Volume 2 of 2

LOS VAQUEROS RESERVOIR EXPANSION PROJECT DRAFT SUPPLEMENT TO THE FINAL EIS/EIR

Prepared for

United States Department of the Interior
Bureau of Reclamation
Mid-Pacific Region
Contra Costa Water District

June 2017

Cooperating Agencies

California Department of Water Resources
National Marine Fisheries Services
United States Army Corps of Engineers
United States Fish and Wildlife Service
Western Area Power Administration

Los Vaqueros Reservoir, Contra Costa County

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APENDIX A

EBMUD Component of Los Vaqueros Reservoir Expansion Project

The 2010 Final EIS/EIR did not include East Bay Municipal Utility District (EBMUD) as a potential partner in the Los Vaqueros Reservoir Expansion Project. This Supplement identifies EBMUD as a potential partner in the Phase 2 Expansion. The purpose of this Appendix is to provide an analysis of potential effects related to EBMUD's participation in the Phase 2 Expansion project. This analysis covers water resources and fisheries. The effects of the EBMUD component of the Phase 2 Expansion were evaluated quantitatively by comparing model simulations of the No Project/No Action Alternative to model simulations of the Phase 2 Expansion. The modeling assumptions, modeling output and figures from the model simulations for evaluating the Existing Condition are in Appendix A-1. The modeling assumptions, modeling output and figures from the model simulations for evaluating the Cumulative Future Condition are in Appendix A-2.

A.1 Background – Existing Conditions for EBMUD and the Mokelumne River

This section provides an overview of the existing conditions along the Mokelumne River, the EBMUD Mokelumne River facilities, the Freeport Regional Water Project (FRWP) facilities, and operational and regulatory requirements for the EBMUD component of the proposed Phase 2 Expansion project.

Mokelumne River Overview

The Mokelumne River watershed located upstream of Camanche Dam is relatively narrow and steep and is located north east of the Sacramento-San Joaquin River Delta on the western slope of the Sierra Nevada in Alpine, Amador, and Calaveras Counties. Above Camanche Dam, the Mokelumne River drains over 600 square miles with elevation in the watershed ranging from about 235 feet at the dam to 10,000 feet in the headwater region. The lower portion of the Mokelumne River is located in the Central Valley and the Delta in San Joaquin and Sacramento Counties. The lower Mokelumne River begins downstream of Camanche Dam and runs southwesterly through Lodi and then northwesterly until it is joined by the Cosumnes River. It then enters the Delta, splitting into the North and South Fork channels near the Delta Cross Channel (DCC). Mild summers and cold winters characterize the mountainous eastern region, while hot, dry summers and mild winters prevail in the Central Valley and western foothills portion of the region.

The lower Mokelumne River (i.e., the portion of the river downstream of Camanche Dam) is relatively narrow and fast-running immediately below Camanche Dam and becomes deeper and slower approximately 10 miles downstream of the dam. The lower portion of the river has a more gradual gradient, and travel times are longer than in the upper 10 miles. Travel times also are increased by the presence of the Woodbridge Irrigation District (WID) diversion dam (Woodbridge Dam), which backs up water to form Lodi Lake, and by tidal influence in the lowest 37.5 miles of the river.

Annual precipitation and stream flow in the Mokelumne River watershed upstream of Camanche Dam are extremely variable from month to month and from year to year. Most precipitation normally falls between November and May and very little falls between late spring and late fall. Peak flows in the Mokelumne River normally occur during winter storms or during the spring snow-melt season from March thru June. These flows decrease to a minimum in late summer or fall, and in some years, natural unimpaired flows into Pardee Reservoir in late summer or fall may be minimal to non-existent.

Variations in rainfall and runoff have a major effect on EBMUD’s ability to manage Mokelumne River water supply during normal and drought year conditions. **Figure A-1** demonstrates natural Mokelumne River runoff by water year, illustrating the wide variability in runoff. Long-term average unimpaired flow equaled 726 thousand-acre feet from water year (WY) 1929 through WY 2016. On average, the Mokelumne River contribution to total Delta inflow is around 1.4% (DWR DAYFLOW record WY 1970 through 2009).

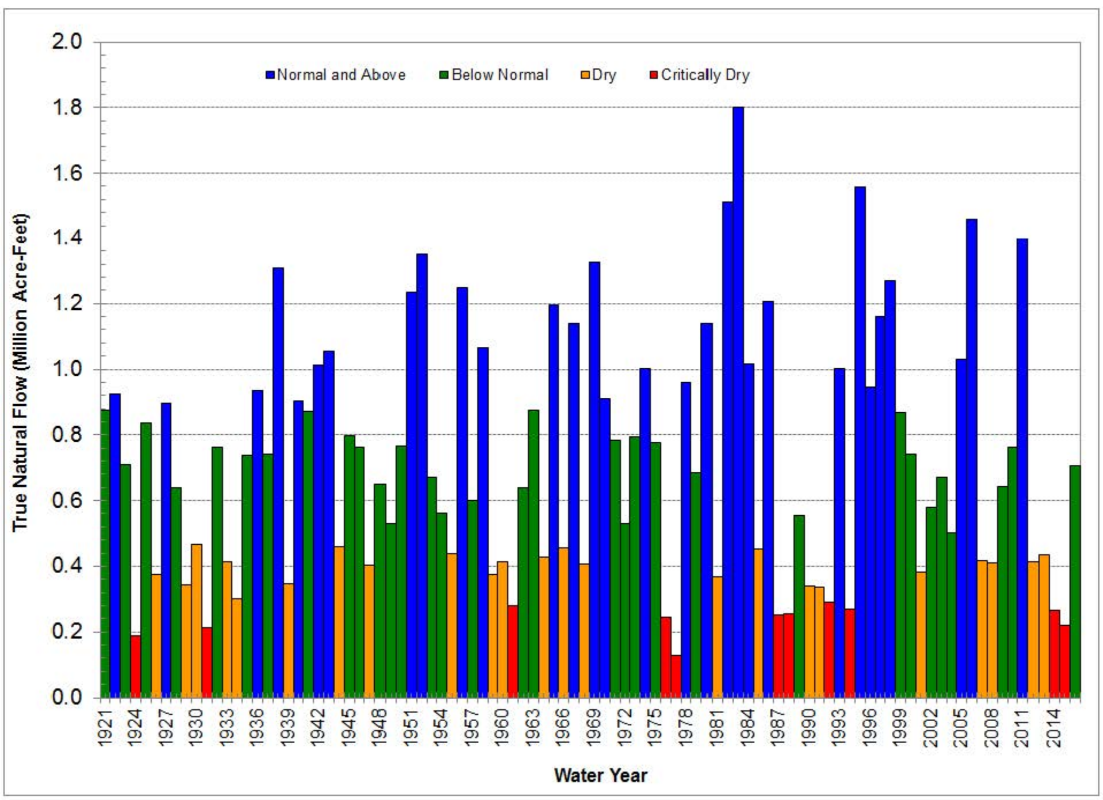


Figure A-1
Historic Mokelumne True Natural Flow

East Bay Municipal Utility District Water Supply Structures

EBMUD water supply facilities for Mokelumne River water include Pardee and Camanche Dams, their associated reservoirs, the Mokelumne Aqueducts, and the East Bay terminal storage reservoirs. During dry years, EBMUD also draws on its CVP water supplies through the FRWP to meet a portion of its dry year water demands.

Pardee Dam and Reservoir

Pardee Reservoir is located on the main stem of the Mokelumne River about 38 miles northeast of Stockton, near the town of Jackson. Construction of Pardee Dam was completed in 1929. Pardee Reservoir has 37 miles of shoreline and a maximum surface area of 2,134 acres at a spillway crest elevation of 567.7 feet. The permitted capacity of Pardee Reservoir is 209,950 acre-feet. Pardee Dam has outlets at two elevations, 260 feet and 375 feet. In comparison, the aqueduct inlets are higher up in the reservoir at approximately 480 feet, 490 feet, 520 feet, and 550 feet. EBMUD uses Pardee Reservoir principally for municipal water supply, diverting its full Mokelumne River water right allocation out of the reservoir. The reservoir also is used as a source of water for the Jackson Valley Irrigation District (JVID).

Camanche Dam and Reservoir

Camanche Dam is located 10 miles downstream from Pardee Dam on the Mokelumne River, though, at times when Camanche Reservoir is full, waters from Camanche Reservoir touch the toe of Pardee Dam, creating in effect, a single reservoir. Construction of Camanche Dam was completed in 1964. Camanche Reservoir has 62 miles of shoreline and a surface area of 7,768 acres (approximately 12 square miles) at a spillway crest elevation of 235.5 feet. The permitted capacity of Camanche Reservoir is 431,500 acre-feet. Camanche Dam has a high-level outlet at 203 feet and low-level outlet at 102 feet.

Mokelumne Aqueducts

Untreated water from Pardee Reservoir is transported approximately 91 miles to EBMUD's water treatment plants and terminal reservoir through the Pardee Tunnel, the Mokelumne Aqueducts and the Lafayette Aqueducts. The Mokelumne Aqueducts are comprised of the three 82-mile long pipelines that transport water from Pardee Tunnel to Walnut Creek. Mokelumne Aqueducts No. 1 and 2 are interconnected near Walnut Creek. The Mokelumne Aqueducts have a total capacity of 200 million gallons per day (MGD) by gravity flow and up to 325 MGD with pumping at the Walnut Creek pumping plant.

EBMUD Water Supply Reservoirs

There are five local water supply reservoirs (referred to as the terminal reservoirs): Briones, Chabot, Lafayette, San Pablo, and Upper San Leandro reservoirs. The total capacity of these reservoirs is 151,066 AF. The terminal reservoirs serve multiple functions that include regulating EBMUD's Mokelumne River supply in winter and spring, augmenting EBMUD's Mokelumne River water supply with local runoff, providing emergency supply during extended drought or other emergencies, providing local supply during high turbidity events upstream, providing environmental and recreational benefits to East Bay communities, and minimizing flooding.

Freeport Regional Water Project Facilities (FRWP)

The Freeport Regional Water Authority (FRWA) is a joint powers agency created by EBMUD and the Sacramento County Water Agency in 2002 to implement the development of the Freeport Regional Water Project. In 2011, EBMUD brought the FRWP online to allow delivery of water from the Sacramento River to customers during dry years. It also delivers surface water in all years to Sacramento County. The FRWP includes a 185-MGD water intake and pumping plant on the Sacramento River near Freeport; a 72” to 84” diameter pipeline from the intake to the Folsom South Canal; a water treatment plant for SCWA and approximately 20 miles of 72” diameter pipeline and two inline 100-MGD pumping plant to convey water from Folsom South Canal to EBMUD’s Mokelumne Aqueducts. Additionally, an 85-MGD EBMUD-CCWD raw water intertie is connected to Mokelumne Aqueduct No. 2 near Brentwood.

Freeport and CCWD

In 2006, EBMUD, FRWA, County of Sacramento and Sacramento County Water Agency entered into a long-term non-emergency agreement for water with CCWD as part of the negotiated settlement of the FRWP EIR/EIS. The agreement allows CCWD to request and receive from EBMUD 3,200 acre-feet per year at a maximum rate of 100 MGD of CCWD’s CVP contract water wheeled via EBMUD through the FRWP facilities to the EBMUD-CCWD Intertie in Brentwood.

EBMUD’s Mokelumne River Reservoir Operational Objectives

EBMUD operates Pardee and Camanche Reservoirs together as an integrated system to deliver municipal water supply of up to 325 MGD to its East Bay service area in the most energy-efficient manner using the Mokelumne Aqueducts, while meeting all other operating goals, objectives, and requirements. These other operating goals, objectives, and requirements include bypassing or releasing water from Pardee and/or Camanche Reservoirs for downstream senior water rights users, meeting downstream fishery flow requirements, regulating streamflow, using best efforts to manage water temperatures to protect fishery and public trust interests, and meeting U.S. Army Corps of Engineers (USACE or Corps) flood-control requirements. Consistent with all other operating objectives and obligations, releases from the two reservoirs also are planned to provide hydropower benefits.

East Bay Municipal Utility District Mokelumne River Water Rights

EBMUD receives its share of Mokelumne River water for municipal and industrial uses pursuant to License 11109 for Pardee Reservoir and Water Right Permit 10478 for Camanche and Pardee Reservoirs. Together, Permit 10478 and License 11109 allow delivery of a maximum of 325 MGD from the Mokelumne River (364,000 acre-feet per year).

Other Mokelumne River Entitlements and Other Supplies

The Mokelumne River serves a variety of uses, including agriculture, fisheries, hydropower, recreation, and municipal and industrial use. Before water can be put to use or diverted to storage under EBMUD's water rights, the needs of senior users (parties with older water rights priority) and fishery release requirements must be met. Riparian landowners, who have rights that are tied to the river's natural flow, and other individuals and agencies with appropriative water rights that predate EBMUD's rights, have claims on the river that are senior to EBMUD's rights.

Mokelumne River Flow and Diversions between Camanche Dam and the Delta

EBMUD's position in the hierarchy of Mokelumne River water right users is determined by a variety of agreements between Mokelumne River water right holders, the appropriative rights, permits, and licenses issued by the State, pre-1914 rights, and riparian rights. EBMUD operates Pardee and Camanche Reservoirs in a coordinated manner to meet its water supply needs while concurrently making releases from Camanche Reservoir to satisfy downstream senior rights and regulatory and environmental obligations.

Flow downstream of Camanche Dam is affected by:

- instream flow requirements under the JSA to protect and enhance conditions for the anadromous fish and ecosystem of the lower Mokelumne River;
- entitlements held by the North San Joaquin Water Conservation District (NSJWCD), and WID;
- diversions by other water right holders and riparian landowners; and
- carriage water releases for losses from evaporation, seepage from the river, and evapotranspiration by riparian vegetation.

Resulting minimum required releases from Camanche Reservoir range from about 135,000 acre-feet in critically dry years to about 315,000 acre-feet in normal and above-normal years.

Hydrologic Requirements for Fish Protection—Joint Settlement Agreement

Hydrologic requirements for fish protection are contained in the JSA, which is summarized below. Portions of the JSA pertaining directly to flows and reservoir storage, including water year type, Camanche release requirements, and hypolimnion goals, are described briefly below.

Water Year Type

The JSA specifies minimum flow releases from Camanche Dam and expected flow below the Woodbridge Dam based on time of year (for fish life stage) and water year types. For the October through March releases, water year types are determined based on the combined storage in Camanche and Pardee Reservoirs on November 5th. For the April through September releases, water year types are determined based on the unimpaired runoff into Pardee Reservoir as forecasted by the California Department of Water Resources (DWR) in the April 1 Bulletin 120 Report, unless the projected combined storage for November 5 is less than 200 thousand acre-feet (TAF), in which case the water year type would be critically dry.

Camanche Release Requirements

The JSA Camanche Dam release requirements vary throughout the year to meet the needs of the life stages of anadromous fish. Minimum release requirements range from 100 to 325 cubic feet per second (cfs) during normal and above normal water year types, 100 to 250 cfs during below-normal years, 100 to 220 cfs during dry years, and 100 to 130 cfs during critically dry years. Additional releases up to 200 cfs are required in April, May, and June in normal and above normal years, and below normal water year types depending on the combined storage in Camanche and Pardee Reservoirs relative to the maximum allowable storage for the end of the prior month.

As described above, EBMUD typically releases more than the JSA minimum flow requirements to also meet downstream senior obligations or when regulating flood-control releases. Since implementation of the JSA in 1998 (water years 1998 through 2012), annual releases from Camanche Dam have ranged from about 197 TAF in water year 2008, to about 1.2 million acre-feet in water year 2006.

The JSA stipulates that, except during emergencies or when flood-control releases are being made, decreases in flow should not be more than 50 cfs per day during October 16 through March 31 (the spawning and incubation period for anadromous fish) and not more than 100 cfs per day during the rest of the year. In addition, the JSA gainsharing provision provides that EBMUD contribute part of the actual yield from new water supplies to river flow.

Hypolimnion Goals

The hypolimnion is the cooler and denser bottom layer of water in a thermally stratified lake or reservoir. Like most deep California reservoirs, Pardee and Camanche Reservoirs become de-stratified and lose their hypolimnion during the colder part of the year. The JSA specifies that EBMUD will use its best efforts to maintain Pardee and Camanche Reservoir stratification with a minimum of 28 TAF of hypolimnetic volume in Camanche Reservoir through October whenever Pardee Reservoir volume exceeds 100 TAF. EBMUD’S Water Quality and Resource Management Program (WQRMP) specifies that the water of the hypolimnion should be less than 16.4 degrees Celsius (°C) (61.5 degrees Fahrenheit [°F]).

Other Diversions along the Lower Mokelumne River

North San Joaquin Water Conservation District

NSJWCD is an irrigation district with diversion facilities along the lower Mokelumne River, located between Camanche Dam and Woodbridge Dam. NSJWCD’s temporary water right allows NSJWCD to divert from December 1 to July 1 up to 20,000 AFY from the Mokelumne River, either directly or to storage in EBMUD’s Camanche Reservoir. NSJWCD historically has used as much as 9,488 AFY under Permit 10477, and in the last 10 years, diversions have declined to between 0 and 3,000 AFY. In dry and critically dry years, when there is no stored water surplus to meet EBMUD's municipal needs, NSJWCD typically receives no water under its entitlement.

Woodbridge Irrigation District

WID serves irrigation water to about 20,000 acres of agricultural land in San Joaquin County in the vicinity of Lodi and Woodbridge. The lower Mokelumne River flows through Lodi Lake, which is an impoundment created by Woodbridge Dam near Lodi. From this lake, WID diverts water into an extensive canal system. WID has pre-1914 water rights senior to EBMUD's Mokelumne River water rights, and also has two overlapping licensed water rights for direct diversions up to 414.4 cfs, the maximum capacity of WID Canal. These entitlements are conditioned by the water rights settlement agreements with EBMUD, which, depending on inflow to Pardee Reservoir, provide WID with firm annual diversions of 60 TAF in normal water years and 39 TAF in dry years.

Riparian and Individual Appropriators

Riparian landowners, who have rights that are tied to the river's natural flow, and other individuals and agencies with appropriative rights that predate EBMUD's rights have claims on Mokelumne River water that are senior to EBMUD's rights. These individuals and agencies include ranches, vineyards, and farms that pump water from the Mokelumne River. Downstream of Camanche Dam, pumped diversions by riparian and senior appropriative users (not including those described above) reached about 34,000 AFY in 1972 but since have declined to less than 15,000 acre-feet.

Carriage Water

EBMUD also releases carriage water from Camanche Reservoir to ensure that sufficient flow actually reaches downstream users. Flow in the Mokelumne River can be lost from evaporation, transpiration, and channel seepage into the groundwater basin. Estimates of loss rates have ranged from 57,000 to 130,000 AFY, with most of the loss occurring in the 21-mile reach between Camanche Dam and Lodi Lake near the town of Lodi (HCG 1998).

Flood-Control Requirements

The Corps' flood-control agreement with EBMUD requires that a combined storage reservation of up to 200 TAF be maintained in Pardee and Camanche Reservoirs between September 15 and July 31 of each year. A portion of the 200 TAF flood-control reservation may be transferable, up to a maximum of 70 TAF, to available space in PG&E's Salt Springs and Lower Bear Reservoirs. By November 5, between 130 TAF and 200 TAF of flood-control reservation must be created in Pardee and Camanche Reservoirs. The flood-control reservation must be maintained at least through mid-March and potentially into July in years of heavy snow accumulation.

EBMUD Water Demands

EBMUD's demand fluctuates seasonally and can also change from year to year. Factors that can affect demand include changes in population, changes in customer usage patterns or changes in customer class, droughts and customer rationing, temperature and climate, and the results of water recycling and conservation programs.

In 2015, EBMUD published the Urban Water Management Plan (UWMP 2015), which provided a broad overview of the EBMUD system, its supplemental supplies, and its demand management efforts. The UWMP 2015 also included an update on demand projections out to the year 2040, using a land-use based methodology informed by the general plans of service area Cities and Counties. As explained more thoroughly in the UWMP 2015, EBMUD found that the effects of drought and economic recession resulted in lower demand than would occur under normal circumstances, but that demands are still expected to increase back to 2040 projected demand levels as development and water use return to pre-drought and pre-recession conditions.

The UWMP 2015 included a planning level demand in 2015 of 190 MGD. For analytical purposes, the No Project/No Action Alternative assumes EBMUD's demand is190 MGD for the Existing Condition. This level of demand does not reflect short-term reductions in demand caused by rationing during the most recent drought. EBMUD considered customer demand over a range of time periods when determining what demand level would best characterize existing conditions. EBMUD ultimately chose to use the UWMP's 2015 level of demand of 190 MGD to recognize its currently lower levels of customer demand while minimizing bias in the demand estimate introduced by the extraordinary weather conditions—and accompanying regulatory mandates—that occurred during the last drought.

For the Future Conditions, the UWMP 2015 projects a demand of 230 MGD in the year 2040. This increased demand reflects anticipated development in EBMUD's service area based on City and County general plans. Planned increases in EBMUD's water recycling and conservation programs are factored into this value as well.

A.2 Description of EBMUD Component of the Phase 2 Expansion Project

The EBMUD component of the Phase 2 Expansion project consists of the use of existing EBMUD and Freeport Regional Water Project (FRWP) facilities to develop a mutually beneficial partnership with CCWD, the Local Agency Partners, and Refuges.

The EBMUD component of the of the Phase 2 Expansion includes two separate scenarios: The first scenario, *Transfer and Exchange of Water Supplies*, would transfer a portion of existing EBMUD Mokelumne River water supplies in certain wet years to CCWD, the other Local Agency Partners, or Refuges, and in return, EBMUD would obtain dry-year water supplies from CCWD or the other Local Agency Partners. The second scenario, W*heeling by EBMUD* would utilize existing EBMUD facilities to wheel water for CCWD, the other Local Agency Partners, or

Refuges. Both of these scenarios are included in all of the action alternatives of the Phase 2 Expansion project.

Scenario One: Transfer and Exchange of Water Supplies

Under Scenario One, EBMUD would utilize existing EBMUD facilities on the Mokelumne River, Mokelumne Aqueduct 2, and the EBMUD-CCWD Intertie to transfer and convey water to Los Vaqueros Reservoir for CCWD, the other Local Agency Partners, or Refuges. Transferred water would be conveyed into the Los Vaqueros Pipeline at a maximum rate of 85 MGD via Mokelumne Aqueduct No. 2, through the EBMUD-CCWD Intertie, and either into storage in Los Vaqueros Reservoir or directly delivered to CCWD, the other Local Agency Partners, or Refuges. It is anticipated that EBMUD would most likely transfer water to the Phase 2 Expansion system in the months of May and June when both water supplies and unused capacity are available in EBMUD's Mokelumne River facilities. However, depending on a myriad of factors including hydrology and EBMUD service area demands, it is possible that transfer window of opportunity could occur over a longer period of time from May through October.

To ensure that the transfers would not adversely affect EBMUD's long-term operational needs, the following limitations would apply to EBMUD transfers to the Phase 2 Expansion system of water available under EBMUD's Mokelumne River water rights:

- Transfers would only occur in years when EBMUD anticipates making flood control releases ("Wet Years").
- Transfers would be limited to 15 TAF annually and would occur no more than two years in a row, such that in any two-year period, no more than 30 TAF of water would be transferred.
- Following any two consecutive years in which transfers totaling 30 TAF are made, no transfers would occur for at least three years.
- EBMUD would retain sole discretion to determine whether to implement transfers, subject to the limits set forth above.

In return for EBMUD transfers of Mokelumne River Wet Year water to the Phase 2 Expansion system, through a series of exchanges with CCWD and Local Agency Partners, EBMUD will have an option to purchase up to 30 TAF per year of CCWD or other Local Agency Partner's water supplies during dry years when EBMUD is seeking additional water supplies. The exchanged water may be diverted at the Freeport Intake and conveyed to EBMUD's service area; no new facilities are needed to enable this exchange. The exchanged waters may also be conveyed from Los Vaqueros Reservoir storage to EBMUD's system; additional facilities would be required to enable delivery of water in this manner. In particular, EBMUD would need to make upgrades at the EBMUD-CCWD Intertie in order to move water into EBMUD's system at sufficient pressures and rates. EBMUD would also need to upgrade the pumps at its Walnut Creek Pumping Plant (WCPP) to include variable frequency drives (VFDs). Following is a brief discussion of those facilities; construction impacts associated with these facilities are analyzed in Chapter 4.

EBMUD-CCWD Intertie Pump Station

A new pump station would be constructed at the EBMUD-CCWD Intertie and used to lift water from the Los Vaqueros Pipeline to Mokelumne Aqueduct No. 2. In order to be conservative for this analysis, it is assumed that a high-lift pump station would provide the 300 feet of head needed to lift water from the Transfer Facility to the EBMUD-CCWD Intertie at 85 mgd. However, a lower power pump station may be sufficient. The pump station would be approximately 9,675 square feet in size; note that this does not include any land that would be needed for an electrical substation or other similar facility, if needed. The pump station would consist of four 2,000-hp pumps (three running to provide 85 mgd plus one standby pump). This pumping plant could cause very high surge pressures on the Los Vaqueros Pipeline, so significant surge controls would be needed. EBMUD would need to purchase land for the pump station.

Variable Frequency Drives at Walnut Creek Pumping Plant

While making deliveries to Los Vaqueros Reservoir, EBMUD would need VFD capability at the WCPP in order to balance raw water flows coming in to meet demands in the EBMUD service area. Currently EBMUD meets customer demand by managing flow rates on the three separate aqueducts, using a combination of pumping and gravity flows. The ability to throttle pumping on these aqueducts is limited. If one or more aqueduct were dedicated to conveying flows to or from the Los Vaqueros Pipeline, it would be very challenging operationally to balance the flows coming into the WCPP with the EBMUD system demands on the other side. VFDs are therefore needed on all three lines to adjust supply to demand while managing deliveries from the Los Vaqueros Pipeline.

The installation of VFDs at the WCPP would require the construction of two new buildings to house the VFDs. A new structure approximately 200’ by 25’ and 20’ tall would be located adjacent to the building housing Walnut Creek Raw Water Pumping Plants 1 and 2. A second structure, 180’ by 25’ and 15’ tall, would be located next to Pumping Plant #3. Both of these structures would be located on existing EBMUD property.

Scenario Two: Wheeling by EBMUD

Under Scenario Two, EBMUD would use existing EBMUD facilities including the FRWP, the Folsom South Canal Connection (FSCC), Mokelumne Aqueducts No. 1 and 2, and the EBMUD-CCWD Intertie to divert up to 30 TAF per year of CCWD and other Local Agency Partners water supplies. These water supplies could include both CVP and non-CVP supplies. At its sole discretion, EBMUD would determine when sufficient unused capacity is available in its facilities to wheel water supplies to the Los Vaqueros Pipeline. Sufficient capacity in EBMUD facilities would most likely be available in Wet Years from October through February when EBMUD’s service area demands are lower and only Mokelumne Aqueduct No. 3 is needed to meet EBMUD demands. The maximum flow rate would be 85 MGD from October through February. Since both Mokelumne Aqueducts No. 1 and 2 are interconnected at Walnut Creek, both Aqueducts need to be dedicated to wheel water supplies from the Sacramento River to Los Vaqueros Reservoir.

EBMUD Existing Mokelumne River Water Rights for Municipal Use

The water to be used for Scenario One (transferring EBMUD's extra Mokelumne River water to CCWD, the other Local Agency Partners, or Refuges) would be water available under EBMUD's water right License 11109 (Application 4228) and Permit 10478 (Application 13156). Since the 1920's, EBMUD's primary source of water has been the Mokelumne River. EBMUD diverts Mokelumne River water for municipal and hydroelectric uses pursuant to a series of rights including License 11109 and Permit 10478 for municipal uses and License 1388, License 6062, Permit 10479, and Permit 17378 for hydroelectric uses.

EBMUD's facilities associated with the Mokelumne River include Pardee and Camanche Dams and Reservoirs, hydro-electric power generation facilities at the base of each dam, the Mokelumne Aqueducts which convey water from Pardee Reservoir to the East Bay, and the Camanche Reservoir Fish Hatchery. EBMUD operates Pardee and Camanche Reservoirs together as an integrated system to efficiently deliver municipal water supply to the EBMUD service area while meeting all regulatory requirements and contractual obligations.

EBMUD's water rights have the following existing key parameters and attributes:

L11109

- Priority Date: September 22, 1924
- Direct Diversion: 310 cfs (year-round)
- Point of Diversion: Pardee Dam
- Collection to Storage: 209,950 AF (Oct 1-Jul 15)
- Total Beneficial Use: 224,037 AF per year
- Total Taken from the source: 316,250 AF per year
- Purpose of Use: Municipal and Recreational
- Place of use: EBMUD's service area and Pardee Reservoir

P10478

- Priority Date: June 16,1949
- Direct Diversion: Dec 1through July 1, up to 194 cfs
- Diversion to Storage: Dec 1 through July 1, up to 353,000 AF
- Point of Diversion: Pardee and Camanche Reservoirs
- Total Beneficial Use: 140,000 AF per year
- Purpose of Use: Municipal and Industrial, Recreational, Fish and Wildlife Preservation and Enhancement
- Place of use: EBMUD's service area, Pardee and Camanche Reservoirs, and Mokelumne River Fish Hatchery

Petitions Necessary to Facilitate the EBMUD Component of the Phase 2 Expansion Project

Scenario One: Transfer and Exchange of Water Supplies

EBMUD would file a change petition with the State Water Resources Control Board to allow for the long-term/temporary transfer of EBMUD's extra Mokelumne River water to Phase 2 Expansion project partners to store in Los Vaqueros Reservoir. The petition will seek to add the service areas of CCWD, the other Local Agency Partners, and Refuges as additional places of use for EBMUD water rights License 11109 and/or Permit 10478. It is possible that a companion change petition to add Los Vaqueros Reservoir as point of rediversion to EBMUD water rights may also be required (Note that both changes can be accomplished with a single change petition).

For CCWD or other Local Agency Partners to be able to transfer a portion of their CVP Contract water to EBMUD through the Freeport facilities, a forbearance agreement with Reclamation would be needed. However, for other Local Agency Partners to be able to transfer a portion of their appropriated non-CVP water to EBMUD, they would need to submit a change petition to the State Water Resources Control Board adding the Freeport Intake as a point of rediversion and adding the EBMUD service area to their place of use.

Scenario Two: Wheeling by EBMUD

In this scenario, no change to EBMUD water rights would be needed, because EBMUD would simply be wheeling water for CCWD, Local Agency Partners, or Refuges. However, change petitions to add a point of rediversion at the Freeport Intake may be needed on CCWD or the other Local Agency Partners' water rights.

A.3 Water Resources

This Section describes Pardee and Camanche Reservoir integrated operations and describes the water resources in the Lower Mokelumne River. The section also assesses the significance of impacts on water resources including fishery and other ecosystem impacts associated with the EBMUD component of the Phase 2 Expansion.

Upstream of Pardee Reservoir

Annual precipitation and streamflow in the Mokelumne River watershed are extremely variable from month to month and from year to year. Most precipitation normally falls between November and May, with very little falling between late spring and late fall. Runoff is generally dominated seasonally by snowmelt, with the highest flows in April through June of wet years. The average annual flow into Pardee Reservoir is about 723 TAF, with a range from less than 324 TAF (10th percentile) to about 1,211 TAF (90th percentile).

Pardee and Camanche Reservoirs

Pardee Reservoir typically is operated between 170,000 and 200,000 acre-feet and has ranged from 48,000 acre-feet (March 1977) to 212,000 acre-feet (May 1984). Camanche Reservoir typically is operated from 270,000 to 340,000 acre-feet and has ranged from approximately 9,200 acre-feet (February 1989) to 423,000 acre-feet (July 1967).

Operations of the two reservoirs are coordinated to achieve multiple objectives. These objectives are to provide municipal water supply benefits, streamflow regulation, fishery/public trust interests, flood control, obligations to downstream diverters, and water temperatures suitable for anadromous fish in the lower Mokelumne River.

Downstream of Camanche Reservoir

The amount of flow in the lower Mokelumne River is important to the anadromous fish that use the river downstream of Camanche Dam. Flow in the Mokelumne River is also important for

- maintaining riparian vegetation,
- providing water supply for downstream users,
- providing recreational opportunities, and
- improving water quality.

Historical flow patterns, including the occurrence of high-flow events, are described below.

Flow Patterns

Flow downstream is principally moderated by Camanche Dam. However, there is still variation in Mokelumne River flows as shown in **Figure A-2**. Based on flow data from water years 1966 through 2012, in years with high flows (90th percentile), the Camanche release flows are highest during May. In contrast, during years with average flow, water is stored in the reservoirs and peak reservoir releases tend to occur in June.

During April, May, and June during normal and above and below-normal water year types, the JSA requires additional releases from Camanche Dam of up to 200 cfs based on Pardee and Camanche storage levels. These additional flows are reflective of the seasonal pattern of flows in the Mokelumne River basin (Figure A-2).

High-Flow Events

High-flow events can have both negative and positive effects. For example, high flows may improve conditions for fish by removing fine sediment and aiding migration but could also damage agricultural lands, property and structure. In the lower Mokelumne, studies indicate floodplain inundation occurs at flows above 3000 cfs. Approximately 32% of water years 1966 through 2012 had 10 or more days with daily flows that exceeded 3000 cfs.

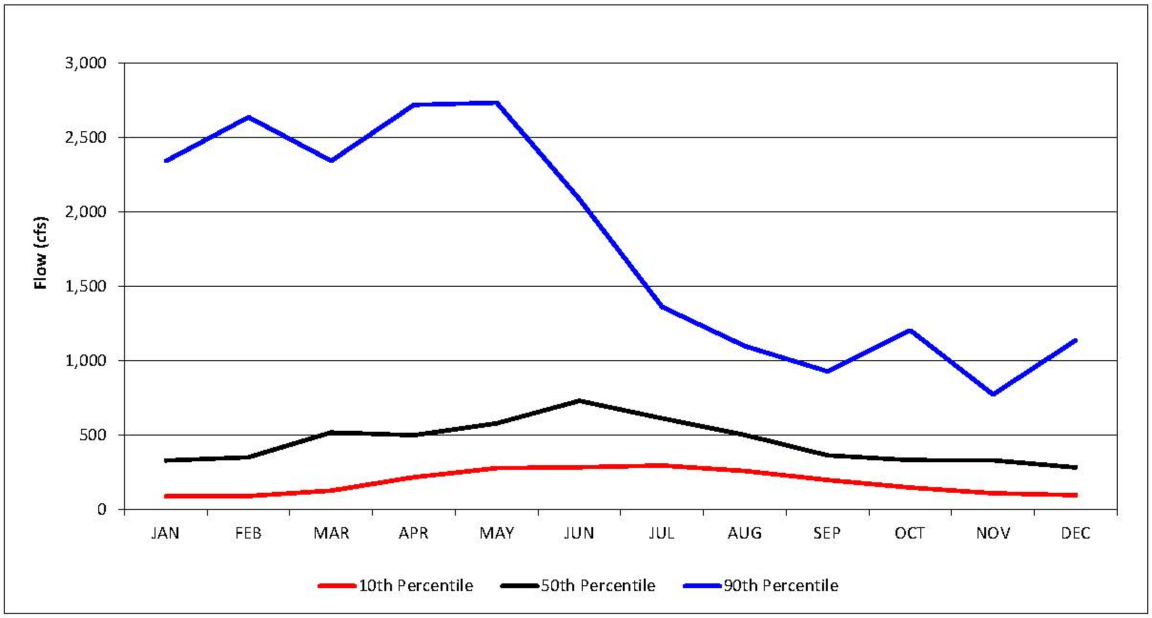


Figure A-2
Average Monthly Flow Releases from Camanche Reservoir for Calendar Years 1966 through 2012

Water Quality

Source waters from the Sierra Nevada to the upper Mokelumne River basin provide excellent water quality. Minimal treatment is needed to meet drinking water health standards for Mokelumne River water. EBMUD further protects water quality at Pardee Reservoir through reservoir use limitations (i.e., prohibition of body contact recreation) and the purchase of conservation easements in areas with significant potential for residential development adjacent to Pardee Reservoir. As a result, the raw water is not exposed to common sources of contaminants such as pesticides, agricultural or urban runoff, municipal sewage discharges, or industrial toxics. There are, however, some water quality issues of concern. Pardee and Camanche Reservoirs are listed as impaired waters on the Central Valley Regional Water Quality Control Board's (CVRWQCB's) proposed changes to the 303(d) list (CVRWQCB 2012). Pardee Reservoir is listed as impaired based on the presence of elevated mercury levels, and Camanche Reservoir is listed as impaired based on the presence of elevated copper, mercury, and zinc levels. Toxic substances, as well as some other water quality constituents of concern for fish and drinking water quality are discussed below.

Water Temperature

Water temperature is the main water quality issue considered to be affected by the Phase 2 Expansion project. The following sections describe the use of critical threshold Camanche Reservoir water surface elevation of 190 feet above mean sea level to determine the potential for temperature impacts in the lower Mokelume River.

Coordinated Operation of Pardee and Camanche Reservoirs to Maintain Cold Water Releases

EBMUD operates Camanche Reservoir and Pardee Reservoir in an integrated manner to maintain low temperatures for fish migration, spawning, egg incubation, and juvenile rearing. This is done by preserving when feasible the coldwater pool (i.e., hypolimnion) in the lower depths of Pardee and Camanche Reservoirs over the summer so that cold water is available for release to the lower Mokelumne River during the fall when warm water temperatures might otherwise adversely affect spawning and incubation of Chinook salmon. However, release temperatures during the summer also are monitored to ensure adequate temperatures for juvenile steelhead rearing in the lower Mokelumne River. EBMUD has developed an operational approach to managing the two reservoirs so that, to the extent feasible, the coldwater hypolimnion in both Camanche and Pardee Reservoirs can be used to maintain stratification. The coldwater supply is used judiciously based on results of water quality monitoring, weekly review of conditions, modeling, and forecasting.

Water Temperature Monitoring and Critical Camanche Storage Threshold of 190 Feet Mean Sea Level (msl)

Water temperatures are monitored at four monitoring stations downstream of Camanche Reservoir: McIntire, Elliott, Golf, and Frandy. These sites are located approximately 1, 10, 24, and 33 miles downstream of Camanche Dam, respectively. Station McIntire temperatures serve as a measure of the temperatures from the Camanche Dam releases and supports salmon and steelhead spawning habitat. Station Elliott is at the downstream end of the primary Chinook salmon and steelhead spawning habitat, Station Golf is located immediately downstream of Woodbridge Dam and is the migration corridor for salmon and steelhead, and Station Frandy is located furthest downstream where the river is tidally influenced. Water temperatures measured at Station Frandy can be influenced by a number of factors, including tide, Delta water temperatures, and Delta diversions.

During periods of drought when Camanche Reservoir storage is drawn down, there is the potential for the coldwater supply at the bottom of Camanche to be depleted. Under these circumstances, release temperatures may increase. As reservoir elevation drops and the hypolimnion is depleted, the low-level outlet at Camanche Reservoir may begin to draw some water from the warmer metalimnion. Because the height of the different temperature layers in the reservoir (hypolimnion, metalimnion, and epilimnion) is variable, there is no consistent, precise reservoir elevation threshold for affecting release temperatures. EBMUD's most recent studies indicate that during March thru October, an elevation of 190 feet appears to be the highest elevation at which release temperatures might be affected by low storage levels.[1] Therefore, this threshold is used to determine potential temperature-based impacts to Lower Mokelumne River resources.

1 Permit 10478 Time Extension Project, Draft EIR- September 2014

Toxic Substances

Penn Mine, a former copper and zinc mine located approximately 10 miles upstream of Camanche Dam, historically has been the source of high concentrations of the trace metals copper, zinc, and—to a lesser extent—cadmium in the river. In 2003, EBMUD and CVRWQCB completed a cleanup of the Penn Mine site and were successful in returning the property to a natural pre-mining condition. Therefore, runoff from Penn Mine is no longer a source of concern.

Dissolved Oxygen

The dissolved oxygen objective presented in the water quality control plan (WQCP) for the Sacramento River and San Joaquin River basins is that dissolved oxygen concentrations should not fall below 7.0 milligrams per liter (mg/L) (CRWQCB 2016). In 1993, EBMUD installed, and since has successfully operated, a hypolimnetic oxygen-diffuser system (hypolimnetic oxygenation system [HOS]) in Camanche Reservoir that has eliminated hydrogen sulfide problems at the downstream Mokelumne River Fish Hatchery.

Turbidity

Turbidity is the condition of cloudiness or haziness caused by suspended solids in the water. On rare occasions, the water supply in Pardee Reservoir is affected by short-term events and/or episodic events that may stir up sediments. High turbidity caused by unusually heavy late winter storms and/or landslides into Pardee Reservoir has created periods of poor water quality that have limited the Mokelumne water supply available for domestic use. In such cases, the Mokelumne Aqueducts supplying water to the EBMUD service area were shut down, or their flows were reduced until turbidity levels returned to acceptable levels.

Regulatory Setting

This section describes the regulations and policies relevant to water resources on the Mokelumne River affected by the EBMUD component of the Phase 2 Expansion project. The potential physical changes to the environment from construction for the EBMUD component of the Phase 2 Expansion are analyzed in Chapter 4. The discussion below focuses only on those regulations that are potentially relevant to the Mokelumne River resources in relation to the EBMUD component of the Phase 2 Expansion.

Porter-Cologne Water Quality Control Act

In 1967, the Porter-Cologne Act established the State Water Board and nine regional water quality control boards (RWQCBs) as the primary state agencies with regulatory authority over California water quality and appropriative surface water rights allocations. Under this act (and the federal Clean Water Act), the state is required to adopt a water quality control policy and waste discharge requirements to be implemented by the State Water Board and the nine RWQCBs. The State Water Board also establishes WQCPs and statewide plans. The RWQCBs carry out State Water Board policies and procedures throughout the state.

WQCPs, also known as basin plans, designate beneficial uses for specific surface water and groundwater resources and establish water quality objectives to protect those uses. WQCPs define surface water quality objectives for multiple parameters, including suspended material, turbidity, pH, dissolved oxygen, bacteria, temperature, salinity, toxicity, ammonia, and sulfides.

2016 Water Quality Control Plan for the Central Valley

The Central Valley WQCP (CVRWQCB 2016) contains water quality objectives for the region that includes the Mokelumne River. The WQCP does not have specific temperature objectives for the Mokelumne River other than that temperature of receiving water should not be increased by more than 2.8°C (5°F). For this objective, the WQCP states "appropriate averaging periods may be applied provided that beneficial uses will be fully protected."

1995 and 2006 Water Quality Control Plans and Decision 1641 for the Delta

The 2006 WQCP is the most recent WQCP for the Delta; however, no changes in water quality objectives were made from the 1995 WQCP. The State Water Board's 1995 WQCP (adopted May 1995) and the Final EIR for implementation (November 1999) incorporated several elements of the U.S. Environmental Protection Agency (USEPA), National Marine Fisheries Service (NMFS), and U.S. Fish and Wildlife Service (USFWS) regulatory objectives for salinity and endangered species protection. The changes from the previous regulatory limits for CVP and SWP Delta operations (Decision 1485) were substantial. The State Water Board fully implemented the 1995 WQCP with D-1641 in March 2000.

In D-1641, the State Water Board balanced the need for water for ecosystem benefits and consumptive needs and found that it would not be in the public interest to require more water from the Mokelumne River system than would be provided under the JSA. The State Water Board further concluded that Decision 1641 established EBMUD's responsibility to help meet Delta flow-dependent objectives.

State Water Board Resolution 68-16 (1968) states that water quality in the state will be regulated to achieve the "highest water quality consistent with maximum benefit to the people of the State." The principles of this resolution are upheld by the RWQCBs. The State Water Board is currently in the midst of considering updates to the Water Quality Control Plan. In September 2016, the State Water Board issued a Revised Draft Substitute Environmental Document for Flow Requirements on the Lower San Joaquin River and Salinity Standards for the Southern Delta. The Mokelumne River is an eastside tributary and will be addressed in the Phase 2 of the Bay-Delta Plan Update.

Assessment of Impacts

This section summarizes the No Project/No Action Alternative hydrologic conditions and changes in these conditions that are expected to occur under the EBMUD component of the Phase 2 Expansion. The modeling methods and results that are summarized in this water resources section also were used to evaluate EBMUD component of the Phase 2 Expansion effects for other resources, particularly fish. Results and figures from the modeling are shown in Appendix A-1.

As discussed earlier in this appendix, the EBMUD component includes a 'Wheeling by EBMUD' scenario under which EBMUD would wheel water for CCWD, other Local Agency Partners, and Refuges by utilizing EBMUD's excess capacity at FRWP and Mokelumne Aqueducts No. 1 and 2. This proposed operation is similar to the current operations wherein EBMUD, as part of the Freeport Settlement, wheels a portion of CCWD's CVP supplies through the FRWP facilities and Mokelumne Aqueducts No. 1 and 2. The dedication of both Mokelumne Aqueducts No. 1 and 2 for CCWD, other Local Agency Partners, and Refuges use would result in less water being diverted from the Mokelumne River and would likely result in marginally higher Pardee and Camanche Reservoir storage levels when Phase 2 Expansion project operations are utilizing Mokelumne Aqueducts No. 1 and 2. Higher storage levels in Pardee and Camanche Reservoir generally result in a higher likelihood that water surface elevations in Camanche Reservoir would be above the critical threshold of 190 ft mean sea level. As a result, higher storage levels could provide marginal benefits to the lower Mokelumne River resources by keeping water temperatures cooler and providing marginally higher flood flow releases in the following years. During the time period when additional waters are diverted from the Mokelumne to recover terminal reservoir storage, the storage levels in Pardee and Camanche would likely be lower; model results indicate that the average reduction in carryover storage would be only 1227 AF out of a total storage volume of 600-650 TAF, which is not a significant difference. Therefore, this document does not assess the potential environmental impacts to the lower Mokelumne River resources associated with this aspect of the EBMUD component of the Phase 2 Expansion.

Under the 'Transfer and Exchange' scenario when EBMUD would obtain exchanged water from CCWD or other Local Agency Partners, both Mokelumne Aqueducts No. 1 and 2 would need to be dedicated to move water from the Los Vaqueros Pipeline to EBMUD's conventional treatment plants. As a result, EBMUD would only be able to use Mokelumne Aqueduct No. 3 to divert Mokelumne River supplies. Therefore, EBMUD would divert less water from the Mokelumne River, which would result in higher storage levels in Pardee and Camanche Reservoirs. The FRWP EIR (certified in 2004) analysis concluded that Pardee and Camanche Reservoirs would be expected to have storage gains when supplemental supplies are used to meet EBMUD's service area demands. Similar to the discussion above, higher storage levels in Pardee and Camanche Reservoir generally result in a higher likelihood that water surface elevations in Camanche Reservoir would be above the critical threshold of 190 ft mean sea level. As a result, higher storage levels could provide marginal benefits to the lower Mokelumne River resources by keeping water temperatures cooler and providing marginally higher flood flow releases in the following years. Therefore, this document does not assess the potential environmental impacts to the lower Mokelumne River resources associated with this aspect of the EBMUD component of the Phase 2 Expansion.

This analysis evaluates the potential changes in hydrology associated with the EBMUD component of the Phase 2 Expansion project when EBMUD transfers water to Los Vaqueros Reservoir. Pardee and Camanche Reservoir storage along with lower Mokelumne River flows were simulated with EBMUD's reservoir operations planning model, Riverware. Potential changes in lower Mokelumne River water temperatures were assessed based on Camanche Reservoir water surface elevation of 190 feet.

RiverWare Modeling

RiverWare is a generalized river basin modeling software for simulating the operations of a water supply system. It was developed by USBR and USGS as a management tool. RiverWare is supported by a number of other agencies and research universities. The software facilitates data input and output efficiently enough for real time operations and provides a selection of water facilities and solution algorithms, all through a graphical user interface. RiverWare is EBMUD's reservoir operations planning model that simulates the operation of EBMUD's current Mokelumne River water supply system under the regulatory constraints that EBMUD must observe. The RiverWare model is used to analyze system performance given the effects of facility modifications, changes in operating rules and regulation, and supplemental water supply options.

The RiverWare model was used to simulate No Project/No Action Alternative hydrologic conditions and conditions with EBMUD component of the Phase 2 Expansion.

Drought Planning Sequence

EBMUD uses historical hydrologic data to inform its modeling and planning for future droughts. The worst hydrologic drought event in EBMUD's history was the 1976-77 drought, when runoff was only 25 percent of average and total reservoir storage decreased to 39 percent of normal. Fortunately, a very wet year in 1978 followed the critically dry year of 1977 and contributed to the water system's rapid recovery. Although the 1976-1977 drought only lasted for two years, to plan for the possibility of an extended drought lasting three years, EBMUD typically uses a three year "drought planning sequence" (DPS) to assess the adequacy of its water supply. The first and second years of this DPS are modeled using the actual runoff that occurred in 1976 and 1977, the driest recorded two-year period. The simulated runoff in the third year is 185 TAF, which is the average from 1976 and 1977.

RiverWare Results

Reservoir Storage

Increased aqueduct diversions to transfer water to CCWD could result in slightly reduced storage in Pardee and Camanche Reservoirs in certain months when water is transferred to CCWD. However, storage levels in Pardee and Camanche Reservoirs will be slightly higher than No Project/No Action Alternative when EBMUD is able to divert exchanged water from Freeport. With the implementation of the EBMUD component of the Phase 2 Expansion, Pardee storage remained stable with little to no changes in storage as compared to No Project/No Action Alternative conditions. Under implementation of the EBMUD component of the Phase 2 Expansion, the maximum reduction in storage level at Pardee is 9500 AF (in simulated September 1979); which translates to 4.8% of Pardee Reservoir capacity of 198 TAF. Results indicate that this change is temporary and Pardee storage recovers to No Project/No Action Alternative levels by December 1979. **Figure WR-1** in Appendix A-1 plots the Pardee storage levels under No Project/No Action Alternative and with the EBMUD component of the Phase 2 Expansion. The insets are included to provide further context to view the changes. The figure illustrates that there is no appreciable difference in Pardee Reservoir storage levels between No Project/No Action Alternative and with the EBMUD component of the Phase 2 Expansion.

As expected, Camanche Reservoir storage levels slightly decline when water is delivered to CCWD and are generally higher in the exchange years when water is delivered to EBMUD. With the EBMUD component of the Phase 2 Expansion, the maximum decline in Camanche Reservoir storage is 17, 830 AF in simulated December 1979 - which translates to 2.06% of Camanche Reservoir capacity of 417 TAF. Results indicate that this decline last just two months and Camanche storage recovers to No Project/No Action Alternative levels by March 1980. Figure WR-2 in Appendix A-1 graphs the Camanche storage levels under No Project/No Action Alternative and With the EBMUD component of the Phase 2 Expansion. The insets are included to provide further context regarding the nature and magnitude of changes. As shown in Figure WR-2, in Appendix A-1 there is no appreciable difference in Camanche Reservoir storage levels as a result of the EBMUD component of the Phase 2 Expansion.

EBMUD considers end of September to be the end of the water year. Figure WR-3 in Appendix A-1 graphs EBMUD's end-of-September total system storage to determine the impacts, if any, to carryover storage. The results indicate that the carryover storage in EBMUD total system storage decreases by about 1227 AF on average with the implementation of the EBMUD component of the Phase 2 Expansion. The carryover impact of just 1227 AF is minor when compared to EBMUD total system storage of 572 TAF. The figure indicates that in dry years – when EBMUD is able to obtain exchanged water supplies from the Phase 2 Expansion project – EBMUD total system storage increases by 6 TAF to over 20 TAF in simulated September 1989. Similarly, in wet years, when EBMUD transfers water to CCWD, the other Local Agency Partners, and/or Refuges, EBMUD relies upon water previously stored in its terminal reservoirs, and EBMUD's total system storage decreases slightly. EBMUD total system storage recovers during the years following deliveries to CCWD, the other Local Agency Partners, and/or Refuges. The minor reduction in overall carryover storage is less than significant. It is also worth noting that RiverWare incorporates operational guidelines for the reservoirs, including the terminal reservoirs; as a result, the model prioritizes maintaining reservoir storage levels within these operational guidelines. EBMUD has a policy of maintaining 180 days of emergency storage in its East Bay terminal reservoirs; changes in terminal storage levels generally occur within these guidelines.

Camanche Releases and Flow in the Lower Mokelumne River

Implementation of the EBMUD component of the Phase 2 Expansion results in negligible reductions in total Camanche releases. Figure WR-4 2 in Appendix A-1 provides a comparison of the Camanche releases under conditions with the EBMUD component implemented versus No Project/No Action Alternative conditions over the 92-year period of record. The figure shows how similar total Camanche releases are under these two conditions. The insets included in the figure illustrate the nature of the changes during assorted time periods.

Under No Project/No Action Alternative conditions, the total Camanche releases over the 92-year period of record (CY 1921-2012) are 48.020 Million Acre-Feet (MAF). With the EBMUD component of the Phase 2 Expansion, the total releases would be 47.670 MAF, resulting in a total reduction of 350,000 Acre-feet (i.e., a 0.7 % reduction in total Camanche releases over the 92-year period of record). The No Project/No Action Alternative average Camanche releases per month during this period are 43,614 AF per month (722 cfs), and the average Camanche releases per month under the Phase 2 Expansion project are marginally smaller at 43,297 (717 cfs).

Therefore, the overall monthly average reduction in Camanche releases is 317 AF (5.25 cfs). With the EBMUD component of the Phase 2 Expansion- when EBMUD transfers water to CCWD, the other Local Agency Partners, and/or Refuges, Camanche releases are reduced in 364 months out of 1,104 months in the period of record with an average reduction of 1257 AF per month (20.82 cfs reduction out of a monthly average flow of 722 cfs). However, when EBMUD obtains exchanged waters from CCWD or the other Local Agency Partners, Camanche releases are increased in 165 months with an average increase of 660 AF per month (11 cfs).

Minimum Required Releases

As described above, EBMUD typically releases more than the JSA minimum flow requirements to also meet downstream senior obligations or when regulating flood-control releases. Under No Project/No Action Alternative conditions, the average minimum required releases per month are 20,096 AF (332.8 cfs). With the EBMUD component of the Phase 2 Expansion, the average minimum required releases per month are 20,084 AF (332.6 cfs) resulting in a difference of just 0.059% or 0.2 cfs reduction compared to the No Project/No Action Alternative. See **Figure WR-5** 2 in Appendix A-1.

Flood Control Releases

A portion of the total Camanche release includes releases to meet the November 5th flood control requirement. Under No Project/No Action Alternative conditions, the total Camanche flood control release is 24.788 MAF over the 92-year period of record. With the EBMUD component of the Phase 2 Expansion, the total Camanche Flood Control release over the 92 year period of record is 24.452 MAF (a reduction of 1.4%). The No Project/No Action Alternative average monthly flood control release is 374 cfs, and With the EBMUD component of the Phase 2 Expansion the average is 369 cfs, resulting in an average monthly reduction in flood flows of 5 cfs (1.3%). The results indicate that when waters are transferred to CCWD, flood control releases are reduced by 21 cfs in certain months, and when EBMUD obtains exchanged water from CCWD or other Local Agency Partners, flood control releases increase by 11 cfs in certain months. **Figure WR-6** 2 in Appendix A-1 illustrates the minor changes in flood control releases over the period of record.

Flows Below WID

The total flows below WID under No Project/No Action Alternative conditions during the 92-year period of record are 36.859 MAF, and with the EBMUD component of the Phase 2 Expansion, total flows below WID are 36.511 MAF, resulting in a slight reduction of about 0.94% over the 92-year period of record. Average monthly flows below WID over the 92-year period of record under No Project/No Action Alternative conditions are 556 cfs, and average monthly flow below WID with the EBMUD component of the Phase 2 Expansion are 551 cfs. With the EBMUD component of the Phase 2 Expansion– when EBMUD transfers water to CCWD – flows below WID are reduced in 364 months (out of the 1104 months in the period of record) on average by 1,256 AF/month (20.8 cfs, which translates to a 3.7% reduction).However, when EBMUD obtains exchanged waters from CCWD or the other Local Agency Partners, flows below WID are increased in 163 months, with an average increase of 667 AF per month (11 cfs or 2%). Results indicate that the maximum reduction of 284 cfs occurs in January 1980; No Project/No Action Alternative flows during this time period are 1,356 cfs, or nearly two times the average monthly flows.

Figure WR-7 2 in Appendix A-1 illustrates the slight reduction in flows below WID during the 92-year period of record. The inset provides further context to view the reduction in flows below WID during certain time frames. The 1979-1981 inset illustrates the maximum change in flow, which occurs in January 1980, and it provides an overall context to view the flood flow releases. There is no appreciable change in flows below WID between the No Project/No Action Alternative and with the EBMUD component of the Phase 2 Expansion.

Woodbridge Irrigation District, North San Joaquin Water Conservation District and Jackson Valley Irrigation District

With the EBMUD component of the Phase 2 Expansion, EBMUD would continue to meet obligations to senior water rights holders before making EBMUD diversions. As noted earlier, senior water rights holders include WID. **Table A-1** indicates that EBMUD's obligations to WID remain the same under both the No Project/No Action Alternative and with the EBMUD component of the Phase 2 Expansion.

NSJWCD's water right to divert water is junior to EBMUD's permit. No Project/No Action Alternative results indicate that NSJWCD's water deliveries would be available from the Mokelumne River in 54 out of 92 years modeled. **Table A-2** indicates that with the EBMUD component of the Phase 2 Expansion, there would be no change in the number of years of NSJWCD's deliveries. In the simulated year of 1949, there would be a slight increase of 11 AF in diversions to NSJWCD with the EBMUD component of the Phase 2 Expansion as compared to the No Project/No Action Alternative.

JVID water rights are senior to EBMUD's water rights under Permit 10478. JVID diverts water from Pardee Reservoir at the Jackson Creek Spillway Facility (elevation 550 ft) to supply water for domestic and irrigation uses to customers in portions of Amador County. With the EBMUD component of the Phase 2 Expansion, water surface elevations fall below 550 ft in an additional 2 months. The recently approved changes to EBMUD Permit 10478 include a new regulatory term which requires EBMUD to assist JVID in installing a submersible pump when Pardee elevation falls below 550 ft and water is available under JVID's water right priority. This permit condition will prevent the drop in surface elevation from impacting JVID's ability to access water.

Camanche Elevation Threshold

Under No Project/No Action Alternative conditions, RiverWare modeling results indicate that Camanche Reservoir end-of-month storage is less than the 190 feet msl approximately 5.7% of the time over the 92-year period of record. With the EBMUD component of the Phase 2 Expansion, Camanche end-of-month storage is less than 190 feet msl approximately 4.9% of the time over the period of record. The improvement with the EBMUD component of the Phase 2 Expansion is related to the additional exchanged water supplies obtained from CCWD or other Local Agency Partners in dry years. This approach to the water temperature analysis provides an estimate of the average Phase 2 Expansion project–related temperature effects in response to estimated changes in reservoir storage and flow for each of the 92 years simulated by RiverWare. See **Figure WR-8** in Appendix A-1.

TABLE A-1
WID DIVERSIONS UNDER NO PROJECT/NO ACTION ALTERNATIVE AND PHASE 2 EXPANSION ALTERNATIVES (CY 1921-2012) IN AF

WID Diversions Under No Project/No Action Alternative and Phase 2 Expansion Alternatives (CY 1921-2012) in AF

Year	No Project/No Action Alternative	Phase 2 Expansion Alternatives	DIFF		Year	No Project/No Action Alternative	Phase 2 Expansion Alternatives	DIFF
1921	60	60	0		1967	60	60	0
1922	60	60	0		1968	60	60	0
1923	60	60	0		1969	60	60	0
1924	39	39	0		1970	60	60	0
1925	60	60	0		1971	60	60	0
1926	60	60	0		1972	60	60	0
1927	60	60	0		1973	60	60	0
1928	60	60	0		1974	60	60	0
1929	39	39	0		1975	60	60	0
1930	60	60	0		1976	39	39	0
1931	39	39	0		1977	39	39	0
1932	60	60	0		1978	39	39	0
1933	60	60	0		1979	60	60	0
1934	39	39	0		1980	60	60	0
1935	60	60	0		1981	60	60	0
1936	60	60	0		1982	60	60	0
1937	60	60	0		1983	60	60	0
1938	60	60	0		1984	60	60	0
1939	39	39	0		1985	60	60	0
1940	60	60	0		1986	60	60	0
1941	60	60	0		1987	39	39	0
1942	60	60	0		1988	39	39	0
1943	60	60	0		1989	60	60	0
1944	60	60	0		1990	39	39	0
1945	60	60	0		1991	39	39	0
1946	60	60	0		1992	39	39	0
1947	39	39	0		1993	60	60	0
1948	60	60	0		1994	39	39	0
1949	60	60	0		1995	60	60	0
1950	60	60	0		1996	60	60	0
1951	60	60	0		1997	60	60	0
1952	60	60	0		1998	60	60	0
1953	60	60	0		1999	60	60	0
1954	60	60	0		2000	60	60	0
1955	60	60	0		2001	60	60	0
1956	60	60	0		2002	60	60	0
1957	60	60	0		2003	60	60	0
1958	60	60	0		2004	60	60	0
1959	60	60	0		2005	60	60	0
1960	60	60	0		2006	60	60	0
1961	39	39	0		2007	60	60	0
1962	60	60	0		2008	39	39	0
1963	60	60	0		2009	60	60	0
1964	60	60	0		2010	60	60	0
1965	60	60	0		2011	60	60	0
1966	60	60	0		2012	60	60	0

TABLE A-2
NSJWCD DIVERSIONS UNDER NO PROJECT/NO ACTION ALTERNATIVE AND PHASE 2 EXPANSION ALTERNATIVES (CY 1921-2012) IN AF

NSJWCD Diversions Under No Project/No Action Alternative and Phase 2 Expansion Alternatives (CY 1921-2012) in AF

Year	No Project/ No Action Alternative	Phase 2 Expansion Alternatives	Diff		Year	No Project/ No Action Alternative	Phase 2 Expansion Alternatives	Diff
1921	0	0	0		1967	20000	20000	0
1922	20000	20000	0		1968	0	0	0
1923	20000	20000	0		1969	20000	20000	0
1924	0	0	0		1970	20000	20000	0
1925	20000	20000	0		1971	20000	20000	0
1926	0	0	0		1972	0	0	0
1927	20000	20000	0		1973	20000	20000	0
1928	20000	20000	0		1974	20000	20000	0
1929	0	0	0		1975	20000	20000	0
1930	0	0	0		1976	0	0	0
1931	0	0	0		1977	0	0	0
1932	20000	20000	0		1978	0	0	0
1933	0	0	0		1979	0	0	0
1934	0	0	0		1980	20000	20000	0
1935	20000	20000	0		1981	0	0	0
1936	20000	20000	0		1982	20000	20000	0
1937	20000	20000	0		1983	20000	20000	0
1938	20000	20000	0		1984	20000	20000	0
1939	0	0	0		1985	0	0	0
1940	20000	20000	0		1986	20000	20000	0
1941	20000	20000	0		1987	0	0	0
1942	20000	20000	0		1988	0	0	0
1943	20000	20000	0		1989	0	0	0
1944	0	0	0		1990	0	0	0
1945	20000	20000	0		1991	0	0	0
1946	20000	20000	0		1992	0	0	0
1947	0	0	0		1993	20000	20000	0
1948	20000	20000	0		1994	0	0	0
1949	19679	19690	11		1995	20000	20000	0
1950	20000	20000	0		1996	20000	20000	0
1951	20000	20000	0		1997	20000	20000	0
1952	20000	20000	0		1998	20000	20000	0
1953	20000	20000	0		1999	20000	20000	0
1954	20000	20000	0		2000	20000	20000	0
1955	0	0	0		2001	0	0	0
1956	20000	20000	0		2002	0	0	0
1957	20000	20000	0		2003	20000	20000	0
1958	20000	20000	0		2004	0	0	0
1959	0	0	0		2005	20000	20000	0
1960	0	0	0		2006	20000	20000	0
1961	0	0	0		2007	0	0	0
1962	20000	20000	0		2008	0	0	0
1963	20000	20000	0		2009	20000	20000	0
1964	0	0	0		2010	20000	20000	0
1965	20000	20000	0		2011	20000	20000	0
1966	0	0	0		2012	0	0	0

Changes in JSA Year Type

RiverWare modeling results indicate that with the EBMUD component of the Phase 2 Expansion, there would be 3 non-consecutive periods over the 92-year period of record when JSA year type changes due to changes in storage levels at Pardee and Camanche (October through March time frame). In October 1928 – March 1929, the JSA year type changes from below normal to dry as compared to No Project/No Action Alternative conditions, reflecting a reduction in storage of 10 TAF in EBMUD total system storage compared to No Project/No Action Alternative conditions. Similarly, in October 2007 –March 2008, the JSA year type changes from below normal to dry as compared to No Project/No Action Alternative conditions, reflecting a reduction in storage of 1.8 TAF in EBMUD total system storage compared to No Project/No Action Alternative conditions. The change to a drier year type is primarily a result of the threshold change in storage levels and would likely result in marginal changes in flows below Camanche. Additionally, under the recently approved EBMUD Permit 10478, EBMUD would implement additional releases from Camanche Reservoir under certain conditions to facilitate fish passage during certain below normal and dry water years. Implementation of this permit term will ensure that potential changes in water resources due to year type change to a drier condition are addressed.

In October 1989 –March 1990, the JSA year type changes from dry under No Project/No Action Alternative conditions to below normal with the EBMUD component of the Phase 2 Expansion, reflecting an increase of 21 TAF storage in EBMUD total system storage from No Project/No Action Alternative conditions. **Table A-3** shows the change in JSA year type.

TABLE A-3
JSA YEAR TYPE UNDER THE NO PROJECT/NO ACTION ALTERNATIVE AND THE PHASE 2 EXPANSION

JSA Year Type (October - March)		
Year type	**No Project/ No Action Alternative**	**Phase 2 Expansion Alternatives**
Normal and Above	48	48
Below Normal	23	22
Dry	17	18
Critically Dry	4	4
Total	92	92

Significance Criteria

The criteria used for determining the significance of an impact on hydrology and water quality are based on Section I of Appendix G (a model Environmental Checklist) of the State CEQA Guidelines and professional standards and practices. Because this Appendix analyzes only the potential modifications to Mokelumne River resources due to operations of the EBMUD component of the Phase 2 Expansion, with construction of new facilities and modification of existing facilities analyzed in Chapter 4, only those criteria that are relevant to this analysis are listed below. Impacts on hydrology may be considered significant if the operations of the EBMUD component of the Phase 2 Expansion would:

- substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of existing nearby wells would drop to a level that would not support existing land uses or planned uses for which permits have been granted);
- substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner that would result in flooding on- or off-site; or
- otherwise substantially degrade water quality.

Impact Discussion

The primary impact mechanisms for water resources are changes in lower Mokelumne River flow, which could affect groundwater recharge or reduce flooding. Less-than-significant impacts on water resources associated with these changes are described in the following sections.

Significant Impacts

As explained below under Less-Than-Significant Impacts, changes in lower Mokelumne River flow associated with the EBMUD component of the Phase 2 Expansion would not result in significant impacts on water resources.

Less-than-Significant Impacts

Impact WR-1: Potential for changes in Mokelumne River flow to affect groundwater recharge (Less than Significant)

Estimated channel loss rates in the lower Mokelumne River have ranged from 57,000 to 130,000 AFY, with most of the loss occurring in the 21-mile reach between Camanche Dam and Lodi Lake near the town of Lodi (HCG 1998). Some of this loss is likely seepage to groundwater. There is some potential for a reduction in river flow to cause a reduction in groundwater recharge. A reduction in groundwater recharge could result from reduced river contact with the substrate caused by reduced channel width and depth. However, percolation to groundwater is controlled largely by the position of the groundwater table compared to river elevation. In addition, the EBMUD component of the Phase 2 Expansion is unlikely to have much effect on channel shape because reduction in flow would be small (overall reduction of 0.7% of flow below Camanche Dam as described above). In RiverWare, channel losses are generally assumed to be in the 50-65 cfs range from below Camanche Dam to Frandy. Since the overall reduction in flow below Camanche Dam is only 5.25 cfs, the EBMUD component of the Phase 2 Expansion would have less than significant impacts on groundwater recharge. No mitigation is necessary.

Impact WR-2: Potential for changes in Mokelumne River flow to reduce flooding (Less than Significant)

As described above, a flow of 3,000 cfs could produce floodplain inundation (and potentially flood-related damage) downstream of Woodbridge Dam. The data show the same number (25) of days with flows above 3,000 cfs for both the No Project/No Action Alternative and with the EBMUD component of the Phase 2 Expansion. Therefore, this is considered a less than significant impact. No mitigation is necessary.

A.4 Fish Resources

This section describes fish resources in the Lower Mokelumne River (below Camanche Dam to Frandy gage – a distance of about 33 miles). Fish resources within the Delta are discussed in Section 4.3 of the Supplement.

This section assesses the significance of the impacts associated with implementing the EBMUD component of the Phase 2 Expansion project. This assessment focuses on fall-run Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) in the lower Mokelumne River, which are considered key evaluation species based on their regulatory status, commercial and recreational importance, and sensitivity to project effects. The welfare of these species is indicative of the general quality of the aquatic habitats below Camanche Dam, because of their broad overlap in seasonal habitat requirements with other native fish species.

This analysis concludes that the EBMUD component of the Phase 2 Expansion would not result in significant impacts on fish resources.

Environmental Setting

Sixteen native and 26 introduced fish species have been observed in the lower Mokelumne River downstream of Camanche Dam based on the results of fish monitoring conducted since 1990 (see **Table A-4**). Special-status species observed in the lower Mokelumne River include steelhead (listed as threatened under the Federal Endangered Species Act [ESA]) and delta smelt (listed as threatened under the ESA and as endangered under the California Endangered Species Act [CESA]), fall-run Chinook salmon (listed as a federal species of concern), Sacramento splittail (California species of special concern), and hardhead (California species of special concern). Other runs of Chinook salmon that inhabit the Central Valley include winter-run (listed as endangered under ESA and CESA) and spring-run (listed as threatened under ESA and CESA) that typically do not occur in the lower Mokelumne River and are not addressed in this analysis. Fall-run Chinook salmon and steelhead are the primary management species in the lower Mokelumne River because of their regulatory status and their recreational or commercial value.

Lower Mokelumne River

The lower Mokelumne River (**Figure A-3**). The gradient ranges from 0.1% near Camanche Dam to 0.02% near the Cosumnes River confluence. Tidal influence from the Delta typically extends to the town of Thornton but can reach as far upstream as Woodbridge Dam. The reach below Woodbridge Dam is characterized primarily by flat water habitats (pools and runs); elevated spring, summer, and fall water temperatures; and mud and sand substrates. Lodi Lake, a seasonal impoundment formed by Woodbridge Dam during the irrigation season, is characterized by low water velocities and mud substrates. The river between Lodi Lake and Camanche Dam is

TABLE A-4
FISH SPECIES OBSERVED IN THE LOWER MOKELUMNE RIVER

Family	Common Name	Scientific Name	Distribution
Petromyzontidae: Lamprey Family	Pacific lamprey	*Lampetra tridentata*	Native
Acipenseridae: Sturgeon Family	White sturgeon	*Acipenser transmontanus*	Native
	Green sturgeon	*Acipenser medirostris*	Native
Clupeidae: Herring Family	Threadfin shad	*Dorosoma pretenense*	Introduced
	American shad	*Alosa sapidissima*	Introduced
Cyprinidae: Minnow Family	Hitch	*Lavinia exilicaudia*	Native
	Sacramento splittail	*Pogonichthys macrolepidotus*	Native
	Sacramento blackfish	*Orthodon microlepidotus*	Native
	Sacramento pikeminnow	*Ptychocheilus grandis*	Native
	Hardhead	*Mylopharodon conocephalus*	Native
	Golden shiner	*Notemigonus crysoleucas*	Introduced
	Goldfish	*Carassius auratus*	Introduced
	Common carp	*Cyprinus carpio*	Introduced
Catostomidae: Sucker Family	Sacramento sucker	*Catostomus occidentalis*	Native
Ictaluridae: Catfish Family	Black bullhead	*Ameiurus melas*	Introduced
	Brown bullhead	*Ameiurus nebulosus*	Introduced
	White catfish	*Ameiurus catus*	Introduced
	Channel catfish	*Ictalurus punctatus*	Introduced
Osmeridae Smelt Family	Delta smelt	*Hypomesus transpacificus*	Native
	Wakasagi	*Hypomesus nipponensis*	Introduced
Salmonidae: Salmon and Trout Family	Chinook salmon	*Oncorhynchus tshawytscha*	Native
	Chum salmon	*Oncorhynchus keta*	Native
	Kokanee	*Oncorhynchus nerka*	Native
	Steelhead/rainbow trout	*Oncorhynchus mykiss*	Native
Atherinopsidae: Silversides Family	Inland silversides	*Menidia beryllina*	Introduced
Poeciliidae: Livebearers	Western mosquitofish	*Gambusia affinis*	Introduced
Cottidae: Sculpin Family	Prickly sculpin	*Cottus asper*	Native
Moronidae: Striped Bass Family	Striped bass	*Morone saxatilis*	Introduced
Centrarchidae: Sunfish Family	Bluegill	*Lepomis macrochirus*	Introduced
	Pumpkinseed	*Lepomis gibbosus*	Introduced
	Redear sunfish	*Lepomis microlophus*	Introduced
	Warmouth	*Lepomis gulosus*	Introduced
	Green sunfish	*Lepomis cyanellus*	Introduced
	White crappie	*Pomoxis annularis*	Introduced
	Black crappie	*Pomoxis nigromaculatus*	Introduced
	Largemouth bass	*Micropterus salmoides*	Introduced
	Smallmouth bass	*Micropterus dolomieu*	Introduced
	Redeye bass	*Micropterus coosae*	Introduced
	Spotted bass	*Micropterus punctulatus*	Introduced
Percidae: Perch Family	Bigscale logperch	*Percina macrolepida*	Introduced
Embiotocidae: Surfperch Family	Tule perch	*Hysterocarpus traski*	Native
Gobiidae: Goby Family	Yellowfin goby	*Acanthogobius flavimanus*	Introduced

SOURCE: EBMUD data

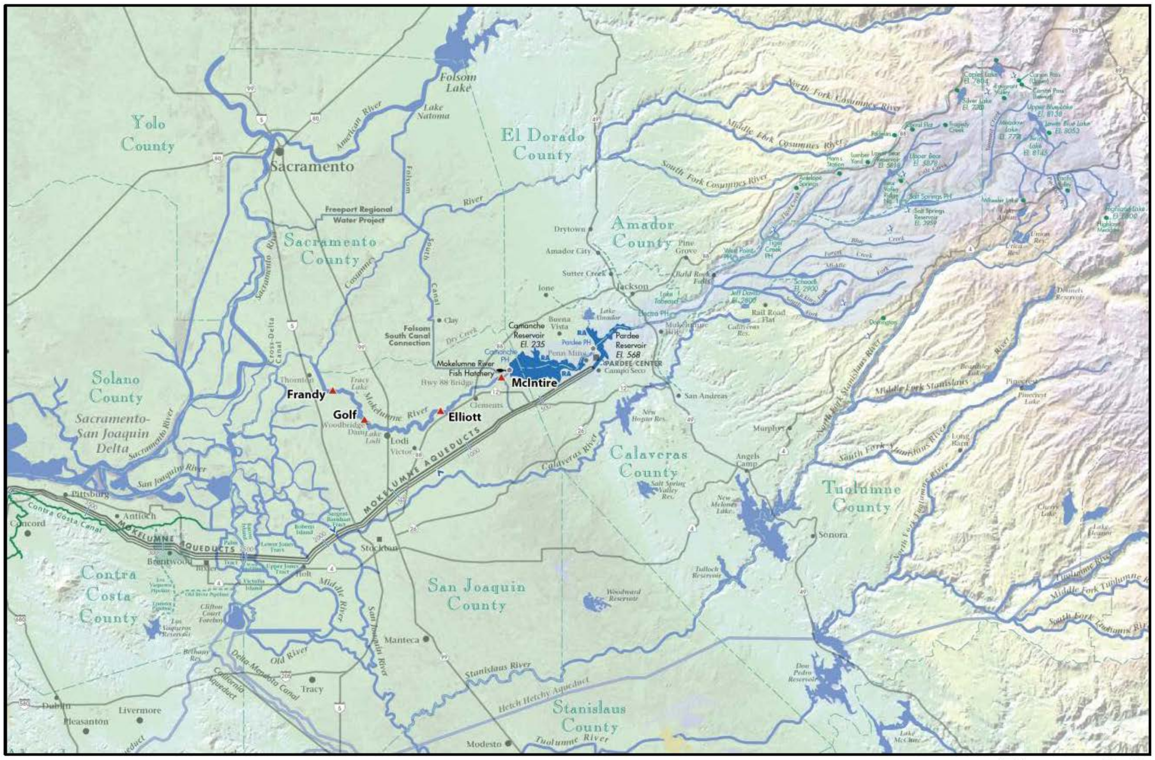


Figure A-3
Lower Mokelumne River

characterized by alternating bars and flat water habitats. The uppermost 6 to 9 miles of this reach below Camanche Dam support most of the salmon and steelhead spawning and juvenile rearing habitat. This segment is characterized by higher-gradient runs and riffles; cooler spring, summer, and fall water temperatures; and gravel-cobble substrates.

Fall-Run Chinook Salmon

Fall-run Chinook salmon are the most abundant and widely distributed of the four Chinook salmon runs in the Central Valley (Williams 2006). They historically spawned in the Central Valley and lower foothill reaches of all major tributaries of the Sacramento and San Joaquin Rivers. Dams currently restrict their distribution to the lowermost reaches of their historical spawning habitat where populations are sustained by natural and hatchery production.

Status

NMFS conducted a status review of Central Valley fall-/late fall–run Chinook salmon Evolutionarily Significant Unit (ESU) in 1999 and concluded that this ESU did not warrant listing as threatened or endangered under the ESA (64 *Federal Register* [FR] 50394). This ESU is classified as a species of concern (69 FR19975).

Life History and Habitat Requirements

Central Valley fall-run Chinook salmon have an ocean-type life history in which adults enter fresh water at an advanced stage of maturity, move rapidly to spawning areas in lower mainstem and tributary reaches, and spawn within a few days or weeks of freshwater entry (Healey 1991). Central Valley fall-run Chinook salmon typically enter spawning streams from July through December and spawn from October through December. Most fry emerge from December through March and typically emigrate from their natal streams within 1 to 7 months of emergence, entering the estuary as fry or smolts primarily from January through June. This life-history pattern has allowed fall-run Chinook salmon to sustain relatively large populations in low-elevation reaches of the Central Valley floor below dams where unfavorable water temperature and low-flow conditions frequently occur in summer.

Most adult fall-run Chinook salmon in the lower Mokelumne River return in September (2%), October (32%), November (55%), and December (11%) (**Table A-5**). During this period, adults actively migrate through the lower reaches of the lower Mokelumne River above the confluence with the San Joaquin River until they reach the primary spawning areas between the Elliott Road Bridge and Camanche Dam.

TABLE A-5
FALL-RUN CHINOOK SALMON AND STEELHEAD LIFE STAGE OCCURRENCE IN THE LOWER MOKELUMNE RIVER

	July	August	September	October	November	December	January	February	March	April	May	June
Fall-run Chinook Salmon												
Adult Migration			■	■	■	■						
Spawning and incubation				■	■	■	■	■	■			
Juvenile rearing							■	■	■	■	■	■
Smolting												
Emigration							■	■	■	■	■	■
Steelhead												
Adult migration			■	■	■	■	■	■				
Spawning and incubation						■	■	■	■	■	■	
Juvenile rearing	■	■	■	■	■	■	■	■	■	■	■	■
Smolting												
Emigration								■	■	■	■	■

SOURCE: EBMUD data.

Chinook salmon spawn in the lower Mokelumne River typically from October through December (Table A-5), primarily between the Elliott Road Bridge and Camanche Dam. Upon reaching spawning areas, female Chinook salmon dig depressions in the riverbed where they deposit their eggs. Females typically select sites with gravel-cobble substrates and sufficient subsurface flows to provide oxygen to the developing embryos. Following fertilization of the eggs by an attending male, the female buries the eggs with gravel and then spends up to 3 weeks defending the nest (redd) from other females. All Chinook salmon die after spawning.

The incubation period extends from the time of spawning to fry emergence, and is controlled largely by water temperature. Based on general relationships between water temperature and emergence times, the incubation period in the lower Mokelumne River extends primarily from the onset of spawning through March (Table A-5).

After emergence, Chinook salmon fry disperse downstream or reside for several months in the lower Mokelumne River from Camanche Dam downstream to Woodbridge Dam before emigrating to the ocean. In the lower Mokelumne River, EBMUD monitoring since 1992 suggests a bimodal emigration pattern occurs with a distinct fry emigration period from January through March (about 66% of total juvenile outmigration on average) and a distinct smolt emigration period from April through June (about 33% of total juvenile outmigration on average). Small numbers (<1% of outmigrating Chinook) of yearling smolts also are observed between December and May. When hydrologic conditions allow (e.g., under higher flow conditions), fry typically disperse downstream from spawning areas soon after emergence. These movements, facilitated by peak winter flows, result in dispersal of fry throughout the lower reaches of the spawning streams and upper reaches of the Bay-Delta estuary, where they seek out shallow river margins, floodplains, and tidal wetlands. During dryer hydrologic conditions, more fry remain near the spawning areas, where they rear for several months before emigrating in the late spring.

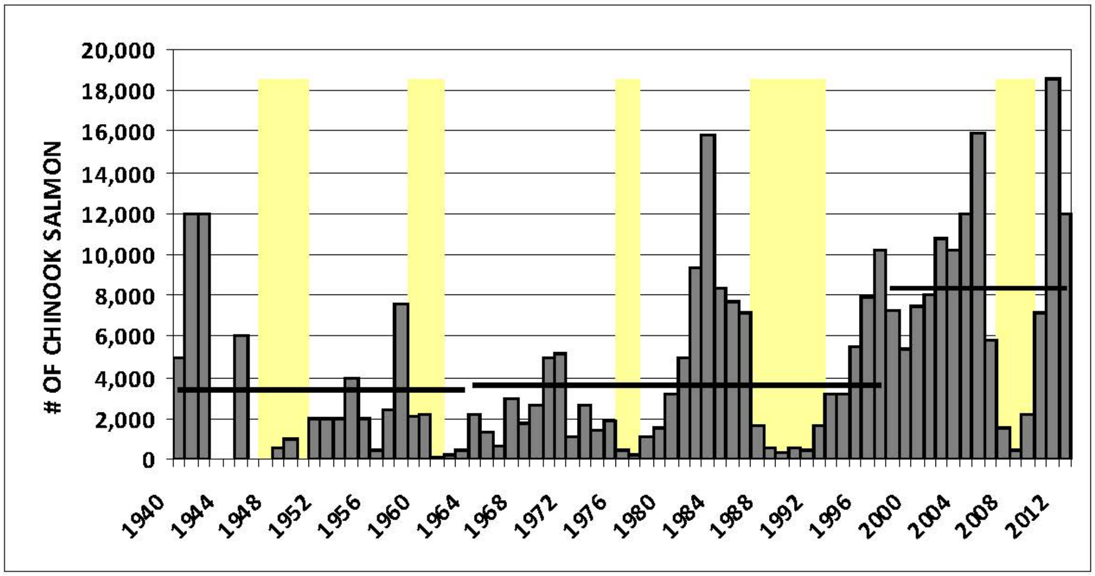
The transition from fry to the juvenile life stage (parr) occurs at a length of approximately 1.8 to 2.4 inches and is generally associated with rapid growth and increased utilization of deeper, higher-velocity habitats. Newly emerged fry that remain in their natal stream move to shallow water along the margins of the river where they complete their transition from yolk-sac to external feeding. As they grow, juvenile salmon move into deeper areas of the channel near cover, faster currents, and higher concentrations of food.

During emigration, juvenile Chinook salmon undergo a series of behavioral, physiological, and morphological changes as they transition from parr to smolts and prepare to enter the marine environment.

Optimal temperatures for Central Valley fall-run Chinook salmon fry growth and survival are 13 to 18 °C, although throughout their range, positive growth is experienced at temperatures of 5 to 19°C (Moyle 2002). Major mortality occurs at 22 to 23°C and maximum embryo survival temperatures are 5 to 13°C (Moyle 2002).

Population Status

Annual escapement (i.e., numbers of adults returning to spawn) of fall-run Chinook salmon in the Mokelumne River has varied considerably over the period of record (**Figure A-4**). Coinciding with the 1987–1992 drought, adult salmon returns to the river declined markedly, averaging less than 840 adults annually. EBMUD implemented experimental management actions beginning in the mid-1990s that, in combination with favorable hydrologic conditions in the watershed, improved habitat conditions and resulted in an increasing trend in the abundance of juvenile salmon produced in the river and the numbers of adult fall-run Chinook salmon returning to the river to spawn. In addition, in 1998 EBMUD, together with the California Department of Fish and Wildlife (CDFW) and the U.S. Fish & Wildlife Service, approved the Joint Settlement Agreement



Horizontal lines indicate pre-Camanche, post-Camanche, and post-JSA periods, respectively.

1. Pre-Camanche" escapement (3,374) is the average estimate at Woodbridge Dam for the period from 1940 through 1963 (excluding years when no data were recorded: 1943, 1944, 1946, 1947, and 1950).
2. Post-Camanche" escapement (3,636) is the average estimate at Woodbridge Dam for the period 1964 through 1997.
3. "Post-JSA" escapement (8,318) is the average estimate at Woodbridge Dam since implementation of the JSA in 1998.
4. Yellow shaded areas are periods of drought in California (California Department of Water Resources 2009a).

Figure A-4
Estimated Annual Spawning Escapement of Fall-Run Chinook Salmon in the Lower Mokelumne River since 1940

(JSA), which contains a suite of comprehensive flow and non-flow measures to protect and enhance the Mokelumne fishery. Chinook salmon escapement from 1993 through 2006 averaged over 8,000 annually. The adult return to the river in 2007–2009 was, however, one of the lowest since implementing the JSA. These recent low escapements of adult fall-run Chinook salmon to the river reflect a regional decline of Central Valley fall-run Chinook salmon attributed primarily to poor marine survival that began in spring 2005, compounded by drought, past and present fish management, hatchery practices, and inland habitat conditions (Lindley et al. 2009). Following the return of better oceanic conditions and the end of the 2007–2009 drought, fishery returns on the Mokelumne rebounded. For example, the 2011 return was 18,589 fall-run Chinook salmon, a record for the Mokelumne River during the 1940–2011 period (Figure A-4.).

Chinook salmon production in the lower Mokelumne River is supplemented by hatchery fish reared at the Mokelumne River Fish Hatchery. Since 1998, the CDFW annual fall-run Chinook salmon production at the Mokelumne River Fish Hatchery has averaged 5.5 million juvenile fish, with about 55% of these fish released in the lower Mokelumne River. Most of the remaining production has been released in San Pablo and San Francisco Bays, and the San Joaquin and Sacramento Rivers.

Because of the hydraulic conditions in the Delta, interactions of the Central Valley Project (CVP) and the State Water Project (SWP) with populations of salmonids in the San Joaquin River basin, as well as the Mokelumne River, are exceptionally adverse (National Marine Fisheries Service

2009). Under current CVP and SWP operating conditions, adverse effects on migrating juvenile and adult fall-run Chinook salmon and steelhead originating in the Mokelumne River basin are likely to continue (National Marine Fisheries Service 2009).

Steelhead

Steelhead and resident rainbow trout, collectively referred to as *Oncorhynchus mykiss*, were once widespread in the Central Valley before dams blocked access to most of their historical spawning and rearing habitat. All extant populations of Central Valley steelhead are recognized as winter-run based on their state of sexual maturity and time of river entry. Although these populations occur largely in the upper Sacramento River and its tributaries, steelhead adults and juveniles have been documented in other accessible rivers throughout the Central Valley (Good et al. 2005), including the lower Mokelumne River.

Status

Oncorhynchus mykiss may exhibit anadromy or freshwater residency. Resident forms are usually referred to as rainbow trout, while anadromous forms, which spend a portion of their life cycle in coastal marine waters, are termed steelhead. Resident rainbow trout can produce anadromous progeny, and anadromous steelhead can produce resident progeny in the Central Valley (Zimmerman et al. 2008).

There appear to be no steelhead-bearing rivers in the Sacramento River Basin that have not received releases of multiple hatchery stocks (California Department of Fish and Game 1995; Cramer et al. 1995). Prior to the establishment of the Mokelumne River Fish Hatchery, there were numerous releases of steelhead from the Mount Shasta, Mount Whitney, Basin Creek, Fern Creek, Kaweah, and Mormon Creek hatcheries into the San Joaquin River Basin (West Coast Steelhead Biological Review Team 1998). There is no documentation of egg collections from San Joaquin River basin sources, so it is presumed that these hatchery releases came from sources in the Eel River and Scott Creek and San Lorenzo Basins (West Coast Steelhead Biological Review Team 1998). However, the exact origin of these steelhead releases is unknown.

CDFW determined that by 1952, steelhead were “virtually nonexistent” in the Mokelumne River below Pardee Dam (California Department of Fish and Game 1959), most likely the result of mining, cannery, and winery waste discharges. From 1953 to 1959, CDFW released more than 1,250,000 steelhead fingerlings between Pardee Dam and Thornton in an effort to revitalize the Mokelumne steelhead population.

NMFS listed the Central Valley steelhead Distinct Population Segment as a threatened species in 1998 (63 FR 13347). Critical habitat designated by NMFS for steelhead includes the Delta and Central Valley Rivers, including the tributaries and mainstem of the San Joaquin River and the Sacramento River. Natural-origin anadromous steelhead in the lower Mokelumne River and Feather River Hatchery steelhead, which served as a supplemental brood stock source at Mokelumne River Hatchery until 2008, are part of the Central Valley steelhead Distinct Population Segment. Following completion of Camanche Dam in 1964, Nimbus Hatchery stock, as well as fish from Coleman National Fish Hatchery and Feather River Hatchery, have been introduced to the Mokelumne River (California Department of Fish and Game 1995; Cramer et al. 1995; McEwan and Jackson 1996). Nimbus Hatchery, located on the American River (tributary to the Sacramento River), was founded with Eel River winter steelhead from the Van Arsdale Fisheries Station and returning American River steelhead; Mad River and Russian River stocks, as well as Sacramento River stocks, have been mixed into the Nimbus Hatchery population over time (California Department of Fish and Game 1995; Cramer et al. 1995). The Mokelumne River and Nimbus Hatchery stocks were excluded from the Distinct Population Segment because of their genetic affinities with mixed steelhead stocks (Good et al. 2005; National Marine Fisheries Service 1998).

Life History and Habitat Requirements

Based on EBMUD's monitoring since 1992, more than 90% of adult steelhead in the lower Mokelumne River migrate upstream from September through February (September 13%, October 31%, November 13%, December 14%, January 17%, February 6%). In the lower Mokelumne River, most steelhead spawn in the upper reaches of the lower Mokelumne River from December through March (Table A-5).

Like Chinook salmon, steelhead deposit their eggs in excavated gravel nests or redds. Unlike salmon, some adults survive spawning (referred to as kelts), return to the ocean, and return to fresh water to spawn again. Based on general relationships between water temperature and emergence times, the incubation period extends primarily from December through May.

Central Valley steelhead typically rear in freshwater for 1 or 2 years before emigrating to the ocean. Juvenile steelhead have been reported to emigrate from natal streams during fall, winter, and spring, but the peak emigration period for naturally produced juveniles typically occurs in late winter and spring (Nobriga and Cadrett 2003). Juveniles typically are observed passing Woodbridge Dam from February through June, including young-of-year (fish born in the year of capture) that appear from March through June.

Zimmerman et al. (2008) revealed that the Central Valley *O. mykiss* population is skewed toward the non-anadromous resident form as 77% of the analyzed *O. mykiss* in that study were progeny of resident rainbow trout. Similarly, results from Del Real et al. (2012) suggest a large proportion (78%) of natural-origin *O. mykiss* in lower Mokelumne River demonstrate a resident life history.

O. mykiss are found where daytime water temperatures are 0 to 27°C, although extremely low (<4°C) or extremely high (>23°C) temperatures can be lethal if the fish have not previously been gradually acclimated (Moyle 2002). The optimal temperatures for *O. mykiss* growth are around 15 to 18°C (Moyle 2002).

Population Status

Steelhead runs on the lower Mokelumne River appear to be supported largely by hatchery production and, prior to 2008, imported eggs and fry from Nimbus (American River) and Feather River hatcheries. Natural production of steelhead in the lower Mokelumne River appears to be low, based on the dominance of hatchery adults in the run and small numbers of unmarked juveniles observed at Woodbridge Dam (all *O. mykiss* produced at the Mokelumne River Fish Hatchery have been marked with an adipose fin clip since 1998). In 2005 EBMUD developed a population estimate of natural-origin *O. mykiss* in the lower Mokelumne River from Camanche Dam downstream to the Woodbridge Dam using a mark-recapture study with passive integrated transponder (PIT) tags. That estimate was about 9,200 adult *O. mykiss*.

The existing population was supplemented by imported eggs (mostly from Feather River Hatchery) until 2008, and since then CDFW and EBMUD are supplementing the population with Mokelumne-origin steelhead. This objective is consistent with current policies and management direction to minimize adverse genetic and ecologic interactions between hatchery and natural populations of anadromous fish (California Department of Fish and Game and East Bay Municipal Utilities District 2012).

Since 1998, CDFW's annual steelhead production at the Mokelumne River Fish Hatchery has averaged 189,000 yearlings that have been released each year into the lower Mokelumne River at various locations (e.g., New Hope Landing).

Other Fish Species

In addition to Chinook salmon and steelhead, other fish—including delta smelt, green and white sturgeon, hardhead, hitch, longfin smelt, Pacific lamprey, prickly sculpin, Sacramento blackfish, Sacramento pikeminnow, Sacramento splittail, Sacramento sucker, and tule perch have been observed or may occur in the lower Mokelumne River. Striped bass and American shad, which typically occur in the lower Mokelumne River below Woodbridge Dam, and kokanee, which occur in Pardee Reservoir, are of recreational importance.

Regulatory Setting

In addition to the State CEQA Guidelines, select local agreements and programs influence the protection of biological resources in the project area. Because this Appendix analyzes only the potential modifications to Mokelumne River resources due to operations of the EBMUD component of the Phase 2 Expansion, with construction of new facilities and modification of existing facilities analyzed in Chapter 4, the discussion below focuses only on those regulations that are *potentially* relevant to the operations of the EBMUD component of the Phase 2 Expansion.

This section describes those agreements and programs relevant to fish resources in the lower Mokelumne River. Specifically, this section describes the JSA that defines goals, measures, performance criteria and responsive actions associated with implementation of the JSA.

Lower Mokelumne River Project (FERC Project No. 2916-004), Joint Settlement Agreement

A condition in EBMUD's State Water Board Permit 10478 required EBMUD to reach an agreement with CDFW regarding flows to be released downstream for the protection of fish in the lower Mokelumne River. Accordingly, in 1961, EBMUD entered into an agreement with

CDFW (1961 Agreement) that required EBMUD to release 13 TAF annually from Camanche Reservoir to the lower Mokelumne River to benefit aquatic habitat and fish production. These 13 TAF were in addition to releases for the WID, riparian and senior appropriators, and channel losses. The 1961 Agreement, at CDFW's request, also required EBMUD to construct a fish hatchery at Camanche Dam, with the hatchery to be operated by CDFW. Consistent with the 1961 Agreement, EBMUD built the fish hatchery, which is operated by CDFW.

EBMUD, CDFW, and USFWS approved a JSA in 1998. Its purpose is to protect and enhance conditions for the anadromous fish population and associated ecosystem of the lower Mokelumne River while simultaneously protecting EBMUD's Lower Mokelumne River Project as a reliable, high-quality water supply for EBMUD.

The provisions of the JSA build upon and expand some of the requirements of the 1961 Agreement. Principally, the JSA specifies a more complex schedule of release requirements from Camanche Dam. EBMUD also agreed to expand and upgrade the hatchery in accordance with the 1996 Hatchery Master Plan, in consultation with CDFW, USFWS, and NMFS. Reconstruction was completed in 2002 at a cost of about $12.5 million. The JSA also requires implementation of non-flow enhancement measures, such as gravel augmentation, and new monitoring and reporting objectives.

The JSA fish releases from Camanche Dam are significantly higher than the prior releases required under the 1961 Agreement. EBMUD voluntarily began releasing the JSA flows in 1996 when they were first negotiated, prior to formal conclusion and execution of the JSA in 1998. NMFS completed its conferencing opinion of the JSA effects on Central Valley steelhead and in April 1998 concluded the following:

> The conferencing previously done for Central Valley steelhead is adequate and serves as the section 7 consultation for this species, now that it has been listed as threatened. Given our original analysis of the proposed action, which concluded that the proposed action should improve conditions for fall-run Chinook salmon, I [William T. Hogarth, Regional Administrator] also conclude that this action is not likely to adversely affect the proposed-threatened Central Valley fall-run/late-fall-run Chinook salmon ESU. This concludes section 7 consultation for the threatened Central Valley steelhead, and conferencing for the proposed-threatened Central Valley fall-run/late-fall-run Chinook salmon. Although conferencing does not take the place of a section 7 consultation, no further consultation should be necessary in the event of a Central Valley fall-run/late-fall-run Chinook listing, provided that the project is implemented substantially as described in the November 1993 Final Environmental Impact Statement.

In addition, on March 23, 1998, the USFWS completed a Biological Opinion on the JSA, entitled *Formal Endangered Species Consultation on the Joint Settlement Agreement Alternative for the Operations of the Lower Mokelumne River Project (FERC Project No. 2916-004) Operated by East Bay Municipal Utility District in Calaveras, Amador, and San Joaquin Counties, California*, reaching a no jeopardy conclusion. The Federal Energy Regulatory Commission (FERC) subsequently issued its Order Approving Settlement Agreement and Amending License on November 27, 1998, amending EBMUD's FERC License for its Mokelumne Project by requiring the JSA.

The State Water Board incorporated the flow provisions of the JSA into EBMUD's Mokelumne River water rights in 2000 under Decision 1641. By that action, the State Water Board replaced the 1961 Agreement flows with the JSA flows in EBMUD's water rights. EBMUD continues making fish releases to the lower Mokelumne River consistent with the JSA.

Flow Measures

The JSA specifies minimum flow releases from Camanche Dam to attain expected flow below Woodbridge Dam based on time of year (corresponding to fish life stages) and water year types. For the October through March releases, water year types are determined based on combined storage in Camanche and Pardee Reservoirs on November 5. For the April through September releases, water year types are determined based on the unimpaired runoff into Pardee Reservoir unless the projected combined storage for November 5 is less than 200 TAF, in which case, the water year would be critically dry. Minimum JSA flow releases from Camanche Dam and the expected flows below Woodbridge Dam are designed to protect fish resources in the lower Mokelumne River. Actual flows from 1998 to date have met or exceeded the required JSA flows below Camanche and Woodbridge Dams.

The JSA Camanche Dam release requirements vary throughout the year to meet the needs of the life stages of anadromous fish. Minimum release requirements range from 100 to 325 cfs during normal and above-normal runoff water year types, 100 to 250 cfs during below-normal years, 100 to 220 cfs during dry years, and 100 to 130 cfs during critically dry years. Additional releases up to 200 cfs are required for juvenile salmonid migration in April, May, and June, depending on the combined storage in Camanche and Pardee Reservoirs.

For more than 100 years (water years 1901 through 2012), annual Mokelumne River flows just upstream of Pardee Reservoir (Mokelumne Hill Station) have ranged from 129 TAF to 1.8 million acre-feet. Since implementation of the JSA in 1998, flow releases below Camanche Dam have ranged from 198 TAF to 1.2 million acre-feet.

Ramping Rates

The JSA stipulates that except during emergencies or when flood-control releases are being made, decreases in flow should not be more than 50 cfs per day during October 16 through March 31 (the spawning and incubation period for fall-run Chinook salmon and steelhead) and not more than 100 cfs per day during the rest of the year.

Camanche Hypolimnion

The JSA specifies temperature management goals for the hypolimnion in Camanche Reservoir. EBMUD is committed to using its best efforts to maintain the volume of the hypolimnion in Camanche Reservoir above 28 TAF through October if Pardee Reservoir storage is more than 100 TAF. The JSA states that water quality in the hypolimnion should be preserved by maintaining adequate oxygenation and reducing the presence of hydrogen sulfide levels by use of the HOS. The WQRMP specifies that water of the hypolimnion should be less than 16.4°C.

Gainsharing

The JSA gainsharing provision requires EBMUD to augment instream flows by 20% from the yield of new water supplies developed by EBMUD up to 20 TAF per year. Examples of these new water supplies include development of additional storage capacity on the Mokelumne River and groundwater from a conjunctive use program. Water from conservation programs, recycled water projects, or the Amador Canal pipeline project, are not subject to gainsharing.

For example, in 2015, due to drought conditions and reduced Mokelumne River runoff, EBMUD obtained additional water through its Freeport facilities including 33,250 AF of water from its Central Valley Project contract and 24,680 AF of transfer water. Based on these deliveries, a total 11,586 AF of water was made available through the JSA gainsharing provision. An additional 2,891 AF of gainsharing water was carried over from 2014. In September 2015, a draft fall plan for the gainsharing was forwarded to the Partnership Coordinating Committee for review and approval. A total of 6,093 AF of the gainsharing supply was used from October 16, 2015 through December 31, 2015 to augment base flows and for additional pulse flows. The remaining 8,384 AF was carried over to 2016.

In 2016, the Partnership Coordinating Committee requested to use some of the gainsharing water to increase the minimum flow release from Camanche Reservoir for the months of January and February. The remaining water was used for pulse flow releases in April and in the fall.

Non-Flow Measures

The JSA includes the following non-flow measures:

- Capital investments, such as the expansion and upgrade of the Mokelumne River Fish Hatchery described previously.

- Sustaining the long-term viability of the salmon and steelhead fishery while protecting the genetic diversity of naturally producing populations in the lower Mokelumne River. This involves supporting the development and implementation of Mokelumne River steelhead and fall-run Chinook HGMP to minimize adverse effects on the wild stocks. CDFW operates the Mokelumne River Fish Hatchery. Section 7 of the ESA obligates consultation with NMFS on any activities that may affect a listed anadromous fish species, including hatchery programs. HGMPs are a mechanism for addressing the take of certain listed species that may occur as a result of artificial propagation activities. NMFS uses the information provided by HGMPs to evaluate impacts on anadromous salmon and steelhead listed under the ESA, and in certain situations, the HGMPs will apply to the evaluation and issuance of Section 10 take permits. Completed HGMPs also may be used for regional fish production and management planning by federal, state, and tribal resource managers. The primary goal of the HGMP is to devise biologically based artificial propagation management strategies that ensure the conservation and recovery of listed ESUs.

- Managing the coldwater pools in Camanche and Pardee Reservoirs to provide suitable water temperatures for all salmonid and native fish life stages. This involves operating both Camanche and Pardee Reservoirs in concert to allow storage of an adequate volume of cold water during the winter and spring to prevent early turnover (destratification) in Camanche Reservoir, and provide sufficient cold water for release in the lower Mokelumne River through early November. This action will provide long-term benefits to salmonids and other native fish species in the lower Mokelumne River.

- Use coded-wire tagging on a greater proportion or all of the juvenile Chinook salmon produced at the Mokelumne River Fish Hatchery, if it is part of a statewide program. Currently the proportional coded-wire tagging and marking program for Central Valley Chinook salmon is 25% of the salmon released, and all steelhead released are tagged with an adipose fin clip but no coded-wire tag. The tagging program is a cooperative effort between CDFW, California Department of Water Resources, USFWS, Pacific States Marine Fisheries Commission, U.S. Bureau of Reclamation, and EBMUD. Since 2007, over 6.8 million fall-run Chinook salmon produced at the Mokelumne River Fish Hatchery have been tagged and released.

- Activities that enhance habitat conditions:

  – Plant trees and shrubs along the river for shade and remove undesirable vegetation. EBMUD initiated efforts in the early 2000s to improve the river’s ecosystem, including riparian restoration and enhancement on private lands. Since 2004, over 11,500 native trees and shrubs have been planted in the lower Mokelumne River riparian zone downstream of Camanche Dam.

  – Improve spawning gravels through continued implementation of the spawning gravel augmentation plan for the lower Mokelumne River. This plan, developed in cooperation with the University of California, Davis, has resulted in the placement and configuration of more than45,000 cubic yards of suitable-sized salmonid spawning gravel. Additional gravel placement to replace gravel lost to historical mining, scouring and subsidence, and annual supplementation to compensate for the lack of gravel recruitment is needed for the long term. This action will provide long-term benefits to salmonid and other native fishes spawning and incubation habitat.

  – Create side channels adjacent to the main channel of the lower Mokelumne River to provide suitable and beneficial habitat to juvenile Chinook salmon and steelhead, as well as habitat for a community of other fish and aquatic invertebrates. Two channels were created in 2005 (Channel 1 has a length of approximately 300 feet and a mean width of 17 feet; Channel 2 has a length of 200 feet and a mean width of 27 feet).

  – Work cooperatively with local landowners along the lower Mokelumne River to implement the conservation practices and restoration and enhancement projects identified in the San Joaquin County Resource Conservation District’s Lower Mokelumne River Conservation Handbook.

  – Identify, design, and install fish screens on diversion facilities in cooperation with diverters. CDFW is the lead for this activity subject to available funding.

- Procedural measures:

  – Perform monitoring to gage success.

  – Update and maintain a Mokelumne River science database.

Lower Mokelumne River Partnership

As part of the JSA, a Lower Mokelumne River Partnership has been established to support the protection of anadromous fish and the ecosystem of the lower Mokelumne River, encourage stakeholder participation, and integrate Mokelumne River strategies with other programs. The steering committee for the partnership is composed of one representative each from EBMUD, CDFW, and USFWS. The partnership program is funded by earnings from the $2 million Partnership Fund established by EBMUD in 1998 and any additional funding sources that can be secured. As of February 2017, the Fund had earned $837,448. In addition to the steering committee, the partnership includes a group of stakeholders with an interest in the lower Mokelumne River. The purpose of having a stakeholder group is to foster communication, make recommendations to the steering committee, and participate in enhancement work.

To facilitate operation of the JSA Partnership Steering Committee, a coordinating committee was formed. The JSA Coordinating Committee includes biologists and related staff of CDFW, EBMUD, USFWS, and NMFS. The Coordinating Committee meets in April and October of each year, and its work includes assessing the upcoming water year type and flow conditions; developing habitat projects and making recommendations to the JSA Partnership Steering Committee for expenditure of the Partnership Fund; and developing proposed adaptive management flow modifications to benefit the fishery.

Adaptive Management

To optimize habitat conditions, the JSA provides that river operations can be modified if warranted by river conditions and scientific information. With concurrence of CDFW, USFWS, and NMFS, and approval from the State Water Board, EBMUD may modify the JSA Camanche releases as long as the total volume released during the year would not be less than that specified in the JSA for the water year type.

Adaptive management flow modification occurred in March 2004, when WID requested EBMUD delay planned April flow increases required by the JSA and instead release the deferred water in May to allow completion of the fish bypass pipeline component of their dam construction. With concurrence of CDFW, USFWS, NMFS, and approval from the State Water Board, EBMUD maintained Camanche release at the lower rate of 330 cfs until mid-April, when WID completed the portion of the work that would have been affected by a higher release rate. The release then increased to 515 cfs by the end of April as WID initiated its seasonal diversions. The deferred volume of water originally scheduled to be released during April was released in addition to JSA requirements in May to coincide with outmigration of juvenile Chinook salmon and the volitional release of juvenile Chinook salmon from the Mokelumne River Fish Hatchery.

With prior concurrence of CDFW, USFWS, and NMFS, and approval from the State Water Board, EBMUD modified the below-normal JSA minimum flows in April and May 2009 to provide a fall pulse flow to attract adult fall-run Chinook salmon into the Mokelumne River. A total of 5,183 acre-feet of water was reallocated from the spring to provide flows in October that ranged from 308 cfs to 2,275 cfs.

In October, adult fall-run Chinook salmon move up through the Bay-Delta estuary toward their natal spawning grounds. Open DCC gates can result in straying of adult salmon as Sacramento River water is routed into the Mokelumne and San Joaquin Rivers. To maximize the effectiveness of fall pulse flows, the Lower Mokelumne River Partnership sent a letter to the U.S. Bureau of Reclamation (USBR or Reclamation) requesting the closure of the DCC for a 10-day period in October 2011. Similar requests were made in 2009 and 2010 resulting in a 48-hour closure in October 2010. Through efforts by the partnership, USBR, and DWR, a 10-day closure of the DCC was initiated from October 4 through October 14, 2011. The closure coincided with the first of four fall pulse flows with a peak magnitude of 1,800 cfs. Recent studies in the Mokelumne River have shown that a combination of pulse flows along with closure of the DCC gates in October can not only increase the number of Chinook salmon returns, it can also reduce straying of Mokelumne-origin salmon to the lower American River (California Department of Fish and Game 2012a).

Upon recommendation from the JSA Partnership and approval from the State Water Resources Control Board, minimum JSA flow releases from Camanche Dam were reduced in March 2012 to provide additional Chinook salmon attraction flows in October 2012. A series of pulse flows totaling 5,140 acre feet was released from October 8 through November 8, 2012 to facilitate passage of adult Chinook salmon in the lower Mokelumne River.

In 2015, critically dry conditions required adaptive management to maximize the use of limited water supplies. The Partnership Coordinating Committee decided at its October 8, 2015 meeting to eliminate the ramping rate criteria for October through December 2015 to prevent the waste of water during the ramp down steps that could otherwise be used for pulse flows. The Committee agreed that using the water for pulses rather than for maintaining ramping rates would benefit the fisheries to a much greater extent.

Assessment of Impacts

This section describes the approach, significance criteria, impact mechanisms, methods, and results of the assessment of potential effects on fisheries resources that could result from the Phase 2 Expansion.

Approach

Historical data on Chinook salmon and steelhead populations and habitat conditions in the project area, and general habitat relationships reported in literature, are used as the basis for this resource assessment. Modeling of reservoir operations and water temperatures was used to evaluate quantitatively the magnitude and frequency of changes in reservoir storage, flows, and water temperatures potentially affecting the quantity and quality of habitat of the key evaluation species (fall-run Chinook salmon, steelhead, selected resident reservoir fish). The assessment procedure included:

- summarizing existing knowledge of the life history, habitat requirements, ecology of the evaluation species, and historical relationships between habitat conditions and fish populations in the project area;

- describing potential impact mechanisms based on observed or predicted relationships between key environmental variables (reservoir storage, flows, and water temperatures) and species responses or habitat conditions in the project area;
- using monthly operations and water surface elevations modeling to quantitatively evaluate the magnitude and frequency of changes in reservoir storage, flows, and elevations due to Phase 2 Expansion operations compared to No Project/No Action Alternative conditions; and,
- assessing potential changes in habitat conditions from the Phase 2 Expansion compared to simulated No Project/No Action Alternative conditions.

Determination of significance was based on the sensitivity of the affected life stages of key evaluation species, the proportion of the population likely to be adversely affected by project conditions, and the frequency and/or duration of their exposure to these conditions.

Significance Criteria

Generally, the criteria used for determining the significance of an impact on fish resources are based on Appendix G (a model environmental checklist) of the State CEQA Guidelines. The CEQA Guidelines environmental checklist, however, is only a model and, because of its generic nature, its specific criteria are not necessarily suitable for every project. The following criteria reflect the potential impacts of the Phase 2 Expansion on Mokelumne River and Pardee and Camanche Reservoir fish resources.

Significant impacts on fish resources may occur if the Phase 2 Expansion would result in

- substantial interference with the movement of any resident or migratory species;
- substantial short- or long-term losses of habitat quantity or quality;
- substantial effects on rare or endangered species or their habitat; or
- substantial effects on fish communities or species protected by applicable federal, state, and local environmental regulations, policies, or programs.

Determining the significance of an impact requires that changes in environmental conditions associated with the Phase 2 Expansion are measurable, likely to adversely affect a substantial proportion of a species population or habitat, and potentially cause substantial short-term or long-term reductions in abundance.

EBMUD, USFWS, and CDFW have agreed that the flows, non-flow measures, and other elements of the JSA provide reasonable protection and enhancement of the anadromous fish and ecosystem of the lower Mokelumne River, compared to pre-1998 conditions. EBMUD's actions in compliance with the JSA constitute a reasonable contribution toward federal fishery restoration goals. In September 2008, the JSA Partnership Steering Committee (USFWS, CDFW, EBMUD) concluded that during the 10 years since JSA implementation, significant progress has been made toward partnership goals, and numerous successes and milestones have been achieved. Consequently, the assessment of impacts was based on the assumption that protection of fish resources in the lower Mokelumne River depends on EBMUD's ability to continue to meet the

JSA flow requirements and successfully implement other elements of the agreement during the Phase 2 Expansion.

Impact Mechanisms

Changes in flows, reservoir storage, and water temperatures can influence the biological performance of individuals and populations (e.g., growth, survival, production) through their direct and indirect effects on habitat quantity and quality. These general mechanisms are described below for each of the key evaluation species. Key evaluation species in Pardee and Camanche Reservoirs include coldwater fish (rainbow trout, kokanee) and warmwater fish (black bass). Key species in the lower Mokelumne River include fall-run Chinook salmon and steelhead.

Flow

Alteration of natural flow patterns below major reservoirs has been identified as a contributing factor to historical declines of Chinook salmon and steelhead in the Central Valley (Yoshiyama et al. 1998). However, the relationship between flow and fish populations is poorly understood because of the complex linkages between flow and the physical and biological attributes of stream ecosystems. This assessment concerns fall-run Chinook salmon and steelhead, the key evaluation species discussed above. Abundance of these species is indicative of the general quality of the lower Mokelumne River aquatic habitat because of the broad overlap of flow and temperature requirements with other native species.

Adult Immigration

Low flows, typically in association with high water temperatures, along the migration routes of adult salmon and steelhead can impede or delay these species’ migration to spawning areas (Bjornn and Reiser 1991). Fall-run Chinook salmon may delay their upstream migration to spawning areas until water temperatures begin to decline and flow increases to levels that permit passage over natural (e.g., shallow riffles) or artificial obstructions. Most adult fall-run Chinook salmon (99%) in the lower Mokelumne River return in September through December. More than 90% of adult steelhead in the lower Mokelumne River migrate upstream from September through February.

To successfully navigate to their natal streams, adult Chinook salmon and steelhead require sufficient flow to provide adequate water depth in stream channels and to overcome flow-related barriers. JSA flow releases from Camanche Dam exceed 100 cfs in all water year types during all months, and these flows provide adequate fish passage depths in the lower Mokelumne River from Camanche Dam downstream to Woodbridge Dam (California Department of Fish and Game 1991). Flows in the lower Mokelumne River below Woodbridge Dam are typically lower than the reach above Woodbridge Dam and are tidally influenced. Instream flows and tidal action influence water velocity, water depths, and consequently, upstream salmonid migration.

Spawning and Incubation

Flow affects the quantity of available spawning area for Chinook salmon and steelhead through its effect on water depths and velocities over suitable substrates, and the quality of the intergravel environment (temperature and dissolved oxygen) for embryos and alevins (fry with yolk sacs).

In addition to spawning habitat quantity, survival of salmonid embryos has been tied to dissolved oxygen (Coble 1961), percent fine sediment (Sear 1993), and permeability (Kondou et al. 2001) in spawning gravels. Merz and Setka (2004) showed that strategically placed gravel in the lower Mokelumne River significantly improved spawning habitat quality and availability, which supports salmonid spawning and egg incubation.

Flows of sufficient magnitude and duration are also needed periodically below dams to flush fine sediments from spawning gravels and promote the natural geomorphic processes that maintain salmon and steelhead spawning and rearing habitat (Kondolf et al. 1991). A study in the North Fork Feather River indicated a flushing flow of 2,000 cfs occurring as a planned release or natural flow for 1 to 3 days would be sufficient to transport sediment from salmonid spawning gravels (Reiser et al. 1989). Merz et al. (2008) estimated that flows of 2,000 cfs or greater are needed to mobilize sediments and dislodge aquatic plants from spawning areas. That study predicted that a flow of 2,000 cfs for 1 day in the lower Mokelumne River (ramped up 45% daily for 4 days and ramped down 15% for 8 days) would mobilize about 42% of the surface bed material and found that it reduced rooted aquatic vegetation about 12.5%. Fine-grained sediments that are not flushed through the system reduce the quality of salmonid spawning habitat and provide a substrate for vegetation establishment. The longer the duration of the flow, the more fine sediment and sand would be flushed from the substrate (Holmquist-Johnson and Milhous 2010). The duration of these flows should occur continuously over a few days and should be as frequent as hydrologic conditions provide sufficient runoff (i.e., in wetter years when floodflow releases from Camanche Dam are required).

Juvenile Rearing and Emigration

Flow affects juvenile salmon and steelhead rearing habitat through direct effects on water depths, velocities, and access to cover, and through indirect effects on prey abundance or availability.

Rapid fluctuations in flow below reservoirs also may cause stranding of juveniles along shorelines. With the exception of emergencies or flood-control releases, the JSA specifies that daily flow releases from Camanche Dam not decrease by more than 50 cfs per day during the period October 16 through March 31 and by more than 100 cfs per day at other times of the year.

Flow also may affect the quality of migration habitat for emigrating juveniles. Water travel time has been identified as a potential factor influencing the survival of juvenile salmon and steelhead during their downstream migration to the Delta, although evidence of a direct link between flow, travel time, and survival has not been demonstrated (Baker and Morhardt 2001). Flow also affects the distribution and extent of suitable water temperatures for rearing juveniles. Lower flows tend to result in higher water temperatures downstream of Camanche Dam from March through

October and lower water temperatures from November through February. Higher flows tend to ameliorate temperature increases resulting from air temperature and solar radiation.

Floodplain Habitat

Winter and spring inundation of floodplain habitat provides important habitat and ecosystem functions in lowland rivers. In the Central Valley, remnant floodplains and side channels provide important refuges and food resources for juvenile salmon (Sommer et al. 2001a, 2001b, 2005; Jeffres et al. 2008). The seasonal timing, magnitude, and duration of overbank flows affect the availability of floodplain habitat for juvenile salmon, Sacramento splittail, and other native fishes that use floodplain habitat for spawning and rearing. In the lower Mokelumne River, relationships between modeled water surface elevations and top of bank elevations developed by the U.S. Geological Survey (USGS) in 1970 indicate that floodplain inundation occurs at flows greater than 3,000 cfs in the lowermost reaches of the lower Mokelumne River between the confluence of the Cosumnes River and Tracy Lake (Florsheim and Mount 2003). Based on extensive monitoring of native and nonnative fish species that spawn and/or rear on the Cosumnes floodplain, the characteristics of floodflows that maximize the benefits of the floodplain spawning and rearing habitat include multiple events or continuous flows between March and May, with one or more peaks in early May (Mount pers. comm.). These flows should be as frequent as hydrologic conditions provide sufficient runoff (i.e., in wetter years when floodflow releases from Camanche Dam are required).

Reservoir Storage

EBMUD's model prioritizes meeting operational guidelines for EBMUD's terminal reservoirs (Briones, Chabot, Lafayette, San Pablo, and Upper San Leandro), which includes maintaining certain minimum storage levels. Results show that changes in terminal reservoir storage are not significant; the greatest reduction in total terminal reservoir storage modeled occurs in June 1928, when the total storage drops by approximately 7,100 acre-feet, out of a total volume of 151,066 acre-feet. Therefore, the Phase 2 Expansion's minimal alterations on the terminal reservoir operations are not anticipated to have effects on fish populations in these reservoirs.

Water levels in Pardee and Camanche Reservoirs typically peak in May or June and then decline through the summer, potentially affecting the quantity and quality of spawning and rearing habitat for littoral fish species. Inundated shallow-water areas provide habitat for spawning and rearing black bass (largemouth, smallmouth, and spotted bass). Fluctuating water levels can significantly influence the spawning and rearing success of black bass in reservoirs. A likely mechanism for poor reproductive success of black bass under rapidly rising water level conditions is decreasing water temperature at the nest site, nest desertion by the male (male bass guard the nest from potential predators), and subsequent increased risk of predation (Kohler et al. 1993; Mitchell 1982). With decreasing water levels, these mechanisms may include loss of habitat, increased egg and larval mortality by stranding or suffocation by eroded sediments, nest desertion, poor egg survival, and disrupted spawning (Kohler et al. 1993; von Geldern 1971).

Pardee and Camanche Reservoirs thermally stratify from spring through early fall, providing habitat for both coldwater and warmwater fish species. The amount of coldwater habitat is determined by runoff water temperatures, reservoir storage, reservoir morphology, meteorological conditions, season, and extent of vertical mixing. Drawdown of reservoir storage from June through October can diminish the volume of cold water in the reservoir's hypolimnion, thereby reducing the amount of habitat for coldwater fish (trout and kokanee) during these months. Flood-control releases also can reduce the amount of cold water in Pardee and Camanche Reservoirs by reducing residence times and increasing the contribution of warm inflows from upstream storage reservoirs.

Reservoirs also serve as a source of cold water for maintaining habitat for anadromous salmonids (fall-run Chinook salmon and steelhead) in the reaches below Camanche Dam. During the summer and fall when air temperatures exert a strong influence on river temperatures, the water temperature requirements of these species can be met by withdrawing and releasing water from the hypolimnion of upstream reservoirs. The downstream extent of suitable water temperatures depends on release temperature (a function of reservoir temperature profile and outlet depth), discharge, and meteorological conditions.

Since implementation of the JSA, EBMUD has been adaptively managing coldwater storage in Pardee and Camanche Reservoirs to minimize exposure of Mokelumne River adult Chinook salmon and salmon eggs to elevated water temperatures throughout the spawning season. EBMUD uses its best efforts to maintain 28 TAF of water colder than 16.4°C through October whenever Pardee Reservoir's total volume is greater than 100 TAF to prevent early turnover of Camanche Reservoir.

Water Temperature

Changes in water temperature may directly or indirectly affect fish populations by influencing a number of physiological, behavioral, and ecological mechanisms that affect survival, growth, migration, and reproduction. Each species and life stage has a specific temperature tolerance range that is bracketed by upper and lower lethal thresholds, commonly defined as the temperatures at which 50% mortality occurs for a given acclimation temperature and exposure duration. Within this range, criteria for evaluating water temperature effects typically are based on the physiological performance of fish under controlled laboratory conditions as measured by growth, food conversion efficiencies, swimming ability, and other physiological functions. Physiological performance is generally greatest over a relatively narrow range of temperatures and decreases as temperatures approach the lethal thresholds.

As described in Water Resources Section, Camanche Reservoir water surface elevation of 190 feet can be used a threshold for criteria for determining the potential for temperature related impacts. During periods when Camanche Reservoir storage is drawn down, there is the potential for the cold water supply at the bottom of the reservoir to be depleted, resulting in an increase in release temperatures. Because the height of the different temperature layers in the reservoir is variable, there is no consistent, precise reservoir elevation threshold for affecting release temperatures. EBMUD's most recent studies indicate that during the March through October timeframe, an elevation of 190 feet appears to be the highest elevation at which release temperatures may be affected by low storage levels. Therefore, this threshold criteria of 190 feet msl is used as a significance criteria to determine the potential for temperature related impacts in the Lower Mokelumne River. EBMUD attempts to maintain this level during operations to ensure a sufficient cold water pool.

Adult Immigration

Chinook salmon and steelhead undergo long and rigorous migrations en route to natal rivers and encounter many stressors along the way. The effects of stressors are magnified at higher water temperatures. Stress from high water temperatures can increase adult pre-spawn mortality, reduce embryo survival, and increase the incidence of disease (McCullough 1999). The effects from exposure to elevated water temperatures are positively correlated with exposure time (McCullough 1999), and the cumulative effects may be delayed until adults arrive on spawning grounds. Adult pre-spawn mortality is of particular concern. McCullough (1999) stated that adult salmon, which fast during a long upstream journey, exhaust virtually all energy reserves prior to spawning. High water temperatures during immigration and holding can magnify these demands and potentially reduce survival and reproductive success. Many freshwater diseases that afflict Chinook salmon and steelhead are most virulent within specific water temperature ranges.

Spawning and Incubation

The Chinook salmon and steelhead spawning and embryo incubation life stage is defined as the time period from redd construction and egg deposition through alevin emergence. The spawning component of this life stage extends from redd construction through egg deposition. The embryo (eggs and alevins) incubation component of this life stage extends from egg deposition until the alevins emerge from gravel substrates as free-swimming fry. The amount of time between fertilization and emergence from the gravel as fry varies temporally and spatially and is heavily dependent on water temperature (Moyle 2002). Under ideal water temperatures and dissolved oxygen levels, Chinook salmon embryos hatch in 40 to 60 days and remain in interstitial spaces of gravel substrates as alevins for another 4 to 6 weeks (Moyle 2002).

Juvenile Rearing and Emigration

The Chinook salmon juvenile rearing and smolt emigration life stage is defined as the time period from fry emergence through ocean entry. The juvenile component consists of three stages: fry, parr (fingerling), and smolt. Young Chinook salmon are called fry upon emergence from gravel beds. During the transition from fry to parr, juvenile salmonids grow in size and spend more time using deeper and higher-velocity habitats for feeding and rearing (Moyle 2002). The fry-to-parr transition occurs at approximately 1.8 to 2.4 inches (National Marine Fisheries Service 1997). Juvenile Chinook salmon spend several months to more than a year rearing in fresh water prior to emigrating to saltwater. During emigration, the parr-smolt transformation takes place and involves morphological, physiological, and behavioral changes that prepare juveniles for the ocean environment. In general, these changes occur while juvenile salmonids are en route from natal streams to the ocean.

The life-history patterns of *O. mykiss* are variable and flexible (Moyle 2002). Two basic patterns are migratory life history (steelhead) and resident life history (resident rainbow trout), and both types often exist in the same population. Migratory *O. mykiss* are either sea-run (anadromous) or within river (potadromous) migrants. Regardless of life-history strategy, for the first year or two, most *O. mykiss* typically remain in the lower Mokelumne River.

A decrease in the survivability of emigrating juvenile salmonids may occur when water temperatures are not optimal for growth (Folmar et al. 1982). Thermal stress loading occurs when water temperatures are outside suitable ranges, which, by itself, can cause immediate or delayed mortalities (Brett 1952). Also, adverse effects related to water temperature can be secondary in nature, such as reduced growth, salinity and disease resistance, and susceptibility to predation. For example, growth is a function of water temperature, and survival of smolts to adulthood has been reported to be positively correlated with body length (Ward et al. 1989).

Impact Assessment

Quantitative assessment of Phase 2 Expansion effects on fish resources was based on monthly hydrologic and water temperature modeling results presented in Section 3, Water Resources.

This analysis focuses on Pardee and Camanche Reservoir storage and surface water elevations, as well as flow. As discussed in the Water Resources Section, a Camanche Reservoir water surface elevation of 190 feet msl during March thru October appears to be the highest elevation at which release temperatures might be affected by low storage levels. The methods used to assess potential fish impacts related to each of the potential impact mechanisms are presented below. In general, impacts to fish resources were assessed using a combination of monthly reservoir operations modeling and selected biological criteria to quantitatively evaluate the magnitude and frequency of Phase 2 Expansion effects on key habitat variables in Camanche and Pardee Reservoirs and lower Mokelumne River fishery resources.

The protection of fish resources in the lower Mokelumne River depends on EBMUD's ability to continue to meet the JSA flow requirements and successfully implement other elements of the agreement. The following impact assessment focuses on fish impacts related to the following topics:

- flow
- reservoir storage
- water temperature (as related to Camanche reservoir water surface elevation)
- water quality

Each impact identified in the following discussion relates to one or more of the significance criteria listed above under Significance Criteria above.

Flow

Phase 2 Expansion effects on the magnitude and frequency of flows potentially affecting the quantity and quality of habitat of each species and life stage of concern were quantified by comparing average monthly flow releases from Camanche Dam and expected flows below

Woodbridge Dam under the simulated No Project/No Action Alternative and Phase 2 Expansion conditions. On average, the No Project/No Action Alternative and Phase 2 Expansion monthly flows below Camanche are 722 cfs and 717 cfs, respectively. The Phase 2 Expansion would result in a slight reduction in average monthly flow below Camanche Dam of 5 cfs (or 0.6%).

On average, the No Project/No Action Alternative and Phase 2 Expansion monthly flows below Woodbridge Dam are 556 cfs and 551 cfs, respectively. The Phase 2 Expansion would result in a slight reduction in average monthly flow below WID of 4 cfs (or 0.7%).

Adult Salmonid Migration

Impact MOKFISH-1: Reduced migration habitat for adult fall-run Chinook salmon and steelhead (Less than Significant)

To successfully navigate to their natal streams, adult Chinook salmon and steelhead require sufficient flow to provide adequate water depth in stream channels and to overcome flow-related barriers. Flows that result in water depths of at least 0.8 foot typically provide adequate adult salmonid passage (Taylor and Love 2003). The State Water Resources Control Board recommendation for northern California coastal streams is at least 0.7 foot of water depth for steelhead and 0.9 foot of water depth for Chinook salmon (State Water Resources Control Board 2010). EBMUD measurement of flow below Woodbridge Dam and upstream salmonid passage at Woodbridge Dam indicate that 95% of adult salmonid passage occurs at flows exceeding 100 cfs.

Based on observations of fish passage at Woodbridge Dam at low flows, flows below Woodbridge Dam of at least 100 cfs from September through December and from September through February provide adequate passage for adult fall-run Chinook salmon and adult steelhead, respectively.

Effects of Phase 2 Expansion flow conditions below Woodbridge Dam relative to the No Project/No Action Alternative condition are shown in **Table A-6**. Over the 92-year hydrologic period modeled, 551 months fell between September and February, when reduced flows below Woodbridge Dam could result in reduced migration habitat for fall-run Chinook salmon and steelhead. Comparison of No Project/No Action Alternative and Phase 2 Expansion modeling results indicates that the Phase 2 Expansion would only result in two additional months out of those 551 months when average flows below Woodbridge Dam would drop below 100 cfs (see Table A-5). Further, as previously mentioned, EBMUD's Permit 10478 includes a new regulatory term which, subject to certain conditions, requires EBMUD to release up to 2 TAF of additional water during September through February during below normal and dry years to assist upmigration. These additional releases were not included in the modeling and would offset the reduced flows in those two additional months with average flows below Woodbridge Dam of less than 100 cfs. As a result, this impact is less than significant.

TABLE A-6
NUMBER OF MODELED YEARS WHEN FLOWS BELOW WOODBRIDGE DAM MAY IMPEDE ADULT SALMONID MIGRATION BASED ON JSA YEAR TYPE (WHEN AVERAGE FLOW IS LESS THAN 100 CFS)

	Number of months Flows below WID are less than 100 cfs from Sept - Feb									
	Baseline					Project				
	Normal	BN	Dry	CD	Total	N	BN	D	CD	Total
Sept	2	7	22	9	40	2	8	22	9	41
Oct	0	0	5	4	9	0	0	6	4	10
Nov	0	0	0	4	4	0	0	0	4	4
Dec	0	0	0	4	4	0	0	0	4	4
Jan	0	0	0	4	4	0	0	0	4	4
Feb	0	0	0	4	4	0	0	0	4	4
					65					67

Salmonid Spawning and Rearing Habitat

Impact MOKFISH-2: Reduced spawning and rearing habitat for fall-run Chinook salmon and steelhead (No Impact)

Flow affects the quantity of available spawning, fry, and juvenile rearing habitat for fall-run Chinook salmon and steelhead through its effect on water depths and velocities over suitable substrates. To evaluate the potential impact of these flow reductions on salmonid spawning and rearing habitat, the changes in Chinook salmon and steelhead habitat Weighted Usable Area (WUA) were examined under the No Project/No Action Alternative conditions and Phase 2 Expansion flows using the flow and WUA curves developed by CDFW in 1991 (California Department of Fish and Game 1991). Estimates of suitable habitat area, such as WUA, are species and life-stage-specific measures of suitable depth, velocity, and substrate area commonly used to quantify flow effects on fish habitat availability. CDFW's 1991 approach set the following ranges of optimal flows for different life stages of fall-run Chinook salmon and steelhead. Fall-run Chinook WUA is maximized at flows (Camanche Dam releases) of 300 to 500 cfs (spawning), 100 to 200 cfs (fry rearing), and 100 to 200 cfs (juvenile rearing). Steelhead WUA is maximized at flows of 200 to 600 cfs (spawning), 100 cfs (fry rearing), and 100 to 600 cfs (juvenile rearing).

The flow duration curve for Camanche minimum required releases under No Project/No Action Alternative and Phase 2 Expansion indicates minimal changes in flows below 600 cfs during the 92-year period of record (Figure WR-5 in Appendix A-1). Over the course of the modeled period, the overall average reduction in monthly flows below Camanche is approximately 5 cfs. The Phase 2 Expansion objective is to divert Mokelumne River water during wet years when water is available above EBMUD's needs and other obligations and reduce diversions from the Mokelumne River in drier years by obtaining exchanged water supplies to meet demands. Reducing diversions from the Mokelumne River in drier periods is expected to provide net benefits to lower Mokelumne River resources. As a result, this impact is considered less than significant.

Salmonid Juvenile Outmigration

Impact MOKFISH-3: Reduced outmigration for juvenile fall-run Chinook salmon and steelhead (No impact)

In the lower Mokelumne River, a bimodal emigration pattern occurs with a distinct fry emigration period from January through March and a distinct smolt emigration period from April through June. Under certain hydrologic conditions (e.g., higher flow conditions), more fry typically disperse downstream from spawning areas soon after emergence. These movements, facilitated by peak winter flows, result in dispersal of fry throughout the lower reaches of the spawning streams and upper reaches of the Bay-Delta estuary, where they seek out shallow river margins, floodplains, and tidal wetlands. These fry are dependent on the Delta and estuary for the majority of their rearing before emigrating as smolts in the late spring. During dryer hydrologic conditions, more fry remain near the spawning areas, where they rear for several months before emigrating in the late spring.

Based on data collected from rotary screw traps in the river just below Woodbridge Dam from 1993 through 2012, there is no significant relationship (R2=0.09) between average monthly flow release from Camanche Dam and the normalized number (juveniles per spawning adult) of juvenile fall-run Chinook salmon outmigrating during that month. However, there is a significant relationship (R2=0.49, P<0.001) between the average flow from January through March and the proportion of juvenile fall-run Chinook salmon that migrate downstream as fry. These data suggest that average flow releases from Camanche Dam of approximately 800 cfs and above during January through March may encourage early outmigration.

Outmigration timing and emigrant size and abundance are influenced by a variety of factors including the abundance of adult spawners and the timing of their return; temperatures during early development ultimately affecting the timing of fry emergence; and conditions during juvenile rearing including habitat quality and predation (Groot and Margolis 1991; Quinn 2005). Numerous studies indicate that transiting the Delta interior is a very risky undertaking for juvenile salmonids (National Marine Fisheries Service 2009) and may be more difficult as fry. However, management and recovery of salmon populations should focus on maintenance of life-history variation, including outmigration timing and emigrant size (Miller et al. 2010).

There are 34 years under both No Project/No Action Alternative and Phase 2 Expansion conditions when the average flows for the January through March period are greater than 800 cfs. That is, the frequency of flows greater than 800 cfs during January thru March does not change as a result of the Phase 2 Expansion. Therefore, the impacts are less than significant.

Floodplain Habitat

Impact MOKFISH-4: Reduced floodplain habitat for native fish species (No Impact)

As discussed in Impact Mechanisms above, inundation of floodplain habitat for native fishes is most important in March, April and May, and flows in excess of 3,000 cfs below Woodbridge Dam may support floodplain inundation (i.e., in wetter years when floodflow releases from Camanche Dam are required). According to Mount (pers. comm.), connectivity between the river channel and floodplain should occur in multiple events or continuously between March 1st and May 1st, and one or more flood peak flows should occur in early May to maximize benefits to native fish species. These flows should be as frequent as hydrologic conditions provide sufficient runoff (i.e., in wetter years when floodflow releases from Camanche Dam are required). Of the 92 simulated years, the frequency of flows exceeding 3,000 cfs in March, April, and/or May below Woodbridge Dam are infrequent (approximately 11 months out of a total of 276 months) but are the same with Phase 2 Expansion conditions and No Project/No Action Alternative conditions; therefore, impacts are less than significant.

Salmonid Spawning Habitat Maintenance

Impact MOKFISH-5: Reduced mobilization of substrate for salmonid spawning habitat maintenance (Less than Significant)

Merz et al. (2008) estimated that flows of 2,000 cfs or greater were needed to mobilize surface bed material and dislodge aquatic plants from salmonid spawning areas. The duration of these flows should occur continuously over a few days and should be as frequent as hydrologic conditions provide sufficient runoff (i.e., in wetter years when floodflow releases from Camanche Dam are required. Flows of this frequency, duration, and magnitude can serve as a general indicator of the flows needed for maintaining the quantity and quality of spawning gravel in the lower Mokelumne River. Under both No Project/No Action Alternative and Phase 2 Expansion conditions, the frequency of flows exceeding 2,000 cfs below Camanche Dam occur approximately 8% of the time (88 months out of 1101 total months). There is no change in the frequency of flows greater than 2,000 cfs below Camanche Dam under Phase 2 Expansion conditions as compared to No Project/No Action Alternative conditions. Therefore, impacts are less than significant.

Native Fishes Habitat

Impact MOKFISH-6: Reduced flows that support native fish species habitat (Less than Significant)

Native fishes that typically occur in the lower Mokelumne River upstream of the Delta include hardhead, hitch, Pacific lamprey, prickly sculpin, Sacramento pikeminnow, Sacramento blackfish, Sacramento sucker, and tule perch. Flows that provide adequate habitat for salmonids are expected to be sufficient to accommodate all life stages of the native fishes observed in the lower Mokelumne River; therefore, this impact is considered less than significant.

Reservoir Storage

Impact MOKFISH-7: Short term reduction in fish habitat in Pardee and Camanche Reservoirs (Less than Significant)

Phase 2 Expansion effects on fish habitat in Pardee and Camanche Reservoirs were evaluated by comparing the magnitude of reservoir surface elevation changes (i.e., monthly average of extrapolated daily rates) based on modeled end-of-month (EOM) reservoir water surface elevations under simulated No Project/No Action Alternative and Phase 2 Expansion conditions.

The difference in EOM Pardee storage under Phase 2 Expansion conditions relative to No Project/No Action Alternative is minimal, with a maximum storage level change of 9,500 AF in simulated September 1979. This change in level equates to 48 inches out of 172 ft (height of Pardee Reservoir). Similarly, the maximum difference in Camanche storage is 17,830 AF in simulated December 1979, which equates to 30 inches. Results indicate that this decline lasts just two months and Camanche storage recovers to No Project/No Action Alternative levels by March 1980. Because the storage change is relatively minimal in Pardee and Camanche Reservoirs, the impact to fish in these Reservoirs is considered less than significant.

Water Temperature

Reservoir Storage Effects and Downstream Temperature

As discussed in "Impact Mechanisms" above, there is a relationship between the storage level in Camanche Reservoir and temperatures in the Lower Mokelumne River. Based on available and reconstructed historical data (March 1974 through October 2008), there is a significant correlation between Camanche Reservoir water surface elevation below elevation 190 feet and Camanche Reservoir storage effects on release temperatures. This relationship was used to evaluate the effects of Phase 2 Expansion-related changes on temperature impacts in the Lower Mokelumne River.

Additionally, EBMUD's JSA requirements include maintaining minimum pool volume to ensure sufficient cold water pool for fishery needs, along with dissolved oxygen levels. For both the No Project/No Action Alternative and Phase 2 Expansion conditions, the modeling results show EBMUD meeting all JSA flow release requirements.

Impact MOKFISH-8: Substantial short or long-term change of water temperature for coldwater fish species (Less than Significant)

Coldwater species include kokanee and rainbow trout in Pardee Reservoir, and rainbow trout in Camanche Reservoir. Kokanee salmon prefer well-oxygenated open water in reservoirs where temperatures are 10 to 15°C, and rainbow trout growth is optimal when temperatures are around 15 to 18°C (Moyle 2002). Potential impacts on these species were evaluated based on the 190 msl Camanche elevation threshold discussed above.

According to **Figure WR-8** in **Appendix A-1**, under No Project/No Action Alternative conditions, Camanche Reservoir is below 190 ft threshold 5.7% of the time (5.2 years). The Phase 2 Expansion would result in improvements – whereby Camanche Reservoir is below the 190 ft threshold 4.9% of the time (4.5 years). Using Camanche water surface elevation threshold of 190 msl as a criteria for cold water pool, there was is a slight improvement in the number of years when Camanche water surface elevation was below 190 ft msl under Phase 2 Expansion conditions relative to No Project/No Action Alternative. Therefore, the impacts are less than significant.

Fall-Run Chinook Salmon Adult Migration, Spawning, and Incubation

Impact MOKFISH-9: Reduction in suitable water temperatures for migration, spawning and incubation of fall-run Chinook salmon (Less than Significant)

Most adult fall-run Chinook salmon in the lower Mokelumne River return in September, October, November, and December. During this period, adults actively migrate through the lower reaches of the lower Mokelumne River until they reach the primary spawning areas. Fall-run Chinook salmon spawn in the lower Mokelumne River primarily from October through December, particularly from Camanche Dam downstream to the Elliott Road Bridge. The incubation period extends from the time of spawning to fry emergence, and is controlled largely by water temperature. Based on general relationships between water temperature and emergence times, the incubation period in the lower Mokelumne River extends primarily from the onset of spawning through March.

According to **Figure WR-8** in **Appendix A-1**, under No Project/No Action Alternative conditions, Camanche Reservoir is below 190 ft threshold 5.7% of the time (5.2 years). The Phase 2 Expansion conditions result in improvements whereby Camanche Reservoir is below the 190 ft threshold 4.9% of the time (4.5 years). Using Camanche water surface elevation threshold of 190 msl as a criteria for cold water pool, there was is a slight improvement in the number of years when Camanche water surface elevation was below 190 ft msl under Phase 2 Expansion conditions relative to the No Project/No Action Alternative. Therefore, the impacts are less than significant.

Moreover, actual operations including JSA requirements related to maintaining a volume of coldwater (<16.4 degrees C) would be adhered to. Therefore, the impacts are less than significant.

Fall-run Chinook Salmon Juvenile Rearing, Smoltification, and Emigration

Impact MOKFISH-10: Reduction in suitable water temperatures for rearing, smoltification, and emigration of juvenile fall-run Chinook salmon (Less than Significant)

After emergence, Chinook salmon fry disperse downstream or reside for several months in their natal streams before emigrating to the ocean. In the lower Mokelumne River, a bimodal emigration pattern occurs with a distinct fry emigration period in late December through March and a distinct smolt emigration period in late April through June. Smaller numbers of yearling smolts also are observed between late December and May. Most of the juvenile salmon rearing and smolting in the lower Mokelumne River takes place from Camanche Dam downstream to Woodbridge Dam (location of Station Golf). The critical period for juvenile salmon rearing is January through June, and from April through June for smolting. During the emigration period (primarily from January through June), juveniles actively migrate through the lower reaches of the lower Mokelumne River until they reach the Delta.

According to **Figure WR-8** in **Appendix A-1**, under No Project/No Action Alternative conditions, Camanche Reservoir is below 190 ft threshold 5.7% of the time (5.2 years). The Phase 2 Expansion conditions result in improvements whereby Camanche Reservoir is below the

190 ft threshold 4.9% of the time (4.5 years). Using Camanche water surface elevation threshold of 190 msl as a criteria for cold water pool, there was is a slight improvement in the number of years when Camanche water surface elevation was below 190 ft msl under Phase 2 Expansion conditions relative to No Project/No Action Alternative. Therefore, the impacts are less than significant.

Steelhead Adult Migration, Spawning, and Incubation

Impact MOKFISH-11: Reduction in suitable water temperatures for migration, spawning and incubation of steelhead (Less than Significant)

In the lower Mokelumne River, most steelhead pass Woodbridge Dam from September through February and spawn in the upper reaches of the lower Mokelumne River from December through March. During this period, adults actively migrate through the lower reaches of the lower Mokelumne River until they reach the primary spawning areas.

The steelhead spawning and incubation period in the lower Mokelumne River occurs primarily from December through May, particularly from Camanche Dam downstream to the Elliott Road Bridge. Water temperatures from Camanche Dam downstream to Station Elliott (where most steelhead spawning occurs in the lower Mokelumne River) during December through May are considered in the analysis of Phase 2 Expansion temperature effects on adult steelhead spawning and incubation habitat.

According to **Figure WR-8** in **Appendix A-1**, under No Project/No Action Alternative conditions, Camanche Reservoir is below 190 ft threshold 5.7% of the time (5.2 years). The Phase 2 Expansion conditions result in improvements whereby Camanche Reservoir is below the 190 ft threshold 4.9% of the time (4.5 years). Using Camanche water surface elevation threshold of 190 msl as a criteria for cold water pool, there was is a slight improvement in the number of years when Camanche water surface elevation was below 190 ft msl under Phase 2 Expansion conditions relative to No Project/No Action Alternative. Therefore, the impacts are less than significant.

Steelhead Juvenile Rearing, Smolting, and Emigration

Impact MOKFISH-12: Reduction in suitable water temperatures for rearing, smoltification, and emigration of juvenile steelhead (Less than Significant)

Central Valley steelhead typically rear in freshwater for 1 or 2 years before emigrating to the ocean. Juveniles typically are observed passing Woodbridge Dam from December through July, including young-of-year (fish born in the year of capture) that appear from March through July. Juvenile steelhead rear in the lower Mokelumne River year-round, and smolting typically occurs from February through June. Most rearing and smolting take place from Camanche Dam downstream to Woodbridge Dam. Steelhead emigrate from the lower Mokelumne River primarily from February through June. During the emigration period, juveniles actively migrate through the lower reaches of the lower Mokelumne River until they reach the Delta.

According to Figure WR-8 in Appendix A-1, under No Project/No Action Alternative conditions, Camanche Reservoir is below 190 ft threshold 5.7% of the time (5.2 years). The Phase 2 Expansion conditions result in improvements whereby Camanche Reservoir is below the 190 ft threshold 4.9% of the time (4.5 years). Using Camanche water surface elevation threshold of 190 msl as a criteria for cold water pool, there was is a slight improvement in the number of years when Camanche water surface elevation was below 190 ft msl under Phase 2 Expansion conditions relative to No Project/No Action Alternative. Therefore, the impacts are less than significant.

Water Quality

Impact MOKFISH-13: Reduction in water quality (dissolved oxygen, pH, and turbidity) for fall-run Chinook salmon and steelhead (Less than Significant)

In addition to flow, aquatic organisms can be affected by various water quality parameters. In addition to cold water, salmon and steelhead need high levels of dissolved oxygen, a pH close to neutral and limited turbidity. As explained below, prior studies have not found these water quality parameters to be problematic on the lower Mokelumne River.

Studies of the effects of pH on salmonids have that levels between 5.0 and 9.0 are generally acceptable (Deas and Orlob 1999), and long-term (2000 through 2012) monthly sampling on the lower Mokelumne River showed pH levels ranging from 6.37 to 8.03, with a mean of 7.07. The EBMUD component of the Phase 2 Expansion would not be expected to result in changes in pH, so significant impacts related to pH are not anticipated.

Similarly, studies of turbidity show that suspended solid concentrations below 20 to 25 mg/L would result in few, if any, measurable effects on fish populations (Robertson-Bryan Inc. 2006), with the possible exception of egg and larvae mortality and reduced growth rates in salmonids at lower levels (10 to 20 mg/L) (Newcombe and Jenson 1996). However, analysis of total suspended solids in the lower Mokelumne River of samples collected monthly by EBMUD at the Elliott Road Bridge from December 1999 through May 2005 (extent of EBMUD's existing data) resulted in measures ranging from 1.5 to 7.2 mg/L (mean 2.98 mg/L). The EBMUD component of the Phase 2 Expansion would not be expected to result in changes in total suspended solid concentrations, so significant impacts related to turbidity are not anticipated.

In terms of dissolved oxygen, the California Regional Water Quality Control Board's Basin Plan for the Sacramento River and San Joaquin River basins dissolved oxygen objective is a minimum of 7.0 mg/L (California Regional Water Quality Control Board 2011), and EBMUD targets maintaining a dissolved oxygen level of 7 mg/L downstream from Camanche at Station 11. EBMUD manages dissolved oxygen levels by changing how water is released from Camanche, increasing sluicing to oxygenate water heading downstream. In addition, as part of EBMUD's Permit 10478 Time Extension Project EIR, EBMUD determined that downstream dissolved oxygen levels were related to flow, reservoir surface elevation, and temperature. Using modeling based on that relationship, the Permit 10478 Time Extension Project EIR determined that the Permit 10478 time extension would result in no impacts related to dissolved oxygen levels in the lower Mokelumne River. Given that the EBMUD component of the Phase 2 Expansion would result in overall minor changes in flow below Camanche Reservoir and is not expected to have significant impacts on reservoir surface elevations that could cause temperature impacts on the Lower Mokelumne River, significant impacts on the lower Mokelumne River related to dissolved oxygen levels are not expected to occur.

For these reasons, impacts to fishery resources related to water quality would be less than significant.

A.5 Cumulative Analysis

This chapter analyzes the cumulatively significant impacts associated with the EBMUD component of the Phase 2 Expansion. The State California Environmental Quality Act (CEQA) Guidelines Section 15355 defines a cumulative impact as "two or more individual effects which, when considered together, are considerable or which compound or increase other environmental impacts." Individual effects may be changes resulting from a single project or a number of separate projects. The cumulative impact from several projects is the change in the environment which results from the incremental impact of the project when added to other closely related past, present, and reasonably foreseeable future projects. Cumulative impacts can result from individually minor but collectively significant projects taking place over a period of time. An environmental impact report (EIR) must address the cumulative impacts of the project when the project's incremental effect is cumulatively considerable (State CEQA Guidelines Section 15130).

Approach to Cumulative Impact Analysis

Legal Requirements

A cumulative impact is one that is created as a result of the combination of the project evaluated in the EIR together with other projects causing related impacts (State CEQA Guidelines, Section 15130[a][1]). The State CEQA Guidelines require a discussion of cumulative impacts when the project's incremental effect is cumulatively considerable, as defined in Section 15065(a)(3).1. This analysis conforms to Section 15130 of the Guidelines, which also includes the following:

(a) …Where a lead agency is examining a project with an incremental effect that is not "cumulatively considerable," a lead agency need not consider that effect significant, but shall briefly describe its basis for concluding that the incremental effect is not cumulatively considerable.

  (1) …An EIR should not discuss impacts which do not result in part from the project evaluated in the EIR.

  (2) When the combined cumulative impact associated with the project's incremental effect and the effects of other projects is not significant, the EIR shall briefly indicate why the cumulative impact is not significant and is not discussed in further detail in the EIR. A lead agency shall identify facts and analysis supporting the lead agency's conclusion that the cumulative impact is less than significant.

(3) An EIR may determine that a project's contribution to a significant cumulative impact will be rendered less than cumulatively considerable and thus is not significant. A project's contribution is less than cumulatively considerable if the project is required to implement or fund its fair share of a mitigation measure or measures designed to alleviate the cumulative impact. The lead agency shall identify facts and analysis supporting its conclusion that the contribution will be rendered less than cumulatively considerable.

State CEQA Guidelines Section 15130[b][1] identifies two methods for establishing the cumulative environment in which a project may be considered:

- A list of past, present, and probable future projects that may cause related or cumulative impacts; or
- Adopted projections from a General Plan or other regional planning document.

The following sections describe the methods and assumptions used for the cumulative impact analysis in this Supplement for the EBMUD component of the Phase 2 Expansion.

Methods and Assumptions

Certain aspects of the EBMUD component of Phase 2 Expansion includes factors that cannot be meaningfully analyzed under the typical CEQA assessment of comparing No Project/No Action Alternative and the Phase 2 Expansion project conditions. The passage of time alone could result in changes to water demand (due to population growth or other factors) that may occur with or without a specific project in place, and some projects with the potential to contribute to cumulative impacts on the Mokelumne River are not readily subject to quantified analysis. In order to provide a more comprehensive analysis, EBMUD completed a qualitative analysis which provides a framework within which all cumulative impacts may be better understood, and then used that qualitative analysis to inform a comprehensive consideration of cumulative impacts readily susceptible to quantification.

The qualitative analysis, which forms the framework for cumulative impacts assessment is derived primarily from the modeling conducted in Permit 10478 Time Extension EIR (Permit 10478 EIR), certified by EBMUD's Board of Directors in September 2014. The Permit 10478 EIR analyzed the environmental impacts resulting from an increase in EBMUD's water demand from the year 2005 to the year 2040, and considered cumulative impacts on the Mokelumne River resulting from that increase in demand and anticipated 2040 level of demand for upstream senior water rights on the river. Consideration of the Phase 2 Expansion in the context of the Permit 10478 EIR's cumulative impact analysis provides an understanding of how the Phase 2 Expansion's contribution to cumulative impacts relate to those other stressors on the Mokelumne River.

The quantitative approach uses RiverWare modeling of future cumulative conditions with and without the Phase 2 Expansion to isolate the impact the Phase 2 Expansion from the impacts of other stressors on the river. The quantitative cumulative model results are based upon the year 2040 Level of Demand for both EBMUD (assumed to be 230 MGD average annual demand) and upstream senior water right users on the Mokelumne River (Amador and Calaveras Counties) using their full water right entitlement of 47 TAF.

Water Resources

Qualitative Analysis—Cumulative Impacts Framework

Permit 10478 Time Extension

The Permit 10478 Time Extension Draft EIR (Permit 10478 EIR) provides a useful framework for beginning the analysis of cumulative conditions. The Permit 10478 EIR looked at changes resulting from an increase in EBMUD demand from 214 MGD in 2005 to 230 MGD in 2040. For the project level analysis, the Permit 10478 EIR considered a 2005 level of development on the Mokelumne River. The cumulative analysis then considered a higher level of development (2040 levels) and added in EBMUD's anticipated increase in available supplemental supplies.

According to Permit 10478 EIR, average annual demand of 230 MGD in the year 2040 diverted from the Mokelumne River (along with other assumptions) resulted in no significant impacts to water resources, vegetation and wildlife resources, recreational or other visual resources.

The analysis of the 230-MGD demand included detailed modeling of lower Mokelumne River temperatures, flows and storage elevations. Population changes, general and local economic conditions and a myriad other factors that are not within EBMUD's control influence the average annual water demand. Nonetheless, the average annual demand is a key parameter in that it directly influences the amount of water diverted from the Mokelumne River as well as the reservoir levels and other river conditions.

Two potentially significant impacts were identified in fishery resources and agricultural resources. These impacts were mitigated to less than significant impacts after implementation of certain mitigation measures. These measures have now been incorporated into Permit 10478 as new permit terms and are described below.

First, the Permit 10478 EIR identified reduced migration habitat for adult fall-run Chinook salmon and steelhead as a potentially significant impact resulting from the proposed permit extension. To successfully navigate to their natal streams, adult Chinook salmon and steelhead require sufficient flow to provide adequate water depth in stream channel and to overcome flow related barriers. Based on EBMUD observation of fish passage below WID, flows in excess of 100 cfs from September through February were considered adequate for passage. The JSA flows below Camanche exceed 100 cfs in all water year types and these flows provide adequate flow depth. Flows below WID are typically lower than in the Camanche reach and are tidally influenced. The tidal influence may affect the flow depth and velocity.

As mitigation, the new regulatory term for Permit 10478 requires EBMUD to release up to 2,000 AF of additional water above required releases during September thru February in Below Normal and Dry years, when determined necessary by the JSA Partnership Steering Committee, to facilitate fish passage below WID. With this term in place, EBMUD does not anticipate significant impacts to fish passage as a result of the increase in average annual demand.

The second potentially significant impact noted in the Permit 10478 EIR included impacts to JVID's ability to divert water under its senior water right.[2]. When Pardee storage levels fall below 550 ft (i.e., Pardee storage volume threshold of approximately 167 TAF), and water is available under JVID's water right, JVID would not be able to physically access their water supplies. As part of the new regulatory requirement, EBMUD will work with JVID to install a submersible pump during periods when Pardee water surface elevation is below 550 ft and water is available under JVID's priority. Therefore, EBMUD does not anticipate significant impacts to agricultural resources (i.e., this senior water right holder) as a result of the increase in average annual demand.

The Permit 10478 EIR also considered cumulative impacts at a 2040 level of development on the Mokelumne River, which assumed that Amador and Calaveras Counties use their full water right entitlement of 47 TAF as compared to the 27 TAF assumed in the No Project/No Action Alternative assessment of this Supplement. For the cumulative analysis, the Permit 10478 EIR also took into consideration additional supplemental supplies that EBMUD planned to obtain to meet its dry year needs. The analysis drew on EBMUD's Water Supply Management Program (WSMP) 2040, assuming that by 2040 EBMUD would have secured or otherwise obtained some of the additional dry-year supplies identified in that document. EBMUD's ability to obtain dry year supplies was proven in 2014 and 2015, when EBMUD was able to obtain approximately 24,680 AF of transfer water and approximately 51,850 AF of CVP water through Freeport. The cumulative analysis in the Permit 10478 EIR concluded that with implementation of the two permit terms described above, cumulative impacts would be less than significant. As such, the Permit 10478 EIR's impact analysis provides a point of comparison for understanding the environmental significance of impacts identified in the quantitative assessment below.

Other Mokelumne River Projects and Programs

The Permit 10478 EIR was certified in September 2014, and the Permit extension was issued in 2016, including the new terms identified as mitigation measures. Since the Permit 10478 EIR analysis was completed, new projects and management programs have emerged that could contribute to cumulative effects on water quality and fish resources in the Mokelumne River in the future. Following is a description of those projects and programs.

Ecosystem Restoration Program

The Ecosystem Restoration Program (ERP) is administered by the CDFW. The ERP is a multi-agency effort aimed at improving and increasing aquatic and terrestrial habitats and ecological function in the Delta and its tributaries. The goals of the ERP are to contribute to the recovery of at-risk native species; rehabilitate natural ecosystem processes; maintain and enhance fish populations critical to commercial, sport, and recreational fisheries; protect and restore functional habitats; reduce negative impacts of invasive species; and improve and maintain water and

[2] JVID holds a senior water right, for agricultural purposes.

sediment quality to better support ecosystem health. ERP actions contribute to cumulative benefits on fish and wildlife species, habitats, and ecological processes. As such, it is not considered in further detail in the cumulative impacts analysis. Additional information is available at <http://www.dfg.ca.gov/ERP>.

Bay-Delta Water Quality Control Plan

The State Water Board is in the process of reviewing and updating its Water Quality Control Plan for the San Francisco Bay / Sacramento-San Joaquin Delta Estuary (Bay-Delta WQCP). In considering potential changes to the Bay-Delta WQCP, the State Water Board is reviewing changes that should be made to water quality objectives and the program of implementation to protect beneficial uses in the Bay-Delta, both in the immediate future under existing conditions and in the longer term. In October 2016, the State Water Board issued a working draft Scientific Basis Report for Phase 2 of the Bay Delta Plan Update. The Mokelumne River is listed as one of three eastside tributaries that are assessed as part of Phase 2. Because of substantial uncertainty regarding the changes in water quality objectives that may be implemented as part of the plan update, it is not considered in any further detail in the cumulative impacts analysis.

California WaterFix

The California Department of Water Resources is proposing the construction of twin tunnels below ground to transport water from the Sacramento River underneath the Delta to the intakes for the Central Valley Project and State Water Project. It is estimated that the California WaterFix project would provide up to 4.9 million AF of water per year on average. California WaterFix may result in increased openings of the Delta Cross Channel gates, which EBMUD has determined would significantly increase the risk that Mokelumne salmonids will stray to the Sacramento and American Rivers, rather than returning to the Mokelumne River. EBMUD has determined that the project may also result in flow and water delivery changes that would impact juvenile salmon and steelhead migration in the spring. There is not currently sufficient information to evaluate these impacts.

San Joaquin County DREAM Project

The Demonstration Recharge Extraction and Aquifer Management (DREAM) Project is a collaboration of San Joaquin County, NSJWCD, and EBMUD. San Joaquin County has responsibility for planning and engineering of the DREAM Project. EBMUD will provide the DREAM Project with a surface water supply of up to 1,000 AF, at a rate of 2 cfs, to be applied to approximately 350 acres of developed farmland in lieu of groundwater extraction. The NSJWCD Mokelumne River South System intake and delivery pipeline would be used to convey surface water to farmlands currently pumping groundwater. In exchange for providing 1,000 AF of surface water to the DREAM Project, EBMUD would receive up to 500 AF (half of the amount delivered for irrigation) of groundwater extracted from an existing well located near the proposed surface water irrigation site for export to EBMUD customers. San Joaquin County issued the export permit for the DREAM Project in April 2017, and design is underway for project facilities. Feasibility and environmental information developed as part of the DREAM Project would inform future efforts toward additional and potentially expanded projects such as those considered in the protest dismissal agreement with San Joaquin County noted below. Because the

DREAM Project consists of a one-time conveyance of 1,000 AF of water for in-lieu groundwater recharge, and subsequent 500 AF extraction of groundwater for delivery to EBMUD, and is likely to be completed prior to any EBMUD participation in the Phase 2 Expansion project, it is not considered in further detail in the cumulative impact analysis.

Protest Dismissal Agreement (PDA)

In November 2014, EBMUD entered into a protest dismissal agreement (PDA) with San Joaquin County, NSJWCD, Stockton East Water District (SEWD), Central Delta Water Agency (CDWA) and South Delta Water Agency (SDWA). Under the PDA, the parties agreed to work jointly to improve the health and sustainability of the Eastern San Joaquin groundwater basin and to set aside the respective protests on pending water right applications and petitions.

Under the PDA, EBMUD agreed to provide additional water to NSJWCD subject to certain conditions, utilize unused capacity in the Mokelumne Aqueducts to convey NSJWCD's water to SEWD under certain conditions, and, solely at EBMUD's discretion and upon issuance of a water rights permit by the State Water Resources Control Board to San Joaquin County (under County Application 29835), EBMUD also agreed to temporarily store water for the County in Pardee and/or Camanche Reservoirs during each storage season (from about December 1st to the following June 30th). In return for releasing water to NSJWCD (the purpose of which is direct or in lieu recharge of the Eastern San Joaquin groundwater basin), EBMUD would receive groundwater banking extraction credits for 50% of the amount of released water actually applied through direct or in-lieu recharge in the NSJWCD service area.

The PDA acknowledges that CEQA review must be completed before its various elements are implemented, and that individual components of the PDA remain subject to the discretion of the agencies involved, including the discretion to disapprove an element or require implementation of mitigation measures or alternatives to address any significant environmental impacts that may be identified during the CEQA review process. At this point, environmental review pursuant to CEQA has not yet been initiated on PDA elements other than the DREAM Project discussed above, and therefore the various elements of the PDA are still subject to potential modification. For these reasons, the PDA is not considered in further detail in this cumulative analysis.

EBMUD Component of the Phase 2 Expansion - Quantitative Cumulative Impact Analysis

The discussion above provides a context for evaluating the potential cumulative impacts of the proposed EBMUD component of the Phase 2 Expansion. Of the two scenarios considered for EBMUD participation in the Phase 2 Expansion, in terms of Mokelumne River impacts, the most relevant is the scenario in which EBMUD transfers Mokelumne River water to CCWD, other Local Agency Partners, and Refuges during wetter years, and then receives an exchange of water from CCWD and Local Agency Partners during drier years.

Some of the potential future projects discussed above could not be evaluated quantitatively because of uncertainty and a lack of quantitative detail. However, modeling the Phase 2 Expansion at 2040 conditions – including EBMUD's projected demand of 230 MGD, the 47 TAF level of demand from Amador and Calaveras Counties, and the proposed EBMUD component of the Phase 2 Expansion– provides a reasonable quantitative analysis of potential cumulative impacts. A discussion of the methodology and results follows.

For the quantitative component of the cumulative analysis, RiverWare model results were used to compare the 2040 projected demands on the Mokelumne River both with and without the EBMUD component of Phase 2 Expansion in place. The 2040 demands included EBMUD's projected customer demand of 230 MGD and a 2040 level of development on the Mokelumne River that included Amador and Calaveras Counties using their full 47 TAF water rights entitlement. The quantitative analysis provides more detailed information to evaluate the environmental resources in the lower Mokelumne River and the magnitude of the Phase 2 Expansion's potential contribution to cumulative impacts.

Reservoir Storage

As expected, Pardee Reservoir levels with and without the Phase 2 Expansion under cumulative conditions generally follow the upper operational rule curve. The increased aqueduct diversions under cumulative conditions result in a greater degree of variability than under the Phase 2 Expansion conditions. The benefits of the Phase 2 Expansion are realized in dry years when the Pardee Reservoir levels are higher because EBMUD obtains additional non-Mokelumne supplemental supplies to meet demand.

Figure CWR-1 in Appendix A-2 illustrates the end-of-month storage levels for Pardee Reservoir under cumulative conditions with and without the Phase 2 Expansion. One of the insets provided in the figure shows the typical change in monthly storage using the 1990 to 1993 time frame. In general, there is no appreciable difference in Pardee storage with and without the Phase 2 Expansion. The largest difference in storage at Pardee is noted in June 1992 when Pardee storage is reduced from 159 TAF to 136 TAF as a result of the Phase 2 Expansion. This drop of nearly 23 TAF (12% of the 198 TAF capacity) occurs because Pardee Reservoir is providing support to maintain the coldwater pool in Camanche Reservoir for the benefit of fisheries. This Phase 2 Expansion-induced change in Pardee Reservoir storage lasts just a few months. By October 1992, Pardee Reservoir storage under cumulative conditions with the Phase 2 Expansion is nearly the same level as Pardee Reservoir storage without the Phase 2 Expansion.

Figure CWR-2 in Appendix A-2 illustrates the end-of-month storage levels for Camanche Reservoir under cumulative conditions with and without the Phase 2 Expansion. As expected, Camanche Reservoir generally fluctuates from season to season as Camanche releases water to meet downstream obligations. Typically, in dry years, the storage levels generally increase under cumulative conditions with Phase 2 Expansion as EBMUD obtains exchanged water supplies from CCWD or other Local Agency Partners. The largest reduction in Camanche Reservoir storage occurs in April 1992 when Camanche storage is reduced from 171 TAF to 147 TAF. The nearly 24 TAF reduction (5.7% of the 417 TAF capacity) is illustrated in the inset of Figure CWR-2(b) in Appendix A-2. The model results indicate that, as with Pardee Reservoir, Camanche Reservoir levels recover within a few months. Thus, there is no appreciable difference between Camanche storage levels under cumulative conditions.

End-of-month storage levels for EBMUD total system storage under cumulative with Phase 2 Expansion conditions are consistently lower than cumulative No Project/No Action Alternative Phase 2 Expansion. The average reduction in storage under the Phase 2 Expansion is approximately 2.8 TAF (2.4%) out of an average end-of-month storage of 115 TAF. The maximum reduction occurs in June 1946 with a reduction of 10.3 TAF as compared to 119 TAF under cumulative No Project/No Action Alternative Phase 2 Expansion.

Figure CWR-3 in Appendix A-2 graphs the end of September EBMUD total system storage to determine the impacts, if any, to carryover storage. The results indicate that the carryover storage in EBMUD TOTAL SYSTEM STORAGE decreases by about 1670 AF on average under cumulative with Phase 2 Expansion conditions. The carryover storage impact of 1670 AF is minor when compared to a EBMUD total system storage of 532 TAF under cumulative conditions without the Phase 2 Expansion.

Camanche Releases and Flow in the Lower Mokelumne River

RiverWare results indicate that implementation of the EBMUD component results in negligible reductions in total Camanche Releases under cumulative with Phase 2 Expansion conditions. Appendix A-2 provides a comparison of total Camanche releases under cumulative conditions with and without the Phase 2 Expansion. The Figure generally shows how closely the Phase 2 Expansion conditions mimic the cumulative No Project/No Action Alternative condition. The insets included in the Figure typify and illustrate the magnitude and nature of the changes during assorted time periods.

Under cumulative conditions, the total Camanche releases over the 92-year period of record are 44.125 MAF, whereas the total releases under cumulative conditions with Phase 2 Expansion would be 43.907 MAF - resulting in a total reduction of 218 TAF (i.e. 0.6 % reduction in total Camanche releases over the 92 year period of record). The average Camanche releases per month for the No Project/No Action Alternative during this period are 664 cfs and are marginally smaller at 661 cfs with the Phase 2 Expansion. Therefore, the overall monthly average reduction in Camanche releases is only 3 cfs. Under cumulative with Phase 2 Expansion conditions, when EBMUD transfers water to CCWD and Local Agency Partners, Camanche releases are reduced in 364 months out of 1104 months in the period of record with an average reduction of 1257 AF per month (20.82 cfs reduction out of an average flow of 664 cfs). The maximum decline occurs in May 1996, with a 180 cfs reduction under the Phase 2 Expansion as compared to No Project/No Action Alternative flows of 2456 cfs (nearly 4 times the average monthly flow). Additionally, there are a total of 31 months out of 1104 months with declines greater than 5%. Of these, 14 months occur when monthly flows are above average both with and without the Phase 2 Expansion. All Camanche releases meet JSA requirements and other regulatory criteria.

Minimum Required Releases

As described above, EBMUD typically releases more than the JSA minimum flow requirements to also meet downstream senior obligations or when regulating flood-control releases. Under No Project/No Action Alternative conditions, the average minimum required releases per month are

339 cfs and under cumulative with Phase 2 Expansion, minimum required releases are actually slightly higher at 340 cfs - resulting in an increase of just 1 cfs. See Figure CWR-5 in Appendix A-2.

Flood Control Releases

A portion of the total Camanche release includes releases to meet the November 5th flood control requirement. Under cumulative No Project/No Action Alternative conditions, the total Camanche Flood control release is 325 cfs as compared to 320 cfs under the Phase 2 Expansion conditions. The maximum monthly reduction in Flood Control Release occurs in May 1996 with a reduction of 180 cfs out of 1679 cfs (which is over five times the average Flood Control Release) under the cumulative No Project/No Action Alternative. Figure CWR-6 in Appendix A-2 illustrates the minor changes in flood control releases over the period of record.

Flows Below WID

The average monthly Total Flows below WID under cumulative conditions No Project/No Action Alternative are 500 cfs as compared to 497 cfs under the Phase 2 Expansion conditions. The 3 cfs difference is minor – resulting in a negligible reduction of 0.6% when compared to average monthly total flows No Project/No Action Alternative. Similar to the change in total Camanche release and flood control releases, the maximum decline of 180 cfs occurs in May 1996, when total flows below WID are 2180 cfs (i.e. over 4 times the monthly average). This decline in flows translates to a reduction of 8.25% from the No Project/No Action Alternative. Results indicate that the reduction in flow is due to a result of a reduction in flood releases. EBMUD would continue to exceed JSA requirements below Camanche and below WID and meet senior obligations below WID. Figure CWR-7 in Appendix A-2 there is a slight increase in flows below WID in years when EBMUD obtains exchanged waters. The figure provides an overall context to view the minor changes in Total flows below WID The figure illustrates that there is no appreciable change in flows below WID under cumulative conditions with and without the Phase 2 Expansion project.

Woodbridge Irrigation District, North San Joaquin Water Conservation District and Jackson Valley Irrigation District Diversions

Under cumulative conditions with the Phase 2 Expansion, diversions by NSJWCD, a junior water rights holder, would occur in 51 years – equivalent to the number of years under the No Project/No Action Alternative. However, there is 17,368 AF increase in the total diversions to NSJWCD in the cumulative with Phase 2 Expansion conditions, most likely due to exchanged water in EBMUD’s system. See **Table A-7**.

Under cumulative conditions with the Phase 2 Expansion, water use by the WID would remain the same as under the cumulative No Project/No Action Alternative. See Table A-6.

This cumulative analysis also assumes that by 2020, JVID, a senior water rights holder, is supplied water from the Amador Water Agency (AWA), so it would no longer be subject to intermittent limitations as a result of low water surface elevations in Pardee Reservoir. However, should JVID continue to divert its full 3,850 AF at Pardee Reservoir through year 2040, there

TABLE A-7
NSJWCD AND WID DIVERSIONS FOR CUMULATIVE WITH PHASE 2 EXPANSION ALTERNATIVES AND NO PROJECT/NO ACTION ALTERNATIVE CONDITIONS

Year	NSJWCD Diversions		WID Diversions	
	No Project/ No Action Alternative	Phase 2 Expansion Alternatives	No Project/ No Action Alternative	Phase 2 Expansion Alternatives
1921	0	0	60	60
1922	20000	20000	60	60
1923	20000	20000	60	60
1924	0	0	39	39
1925	20000	20000	60	60
1926	0	0	60	60
1927	20000	20000	60	60
1928	20000	20000	60	60
1929	0	0	39	39
1930	0	0	60	60
1931	0	0	39	39
1932	0	0	60	60
1933	0	0	60	60
1934	0	0	39	39
1935	20000	20000	60	60
1936	20000	20000	60	60
1937	20000	20000	60	60
1938	20000	20000	60	60
1939	0	0	39	39
1940	20000	20000	60	60
1941	20000	20000	60	60
1942	20000	20000	60	60
1943	20000	20000	60	60
1944	0	0	60	60
1945	20000	20000	60	60
1946	20000	20000	60	60
1947	0	0	39	39
1948	647	20000	60	60
1949	0	0	60	60
1950	20000	20000	60	60
1951	20000	20000	60	60
1952	20000	20000	60	60
1953	20000	20000	60	60
1954	4505	2520	60	60
1955	0	0	60	60
1956	20000	20000	60	60
1957	20000	20000	60	60
1958	20000	20000	60	60
1959	0	0	60	60
1960	0	0	60	60
1961	0	0	39	39
1962	0	0	60	60
1963	20000	20000	60	60
1964	0	0	60	60
1965	20000	20000	60	60
1966	0	0	60	60
1967	20000	20000	60	60
1968	0	0	60	60
1969	20000	20000	60	60
1970	20000	20000	60	60
1971	20000	20000	60	60

**TABLE A-7 (CONTINUED)
NSJWCD AND WID DIVERSIONS FOR CUMULATIVE WITH PHASE 2 EXPANSION ALTERNATIVES AND NO PROJECT/NO ACTION ALTERNATIVE CONDITIONS**

Year	NSJWCD Diversions		WID Diversions	
	No Project/ No Action Alternative	Phase 2 Expansion Alternatives	No Project/ No Action Alternative	Phase 2 Expansion Alternatives
1972	0	0	60	60
1973	20000	20000	60	60
1974	20000	20000	60	60
1975	20000	20000	60	60
1976	0	0	39	39
1977	0	0	39	39
1978	0	0	39	39
1979	0	0	60	60
1980	20000	20000	60	60
1981	0	0	60	60
1982	20000	20000	60	60
1983	20000	20000	60	60
1984	20000	20000	60	60
1985	0	0	60	60
1986	20000	20000	60	60
1987	0	0	39	39
1988	0	0	39	39
1989	0	0	60	60
1990	0	0	39	39
1991	0	0	39	39
1992	0	0	39	39
1993	20000	20000	60	60
1994	0	0	39	39
1995	20000	20000	60	60
1996	20000	20000	60	60
1997	20000	20000	60	60
1998	20000	20000	60	60
1999	20000	20000	60	60
2000	20000	20000	60	60
2001	0	0	60	60
2002	0	0	60	60
2003	20000	20000	60	60
2004	0	0	60	60
2005	20000	20000	60	60
2006	20000	20000	60	60
2007	0	0	60	60
2008	0	0	39	39
2009	20000	20000	60	60
2010	20000	20000	60	60
2011	20000	20000	60	60
2012	0	0	60	60

could be intermittent limitations as a result of low water surface elevations at Pardee Reservoir under cumulative conditions. As discussed in the qualitative analysis above, the new regulatory term in Permit 10478 requires EBMUD to work with JVID to install a submersible pump during periods when Pardee Reservoir surface levels are below 550 ft and water is available to JVID under their water right priority. Compliance with this permit term would ensure that there would be no impacts to JVID's ability to divert under cumulative conditions.

Camanche Elevation Threshold

As discussed in the Mokelumne River Fish Resources Section above, the 190 ft elevation threshold in Camanche Reservoir is used as a threshold to evaluate potential temperature related impacts to flows below Camanche. Under cumulative No Project/No Action Alternative conditions, RiverWare modeling results indicate that Camanche Reservoir end-of-month storage is less than the 190 feet msl approximately 8.2% of the time over the 92-year period of record. Under cumulative Phase 2 Expansion conditions, Camanche end-of-month storage is less than 190 feet msl approximately 8.0% of the time over the period of record. The improvement under the cumulative Phase 2 Expansion conditions is related to the additional exchanged water supplies obtained from CCWD and other Local Agency Partners in dry years.

Changes in JSA year type

RiverWare modeling results indicate that under cumulative Phase 2 Expansion conditions, there would be two changes in JSA year type (in both cases moving from drier to wetter conditions) as compared to cumulative No Project/No Action Alternative conditions. The changes occur in October 1948 going from the below normal category to normal and above normal – this reflects an increase of 15 TAF in EBMUD total system storage. In October 1991, the JSA year type category changes to critically dry to dry – reflecting an increase of 2,071 AF in EBMUD total system storage. The improvement to wetter conditions is most likely related to the use of exchanged water from CCWD and other Local Agency Partners. **Table A-8** shows the comparison of JSA year types under the No Project/No Action Alternative and the Phase 2 Expansion.

TABLE A-8

JSA Year Type (October - March)		
Year type	**No Project/No Action Alternative**	**Phase 2 Expansion Project**
Normal and Above	43	44
Below Normal	19	18
Dry	21	22
Critically Dry	9	8
Total	92	92

Significance Criteria

The criteria used for determining the significance of an impact on hydrology and water quality are based on Section I of Appendix G (a model Environmental Checklist) of the State CEQA Guidelines and professional standards and practices. Because this Appendix analyzes only the potential modifications to Mokelumne River resources due to operations of the EBMUD component of the Phase 2 Expansion, with construction of new facilities and modification of existing facilities analyzed in Chapter 4, only those criteria that are relevant to this analysis are listed below. Impacts on hydrology may be considered significant if the operations of the EBMUD component of the Phase 2 Expansion project would:

- substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of existing nearby wells would drop to a level that would not support existing land uses or planned uses for which permits have been granted);
- substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner that would result in flooding on- or off-site; or
- otherwise substantially degrade water quality.

Impact Discussion

The primary impact mechanisms for water resources are changes in lower Mokelumne River flow, which could affect groundwater recharge or reduce flooding. Less-than-significant impacts on water resources associated with these changes are described in the following sections. As explained above, the quantitative cumulative impact analysis helps isolate the degree to which the Phase 2 Expansion project contributes to potential cumulative impacts. To put those contributions into perspective and help reach conclusions regarding impact significance, the analysis below discusses the cumulative impacts attributable to the Phase 2 Expansion project in relation to the Permit 10478 EIR's cumulative impact analysis, which considers the effects of EBMUD's increasing demands to 230 MGD and increased levels of demand on the Mokelumne River through the year 2040.

Significant Impacts

As explained below under Less-Than-Significant Impacts, changes in lower Mokelumne River flow associated with cumulative Phase 2 Expansion conditions would not result in significant impacts on water resources.

Less-than-Significant Impacts

Impact WR CUM-1: Potential for changes in Mokelumne River flow to affect groundwater recharge (Less than Significant)

Estimated channel loss rates in the lower Mokelumne River have ranged from 57,000 to 130,000 AFY, with most of the loss occurring in the 21-mile reach between Camanche Dam and Lodi Lake near the town of Lodi (HCG 1998). Some of this loss is likely seepage to groundwater. There is some potential for a reduction in river flow to cause a reduction in groundwater recharge. A reduction in groundwater recharge could result from reduced river contact with the substrate caused by reduced channel width and depth. However, percolation to groundwater is controlled largely by the position of the groundwater table compared to river elevation. In addition, the cumulative Phase 2 Expansion condition is unlikely to have much effect on channel shape because reduction in flow would be small (overall reduction of 0.6% of flow below Camanche Dam as described above). In RiverWare, channel losses are generally assumed to be in the 50-65 cfs range from below Camanche Dam to Frandy, and the overall reduction in flow below Camanche attributable to the Phase 2 Expansion project under cumulative conditions is only 3 cfs. Given that the Permit 10478 EIR concluded that cumulative impacts associated with meeting EBMUD's 2040 anticipated demand of 230 MGD and 2040 level of demand on the river would be less than significant, and given the overall small (3 cfs) additional reduction in flows that would be attributable to the Phase 2 Expansion project under cumulative conditions, cumulative impacts on groundwater recharge would be less than significant.

Impact WR CUM-2: Potential for changes in Mokelumne River flow to reduce flooding (Less than Significant)

As described above, a flow of 3,000 cfs could produce floodplain inundation (and potentially flood-related damage) downstream of Woodbridge Dam. Modeling results show that the cumulative Phase 2 Expansion conditions result in one fewer day with flows above 3,000 cfs (21 vs. 22 days, out of 1,101 days modeled). The Permit 10478 EIR concluded that the cumulative impacts associated with EBMUD's projected 2040 demand of 230 MGD and the 2040 level of development on the river would be less than significant. Given that the addition of the Phase 2 Expansion project shows a very slight improvement, cumulative impacts on flooding would be less than significant.

Fish Resources

This section describes cumulative conditions for fish resources based on results from the cumulative RiverWare simulations and other considerations described above under water resources. This section discusses impacts to fish resources in the Lower Mokelumne River (below Camanche Dam to Frandy gage – a distance of about 33 miles) under the cumulative Phase 2 Expansion and the cumulative No Project/No Action Alternative conditions. Fish resources within the Delta are discussed in Section 4.3 of the Supplement.

This section assesses the significance of the impacts associated with implementing the EBMUD component of the Phase 2 Expansion under cumulative conditions. This assessment focuses on fall-run Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) in the lower Mokelumne River, which are considered key evaluation species based on their regulatory status, commercial and recreational importance, and sensitivity to project effects. The welfare of these species is indicative of the general quality of the aquatic habitats below Camanche Dam, because of their broad overlap in seasonal habitat requirements with other native fish species.

This analysis concludes that the EBMUD component of the Phase 2 Expansion would not result in cumulatively considerable impacts on fish resources.

Lower Mokelumne River

Projected increases in water demands could affect fish resources in the Mokelumne River through changes in reservoir inflows, storage, and releases to the lower Mokelumne River. Potential changes in lower Mokelumne River water temperature could also affect fish resources. These effects are described in the following sections. As explained above, the quantitative cumulative impact analysis helps isolate the degree to which the Phase 2 Expansion project contributes to potential cumulative impacts. To put those contributions into perspective and help reach conclusions regarding impact significance, the analysis below discusses the cumulative impacts attributable to the Phase 2 Expansion project in relation to the Permit 10478 EIR’s cumulative impact analysis, which considers the effects of EBMUD’s increasing demands to 230 MGD and increased levels of demand on the Mokelumne River through the year 2040.

Flow

The magnitude and frequency of Mokelumne River flows which could potentially affect the quality and quantity of habitat for fall-run Chinook and steelhead were assessed under both the cumulative No Project/No Action Alternative and the cumulative Phase 2 Expansion conditions. Cumulatively considerable effects were determined by comparing the average monthly flow releases below Camanche Dam and below WID under the cumulative with and No Project/No Action Alternative conditions. On average, modeled monthly flows below Camanche Dam under cumulative No Project/No Action Alternative conditions and cumulative Phase 2 Expansion conditions are 664 cfs and 661 cfs respectively. The cumulative Phase 2 Expansion conditions result in a nominal reduction of 3 cfs (0.45%) of average monthly flow below Camanche.

On average, modeled monthly flows below WID under the cumulative Phase 2 Expansion conditions and the cumulative No Project/No Action Alternative are 500 cfs and 497 cfs respectively. The cumulative conditions Phase 2 Expansion result in a nominal reduction of about 3 cfs (0.6%) in average monthly flows below WID.

Adult Salmonid Migration

To successfully navigate to their natal stream, adult Chinook salmon and steelhead require sufficient flows to provide adequate water depth in stream channels and to overcome flow-related barriers. JSA flow releases from Camanche Dam exceed 100 cfs in all year-types and during all months and these flows provide adequate fish passage depths in lower Mokelumne River from Camanche Dam downstream to WID. Threshold flows that may impede upstream migration of adult salmon and steelhead in the lower Mokelumne River are discussed in greater detail in the Fish Resources Section.

Analysis of flows below WID indicate that conditions for migration of fall-run Chinook salmon are optimized 12% more frequently under cumulative Phase 2 Expansion conditions as compared to cumulative No Project/No Action Alternative conditions. According to **Table A-9**, under cumulative No Project/No Action Alternative conditions, flows below WID are less than 100 cfs from Sept-February for a total of 92 months (out of 552 total months). Under cumulative Phase 2 Expansion conditions, flows below WID are less than 100 cfs for a total of 89 months (out of

TABLE A-9
NUMBER OF MODELED YEARS WHEN FLOWS BELOW WOODBRIDGE DAM MAY IMPEDE ADULT SALMONID MIGRATION BASED ON JSA YEAR TYPE (WHEN AVERAGE FLOW IS LESS THAN 100 CFS)

	Number of Months Flows below WID are less than 100 cfs from Sept - Feb										
	Cumulative No Project/No Action Alternative(230MGD)						Cumulative Phase 2 Expansion (230MGD)				
	AN	BN	Dry	Crit	Total		AN	BN	Dry	Crit	Total
Sept	2	10	23	9	44		2	12	23	9	46
Oct	0	0	3	9	12		0	0	3	8	11
Nov	0	0	0	9	9		0	0	0	8	8
Dec	0	0	0	9	9		0	0	0	8	8
Jan	0	0	0	9	9		0	0	0	8	8
Feb	0	0	0	9	9		0	0	0	8	8
	2	10	26	54	92		2	12	26	49	89

552 months). The table indicates that there are improvements in critically dry years and a slight decline in below normal years.

Salmonid Spawning and Rearing Habitat

Under cumulative No Project/No Action Alternative conditions, the flows below WID were very close to or near the 100-cfs threshold such that an increase of just a few cubic feet per second would increase the flows to the 100-cfs threshold. Similarly, two months in below normal years (September 1946 and September 1957) resulted in slightly less flows. These reductions in flows in below normal years would be addressed through the Permit 10478's new regulatory term which requires additional flow releases from September through February in below normal and dry years (subject to certain conditions), ensuring that the Phase 2 Expansion project would not contribute to any cumulative impacts in those years. This regulatory term requires implementation of Mitigation Measure FISH-1 from the Permit 10478 EIR. While the Permit 10478 EIR determined that cumulative impacts on adult salmonid migration would be cumulatively considerable, it also concluded that implementation of FISH-1 would ensure that EBMUD's contribution to that impact would be less-than-significant. Similarly here, because compliance with the new permit term would ensure the Phase 2 Expansion project would not contribute to potential cumulative impacts in below normal years, and because the Phase 2 Expansion project would actually improve conditions for migrating salmon in critically dry years, overall the Phase 2 Expansion project implementation would be beneficial for migrating salmon under cumulative conditions. Accordingly, the Phase 2 Expansion project's contribution to cumulative impacts on adult salmonid migration would be less-than-significant.

As described under the Fish Resources Section, flow affects the quantity of available spawning, fry and juvenile rearing habitat for fall-run Chinook salmon and steelhead through its effect on water depths and velocities over suitable substrates. In 1991, CDFW developed optimal flows for different life stages for fall-run chinook and steelhead. Habitat for fall-run chinook is maximized at flow below Camanche Dam of 300-500 cfs (spawning), 100 to 200 cfs (fry-rearing), and 100 to

200 cfs (juvenile rearing). Steelhead WUA is maximized at flows of 200 to 600 cfs (spawning), 100 cfs (fry rearing), and 100 to 600 cfs (juvenile rearing).

As shown in Figure CWR-5 in Appendix A-2, the flow duration curve for Camanche minimum required releases indicates that 92% of the time flows are below 600 cfs under both cumulative Phase 2 Expansion and cumulative No Project/No Action Alternative conditions. The Figure indicates that flows are below 200 cfs approximately 7.5% of time under cumulative No Project/No Action Alternative conditions. Under the cumulative Phase 2 Expansion conditions, the flows are below 200 cfs approximately 7% of time.

As stated earlier, the overall reduction in monthly average flows below Camanche Dam attributable to the Phase 2 Expansion project under cumulative conditions is approximately 3 cfs (0.45%), but these reductions in flow occur in primarily in wetter years when the availability of spawning and rearing habitat is less limiting for fish due to overall higher flows on the river. In drier years when spawning and rearing habitat is more limiting, flows on the river are actually improved Phase 2 Expansion Implementation. The slight reduction in flows under cumulative Phase 2 Expansion conditions would not meaningfully limit the availability of salmon spawning and rearing habitat. Given the potential to improve the availability of spawning and rearing habitat on the river drier years, and the overall de minimis reduction in flow, Phase 2 Expansion project implementation would be beneficial to salmonids under cumulative conditions. Given all this and the Permit 10478 EIR’s conclusion that cumulative impacts on salmonid spawning and rearing habitat associated with meeting EBMUD’s 2040 anticipated demand of 230 MGD and 2040 level of demand on the river would be less than significant, neither cumulative impacts nor the Phase 2 Expansion project’s contribution thereto are expected to be significant.

Salmonid Juvenile Outmigration

As described under in the Fish Resources Section, evaluation of impacts on outmigration of juvenile salmon was based on changes in the frequency of flows associated with increased fry outmigration (average flows exceeding 800 cfs below Camanche Dam during January through March). Under cumulative conditions No Project/No Action Alternative, the modeling showed 28 years with January through March average flows exceeding 800 cfs out of the 92-year record, and the cumulative conditions Phase 2 Expansion showed 29 years. This slight improvement in the number of months average flows exceed 800 cfs is likely due to the cascading effect of obtaining exchanged water supplies from CCWD or other Local Agency Partners to meet EBMUD’s dry year needs. Therefore, cumulative impacts on juvenile salmon outmigration would be less than significant. Because there would be no cumulative impact on salmonid juvenile outmigration, the contribution of the Phase 2 Expansion project would not be cumulatively considerable.

Floodplain Habitat

As discussed under Fish Resources Section (Section 4), native fish may benefit from flows that result in inundation of floodplain habitat in the lower Mokelumne River in March, April and May. This has been estimated to occur at flows greater than 3,000 cfs below Woodbridge Dam, which typically occur in wetter years when floodflow releases from Camanche Dam are required. The frequency of flows exceeding 3,000 cfs below WID in March, April and May is 10 months (out of total 276 months) under both cumulative No Project/No Action Alternative and cumulatively Phase 2 Expansion conditions. Therefore, the Phase 2 Expansion project would not contribute to any cumulative impacts associated with floodplain habitat inundation. (The Permit 10478 EIR also found no cumulative impacts resulting from meeting EBMUD's 2040 anticipated demand of 230 MGD and 2040 level of demand on the river.)

Salmonid Spawning Habitat Maintenance

As discussed under Fish Resources Section, the occurrence of flows of 2,000 cfs or greater provides a general indicator of the magnitude of flows needed for maintaining the quantity and quality of spawning gravel in the lower Mokelumne River. Under cumulative No Project/No Action Alternative conditions, 75 months (out of total 1101 months) result in flows of 2,000 cfs or greater below Camanche Dam. Under cumulative Phase 2 Expansion conditions, there is a slight reduction by 1 month – i.e., 74 months out of a total 1101 months have in flows of 2,000 cfs or greater below Camanche Dam. The Permit 10478 EIR concluded that no cumulative impacts would result from meeting EBMUD's 2040 anticipated demand of 230 MGD and 2040 level of demand on the river. The minimal reduction in the number of months with flows of 2,000 cfs or greater below Camanche Dam attributable to the project would not cause significant cumulative impacts.

Pardee and Camanche Reservoirs

Cumulative impacts of the Phase 2 Expansion project on fish habitat in Pardee and Camanche Reservoirs were evaluated by comparing the magnitude of reservoir surface elevation changes based on modeled end-of-month reservoir water surface elevations under cumulative Phase 2 Expansion and cumulative No Project/No Action Alternative conditions. Pardee storage under both these modeled conditions is generally stable (Figure CF-1 in Appendix A-2) with the exception of simulated June 1992. Under the cumulative Phase 2 Expansion condition, Pardee water surface elevation differs by 13 feet (out of Pardee total height of 172 ft) in June 1992. This decline is precipitated by changes in JSA year types, which resulted in a decline in Camanche Reservoir storage from October 1991 to March 1992. In June 1992, storage in Pardee Reservoir declines as the generally cooler waters in Pardee Reservoir storage is used to support Camanche Reservoir hypolimnium (cold water pool). This action is intended to help maintain water temperatures cooler for the benefit of lower Mokelumne River fisheries. However, the rate of decline is dictated by operational conditions and practices, which will not be altered by Phase 2 Expansion project conditions. The rate of reservoir elevation change will be similar between cases, indicating that the Phase 2 Expansion project does not negatively contribute to reservoir elevation impacts under cumulative conditions

There is slightly more variability in Camanche Reservoir storage levels as compared to Pardee Reservoir (Figure CF-2 in Appendix A-2). The maximum change in Camanche Reservoir levels occur in April 1992, with a difference of approximately 5 feet (out of total Camanche height of 116 ft). However, the rate of decline is dictated by operational conditions and practices, which will not be altered by Phase 2 Expansion project conditions. The rate of reservoir elevation change will be similar between cases, indicating that the Phase 2 Expansion project does not negatively contribute to reservoir elevation impacts under cumulative conditions.

Water Temperature

Based on available and reconstructed historical data (March 1974 through October 2008), there is a significant correlation between Camanche Reservoir water surface elevation below elevation 190 feet and Camanche Reservoir storage effects on release temperatures. This relationship was used to evaluate the effects of Phase 2 Expansion project-related changes in reservoir water surface elevation on Camanche release temperatures and the adequacy of the cold water pool volume. EBMUD must also meet additional JSA requirements include maintaining minimum pool volume along with dissolved oxygen levels.

Potential impacts on cold water species (kokanee and rainbow trout in Pardee Reservoir, and rainbow trout in Camanche Reservoir) were based on the availability of cold water habitat during the summer and early fall (July through November), when cold water habitat is most restricted.

Kokanee salmon prefer well-oxygenated open water in reservoirs where temperatures are 10 to 15°C, and rainbow trout growth is optimal when temperatures are around 15 to 18°C (Moyle 2002). The Permit 10478 EIR concluded that less-than-significant cumulative impacts on cold water fish species would result from meeting EBMUD's 2040 anticipated demand of 230 MGD and 2040 level of demand on the river. According to Figure CWR-8 in Appendix A-2, under cumulative No Project/No Action Alternative conditions, Camanche Reservoir is below 190 ft threshold 8.2 % of time (7.54 years). The cumulative Phase 2 Expansion conditions result in slight improvements; Camanche Reservoir is below the 190 ft threshold 8% of the time (7.36 years). Using Camanche water surface elevation threshold of 190 feet as a threshold criteria for cold water pool, there is a slight improvement in the number of years when Camanche water surface elevation is below 190 ft msl under cumulative Phase 2 Expansion relative to cumulative No Project/No Action Alternative. This slight improvement under cumulative Phase 2 Expansion conditions is likely due to EBMUD obtaining exchanged water from CCWD or other Local Agency Partners to meet dry year demands and would result in improved conditions for cold water fish species. As a result, the Phase 2 Expansion project would not contribute to cumulative impacts to cold water fish species.

Water Quality

As discussed in the Water Resources section, dissolved oxygen, pH, and turbidity are water quality parameters that can affect aquatic organisms. Dissolved oxygen levels are of particular concern, and the California Regional Water Quality Control Board's Basin Plan for the Sacramento River and San Joaquin River basins set a dissolved oxygen objective of a minimum of 7.0 milligrams per liter mg/L (California Regional Water Quality Control Board 2011). Dissolved oxygen levels are correlated to water temperature. Given that the cumulative Phase 2 Expansion conditions show a slight improvement in the number of years that meet the Camanche water surface elevation threshold of 190 feet, as a threshold criteria for cold water pool, it is not expected that dissolved oxygen levels would be less under the cumulative Phase 2 Expansion condition than under the cumulative No Project/No Action Alternative condition. As a result, the Phase 2 Expansion project would not contribute to cumulative water quality impacts affecting aquatic organisms.

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