supplementation. Staff's further evaluation of the habitat requirements of steelhead juveniles (Section 3.3.2) and the available habitats in the Lower Mokelumne River suggests that suitable habitat is nearly completely lacking. Even modest habitat improvements recommended probably will not make much habitat available (Section 4.4.3).

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Camanche Reservoir, citing a 1959 DFG report (DEIS, p. 3-49), and concludes that the naturally spawning steelhead population has essentially been lost since 1963, which "should be of major concern" (*id.*, p. 5-1). On this basis, the DEIS concludes that "the greater management deficiency and need for attention to protect and enhance the once-important resource lies with steelhead" (*id.*, p. 5-2), that DFG and EBMUD "should establish escapement goals for a natural steelhead run" (*id.*, p. 5-3), and that hatchery production of steelhead should not be considered a suitable substitute for natural population (*id.*). Despite these statements, the Staff alternative preferred by the DEIS includes no measures directed to development of an anadromous steelhead fishery in the Mokelumne River, and the DEIS justifies its preference for the Staff alternative exclusively on the basis of the impact of that alternative on spawning habitat for chinook salmon (*id.*, p. 2-24).

The DEIS' assertion that steelhead trout were the dominant fish in the lower Mokelumne before the construction of Camanche Reservoir is unsupported. In fact, a 1965 DFG report states that, prior to the construction of Camanche Dam, no records were kept on the population of steelhead in the Mokelumne River. (MRH, EBMUD Ex. 32, p. 3-51.) Moreover, there has never been an official stock estimate of steelhead since that time, and there is little evidence that substantial spawning occurs. (MRH, EBMUD Ex. 32, p. 3-51.) Past efforts to establish a natural steelhead run in the Mokelumne River have proven unsuccessful.

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(cont.)

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10-114 The 1959 CDFG report cited in the DEIS clearly establishes the importance of steelhead in the Lower Mokelumne River. There is also considerable evidence that steelhead spawning was eliminated by Camanche Dam and Reservoir prior to the issuance of the current FERC license.

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Steelhead now in the Mokelumne are the result of eggs raised in the MRFF. In recent years, DFG has managed rainbow trout as a "put-and-take" fishery, in which yearling fish are released in the Spring and Summer to support a local recreational fishery.^{52/} Those fish that are not caught are theoretically capable of migrating to the sea (hence the DFG's description of them as "catchable steelhead trout"). Very few, however, return to the Mokelumne River as adults, for reasons that are not clear. (MRH, EBMUD Ex. 32, p. 3-52.)

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10-115 Your comment is noted.

There is no evidence that the goal of the development of an exclusively natural run of steelhead in the lower Mokelumne River is achievable. Habitat requirements for steelhead trout are similar to those for chinook salmon during spawning and rearing. (MRH, EBMUD Ex. 32, p. 3-52.) Since suitable requirements for successful steelhead reproduction exist in the lower Mokelumne River during most years, but there has been no evidence of self-sustaining reproduction, suitable spawning or rearing habitat does not appear to be the primary factor limiting the establishment of a natural run of steelhead in the Mokelumne River. (Id.)

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10-116 The comment on difficulties in attaining a natural run of steelhead in the Lower Mokelumne River was a useful expansion of the discussion in the DEIS. Further staff study of the habitat requirements of steelhead juveniles suggests that they differ significantly from those for chinook salmon and that the needed habitat is not now present in the Lower Mokelumne River (Section 3.3.2).

The District agrees that steelhead management in the lower Mokelumne River should be focused on trying to establish a viable anadromous fishery. The evidence indicates, however, that this objective cannot be achieved by focusing exclusively on modifying

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10-117 Staff concurs with the comment. In addition to stocking and hatchery practices (outside the scope of the FEIS), staff has suggested modest habitat improvements for steelhead juveniles (Section 4.4.3).

^{52/} These management practices for steelhead may interfere with chinook salmon management goals because steelhead yearlings prey on smaller chinook juveniles that are still in the river.

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flows to improve habitat conditions in the river. Instead, changes should be made in stocking and hatchery practices and fishing regulations in order to promote the return to the Mokelumne of steelhead raised in the MRFF. (MRH, EBMUD Ex. 32, p. 5-4.) In particular, establishment of a viable natural run of steelhead trout depends critically on modification of DFG's present management of the steelhead produced in the MRFF and its regulation of in-river fishing for those fish.

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(cont.)

B. The Analysis in the DEIS of Temperature Issues Is Severely Flawed.

The DEIS combines the results of two temperature simulation models -- one to simulate the temperatures in Camanche Reservoir and another to simulate temperatures in the Mokelumne River below Camanche Dam -- to evaluate the impacts of the alternatives considered to manage the water in Camanche Reservoir so as to maintain temperatures to benefit downstream fish resources. The DEIS favors Staff's recommendation that the District be required to maintain a minimum pool elevation in Camanche Reservoir of 180 feet msl, except in water years characterized as "dry" under criteria described in the DEIS. (DEIS, p. 5-7.) In those years, Staff's recommendation would require EBMUD to "share" water deficits with fishery resources under a mechanism that the DEIS does not describe.

Although EBMUD's ability to comment effectively on the DEIS analysis of temperature issues has been hampered by Staff's refusal to provide key information, EBMUD has identified a number

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of critical errors, both in the data and methodologies used in different components of the analysis and in the failure to consider whether the combined results are realistic. These shortcomings bring into serious question the validity of the DEIS finding in favor of Staff's proposed 180 ft. minimum pool requirement.

1. **The Stream Temperature Model Used in the DEIS Is Unsuitable for the Purpose of Modeling the Lower Mokelumne River.**

The DEIS used the SNTMP model to simulate the temperatures in the lower Mokelumne River under different operating assumptions for Camanche Reservoir. (DEIS, p. 4-28.) As the specifications for this model clearly indicate, the SNTMP model assumes that no stratification is present in the waters modeled. (See MRH, EBMUD Ex. 32, App. A, p. 1-1, App. C, p. C-3.) The DEIS acknowledges, however, that, Lake Lodi stratifies when flashboards are in place at Woodbridge Dam (April through mid-October), and that the effects of the stratification are not reflected in the model's results. (DEIS, p. 4-28.) The seriousness of this error and its implications for the validity of the model results would depend upon the amount of flow through Lake Lodi, and therefore could be different for dry, normal and wet years. Nevertheless, the DEIS's failure to account for this fundamental assumption in the SNTMP model vitiates the reliability and reasonableness of any conclusion drawn in the DEIS based on its use of the SNTMP model.

10-118

10-118 The staff's analysis of the predicted temperatures in the Lower Mokelumne River with the SNTMP model did not account for possible stratification in Lake Lodi. Because of the small volume of Lake Lodi and the limited amount of stratification that takes place there during the critical months (October-June) of our temperature analysis, staff initially chose to use the SNTMP model for the entire Lower Mokelumne River and compared the uncalibrated output below Woodbridge Dam to actual temperature measured there for five different years. The results of this analysis showed that the SNTMP model underestimated temperatures directly below Woodbridge Dam by an average difference of less than 1.8°F (1°C) as stated in the DEIS (p 4-28). Staff has presented the results of this analysis in the FEIS. Staff felt that this amount of error was acceptable and was just as good as using an additional model to model Lake Lodi given the risk of incurring additional model uncertainty. Staff doesn't believe the use of the model in this fashion in any way detracted from the results staff obtained.

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The DEIS attempts to dismiss this omission by indicating that the temperatures predicted by the model were nevertheless relatively close to observed temperatures below Lake Lodi during the five year period modeled. (Id.) However, the DEIS does not present the data underlying this statement (and FERC Staff has declined to provide it to the District). Moreover, the fact remains that the DEIS uses the SNTMP model for a use that is inconsistent with the model's design. The correlation that the DEIS found between the SNTMP model predictions and actual river temperatures could easily have resulted from errors introduced while calibrating the model to minimize the impact of the stratification of Lake Lodi which SNTMP assumes -- contrary to reality -- does not exist.^{44/}

10-119

10-119 See response to previous comment.

The LMRMP also used the SNTMP model but recognized that stratified conditions in Lake Lodi violate the stated assumptions of the model. Accordingly, the LMRMP used a different model developed at the Hydrologic Engineering Center by the U.S. Army Corps of Engineers to simulate temperatures in Lake Lodi. (MRH, EBMUD Ex. 32, App. A, p. 1-1). That same model was also used to simulate temperatures in Camanche Reservoir. As shown in the LMRMP and in Section IV.F of these Comments, the approach used in the LMRMP produces more accurate temperature estimates and, more important, contradicts the findings of the DEIS.

10-120

10-120 The results of the simulations on the Lower Mokelumne River temperatures presented by EBMUD in their LMRMP did not include sufficient supplemental information for us to compare them to staff's predictions. Evidence that EBMUD's temperature results contradict the findings of the DEIS could not be found in Section IV.F of the comments as stated.

^{44/} Staff has declined to provide the District with the model coefficients derived for the calibrated model.

2. The DEIS Uses Inappropriate and Unrepresentative Data in Modeling Stream and Reservoir Temperatures.

The DEIS attempts to model reservoir and stream temperatures for both "normal" and "dry" years. To model Camanche Reservoir temperatures, the DEIS used temperatures for 1988 as representative of a dry year, and data for 1989 as representative of a normal year. (DEIS, p. 4-29.) The DEIS assumes that the temperature of water flowing into Camanche Reservoir from Pardee Reservoir is equal to the recorded temperatures of water in Pardee Reservoir at a depth of 100 feet, measured at the outlet tower for the Mokelumne Aqueduct. (Id.) For its stream temperature model, the DEIS used actual Camanche release temperatures from 1964 to simulate a dry year and from 1975 to simulate a normal year. (Id., p. 4-28.) As shown below, the data used in the DEIS are likely to be inaccurate and unrepresentative of conditions that would actually result from implementation of any of the alternatives studied.

(a) **The DEIS uses unreliable data for Pardee release temperatures.** First, the evidence does not support the assumption in the DEIS that the temperature of Pardee releases equal the temperatures recorded at the Mokelumne Aqueduct outlet tower. The outlet tower is in a different arm of the reservoir than the outlet for Pardee releases to Camanche. Data for temperatures in the Pardee afterbay show little annual variation, averaging 13.5°C over ten years, but the temperature at the outlet tower at the 100-foot depth was cooler than average in

10-121

10-121 In the FEIS, reservoir modeling of normal and dry years differ only in the volume of water flowing into and out of Camanche Reservoir. The same meteorological data and Camanche inflow temperatures were used for each type of year. See also responses to comments No. 10-122 and No. 10-123.

10-122

10-122 We agree that the temperature of inflow to Camanche will probably not be equal to the temperature measured at the Pardee outlet tower. No other data were available. Modeling of Camanche in the FEIS uses Camanche inflow temperatures with an annual average of approximately 56.3°F (13.5°C) as suggested in this comment.

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1988 (peak of 12°C), but warmer than average in 1989 (peak of 16°C). (EBMUD File Data: Pardee Section Report, Hydrolab Data.) Use of temperature data from the outlet tower is therefore likely to distort the results of the DEIS modeling of Camanche Reservoir.

(b) Unrepresentative data were used to calibrate the DEIS reservoir temperature model. Second, 1988 and 1989 are poor choices as representative dry and normal years. By 1988, there had been below-normal runoff in the Mokelumne River watershed since the Fall of 1986, causing Camanche Reservoir to be drawn down in 1988 to the lowest levels since the reservoir began filling in 1964 (water surface elevation 125.73 feet, and storage of 9630 acre feet -- 2% of capacity). See Exhibit 4. These unprecedented conditions are not representative of typical dry years. And, although the DEIS considers 1989 "normal," runoff in that year was only slightly above half the historical average, following two years of below-normal runoff -- hardly "normal" conditions. Even at peak elevations in June 1989, Camanche Reservoir elevations are more typical of levels during a dry year than during a normal year. Throughout 1988 and 1989, Camanche Reservoir end-of-month elevations never exceeded 191 feet; in eight of the twenty-four months during the period which the DEIS treated as representative, the reservoir was below 140 feet. See Exhibit 4. Since it began filling in 1964, the reservoir end-of-month elevation never has been below 140 feet except during the 1988-1989 period. Id.

10-123

10-123 We agree that 1988 and 1989 were atypical years. There were, however, no other reservoir temperature data available, and we believe calibration for atypical years is better than no calibration. The FEIS contains modeling results for a wider range of operational scenarios.

Camanche Reservoir elevations in 1988 and 1989 are plainly atypical and using them to calibrate the model clearly could lead to distorted results. Although hydrolab data limit model calibration to those years, the DEIS should have recognized that the conditions were unusual and accordingly should have simulated a much wider range of conditions, as well as number of years in sequence, as the LMRNP does in its temperature modeling of the reservoir. (MRH, EBMUD Ex. 32, App. B.)

(c) The DEIS combined the results of its temperature models in an unreliable manner. Finally, the use in the DEIS of different data to calibrate the reservoir and stream temperature models appears to have produced unreliable results. For its analysis of temperatures during "normal" water years, the DEIS uses 1989 data to predict the temperature of Camanche Dam releases, but uses 1975 data to predict downstream temperature impacts of those releases. The problem with this methodology is that actual releases from Camanche in 1975 (over 800 cfs and as high as 1100 cfs during March through November) were far greater than actual releases in 1989 (less than 330 cfs during March through November). The unusually high releases in 1975, which would be expected to result in lower temperatures downstream, appear to be influencing the results of the DEIS stream temperature analysis. When the simulations in the DEIS indicate that a minimum pool requirement in Camanche of 180 ft. msl or 210 ft. msl would provide temperatures below stressful levels for rearing as far downstream as the confluence with the Cosumnes

10-124

10-124 The CE-QUAL-W2 model produced predictions of the Camanche release temperature for different operation scenarios based on the only two years when enough reservoir limnological data was available for this analysis, 1988 and 1989. For the analysis of the Lower Mokelumne River temperatures, staff took these release temperatures and used various combinations of actual meteorological and hydrological data from several years to predict stream temperatures at various locations and dates of hypothetical hot/dry and normal conditions. This allowed us to evaluate the effect of various reservoir operation modes on downstream temperatures during extreme and normal conditions.

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River in most years, that is more likely to be attributable to the influence of the unusually high flows in 1975 than to the minimum pool alternatives.

This hypothesis is confirmed by EBMUD's temperature analysis, which shows that even with adequate Camanche release temperatures, Staff's proposed flow below Woodbridge Dam would result in lethally high temperatures in May and June. (NRH, EBMUD Ex. 32, Table D-2.) Under either minimum pool requirement, Staff's flow recommendations would result in temperatures that would be far higher below Woodbridge Dam than are shown in the DEIS.

10-125

10-125 See Section 4 of the FEIS and Appendix C for revised temperature analysis.

3. The Temperature Analysis in the DEIS Is Internally Inconsistent and Inconsistent With the Hydrologic Analysis.

No attempt is made in the DEIS to validate the assumption that the recommended minimum pool requirement would in fact produce the expected results under the actual operating conditions resulting from the other parts of Staff's recommendation. In fact, the temperature evaluation in the DEIS is both internally inconsistent and inconsistent with meeting Staff's minimum flow recommendations. In neither case, does the DEIS consider the effects of a drawdown of Pardee Reservoir on the efficacy of a Camanche minimum pool elevation requirement.

10-126

10-126 The FEIS contains results of reservoir temperature modeling for constant elevations ranging from 170 to 210 feet for Camanche releases in both dry and normal years. In addition, Pardee reservoir has been modeled to determine the effect on Pardee water surface elevations of releasing sufficient water to maintain various constant elevations in Camanche reservoir.

To illustrate, because of the extremely low runoff since the Fall of 1986, very little water was released from Pardee in 1988, leading to the unprecedented low levels in Camanche Reservoir and

10-127

10-127 The FEIS demonstrates through Pardee reservoir modeling that if Camanche is maintained at a constant elevation, Pardee reservoir would be drawn down to approximately 505 ft (99 TAF) on August 28 and 488 ft (78 TAF) on October 27 to maintain a constant Camanche Reservoir elevation of 190 feet. With corresponding depths of approximately 255 and 238 ft above the lower outlet at Pardee Dam, releases should not be much, if any, warmer than assumed in the modeling.

very high observed Camanche release temperatures. However, to model the minimum pool alternatives, the DEIS simply assumes that Camanche Reservoir is at an elevation of 210 ft. msl or that a continuous release of 250 cfs is maintained from Pardee Reservoir. In actual practice, meeting either requirement would cause Pardee Reservoir to be drawn down to very low levels. Under those conditions, flows from Pardee Reservoir to Camanche Reservoir would be much warmer than is assumed in the DEIS temperature analyses. The operating assumptions in the DEIS temperature analyses cannot all be reconciled.

10-127
(cont.)

The same deficiency is apparent when the DEIS temperature analysis of minimum pool alternatives is considered over a number of years, in conjunction with other requirements that Staff and DFG would impose on the Project. While the DEIS temperature modeling assumes that cold water from Pardee Reservoir is used to maintain a sufficient volume of cold water in Camanche to hold down temperatures in downstream reaches, this is impossible when the water in Pardee Reservoir has already been drawn down to meet minimum flow and minimum pool elevation requirements. The DEIS, however, fails to analyze the minimum pool alternatives to determine whether the purported benefits can be achieved under actual operating conditions.

10-128

10-128 This is a valid comment. The water budget model has no temperature component. It preserves mass balance by reducing outflows or depleting reservoir storages as required (and as dictated by the prioritized operating constraints described in Appendix B). Simulations conducted for the DEIS and also for the FEIS, show that under some of the flow alternatives, Pardee and Camanche Reservoirs will be severely drawn down, if not entirely depleted.

4. The DEIS Temperature Analysis Misrepresents the LMRP.

The DEIS interprets the LMRP to call for the maintenance of a minimum pool elevation of approximately 142 ft. msl in Camanche

10-129

10-129 Staff agrees with this comment; the FEIS presents a corrected interpretation of EBMUD's LMRP proposals.

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Reservoir. (DEIS, p. 4-37.) The DEIS concludes that a 142 ft. minimum pool elevation would have minimal effects on downstream temperatures. (Id., p. 4-38.)

10-129
(cont.)

The DEIS misconstrues the LMRMP's proposal. The LMRMP is based on operation of both Camanche Reservoir and Pardee Reservoir, based on monitoring results and field observations, so as to maintain cool releases to the MRFF and the lower Mokelumne River. The approach in the LMRMP, which is based on successful operational experience during 1990, 1991, and 1992, is designed to use releases of cool water from the hypolimnion of Pardee Reservoir to maintain a hypolimnion in Camanche Reservoir of at least 28 TAF through the end of October and thereby to prevent destratification (or turnover) of Camanche Reservoir before mid-November. (MRH, EBMUD Ex. 32, p. 5-6.)

10-130

10-130 This explanation has been incorporated into the FEIS.

The LMRMP thus envisions maintenance of a hypolimnion in Camanche with a minimum volume of 28 TAF, not total reservoir volume of 28 TAF, which the DEIS equates to a minimum elevation of 142 ft. Camanche elevations would be expected to be substantially higher than 142 feet under the LMRMP in order to maintain the desired hypolimnion volume in the reservoir.²⁹ It bears repeating, though, that the elevation of the reservoir is less important than the maintenance of a sufficient hypolimnion to prevent early turnover.

10-131

10-131 See previous two responses.

²⁹ In 1991 and 1992, when the District employed the hypolimnion preservation approach contained in the LMRMP to preserve the water quality of Camanche releases, the impact of that approach was to keep the elevation of the reservoir between 170 and 180 feet msl during May through October.

Moreover, unlike the DEIS, the LMRMP recognizes that Pardee releases will be ineffective to maintain stratification in Camanche if Pardee Reservoir is drawn down too far. If Pardee Reservoir destratifies (which is expected when the storage volume in the reservoir falls below 100 TAF), Pardee releases will be too warm to maintain the hypolimnion in Camanche. (MRM, EBMUD Ex. 32, p. 5-7.) As noted earlier, the DEIS does not evaluate the combined operation of the two reservoirs, even though cold water from Pardee Reservoir is critical to its recommended minimum pool elevation requirement. Under the Staff recommendation, storage volume in Pardee Reservoir would be drawn down below 100 TAF during critical periods of the year in over 20% of the water years over the 70-year hydrologic record (see Exhibit 5), rendering it infeasible to rely on Pardee Reservoir releases to maintain a hypolimnion in Camanche Reservoir and thereby to control downstream temperatures.

The LMRMP also differs from the DEIS in its recognition that there is no point in maintaining minimum pool elevations in Camanche Reservoir year-round, when the objective is to prevent early destratification in the summer.²⁷ Modeling results indicate that releases from Pardee Reservoir are not necessary from November through April because Camanche Reservoir would be uniformly cold. (MRM, EBMUD Ex. 32, p. 5-6.) The LMRMP is thus based on using water from the Pardee hypolimnion to preserve and

²⁷ Staff has refused to supply the data underlying its recommendation of a year-round minimum pool in Camanche for temperature control.

10-132

10-132 The water budget model can predict how often Pardee is drawn down below any given level in our 25 year simulation period for any flow alternative investigated. We agree that the lack of linkage between the water budget and reservoir models may introduce some errors in our predictions, but these uncertainties are acceptable for the purposes of this assessment.

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10-133 Staff agrees. The FEIS contains time-variable minimum pool elevations in staff's alternative.

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replenish the hypolimnion in Camanche Reservoir in May through October, thereby preserving reservoir stratification through mid-November. (Id.)

10-133
(cont.)

The approach in the LMRMP was successful in maintaining stratification of Camanche Reservoir in 1990 and 1991, even though overall water levels in the reservoir were similar to those in 1987, when early turnover caused a loss of fingerlings in the MRFF. Computer simulations indicate that, over the 70-year hydrologic record, the District's approach would substantially meet the temperature criterion in the river in all but three years. (MRH, ERMUD Ex. 32, p. 5-7.) In those years, however, neither the 180 ft. minimum pool elevation recommended by Staff, nor the 210 ft. minimum pool elevation recommended by DFG would satisfy that criterion either.

10-134

10-134 These results have been incorporated into the FEIS.

5. Other Errors in the DEIS Temperature Analysis

(a) Camanche Reservoir temperatures. The DEIS describes Camanche Reservoir as typically isothermal at temperatures higher than 18°C during the Fall. (DEIS, p. 3-25.) This does not reflect typical temperature conditions. In fact, releases from Camanche Dam have never exceeded 18°C during the past four years, despite the existence of drought conditions. The reservoir typically destratifies at a temperature of 15°C or less.

10-135

10-135 We agree that destratification at temperatures above 64.4°F (18°C) is probably unusual, but it did happen in 1988. Hydrolab data show temperatures above 68°F (20°C) throughout the water column on September 20 and 24, 1988; above 64.4°F (18°C) on August 14 and 28 and October 9; and above 66.2°F (19°C) on July 31.

(b) Temperature analyses for rearing. The DEIS temperature simulation is used to model temperatures below Woodbridge Dam down to the Cosumnes River confluence, 40 miles downstream of

10-136

10-136 This section has been re-written and the statement in question no longer exists.

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Camanche Dam, areas which are stated to be "representative of downstream mid-summer rearing areas from May to August." (DEIS, p. 4-28.) Data documented in the LMRMP indicate, however, that the only salmon entering this reach during this period are migrating out of the river and that, on average, 95% of them have left by the end of June. (MRH, EBMUD Ex. 32, App. A.) The temperature data for this reach are therefore of doubtful significance.

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(cont.)

Also, for the reasons discussed in Section IV.A, the DEIS is in error in assessing the suitability of stream temperatures for the rearing of juveniles based on temperatures at the Bruella Road site.

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10-137 Temperatures at the Bruella Road site are clearly relevant to rearing of juvenile salmonids, although they may not be sufficient for characterizing the entire rearing area. The FEIS has an expanded analysis of temperatures in the Lower Mokelumne from Camanche Dam to Lake Lodi (Section 3.2.4).

C. The Analysis in the DEIS of Water Balance and Hydrologic Modeling Issues Is Severely Flawed.

The DEIS relies on a water budget model to simulate the inflows to and diversions from the Mokelumne River and thereby to estimate the water available for the District, for fishery protection and for other users of Mokelumne River water under the alternatives considered. (DEIS, p. 4-1.) The District's ability to comment on the water budget modeling that forms the basis of the DEIS analysis has been limited by Staff's refusal to identify key data used to run the model, the results obtained by the model or statistical measures of the reliability of those results (see n. 4, above). As a consequence, the District is unable to point out potential errors in areas such as:

10-138

10-138 See response to comment No. 10-9.

- the reservoir storage levels determined by the model;

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- the reservoir releases determined by the model to meet fishery flows required under each alternative and other release requirements;
- the annual "need for water" resulting from the model's simulation of each alternative;
- the accuracy of the channel loss function used in the model; or
- the estimate of runoff computed by the model (DEIS Table B-2).

10-139

10-139 Your comment is noted, but we disagree.

Although the absence of this critical information necessarily limits the scope and specificity of the District's comments on the DEIS, the District has identified a number of serious problems with the DEIS's hydrologic analysis, which are discussed below. The District has also determined, using its own hydrologic model, which it developed specifically for use in analyzing conditions on the Mokelumne River, that the DEIS does not accurately portray the results of the different alternatives considered.

1. Errors and Ambiguities in the DEIS Water Budget Analysis.

(a) The DEIS water balance analysis yields anomalous estimates of runoff. As the DEIS recognizes (DEIS, p. B-3) the key unknown in analyzing the hydrologic water balance for the Project is the determination of runoff. The DEIS presents a graphic depiction of the runoff computed by the water balance model in DEIS Figure B-2. It is not clear that the runoff estimates computed by the model were compared with historical runoff data to verify the reliability of this critical component

10-140

10-140 Your comment is noted. Appendix B of the FEIS describes the nature and magnitude of the unknown "runoff" term (to avoid further confusion, the term has been renamed "net local inflow" in the FEIS). The text clearly differentiates between this term and the Mokelumne River discharge measured at various gaging stations. Since the net local inflow term is unknown, there are no "historical" runoff data to compare it with. Appendix B of the FEIS includes a comparison between the staff's computation of the magnitude of this term and EBMUD's. These terms are highly correlated.

of the model. In fact, such a comparison reveals significant problems.

DEIS Figure B-2 indicates that the water balance model used in the DEIS computes higher runoff in 1978 and 1989 than in 1983 or 1986. This is contradicted by actual runoff measurements, as shown in Table IV.C.1.

TABLE IV.C.1 MOKELUMNE RIVER TRUE NATURAL FLOW PROJECTIONS; SELECTED YEARS	
Year	True Natural Flow (TAF)
1978	959
1983	1,820
1986	1,232
1989	563
Source: MRH, EBMUD Ex. 34, App. A.	

The anomalous estimates of runoff produced by the water balance model used in the DEIS render the model's derivation of runoff highly suspect. Analyses based on the runoff derived by the model are also necessarily questionable.

Although Staff's refusal to provide the data depicted in DEIS Figure B-2 precludes EBMUD from quantifying or identifying the causes of the apparent problems in the model's calculation of runoff, we note that the model assumes that the Mokelumne River in the vicinity of the Project is a "gaining" reach, in which groundwater inflows are significant. This assumption is based on

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(cont.)

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10-141 This comparison is not correct. The runoff term shown in Figure B-2 of the DEIS is a local runoff term used to represent additional flow contributions below the Mokelumne Hill gaging station. An expanded discussion of this local runoff term has been added to Appendix B of the FEIS. The data tabulated here are the stream flow directly entering Pardee Reservoir. It appears to us that Table IV.C.1 should be compared to DEIS Figure 3.2.1, in which case there is no contradiction.

10-142 Staff agrees that the Lower Mokelumne River below Camanche Dam is a "losing" river and have accounted for this in our analyses. However, several independent pieces of evidence indicate that the river above Camanche Dam has significant influxes from ground water. This evidence was presented in the FEIS in Sections 3.2 and Appendix B. Staff disagrees with EBMUD's assertion that the data presented in Figure 16 of Exhibit No. 23 from EBMUD's testimony to the State Board's Mokelumne River Hearings conclusively demonstrates that carriage losses have been steadily increasing since 1942 and, by implication, will continue to do so.

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studies that are more than fifty years old and should be verified. Some portion of the error in the estimation of runoff may be due to an overestimation of gaining. In fact, the District's own studies show that the Mokelumne River is a "losing" river with seepage losses having increased steadily since 1942. See Exhibit 6; MRH, Ex. 24, Figs. 16, 17.

10-142
(cont.)

(b) The DEIS water balance analysis does not include all downstream release obligations. A review of Tables B-2 through B-5 of the DEIS (which were distributed on November 30, 1992) indicates that, in calculating Camanche release requirements, the DEIS hydrologic analysis does not provide releases for riparian rights holders or senior appropriators. (MRH, EBMUD Ex. 23, pp. 25-32.) The DEIS would therefore tend to understate the releases from Camanche Dam required to implement each alternative, to overstate reservoir storage levels, and to understate the EBMUD's need for additional water supplies.

10-143

10-143 As staff explained at the public meeting on the DEIS on November 30, 1993, and in the FEIS, riparian rights holders and senior appropriators are accounted for by the method by which staff estimated carriage losses. See Appendix B of the FEIS for further explanation.

(c) The DEIS water balance analysis uses inconsistent carriage loss assumptions. Some of the values used in DEIS Tables B-2 through B-5 to determine Camanche releases required to account for carriage losses appear to be inconsistent with Staff's carriage loss function, as shown in Figure 3.2-6 of the DEIS. For example, the DEIS calculates a required Camanche release of 738.1 cfs for May during wet years under the DFG proposal, and a corresponding carriage loss of 89.4 cfs. (DEIS Table CAMCFG2.XLS.) However, the curve in DEIS Figure 3.2-6 would yield a carriage loss of over 100 cfs for a release of this

10-144

10-144 One data point was plotted incorrectly in Figure 3.2-6 of the DEIS. This error has been corrected in the FEIS. However, the plotting error did not affect the accounting of carriage losses in the water balances in the DEIS; the correct function was used in Tables B-2 to B-5 to determine Camanche release requirements. As can be seen in the revised Figure 3.2-6, our carriage loss function is very similar to EBMUD's.

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size. The inconsistent treatment of carriage losses presents another potential source of error in the DEIS water balance analysis, which would tend to underestimate the impact of the Staff and DFG alternatives on the District's water supply system.

(d) The DEIS water balance analysis may understate releases under the no-action alternative. The DEIS analysis of the no-action alternative shows total required Camanche releases of 91 TAF in dry years. (DEIS Table CAMNOACT.XLS.) However, the minimum historic Camanche releases have never been this low. Although the District does not have sufficient information to identify the cause of this error, it may be due to the DEIS's failure to consider releases required for riparian and senior appropriators.

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10-145 Staff has corrected this problem in the FEIS.

2. The DEIS Uses Inappropriate and Unworkable Criteria To Distinguish Between Dry, Normal and Wet Water Years.

The DEIS distinguishes between dry, normal and wet years based on observed inflows to Pardee Reservoir at the USGS stream gauge at Mokelumne Hill. (DIES, p. 2-13.) The DEIS defines a normal water year as an year in which inflow is between 500 cfs and 1100 cfs (approximately 50% and 110% of average inflows, respectively). (Id.) The hydrologic model establishes the water year on October 1, which then governs fish flow requirements for the next twelve months.

10-146

10-146 Staff has revised the definition of water year type in the FEIS in response to comments. See Section 2.2.1 and subsequent analyses.

(a) Observed inflows to Pardee Reservoir do not reflect natural runoff. The DEIS describes its method of classifying

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10-147 See previous response.

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water years as "the cleanest, most direct approach to determining flow requirements." (DEIS, p. 2-13.) The problem, however, is that observed inflows to Pardee Reservoir do not represent natural runoff in the Mokelumne River basin. Inflow to Pardee Reservoir reflects regulated flows controlled by upstream diversions and is governed by court decrees establishing priorities among water rights holders. As a result of those decrees, variations in natural runoff are "smoothed," resulting in similar inflows to Pardee over a wide range of runoff conditions.

Using these regulated flows to determine water year type has the effect of divorcing the balancing of water uses from natural conditions. This is apparent from Table B-1 of the DEIS, which classifies 1989 and 1990 as normal water years, even though the DEIS acknowledges that drought conditions prevailed throughout this period. There is no reason why the District's customers should be deprived of water because of changes in regulated flows, rather than natural conditions. Moreover, this methodology effectively requires EBMUD to carry the full burden of fishery protection flows on the Mokelumne River, shielding upstream diverters from any impact.^{12/}

(b) **Classification of water years in practice.** Although Staff has indicated that the hydrologic model in the DEIS

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(cont.)

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10-148 See previous two responses.

^{12/} The failure of the DEIS to recognize this result could well be a direct product of its refusal to evaluate the cumulative impacts of the interactions between the alternatives considered for the Project and those of other projects and actions affecting the target resources. See Section II(B), above.

establishes the water year type of October 1 for the following twelve months, the DEIS does not explain the basis on which the prediction would be made. While a retrospective modeling exercise can, with the benefit of hindsight, endow Project operators with perfect foresight, the DEIS does not explain how the District would be expected in practice to predict the type of water year to expect, and therefore the applicable flow requirements. In fact, it cannot be predicted on October 1 what precipitation and runoff will occur during the following twelve months.

The consequences of an incorrect prediction are enormous. If the District were to project a wet year on October 1, but the water year in fact turned out to be dry, water in storage could be seriously depleted, affecting both EBMUD's customers and fish releases later in the year and in subsequent years. The DEIS also makes no allowance for mid-year flow adjustments, based on differences between forecasted and actual Pardee inflow. Nor does it allow for the fact that a normal or wet year might follow several years of drought, with reservoir storage levels substantially depleted.

In addition, the DEIS does not indicate whether water year type is based on annual amounts, monthly flows or daily flows. The difference could be significant. For example, if the water year is determined on daily flows and the inflow was measured as 1,000 cfs yesterday, and 300 cfs today, is the release today dry or normal? Is the release tomorrow dry or normal? If the water

10-148
(cont.)

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year is determined on the basis of annual amounts, whose projection will be used (the State does not forecast project inflow, only project runoff)?

(c) The LMRMP classification approach. The LMRMP takes these practical considerations into account expressly. Fish releases are determined in April, based on the April 1 snow survey forecast of unimpaired runoff, which forecasts runoff for the remainder of the water year (through September). Based on this runoff forecast, EBMUD projects end-of-October storage in Pardee and Camanche reservoirs. If end-of-October storage is forecast to be full, wet/normal fish releases are made beginning in May. If Pardee and Camanche reservoirs are projected to be less than full, but to have more than 260 TAF in storage, dry year releases are made.^{14/} If the end-of-October storage projected for Pardee and Camanche is 260 TAF or less, critically dry year fish releases are made. Fish releases for November through April can be adjusted in November to the extent actual end-of-October storage differs from the forecast made the previous April.

This approach establishes fish releases on the basis of the most directly relevant information: the impact of runoff on the level of storage in Pardee and Camanche Reservoirs, which determines the amount of water available for all purposes during the water year -- in effect, allowing the fishery to benefit from

^{14/} The 260 TAF storage threshold is lowered (by up to 70 TAF), depending upon storage conditions in reservoirs above Pardee controlled by Pacific Gas & Electric Company.

10-149

10-149 Your comment is noted; staff believes that this alternative has been described accurately in the DEIS and the FEIS.

the District's storage. In a recent decision regarding the Sacramento-San Joaquin Delta, the SWRCB expressly recognized that carry-over storage should be taken into account in water year classification.¹⁴ DFG has also recognized reservoir storage as a valid consideration in water year classification, basing minimum fish flows in critically dry years under the 1961 agreement with EBMUD -- which the FERC license for the Lower Mokelumne River Project expressly incorporated -- on reservoir storage levels.

Under the LMRMP, fish releases are based on information that is available to Project operators and which represents the most current available information on hydrologic conditions (including the affect of antecedent hydrology on storage levels). This approach allows flexibility to best manage the water available in any year for fishery protection and municipal water supply purposes.

3. The DEIS Water Balance Analysis Distorts the Conclusion of the DEIS.

In order to test the accuracy of the DEIS water balance analysis, and therefore the validity of the conclusions that the DEIS draws from that analysis, the District modeled the DFG, Staff and LMRMP alternatives using its Operations Simulation Model ("EBMUDSIM"). EBMUDSIM is a water budget model developed

¹⁴ Decision Establishing Terms and Conditions for Interim Protection of Public Trust Uses, Draft Water Rights Decision 1630, p. 28, Table II (Nov. 17, 1992).

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10-150 The referenced decision was withdrawn by the state as of April 1993. The value of accounting for carry-over storage in water year classification has been discussed fully in the FEIS.

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10-151 The Commission staff did not have full access to EBMUDSIM in this proceeding. Therefore, in order to conduct an independent analysis of the benefits and costs of project modifications considered in the DEIS, staff developed our own water balance model. Staff has attempted to model the basin as accurately as possible, based on all available information. Because staff has employed different modeling approaches than those used by EBMUD, the results may differ. Improvements have been made in our model between the DEIS and the FEIS incorporating new information wherever possible. See Appendix B for full modeling details.

by the District to simulate the operation of its water supply system and the Project. Using information on streamflow, system physical characteristics and operating requirements, EBMUDSIM computes resulting reservoir storage levels, diversions and releases.^{22/}

10-151
(cont.)

To perform modeling studies of Staff's preferred alternative, the District had to make several simplifying assumptions to take into account ambiguities in that proposal, some of which are discussed elsewhere in these Comments:

- Because it is unclear how Staff's ramping recommendations would be implemented, the impact of these recommendations is not reflected in the EBMUDSIM study of Staff's proposal.
- Because there is no way of determining in October what type of water year to expect in the following twelve months, fishery release requirements are determined in April, when water year runoff can be accurately projected based on snow survey information, for the following May through April period. For the EBMUDSIM study of Staff's proposal, fishery release requirements are based on projected inflow into Pardee during May through April. This may result in normal or wet year fishery releases in October through April, even though the water year turns out to be dry or critically dry.
- For the same reason, the availability of excess water for experimental attraction flows cannot be determined. The EBMUDSIM study of the Staff proposal assumes that experimental outmigration flows (10 TAF) and attraction flows (20 TAF) are made in years projected as normal or wet, as explained above. As discussed in the preceding paragraph, attraction flows could be made in a year when there turns out to be no excess water.
- Finally, the DEIS does not contain sufficient information to model the "deficit-sharing" provisions of Staff's recommendation. For example, if mean

^{22/} A description and verification of EBMUDSIM may be found at MRH, EBMUD Ex. 34. Further verifications may be found in the Draft EIR/EIS for the District's Updated WSP.

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monthly inflow to Pardee is below 50% for only a portion of the year, would the District be allowed access to Camanche storage below 180 ft. msl? Because of the lack of specificity in this aspect of the Staff proposal, the EBMUDSIM study does not include access to Camanche storage below 180 ft. msl.

The results of the District's analyses demonstrate that the DEIS water balance analysis is unreliable. The DEIS estimates that the LMRMP alternative would provide total releases of 111, 165, 241, and 252 TAF from Camanche Dam in critically dry, dry, normal, and wet water years, respectively. (DEIS, Table EBMUD2.XLS.) The DEIS also concludes that Staff's proposal would increase the District's need for additional water by 95 TAF per year, while the DFC proposal would result in an annual need for an additional 123 TAF, and the LMRMP would produce an annual shortfall of 71 TAF. (DEIS, pp. 4-12, 4-22.) Each of these estimates is incorrect and, moreover, the errors all tend to understate the water provided for fish under the LMRMP and to understate the impact of each of alternatives on the District's water supply system.

(a) Required flows for fisheries. First, by focusing on the flows that are designated as fishery protection flows (p. 2-11), the DEIS does not portray an accurate picture of the water that benefits downstream fish populations. Water is released from Camanche Dam for a variety of purposes other than fishery protection: to fulfill obligations to downstream users, to compensate for channel losses, and for flood control purposes. Even though these releases are not the result of fishery-specific

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10-152 Your comment is noted. Revised estimates are contained in the FEIS.

flow requirements, they nevertheless affect habitat abundance, water temperature, and other conditions for fish populations. As shown in Table IV.C.2, the DEIS underestimates the flows that would be released from Camanche Dam under the LMRMP.

TABLE IV.C.2 CAMANCHE RELEASE REQUIREMENTS UNDER LMRMP		
Water Year Type	Total Releases (TAF)	
	DEIS Estimate	EBMUD Estimate
Critically Dry	111	133
Dry	185	188
Normal	241	271
Wet	252	271
Sources: DEIS Table EBMUD2.XLS; MRH, Ex. 32, Table 5.8.		

The DEIS also understates the total required flows, as well as the minimum fishery-protection flows, provided under the DFG and Staff alternatives. Tables IV.C.3 and IV.C.4 show the Camanche release requirements under the DFG proposal and the Staff recommendation, as estimated by the DEIS and by the District. As these tables illustrate, the DEIS water balance modeling generally understates the required releases. In some cases, the underestimates are substantial.

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10-153 The FEIS has been revised to reflect these comments. One problem in the DEIS was that pulse flows were not accounted for in the Camanche releases shown in Tables B-2 through B-4. One effect of this change will be to make the water supply deficits under the EBMUD alternative more similar to those of staff's recommended alternative.

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10-154 The difference between the DEIS release requirements under CDFG's alternative and EBMUD's estimates can be attributed to two things: (1) CDFG corrected their wet year requirements after the DEIS was released, and (2) EBMUD included pulse flows and ramping rates on pulse flows in their estimates. The FEIS reflects the full consequences of CDFG's alternative. However, these changes do not change staff's finding that the CDFG flow requirements impose unacceptably high costs to EBMUD's water supply system.

TABLE IV.C.3 CAMANCHE RELEASE REQUIREMENTS UNDER DFG PROPOSAL (TAF)				
Water Year Type	Fish Releases		Total Releases	
	DEIS Estimate	EBMUD Estimate	DEIS Estimate	EBMUD Estimate
Dry	98	115	190	258
Normal	207	239	336	347
Wet	256	274	349	375
Sources: DEIS Table CAMCDFG2.XLS, MRH, Ex. 29, Fig. 19.				

TABLE IV.C.4 CAMANCHE RELEASE REQUIREMENTS UNDER FERC STAFF PROPOSAL (TAF)				
Water Year Type	Fish Releases		Total Releases	
	DEIS Estimate	EBMUD Estimate	DEIS Estimate	EBMUD Estimate
Dry	65	55	154	171
Normal	135	153	262	309
Wet	169	186	308	343
Sources: DEIS Table CAMORN12.XLS, Exhibit 7.				

10-154
(cont.)

(b) Water supply deficits. The DEIS water budget analysis also understates the water supply deficiency that the District would suffer under the DFG and Staff fishery protection proposals. Table IV.C.5 shows the annual deficiencies resulting from each of the alternatives considered, as shown in the DEIS and in the District's analysis.

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10-155 The water supply deficits associated with alternative flow requirements have been revised in the FEIS to reflect DEIS comments and new information provided since the DEIS was issued.

TABLE IV.C.5 AVERAGE ANNUAL NEED FOR ADDITIONAL WATER UNDER ALTERNATIVE FISHERY PROTECTION PLANS (IN TAF PER YEAR DURING 3-YEAR DROUGHT SEQUENCE)		
Alternative	DEIS Estimate	EBMUD Estimate
CDFG	123	240
FERC Staff	95	127
LMRMP	71	43

Sources: DEIS Table 5.2.1; Exhibits 5, 8 and 9.

The DEIS overestimates the water supply deficit under the LMRMP and underestimates the deficit under the Staff proposal. As a result, the DEIS substantially understates the incremental need for additional water under the Staff proposal over the LMRMP. If the Staff proposal were implemented instead of the LMRMP, the District would need an additional 84 TAF of water per year (on average) during a three-year drought, not 24 TAF, as the DEIS concludes. (DEIS, p. 5-5).

(c) **Customer Deficiencies.** The DEIS does not analyze the extent to which adoption of the Staff recommendation would impose shortages on EBMUD's customers. The District has used EBMUDSIM to simulate the impact the Staff recommendation would have on EBMUD's ability to meet its customers' projected demands in the year 2020 over the hydrologic record. As shown in Exhibit 5, customers would suffer deficiencies on a regular basis. Rationing would be required almost one-half of the time (32 out of 70 years). Rationing in excess of the maximum achievable

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(cont.)

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10-156 The FEIS does discuss this issue using staff's model (see Section 4.1).

levels would be required in eight years; in six years, rationing would be at levels of 50% or greater.

(d) **Pardee Reservoir Storage.** The DEIS uses its water balance model to simulate the impact of the Staff recommendation on Pardee Reservoir storage over the 1966-1991 period (DEIS, p. 4-20). That portrayal shows that Staff's recommendation would draw down Pardee Reservoir to "dead storage" whenever two dry years occur in succession. EBMUD's analysis reveals -- on the basis of 70 years of hydrologic data -- that the DEIS substantially understates the impact of Staff's proposal on Pardee storage. As shown in Exhibit 5, under Staff's proposal, Pardee Reservoir would be drained several times over the hydrologic record. Moreover, Pardee Reservoir storage would be drawn below 100 TAF on a regular basis, permitting destratification of the reservoir and eliminating it as a source of cold water to maintain a hypolimnion in Camanche Reservoir. (MRH, EBMUD Ex. 32, p. 5-7.)

(e) **Implications.** The failure of the DEIS to portray accurately the releases required under each alternative and the impact of each alternative on EBMUD's need for additional water has three important implications.

- First, because it does not accurately estimate the water that would be released from Camanche Reservoir to satisfy each alternative, the DEIS does not present an accurate assessment of the impact of each alternative on instream fishery resources. For example, by understating the releases under the LMRMP, the DEIS may underestimate the benefits of the LMRMP-required flows on spawning conditions.

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(cont.)

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10-157 Staff's water balance model has been updated in the FEIS in response to numerous comments, including those of EBMUD. However, the comment is comparing model runs with different assumptions, and therefore, it is not valid. One of the biggest differences between EBMUD's simulations and staff's is that inflows to Pardee Reservoir are described differently, especially with respect to the two blocks of unused water that are currently held by the State Board for counties of origin (Amador and Calaveras counties). At this time, it is not clear when or by whom these blocks of water will be used. Currently, the unallocated portion of this 47 TAF of water flows through the river basin. Staff's analysis assumes this water is available as inflow to Pardee Reservoir. Our understanding of EBMUD's modeling is that it removes this water from inflows. Therefore, EBMUD's results are more conservative than ours. There is not necessarily anything wrong with these different modeling approaches, because the models were developed for different purposes. EBMUD's model is intended for long-term water planning. Staff's model is intended to support Commission decisions about the system as it is now.

10-158 The FEIS has been revised to ensure that flow releases from Camanche are accurate. Nevertheless, the DEIS did not underestimate the benefits of LMRMP releases to spawning, because the differences were due mostly to pulse flows and ramping rates on pulse flows.

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- Second, the DEIS severely underestimates the amount of additional water the District would need if either the DFG or Staff alternative were adopted. The District would need 95% more water per year under the DFG alternative and 33% more water per year under the Staff alternative than the DEIS assumes. The Staff proposal would require EBMUD to secure more additional water than the DEIS estimated would be required under the DFG proposal.
- Third, at the most basic level, the DEIS does not accurately portray the balance among competing uses of Mokelumne River water under the District, DFG and Staff alternatives. Under both the DFG and Staff proposals, substantially greater flows are provided for instream resources and the District's customers receive significantly less water from the Project and bear much greater costs to improve conditions for the river's fish populations than the DEIS estimates.

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10-159 These estimates have been revised and improved in the FEIS.

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10-160 During drought conditions there is not enough water to satisfy all users. Increased stream flows in reduced offstream uses.

D. The DEIS Contains Other Significant Flaws.

The limited time available for review, especially in light of ongoing proceedings before the California State Water Resources Board, and FERC Staff's decision not to make available to the District key inputs for and results of the analyses underlying the DEIS have constrained the District's ability to conduct an in-depth review and to identify all of the errors and omissions in the DEIS. Based on the review that has been possible to date under these conditions, the District notes additional problems in the following areas.

1. Water Quality Issues.

The DEIS includes a description of Penn Mine, an abandoned mining operation located outside the Project boundaries next to the Mokelumne River between Pardee and Camanche Reservoirs.

Because the DEIS does not consider directly issues associated with Penn Mine (DEIS, p. 3-10), the District will address only two issues relating to Penn Mine.

First, the DEIS claims that fish kills caused by acid mine drainage, presumably from Penn Mine, occurred in the late 1980's. (DEIS, p. 1-5.) This is incorrect. As the District has previously advised PERC Staff, those fish losses -- which occurred in the MRFF, not in the river -- were not associated with acid mine drainage.^{24/} Moreover, the remedial measures implemented through the cooperative efforts of the Regional WQCB, DFG, and EBMUD have been effective in preventing the losses of fish due to acid mine drainage from Penn Mine in the river and the MRFF since 1979.

Second, the DEIS also refers to heavy metal concentrations as a requirement for downstream habitat. (DEIS, p. 3-22.) The DEIS does not consider bioavailability and does not take into account studies of hatch rates, salmonid growth rates and invertebrate biomass in the Mokelumne River, all of which indicate an absence of acute or chronic toxicity problems. (MRH, EBMUD Ex. 32, p. 3-4.)

^{24/} See, MRH, EBMUD Ex. 32, Executive Summary of Camanche Reservoir Water Quality Study, Brown and Caldwell (submitted to PERC February 1, 1990); Biology and Water Quality of Camanche Reservoir in the 1987-88 Drought as it Relates to the Fish Facility Problems, Alex Horne Associates (submitted to PERC February 1, 1990); Final Report: Camanche Reservoir Water Quality Studies, EVS Consultants, Inc. (submitted to PERC February 1, 1990). All these references were most recently identified in East Bay Municipal Utility District's Eighth Partial Response to the Commission's Second Request for Information, dated September 29, 1992.

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10-161 The claim attributed to the DEIS is misstated. What the DEIS does say is that Bond (1988) makes that claim. The DEIS and the FEIS go on to say that the real cause of the fish kills of the 1980's is uncertain and cite decaying vegetation and organically derived H₂S as possible causes of the fish kills. Staff agrees that there is no conclusive evidence that suggests that acid mine drainage (or the resulting concentrations of heavy metals in Camanche release) was (or was not) the primary factor in the fish kills during the late 1980's. The error in Figure 1.3-1 has been corrected in the FEIS.

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10-162 Staff hesitates to evaluate the impact of contaminants based solely on environmental concentrations and suggested criteria. Therefore, staff will also rely on any biological evidence which suggests the presence or absence of effects of environmental contamination. This evidence includes fish and invertebrate community measures, fish growth and survival, egg viability and hatching rates, etc. This analysis is included in the FEIS.

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2. Non-flow Recommendations

The DEIS describes a number of non-flow measures that are included in Staff's recommendation. EBMUD has had only a limited opportunity to review these recommendations, but offers the following comments.

Both the DEIS and LMRMP recognize that Lake Lodi, Woodbridge Dam and the Woodbridge Irrigation District diversion present formidable obstacles to downstream migration by anadromous fish reared in the Mokelumne. These obstacles are so substantial that the DEIS correctly recognizes that failure to remove or avoid them could substantially diminish the likelihood of achieving any beneficial results from any modification in Project operations. At the same time, the DEIS, the District, as well as DFG, all recognize that Woodbridge Dam and the adjacent diversion are beyond the control of the District (and the Commission as well).

While the DEIS presents several ambitious alternatives for modifications to Lake Lodi, it presents no analysis of the likelihood that the hoped-for benefits will actually be achieved. The LMRMP also presents an analysis of conditions at Lake Lodi. EBMUD believes that it may be best to attempt at first to improve the condition of existing structures, rather than to implement large-scale changes that could be costly, but may be ineffective.

10-163

E. Staff's Recommendation Does Not Provide Greater Fishery Benefits Than the District's LMRMP.

Although limited time and information have prevented EBMUD from identifying all methodological and factual errors in the

10-163 Staff presented several conceptual alternatives for enhancing passage of juvenile salmon past Lake Lodi under the assumption that there are, indeed, high levels of mortality in the lake (but see comments 7-8 and 7-10). The concepts were offered to span a range of options, not to infer that staff recommended them all. The preferred submerged dam option is in the realm of modifying existing structures, is based on successful operation of such skimmer devices elsewhere, and is the least expensive of the three alternatives. More discussion of the likelihood of its providing the desired benefits is included in the FEIS. Other alternatives for both facilitating fish passage and releasing cooler water to the river below the dam may be as effective and less costly. The staff hopes to stimulate some creative thinking by the parties.

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DFIS analyses of the impacts of changes in Project operation on fish populations, the District has nevertheless endeavored to analyze the cumulative impact of any such errors.

The District first evaluated the impact of the no-action (the 1961 DFG/EBMUD agreement), DFG, Staff, and LMRMP alternatives on habitat suitability in the lower Mokelumne River for chinook salmon and steelhead rainbow trout. The Stream Corridor Inventory and Evaluation System ("SCIES"), which is described in Appendix D to the LMRMP (MRH, EBMUD Ex. 32), was used to assess the combined effects of habitat abundance, based on the WUA derived from DFG's IFIM study, and temperature conditions. SCIES represents habitat (WUA) and temperature on a scale from 0 to 100, with 100 representing maximum WUA and optimum temperature conditions.^{12/} The SCIES model runs were based on the EBMUDSIM output for the 70-year hydrologic record (with 1978 run-off replaced by 185 TAF under the District's drought planning sequence). Each alternative was evaluated in dry, normal and wet water years, based on Mokelumne Basin runoff, as explained in the note to Exhibit 1.

The results of the SCIES model runs are shown in Exhibit 1. In dry years, all of the management alternatives provide increased spawning habitat, but reduced habitat for fry and juvenile rearing, compared with historical conditions (the no-

^{12/} The manner in which habitat abundance and temperature values are combined to yield a SCIES score for each life-stage is explained at MRH, EBMUD Ex. 32, App. D, pp. D-3 - D-4, and the accompanying figures and tables.

10-164

10-164 Staff performed a similar analysis which we believe is better than the Stream Corridor Inventory and Evaluation System (SCIES) for describing the amount of habitat that is useful from both a physical and thermal standpoint (see Appendix F).

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action alternative). The Staff proposal provides a greater percentage of optimum spawning habitat than the LMRMP, but lower percentages of fry and juvenile rearing habitat. The difference is substantial in the case of fry rearing habitat. In normal years, the difference in spawning habitat under the Staff and LMRMP alternatives is much more narrow, but the LMRMP provides a substantially greater percentage of optimum fry rearing conditions for chinook salmon, as well as significantly better conditions for outmigration below Woodbridge Dam. In wet years, all alternatives are very similar. Overall for chinook salmon, the LMRMP provides better rearing and outmigration conditions than the Staff proposal and somewhat lower levels of spawning habitat. The LMRMP would provide 83% of optimum spawning conditions across the hydrologic record, which is only 5 percentage points less than the Staff proposal. The Staff alternative's advantage in spawning conditions is about equal to the LMRMP's advantage in outmigration conditions and one-half of the LMRMP's advantage in fry rearing conditions. The combined reaches score for the Staff alternative is one point below that for the no-action alternative and three points below that of the LMRMP alternative.

To evaluate the impact of the different alternatives on the chinook salmon fishery resource, the District used the life-cycle model, which is documented in Appendix E of the LMRMP. The life-cycle model compares the effects of different fishery management alternatives on the number of naturally-produced smolts migrating

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10-165 See response to comment No. 10-164. Staff has included reference to the comparisons of habitats in the FEIS.

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10-166 Staff realizes that production options for the MRFF (fish hatchery) will be important components of any attempt to model chinook salmon in the Lower Mokelumne River with a life-cycle model. However, it was determined that analysis of the management options for the MRFF were not appropriate to the EIS for this proceeding. Staff endorses cooperation among the parties toward establishing a management plan for the hatchery that supplements attempts to improve naturally spawning stocks.

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from the Mokelumne River, the total numbers of smolts and yearlings (including both natural and hatchery production) migrating out of the Delta, the harvest of salmon in the ocean, and the numbers of salmon returning to the Central Valley and to the Mokelumne River to spawn. While this model is not meant to predict future conditions, it is useful for comparing the expected results of different management alternatives.

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(cont.)

The Staff proposal is evaluated two ways in the life-cycle analysis to reflect the ambiguity of the DEIS with respect to the MRFF. The DEIS seems to concur with the development of a master plan for the MRFF, but did not review the plan presented by EBMUD in the LMRMP and does not present specific recommendations for changes in hatchery operations. For that reason, the Staff proposal was evaluated both with existing MRFF operations, to isolate the effects on the chinook resource of the changes in flows and reservoir operations recommended by Staff, and with the MRFF master plan provisions presented in the LMRMP.

The results of the life-cycle analysis are summarized in Exhibit 10. These results show that the changes in flows and reservoir operations recommended by Staff will have virtually no impact on the natural production of chinook smolts in the lower Mokelumne River or on returns of chinook spawners to the Central Valley or to the Mokelumne River; the Staff and no-action alternatives produce virtually identical results if hatchery operations are not modified. With the addition of the LMRMP modifications to the MRFF, the Staff proposal produces results

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10-167 See response to comment No. 10-165.

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that are comparable to LMRMP alternative, with one exception: Regardless of the assumption made regarding hatchery operation, the Staff proposal would produce significantly lower natural chinook smolt production than the LMRMP alternative. The Staff proposal would provide only about 80% as many naturally produced smolts migrating out of the Mokelumne River as the LMRMP alternative.

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(cont.)

These analyses show that the Staff proposal preferred in the DEIS does not provide significantly better habitat for anadromous fish than the LMRMP. Moreover, the changes in flows recommended by Staff would not enhance either the natural production of chinook salmon in the river or returns of spawning salmon. Even when the Staff proposals are combined with the LMRMP's proposed enhancements to the hatchery, the LMRMP alternative is superior in terms of the natural production of chinook salmon in the river -- which Staff has identified as its primary fishery management objective (see n. 4, above). And, the LMRMP alternative achieves these benefits at substantially lower cost to the District's municipal water supply system and without the disastrous impact that the Staff proposal would have on the productive fishery in Pardee Reservoir and on the recreational resources that depend on that fishery.

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10-168 See response to comment No. 10-165.

F. The DEIS Seriously Understates the Impacts of the Staff and DFG Proposals on the District's Water Supply System.

In attempting to assess the impacts that each alternative would have on the District's water supply system, the DEIS is hampered by a lack of familiarity with and understanding of water supply issues. The DEIS correctly finds that the DFG proposal would place such severe constraints on the District's ability to rely on the Project for water storage that the Project "would essentially [be] eliminate[d] ... as a reliable source of water for KEMUD." (DEIS, p. 4-7.) The DEIS fails to recognize, however, that Staff's recommendation would have a similar effect. The DEIS also understates the impact on the District's water supply of the Staff and DFG proposals.

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10-169 See response to comment No. 10-159. Staff disagrees; under our recommended alternative, the Mokelumne could still serve as the major source of water for the East Bay area.

1. The DEIS Reflects an Incomplete Understanding of Water Supply Planning Issues.

Any assessment of the environmental and socio-economic consequences of modifications in the facilities and operations of the Project must take into account the impact of any such modifications on the District's water supply system. Although it is intended to provide such an assessment, the DEIS reveals an incomplete understanding of water supply issues, which leads to basic and critical errors in the analysis of alternatives.

(a) The importance of storage capacity to water supply planning. First, the DEIS assumes incorrectly that the District's first operational priority is to keep its terminal reservoirs as full as possible. (DEIS, p. 2-8.) The District's

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10-170 The statement in the DEIS concerning keeping terminal reservoirs full as possible has been taken out of context. See Appendix B of the FEIS for an updated and expanded explanation of this issue.

terminal reservoirs serve several purposes, including storing local runoff, providing short-term emergency standby capacity and the reregulation of the District's Mokelumne River supply in the Winter and Spring, when Sierra runoff occurs, for use during the high demand period in the Summer months. To meet these objectives, EBMUD draws down the terminal reservoirs during the Summer and early Winter and generally refills them to maximum levels by the following Spring. They are not, however, kept as full as possible throughout the year.

The DEIS also fails to recognize the importance of carry-over storage to the reliable operation of a water supply system in Northern California. In the face of annual and seasonal variation in natural runoff, the storage capacity of Pardee and Camanche Reservoirs is absolutely critical to enabling the District to meet the needs of fish populations and its customers for water year-round and during years of inadequate runoff, when water held over in storage must be used to meet demand.

Carry-over storage is also critical in providing water for the protection of instream natural resources. If all of the water is withdrawn from Pardee Reservoir in a given year, then there may be insufficient water during a subsequent dry period to provide releases for downstream fisheries. Certainly, the District could not release cold water from Pardee Reservoir to maintain the hypolimnion in Camanche Reservoir until November if Pardee has been drained to meet release requirements in previous years.

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(cont.)

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10-171 Additional discussion and detail has been added to reflect the importance of carryover storage. Staff models the three year drought sequence using EBMUD's inflow terms.

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10-172 Your comment is noted.

The DEIS, however, would impede the District's ability to rely upon the storage capacity of these reservoirs. EBMUD would have to withdraw water from storage to comply with Staff's proposal, seriously diminishing its ability to meet its customers' needs during extended dry periods, such as the recent six-year drought or during a severe drought, such as occurred in 1976-1977. The reduction in the storage capacity effectively available to the District is a major adverse impact of the Staff recommendation that is not discussed in the DEIS.

(b) The drought planning sequence. The statement in the DEIS that the District's water supply planning may be unduly conservative reflects a similar lack of appreciation of water supply fundamentals. The District analyzes its need for additional water supplies by examining its ability to meet its estimated demands in a three-year drought sequence (with rationing imposed during the drought period). The DEIS opines that "Planning for water needs on this basis is very conservative and may overestimate EBMUD's need for additional water." (DEIS, p. 4-2.) This statement is flatly wrong -- and dangerous. EBMUD's drought planning sequence is grounded both in experience and in sound water supply planning.

The worst drought event in EBMUD's history was the 1976-1977 drought. In that case, the critically dry year of 1977 (true natural flow of 129 TAF) was followed by a very wet year, which allowed the system to recover rapidly. However, at the end of the 1977 water year, it was not known what precipitation and

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10-173 Certainly, higher fish flow requirements would necessarily imply greater withdrawals from storage. Securing additional supplies for drought situations would mitigate the adverse impacts borne by EBMUD customers.

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10-174 See response to comment No. 10-57.

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10-175 Staff adopted EBMUD's synthetic 3-year drought sequence in the FEIS as our method for providing an upper-bound on water supply deficits.

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runoff would be the next year. EBMUD thus could not allow its storage to become fully depleted at the end of 1977 in anticipation of plentiful water the following year. Had the District done so and, if 1978 had turned out to be a third dry year, the District would quickly have found itself with no water to meet its customers' needs or its downstream obligations (including for fishery resources). Accordingly, EBMUD retained adequate, albeit significantly reduced, "carry-over" storage to preserve water supplies if the drought continued through 1978. (MRH, EBMUD Ex. 34, p. 15.) The operational reality that water in storage cannot be completely used up to meet needs in a drought in the hope that the next water year will be wet must be reflected in water supply planning.^{24/}

10-175
(cont.)

In assessing the adequacy of its water supply system for planning purposes, the District therefore cannot assume that its worst two-year drought on record will be followed by a very wet year, has happened in 1978. To plan for the possibility that the 1976-1977 drought might recur during the 30-year planning horizon, followed by a dry year instead of a very wet year, EBMUD analyzed alternatives by replacing actual 1978 runoff in the EBMUDSIM data base with an average of the runoff during 1976 and 1977 (185 TAF). It was assumed, however, that the severe drought would not continue beyond the third year, so that all accessible

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10-176 See responses to comment No. 10-57 and No. 10-174.

^{24/} Like the EMBUD planning studies, the model studies prepared by the California Department of Water Resources for the SWRCB in the Bay-Delta proceedings do not call for depletion of reservoir storage at the end of the 1976-1977 drought sequence.

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storage could be used to meet requirements during the third year, with none held back as carry-over storage. (Id., pp. 15-16.)

10-176
(cont.)

The postulated event, while remote, serves as a reasonable and socially responsible criterion for planning EBMUD's future supply needs and for evaluating the impact of alternative fishery management programs. Indeed, the assumption that all available storage could be utilized in the third year is probably optimistic since, if a severe three-year drought were to occur, it would be very difficult for the District to utilize all water in storage in the hope that a wet year would follow.

10-177

10-177 In the FEIS, staff uses the EBMUD's hypothetical three-year drought sequence in estimating water supply deficits.

(c) Practical difficulties associated with augmenting water supplies. Finally, the DEIS contains no consideration of the practical difficulties associated with implementing projects to provide additional water supplies. In discussing expanded conservation programs, groundwater banking, withdrawals from the Delta and markets in water rights, the DEIS assumes that there are no obstacles to implementing any of these programs. This is incorrect. For example, EBMUD's extensive existing conservation program may limit the ability to gain the equivalent of new supplies through expanded conservation measures. (See MRH, EBMUD Ex. 29, pp. 30-33.)

10-178

10-178 Staff's discussion of this issue in the FEIS has been augmented by pointing out some of these implementation obstacles (e.g., securing water rights, etc.). See the revised discussion of supplies and demand in the FEIS at Section 3.6 and Appendices D and E.

The failure in the DEIS to take into account the practical difficulties in implementing a new supply alternative is most evident in the case of Delta diversions, discussed in Section IV.F.3 of these Comments.

10-179

10-179 See previous comments regarding the use of the Delta.

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2. The DFG and Staff Alternatives Would Effectively Eliminate the District's Ability To Rely on the Project as a Reliable Source of Water Supply.

The DEIS assumes that the if Staff's recommendation were implemented, the District would need only 24 TAF more water per year than under the LMRMP (using a three-year drought sequence for planning purposes) and that the District could make up the shortfall by purchasing 16 TAF of supplemental Delta supplies at a cost of \$175 per acre-foot. The DEIS estimates the total cost of making up the water supply deficits resulting from the Staff proposal at \$15.1 million in levelized annual costs. (DEIS, p. 4-22.) In the case of the DFG alternative, the DEIS estimates a water supply deficiency of 123 TAF annually under a three-year drought sequence and a total cost of satisfying this deficiency of \$21.2 million. (Id., p. 4-12.) These estimates fail to take into account the true impact of the DFG and Staff alternatives on the District's water supply system.

The DEIS acknowledges correctly that adoption of the DFG alternative would lead to such frequent and severe drawdowns of Pardee Reservoir that the Project "would essentially [be] eliminate[d] ... as a reliable source of water for EBMUD." (DEIS, p. 4-7.) This conclusion is confirmed by the District's analysis, which is discussed in Section II.C of these Comments and which shows even more severe impacts. Under these circumstances, the effect of the DFG alternative cannot be measured simply by examining the cost of making up the deficit that would result if the District were able to continue to rely

10-180

10-180 This position has been fully evaluated in staff's FEIS analyses. We do not agree that impacts to water supplies, particularly under staff's alternative, will be as catastrophic as the comment implies.

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10-181 Your comment is noted, but the DEIS did not recommend the CDFG alternative, as this comment seems to imply.

- 99 -

on the Project's storage capacity. Instead, the assessment must recognize that, if the DFG alternative were implemented, the District would have to secure new sources of water sufficient to replace the storage capacity that it would lose on the Mokelumne.

10-181
(cont.)

Although the Staff recommendation causes impacts that are less severe than the DFG proposal, it, too, would substantially diminish the reliability of the Project as a source of water supplies for the District. The DEIS acknowledges that the Staff recommendation would cause Pardee Reservoir to be drawn down to dead storage whenever two dry water years occur in succession. (DEIS, p. 4-20.) Moreover, EBMUD's modeling studies show that if the Staff's recommendation were implemented, EBMUD would receive no water from the Project's storage capacity during the third year of the three-year drought planning sequence. (See Table IV.F.1.)

10-182

10-182 See response to comment No. 10-74. Staff's analyses presented in the FEIS do not support these conclusions, in part because of differences in modeling assumptions.

TABLE IV.F.1 IMPACT OF STAFF PROPOSAL ON EBMUD DELIVERIES FROM MOKELUMNE AND CUSTOMER SHORTAGES (2020 DEMAND)		
Year of Drought Planning Sequence	Delivery (TAF)	Shortages Above 25% Rationing (TAF)
One (1976)	255	0
Two (1977)	122	125
Three (198 TAF)	0	259
Total Shortage During Drought (TAF)		383
Source: Exhibit 5.		

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Because it would obtain no water from the Project, the District would have to obtain water from other sources sufficient to meet its customers' entire demand (above an assumed rationing level of 25%) of 259 TAF in the third drought year, as well as the 125 TAF shortfall during the second year of the drought. If the Staff proposal were implemented, the Project plainly could not serve the fundamental purpose for which it was built: to provide the storage necessary for the District to continue to meet its customers' needs for water during dry periods.

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10-183 See response to comment No. 10-182.

3. The DEIS Ignores the Practical Obstacles To Reliance on Delta Withdrawals To Meet Water Supply Deficiencies.

Even if the DEIS were correct in its assumption that it would be sufficient for the District to respond to the adoption of the Staff recommendation by securing supplies to make up the deficiency that would result and that the deficiency were limited to 24 TAF per year, it is unrealistic to assume that the District could prudently meet this additional need by withdrawing water from the Delta.

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10-184 See response to comment No. 10-75. EBMUD assumes that water could come from the Delta given the development of Composite Program III.

While withdrawing water from the Delta is theoretically possible and has been studied by the District as an alternative approach (MRH, EBMUD Ex. 26, pp. 36-39), the DEIS ignores the substantial practical difficulties that would be associated with Delta withdrawals. As discussed in Section III.B, above, Federal and State agencies, as well as public interest advocacy groups, have expressed concern regarding the cumulative impacts of Delta

10-185

10-185 See previous comments concerning the use of the Delta.

- 101 -

withdrawals on fish populations in the Delta. (MRH, EBMUD Ex. 30, p. 16-17.) Based on those concerns, witnesses testifying before the SWRCB on behalf of those agencies and groups have opposed increased water exports from the Delta. (Id., pp. 18-20.) Similar concerns were also expressed in response to a 1988 application by the District for a permit under the Federal Clean Water Act to operate its Bixler pumping plant to divert a temporary emergency supply from the Delta. (Id. at 21-23.) In response to these concerns, the permit was limited to one year and was conditioned upon the implementation of a biological monitoring program and a detailed assessment of adverse environmental impacts. Because the diversion facility was not used before the expiration of the permit, the monitoring and assessment programs were not implemented (Id. at 24.)

10-185
(cont.)

In addition, water from the Delta is of substantially lower quality than water from the Mokelumne River. Federal and State regulations may preclude available options for treating water withdrawn from the Delta. As a consequence, the SWRCB has stated, "It is clear that water utilities charged with protecting the public health through treating drinking water from the Delta will face serious problems in meeting anticipated state and federal regulations." (MRH, EBMUD Ex. 31, App. A-2, p. v.) The SWRCB also discussed application of this general principle to EBMUD as follows:

EBMUD has a duty to ensure the quality of its water supply.... Prudence dictates that a public water supplier should minimize treatment uncertainties by

10-186

10-186 See response to comment No. 10-69 and other comments about the viability of using Delta water.

- 102 -

seeking water from the best available source and as removed from the potential for degradation as possible.

(MRH, EDMUD Ex. 31, p. 4.)

In deciding how to meet the water supply deficiency that would result under Staff's proposal, the District would have to expect that a proposal to divert water supplies from the Delta would face substantial opposition on environmental and water quality grounds. In fact, the opposition would likely be greater than that associated with its 1988 proposal to use the Bixler pumping plant on an emergency basis, because: (1) the District would be relying on Delta supplies to supplement its Mokelumne supplies on a regular basis, not for a single year under emergency conditions; (2) concerns about the condition of Delta fisheries have become more acute since 1988; and (3) EPA now considers drinking water quality to be among the most significant environmental issues facing the Nation, with the consequence that regulations governing drinking water quality are expected to become more restrictive. An attempt to obtain approval for Delta diversions would also run up against the policy embodied in the California Safe Drinking Water and Toxic Enforcement Act of 1986, which was adopted by the voters of California in order to further their declared right "[t]o protect themselves and the water they drink against chemicals that cause cancer, birth defects, or other reproductive harm." (MRH, EDMUD Ex. 31, p. 19.)

In these circumstances, the District could not prudently plan to rely on Delta diversions as a source of supplemental supply to make up the water deficits that would result under the

10-187

10-187 There are a number of issues in this comment that have been raised previously. The bottom line might be that Delta water can in fact be treated cost-effectively to meet drinking water standards (although maybe not for taste and odors). See comment No. 10-72.

10-188

10-188 See response to comment No. 10-186 and others on availability of the Delta.

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Staff plan even if the resulting contaminant levels would comply with current requirements. In analyzing the use of Delta diversions as a source of supplemental water supplies, ERMUD concluded that, "Unknown future restrictions on timing and rate of use of Delta water may make its use unreliable, especially in a drought." (MRH, ERMUD Ex. 26, Fig. 22.) The basis for this concern was explained as follows:

Even if an ERMUD Delta Diversion, for instance, were initially approved and a facility constructed, there is no assurance that ongoing concerns for the Delta would not prohibit ERMUD from realizing this yield at some unknown future time. This is especially true since ERMUD would need the yield during a severe drought, precisely when other users would most need Delta water and when the resources of the Delta would be most stressed. There is, therefore, serious question that a Delta supply source would meet the District's need for water.

(Id., p. 56.) Prudent water supply planning must account for these considerations -- all of which are ignored in the DEIS.

The assumption in the DEIS that additional Delta diversions will be an available, reliable source of water supply is unsupported by any evidence or analysis and, moreover, is flatly inconsistent with the prescriptions of the SWRCB (quoted above) and other State and Federal agencies concerned with water quality and the Delta environment. The District suggests that it is inappropriate for a Federal agency charged with addressing hydropower issues -- not drinking water safety -- effectively to override a State agency's determination regarding appropriate considerations and tolerable levels of risk in selecting sources of drinking water supplies.

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(cont.)

10-189

10-189 See previous Delta comments.

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4. The DEIS Understates the Cost of Diverting Water From the Delta.

The DEIS estimates the cost that the unit water cost of obtaining supplemental water supplies from the Delta as \$965 per acre foot. (DEIS, p. E-10.) However, in assessing the water supply impacts of the Staff alternative, the DEIS assumes that the District could obtain supplemental water supplies from the Delta at a cost of \$175 per acre-foot -- less than one-fifth of the estimated cost of developing a Delta supply source. (DEIS, p. 4-22.) Had the DEIS used the estimated cost of developing a Delta supply source, rather than this assumption, the cost impact of the Staff alternative would have been assumed to be over \$56 million per year, on a levelized basis (DEIS, p. E-10) -- almost four times greater than was in fact assumed (id., p. 4-22).^{20/}

The \$175/acre-foot cost assumption used in the DEIS's assessment of the cost of the Staff alternative is apparently based on an allocation of emergency supplies by the State Emergency Drought Water Bank ("SEDWB") at this price some time after 1989. (DEIS, p. 4-4.) The DEIS identifies no basis, however, for presuming that EBMUD would be able to secure Delta supplies at a cost of \$175 per acre-foot in the future. In fact, this assumption is faulty for several reasons.

^{20/} The DEIS estimate of \$56 million as the levelized annual cost of developing a Delta supply source was based on the District's estimate of \$374 million as the NPV of the cost of a Delta supply. EBMUD has updated that estimate in its Draft EIR/EIS. The latest estimate of the NPV of the cost of a Delta supply is \$470 million. (Draft EIR/EIS, vol. six, P. F2-11.)

10-190

10-190 This comment points out that there are discrepancies regarding the cost of securing Delta supplies. Testimony refuting the EBMUD's estimates of costs was presented in the State Board's water rights hearing and both sides of the issue were considered by staff in preparation of the FEIS. Options available to EBMUD are discussed in the FEIS (Section 3.6 and appendices).

10-191

10-191 The availability of water through the State Emergency Water Bank may not be available to EBMUD. As pointed out by the CCSF (comment No. 9-19), EBMUD has not participated fully in this program.

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First, if the District were forced, as a result of the adoption of the Staff recommendation, to rely on Delta diversions for a significant portion of its water supply during dry periods, it could not, consistent with its statutory responsibility to provide reliable water supplies, simply hope that emergency allocations would be available when the need arises. Especially in light of the environmental and water quality concerns associated with the use of Delta water, the District would have to make advance plans to secure access to supplemental supplies. The cost of obtaining those supplies would necessarily reflect the fact that the District would take Delta water during dry periods, when demands on Delta water supplies and environmental concerns with Delta diversions are both greatest. Indeed, it would be inconsistent with the purpose for which the SEDWS was created for a water utility to rely on SEDWS allocations as part of a plan to provide reliable service. The SEDWS is intended to meet unanticipated needs, resulting from unforeseen and unavoidable circumstances, not to take the place of prudent supply planning.

Second, the cost of obtaining a water allocation from the SEDWS, even if available, is only a small part of the cost of using Delta supplies. If it were to plan to rely on Delta diversions whenever customer demands could not be served from other sources, the District would have to modify or replace its Bixler pumping plant, which is designed to serve emergency purposes only, and also to construct and operate treatment

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10-192 See responses to previous two comments.

10-193

10-193 EBMUD may have to upgrade its treatment facilities if it is to meet its statutory responsibilities to provide reliable and safe water supplies.

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facilities necessary to meet applicable regulations. Substantial capital costs would be incurred regardless of the quantity of water taken from the Delta. These costs are many times higher than \$175 per acre-foot. (NRM, EBMUD Ex. 31.)

The DEIS thus bases its finding that the Staff recommendation would not impose undue costs on EBMUD's water supply system on a gross understatement of the cost of obtaining supplemental supplies from the Delta. This error alone invalidates the DEIS's conclusion.

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10-194 Again, there is testimony that refutes EBMUD's claims regarding the Delta. See previous comments.

5. The DEIS Understates the Degree to Which Delta Supplies Would Be Needed Under the Staff Recommendation.

As discussed in Section III.B of these Comments, the DEIS gives unduly short shrift to the consequences of using Delta supplies on the quality of the District's water supplies. Even the DEIS acknowledges, however, that water from the Delta cannot be used if it would constitute more than 10% of gross water consumption. (DEIS, p. 4-12.) The DEIS fails to recognize, however, that meeting the water supply shortfall that would be created by the Staff recommendation would require Delta supplies in excess of this level.

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10-195 See previous responses to Delta comments (e.g., responses to comments No. 10-69 and 10-72).

The DEIS assumes (p. 4-22) that the shortfall in a three-year drought sequence could be met by obtaining 95 TAF per year of additional water supplies, 16 TAF of which would come from the Delta. The first problem with this assumption is that it is impossible to know, in the first year of a drought, whether the

10-196

10-196 Your comment is noted. EBMUD is correct in pointing out that it is impossible to know in advance how long a drought will last. The comment about having 16 TAF available from the Delta every year is correct. See Appendices B and D for explanation of how this is handled in the FEIS.

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drought will continue for a second and third years (or beyond). To implement this approach to making up the water supply deficit caused by the Staff proposal, EBMUD would have to secure 16 TAF of water from the Delta in every year in which it appeared that the District's water supplies would be as limited as they were in 1976. The District's modeling study of the Staff proposal indicates that this would occur, i.e., the annualized customer deficiency would be at least as great as it was in 1976, in 30% of the water years in the hydrologic record. See Exhibit 5. If EBMUD were to have followed Staff's assumed approach over the course of the past 70 years -- the current universe of relevant hydrologic data -- it would have had to pump water from the Delta almost one-third of the time and not, as the DEIS estimate of the cost of Staff's proposal assumes, to meet a single contingency. The costs would therefore be far greater than estimated in the DEIS.

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(cont.)

In fact, it is unlikely that the District would start to take Delta supplies in every year that appeared to be dry. It would be more reasonable to assume that Delta supplies would be used only when supplies from other sources were insufficient, in the second and third years of the drought planning sequence. This, however, would be infeasible. As shown in Table IV.F.1, under the Staff proposal, in the second year of the drought planning sequence the District would need to obtain slightly more than one-half of its total water supplies, 125 TAF, from sources other than the Project. In the third year of the drought, the

10-197

10-197 See response to comment No. 10-196. This comment is moot given updated model runs presented in the FEIS.

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District would receive no water from the Project's storage, and would have to obtain 259 TAF from other sources. As explained in Section IV.F.3, there is substantial doubt that Delta diversions would be permitted during sustained dry periods. Even if water were available from the Delta, using water from the Delta to meet all of the projected shortfall in the second or third drought year (above the supplies available from conservation and groundwater programs) would result in Delta supplies constituting far more than 10% of the District's gross water consumption.²⁴ Under the DEIS's own standard, therefore, Delta water supplies are not a realistic option.

10-197
(cont.)

6. As a Result of These Errors, the DEIS Severely Underestimates the Cost to the District of Making Up the Water Supply Deficiency Under the Staff Proposal.

The preceding discussion makes it clear that the DEIS underestimates the burdens that Staff's recommendation would impose on the District's water supply system. The DEIS:

(1) assumes, without any valid basis, that the District could prudently rely on access to Delta supplies to make up the water supply shortfall resulting from the Staff proposal;

(2) understates the amount of that shortfall both by disregarding fundamental water supply planning principles and by errors in

10-198

10-198 See all previous Delta responses and response to comment No. 10-197.

10-199

10-199 See previous response.

²⁴ Even under the DEIS's flawed water balance analysis, EBMUD would need an additional 106 TAF in the second year of the drought planning sequence and 179 TAF in the third, which would require the use of Delta supplies (if they were available) for more than 10% of gross water consumption in both years.

hydrologic analysis; and (3) relies on an unsupported and seriously understated estimate of the cost of obtaining Delta supplies. The impact of these errors -- separately and in combination -- is enormous. The District has estimated the cost of meeting the shortfall under the Staff proposal, estimated to total 183 TAF during a three-year drought sequence, under two different programs.

In the first program, the District began with the composite program that currently appears to be the most feasible approach to meeting the supply shortfall forecast under the LMRMP.^{21/} To make up the additional shortfall, two additions were assumed. First, the groundwater programs would be significantly expanded. The District would hope to achieve a yield of 168 TAF from groundwater programs at a 30-year gross cost of \$248 million.^{22/} In addition, Pardee Dam would be raised, providing a yield of 150 TAF at a cost of \$206 million. This combined program would yield 386 TAF during the drought, at a 30-year gross cost estimated to total \$753 million. See Exhibit 11.

^{21/} The District estimates that this program would yield 129 TAF at a 30-year gross cost of \$384 million. "Gross cost" includes capital, operations and maintenance and energy costs.

^{22/} The groundwater yield necessary for this program would push the physical limits of the aquifer. The volume of water to be pumped would approach the total groundwater overdraft accumulated over the past 60 years. Such groundwater extractions would likely adversely impact existing wells of current groundwater users. Furthermore, such a large program would allow little participation by San Joaquin County entities, which could make implementing the program extremely difficult.

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10-200 See previous responses regarding the cost of Delta treatment.

10-201

10-201 Your comment is noted. This information has been considered in the FEIS.

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While this program appears to be the least-cost means of meeting the water supply shortfall under the Staff recommendation, it may be unrealistic to expect that the District could receive all of the regulatory approvals necessary to raise Pardee Dam and that it could economically mitigate all environmental impacts that may be identified. Accordingly, EBMUD also evaluated the cost of an alternative program. Under this alternative, instead of raising Pardee Dam, the District would expand its conservation and reclamation programs to increase their yields during the drought to 118 TAF and 88 TAF, respectively. The expanded groundwater program described above would also be implemented. The total 30-year gross cost of obtaining 374 TAF during the three-year drought through this alternative program would be \$1.47 billion. See Exhibit 11.

The cost of making up the District's water supply deficit under the Staff proposal would therefore be between \$753 million and \$1.47 billion in 30-year gross costs. The levelized annual cost would be \$48 million to \$80 million per year for 30 years. This compares with a 30-year gross cost of \$384 million (or a levelized annual cost of \$24 million) to obtain the additional water supplies needed to implement the LMRMP: a difference of \$369 million to \$1.1 billion in 30-year gross costs or \$24 million to \$56 million in levelized annual costs. The cost to the District's water supply system of the Staff proposal would be three to six times greater than is shown in the DEIS (p. 4-22).

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10-202 See previous response.

10-203

10-203 See response to comment No. 10-201.

- 111 -

It is therefore clear that the errors in the DEIS lead to a severe understatement of the cost that the District's water supply system would bear if the Staff recommendation were adopted. Even if the Staff proposal had been shown to be clearly superior from an environmental standpoint -- and the District submits that it has not -- the costs of the proposal would be out of all proportion to the environmental benefits that would be achieved.

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10-204 Your comment is noted. We appreciate EBMUD's input in the FEIS.

V. Conclusion

Although the District has been hampered in its ability to comment fully on the DEIS because it has not been given access to the underlying data, models and analyses, the review it has been able to undertake has identified numerous critical errors in the DEIS. As a consequence of these errors, the DEIS is flawed in at least the following key respects:

- The DEIS presents an overly limited analysis, that fails to assess the impact of changes in Project operation in light of other pending FERC license applications on the Mokelumne River and of other factors affecting anadromous fish on the Mokelumne.
- The DEIS fails to assess the impact of factors other than Project operation on anadromous fish populations in the Mokelumne or to analyze whether, in light of those factors, the Staff or DFG proposals to modify Project operations will achieve the fishery benefits claimed for them.
- The DEIS fails to conduct the analyses necessary to identify the factors limiting the populations of anadromous fish in the Mokelumne and, as a result, endorses a proposal for modified Project operations that is least likely to improve conditions for

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10-205 Your comments have been noted. Staff appreciates the effort EBMUD has put into their comments and the information that has been provided during this proceeding. Staff has tried to address EBMUD's comments and concerns in the FEIS so that benefits and costs of project modification can be accurately represented. The ultimate decision of whether benefits justify costs will be made by the Commission.

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outmigration, which is the most important need of those fish.

- Because of its inadequate analyses, the DEIS endorses an alternative that is least likely to achieve Staff's stated objective: enhancing the natural reproduction of chinook salmon in the Mokelumne River. The DEIS fails to recognize that the LMRMP would achieve this objective at a lower cost, and without the adverse environmental consequences that would be associated with its preferred alternative.
- The DEIS presents an erroneous analysis of the water supply deficiencies that the District will suffer as a result of the increased fishery protection requirements that are evaluated.
- The DEIS underestimates the practical obstacles and the cost of obtaining additional water supplies to meet the deficiencies that would result from implementation of any of the proposals considered.
- The DEIS does not take into account the environmental impacts of water supply projects that the District will be required to undertake to meet the incremental deficiencies resulting from implementation of the Staff or DFG proposals.

10-205
(cont.)

The DEIS's ultimate endorsement of the Staff recommendation fails to balance the modest and speculative benefits that would be achieved under that approach (which are inflated as a result of errors in the analysis) against the monumental and unprecedented cost that adoption of Staff's recommendation would impose on the District (which are severely understated in the DEIS), on the fish populations in Pardee Reservoir and on the fragile Delta ecosystem.

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10-206 See response to comment No. 10-205.

Correction of the errors in the DEIS and a fair consideration of the costs and benefits of the different alternatives demonstrates that the District's LMRMP provides substantial benefits to the anadromous fisheries in the lower

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Mokelumne River at a cost to the District's water supply system that, while high, is far less than the cost of the DFG and Staff alternatives. The District trusts that once the FERC Staff has fully reviewed the LMRMP, it will concur.

Respectfully submitted,

East Bay Municipal Utility District
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(202) 944-4300

Dated: March 1, 1993

*Tabular data, figures, and computer printout attached to this comment letter were considered by staff in preparation of the FEIS. However, they are not reproduced here, because we did not have any additional responses to this extensive set of information. Staff does appreciate the effort extended by EBMUD in these comments.

CERTIFICATE OF SERVICE

I hereby certify that I have this day served the foregoing document upon each person designated on the official service list compiled by the Secretary in this proceeding in accordance with the requirements of the Commission's Rules of Practice and Procedure.

Dated at Washington D.C. this 1st day of March, 1993.

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ORIGINAL

United States Department of the Interior

93-03-3 1-10 FISH AND WILDLIFE SERVICE
Environmental Systems 3 10:21Bureau Field Office
200 Camp Way, Room B-100
Sacramento, California 95825-1000

March 2, 1993

Mr. Lois Gashell, Secretary
Federal Energy Regulatory Commission
825 North Capitol Street N.E.
Washington, D.C. 20006

SUBJECT: DEIS for Proposed Modifications to the Lower Mokelumne River
Project, California. FERC No. 2916-0004

This responds to your October 23, 1992 memorandum regarding the Draft
Environmental Impact Statement (DEIS) for the Proposed Modifications to the
Lower Mokelumne River Project, FERC No. 2916. We have reviewed the document
and offer the following comments for your consideration.

General Comments

The DEIS adequately describes the fish and wildlife resources associated with
the Lower Mokelumne River Project. It summarizes the numerous habitat
deficiencies that are impacting natural anadromous fish populations and
riparian corridor wildlife, and it points out many of the project features and
operations that have contributed to declining resource levels.

The DEIS describes the limitations deemed appropriate by the Federal Energy
Regulatory Commission (FERC) for this Article 15 proceeding. However, from a
best-management perspective, we believe it would be prudent for the FERC
to be cautious in formulating alternatives. We do not want to see the FERC
preclude additional fish and wildlife habitat improvements that may be
available through other regulation or regulatory mechanisms. For example, in
our view, the option to change water supply management for the project, in
point of diversion to maintain multiple and multiple benefits of the water supply is a
feasible and prudent alternative. The FERC should keep this in mind when
formulating their preferred alternative.

We also believe that the best alternative for resolving the numerous water
quality problems associated with Camanche Reservoir is to convey all of the
supply allocation for the Mokelumne River Fish Facilities (MRFF) and a
significant portion of the required river release via pipeline directly from
Pardoe Reservoir to those locations. Over the long-term, this would be far
less costly than undertaking years of technical scientific study, pilot
projects, addition of chemicals to the water supply and many other solutions
proposed to protect fish and wildlife resources. The existing project
conveyance channels and operations basically permit contamination (Pardoe Mine)
of exceptionally high quality water (Pardoe Reservoir) on 1/2 as the fish and
wildlife resources in the MRFF and Lower Mokelumne River under constant threat

11-1

This proceeding does not preclude other third-party agreements that the
licensee may pursue. Rather, the alternatives evaluated in this assessment are
designed to ensure that the licensee meets its obligation under the Federal
Power Act to conserve and protect fish and wildlife resources.

11-2

Your comment is noted. These options were considered in the development
of the FEIS.

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of contamination. This is evidenced by the recent spill from Fern Mine (Enclosure 1). If the Fish and Wildlife Service (Service) were asked today to identify the best source of a hatchery water supply, we would opt for a ground water well system away from Camanche Reservoir, disconnected from the reservoir water table. The next best water supply for the hatchery would be Pardo Reservoir.

11-2
(cont.)

We appreciate the clear separation of flow and nonflow issues in the DEIS. We believe that lack of instream flows, resulting in reduced habitat at crucial life stage periods, has been the most significant problem contributing to long term population declines in the anadromous fishery. We are certain that far greater benefits in terms of increased habitat and populations would be derived from increased flows than from various nonflow proposals. In fact, we are unaware of any restoration programs that have demonstrated that nonflow benefits outweighed flow benefits in terms of habitat and production gains. Besides the direct benefits from increased flows, we would expect eventual development of some form of lower Mokelumne riverine corridor pathway. Thus, additional public trust and recreational benefits would be gained.

11-3

We are in agreement with the FERC that project improvement should focus on the natural fish and wildlife resources of the river. We prefer to see the majority of effort and expenditures placed on river corridor planning and instream measures implementation, in contrast to increasing or expanding the hatchery program.

11-4

The Service agrees with much of the FERC's assessment of habitat conditions described in the DEIS, and the mitigative actions proposed. We are not in agreement with the FERC's assessment of, and recommendation of, fall pulse flows for adult salmon attraction and spring flows for juvenile downstream migration and survival. We believe that the FERC's recommendations for these flows are inadequate.

11-5

We believe there is ample documentation for the Mokelumne River, the Eel River, and other rivers that shows a correlation between natural fall freshets, or planned reservoir pulse releases, and increased adult salmon upstream migration. Because of the unusually complex migration corridors and hazardous conditions in the San Francisco Bay/Sacramento-San Joaquin Delta estuary, we believe substantial attraction flows are necessary to guide adults back to their natal streams.

Juvenile salmon flows should not be based solely on availability of salmonid rearing micro-habitat, or weighted usable area (WUA), as determined by Instream Flow Incremental Methodology (IFIM) analysis. In our opinion, considerably higher flows than those recommended in either the FERC staff alternative or the East Bay Municipal Utility District (EBMUD) alternative are necessary to ensure survival of downstream migrants. We view the juvenile/smolt life stage as the final product of the riverine system. Therefore, every safeguard to improve survival is essential. Without appropriate habitat conditions, much of the prior seasonal efforts to nurture these fish would be rendered useless. In addition to the IFIM results, there are other important factors that must be considered in determining adequate spring outmigration flows, including water quality (e.g., water temperature),

11-6

11-3 This opinion generally agrees with staff's recommendations in the FEIS.

11-4 Your comment is noted, and staff agrees.

11-5 Staff agrees with the importance of fall attraction flows and spring outmigration flows. However, there is little quantitative information to use in setting specific pulse flows in the Lower Mokelumne River. Staff concluded in the DEIS on p. 4-47, and retained in the FEIS, that interim pulse flows in fall should be evaluated with additional studies to determine the timing, duration and magnitude most appropriate. Likewise, staff concluded on p. 4-48 of the DEIS that interim pulse flows in the spring should be evaluated to define the timing, magnitude and duration best suited to maximize outmigrant survival. In addition, the FEIS includes interim attraction flows of at least 300 cfs in normal and wet years and 200 cfs in dry years. Staff thoroughly expects that fall attraction flows and spring outmigrant flows will be set.

11-6 Staff agrees with the FWS comment that the IFIM WUA estimations do not address all of the factors regulating salmon and steelhead. The FEIS includes more information on physical habitat requirements of chinook salmon and steelhead that is not included in usual IFIM studies. Habitat requirements for juveniles of both species have been added to Section 3. Higher instream flows alone may not provide the needed habitat. In recognition of these needs, additional non-flow alternatives have been presented for additional study by the parties, including development of off-stream rearing habitats for chinook salmon in abandoned gravel mining ponds, such as those found useful for chinook salmon in Idaho, and addition of boulders and rubble to steeper gradient reaches for steelhead.

species competition, food production and availability, predation, entrainment into diversions, and favorable conveyance of smolts to and through the Sacramento-San Joaquin River Delta

11-6
(cont.)

The FERC should be aware that the resource agencies, (i.e., California Department of Fish and Game (CDFG) and the Service), are now coordinating fall attraction and spring outmigration pulses for the San Joaquin Basin in an attempt to induce more timely return to natal streams and improve juvenile/smolt survival from the Mokelumne, Merced, Stanislaus and Tuolumne Rivers. Coded-wire tagging evaluations are underway to evaluate the benefits of these pulse flow releases.

11-7

11-7 Staff is aware of these studies and has inserted specific reference to them in sections of the FEIS dealing with autumn attraction flows and spring outmigration flows. Results have not yet been sufficiently quantitative to indicate specific flows best for the Mokelumne, and our recommendation for continued study among the parties to define the most appropriate timing, magnitudes, and durations remains in the FEIS.

The California State Water Resources Control Board (SWRCB) issued a draft decision on December 10, 1992, on a plan that would essentially mandate water agencies, including EBRPD, to release more water in the fall and spring to meet fish and water quality needs, including improvement of upstream and downstream salmonid migration. This decision, requested by the Governor of California, is aimed at improving estuarine conditions where populations of chinook salmon, striped bass, and other fish have declined drastically and several fish species are being considered for Federal listing under the Endangered Species Act.

11-8

11-8 See the response to comment No. 6-3.

The SWRCB's plan would impact over 60 irrigation districts and water agencies that divert from the waters that flow into the Delta, and would require them to release more water or stop diverting water for a specified time in the spring and fall when fish are migrating. In our view, this Bay Delta Interim Protection Plan, or SWRCB Decision 1630, constitutes a major comprehensive basin plan that requires consideration by FERC in decisions related to instream flow releases.

Compatibility of the minimal spring and fall flow releases recommended by the FERC and EBRPD for the Lower Mokelumne River Project, and the objectives and mandates of the SWRCB's draft Bay Delta Interim Protection Plan, should be thoroughly considered and addressed in the final EIS.

Specific Comments

Page 1-4 and 1-5. In reference to the history of problems and stresses impacting naturally spawned chinook salmon and steelhead trout, acid mine discharge should be included with the causes identified (water diversion, regulation and hydroelectric power). Also, the abbreviation "AMD" should be spelled out in Figure 1.3-1.

11-9

11-9 The FEIS has been modified to reflect your comment.

Page 2-7, Figure 2.1-1. It would be helpful to label the months of the year on the y-axis since you refer to them in text on page 8.

11-10

11-10 This change has been made in the FEIS.

Page 2-11. The Service concurs with the FERC's definition of water year type based on observed flows to Pardee Reservoir at the USGS Mokelumne Mill stream gauge. However, we recommend that the Final EIS precisely define (1) the runoff threshold criteria for dry, normal and wet years in thousands of acre-foot per year (TAF/y), and (2) the calendar dates to be used in determining the water year type. We assume from FERC's definition, that a dry year

11-11

11-11 Staff's water year definition has been modified in the FEIS in response to comments. See Section 2.2.1 of the FEIS.

- 11-11 (cont.) occurs, when cumulative flows are less than (approximately) 360 TAF/y and a wet year occurs when cumulative flows exceed (approximately) 760 TAF/y.
- 11-12 (cont.) Page 2-15, Attraction Flows. In 1992, a dry water year, coordinated flow releases were provided from tributaries of the San Joaquin River to improve water quality conditions and attract salmon spawning runs the system. Short-term attraction flow releases (400 cfs) from Camanche Dam, in conjunction with coordinated San Joaquin flows, favorably attracted salmon into the Mokelumne River that may not have entered the system otherwise.
- 11-12 The Service disagrees with the FERC's recommendation for experimental (uncertain) attraction flows only when excess water is available in normal and wet water years. It is important that adequate flows for attraction be provided in all years. We recognize that multiple pulses of large flows, for example, greater than 300 cfs, may not be feasible in dry and critical water years; however, we do believe that at least one major pulse flow should be provided. It would be helpful to define "excess" water.
- 11-13 Page 2-20, Interstream 2. Conceptually, this is an interesting proposal that may warrant further reconnaissance level investigation. However, it is likely that sediment and debris would continually accumulate in the constructed deepwater channel and require regular maintenance. Also considering the shallow nature of Lodi Lake and the low stream gradient, we have doubts that a channel of sufficient depth could be constructed to ensure thermal stratification during the juvenile emigration period. We believe the construction of a new channel separate and apart from the existing channel to the south is a more practical approach from an engineering and long-term maintenance perspective.
- 11-14 Page 2-22, Table 2.4.1. Under the component attraction flows, the term excess water should be clearly defined. Under the component minimum pool at Camanche, there should also be a recommendation for dry and wet years. Under the component for water temperature, we disagree with the staff proposal. The temperature mobilizing indicators that in many years, spring water temperatures in the lower Mokelumne River exceed acceptable criteria for salmonids. Although ambient air temperatures eventually become the controller in the spring, a selective level withdrawal feature would help optimize the Camanche storage temperatures and decrease the periods of criteria exceedance in significant portions of the lower river.
- 11-15 Page 2-22, Interstream 1. In our view, spawning habitat is more limiting than dry habitat and will become more limiting as stocks recover. Thus, greater emphasis should be placed on improving spawning habitat when developing the best flow regime.
- 11-16 Page 3-28, Interstream 1. Hydrogen sulfide was identified as a major contributor to MRF fish kills in 1987-1989 and should be included in the list of primary water quality concerns in both the reservoir and reservoir releases.
- 11-12 Staff recognizes that since its preparation of the DEIS, the 1992 flow augmentation studies using 600 cfs were successful in drawing more chinook salmon spawners to the Lower Mokelumne River. This additional information has been added to the FEIS.
- 11-12 The comment correctly points out a discrepancy in the DEIS between the text section 4.3.2 and the Section 2 summary of proposed actions and alternatives. Staff intends that minimum autumn attraction flows apply to all years, although 300 cfs may not be feasible in dry years and 200 cfs is an acceptable option. Experimentation with flows higher than 300 cfs to help establish information about the best timing, magnitudes and durations of flow was recommended only in years when there is abundant water available for experimental purposes. The base condition was, regrettably, left out of the summary. The staff alternative has been clarified in FEIS Section 4.3.2 and the base condition added to Section 2.2.3.
- 11-13 Staff appreciates the thoughts about the conceptual proposals for assisting fish passage through Lake Lodi. Staff encourages FWS to work with the parties to further explore these alternatives for their feasibility and cost effectiveness. The FEIS designates the stratification sill as the preferred alternative among the three options discussed, because of its apparent multiple benefits and lowest cost.
- 11-14 See response to comment No. 11-12. The base condition of 200-300 cfs weekly average autumn minimum flow was also left out of the summary table. This has been corrected.
- 11-15 Staff has included in the FEIS a limiting factor analysis that also defends the importance of spawning habitat. One must recognize, however, that the limiting factor may vary from year to year. Thus, it is advisable to enhance (where possible) the habitat for all life stages within capabilities of the system. In addition to flow measures designed to support spawning, staff encourages all parties to seriously consider the development of off-stream rearing habitat as a non-flow measure.
- 11-16 Hydrogen sulfide will be included in the list of primary water quality concerns.

<p>Para. 3.1.3. INTERCOMB.1. We do not agree that the impacts of the Delta Water Projects are beyond the scope of this EIS. We understand the constraints on the FPM's project sphere of influence, but the effects of the Delta projects must be considered, if this is to be a comprehensive and complete environmental analysis. Clearly, the strategic planning underway to improve fisheries conditions, including fish passage through the Delta, must be coordinated with the strategic planning of riverine flow regimes. The anadromous fish life cycle and habitat needs are a continuum and should not be developed in an isolated single tributary habitat.</p>	11-17	11-17 The effects of the Delta water projects are discussed in the FEIS and have been considered in staff's recommendations.
<p>Para. 3.1.3. INTERCOMB.2.2. Due to the scale and poor reproduction, this graph offers little useful information. We suggest changing the scale and improving reproduction.</p>	11-18	11-18 This figure has been improved in the FEIS.
<p>Para. 3.2. INTERCOMB.1. This points out an important water quality concern for each aquatic resource and downstream domestic use. This is a resolvable problem that needs to be addressed. Irrigation runoff from lands that drain to the river due to over watering and inefficient watering systems needs correction. Runoff from pastureslands with domestic stock waste products and bacteria is a serious issue, but needs correction.</p>	11-19	11-19 Staff agrees that these issues may affect fish in the lower river and acknowledges such in the FEIS. However, the responsibility for regulation of these problems resides with other federal and state agencies.
<p>Para. 3.2. INTERCOMB.1.5. At maximum pool elevation, storage capacity in Comanche Reservoir is 217AF. Please check figures.</p>	11-20	11-20 This error has been corrected in the FEIS.
<p>Para. 3.2. INTERCOMB.2. There are 3 outlets from Comanche Reservoir, but because the reservoir level has been below normal since early 1992, the upper outlet (202 feet) has been unusable. Thus Comanche Reservoir water level is low, only the lower outlet (185 feet) is available for use. The flooding platform was completed in 1999 to allow withdrawal of higher quality water from alternate depths in the reservoir.</p>	11-21	11-21 Your comment is noted. This description is consistent with Facilities Section 2.1.2 of the FEIS.
<p>Hydrogen sulfide was detected in the Comanche Reservoir discharge even with the use of the floating platform (EMUD Habitat River Baring Exhibit #11)</p>	11-22	11-22 This information will be included in our analysis of the hydrogen sulfide problem.
<p>Para. 3.2. INTERCOMB.5. Babye and larval stages of salmonids require water column dissolved oxygen levels > 11.0 ppm for no production impairment to occur, and all other life stages require > 8.0 ppm (BNA 1986).</p>	11-23	11-23 The comment provides the optimum (no production impairment) levels from EPA (1986) that are not considered by EPA or most others as "requirements." Staff has included the table of national criteria levels from EPA (1986) in the FEIS.
<p>Para. 3.2. INTERCOMB.2. Hydrogen sulfide was identified as a major contributor to MRY fish kills in 1997-1999 and should be included in the list of primary water quality concerns in both the reservoir and reservoir releases.</p>	11-24	11-24 See response to comment No. 11-16.
<p>Para. 3.2. INTERCOMB.3. The impact of heavy metal contamination below Comanche Dam seems to have been significantly reduced since the dam's construction, due to the retention and dilution capacities of the Comanche Reservoir and retention dam installed on the Puma River watercourse in sitelisting. The water quality data provided by EMUD at the recent Habitat River Baring, show that elevated levels of heavy metals and accumulation of the EPA (1986) metals criteria for the salmonids and protection of aquatic resources still occur on a regular basis (Enclosure 2).</p>	11-25	11-25 Staff will include an analysis of EMUD's recent water quality data along with a comparison to EPA's water quality criteria and a discussion of possible ecological effects.

<p>11-26</p> <p>Information on all old mines in the Mokelumne River watershed would be useful for evaluating toxic materials in the lower river. However, staff is aware only of efforts to study the effects of Penn Mine, the location most directly discharging to Camanche Reservoir.</p>	<p>11-26</p> <p>Page 3-32, paragraph 5. Penn Mine is the most apparent mine drainage problem into Camanche Reservoir. There should be some discussion about the status of other mines that dot the watershed above Camanche and Pardee. How much investigative effort is underway to determine their effects on water quality?</p>
<p>11-27</p> <p>The imprecision of fish counts in early years has been noted in this paragraph of the FEIS. We note that the accuracy of the early counts is unknown.</p>	<p>11-27</p> <p>Page 3-33. Salmon spawning population estimates in 1961-1962 were based on less precise technology than the Woodbridge fishway trap and video counting methods employed in 1970-1992. Therefore, comparison of escapement estimates may be biased.</p>
<p>11-28</p> <p>Although covered earlier with discussion of straying, this point has been added to this paragraph in the FEIS.</p>	<p>11-28</p> <p>Page 3-33. Migration Through Lower River and the Delta. Although the MEFF practice of transporting part of its production to the Salmon Bay release site may be a valuable way to increase survival, the MEIS should clearly point out that very few of these fish return to the MEFF or to the Mokelumne River.</p>
<p>11-29</p> <p>Staff would like to have conducted a similar analysis of the factors affecting survival for Mokelumne River fish, but could not for lack of tagging data on the Mokelumne. Staff recommends that such tagging be done to obtain the needed data. Until that time, staff assumes that the relationships seen elsewhere hold for this river as well.</p>	<p>11-29</p> <p>Page 3-32/34. Environmental Variables. Factors discussed include fish size, season and planting locations. The discussion indicates that survival rates for juvenile chinook salmon planted in Sacramento River and tributaries were positively correlated with river flows and Delta outflows and were negatively correlated with water temperature and diversions to the lower Delta. Although these data suggest that survival of salmon smolts migrating from the Mokelumne River might be increased similarly by higher river flow, FEIS staff could not develop such a correlation because of a paucity of tagging information from fish planted from the MEFF.</p>
<p>11-30</p> <p>The comment correctly notes that not all factors affecting salmon survival were identified in the DEIS. The factors listed in the comment have been added to Section 3.3.1 of the FEIS, although no quantitative information is available to evaluate most of them.</p>	<p>11-30</p> <p>This section does not address a multitude of other factors which influence juvenile salmon and smolt survival, many of which may be exacerbated by low flow conditions. These include adverse water quality, increased competition and predation, decreased food production, increased stranding rates, increased potential for overwintering, and increased emigration period because of greatly reduced conveyance flows.</p>
<p>11-31</p> <p>A paragraph has been added to the FEIS under temperatures requirements that describes the problem of limiting temperatures at both ends of the freshwater life phase, with reference to Figure 3.3-10 where this was shown.</p>	<p>11-31</p> <p>Another important factor that should be considered is the total length and timing of riverine life cycle. Lack of adequate, timely fall flows and satisfactory water temperatures extend the life cycle further into the spring/summer season, thereby decreasing the chance for survival. Water temperatures often exceed acceptable criteria in late spring and early summer, thus earlier emigrations have a better chance for survival.</p>
<p>11-32</p> <p>See response to comment No. 11-8.</p>	<p>Page 3-35. Estimation Outflow to Salinity. These series of workshops have led to a draft decision (D-1630) announced on December 10, 1992 by the SMCB regarding an interim plan to improve and protect Delta water quality, aquatic habitat and fisheries. A formal announcement regarding adoption of the plan is expected around mid-March 1993. Adoption of this plan will likely have a significant impact on all major tributaries to the Delta where waters are stored, diverted or exported from the system.</p>
<p>11-33</p> <p>Staff agrees with the complex of factors that may limit production of juvenile salmon. Most of the rest of the section is devoted to these other factors. A paragraph has been added to the subsection on habitat availability to emphasize this point. Also, a paragraph has been added to DEIS p. 3-36 on microhabitat requirements of chinook salmon juveniles. This is not, however, the part of the EIS in which impacts are evaluated.</p>	<p>11-33</p> <p>Page 3-36/39. Habitat Availability. This section includes that habitat availability for (1) salmon spawning is greatest at about 100 cfs, and (2) salmon fry and juvenile salmon is greatest at streamflows at or below 100 cfs, and that these habitat response relationships constitute the most important and perhaps determinant factors for selecting minimum flows in Camanche Reservoir.</p>

- 11-33 (cont) We disagree with this premise. There are many additional survival factors that should be considered before selecting the correct flow for a given life stage. This is especially applicable to flow decisions for fry and juvenile salmon life stages. We believe that water temperature, predation, substrate cover and other factors may be more significant in limiting production than WMA for fry or juveniles.
- 11-34 The legend for Figure 3.3.11 has been corrected in the FEIS.
- 11-35 The comment is incorrect. A more complete discussion of these issues is presented in the body of the FEIS.
- 11-36 Your comment is noted. This apparent contradiction has been clarified in the FEIS.
- 11-37 The background paragraphs on attraction flows have been expanded to include the recent studies that demonstrate attraction. The staff alternative has been modified to include rapid pulsing (spike) flows within minimum weekly average flows of 300 cfs (normal and wet years) and 200 cfs (dry years), and the recommendation that these limits be enforced with flexibility subject to coordinate determination by the agencies and EBMUD.
- 11-38 The FWS notes the need by the Delta ecosystem for higher spring flows. A new paragraph has been added to the background text in Section 4.3.3. Staff has also recommended a basic minimum flow of 300 cfs (normal and wet years) and 200 cfs (dry years), not including obligations to WID and other water users. These minimum spring flows would be in effect unless other coordinated actions were taken by the agencies and EBMUD.
- 11-33 (cont) We disagree with this premise. There are many additional survival factors that should be considered before selecting the correct flow for a given life stage. This is especially applicable to flow decisions for fry and juvenile salmon life stages. We believe that water temperature, predation, substrate cover and other factors may be more significant in limiting production than WMA for fry or juveniles.
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- 11-38 The FWS notes the need by the Delta ecosystem for higher spring flows. A new paragraph has been added to the background text in Section 4.3.3. Staff has also recommended a basic minimum flow of 300 cfs (normal and wet years) and 200 cfs (dry years), not including obligations to WID and other water users. These minimum spring flows would be in effect unless other coordinated actions were taken by the agencies and EBMUD.

11-38 (cont.)	increased spring flows for the benefit of the entire downstream ecosystem is not given sufficient consideration in either EISB's or FERC's alternative discussion.
11-39	<p>Para. 4-46, 4-5 Cumulative Environmental Impacts. Cumulative impacts of major water development projects for the Moholomo River should be addressed in this section including the relicensing of the Moholomo River Project, FERC No. 137, and proposed major licenses for the Middle Bar Project (FERC No. 11171) and the Devil's Run Project (FERC No. 8799). These projects include extensive storage and diversion potential, and are likely to significantly impact availability of instream flows for fish and wildlife habitat maintenance for the Lower Moholomo River Project. Also, this section should address cumulative environmental impacts of the project to the Sacramento-San Joaquin River Delta, especially in light of SMCB Decision 1639.</p>
11-40	<p>Para. 5-1, Fish Population Declines. Although statistical evidence is inconclusive with regard to Moholomo River salmon run sizes, we believe concern about run declines is justified, that the run is more threatened now than during pre-Camanche Run periods. This concern is supported by continued poor return runs of 1991 and 1992 (not included in CMFC's Lower Moholomo River Fisheries Management Plan), the failure of artificial fish propagation since 1964 to significantly increase Moholomo River escapement, the chronic problem of adult salmon straying to other rivers, increased water demands and diversions upstream from Camanche Run, and increased incidence of water quality degradation.</p>
11-41	<p>Para. 5-2, Streamflow. According to the FERC, they have independently developed minimum instream flow recommendations to accommodate more of the desirable fish and wildlife values than either CMFC or EISB recommendations. These recommendations are presented in tables 2.2-1, 2.2-2 and 2.2-3. Based on our analysis of the EIS and available study findings and biological information presented at the SMCB Lower Moholomo River water rights hearings held in November, 1992, the Service has also independently developed minimum instream flow recommendations. These more closely parallel those of the CMFC than either EISB or FERC.</p>

For comparison, we included our recommendations for normal water years as measured below Woodbridge Run, along with those of CMFC, EISB and FERC. Following the comparison table, we have included our recommendations for all water year types.

11-39 The discussion of cumulative impacts has been expanded somewhat in the FEIS, but it remains limited by the scope of this proceeding, as explained in Section 1. Also see response to comment No. 11-8.

11-40 Staff agrees with the comment and has added similar wording in the section.

11-41 Staff appreciates FWS's efforts in defining their own specific flow recommendations, and thus instream flow regime has been explicitly evaluated in the FEIS.

MINIMUM FLOWS PROPOSED BELOW WOODBRIDGE DAM,
NORMAL AND ABOVE WATER YEARS

Management Area River Segment (RM)	Controlling Life Stage* Coincident Life Stage	Time Period	Water Temp. (°F)	Flow Range (cfs)		Total Volume
				Woodbridge	Hwy 99	
22.7-63.7 ¹	Upstream Attraction*	Oct 1-Oct 17	60°F or less	200-700 ²	200-700	13,384
"	Spawning*/Incubation	Oct 18-Dec 31	56°F or less	300	300	44,330
"	Incubation*	Jan 1-Feb 15	"	300	300	27,324
"	Incubation*/Alevin	Feb 16-Mar 31	"	300	300	26,136
"	Fry/Juvenile*	Apr 1-Apr 30	60°F or less	300	300	17,820
"	Juvenile/Smolt					
"	Outmigration*	May 1-May 10	"	400	400	7,920
"		May 11-May 20	"	530	530	10,890
"		May 21-May 31	"	700	700	15,246
"		Jun 1-Jun 10	"	400	400	7,920
60-63.7		Jun 11-Sep 30	"	100	100	22,176
						193,566 ³

¹ Total mgt. area is 41 river miles from Thornton (RM 22.7) to Camanche Dam (RM 63.7)

² Fall pulse flows, two six-day series - 15,000 ac. ft. block 200/400/700/700/400/300

³ Total acre-feet delivered to Woodbridge measured at USGS gage below Woodbridge Dam

The Service generally agrees with the CDFG's approach and recommendations for fall attraction and spawning flows. In our opinion, fall attraction flows are an important cue in aiding adult salmonid migration, especially when coordinated with draining Lake Lodi and pulsed releases from San Joaquin River tributaries. However, we recognize that more evaluations are necessary to determine the magnitude and duration of attraction flows downstream from Woodbridge Dam. Another alternative which would accommodate flexible use of attraction flows is a combination of FERC's October 1 through November 15 flow proposals of 200 to 300 cfs and the 20,000 acre-foot of storage recommended by the CDFG for attraction flow augmentation.

The Service concurs with the FERC's and CDFG's recommended 300 cfs spawning and incubation flow from November through January.

We do not concur with the FERC's recommendation for a flow reduction in February, as salmon eggs are still incubating in spawning gravels. Also, steelhead trout spawn in January and February. The CDFG's lower Mokelumne River Management Plan provided substantive evidence that reducing flows in the range of 400 cfs or less would result in dewatering of eggs and stranding losses. We note that FERC encourages the natural spawning of steelhead in addition to the hatchery production. We recommend maintaining flows at 300 cfs, consistent with that recommended by the CDFG.

The Service recommends maintaining a flow regime of 300 cfs during the fry rearing period of March through April. This flow will provide favorable rearing habitat for salmon fry/juveniles and suitable spawning and egg incubation for steelhead trout. This recommendation is higher than FERC's recommendation, however, it should provide improved habitat for steelhead trout. In our opinion, any reduction of flow less than 300 cfs during this period would likely cause problems related to water quality, water temperature, fry stranding, food production and predation.

During the period April 15 through June, the Service recommends much higher flows than the FERC for reasons other than maintaining favorable salmonid fry microhabitat as identified by the IFM. The justification for much higher spring flows include: (1) favorable maintenance of water quality (e.g., water temperature), (2) improved conditions for species competition, food production and availability, growth, predator avoidance, (3) reduced entrainment into diversions, and (4) favorable conveyance of smolts to and through the Sacramento-San Joaquin Delta. We believe this recommendation is consistent with the draft Bay Delta Interim Protection Plan (D-1630) recently released by the State Water Resources Control Board.

Finally, we support flows of 100 cfs for the July 1 through September 30 period, which are somewhat less than those recommended by the CDFG for maintenance of riparian vegetation, wildlife habitat, resident fish and steelhead trout rearing habitat.

Page 5-5/6. Flow Alternatives. See comments above referencing streamflows. The Service concurs with the FERC's conclusion that spawning habitat improvement via increased flows is more important biologically than fry habitat reduction. In our opinion, spawning, juvenile rearing and smolt

11-42

11-42 Staff agrees that the goals are similar, but prefers not to recommend both flows from Pardee and storage in Camanche, because these constraints on operation are essentially redundant.

11-43

11-43 Your comment is noted and has been incorporated into the FEIS.

11-44

11-44 Staff agrees that a significant lowering of flows in February would be detrimental to emerging salmon alevins and spawning steelhead. Staff now recommends holding the spawning-incubation flows for chinook salmon through February 15. Also, because downstream water rights pick up in March, minimum stream flows for fish are augmented by conveyance flows.

11-45

11-45 The FWS alternative has been presented along with the other alternatives in the FEIS.

11-46

11-46 The FWS minimum flow alternative has been presented along with other flow alternatives in the FEIS.

11-47

11-47 Your comment is noted and has been incorporated into the FEIS.

11-48

11-48 Your comment is noted.

**MINIMUM FLOWS PROPOSED BELOW WOODBRIDGE DAM,
DRY AND CRITICAL WATER YEARS**

<u>Management Area River Segment</u>	<u>Controlling Life Stage*</u> <u>Coincident Life Stage</u>	<u>Time Period</u>	<u>Water Temp. (°F)</u>	<u>Flow Range (cfs)</u>		<u>Total Volume</u>
				<u>Woodbridge</u>	<u>Hwy 92</u>	
22.7-63.7 ¹	Upstream Attraction*	Oct 1-Oct 17	60°F or less	200	200	8,178
"	Spawning*/Incubation	Oct 18-Dec 31	56°F or less	200	200	29,700
"	Incubation*	Jan 1-Feb 15	"	200	200	18,216
"	Incubation*/Alevin	Feb 16-Mar 31	"	200	200	17,424
"	Fry/Juvenile*	Apr 1-Apr 30	60°F or less	200	200	11,880
"	Juvenile/Smolt					
"	Outmigration*	May 1-May 10	"	300	300	5,940
"		May 11-May 20	"	400	400	7,920
"		May 21-May 31	"	500	500	10,890
"		Jun 1-Jun 10	"	50	200	3,960
60-63.7		Jun 11-Sep 30	"	50	50	<u>11,088</u>
						125,196 ₃

¹ Total mgt. area is 41 river miles from Thornton (RM 22.7) to Camanche Dam (RM 63.7)

² Fall pulse flows, two six-day series - 15,000 ac. ft. block 200/400/700/700/400/300

³ Total acre-feet delivered to Woodbridge

survival are the conditions which need improvement the most.

11-48
(cont.)

Page 3-6. Non-Flow Alternatives. The Service concurs with the FERC's conclusion that improving the hydraulics of Lake Lodi and fish passage conditions at Woodbridge Dam are likely the most effective non-flow related measure for improving fish survival. Potential losses of juveniles from predation, migration delay, and water quality impacts resulting from hydraulic conditions at Lake Lodi and Woodbridge Dam may be very significant, especially under low flow conditions in the spring.

11-49

11-49 Your comment is noted.

Page 3-7. BAKASKASH 2. #2. The interim solution recommendation of allowing EBMUD access to storage volumes "below 180 feet NSL lower pool requirement" needs to be further defined. Additional studies need to be conducted to determine which lower pool levels could maintain a hypolimnion with sufficient water quality for fisheries and aquatic resources in the lower Mokelumne River, MRFF, and Camanche Reservoir.

11-50

11-50 The details and discussion of this issue have been expanded in the FEIS.

Some minimum pool level in Camanche Reservoir must be maintained even in dry years.

Summary

The Service finds that a combination of flow and non-flow modifications to the existing license for the Lower Mokelumne River Project is needed to adequately protect, maintain and enhance fish and wildlife resources in and downstream from the project area. Although there are several recommendations proposed by the FERC that are acceptable to the Service in the nonflow alternatives, there are several of the flow recommendations that are inadequate. We have described these inadequacies and offered our own recommended flow schedule alternative. We have included justification for our views.

11-51

11-51 Staff considered fall attraction flows and spring outmigration flows, but felt that the quantitative basis for the timing, magnitude and duration of such flows was not substantial enough to finalize this type of mitigation. Staff recommended in the DEIS studies to determine what those flows should be. Staff now has specified base flow conditions in the FEIS for each of these times, to be in effect unless coordinated actions are taken by the agencies and EBMUD to conduct the requested experimental flow studies.

We do not agree with the FERC's assessment of, and recommendation for, fall adult attraction flows. We believe they are necessary and should be included in all water years. We also disagree with the FERC's assessment of, and recommendations for spring flows needed for favorable downstream migration and survival of juvenile chinook salmon, and for the entire lower river ecosystem downstream from Lodi Lake. These spring flows, in the Service's opinion, need to be substantially increased. The Service recommends an alternative flow regime of 400 cfs or greater during the period from May through mid-June, as compared with the FERC's recommendation for flows ranging from 100 to 150 cfs. In our opinion, these increased spring flows are necessary to provide conditions favorable for survival of downstream migrants, including adequate water quality (e.g., suitable water temperatures), food production and availability, reduced predation and entrainment into diversions, and favorable conveyance of smolts to and through the Sacramento-San Joaquin River Delta.

11-52

11-52 This alternative has been evaluated in the FEIS.

Compatibility of the minimal spring flow releases recommended by the FERC's staff and the EBMUD for the Lower Mokelumne River Project, and the objectives and mandates of the SMCB's draft Bay Delta Interim Protection Plan, and the CDFG's Mokelumne River Management Plan should be thoroughly considered and addressed in the final EIS.

11-53

11-53 See the response to comment No. 11-8.

References

ESWSD Mokelumne River Hearing Exhibit #33. Camanche Reservoir Water Quality. Testimony of Russell E. Brown. November 1992.

EPA (U. S. Environmental Protection Agency). 1986. Quality Criteria for Water 1986. EPA 440/5-86-001-Update #2.

Sincerely,

James D. Larson
for Wayne S. White
Field Supervisor

Enclosures (2)

cc: AED, ES, FWS, Portland, OR
Reg. Dir., CDFG, Sacramento
Reg. Mgr., Reg. II, Rancho Cordova
RMCB, Div. Water Rights, Sacramento
FWS, San Francisco
Committee to Save the Mokelumne
Attn: Bill Jennings
CWA, Attn: Bob Biscoe
MVA (Kolar), Washington D.C.
FWS, Wash., D.C.

Dec. 5, 1992

Ms. Lois R. Cashill, Secretary
Federal Energy Regulatory Commission
825 North Capitol Street, N. E.
Washington, D.C. 20426

Subject: Draft Environmental Impact Statement for Proposed
Modifications to FERC Project No. 2916-004, Lower
Mokelumne River Project, Amador, Calaveras And San
Joaquin Counties, CA, October 23, 1992.

Your agency has spent considerable time and expended a lot of hard work in preparing subject document. However I do not agree with all the underlying assumptions, conclusions or the FERC recommended flow regimen.

FERC's primary concern is East Bay Municipal Utility District's (EBMUD) operation of Pardee/Camanche Dam and Reservoir projects for hydro electric power production. The recommendations proposed by the California Department of Fish and Game are for the specific purpose of conserving the anadromous fish resources of the Lower Mokelumne River (LMR). The efforts of EBMUD are to produce hydropower and exercising its water rights by diverting water from the Mokelumne River for urban and industrial needs. The overall concern is - Can EBMUD's full water rights be diverted at the Pardee Dam point of diversion and still meet the water needs of public trust resources, and associated interests and other water right holders along the Lower Mokelumne River?

12-1

12-1 This is not an accurate representation of the concern and purpose of this compliance proceeding. See Section 1 of the FEIS for the purpose of this proceeding and assessment.

There are other issues that impact anadromous fish resources of the Lower Mokelumne River that are not part of this License review but some are under FERC jurisdiction. The impacts in the Delta and the operations of Delta export facilities have come under considerable discussion. The Central Valley Project's diversion from the Delta commenced in 1951 while the State Water Project's diversion commenced in 1967.

In order to better understand the Mokelumne River developments and the conservation and protection needs of instream resources and associated uses, the Mokelumne River could be considered to be tributary to a theoretical lake. This lake could be synonymous to the Delta and San Francisco Bay.

12-2

12-2 The scope of this compliance proceeding is more limited; see Section 1 and 2 of the FEIS for a restatement of the scope of this proceeding.

Man's activities have impacted the lands, waters and biological resources of the Mokelumne River Basin. During the gold rush era with water was supplied to the hydraulic mining operations by a maze of canals. Today dams and conduits supply water for generating electricity, agricultural uses and for domestic and industrial uses.

The Mokelumne River, rising from the snow fields at the crest of the Sierra extends to the Sacramento/San Joaquin Delta, a distance of about 130 miles. The Mokelumne River drainage area is about 700 square miles and has an annual runoff (unimpaired) of about 730,000 acre feet measured at Pardee Dam and Reservoir (DWR -1978).

In the upper watershed, the Mokelumne River is harnessed repeatedly through a chain of reservoirs and conduits and then released through powerhouses for the generation of electricity. This portion of the Basin has been heavily developed by the Pacific Gas and Electric Company (PGE). Salt Springs Reservoir (141,900 acre feet) is PGE's largest facility in the Basin. However, there is about 865,000 acre feet of storage in the Mokelumne River Basin (USGS Water Papers).

Pardee Dam and Reservoir with a storage capacity of 210,000 acre feet at elevation 576.6 feet (NGVD) was completed in 1929. Camanche Dam and Reservoir with a storage capacity of 431,500 acre-feet at elevation 235.5 feet (NGVD) was completed in 1964. The Federal government contributed \$10.7 million to the Camanche Dam and Reservoir project for flood control purposes. A contract between the Secretary of the Army and EBMUD provides for the operation of the Pardee/Camanche Project for flood control in accordance with rules and regulations prescribed by the Secretary of the Army. In addition if there are project caused damages to fish and wildlife, EBMUD is responsible for mitigating those damages (Corps of Engineers 1977).

The EBMUD indicated in its letter of Jan. 14, 1991 to FERC, that it has water rights to utilize the waters of the Mokelumne River for various purposes of which about 563,000 acre-feet are to storage for municipal and industrial purposes. In addition EBMUD has rights to divert up to 200 MGD to its service area via Pardee Reservoir. EBMUD's storage facilities within its service area (Briones, San Pablo, Upper San Leandro and Chabot Reservoirs) have a total storage of about 155,000 acre feet. This storage increase the actual amount of storage available for Mokelumne River water or water from any other source. This also increases the operational flexibility of EBMUD's water supply.

A review of the estimated unimpaired flow data for the Mokelumne River at Pardee Reservoir for the period 1921 thru 1983 (DWR-1987) indicates high flows during April, May and June in average and above runoff years with May being the peak runoff month. During below normal and dry years, the peak runoff months are April and May. The runoff pattern exhibit rain events during October, November and into December with snow piling up at the higher elevations during December, January, February and into early March. With the event of spring the snowmelt commences, with

streamflows as well as runoff peaking during April, May and June. During less than normal runoff years (also years of less than average snow pack) there is a gradual increase in streamflows during November through March with greatly increased streamflows during April and May. About two-thirds of the estimated average unimpaired runoff occurs from about the middle of March through the middle of June.

It is this average runoff pattern that biologists are trying to mimic in their recommendations to conserve and restore the anadromous fish resources to the Lower Mokelumne River.

12-3

The flow regimen released from Pardee/Camanche Reservoirs by EBMUD is supposed to (1) conserve and protect water quality and the ecosystem of the Lower Mokelumne River, (2) assure the continued renewability of the fish, other aquatic resources and beneficial uses of the LMR, (3) provide a water supply to the Mokelumne River Fish Facility (MRFF) of sufficient quality to assure adequate survival of holding adult salmon and steelhead trout, optimum survival and incubation of eggs and the growth of fry and yearlings, and (4) meet downstream water rights and the stability of the theoretical lake, associated uses and values.

Reports of the Water Resources Control Board, Regional Water Quality Control Board, Department of Fish and Game, and the East Bay Municipal Utility District confirm the inadequate flow and stream conditions and that water quality (leachate) from Penn Mine wastes and tailings (copper, zinc, aluminum, cadmium and various other metals) are at high enough concentrations to be toxic to fish and other aquatic life. Fish kills have occurred both in the river and in the facility. The latest kill was September/October 1989 at the MRFF. However human/mechanical error resulted in a fish kill during late summer of 1992.

Clearly the operation of the Pardee/Camanche project by EBMUD has resulted in inadequate stream flows and poor water quality evidenced by 1) low dissolved oxygen, 2) elevated temperatures, 3) toxic concentrations of metal sulfides, 4) turbidity, and 5) down ramping of stream flows. Any one of these parameters can impact fish and other aquatic life. All too often these items occur in concert, thereby severely impacting fish spawning and egg incubation, other life stages, and aquatic invertebrates.

12-4

Management Considerations Needed

In the dark ages of FERC permitting and licensing (same for SWRCB), some entities were allowed to divert all or nearly all the water from a river or stream. This resulted in the near or total destruction of instream resources, ecological values and beneficial uses. The stair-step hydropower developments on the Pit

12-3 It is not clear which "biologists" are being referred to here. Staff does not agree that it is necessary, or even possible, to mimic the full, original hydrology of the Mokelumne River given the water resource development that pre-exists here.

12-4 Your comment is noted. These issue have been evaluated in the DEIS and the FEIS.

and Feather Rivers and the new developments on the Tuolumne River (New Don Pedro completed in 1971), on the Merced River (New Exchequer completed in 1966) the Yuba River (New Bullards Bar completed in 1970) are examples. This extremely valuable permit privilege was often granted without a fair return to the public (i.e. such as mitigation measures or actions to protect or improve anadromous fish, other stream resources and associated beneficial uses). Today this permit or license privilege may be unreasonable because of its past and continuing impacts to resources, uses and values covered by the public trust or because Federal or state agents failed to act to protect the people's interests and their rights (Cal Trout v SWRCB 207 Cal App 3d 585 - 1989).

The entity obtaining permission to use the water resource of a river is the one legally and morally responsible for preserving and protecting the people's fish resources, water quality and other interests of that river by incorporating mitigation or compensation features into project operations. This could involve stream flows, cleaning gravels, channel modifications, replenishing lost gravels, restoring riparian vegetation, etc. FERC should be reminded that the construction and operation of a hatchery or other facility or the release of hatchery raised chinook salmon or steelhead trout does not negate the need for a flow regimen to keep the riverine habitat and its fish resources downstream from a dam "in good condition".

Fish and other aquatic resources are inextricably tied to the physical, chemical and biological aspects of the flow regimen. The availability and quality of instream flow to meet the biological and ecological needs of salmon, steelhead trout, striped bass and American shad and the aquatic ecosystem are inextricably tied to the flows, depths, velocities, temperature, and physical nature of the water course (spawning gravels, riparian cover, pools, riffles, etc).

Water temperatures needed to conserve and protect Chinook salmon can be generally described as less than 60 degrees F (range 45 to 65 degrees F) during migration; 56 degrees F (range 45 to 57.5 degrees F) during holding, spawning and egg incubation; less than 60 degrees F (range 45 to 69 degrees F) for nursery and rearing. These conditions also could be applied to steelhead trout, during the late spring, summer and early fall months. Water temperature above 57.5 degrees F (56 degrees preferred) will impair survival of salmon and steelhead adults holding in the river, their eggs and the incubation of those eggs both in the gravel as well as in the Mokelumne River Fish Hatchery. At 62 degrees F mortality is about 100 percent.

Chinook salmon after spending from 1 up to 6 years in the ocean return to their natal stream to spawn. The annual salmon spawning

12-5

Staff agrees that recent federal and state legislation have strengthened the obligation of hydropower developers to protect, mitigate, and, where appropriate, enhance aquatic resources affected by their projects. However, the Federal Power Act places this obligation in the context of balanced power and non-power development.

12-6

The DEIS quotes similar temperature requirements for chinook salmon and steelhead in Section 3.

12-7

The life cycle requirements of salmon are discussed in Section 3 of the DEIS and the FEIS. Except where the Endangered Species Act is concerned, the Federal Power Act requires the Commission to weigh the uses and needs of non-power resources, such as anadromous fisheries, against the benefits of hydropower resources and other developmental purposes such as water supply.

12-7

run could be equated to the harvestable production from a perennial crop. However, because salmon live just a few years and only spawn once, they need conditions that assure successful spawning, rearing and emigration in order to provide for the next generation and to continue their genetic diversity. Therefore the life requirements of chinook salmon should receive priority in any water management or use program formulated for this river.

12-7
(cont.)

Steelhead trout fry and juveniles remain in the river for 1 to 4 years prior to smolting and emigration to the ocean. After spending 1 to 4 years in the ocean, adult steelhead trout return to their natal stream to spawn. Because of this 1 to 4 year stay in fresh water, young and juvenile steelhead have water quality needs that must be provided throughout the year. For example, failing to meet just one of water quality parameter (i.e. adequate water temperature), even for a short period of time, could easily impair the survival of the entire juvenile steelhead trout population in the LMR.

12-8

All reservoir operations alter the amount and timing of flows as they pass down stream. In these enlightened times it is most reasonable that all FERC licensed projects in the MRB should contribute their fair ecological share to the flows necessary to protect, conserve and restore resources and values protected by the public trust. This fair ecological share of stream flow would pass downstream, commingle with other waters would continue on to the Delta, thereby contributing to the protection of environmental amenities, beneficial uses, public trust concerns and to Delta outflow.

If every FERC licensed project in the Mokelumne River Basin (tributary to this theoretical lake), as well as in the Central Valley Basin, provided its fair ecological share of stream flow to protect and promote instream fisheries, to protect other trust interests and contribute to Delta inflow and positive Delta outflow, the present problems associated with water quality, fish resources and aquatic ecosystem protection and renewability of the Lower Mokelumne River, the Sacramento / San Joaquin Delta and San Francisco Bay would be greatly reduced.

Therefore, FERC should assume the posture that instream flows will receive priority in this licensing process with a certain level of historic natural flow be reserved for non-consumptive instream uses for the viability and renewability of ecological and biological resources.

12-9

Down ramping of stream flows can result in a loss of incubating eggs, and lost females driven off their nests and who do not have enough energy to build other nests could result in pre-spawning mortality. For example between January 1 and 9, 1985, Mokelumne

12-10

12-8 Staff agrees that short term changes in water quality can have long term damaging effects on fish populations. However, this assertion must be accepted in the light of the special situation for steelhead in the Lower Mokelumne River. It is well known that attempts to rehabilitate wild steelhead in the Lower Mokelumne River have not been successful. Staff has examined the habitat requirements of steelhead juveniles in the 1-4 year freshwater residence to see if physical habitat conditions in the existing Lower Mokelumne River are suitable. These conditions must be present before management of other factors such as water temperature will be effective in sustaining steelhead. Our literature review, which included much research by Dr. Chapman, suggests that there is not the proper habitat of steep-gradient, rocky riffles needed by juvenile steelhead. Therefore, maintaining optimal temperatures is less of a crucial matter. With modest habitat improvement to meet more of the physical habitat requirements of steelhead, the need for more river temperature control in summer may be more important.

12-9 The scope of this compliance proceeding is related to existing License Articles 12 and 15 (Appendix A) and the "conservation and development of fish and wildlife resources." Staff does not agree that such conservation and development is necessarily tied to historical natural flows.

12-10 Staff discussed downramping in the DEIS on p. 4-44. The discussion has been expanded for the FEIS.

river flows downstream of Camanche Reservoir were reduced from 650 cfs to 200 cfs. Four weeks later the flows were reduced to 100 cfs. Fifty percent of the chinook salmon spawned after November 21, 1954. From that date through December the flows were 800 cfs. CDFG estimated that 20.7% of 1984 spawn from a run of about 8,200 chinook salmon were lost as a result of the flow reduction (Heinz - 1987).

12-10
(cont.)

A properly sized minimum pool of cool water in Camanche Reservoir and an operating temperature control device (tower, shutter facility, etc.) would greatly improve the quality of the available water supply. The State Water Resources Control Board recommended a minimum water surface elevation of at least 190 feet (SWRCS memo of July 11, 1990). This would be about 156,000 acre-feet of storage (USGS Water Data Reports). Such a minimum pool along with a temperature control device would facilitate the release of water having the quality to increase the efficiency and effectiveness of the MRRF and to help restore the salmon and steelhead trout resources of the LMR. If there is insufficient storage of cold water, releases of cold water should be made from Pardee Reservoir in amount equal to Camanche Reservoir releases.

12-11

12-11 Minimum pool elevations are considered as one of the flow-related alternatives in the DEIS and the FEIS. The FEIS fully addresses these issues.

The flows released from Camanche Reservoir should meet the depth, velocity, temperature and water quality parameters necessary for needs optimum spawning, survival and growth of Chinook salmon and steelhead trout. While American shad and striped bass populations thrive on the unimpaired flows of the Central Valley streams prior to significant water development and that their needs should be considered, those needs should not override those of salmon and steelhead trout. The California Department of Fish and Game recommended flow schedule has the best chance for restoring the salmon and steelhead trout resources of the LMR. In addition 15,000 to 30,000 acre feet should be reserved for ecological needs (attraction flows, temperature out migration pulses, etc.) and be made available as designated by the CDFG.

12-12

12-12 Staff has used standard IFIM habitat suitability information to estimate weighted useable areas for chinook salmon life stages and has also qualified areas with suitable temperatures. We did not do this for striped bass and American shad because they are less important in the Lower Mokelumne River. We used quantitative methods to show which alternatives provide the most habitat in each salmonid life stage. These analyses are presented in the FEIS.

Water quality objectives:

1. Dissolved oxygen should not be less than 7.0 milligrams per liter (8.0 mg/l preferred) for any flows released from Camanche Reservoir. Technical fixes such as the operation of the Speece Cone are prone to failure in time of need.
2. Hydrogen sulfide should not be greater than 0.002 milligrams per liter (mg/l).
3. Turbidity levels of controlled releases should not exceed 50 Jackson Turbidity Units (JTU).

12-13

12-13 Staff is recommending that dissolved oxygen levels in the tailrace of Camanche Dam meet EPA National Water Quality Criteria. Staff agrees that technical fixes like the Speece Cone are not necessarily the mitigation of first choice, but such tools are sometimes necessary and often provide an important backup system when other means of controlling dissolved oxygen concentrations do not work. Staff is recommending that hydrogen sulfide levels in water being released into the Camanche tailrace not exceed 0.002 mg/L and staff is considering whether turbidity requirements are necessary.

4. Camanche Reservoir waters should be free of materials that in elevated concentrations could produce responses that are toxic or otherwise detrimental to fish, other aquatic life, wildlife or to beneficial uses. The criteria of the U.S. Environmental Protection Agency and the State Water Resources Control Board for maximum levels of aluminum, zinc, copper, cadmium, iron and manganese in freshwater should be strictly enforced to protect aquatic life. Because some of the concentrations can be additive to increase their toxic effects, a conservative approach regarding total loading should be taken to protect all beneficial uses of water.
- 12-14
5. The temperature parameters discussed earlier should be maintained at all times. To avoid stress to any life stages of salmonid fishes, the maximum operating temperature of the range should not be sustained at any time. For example temperatures in the deeper pools should be considerably lower than 65 degrees, preferably below 60 degrees F. To help ensure optimum spawning and survival of incubating eggs temperatures should not be greater than 57.5 degrees F (56 degree F preferred).
- 12-15
- All water quality parameters should be continuously monitored. Contingency plans, including necessary equipment, should be capable of being placed into operation at a moments notice.
- 12-16
- The flow ramping and flow reduction schedule in the Management Plan is too liberal. To reduce stranding of fish, stream flow reductions under these managed conditions should not be greater than 5 percent per day nor greater than 20 percent per week for the established flow standard. All flow reductions should occur at night. This is of course exclusive of flood flow releases. In addition during any major water transfer, FERC in cooperation with the State of California, should appoint or field a multi-agency / team to assess and evaluate the stream flow conditions, spawning activity and numbers of salmon that may be present in the LPR. Full cost of this team, including the public interest (non-agency) member, should be borne by EBRUD (the seller) and buyer of the water, not subsidized by the general tax payer or the fishing license buyer.
- 12-17
- FERC should appoint or encourage the formation of a Lower Mokelumne River Temperature-Flow Technical Group. This Group would review estimated runoff, carry-over storage, need and availability of water for flushing and attraction flows, management options, temperature patterns and generally overview the EBRUD projects and activities. Interests to include EBRUD, SLC, CDFG, SWRCB, USFWS, USGS and members of concerned constituent groups.
- 12-18
- 12-14 It is impossible to remove all possible contaminants from Camanche Reservoir since the heavy metals are naturally occurring minerals. However, minimizing those conditions that favor the resuspension and transport of harmful heavy metals from Camanche Reservoir was an important consideration in the development of staff's recommendations for reservoir operation. Because staff is unsure whether EPA's water quality criteria are either over- or under-protective in this particular case, and because the release of such contaminants from Camanche Reservoir may be difficult to control, staff is recommending that an extensive monitoring program be developed. This program would provide more information on (1) the release of contaminants from Camanche and the fate of those contaminants (i.e., concentrations in downstream water, sediment, and fish) and (2) ecological effects (e.g., chinook hatching success, fry survival and growth, and invertebrate community health).
- 12-15 The temperature criteria proposed by staff are described in the EIS. Our primary concern was for the development and survival of those fish produced naturally in the stream.
- 12-16 Your comment is noted.
- 12-17 It is not clear which Management Plan is referred to here. The FEIS considers several different approaches to defining ramping rates and recommends that which staff feels is best supported by available information.
- 12-18 Your comment is noted.

The effectiveness of the flows released from the Pardee / Camanche projects can be negated if the fish bypass and upstream passage facilities are inadequate or ineffective to serve all anadromous species that utilize the Mokelumne River. The Woodbridge Dam fish ladder should be brought up to the state-of-the-art science and technology. Consideration should also be given for removing Woodbridge Diversion Dam during part of the year. Isolating Lodi Lake from the main flow of the river should be considered.

12-19

12-19 Staff appreciates these comments and has attempted to include discussion of them at several places in the FEIS.

FERC should verify the effectiveness of all fish protection and conservation facilities and the stream regimen incorporated into any permit or license issued or modified relative to these projects. Costs should be borne by the licensee as a cost of doing business and under the general supervision of FERC.

In a policy statement presented at the State Water Resources Control Board's hearing regarding EBMUD's water rights to the Mokelumne River, a grass roots organization wanted to know: How can 100 percent of the renewable resources, uses and values of the LMR be protected, conserved or restored by the maximum flow regimen proposed by EBMUD which involves only about 16 percent of the unimpaired runoff? This was likened to a person being asked to get by on 16 percent of this food and oxygen rations while demanding a full day work every day.

The flows outlined in the CDFG Fishery Management Plan would gradually increase the size of the theoretical lake from the 13,000 acre feet released by EBMUD to 207,000 acre feet contained in the Management Plan, but considerably less than the 730,000 acre feet of unimpaired flows. The recommended habitat modifications, (gravel replenishment, gravel cleaning, channel modification, improved water quality through control of temperature and chemical parameters, riparian habitat restoration, etc.) are a few of the efforts to bring the shattered fishery back to some level of respectability.

The Instream Flow Incremental Methodology (IFIM) used in the CDFG study and presented in the Lower Mokelumne River Fisheries Management Plan is just one of many tools used by fishery biologist to help determine a flow regimen. The IFIM is based on some physical parameters as fishery biologists presently understand them. There is still a lot that we do not know. However some people try to use the IFIM to give a jeweler's engineering precision to ecological conditions in a dynamic environment. These folks enjoy such engineering preciseness and are quick to challenge the exact values and impacts of a 1 to 2 inch change in stream surface elevation. However these same engineer types add safety factors when designing buildings, elevators, bridges, etc., as a hedge to cover what they don't

12-20

12-20 The IFIM is a suite of many different assessment methods that can be applied in many different ways, with or without safety factors. Staff has used IFIM procedures, along with other independent considerations, to set a recommended instream flow regime in the FEIS. Staff does not agree that staff has relied excessively to the precision of IFIM studies or have ignored other influences on fish resources.

know. There are no safety factors built into the IFIM to protect fish and other interests, only the integrity of the user. Clearly the total value of the many uses and values of the LMR ecosystem is far greater than the sum of its component parts and interests covered by the public trust.

12-20
(cont.)

Tennant (1975) indicated that 30 percent of the average flow was recommended as a base flow to sustain good habitat conditions, while 60 percent of the average flow is recommended to provide excellent habitat conditions. ERMCO's recommended average year flows would be about 10 percent of the annual runoff, while the FERC flows would be about 18 percent of the average annual runoff. Even with 28 percent of the normal year runoff, as described in the CDFG Management Plan dedicated to the protection and restoration of Chinook salmon and steelhead trout resources and with all the habitat modifications possible, it is going to be a challenge to restore the anadromous fish resources of the LMR to a level of respectability.

12-21

Responsible actions are needed now to protect and restore these public trust resources and help restore the public's confidence in agencies that are supposed to work on behalf of all the people and the long term public interest.

12-22

Respectively submitted

Felix E. Smith

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cc: interested parties

a:FERCEIS.doc Dec. 5, 1992 FES

12-21 The Tennant Method is not an appropriate method for instream flow assessment for the Lower Mokelumne River at this point in time, because the natural hydrology has been highly modified. Furthermore, there is no substantial evidence that a fixed percentage of mean annual flow is directly related to the status of anadromous fisheries in a river such as the Lower Mokelumne River.

12-22 Staff agrees. The proceeding that this assessment supports is one such action.

Selected References EIS Comments

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- Meinz, Mike. 1985. Effects of EBRPD's Dewatering of Mokelumne River on Chinook Salmon Redds. Memo to Jerry Menach, CDFG dated February 25, 1985.
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- U.S. Geological Survey Water-Data Report CA-86-3. Schematic diagram showing diversions and storage in Mokelumne River Basin. Water Resources Data, California, Water Year 1986.

END

DATE

FILMED

3/4/94