

PERMIT 10478 TIME EXTENSION PROJECT DRAFT ENVIRONMENTAL IMPACT REPORT

September 2013

Pardee Reservoir



Camanche Reservoir



Prepared by East Bay Municipal Utility District
with assistance from ICF International

PERMIT 10478 TIME EXTENSION PROJECT

DRAFT ENVIRONMENTAL IMPACT REPORT

STATE CLEARINGHOUSE NO. 2008112043

September 2013

PREPARED BY



WITH ASSISTANCE FROM



ES.1 Introduction

The Permit 10478 Time Extension Project (Project)¹ evaluated in this document is the extension of the existing water right Permit 10478 to allow the East Bay Municipal Utility District (EBMUD) additional time to apply water provided by the permit to beneficial uses. EBMUD is not proposing to alter the authorized quantities that it diverts from the Mokelumne River, obtain any authorizations for new rights, construct new facilities, or change operations.

ES.2 Background

EBMUD is a multi-purpose public agency that supplies water to more than 1.3 million customers in Alameda and Contra Costa Counties on the eastern side of San Francisco Bay. Since the 1920s, EBMUD's primary source of water has been the Mokelumne River. EBMUD's facilities on the Mokelumne River include two reservoirs, Pardee and Camanche, as well as the Mokelumne Aqueducts which convey waters from Pardee to the East Bay, and hydroelectric generation facilities at the base of Pardee and Camanche Dams. EBMUD has two municipal water rights allowing it to divert up to 325 million gallons per day (MGD) from the Mokelumne River for use within its service area. In 1924, EBMUD applied for a water rights permit (Application 4228) for Pardee Reservoir and was ultimately issued License 11109 in 1981. Among other attributes License 11109 allows EBMUD to divert up to 200 MGD (310 cubic feet per second [cfs]). The quantity that EBMUD can take annually from the Mokelumne River under License 11109 is limited to 224,037 acre-feet per year (AFY) by direct diversion and/or withdrawal from storage year-round for municipal use in the EBMUD service area.

In July 1956, the State Engineer, predecessor to the State Water Resources Control Board (State Water Board), issued Permit 10478 allowing EBMUD to construct Camanche Reservoir and its associated facilities to supplement the water that EBMUD uses at Pardee Reservoir and allow additional diversions above the quantities permitted by the Pardee municipal water right issued in 1924. EBMUD built Camanche Reservoir and enhanced its conveyance facilities in reliance on Permit 10478 and has been using these supplies since 1968.

Under Permit 10478, EBMUD can divert up to 194 cubic feet per second (cfs) (125 MGD) from the Mokelumne River to direct use from December 1 to July 1, and can divert up to 353,000 AFY of water to storage in Pardee and/or Camanche Reservoirs between December 1 and July 1 for municipal use in its East Bay service area. Together, Permit 10478 and License 11109 allow delivery of a maximum of 325 MGD from the Mokelumne River, or 364,037 AFY, subject to the availability of Mokelumne River runoff and storage and EBMUD meeting obligations to senior water rights, downstream fishery flow requirements, and other Mokelumne River water uses.

EBMUD operates the Mokelumne River facilities in a coordinated and integrated manner, as a single unified Mokelumne project. EBMUD diverts its municipal supply from Pardee Reservoir, while

¹ The Permit 10478 Time Extension Project is also described as the Camanche Permit Extension (CPE) Project in other documents.

operating Camanche Reservoir to support those diversions and concurrently making releases from Camanche Reservoir to satisfy downstream senior rights and regulatory and environmental obligations. This operation allows EBMUD to efficiently provide high quality water supply for a population of over 1.3 million people and associated industries in the East Bay, while also allowing EBMUD to minimize pumping needs and ensure that it can satisfy senior water right requirements, provide flood-control protection for the lower Mokelumne River area, meet instream flow requirements, manage water temperatures to benefit the Mokelumne River fishery, satisfy recreational needs, and generate hydroelectric power.

ES.3 Permit 10478 Time Extension

Permit 10478 identified December 1, 2000, as the date by which EBMUD was to have completed application of the water to beneficial use. EBMUD is proposing to extend this permit, consistent with California Water Code Section 1398. In 1964, EBMUD essentially completed construction of Camanche Reservoir and the related conveyance facilities needed to use water diverted under Permit 10478 to meet service area needs. Due to a variety of factors, including EBMUD's implementation of water conservation and recycling programs for over 30 years, EBMUD's annual water usage is such that it has not diverted the maximum amounts allowed annually under Permit 10478. Programs undertaken by EBMUD to slow the growth in water use from what it would have otherwise been—considering the increase in population in EBMUD's service area—are a primary factor that has resulted in less usage of Mokelumne River water on an annual basis.

Consequently, in November 2000, EBMUD filed a petition with the State Water Board to extend and continue the terms of Permit 10478 to the year 2040, to allow EBMUD to continue to rely on the permit and the quantities that EBMUD is authorized to divert under the permit to meet the anticipated need within its service area consistent with its mission of providing high-quality water at fair and reasonable rates, in a manner that protects the environment.

EBMUD is petitioning to extend Permit 10478 through the year 2040 to ensure its continued ability to exercise the water rights authorized under the permit using its existing Mokelumne Project² facilities to meet the needs of the growing population in the municipal area that EBMUD serves. EBMUD has requested a 40-year extension with the understanding that further proceedings could take place after that time. These future actions could include a decision to seek a license or continue the permit.

ES.3.1 Objective of and Need for the Project

The objective of the Project is to ensure the continued ability to reliably meet existing and future water demands in EBMUD's service area in the most cost-effective manner. EBMUD has determined that the best way to do this is by ensuring the continued full availability of existing water supplies provided by the water rights that EBMUD holds. EBMUD funded and built the Mokelumne River facilities to convey and store these supplies, which are needed for EBMUD to have water available to meet existing and future water demands within EBMUD's service area.

² EBMUD operates its Mokelumne River facilities in a coordinated and integrated manner, as a single unified system. This single unified system is known as the Mokelumne Project.

Included in this objective is EBMUD's need to ensure that it has the operational ability to meet existing demands during peak times or in the event of outages or severe droughts, in the most cost-effective manner and to continue to meet these peak demands in the future as the overall demand increases. EBMUD is also seeking to ensure that permit supplies are available so that it can fully use the facilities it has already constructed to meet its customer needs, while continuing the environmental protections it has put in place and maintaining the high quality of municipal water that it provides. To ensure it can serve the cities and unincorporated areas within its service area in a cost-effective and environmentally responsible manner, both now and in the future as populations grow, EBMUD must:

- have sufficient supplies to meet projected increases in overall demand for water in its service area;
- be able to meet peak demands;
- have flexibility to ensure it can meet demands in the event of Mokelumne River water supply outages or following a drought or catastrophic event(s); and
- be able to meet water quality and flow commitments in the Mokelumne River to protect the ecosystem and anadromous fish.

EBMUD believes that the most efficient, cost-effective way to meet demand with minimal environmental impacts is to use its existing water rights and the infrastructure that it has already financed and constructed. Other methods of obtaining needed water supplies could require constructing and operating new, extensive infrastructure that could result in additional impacts on the environment.

ES.3.2 Project Baseline

The California Environmental Quality Act (CEQA) requires an environmental document to include a description of baseline physical conditions against which a project's potentially significant impacts are compared, to determine whether the impacts are significant.

EBMUD's demand for water varies from year to year, sometimes considerably, because it is a function of a variety of factors EBMUD does not control, including weather (precipitation and temperature), local land use agency development approvals, the local economy, and the general economy. EBMUD's demand directly influences the amount of water drawn from the Mokelumne River into the Mokelumne Aqueducts, as well as reservoir levels and other river conditions. The drawback in selecting an individual year of demand as the baseline for environmental analysis is that doing so can obscure the natural variation in demand that occurs in any given year because of the above-referenced meteorological, economic, and other factors. A single year, thus, does not accurately reflect existing physical conditions in the affected area over time.

To account for such natural variation, rather than selecting a single year as the baseline for this environmental impact report (EIR), EBMUD used the results from its recently completed 2040 Demand Study. That analysis, conducted as part of its Water Supply Management Program (WSMP) 2040, reviewed recent demands and the various factors affecting it and culminated in the development of normalized 2005 demand (normalization is an adjustment for the temporal variations in consumption from weather and non-weather effects). The demand analysis concluded that normalized average annual demand was 214 MGD. This EIR uses that 214 MGD average annual demand figure as its baseline for analytical purposes.

The baseline also incorporates EBMUD's existing supplemental dry year supplies. The Freeport Regional Water Project (FRWP) allows EBMUD to take delivery of Central Valley Project (CVP) water under a contract with the U.S. Department of Interior, Bureau of Reclamation (Reclamation) to meet a portion of EBMUD's drought-year needs once the total system storage has declined to a defined level. The CVP contract provides that up to 100 MGD of water from the Sacramento River may be delivered to EBMUD customers in a dry year and that EBMUD is limited to a total delivery of 165 thousand acre-feet (TAF) over any consecutive 3-year period.

ES.3.3 Impact Assessment and Analytical Approach

The Project (i.e., time extension for an existing permit under which existing facilities have been constructed and in use for decades) cannot be meaningfully analyzed under a typical CEQA assessment process of comparing baseline conditions to the future with-project conditions. Under current conditions (baseline), EBMUD is permitted to divert, and has on occasion diverted, at the maximum rate allowed under Permit 10478 and has diverted to storage virtually the entire maximum annual amount (352,000 acre-feet out of a maximum 353,000 acre-feet) allowed under Permit 10478 (see Chapter 2, Project Description, Baseline, and Alternatives, for a description of the Project and baseline). In the future (with-project conditions), EBMUD would continue to use Permit 10478 to divert the maximum quantities authorized in the permit. Under the future with-project conditions, operations of Pardee and Camanche Reservoirs would change gradually over time as more water is drafted from the Mokelumne River.

To derive more meaningful and comparative results for CEQA purposes, EBMUD has developed modeling parameters, such as average annual demand, to illustrate the potential differences and impacts between baseline conditions and future with-project conditions. The project being considered in this document is the extension of the existing Permit 10478 to the year 2040. Variances in modeling parameters are merely an analytical device used to provide a comparative basis to assess impacts of the Project.

The baseline used to assess potential impacts in this EIR includes an average annual demand of 214 MGD, which is based on the recently completed 2040 Demand Study. The Demand Study projects water demands in the EBMUD service area into year 2040 using land use planning information from the communities that EBMUD serves. The Demand Study determined that without water savings from EBMUD's existing and future conservation and recycling programs, projected year 2040 demand would be 312 MGD. The implementation of the existing and planned future water conservation and recycling measures is projected to reduce the year 2040 average annual demand from 312 MGD to 230 MGD. For planning purposes, 230 MGD represents the most likely level of projected average annual demand in year 2040. As a result, this document uses the demand of 230 MGD in the year 2040 as an analytical tool to assess potentially significant environmental impacts resulting from the time extension.

Demand is expected to continue to grow beyond the year 2040 timeframe; however, it is difficult to ascertain the timing and extent. This EIR, therefore, also examines the continued use of Permit 10478 water supplies beyond year 2040 at a programmatic level.

ES.4 Project Alternatives

CEQA Guidelines Section 15126.6 requires that an EIR describe a reasonable range of alternatives to the project that would feasibly attain most of the basic objectives of the project but would avoid or substantially lessen any of the significant effects of the project, and evaluate the comparative merits of the alternatives. Although EBMUD considered several alternatives to the Project, this EIR examines only one alternative, the No-Project Alternative, which CEQA requires to be analyzed. All other alternatives that EBMUD had considered were determined to be infeasible and, therefore, rejected.

EBMUD identified other water supply alternatives, but eliminated them from further consideration based on their inability to meet the project objectives and other factors affecting feasibility.

- Extension to the Year 2025 Alternative
- Extension to the Year 2060 Alternative
- Additional CVP Contract Supplies Alternative
- Additional Demand Management Measures Alternative

See Section 2.6, Alternatives Considered but Rejected, for additional details.

ES.4.1 No-Project Alternative

Under the No-Project Alternative, Permit 10478 would not be extended. For purposes of assessing the consequences of the No-Project Alternative, this EIR assumes EBMUD would continue to divert water up to the baseline average annual demand of 214 MGD annually from the Mokelumne River, and that EBMUD would continue to be able to divert at a maximum rate of 325 MGD for periods of time as it has historically done to meet demand and refill terminal reservoirs following temporary water supply outages. EBMUD would also be allowed to continue to store water under Permit 10478 in Pardee and/or Camanche Reservoirs. The No-Project Alternative also includes actions EBMUD would have to undertake to obtain replacement water supplies to meet its statutory obligation of meeting water demands in EBMUD's service area.

Regardless of whether Permit 10478 is extended, demands in EBMUD's service area would continue to increase as the population grows and development proceeds consistent with the general plans of the respective communities served by EBMUD. In accordance with recent trends, this increased demand would come, in part, from increased densities in existing developed urban areas, as formerly lower-water-consumption land uses are replaced by more intensive, mixed-use, and other developments having greater water consumption. As a result, EBMUD would need to obtain replacement water supplies of 16 MGD (about 18,000 AFY) on a year-in year-out basis to year 2040 and additional replacement supplies after year 2040. Potential water supply options to replace the Mokelumne supplies needed to serve the 16 MGD increase in demand up to year 2040 include long-term purchases of surface water, development of a desalination project, or transactions to obtain groundwater supplies from the Sacramento River basin. New desalination facilities would be required under that option. New infrastructure, including facilities to convey, treat, and store and/or extract water, may need to be constructed for the other options. EBMUD would also need to develop a series of complex partnership agreements, operational coordinating agreements, and cost-sharing arrangements with numerous stakeholders to replace waters that are currently available under Permit 10478 using existing facilities. These possible replacement water supply options are

considered and the potential impacts on the environment are evaluated for the No-Project Alternative.

ES.5 Summary of Impacts and Available Mitigation Measures

This EIR conducted an assessment of environmental impacts for each resource category that could be affected by the Project. EBMUD has determined that the Project would not result in adverse effects on the following resource categories:

- air quality,
- cultural resources,
- geology and soils,
- hazards and hazardous materials,
- land use and planning,
- mineral resources,
- noise,
- population and housing,
- public services,
- transportation and traffic, and
- utilities and service systems.

These resources are not analyzed separately in the EIR but instead are briefly discussed in Chapter 1, Objective and Need for the Permit 10478 Time Extension Project, Section 1.7, Resources Not Analyzed in This EIR.

ES.5.1 Less than Significant Impacts

EBMUD has determined that the Project may have environmental impacts on the resource areas noted below:

- water resources (hydrology, water supply, and water quality);
- fish resources;
- vegetation, wildlife, and wetland resources;
- agricultural resources;
- recreational resources; and
- visual resources.

Table ES-1 summarizes impacts associated with the Project. The table is organized to present impacts by environmental topic area and to indicate the significance of each impact, available mitigation measures, and the significance of each impact if mitigation is implemented. The EIR

concludes that all impacts associated with the Project on the resource areas listed above are considered *less than significant* or *less than significant after mitigation*.

Table ES-1. Summary of Impacts, Levels of Significance, and Proposed Mitigation Measures for the Permit 10478 Time Extension Project

Impact	Level of Significance	Proposed Mitigation Measure(s)	Level of Significance after Mitigation
Water Resources			
WR-1: Potential for changes in Mokelumne River flow to affect groundwater recharge	Less than Significant	N/A	N/A
WR-2: Potential for changes in Mokelumne River flow to reduce flooding	Less than Significant	N/A	N/A
WR-3: Potential for changes in Camanche Reservoir storage and Mokelumne River flow to affect water quality in the Mokelumne River	Less than Significant	N/A	N/A
WR-4: Potential for changes in Mokelumne River flow to affect water quality in the Delta	Less than Significant	N/A	N/A
Fish Resources			
FISH-1: Reduced migration habitat for adult fall-run Chinook salmon and steelhead	Less than Significant with Mitigation	FISH-1: Fall-run Chinook salmon and steelhead adult migration habitat improvements	Less than Significant
FISH-2: Reduced spawning and rearing habitat for fall-run Chinook salmon and steelhead	Less than Significant	N/A	N/A
FISH-3: Reduced outmigration for juvenile fall-run Chinook salmon and steelhead	Less than Significant	N/A	N/A
FISH-4: Reduced floodplain habitat for native fish species	No Impact	N/A	N/A
FISH-5: Reduced mobilization of substrate for salmonid spawning habitat maintenance	Less than Significant	N/A	N/A
FISH-6: Reduced flows that support native fish species habitat	Less than Significant	N/A	N/A
FISH-7: Substantial short or long-term losses of habitat quantity or quality for warmwater fish species	Less than Significant	N/A	N/A
FISH-8: Substantial short or long-term change of water temperatures for coldwater fish species	Less than Significant	N/A	N/A
FISH-9: Reduction in water quality (dissolved oxygen, pH, and turbidity) for fall-run Chinook salmon and steelhead	No Impact	N/A	N/A

Impact	Level of Significance	Proposed Mitigation Measure(s)	Level of Significance after Mitigation
FISH-10: Reduction in suitable water temperatures for migration, spawning and incubation of fall-run Chinook salmon	Less than Significant	N/A	N/A
FISH-11: Reduction in suitable water temperatures for rearing, smoltification, and emigration of juvenile fall-run Chinook salmon	Less than Significant	N/A	N/A
FISH-12: Reduction in suitable water temperatures for migration, spawning and incubation of steelhead	Less than Significant	N/A	N/A
FISH-13: Reduction in suitable water temperatures for rearing, smoltification, and emigration of juvenile steelhead	Less than Significant	N/A	N/A
FISH-14: Reduction in survivability and habitat for anadromous and estuarine fish species	Less than Significant	N/A	N/A
Vegetation, Wetland, and Wildlife Resources			
BIO-1: Potentially adverse effect on special-status plants and special natural communities, directly or through habitat modification, caused by increased reservoir water-surface fluctuations and reduced frequency of river maintenance flows	No Impact	N/A	N/A
BIO-2: Potentially adverse effect on special-status wildlife, riparian communities, and federally protected wetlands caused by increased reservoir water-surface fluctuations and reduced frequency of river maintenance flows	Less than Significant	N/A	N/A
BIO-3: Potential conflicts with the provisions of an adopted habitat conservation plan, natural community conservation plan, or other approved local, regional, or state habitat conservation plan	Less than Significant	N/A	N/A
Agricultural Resources			
AG-1: Potential reduction of surface water supply for agricultural use by senior water rights holders	Significant/ Less than Significant with Mitigation	AG-1: Work with JVID on the installation of a submersible pump in Pardee Reservoir	N/A
AG-2: Potential reduction of surface water supply for agricultural use by junior water rights holders	Less than Significant	Less than Significant	N/A

Impact	Level of Significance	Proposed Mitigation Measure(s)	Level of Significance after Mitigation
Recreational Resources			
REC-1. Diminished recreational boating access as a result of lowered water surface levels in Pardee Reservoir	Less than Significant	N/A	N/A
REC-2. Diminished recreational boating access as a result of lowered water surface levels in Camanche Reservoir	Less than Significant	N/A	N/A
REC-3. Diminished recreation opportunities as a result of reduced flows in the lower Mokelumne River	Less than Significant	N/A	N/A
REC-4. Reduced or lost recreation opportunities as a result of lower reservoir levels in Lafayette, Chabot, or San Pablo Reservoirs	Less than Significant	N/A	N/A
Visual Resources			
VIS-1: Adversely affect a scenic vista, or degrade the existing visual character or quality of Pardee and Camanche Reservoirs and their surroundings	Less than Significant	N/A	N/A
VIS-2: Adversely affect a scenic vista, or degrade the existing visual character or quality along the lower Mokelumne River and its surroundings	Less than Significant	N/A	N/A

ES.5.2 Cumulative Impacts

Cumulative impacts on water resources; vegetation, wetland, and wildlife resources; recreational resources; and visual resources would not be considerable. Chapter 4, Cumulative Impacts, provides more specific details on this cumulative impact assessment.

Cumulative impacts on fish and agricultural resources are determined to be potentially significant. The cumulative analysis assumes that by 2040, upstream water users on the Mokelumne River (Amador and Calaveras Counties) would be using their full senior water-right entitlement of 47,000 AFY as compared to the 27,000 AFY of use identified in the baseline analysis (Figure 1-4 in Chapter 1, Objective and Need for the Permit 10478 Time Extension Project). Thus, the cumulative analysis assumes an additional take of 20,000 AFY by 2040 by upstream diverters with senior water rights. As a result of this increased use, there would be less water available for diversion downstream, which could affect flows and water temperature. This full use of the senior entitlements combined with the Project diversions were assumed in EBMUDSIM to simulate cumulative effects on reservoir inflows, storage volumes, and releases under 1921 through 2009 hydrologic conditions. As discussed in Appendix B, East Bay Municipal Utility District's Water Supply Planning and Supplemental Water Sources, recently EBMUD finalized WSMP 2040 which identified options for meeting EBMUD's dry-year needs in the future. The cumulative analysis assumes that by

2040, EBMUD would have secured or otherwise obtained some of the additional dry-year supplies identified in WSMP 2040.

The Project's contribution to cumulatively significant impacts is mitigated by implementing Mitigation Measure FISH-1, which would improve fish passage by managing the frequency, magnitude, and duration of flows released from Camanche Reservoir during dry and critically dry years (Section 3.2, Fish Resources).

Additionally, future diversions by the Jackson Valley Irrigation District (JVID) at Pardee Reservoir through year 2040 could be limited intermittently as a result of low water surface elevations at Pardee Reservoir under cumulative conditions. To ensure that JVID could continue to divert its senior water right at Pardee when it is available under its water right priority, EBMUD will implement Mitigation Measure AG-1, and assist JVID in diverting its allocated water during such periods, to reduce Impact AG-1 to a *less-than-significant* level with mitigation.

ES.6 Climate Change

Scientific understanding and knowledge of global climate change has improved over the last 20 years through enhancements in dataset modeling procedures, as well as through broader geographic research. While scientific consensus concludes that global warming is indeed occurring, it is sometimes difficult to predict how shifts in the global climate will translate into effects at the local level. Techniques to quantify climate change impacts and develop appropriate mitigation therefore are still continuing to develop and evolve as new information and findings become available.

The increased demand for water by EBMUD's customers by 2040 will require additional energy for conveyance, treatment, and delivery; however, EBMUD anticipates that, in the normal course of business, it will increase its generation of renewable energy, thus offsetting fully or partially the additional energy needed and reducing greenhouse gas (GHG) emissions.

Climate change also has the potential to affect the Mokelumne River hydrology in the future. EBMUD's water supply and service area demand could be affected by climate change as substantial decreases in Sierra Nevada snowpack reduce the available water supply and higher temperatures increase water demands. Climate change also could affect EBMUD's flood management and energy production, as well as water quality and fish resources in the Mokelumne River.

EBMUD has also reviewed the available science regarding climate change impacts on fish resources. Expected changes over the next 50 years in California include freshwater warming; altered timing, frequency, duration, and magnitude of peak flows; further increased winter flood frequency (rain on snow events); altered timing of marine upwelling; decreased marine productivity; and increased marine predators (AFS 2010; Mote 2003). Peak streamflows shifted to earlier in spring, reduced summer flows resulting from an earlier snow melt, and higher air temperatures also reduce the availability of cold-water required by native California salmonids. Although it is predicted that climate change will amplify the existing stresses on Mokelumne River salmonids, data are currently insufficient to determine if the weather extremes; seasonal, inter-annual, and multi-decadal climate variability; and long-term climate change will exacerbate insignificant Project-related impacts to the point that they will result in significant impacts on fish resources.

The scientific understanding of climate change at a more refined local level continues to evolve. Climate-change-related impacts at the local level are dependent on the complex interplay between numerous variables such as timing of flows, temperature and other meteorological factors, vegetative cover, evapotranspiration rates, location and size of existing infrastructure, water diversions, and operational scenarios.

EBMUD continues to monitor ongoing developments in the climate change arena to gain a better understanding of changing conditions in order to manage and operate its Mokelumne River facilities in an appropriate manner. It is anticipated that implementation of adaptive management measures and releases as prescribed in the Joint Settlement Agreement developed by EBMUD, U.S. Fish and Wildlife Service, and California Department of Fish and Wildlife may provide the means to address the predicted range in climatic variations resulting from climate change.

In addition, in response to climate change predictions, EBMUD prepared its Climate Change Monitoring and Response Plan to advise EBMUD's future water supply, water quality, and infrastructure planning, to support no regrets infrastructure investment decisions, and to guide mitigation of EBMUD's GHG emissions that contribute to climate change. Because the science of climate change is still developing, EBMUD's work to address climate change will continue to evolve as the science of climate change is better understood.

ES.7 Areas of Known Controversy

Based on verbal input received during public scoping meetings and written input received during the comment period for the Notice of Preparation (Chapter 9, Agency Consultation and Public Outreach), the primary areas of controversy are water supply for agriculture and fish resources.

ES.8 Growth-Inducing Impacts

As described in Chapter 8, Other CEQA Analyses, of this EIR, the Project would continue to provide water supplies from the Mokelumne River to support demand in the EBMUD service area communities. The land-use agencies have evaluated the potentially significant effects of growth in their respective general plans and related EIRs. These analyses found that there are significant, and in some cases unavoidable impacts, that would result from planned growth.

ES.9 Significant Irreversible Changes

No significant irreversible changes are associated with the Project.

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Acronyms and Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
AB 32	Assembly Bill 32
ABAG	Association of Bay Area Governments'
AF	acre-feet
AFRP	Anadromous Fisheries Program Act
AFY	acre-feet per year
AR ₄	Although the IPCC Fourth Assessment Report
ARB	Agency's Air Resources Board
AWA	Amador Water Agency
BAAQMD	Bay Area Air Quality Management District
Bay-Delta WQCP	San Francisco Bay / Sacramento-San Joaquin Delta Estuary
BDCP	Bay-Delta Conservation Plan
BLM	Bureau of Land Management
BMAS	below maximum allowable storage
BMP	best management practice
CAA	Clean Air Act
CAS	Climate Adaptation Strategy
CCAR	California Climate Action Registry
CCA	Community Choice Aggregation
CCR	Code of Regulations
CDC	California Department of Conservation
CDFW	California Department of Fish and Wildlife
CEC	California Energy Commission
CEQ	Council on Environmental Quality
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CH ₄	methane
CLCA	California Land Conservation Act
CNDDDB	California Natural Diversity Database
CNPS	California Native Plant Society
CNRA	California Natural Resources Agency
CO ₂	carbon dioxide
CO ₂ e	carbon dioxide equivalent

Corps	U.S. Army Corps of Engineers
CPUC	California Public Utilities Commission
CPUD	Calaveras Public Utility District
CR	Camanche Reservoir
CRPR	California Rare Plant Rank
CT	centroid timing
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVRWQCB	Central Valley Regional Water Quality Control Board
CWA	Clean Water Act
dB	decibels
DCC	Delta Cross Channel
Delta	Central Valley and the Sacramento-San Joaquin Delta
DFW	California Department of Fish and Wildlife
DHCCP	Delta Habitat Conservation and Conveyance Plan
DPS	drought planning sequence
DWR	California Department of Water Resources
DWSC	Deep Water Ship Channel
EBMUD	East Bay Municipal Utility District
EBWMP	East Bay Watershed Master Plan
EIR	Draft Environmental Impact Report
EIR/EIS	Environmental Impact Report/Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ERP	Ecosystem Restoration Program
ESA	Federal Endangered Species Act
ESP	energy service provider
ESU	Evolutionarily Significant Unit
ETAW	evapotranspiration of the applied water
FERC	Federal Energy Regulatory Commission
FMMP	Farmland Mapping and Monitoring Program
FR	Federal Register
FRWA	Freeport Regional Water Authority
FRWP	Freeport Regional Water Project
FSC	Folsom South Canal
ft msl	feet above mean sea level
FTA	Federal Transit Administration
FY	fiscal year
GBA	Groundwater Banking Authority
GHG	greenhouse gas

GPCD	gallons per capita per day
GWP	global warming potential
HFC	hydrofluorocarbon
HGMP	Hatchery Genetics Management Plan
HOS	Hypolimnetic Oxygenation System
I-5	Interstate 5
ICUP	Integrated Conjunctive Use Program
in/sec	inches per second
IOU	investor-owned utility
IRCUP	inter-regional conjunctive use project
IRP	Independent Review Panel
IRWMP	Integrated Regional Water Management Plan
IVA	Impacts, Vulnerability and Adaptation
JSA	Joint Settlement Agreement
JVID	Jackson Valley Irrigation District
Km	kilometer
Kwh	kilowatts per hour
kWh/MG	kilowatt-hours/million gallons
lbs. CO ₂	pounds of carbon dioxide
LRM	lower Mokelumne River
MAC	Mokelumne/Amador/Calaveras
MBTA	Migratory Bird Treaty Act
MCCT	Mokelumne Coast to Crest Trail
MG	million gallons
mg/L	milligrams per liter
mgd	million gallons per day
MMT	million metric tons
MokeWISE	Mokelumne Watershed Interregional Sustainability Evaluation Program
MRDUA	Mokelumne River Day Use Area
MRR	Mandatory Reporting Rule
MW	megawatts
MWh	megawatt hours
MWMP	Mokelumne Watershed Master Plan
N ₂ O	nitrous oxide
NEPA	National Environmental Policy Act
NFMR	North Fork Mokelumne River
NMFS	National Marine Fisheries Service
NOP	notice of preparation
NSJWCD	North San Joaquin Water Conservation District

O ₃	ozone
OCAP	Operations and Criteria Plan
PEIR	programmatic environmental impact report
Permit	Permit 10478
PFC	perfluorocarbon
PG&E	Pacific Gas and Electric Company
PHABSIM	Physical Habitat Simulation
PIT	passive integrated transponder
POU	publicly-owned utility
ppm	parts per million
ppt	parts per thousand
PPV	peak particle velocity
PR	Pardee Reservoir
Project	Permit 10478 Time Extension Project
Reclamation	U.S. Department of Interior, Bureau of Reclamation
RPA	Reasonable and Prudent Alternative
RPS	Renewable Portfolio Standard
RWQCB	Regional Water Quality Control Board
Safe Harbor Agreement	Safe Harbor Agreement for East Bay Municipal Utility District Lands in San Joaquin, Amador, and Calaveras Counties
SAR	Second Assessment Report
SB	Senate Bill
SCH	State Clearinghouse
SCWA	Sacramento County Water Agency
SEBP Basin	South East Bay Plain Basin
SIP	State Implementation Plan
SJC	San Joaquin County's
SJMSCP	San Joaquin County Multi-Species Habitat Conservation and Open Space Plan
SJRRP	San Joaquin River Restoration Program
SJVAPCD	San Joaquin Valley Air Pollution Control District
SMAQMD	Sacramento Metropolitan Air Quality Management District
SMUD	Sacramento Municipal Utility District
SR	State Route
SRWWTP	Sacramento Regional Wastewater Treatment Plant
SSTEMP	Stream Segment Temperature
State Water Board	California State Water Resources Control Board
SWP	State Water Project
TAF	thousand acre-feet

TLZ	Timberland Preservation Zones
TMDL	Total Maximum Daily Load
TSS	total suspended solids
UMRWA	Upper Mokelumne River Watershed Authority
UNFCCC	United Nations Framework Convention on Climate Change
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VdB	velocity decibels
VMT	vehicle miles traveled
WAPA	Western Area Power Administration
WBWG	Western Bat Working Group
WCMP	Water Conservation Master Plan
WID	Woodbridge Irrigation District
Woodbridge Dam	WID diversion dam
WQCP	water quality control plan
WQRMP	Water Quality and Resource Management Program
WSMP	Water Supply Management Program
WUA	Weighted Usable Area

Chapter 1

Objective and Need for the Permit 10478 Time Extension Project

1.1 Introduction

The Permit 10478 Time Extension Project (Project)¹ reviewed in this Draft Environmental Impact Report (EIR) is the extension of water right Permit 10478 to allow the East Bay Municipal Utility District (EBMUD) additional time to apply water provided by Permit 10478 to beneficial uses. EBMUD obtained Permit 10478 in 1956, and has relied upon the water rights provided under Permit 10478 (Permit) to divert and store waters from the Mokelumne River. After obtaining the Permit and negotiating necessary agreements and authorizations to facilitate its use of the water, EBMUD promptly completed construction of Camanche Reservoir, which is an essential component of its Mokelumne River facilities. EBMUD is petitioning to extend Permit 10478 through the year 2040 to continue its ability to exercise the water rights authorized under the Permit using its existing Mokelumne River facilities. This extension would enable EBMUD to continue to meet the needs of the growing population in the municipal area that EBMUD serves. EBMUD is not proposing to alter the authorized quantities that it diverts from the Mokelumne River, obtain any authorizations for new rights, construct new facilities, or change operations.

Since the 1920s, 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 on the Mokelumne River include two reservoirs, Pardee and Camanche, as well as the Mokelumne Aqueducts which convey waters from Pardee to the East Bay, and hydroelectric generation facilities at the base of Pardee and Camanche Dams. Pardee and Camanche Reservoirs are located adjacent to one another such that when Camanche Reservoir is full, the waters from Camanche Reservoir touch the toe of Pardee Dam.

EBMUD operates the Mokelumne River facilities in a coordinated and integrated manner, as a single unified Mokelumne project. EBMUD diverts its municipal supply from Pardee Reservoir, while operating Camanche Reservoir to support those diversions and concurrently making releases from Camanche Reservoir to satisfy downstream senior rights and regulatory and environmental obligations. This operation allows EBMUD to efficiently provide high quality water supply for a population of over 1.3 million people and associated industries in the East Bay, while also allowing EBMUD to minimize pumping needs and ensure that it can satisfy senior water right requirements, provide flood control protection for the lower Mokelumne River area, meet instream flow requirements, manage water temperatures to benefit the Mokelumne River fishery, satisfy recreational needs, and generate hydroelectric power.

¹ The Permit 10478 Time Extension Project is also described as the Camanche Permit Extension (CPE) Project in other documents.

As noted, the Project reviewed in this EIR is the petition for time extension to the year 2040 to allow EBMUD to continue applying Permit 10478 water to beneficial use. In addition to analyzing the petition at a project level, EBMUD has also conducted a programmatic evaluation of uses beyond the year 2040; this analysis is included in this EIR.

The EIR also includes a discussion of the auxiliary petitions that have been submitted by EBMUD to ensure that the permits and licenses issued by the California State Water Resources Control Board (State Water Board) for the Mokelumne Project facilities accurately reflect EBMUD's existing Mokelumne River municipal and hydroelectric operations. EBMUD is pursuing the primary extension petition and the auxiliary "clean-up" petitions so that it can continue using its Mokelumne River facilities to meet existing and future water supply needs of the residents in the cities and other areas within EBMUD's service area.

It is anticipated that the State Water Board, as a responsible agency, will use this environmental document when acting on the extension petition for approval. While the auxiliary petitions do not have any potentially significant effect on the environment, EBMUD has included a discussion of these petitions to facilitate State Water Board action on all of the petitions related to water rights held for municipal and other consumptive purposes. The State Water Board may, at its discretion, act on petitions related to single-purpose hydropower water rights either separately or concurrently with its action on municipal water rights.

A brief description of each change petition requested by EBMUD is included in Section 1.5, Additional Petitions Submitted by EBMUD. The primary extension of time petition is included in Appendix A. Additional information on EBMUD's water planning and supplemental water sources is provided in Appendix B. A summary of the auxiliary change petitions is included in Appendix C, Summary of Auxiliary Change Petitions Submitted to California State Water Resources Control Board.

1.1.1 Municipal Water Rights (License 11109 and Permit 10478)

EBMUD has two water rights allowing it to divert up to 325 million gallons per day (MGD) from the Mokelumne River for municipal and industrial use within its service area. In 1924, EBMUD applied for a water right permit (Application 4228) for Pardee Reservoir and was ultimately issued License 11109 in 1981. Among other attributes, License 11109 allows EBMUD to divert up to 200 MGD (310 cubic feet per second [cfs]). The quantity that EBMUD can take annually from the Mokelumne River under License 11109 is limited to 224,037 acre-feet per year (AFY) by direct diversion and/or withdrawal from storage year-round for municipal use in the EBMUD service area.

In July 1956, the State Engineer, predecessor to the State Water Board, issued Permit 10478 allowing EBMUD to construct Camanche Reservoir and its associated facilities to supplement the water that EBMUD uses at Pardee Reservoir and allow additional diversions above the quantities permitted by the Pardee municipal water right issued in 1924. EBMUD built Camanche Reservoir and enhanced its conveyance facilities in reliance on Permit 10478 and has been using these supplies since 1968.

Under Permit 10478, EBMUD can divert up to 125 MGD (194 cfs) from the Mokelumne River to direct use from December 1 to July 1, and can divert up to 353,000 AFY of water to storage in Pardee and/or Camanche Reservoirs between December 1 and July 1 for municipal use in the EBMUD service area.

License 11109 allows EBMUD to divert up to 200 MGD directly from the Mokelumne River and/or Pardee storage, and Permit 10478 allows additional diversions up to 125 MGD from the Mokelumne River or Pardee/Camanche storage. Together, Permit 10478 and License 11109 allow delivery of a maximum of 325 MGD from the Mokelumne River, or 364,037 AFY, subject to the availability of Mokelumne River runoff and storage and EBMUD meeting obligations to senior water rights, downstream fishery flow requirements, and other Mokelumne River water uses.

1.1.2 Petition for Extension of Time for Permit 10478

Permit 10478 identified December 1, 1980, as the date by which EBMUD was to have completed construction and December 1, 2000, as the date by which EBMUD was to have completed application of the water to beneficial use. EBMUD is proposing to extend this permit, consistent with California Water Code Section 1398. In 1964, EBMUD essentially completed construction of Camanche Reservoir and the related conveyance facilities needed to use water diverted under Permit 10478 to meet service area needs. Due to a variety of factors, including EBMUD's implementation of water conservation and recycling programs for over 30 years, EBMUD's annual water usage is such that it has not diverted the maximum amounts allowed annually under Permit 10478. Programs undertaken by EBMUD to slow the growth in water use from what it would have otherwise been—considering the increase in population in EBMUD's service area—are a primary factor that has resulted in less usage of Mokelumne River water on an annual basis.

In November 2000, EBMUD filed a petition with the State Water Board to extend and continue the terms of Permit 10478 to the year 2040 to allow EBMUD to continue to rely on the Permit and the quantities that EBMUD is authorized to divert under the Permit to meet the anticipated need within its service area consistent with its mission of providing high-quality water at fair and reasonable rates, in a manner that protects the environment.

Recently, EBMUD completed the *2040 Demand Study, Water Supply Management Program* (2040 Demand Study) (East Bay Municipal Utility District 2009), a comprehensive demand study to determine anticipated water demands in its service area to the year 2040. The analysis reflected in this environmental document uses the results of the 2040 Demand Study. As noted in the study, water use is expected to grow beyond the year 2040 as population growth and development continue in the cities and other areas that EBMUD serves; however, EBMUD believes it would be speculative at this time to estimate that growth in usage with any degree of specificity beyond 2040 because this is beyond the planning horizon. Nonetheless, because usage will continue to grow as municipal areas within the service area continue to add people and businesses, EBMUD has included a programmatic-level evaluation of impacts for use beyond the year 2040 in this document.

Through a series of auxiliary petitions, EBMUD is seeking to better reflect and report the coordinated and integrated operation of its facilities on the Mokelumne River to meet water supply needs in the East Bay, while continuing to meet senior water rights, downstream obligations, and regulatory requirements. The petition to extend Permit 10478 and the auxiliary petitions that EBMUD is submitting do not initiate construction of new infrastructure or expansion of EBMUD's existing water right entitlements.

1.2 Objective of the Project

EBMUD is a municipal utility district charged with supplying water to the customers in its service area. EBMUD's adopted mission is to manage the natural resources with which it is entrusted; to provide reliable, high quality water and wastewater services to its customers at fair and reasonable rates; and to preserve and protect the environment for future generations.

EBMUD's primary objective for extending Permit 10478 is to ensure its continued ability to reliably meet water demands in EBMUD's service area in the most cost-effective manner through the year 2040. EBMUD has determined that the best way to do this is by ensuring the continued full availability of existing water supplies provided by the water rights that EBMUD holds. EBMUD funded and built the Mokelumne River facilities to convey and store these supplies, which are needed in order for EBMUD to have water available to meet existing and future water demands within EBMUD's service area.

Included in this objective is EBMUD's need to ensure that it has the operational ability to meet existing demands during peak times or in the event of outages or severe droughts, in the most cost-effective manner and to continue to meet these peak demands in the future as the overall demand increases. EBMUD is also seeking to ensure that permit supplies are available so that it can fully use the facilities it has already constructed to meet its customer needs, while continuing the environmental protections it has put in place and maintaining the high quality of municipal water that it provides. To ensure it can serve the cities and unincorporated areas within its service area in a cost-effective and environmentally responsible manner, both now and in the future as populations grow, EBMUD must:

- have sufficient supplies to meet projected increases in overall demand for water in its service area;
- be able to meet peak demands;
- have flexibility to ensure it can meet demands in the event of Mokelumne River water supply outages or following a drought or catastrophic event(s); and
- be able to meet water quality and flow commitments in the Mokelumne River to protect the ecosystem and anadromous fish.

EBMUD believes that the most efficient, cost-effective way to meet demand with minimal environmental impacts is to use its existing water rights and the infrastructure that it has already financed and constructed. Other methods of obtaining needed water supplies could require constructing and operating new, extensive infrastructure that could result in additional impacts on the environment.

1.3 Background

1.3.1 Water Rights Defined

A permit system was established in California in 1913 that requires parties wishing to divert surface water after 1914 to obtain an appropriative water rights permit from the state prior to diverting water. The State Water Board is responsible for the allocation of appropriative rights. The three-step

appropriative water rights process for post-1914 rights includes an application, a permit, and a license.

1. **Application:** Any party wishing to obtain an appropriative right to surface water after 1914 must file an appropriative application with the State Water Board. Applications carry priorities as of the date of filing, although the application of a municipality or its inhabitants for domestic purposes is considered first in right.
2. **Permit:** If the application is approved by the State Water Board, a water right permit is issued to the permittee. The permittee may then begin using water under the permit.
3. **License:** After constructing facilities and beneficially using the water authorized for use under a water right permit, the permittee may request the State Water Board to issue a water right license. The issuance of a license is a ministerial action by the State Water Board and is the last step in the water rights process.

EBMUD's Mokelumne water rights are explained in detail below in the Section 1.3.4, EBMUD's Right to Divert Mokelumne River Water.

1.3.2 Mokelumne River Watershed and Hydrology

The upper Mokelumne River watershed lies on the western slope of the Sierra Nevada in Alpine, Amador, and Calaveras Counties. The lower Mokelumne River watershed, downstream of Camanche Dam, is located in the Central Valley and the Sacramento-San Joaquin Delta (Delta) in San Joaquin and Sacramento Counties. The watershed feeding into EBMUD's storage facilities covers an area of 627 square miles and extends from the peak of Round Top (elevation 10,364 feet) near the crest of the Sierra Nevada to Camanche Reservoir (elevation 235 feet) located in the lower western foothills near Clements. Most of the watershed is forested land within the El Dorado and Stanislaus National Forests. 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.

Viewed from a long-term (multiple-year) perspective, about 90% of the water delivered to EBMUD's customers originates from the Mokelumne River watershed. The remaining 10% originates as runoff from the protected watershed lands in the East Bay.²

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, 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 through 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 1-1 demonstrates natural

² During dry years, local runoff essentially matches evaporation from the local reservoirs, so that there is no net contribution from local runoff. The recent completion of the Freeport Regional Water Project (FRWP) and execution of a contract with the U.S. Bureau of Reclamation allows EBMUD to obtain additional water during dry years. This does not affect the local runoff availability, but it allows EBMUD to supplement that water it receives from the Mokelumne River in dry and critically dry years.

Mokelumne River runoff by water year, illustrating the wide variability in runoff. Long-term average unimpaired flow equals 745 thousand acre-feet (TAF)³ during the last 83 years, and has ranged from a high of 1,848 TAF to a low of 129 TAF.

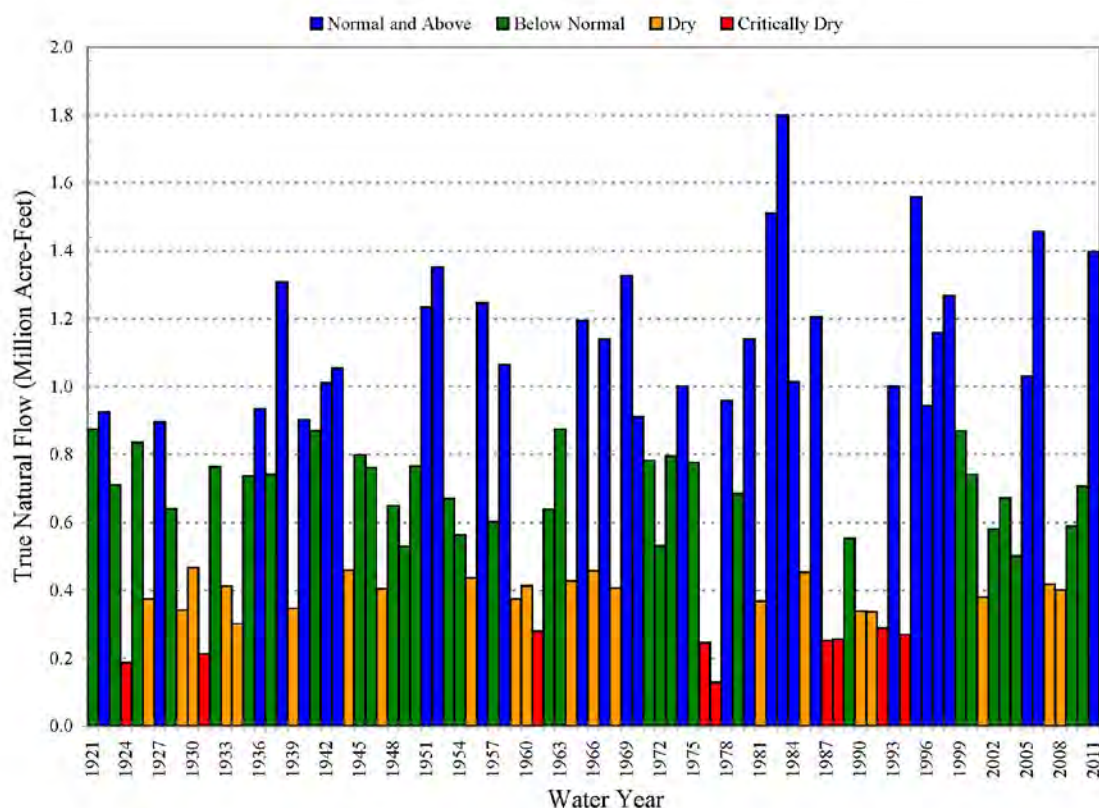


Figure 1-1
Mokelumne River Unimpaired Runoff by Water Year

1.3.3 Water System Facilities

EBMUD's primary water facilities include Pardee and Camanche Dams, their associated reservoirs, the Mokelumne Aqueducts, the local terminal (East Bay) storage reservoirs, treatment plants, and distribution facilities. The raw water facilities extend from EBMUD's principal water source, the Mokelumne River watershed basin in the Sierra Nevada range, across the Sacramento-San Joaquin River Delta (Delta), to the East Bay area. Additional facilities on the Mokelumne River include EBMUD's power generation facilities at the base of Pardee and Camanche Dams.

Figure 1-2 shows the location of Mokelumne River and the EBMUD water supply facilities and service area. Each facility is described below.

³ Average unimpaired flows from water year 1929 to 2011.

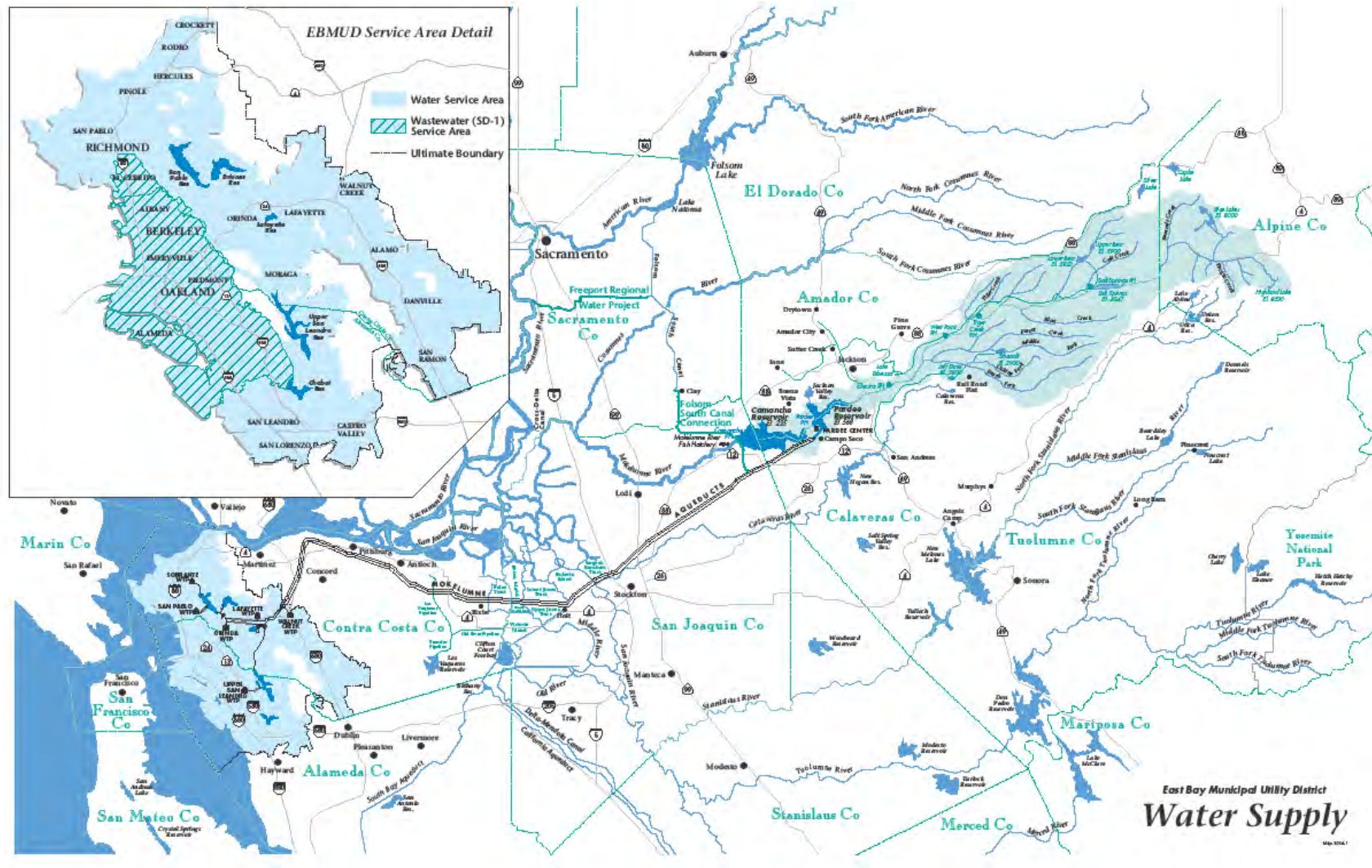


Figure 1-2
East Bay Municipal Utility District Water Supply System

1.3.3.1 Pardee Dam and Reservoir

Pardee Dam and Reservoir are located 38 miles northeast of Stockton near the town of Jackson. Pardee Reservoir was created when construction of Pardee Dam was completed in 1929. License 11109, EBMUD's municipal water right for Pardee Reservoir, has a maximum annual collection to storage of 209,950 acre-feet. Hydroelectric power facilities consisting of three units with a combined nameplate capacity of 23.6 megawatts (MW) are located at the base of Pardee Dam. Water is diverted through these units under License 1388, License 6062, and Permit 10479 for Units 1, 2, and 3.

1.3.3.2 Camanche Dam and Reservoir

Camanche Dam is located 10 miles downstream from Pardee Dam on the Mokelumne River. Construction of Camanche Dam and dikes was completed in 1964. At times when Camanche Reservoir is full, waters from Camanche Reservoir touch the toe of Pardee Dam, creating in effect, a single reservoir. EBMUD has operated Camanche and Pardee Reservoirs as components of a single coordinated water project to meet water supply needs and other obligations.

To provide flood-control benefits, Camanche Reservoir was constructed with a capacity of 431,500 acre-feet. Hydroelectric power facilities consisting of three units with a combined nameplate capacity of 10.7 megawatts (MW) are located at the base of Camanche Dam. Water diversion to the three Camanche Reservoir hydroelectric units is authorized under Permit 17378.

1.3.3.3 Mokelumne Aqueducts

Water is transported over 90 miles to East Bay water treatment plants and local terminal reservoirs through Pardee Tunnel, the Mokelumne Aqueducts, and the Lafayette Aqueducts. Water flowing by gravity takes 30 to 45 hours to reach the Bay Area. The Mokelumne Aqueducts comprise three steel pipelines ranging in size from 5 feet, 5 inches in diameter to 7 feet, 3 inches in diameter. These steel pipelines have a capacity of about 200 MGD by gravity flow (depending on Pardee elevation head) and up to 325 MGD with pumping.

Physical characteristics of EBMUD's existing Mokelumne River facilities, including the Mokelumne Aqueducts, are summarized in Table 1-1.

Table 1-1. EBMUD Water Supply System Characteristics

Reservoir Data		
Capacities		
<i>Mokelumne River Facilities</i>		
Pardee (licensed capacity)		209,950 AF
Camanche (permitted capacity)		431,500 AF
<i>Service Area Facilities</i>		
Local Terminal Reservoirs (East Bay)		151,670 AF
Maximum Elevations (at spillway crest)		
Pardee		567.7 feet
Camanche		235.5 feet
Dead Storage ^a		
Pardee		12,200 AF
Camanche		4,000 AF
Local Terminal Reservoirs (East Bay)		17,500 AF
Aqueduct Data		
	Gravity Flow	Pumped Flow
Maximum Capacity Total ^b	202 MGD	325 MGD
Aqueduct 1 (65-inch)	41 MGD	67 MGD
Aqueduct 2 (67-inch)	54 MGD	87 MGD
Aqueduct 3 (87-inch)	107 MGD	172 MGD
Hydropower Plant Capacities (nameplate)		
Power Generation		
Pardee		23.6 MW
Camanche		10.7 MW
^a Dead storage capacity is defined as that volume of a reservoir below the level of the lowest outlet. ^b Aqueduct capacity is dependent on Pardee elevation. Higher flow rates (up to 325 MGD maximum capacity) require pumping at the Walnut Creek Pumping Plant. AF = acre-feet; MGD = million gallons per day; MW = megawatts.		

1.3.3.4 Local Terminal Storage Reservoirs

The Mokelumne Aqueducts connect Pardee Reservoir to the treatment plants and EBMUD's service area distribution system. EBMUD has five reservoirs in the East Bay (local terminal reservoirs): Briones, Chabot, Lafayette, San Pablo, and Upper San Leandro Reservoirs. Briones, San Pablo, and Upper San Leandro Reservoirs can supply water to EBMUD throughout the year, while Chabot serves as a nonpotable supply for irrigation at two golf courses and as an emergency supply source, and Lafayette Reservoir serves recreational and aesthetic purposes and as an emergency supply. The location of the local terminal reservoirs is shown in Figure 1-2, and their capacity and water sources are shown in Table 1-2.

EBMUD's terminal reservoir storage generally provides, among other uses, a 180-day (6-month) emergency standby reserve in the event of outages or failure of one or more of the Mokelumne Aqueducts. The local terminal reservoir system has a total capacity of 151,670 acre-feet. The terminal reservoirs regulate Mokelumne River supply in winter and spring, augment existing supply with local runoff, minimize flooding, and provide environmental and recreational benefits to East Bay communities.

Table 1-2. Terminal Reservoir Capacity and Water Sources

Reservoir	Capacity (TAF) ^a	Water Sources
Briones	60.5	Mokelumne Aqueducts, Bear Creek
Chabot	10.4	Mokelumne Aqueducts, San Leandro Creek, Upper San Leandro Reservoir, Miller Creek
Lafayette	4.3	Lafayette Creek ^b
San Pablo	38.6	Mokelumne Aqueducts, San Pablo Creek, Bear Creek, Briones Reservoir
Upper San Leandro	38.0	Mokelumne Aqueducts, San Leandro Creek and tributaries

^a Numbers are rounded to the nearest tenth.

^b The raw water line for the Mokelumne Aqueducts was disconnected from the reservoir in 1971.

Source: UWMP 2005:Table 2-1.

1.3.4 Right to Divert Mokelumne River Water

As previously stated, EBMUD has the water rights and capacity to divert up to 325 MGD from the Mokelumne River for municipal use within its service area in Alameda and Contra Costa Counties. EBMUD's rights are affected by the EBMUD's relationship with the rights of other Mokelumne River water users, as well as EBMUD's ability to store water, and the amount of Mokelumne River runoff. The extent of these water rights has been defined by a myriad of orders, decrees, and agreements. Taken as a whole, the overlapping constraints on the use of the Mokelumne River form a "Law of the River." The State Water Board has played a significant role in creating this law through its various orders, decisions, and approvals, but the Law of the River also involves federal directives (e.g., Federal Energy Regulatory Commission [FERC] orders; U.S. Army Corps of Engineers [Corps] flood control requirements); agreements with federal and state wildlife regulatory agencies (e.g., the 1998 Joint Settlement Agreement [JSA] among EBMUD, U.S. Fish and Wildlife Service [USFWS], and California Department of Fish and Wildlife [CDFW]); court orders (e.g., the Lodi Decrees); and numerous upstream and downstream water rights settlement agreements. A summary of EBMUD's Mokelumne River municipal water rights is presented in Table 1-3.

EBMUD also possesses other water rights that allow for hydroelectric power generation, and EBMUD holds separate rights to appropriate runoff into the local terminal reservoirs in EBMUD's service area.

Table 1-3. Mokelumne River Municipal Water Right Entitlements

Water Right	Maximum Direct Diversion Rate to Service Area	Maximum Annual Collection to Storage	Maximum Annual Beneficial use (Direct Diversion plus Withdrawal from Storage) for EBMUD use
Pardee			
1924 Application 4228	200 MGD	209,950 AF	224,037 AF
1981 License 11109 ^a	Year-round	October 1 through July 15	Direct diversion: year round Withdrawal from storage: year-round
Pardee/Camanche			
1949 Application 13156	125 MGD	353,000 AF	140,000 AF ^b
1956 Permit 10478	December 1 through July 1	December 1 through July 1	Direct diversion: December 1 through July 1 Withdrawal from storage: year-round
Total	325 MGD	562,950 AF	364,037 AF
^a Total amount to be taken from the source (the river) under License 11109 shall not exceed 316,250 AF/year. ^b Total amount to be diverted from the watershed by direct diversion or withdrawal from storage under Permit 10478 (and any subsequent license), as restricted by the 1959 Release of Priority, shall not exceed the equivalent of the average flow of 194 cfs (or 140,000 AF/year). AF = acre-feet.			

1.3.4.1 Historical Maximum Use under Permit 10478

This section summarizes EBMUD's maximum historical use under Permit 10478 and is provided for informational purposes.

Under Permit 10478, EBMUD has diverted from the watershed at the following maximum rates and quantities, over the time periods noted:

- 192 cfs (124 MGD) from June 5 through July 10, 2008, (average over 36 days) to assist in meeting demand and to refill standby storage in the service area depleted by drought.
- 191 cfs (123 MGD) from May 11 through May 17, 2000, (average over 7 days) to assist in meeting demand and to test Mokelumne Aqueducts after installation of pressure transient equipment on Mokelumne Aqueduct No. 1.
- 162 cfs (105 MGD) from May 30 through July 21, 1997, (average over 53 days) to assist in meeting demand and to refill standby storage in the service area depleted by extended outage of the Mokelumne Aqueducts because of a high turbidity event that required shutting down the Mokelumne Aqueducts and relying on local storage to meet water demands.
- License 11109 includes both daily and annual use limitations. In a single year, the maximum amount of Permit 10478 water used by EBMUD in excess of the quantities allowed to be used daily under License 11109 is 36,992 acre-feet. This occurred in calendar year 1997. The maximum amount of Permit 10478 water used by EBMUD in excess of the quantities allowed annually under License 11109 is 17,826 acre-feet during calendar year 1976.

EBMUD has collected to storage virtually the entire maximum 353,000 acre-feet allowed under Permit 10478, as EBMUD collected to storage 352,000 acre-feet in the 1966–1967 diversion season on the initial fill of Camanche Reservoir.

The 1959 Release from Priority restricted the maximum quantity of water that EBMUD is allowed to divert under Permit 10478 from the Mokelumne River watershed to the equivalent of an average flow of 194 cfs or 140,000 AFY whether by direct diversion or withdrawal from storage. Mainly because of the success of EBMUD's water conservation and water recycling programs, which have reduced annual demand from what it would have been otherwise, EBMUD has not yet used its full entitlement to Permit 10478 Mokelumne River water for beneficial use on an average annual basis.

1.3.4.2 Factors Affecting Full Entitlement of Mokelumne River Water

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 priority of the appropriative water right permits and licenses that have been issued by the State Water Board, certain pre-1914 rights, and riparian rights. Factors that affect EBMUD's ability to use its full entitlement include:

- variability in rainfall and runoff,
- use by other senior right holders,
- flood control requirements, and
- instream flow requirements to protect fish.

Other Mokelumne Diverters

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 water users (i.e., entities or individuals with the oldest water use 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. Figure 1-3 shows the location of the Mokelumne River diverters. Figure 1-4 provides a generalized overview of the Mokelumne River diversions and interagency agreements, and shows how the river's flow is typically divided among the various uses.



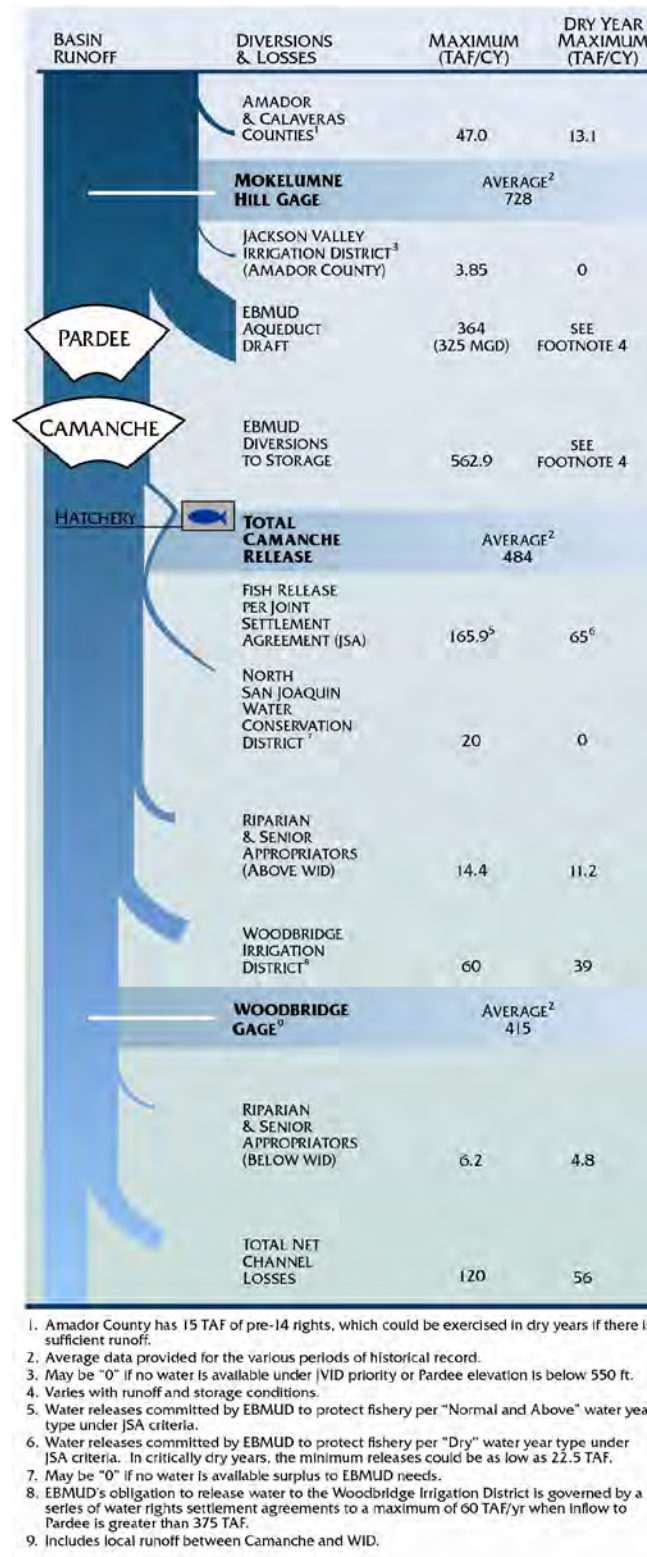


Figure 1-4
East Bay Municipal Utility District Flow Commitments

Upstream Water Use

Upstream of Pardee Reservoir, water use includes use under senior water rights held by agencies in Amador and Calaveras Counties, including Amador Water Agency (AWA), Calaveras Public Utility District (CPUD), Calaveras County Water District, and the Jackson Valley Irrigation District (JVID). As shown in Figure 1-4, these rights of upstream diverters constitute a maximum diversion of approximately 47 TAF per year that is senior to Permit 10478. JVID supplies water to portions of Amador County located below Lake Amador. JVID diverts up to 3,850 AFY of Mokelumne River water to Lake Amador via Pardee Reservoir and Jackson Creek.

Downstream Water Use

Woodbridge Irrigation District (WID), riparian landowners, and other senior downstream appropriators have priorities that are senior to EBMUD's Camanche water right (Figure 1-4). In addition, the North San Joaquin Water Conservation District (NSJWCD) has a junior water right that is derived from Permit 10478 and provides for temporary use of up to 20 TAF of unused Permit 10478 water.

Flood Control Requirements

A condition of Permit 10478 required EBMUD to allow local interests an opportunity to participate financially in the construction of the proposed Camanche Dam for flood control purposes, or to secure federal participation therein. EBMUD met this condition by reaching a flood control agreement in 1962 with the Corps for the operation of the then-proposed Camanche Reservoir to accommodate, together with the existing Pardee Reservoir, the reservation of flood control space for the protection of downstream areas in San Joaquin County. The Corps' agreement contains provisions requiring EBMUD to maintain up to 200 TAF of flood-control space in its Pardee and Camanche Reservoirs during certain times of the year (up to 70 TAF of space is transferrable to Pacific Gas and Electric Company's reservoirs upstream of Pardee Reservoir). These restrictions further constrain EBMUD's operation of its Pardee and Camanche Reservoirs.

Instream Flow Requirements for Fish Protection—Joint Settlement Agreement

A condition of Permit 10478 also required EBMUD to reach an agreement with CDFW regarding flows to be bypassed for protecting 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 for the benefit of fishery production, in addition to the releases for the WID, riparian and senior appropriators, and accounting for channel losses.

The 1961 Agreement fishery flow requirements were modified in the 1990s through a joint settlement among EBMUD, CDFW, and USFWS. This joint settlement agreement, known as the JSA, included a series of flow, non-flow, and other measures designed to protect and enhance the anadromous fishery and ecosystem of the lower Mokelumne River.

The JSA schedule of fishery releases from Camanche Dam is significantly higher than the prior release requirement under the 1961 Agreement. (EBMUD began releasing the JSA flows voluntarily in 1996 prior to formal execution of the JSA in 1998.) FERC issued its Order Approving Settlement Agreement and Amending License on November 27, 1998, amending EBMUD's FERC License for the

Lower Mokelumne Hydroelectric Project (FERC Project No. 2916) by requiring the JSA measures. In addition, the State Water Board incorporated the flow provisions of the JSA into EBMUD's Mokelumne River water rights in 2000 through State Water Board Decision 1641. By that action, the State Water Board replaced the 1961 Agreement flows with the 1998 JSA flows in EBMUD's water rights.

EBMUD continues making fishery releases to the lower Mokelumne River consistent with the JSA. The JSA also provides funding for non-flow enhancement measures, monitoring requirements, and new reporting objectives. For more information, refer to the Regulatory Requirements discussion in Section 3.2, Fish Resources, of this EIR.

The 1961 Agreement also required EBMUD, at CDFW's request, 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. The 1998 JSA contained a provision under which EBMUD was to provide up to \$12.5 million to expand and upgrade the hatchery. The expansion and upgrade of the hatchery were completed in 2002. CDFW continues to operate the hatchery.

The JSA is discussed in more detail in Section 3.2, Fish Resources, of this EIR. A copy of the JSA and the 10-year review of the JSA are available in Appendix D.

1.4 Need for the Project

The water demand within EBMUD's service area varies by year, season, day, and hour. EBMUD needs flexibility to vary its diversions to accommodate this high degree of variability and meet its operational needs. Continuing the availability of the full entitlement provided under Permit 10478 would ensure that EBMUD can meet increases in demand that are forecast for the EBMUD service area; support existing and future peak demands; maintain the operational flexibility to adjust for unforeseeable events; protect environmental resources; and support efficient reservoir operations.

1.4.1 Need to Serve Increasing Demands for Water

EBMUD's normalized average annual water demand for year 2005 was 214 MGD. Adjusted average annual demand for year 2040 is projected to be 230 MGD. While the anticipated increase in average annual demand by 2040 is 16 MGD, actual annual demand varies widely by year, depending on a variety of factors such as weather, local economic conditions, conservation, and rationing. Demand is also expected to increase beyond year 2040, reaching 275 MGD toward the end of the century.

EBMUD's service area encompasses parts of Alameda and Contra Costa Counties. According to the Association of Bay Area Governments' (ABAG) Projections 2009, Alameda County alone is projected to grow by 416,500 people, reaching a total of nearly 2 million people by 2035. It is forecasted that 327,000 jobs also will be added during this period. Almost all jurisdictions in Alameda County are expected to see significant increases in population and especially employment, although most growth is expected to occur in the communities closest to the San Francisco Bay. Some of the biggest population increases are expected to occur in Emeryville and Oakland. The City of Oakland is forecasted to continue to have over 25% of the county's residents and jobs. Nearly 70% of the population growth in western Alameda County is projected to occur in infill neighborhoods, where there is access to public transit.

By 2035, Contra Costa County's population is forecasted to be over 1.3 million, an increase of approximately 233,000. Nearly 180,000 jobs will be added county-wide during this time period, reaching a total of over 555,000. Among the communities expected to see the most population growth are San Ramon and Hercules; each are anticipated to grow by more than 33%. These increases in population and employment expansion in Alameda and Contra Costa counties will result in increased water demands.

In 2008, as part of its long-term water supply planning effort, EBMUD undertook a study to determine the projected demand in its service area to the year 2040. The study examined the adopted general plans of the cities and counties in the EBMUD service area, and also included meetings with local planning agencies regarding the timing and direction of future development in their respective communities. The resulting land use database along with actual demand for year 2005 and other factors was used to calculate base year (year 2005) "normalized" demand and projected future (year 2040) demand.⁴

The 2040 Demand Study was conducted during a period of economic expansion. Although the economy began a period of recession in December 2007, the long-term Demand Study projections continue to reflect development anticipated in the community general plans over the longer period of the study. While the actual development and the associated increase in water demand are likely to be realized more slowly in the near term, the 2040 Demand Study still reflects a reasonable expectation for growth over the long term for demand in year 2040. According to the 2040 Demand Study, adjusted demand in year 2040 will be 230 MGD.⁵ This demand assumes completion of cost-effective conservation and recycling programs, completion of natural replacement of fixtures including non-conserving toilets, and landscape equipment. EBMUD has promoted water conservation since the 1970s, reducing per capita water use from 209 gallons per capita per day (gpcd) in 1970 to 153 gpcd in 2005. EBMUD's existing conservation efforts have reduced demand by 23 MGD since EBMUD implemented its Water Supply Management Plan and developed a water conservation plan in 1993-1994. Its efforts have reduced usage by even greater amounts since conservation efforts began in the 1970s in response to the 1976-1977 drought. Without the benefit of the savings brought about by these conservation efforts, demand and EBMUD's use of water from the Mokelumne River would be markedly higher than current usage. The estimated year 2040 water demand of 230 MGD incorporates these reductions.

Recently, EBMUD finalized the Water Supply Management Program (WSMP) 2040 and certified a Programmatic Environmental Impact Report for the program. EBMUD's water supply planning efforts and supplemental water sources are discussed in further detail in Appendix B.

Even though the 2040 demand study determined projected demand on an average annual basis, the demand for water varies by year, month, day, and even hourly. Figure 1-5 depicts the variability of demand on a daily and monthly basis. The yearly average annual demand is derived from the cumulative daily demands averaged over a 365-day calendar year. Although EBMUD aggressively implements conservation and water recycling measures and imposes additional rationing during droughts, current water use in EBMUD's service area frequently exceeds 275 MGD on a daily basis

⁴ Normalization is an adjustment for the temporal variation in consumption from weather and non-weather effects.

⁵ This amount is reached by first deducting from demand 62 MGD of water savings from EBMUD's conservation efforts and an additional 20 MGD of recycled water savings. Not including these savings, year 2040 demand is estimated to be 312 MGD.

and at times exceeds 300 MGD on a daily basis (Figure 1-5). With the increasing demand, it is anticipated that by year 2040 EBMUD's daily demand may exceed 300 MGD during the warmer spring, summer, and fall months even more frequently than it does currently.

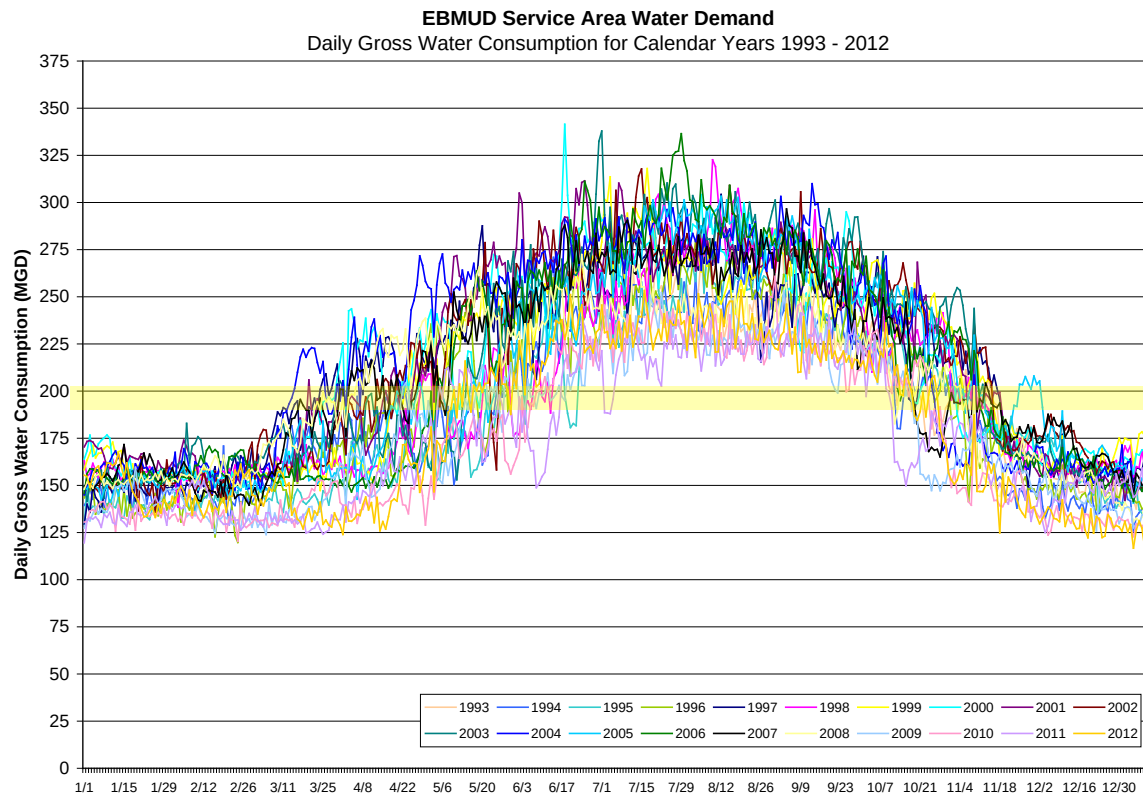


Figure 1-5
Daily Gross Water Consumption (Demand): 1993 to 2012

Water demands in the service area are also expected to continue to grow beyond year 2040 as population grows and businesses develop within the service area. Because most planning documents do not extend beyond 2040, it would be speculative to estimate use beyond 2040 with any degree of certainty. Nevertheless, because it is assumed that usage will continue to increase beyond 2040, a programmatic assessment of impacts beyond 2040 is included in this EIR with the recognition that continuing the availability of the full entitlement of Permit 10478 will ensure that EBMUD has a sufficient supply of water available to meet existing and future demands in EBMUD's service area.

1.4.2 Need to Support Peak Demands

Annual water demand in EBMUD's service area varies from year to year because of various factors such as weather, local economics, rationing, and other conditions. Additionally, demand varies within each year, increasing in the warmer spring, peaking in the summer, and tapering off in fall and winter months. Figure 1-5 shows the year-to-year variability in water demand from 1993 to 2012 and demonstrates how water demand changes throughout the year. There is a general pattern of water consumption by season, in which EBMUD's service area demand is much higher during the warmer spring, summer, and fall months (March through November) and lower during the cooler winter months (December through February). For example, the average monthly demand in the warmer summer (July) of 2006 was 298 MGD, whereas, the demand in the cooler winter (February) of 2006 was 161 MGD.

As shown in Figure 1-5, during the hot, dry summer months, EBMUD's customers have a higher demand for water. Although EBMUD aggressively implements water conservation programs and promotes the use of recycled water, water use in EBMUD's service area frequently exceeds 275 MGD on a daily basis, and at times exceeds 300 MGD on multiple days during the warm, dry, summer to early fall months (June through September). The service area demand is met by water received from the Mokelumne Aqueducts in conjunction with water supplied by the local terminal reservoirs (the terminal reservoirs are supplied by water received from the Mokelumne Aqueducts and local runoff). Having the ability to use the full entitlement provided by Permit 10478 ensures that EBMUD has sufficient water during peak demands.

An extension of Permit 10478 is needed to ensure that the full entitlement of water available under the permit is available to allow the necessary operational flexibility to support peak demands in EBMUD's service area.

1.4.3 Need to Maintain Mokelumne Supply Operational Flexibility in Unplanned Events

Despite considerable investment in its now-completed Seismic Improvement Program, the Mokelumne Aqueduct system remains vulnerable to damage from earthquakes and flooding for segments of the aqueduct that cross the Delta. EBMUD has experienced near-catastrophic failures of the systems that support the Mokelumne Aqueducts as a result of Delta levee failure and associated flooding.

EBMUD uses water from the Mokelumne Aqueducts along with supplies from its terminal reservoirs to meet peak demands. Depending on the time of year, EBMUD targets retention of supplies necessary to meet 6 months (180 days) of water demand in the local system to provide standby supply for emergencies. In the event of an emergency or catastrophic event, or in the event of a prolonged drought, terminal reservoir storage may be drawn down significantly or wholly depleted.

To recover from depletion as a result of terminal reservoir draw down, EBMUD depends on Permit 10478 to deliver 325 MGD from the Mokelumne River. This right would be exercised throughout the recovery period from a water supply outage or catastrophic event that temporarily restricted deliveries through the aqueducts. Without the ability to recover terminal reservoir storage by making full use of its Mokelumne River water rights, the East Bay area is vulnerable to complete failure of its water supply system.

1.4.3.1 Drought

Drought, “a period of abnormally dry weather sufficiently prolonged for the lack of water to cause serious hydrologic imbalance in the affected area,” is a recurring feature of the climate in California (Huschke 1959). In 1976–1977, 1987–1992 and again in 2007–2010, EBMUD imposed drought management programs to reduce customer demands, thereby providing more carryover storage for prolonged dry year conditions.

In the event of a prolonged drought, reservoir storage levels may be drawn down significantly. EBMUD relies on and depends on Permit 10478 to meet both the service area demands and to refill and recover reservoir storage levels. Without the ability to refill the reservoirs, EBMUD does not have a viable, functioning water system to meet the needs of the 1.3 million residents in its service area.

1.4.3.2 1997 Pardee Reservoir Turbidity Event

In 1997, heavy storms caused the water in Pardee Reservoir to become very turbid, which caused EBMUD to stop using the Mokelumne Aqueducts to deliver water early in the year because of public health concerns. This shutdown was the longest shutdown on record (65 days). Once the water quality in Pardee Reservoir improved, it was necessary for EBMUD to divert more than 300 MGD of water through the aqueducts to meet demands and refill the terminal reservoirs, which had been used to meet demand during the 65-day period.

1.4.3.3 2000 Testing of the Mokelumne Aqueducts

In 2000, after installation of new pressure transient (i.e., testing) equipment and improvements on Mokelumne Aqueduct No. 1, the Mokelumne Aqueducts were tested at the full 325 MGD diversion rate for 7 days. The testing was conducted to identify any operational adjustments that would be needed in the future.

1.4.3.4 2008 Refill of Terminal Reservoirs

In 2008, EBMUD diverted 325 MGD through the Mokelumne Aqueducts to recover the drawdown of terminal reservoir storage resulting from two consecutive dry years.

As noted above, among other functions, the terminal reservoirs generally provide a 6-month emergency standby water supply. In the event of episodic conditions, such as high turbidity, seismic testing, or other non-catastrophic/emergency situations, terminal reservoir storage may become drawn down or depleted. As a result, terminal reservoir supply would not be sufficient to meet the short- or long-term water demands of EBMUD customers.

In the event of episodic conditions/events, the full entitlement of Permit 10478 is needed because EBMUD relies on the ability to deliver up to 325 MGD to refill the terminal reservoirs as rapidly as possible while continuing to provide water service to its customers.

1.4.3.5 Effects of Climate Change

California Department of Water Resources (DWR) projects that the impacts of climate change gradually will increase in severity during this century and beyond (California Department of Water Resources 2009). EBMUD’s water supply and service area demand could be affected by climate

change as decreases in Sierra Nevada snowpack reduce the available water supply and higher temperatures increase water demands. Climate change also could affect EBMUD's flood management and energy production, as well as water quality and fish resources in the Mokelumne River. The effects of climate change on the EBMUD's water supply and service area are discussed further in Chapter 7, Climate Change.

1.4.4 Need to Protect Environmental Resources

As described briefly above and in more detail in Section 3.2, Fish Resources, EBMUD entered into a JSA with USFWS and CDFW in February 1998 for the greater protection and enhancement of the anadromous fishery resources of the lower Mokelumne River (Appendix D). A key component of the JSA is a schedule of flow releases that vary by year type and time of year, tailored to the life stages of the anadromous fishery. Pursuant to the JSA, EBMUD operates Pardee and Camanche Reservoirs in an integrated manner to provide sustainable supplies of water, protect other natural resources while rehabilitating and maintaining diverse migratory and resident fish and wildlife populations, and provide hydroelectric power. This operation also includes a comprehensive monitoring and applied research program, integrated with a well-coordinated plan to adaptively manage water and power supply operations, flood control, hatchery operations, and ecosystem rehabilitation.

To benefit the lower Mokelumne River fishery, the JSA requires EBMUD to use its best efforts to manage the cold water temperatures in Pardee and Camanche Reservoirs and maintain stratification in the reservoirs with a minimum of 28 TAF of hypolimnetic volume in Camanche Reservoir through October whenever Pardee Reservoir volume exceeds 100 TAF. This requirement also was incorporated into EBMUD's Pardee License 11109 and Permit 10478 by the State Water Board in its adoption of Decision 1641 in March 2000. Weather and hydrology permitting, this management allows EBMUD to release cold water to benefit Chinook salmon that return to the lower Mokelumne River in the fall to spawn and also to benefit steelhead trout.

This section provides a brief background on reservoir limnology, and summarizes the reservoir operation practices EBMUD employs to meet its JSA obligations to preserve cold water in Pardee and Camanche Reservoirs so that it is available to release downriver in the fall.

1.4.4.1 Reservoir Limnology

Camanche and Pardee Reservoirs are typical of moderately deep, warm-climate reservoirs in that they are thermally stratified in the summer, meaning that the reservoir water is warmer at the top and colder at the bottom of the reservoir. In early summer, sunlight heats the surface of the reservoirs and wind mixes the surface waters to a depth at which turbulence is eventually dissipated. Three zones are formed in the reservoirs: 1) the upper, warmer, and less dense epilimnion; 2) the cold, dense bottom hypolimnion; and 3) the intermediate metalimnion, which contains the most rapid decrease in temperature called the thermocline.

In the fall, with less solar radiation reaching the water and greater heat loss at night, convection and wind mixing begin to erode the thermocline. The epilimnion then increases in depth as it decreases in temperature. Eventually, the temperature and density difference between the overlying water and the water beneath it is so slight that a strong wind in the late autumn overcomes the remaining resistance to mixing, and the reservoirs undergo the fall de-stratification. The stratified structure is lost and the reservoirs become homothermous, i.e., they have a uniform temperature with depth.

1.4.4.2 Operations of Pardee and Camanche Reservoirs to Maintain Temperatures

Appropriate temperatures in Camanche Reservoir releases to the lower Mokelumne River and the Mokelumne River Fish Hatchery depend on the maintenance of thermal stratification in Camanche Reservoir until the reservoir naturally de-stratifies in the fall. When Camanche Reservoir destratifies in the fall, surface waters have cooled such that the temperature of Camanche releases after de-stratification is generally appropriate. If, however, the hypolimnion in Camanche Reservoir is depleted by downstream releases and the reservoir de-stratifies prematurely, surface waters will still be warm and the temperature of Camanche Reservoir releases after such an early destratification may be unacceptably high. Therefore, the key to maintaining Camanche releases of acceptable temperature is the maintenance of thermal stratification in Camanche until the reservoir naturally de-stratifies in the fall. Premature de-stratification at lower reservoir elevations also could create water quality problems by stirring up sediments and drastically increasing turbidity in Camanche releases.

EBMUD's approach to managing the system is based on management of the cold water hypolimnions in both Camanche and Pardee Reservoirs. This approach has been developed operationally, incorporating a flexible response to several unique features of the Pardee Reservoir/Camanche Reservoir system, and is possible because of extensive monitoring during operation. These unique features are listed below.

- Water in the Pardee Reservoir hypolimnion is generally as cold as or colder than water in the Camanche hypolimnion such that, while there may be some warming of Pardee releases between Pardee Reservoir and Camanche Reservoir, releases from Pardee Reservoir remain cold enough to enter directly into the Camanche hypolimnion. Releases from Pardee Reservoir can be used to supplement the Camanche Reservoir hypolimnion during summer and fall.
- Camanche Reservoir generally has a much lower ratio of reservoir volume to surface area than Pardee Reservoir. Therefore, it is more efficient to store cold water in a stratified Pardee Reservoir than in a stratified Camanche Reservoir.
- Maintenance of an adequate hypolimnion in Camanche Reservoir during low-flow years depends on replenishing the Camanche hypolimnion with cold water releases from Pardee Reservoir. Therefore, Pardee Reservoir must remain stratified to ensure Camanche Reservoir remains stratified.

EBMUD's approach to maintaining thermal stratification in Camanche Reservoir is dependent on preserving a sufficient amount of cold water in Pardee Reservoir to transfer into Camanche Reservoir when needed. Because of the unique system features listed above, EBMUD preserves most of the cold water in Pardee as a first priority. To maintain thermal stratification in Camanche Reservoir, EBMUD adjusts the cold water releases from Pardee to Camanche to replenish the cold water that is released from Camanche Reservoir to the lower Mokelumne River. EBMUD conducts extensive monitoring to track changing environmental conditions and to confirm that the temperature management goals are being met. This approach has proved effective since 1990. Therefore, it is critical that Pardee Reservoir remain stratified to ensure Camanche Reservoir remains stratified so that it, in turn, may release cold water for the lower Mokelumne River fishery.

EBMUD's ability to maintain thermal stratification in both Pardee and Camanche Reservoirs is also dependent on a reservoir management system that is flexible and can adapt to actual changing

environmental conditions. EBMUD considers many factors when developing its operations and temperature management strategy for any given year. Environmental factors considered include, for example, the timing of runoff in the Mokelumne watershed, air temperatures, weather patterns, and hypolimnetic volume and water temperatures of both Pardee and Camanche Reservoirs. EBMUD modifies its operations to adapt to changing environmental conditions whenever necessary. For example, EBMUD updates its operations on a weekly basis to preserve cold water, modifies Pardee Reservoir release patterns to maximize the efficiency of cold water transferred from Pardee to Camanche, and adjusts the elevation at which water is released through the outlet structures to preserve the quantity of cold water in both Pardee and Camanche during spring and summer for release in the fall. EBMUD's practice of adapting its operational decisions to adjust to changing environmental conditions is an essential aspect of the operational flexibility needed to manage temperatures. These operational parameters, along with extensive monitoring, maximize EBMUD's ability to manage the system to provide appropriate temperatures in the river.

EBMUD has used these and other measures to manage releases and water temperatures below Camanche Reservoir to protect fishery resources. The need to protect the ecosystem and anadromous fish and the specific requirements of the JSA are discussed in greater detail in Section 3.2, Fish Resources, of this EIR.

1.4.5 Integrated Reservoir Operations

As noted earlier, EBMUD holds multiple rights to divert water from the Mokelumne River for use in the East Bay. Among other parameters, License 11109 allows EBMUD to divert up to 200 MGD from the Mokelumne River on a year-round basis and divert up to 209 TAF to storage in Pardee Reservoir.

Permit 10478 allows EBMUD to divert up to 125 MGD (194 cfs) from the Mokelumne River to direct use from December 1 to July 1, and to divert up to 353 TAF of water to storage in Pardee and/or Camanche Reservoirs between December 1 and July 1 for municipal use. EBMUD diverts both License 11109 and Permit 10478 waters at Pardee Reservoir into its Mokelumne Aqueducts for conveyance and use in EBMUD's service area.

EBMUD operates its facilities on the Mokelumne River, including Pardee and Camanche Reservoirs, as an integrated system to deliver municipal water supply benefits of up to 325 MGD from Pardee Reservoir to the EBMUD service area in the most energy-efficient manner, while meeting all other operating goals, objectives, and requirements. These other operating goals, objectives, and requirements include bypassing/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/public trust interests, and meeting Corps flood control requirements. Consistent with all other operating objectives and obligations, releases from the two reservoirs also are planned to provide hydropower benefits.

To accomplish this tandem operation, EBMUD operates Pardee and Camanche Reservoirs to fill by the end of spring, hydrology permitting, and strives to hold Pardee Reservoir elevation high throughout the summer while drawing down Camanche Reservoir. Operating in this manner improves reliability, allows EBMUD to deliver water through the Mokelumne Aqueducts under gravity flow (thereby minimizing energy consumption), and preserves a cold water pool in Pardee

Reservoir for release to Camanche Reservoir during late summer/early fall to benefit the lower Mokelumne River anadromous fishery.

1.5 Additional Petitions Submitted by EBMUD

As noted in Section 1.1, Introduction, EBMUD submitted several auxiliary petitions to ensure that its Mokelumne water rights accurately reflect existing operations and changes that have occurred as a result of additional regulatory requirements and other developments since the State Water Board issued the water rights. EBMUD's objective in proposing these various auxiliary change petitions is to continue to operate EBMUD's Mokelumne River facilities in the most efficient and reasonable manner to meet water supply needs, while continuing to meet downstream, environmental, and regulatory obligations, and conforming the place of use to the LAFCO-directed service area boundary. Each change petition is briefly explained in the following sections. For a more detailed summary of the petitions, see Appendix C, Summary of Auxiliary Change Petitions Submitted to California State Water Resources Control Board.

1.5.1 Additional Purpose of Use and Change in Place of Use for License 11109

EBMUD is petitioning to add "fish and wildlife preservation and enhancement" at Pardee Reservoir as an additional purpose of use under License 11109. Waters stored in Pardee Reservoir support fish and wildlife resources at Pardee. The proposed change in purpose of use reflects EBMUD's existing operations and would not expand EBMUD's existing water rights to divert water from the Mokelumne River and would not result in any potentially significant impacts.

EBMUD is also petitioning to update the place of use set forth in License 11109. The place of use for License 11109 was last approved when the license was issued by the State Water Board in 1981. The proposed change in place of use is a result of annexation of additional lands to EBMUD's current and ultimate service area boundaries by the LAFCOs of Alameda and Contra Costa Counties. For each of these annexations, LAFCO, as the lead agency, complied with the requirements of CEQA, approved environmental documents, and added the areas to EBMUD's service area, thus, requiring that they be served by EBMUD. The proposed change in the place of use is simply to update the map on file with the State Water Board to conform the place of use to add areas that LAFCO has already ordered to be served, for which CEQA documentation was completed, and which EBMUD is currently serving. Adding these areas would not result in any potentially significant impacts that were not examined in prior CEQA documents.

1.5.2 Change in Place of Use for Permit 10478

The place of use for Permit 10478 was last approved by the State Water Board in 1983. The proposed change in place of use is a result of annexing additional lands to EBMUD's current and ultimate service area boundaries by LAFCO of Contra Costa County. LAFCO, as the lead agency, complied with the requirements of CEQA; this compliance is detailed in the petition EBMUD submitted to the State Water Board. The proposed change in place of use is to simply update the map on file with the State Water Board to conform the place of use to add areas LAFCO has already ordered to be served, for which CEQA documentation was completed, and which EBMUD is currently

serving. Adding these areas that LAFCO has annexed to EBMUD over the past several decades would not result in any potentially significant impacts that were not examined in prior CEQA documents.

1.5.3 Additional Purpose of Use for Permit 10478

EBMUD is also petitioning to formally add “recreation”, “fish and wildlife preservation and enhancement,” and “industrial” as authorized purposes of use at Pardee and Camanche Reservoirs under Permit 10478. Waters stored in Camanche Reservoir support fish and wildlife and recreational resources at Camanche Reservoir. The proposed changes in purpose of use do not expand EBMUD’s existing right to water from the Mokelumne River, and formally adding these uses to Permit 10478 would not result in any potentially significant impacts.

1.5.4 Petition for Change to Add Clarifying Term to Permit 10478 (Clarifying Petition)

In March 2012, EBMUD submitted a petition to add a clarifying term to Permit 10478 to better articulate the manner in which the use of water stored in Camanche Reservoir is recorded and reported to the State Water Board. Permit 10478 authorizes EBMUD to divert and store Mokelumne River water at both Pardee and Camanche Reservoirs, and the integrated operation of EBMUD’s Mokelumne Project optimizes water supply and hydroelectric power benefits, as well as the provision of flood control, fishery protections, and satisfaction of obligations to downstream water rights holders. The clarifying petition is intended to explain EBMUD’s existing water rights and does not initiate a new water right or expand EBMUD’s existing water rights to divert water from the Mokelumne River. The proposed term also does not affect the release and bypass requirements for the lower Mokelumne River or the quantities of water that EBMUD is authorized to divert. Adding the proposed term would not result in any potentially significant impacts, and it is anticipated that the State Water Board will take action on the petition at the same time that it takes action on the petition to extend Permit 10478.

The State Water Board has requested a disaggregation of diversions and use under the individual water rights held by EBMUD on the Mokelumne River. The request necessitated a need to better articulate the manner in which use of water stored in Camanche Reservoir is recorded and reported for Permit 10478. The clarifying petition requests the State Water Board to add a “net depletion” term to Permit 10478 to more explicitly set forth the manner in which authorized diversions are occurring and to account for diversions consistent with EBMUD’s existing water rights and limitations, particularly relative to withdrawals under Permit 10478.

1.5.5 Mokelumne River Hydroelectric Water Rights (License 1388, License 6062, and Permit 10479)

EBMUD currently holds four non-consumptive hydropower rights for hydroelectric power generation at Pardee Power Plant (License 1388, License 6062, and Permit 10479 for Pardee Units 1, 2, and 3) and Camanche Power Plant (Permit 17378). Pardee hydropower rights allow EBMUD to directly divert up to a combined rate of 1,100 cfs at Pardee Power Plant year-round, and up to 1,200 cfs at Camanche Power Plant during the October to July period. The authorized storage quantities under License 1388, License 6062, and Permit 10479 at Pardee Reservoir are 198,965 AFY;

28,702 AFY; and 50,000 AFY, respectively. The authorized storage quantity under Permit 17378 is 353,000 AFY at Camanche Reservoir.

EBMUD is proposing changes to three Pardee hydropower rights (License 1388, License 6062, and Permit 10479) to add the Camanche powerhouse to the place of use and to add Camanche Dam as a point of redirection to License 1388, License 6062, and Permit 10479. These changes to the Pardee hydroelectric power generation licenses and permit would facilitate the continued smooth and efficient operation of EBMUD facilities to meet water supply and hydroelectric power generation needs while meeting all other downstream environmental and regulatory obligations.

1.6 Organization of This Environmental Impact Report

This EIR is an assessment of environmental impacts for each resource area that could be affected by the Permit 10478 Time Extension Project. This EIR is organized into the following chapters and sections:

- Chapter 1, Project Objective and Need for the Permit 10478 Time Extension Project;
- Chapter 2, Project Description, Baseline, and Alternatives;
- Chapter 3, Impacts and Mitigation Measures;
 - Section 3.1, Water Resources;
 - Section 3.2, Fish Resources;
 - Section 3.3, Vegetation, Wetland, and Wildlife Resources;
 - Section 3.4, Agricultural Resources;
 - Section 3.5, Recreational Resources;
 - Section 3.6, Visual Resources;
- Chapter 4, Cumulative Impacts;
- Chapter 5, Alternatives Analysis;
- Chapter 6, Programmatic Evaluation of Use Beyond 2040;
- Chapter 7, Climate Change;
- Chapter 8, Other CEQA Analyses;
- Chapter 9, Agency Consultation and Public Outreach;
- Chapter 10, List of Contributors; and
- Chapter 11, References.

EBMUD has determined that the Project has less-than-significant impacts or less-than-significant impacts with mitigation for the following resource areas:

- water resources (hydrology, water supply, and water quality);
- biological resources (including fish, wildlife, vegetation, and wetland resources);
- agricultural resources;
- recreation; and
- visual resources.

Each chapter or section focuses on a separate resource area and describes the regulatory and environmental setting for that resource area pursuant to CEQA requirements. The State CEQA Guidelines have been used to determine thresholds of significance for assessing environmental impacts including direct, indirect, short- and long-term, cumulative, and unavoidable impacts. Also per the State CEQA Guidelines, feasible mitigation measures are identified when possible to reduce significant and potentially significant environmental impacts to a less-than-significant level. Technical studies may be included as appendices to provide additional details related to key topical areas. A programmatic level of assessment of impacts is included for water use beyond the year 2040.

1.7 Resources Not Analyzed in This EIR

The Permit 10478 Time Extension Project would have less-than-significant impacts, no impacts, and no indirect impacts on the following resources:

- air quality,
- cultural resources,
- geology and soils,
- hazards and hazardous materials,
- land use and planning,
- mineral resources,
- noise,
- population and housing,
- public services,
- transportation and traffic, and
- utilities and service systems.

These resources are not analyzed separately in the EIR, but are briefly discussed below.

1.7.1 Air Quality

The Project would involve EBMUD's continued ability to make full use of its long-existing permit rights and continued operation of the Pardee and Camanche Reservoirs. The Project would not result in new construction and would not conflict with or obstruct implementation of the respective air quality plans in effect in the service area, violate any air quality standard, or contribute substantially to an existing or projected air quality violation. The Project would not result in a cumulatively considerable net increase of any criteria pollutant for which the service area is in nonattainment under applicable federal or state ambient air quality standards. The Project would not expose sensitive receptors to substantial pollutant concentrations, nor create objectionable odors affecting a substantial number of people.

1.7.2 Cultural Resources

The Project would not result in new construction and would not involve new ground disturbance or alteration of cultural resources. Therefore, the Project would not result in an adverse change to historical, archeological, or paleontological resources. Additionally, the Project would not have the potential to disturb any human remains.

1.7.3 Geology and Soils

The Project would not result in new construction and would not expose people or structures to potential substantial adverse effects associated with earthquakes, seismic ground shaking/failure, or landslides. In addition, the Project would not result in soil erosion or loss of topsoil, nor would it result in instability of geological units or soils.

1.7.4 Hazards and Materials

The Project would not result in new construction and would not involve the use of hazardous materials, nor would it have the potential to create hazards or risks for the public or the environment.

1.7.5 Land Use and Planning

The Project would not result in new construction and would not physically divide an established community; conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project; or conflict with any applicable habitat conservation plan or natural community conservation plan.

1.7.6 Mineral Resources

The Project would not result in new construction and would not result in the loss of availability of a known valuable or important mineral resource.

1.7.7 Noise

The Project would not result in new construction or new operations and, therefore, would not expose persons to, or generate noise levels in excess of, standards established in county or city plans, noise ordinances, or applicable standards of other agencies. In addition, the Project would not expose persons to or generate groundborne vibration or groundborne noise levels, or substantially increase ambient noise levels.

1.7.8 Population and Housing

The Project would not result in new construction and would not displace existing housing or people. Potential growth-inducing impacts associated with the Project are evaluated in Chapter 8, Other CEQA Analyses.

1.7.9 Public Services

The Project would not result in substantial adverse impacts associated with the provision of new or physically altered governmental facilities or a need for new or physically altered governmental facilities.

1.7.10 Transportation and Traffic

The Project would not involve any new construction and would not result in an increase in traffic that is substantial in relation to existing traffic load or capacity of the street system. The Project would not require construction or alteration of roads; result in inadequate emergency access or inadequate parking capacity; or conflict with adopted policies, plans, or programs supporting alternative transportation.

1.7.11 Utilities and Service Systems

The Project would not result in the construction of new water or wastewater treatment or stormwater drainage facilities or expansion of existing facilities. The Project would not exceed wastewater treatment requirements of the Central Valley Regional Water Quality Control Board (CVRWQCB), or generate additional solid waste.

Chapter 2

Project Description, Baseline, and Alternatives

The Permit 10478 Time Extension Project (Project) analyzed in this document is described below, followed by a description of the baseline; alternatives to the Project, including the No-Project Alternative and those alternatives that were considered but rejected as infeasible during the scoping process. A detailed analysis of the potential impacts of the project alternatives is presented in Chapter 5, Alternatives Analysis. A general, program-level evaluation of future use is included in Chapter 6, Programmatic Evaluation of Water Use Beyond 2040.

2.1 Permit 10478 Time Extension Project

The Project evaluated in this document is the extension of Permit 10478 to allow EBMUD additional time to apply water provided by the permit to beneficial uses. In November 2000, EBMUD filed a petition with the California State Water Resources Control Board (State Water Board) to extend and continue the terms of Permit 10478 to the year 2040. The objectives and need of this Project are described in Chapter 1, Objective and Need for the Permit 10478 Time Extension Project.

EBMUD obtained Permit 10478 in 1956 and has relied on the water rights provided under the permit to divert and store waters from the Mokelumne River. After obtaining Permit 10478 and negotiating necessary agreements and authorizations to facilitate EBMUD's use of the water, EBMUD promptly completed construction of Camanche Reservoir, which is an essential component of its Mokelumne Project. Construction of Camanche Reservoir was completed in 1964, 16 years prior to the required date of December 1, 1980.

EBMUD is petitioning to extend Permit 10478 through the year 2040 to ensure its continued ability to exercise the water rights authorized under the permit using its existing Mokelumne Project¹ facilities to meet the needs of the growing population in the municipal area that EBMUD serves. EBMUD is not proposing to alter the quantities that it is authorized to divert from the Mokelumne River, obtain any authorizations for new rights, or construct new facilities.

EBMUD operates Pardee and Camanche Reservoirs together as an integrated system to efficiently deliver municipal water supply to the EBMUD service area and meet other obligations. EBMUD holds a senior municipal water right (License 11109) that allows it to divert up to 200 million gallons per day (MGD) from the Mokelumne River. EBMUD's junior municipal water right (Permit 10478) allows additional diversions up to 125 MGD from the Mokelumne River. Together, License 11109 and Permit 10478 allow delivery of a maximum of 325 MGD from the Mokelumne River, or 364,037 acre-feet per year (AFY), subject to the availability of Mokelumne River runoff, reservoir storage, and EBMUD meeting obligations to senior water rights, downstream fishery flow requirements, and other Mokelumne River water uses.

Under Permit 10478, EBMUD can divert up to 194 cubic feet per second (cfs) (125 MGD) from the Mokelumne River to direct use from December 1 to July 1, and can divert up to 353,000 AFY of

¹ EBMUD operates its Mokelumne River facilities in a coordinated and integrated manner, as a single unified system. This single unified system is known as the Mokelumne Project.

water to storage in Pardee Reservoir and/or Camanche Reservoir between December 1 and July 1 for municipal use in the EBMUD service area.

Permit 10478 also identified December 1, 1980, as the date by which EBMUD was to have completed construction, and December 1, 2000, as the date by which EBMUD was to have completed full application of the water to beneficial use. In 1964, EBMUD completed essentially all construction of Camanche Reservoir and related facilities needed to use water diverted under Permit 10478.

EBMUD has at times diverted at the maximum rate allowed under Permit 10478 and has collected to storage virtually all of the permitted maximum quantity (352 thousand acre-feet [TAF] of 353 TAF allowed). EBMUD's annual water usage is such that it has not yet diverted the maximum amounts allowed to be diverted annually under Permit 10478. Significant factors that have reduced EBMUD's annual usage and resulted in use being below the maximum entitlement allowed under Permit 10478 are the water conservation and recycling programs that EBMUD began implementing more than 35 years ago. These programs have slowed the increase in water use from what it would have otherwise been based on the increase in population in EBMUD's service area. Even with the conservation and recycling program measures in place, and even in light of the projected planned expansion of these water use efficiency programs in the future, continuing the ability to make full use of Permit 10478 water rights is crucial for EBMUD to ensure that it can provide the water supply needed to meet existing and future projected municipal and industrial water demand.

Recently, EBMUD completed its 2040 Demand Study that projects water demands in EBMUD's service area into the future (i.e., to year 2040) using the land use planning information from the communities that EBMUD serves. The study determined that without water savings from EBMUD's existing and future conservation and recycling programs, projected year 2040 demand would be 312 MGD. The implementation of the existing and planned future water conservation and recycling measures is projected to reduce the year 2040 average annual demand from 312 MGD to 230 MGD. For planning purposes, 230 MGD represents the most likely level of projected average annual demand in year 2040. As a result, this document utilizes the demand of 230 MGD in the year 2040 as an analytical tool to assess potentially significant environmental impacts resulting from the time extension. Demand is expected to continue to grow beyond 2040, although it is difficult to determine the timing and extent. This EIR, therefore, also examines the continued full use of Permit 10478 supplies at a programmatic level (Chapter 6, Programmatic Evaluation of Use Beyond 2040).

The analytic framework for the Project and programmatic evaluation are fully detailed in Appendix E, Modeling Technical Appendix.

2.2 Additional Petitions submitted by EBMUD

This document also includes a discussion of the auxiliary petitions that were submitted to ensure that the permits and licenses issued by the State Water Board for the Mokelumne River facilities accurately reflect EBMUD's existing Mokelumne River municipal and hydroelectric operations and its service area boundaries. EBMUD has added a discussion of the auxiliary 'cleanup' petitions for informational purposes. The auxiliary petitions do not have any potentially significant effect on the environment but EBMUD has included a discussion of these petitions with the expectation that the State Water Board may act on all of the petitions related to water rights associated with municipal and other consumptive purposes of use as part of a single action. The State Water Board may, at its discretion, act on petitions related to single-purpose hydropower water rights either separately or

concurrently with its action on the municipal water rights. It is anticipated that the State Water Board, as a responsible agency, will use this environmental document when acting on the extension petition for approval.

2.3 Baseline

CEQA requires an environmental document to include a description of baseline physical conditions against which a project's potentially significant impacts are compared, to determine whether the impacts are significant. This section describes the baseline conditions used for impact analysis in this EIR.

As explained in Chapter 1, Objective and Need for the Permit 10478 Time Extension Project, EBMUD's demand for water varies from year to year, sometimes considerably, because it is a function of various factors that EBMUD does not control, including weather (precipitation and temperature), local land use agency development approvals, the local economy, and the general economy. The variation in demand is evident from the changes in demand from calendar year 2000, when the extension petition was filed, and the years immediately following (Table 2-1). For example, from calendar years 2000 to 2003, demand was relatively constant, ranging from 214 to 216 MGD, a difference of only 1% and resulting in a 4-year average annual demand of 215 MGD. In the next year, 2004, due to a warm summer in conjunction with a strong economy, demand increased to 219 MGD, while in the year immediately following, demand dropped to 208 MGD. Since 2007, the impacts of the significant economic recession combined with cool summers and rationing imposed by EBMUD on its customers in response to droughts have dropped average annual demands. This illustrates that demand varies, at times considerably, and even in back-to-back years.

Table 2-1. Average Annual Demand^a

Calendar Year	Average Annual Demand (MGD)
2000	215
2001	216
2002	215
2003	214
2004	219
2005	208
2006	208
2007 ^a	208
2008 ^a	205
2009 ^a	196
2010	178
2011	173
2012	179

^a System Input (Average Annual Demand) is the quantity of treated water delivered to the distribution system.

^b Calendar years 2007 to 2009 were drought years with voluntary and mandatory rationing imposed by EBMUD to reduce water use.

As noted above, EBMUD's demand directly influences the amount of water drawn from the Mokelumne River into the Mokelumne Aqueducts, as well as reservoir levels and other river conditions. Therefore, simply selecting an individual year of demand without normalizing the demand can obscure the natural variation in demand that occurs in any given year because of the meteorological, economic, and other factors. A single year demand without normalization, thus, does not accurately reflect existing physical conditions in the affected area over time.

To account for such natural variation, rather than selecting a single year as the baseline for this EIR, EBMUD used the results from its recently completed 2040 Demand Study. As noted earlier, beginning in 2007, EBMUD undertook a comprehensive, multi-year study to determine the projected demand in the year 2040. The study selected calendar year 2005 as the base year for defining existing land uses and as the starting point for projecting future water demands. The study examined the adopted general plans of the cities and counties within EBMUD's service area, and also included meetings with local planning agencies regarding the timing and direction of future development in their respective communities. The resulting land use database along with the actual demand for year 2005² and other factors was used to calculate a normalized base year demand for year 2005 and projected demands to the year 2040. The demand analysis concluded that normalized average annual demand in year 2005 was 214 MGD. This EIR uses the 214 MGD average annual demand figure as its baseline for analytic purposes.

The baseline also incorporates EBMUD's existing supplemental dry year supplies. The Freeport Regional Water Project (FRWP) allows EBMUD to take delivery of Central Valley Project (CVP) water under a contract with the U.S. Department of Interior, Bureau of Reclamation (Reclamation) to meet a portion of EBMUD's drought year needs once the total system storage has declined to a defined level. The CVP contract provides that up to 100 MGD of water from the Sacramento River may be delivered to EBMUD customers in a dry year and that EBMUD is limited to a total delivery of 165 TAF over any consecutive 3-year period. The analytical assumptions for the project, baseline, and other alternatives are detailed in Appendix E, Modeling Technical Appendix.

2.4 Alternatives to the Project

CEQA Guidelines Section 15126.6 requires that an EIR describe a reasonable range of alternatives to the Project that would feasibly attain most of the basic objectives of the project but would avoid or substantially lessen any of the significant effects of the project, and evaluate the comparative merits of the alternatives. Although EBMUD considered several alternatives to the Project, this EIR examines only one alternative, the No-Project Alternative, which CEQA requires to be analyzed. All other alternatives that EBMUD had considered were determined to be infeasible and, therefore, rejected.

The No-Project Alternative is described in Section 2.5, No-Project Alternative, and the impacts associated with this alternative are evaluated in Chapter 5, Alternatives Analysis. The No-Project Alternative is different than the baseline in that the No-Project Alternative analysis also includes the actions EBMUD would need to undertake to meet water demands in the service area. The analytical assumptions for the baseline are detailed in Appendix E, Modeling Technical Appendix.

² Year 2005 was selected as the base year for the Demand Study because it was the last year of complete data availability that did not experience distribution system anomalies.

CEQA also requires that an EIR identify any alternatives that were considered, but rejected. The rejected alternatives and the reasons for their rejection are discussed in Section 2.6, Alternatives Considered but Rejected.

2.5 No-Project Alternative

Under the No-Project Alternative, Permit 10478 would not be extended. For purposes of assessing the consequences of the No-Project Alternative, this EIR assumes EBMUD would continue to divert water under License 11109. It also assumes that the supplies available under Permit 10478 would continue to be available up to the baseline average annual demand of 214 MGD from the Mokelumne River, and that EBMUD would be able to divert at a maximum rate of 325 MGD for periods of time as it has historically done to meet demand and refill terminal reservoirs following temporary water supply outages. EBMUD would also be allowed to continue to store water under Permit 10478 in Pardee and/or Camanche Reservoirs.

Regardless of whether Permit 10478 is extended, demands in the service area would continue to increase as the population grows and development proceeds consistent with the general plans of the respective communities served by EBMUD. In accordance with recent trends, this increased demand would come, in part, from increased densities in existing developed urban areas, as formerly lower water consumption land uses are replaced by more intensive mixed use and other developments having greater water consumption.

To meet the increasing demand beyond the baseline demand of 214 MGD, EBMUD would need to obtain replacement water supplies of 16 MGD (about 18,000 AFY) on a year-in year-out basis to year 2040 and additional replacement supplies after year 2040. The ability to obtain supplies to replace EBMUD's existing Permit 10478 is not guaranteed. The water quality, quantity, and diversion points of replacement supplies need to be compatible with EBMUD's water system infrastructure and operations. Depending on the source of the replacement water supply and the constraints on it when it is available, EBMUD may need to build new diversion and treatment facilities, potentially modify existing operations to blend the Mokelumne waters with the replacement waters, and further may need to overcome a range of possible institutional and regulatory barriers associated with obtaining replacement water supplies on a year-in year-out basis.

EBMUD also relies on the full use of Permit 10478 (along with License 11109) to deliver up to 325 MGD annually to its service area to ensure its water supply system remains viable if a serious catastrophic event such as an earthquake, levee break, prolonged droughts, or a water quality impairment in Pardee Reservoir occurs. EBMUD operates its terminal reservoirs in the EBMUD service area to provide, among other objectives, a reserve for emergencies such as extended droughts or serious water delivery disruptions. After a catastrophic event, EBMUD relies on the full Permit 10478 and License 11109 water rights entitlements and ability to deliver up to 325 MGD to refill its terminal reservoirs as rapidly as possible to provide the necessary water supply reserves in the terminal reservoirs.

Under the No-Project Alternative, during normal operations, the overall volume of water diverted from the Mokelumne River would be curtailed to 214 MGD (239,000 AFY) on an average annual basis with the remaining 16 MGD (18,000 AFY) diverted from other sources. After a catastrophic event, under the No-Project Alternative, it is assumed that EBMUD would take longer to fully refill

the terminal reservoirs due to limitations in diversions from the Mokelumne River. Additional waters beyond the 16 MGD (18,000 AFY) discussed above would be needed to fully refill the terminal reservoirs to avoid leaving EBMUD's ratepayers vulnerable without adequate reserves after a catastrophic event.

Potential water supply options to replace the Mokelumne supplies needed to serve the 16 MGD increase in demand up to year 2040 include long-term purchases of surface water, development of a desalination project, or transactions to obtain groundwater supplies from Sacramento, San Joaquin, or other groundwater basins. New facilities would be required under the desalination option. New infrastructure, including facilities to convey, treat, and store and/or extract water, may need to be constructed for the other options. EBMUD also would need to develop a series of complex partnership agreements, operational coordinating agreements, and cost-sharing arrangements with numerous stakeholders to replace waters that are currently available under Permit 10478 using existing facilities. These possible replacement water supply options are described in more detail below.

2.5.1 Long-Term Water Replacement Supply Options

Under the No-Project Alternative, EBMUD could seek transfers of surface supplies of 16 MGD (average annual demand) during non-dry year periods to replace the Permit 10478 supplies and meet increasing water demands in the EBMUD service area. These water transfers should not be confused with the supplemental dry-year water transfers that EBMUD has proposed as an option to meet its dry year needs. EBMUD's WSMP 2040 analysis assumed the continued availability of the full amount of the existing Mokelumne River water supplies, and also found that in dry years, these available supplies are insufficient. WSMP 2040 projected that the supplemental dry-year water transfers will be needed in 3 out of 10 years, or an average of about one-third of the time period covered in its modeling, and the planning generally assumes that these supplies would be delivered through the FRWP facilities when EBMUD is taking delivery of its CVP supplies. In contrast, under the No-Project Alternative, without EBMUD's full Permit 10478 supplies, EBMUD would also need to obtain additional supplies in all other year types (i.e., non-dry years) or, in other words, EBMUD would need to also obtain replacement supplies in 7 out of 10 years to make up the supplies that are presently available under Permit 10478. Under the No-Project Alternative, EBMUD could seek to obtain 16 MGD of replacement supplies from transfers of surface water supplies, groundwater, and desalination.

Transfers of surface water supplies could be obtained from regions near EBMUD's existing facilities. Transfers could be obtained from Sacramento, San Joaquin, and other areas and conveyed to EBMUD's service area through EBMUD's existing Mokelumne Aqueducts and/or FRWP facilities. Groundwater supplies could be obtained from basins in EBMUD's service area as well as other basins. The local groundwater basin that has the greatest water supply potential is the South East Bay Plain Basin (SEBP Basin), a deep, confined aquifer located in the southwestern portion of EBMUD's service area. Shallower basins have unacceptable water quality. The SEBP Basin is currently being used by EBMUD as part of a conjunctive use project as a means to provide a modest level of relief during times of drought. Studies show it has limited capacity and recharge capabilities and, therefore, would not be suitable as a means to provide 16 MGD during non-dry years.

EBMUD could also seek to obtain replacement water from groundwater supplies in San Joaquin County; however, the San Joaquin County groundwater basin's ability to supply EBMUD's additional need for replacement water on a year-in year-out basis is limited. Previous studies have indicated

that the San Joaquin County groundwater basin has been over drafted, thereby making it not well-suited and infeasible as a source of replacement water supplies every year (California Department of Water Resources 1980). The San Joaquin County groundwater basin may, however, be well suited for a conjunctive use project, wherein the groundwater basin is recharged during wet years, while extractions occur during dry years. If a groundwater banking or conjunctive use project is developed in San Joaquin County, under the No-Project Alternative EBMUD would not be able to contribute because it would not have sufficient water supplies available.

EBMUD could also seek to obtain replacement water from groundwater supplies in Sacramento County. In general, the Sacramento Valley groundwater basin is currently being used in a sustainable manner. Although much of the groundwater pumping in the basin is not measured, the total average annual groundwater pumping has been estimated to average between 1.4 million acre-feet (Faunt et al. 2009) and 2.7 million acre-feet (California Department of Water Resources 2003), much larger than the 16 MGD (18,000 AFY) that EBMUD would need for replacement supplies under the No-Project Alternative.

Under the No-Project Alternative, EBMUD could construct and operate a desalination facility to produce 16 MGD of replacement supplies. A desalination plant would be sited adjacent to the San Francisco Bay Delta. Depending on the exact location, the plant would either connect directly into EBMUD's existing distribution system or be sited such that a regional plant is created, one that has multiple agency users and, therefore, does not necessarily connect directly into EBMUD's system. A Bay Delta desalination facility would create a number of potential impacts on the environment and, in particular, on Delta and/or Bay Delta fisheries. Further, the desalination process is energy intensive and generates a waste by-product (brine) that must be disposed of. These issues, combined with the fact that desalinated water is costlier than a Mokelumne River-sourced supply, factor into the conclusion that such a system is less desirable as compared to the proposed project.

2.5.2 Conveyance Elements of Obtaining 16-MGD, Non-Dry-Year Replacement Water Supplies

The following describes the features that are common among the replacement water conveyance options consisting of water transfers and groundwater supplies (i.e., FRWP facilities).

Under the No-Project Alternative, if EBMUD seeks replacement surface water supplies it would obtain these supplies from parties located in areas that allow water to be delivered through existing FRWP facilities. Replacement supplies could only be obtained at significant additional cost, and further costs would be incurred in pumping and conveyance of these supplies. Environmental impacts, including greenhouse gas emissions, would also increase. Construction of additional conveyance and/or treatment facilities may be needed at the transfer points to move water into the EBMUD treatment and distribution system. The extent of additional facilities would depend on source, timing, and quality of the water. A brief description of the common elements as well as the specifics associated with the points of diversion for each of the water transfer locations follows.

EBMUD's Mokelumne River water supplies are conveyed to the EBMUD service area through a parallel set of three Mokelumne Aqueducts. Water is conveyed largely using gravity over 90 miles through the Mokelumne Aqueducts primarily to three 'in-line' water treatment plants (Walnut Creek, Lafayette, and Orinda). As Mokelumne water has relatively low turbidity, these treatment plants use only filtration and have no flocculation or sedimentation basins.

Under the No-Project Alternative, depending on the source of the replacement water, EBMUD could use its allocated share of the capacity of the FRWP facilities to convey 16 MGD to its service area for treatment at the conventional treatment plants and eventual distribution and use within the EBMUD service area. Use of FRWP facilities to convey replacement water supplies would require additional pumping during periods when EBMUD would not otherwise be using these facilities and also would require significant coordination and operational agreement(s) among EBMUD, Freeport Regional Water Authority (FRWA), Sacramento County Water Agency (SCWA), and the United States Bureau of Reclamation (Reclamation).

To minimize the duration of pumping at Freeport and other associated facilities, EBMUD would seek to obtain the replacement water within a compressed 3- to 4-month period and would need to adjust operations to accommodate this. As noted, an increase in pumping energy and use of chemicals for water treatment, as well as operational changes in the system would be required to accommodate these waters at the conventional treatment plants.

Water supplies from other sources, such as the Sacramento River, are of a different quality than Mokelumne sources and, therefore, require additional treatment. Replacement supplies from non-Mokelumne sources would be sent to EBMUD's conventional treatment plants (Sobrante and Upper San Leandro), which have the necessary facilities to provide additional treatment. EBMUD typically operates the conventional treatment plants in the summer and early fall months. However, because of the likely differences in the water quality of the replacement waters, EBMUD would need to extend operation of the conventional treatment facilities into the winter and spring months, resulting in additional use of chemicals, energy, labor, and other operational impacts.

Regardless of whether the replacement water is from surface supplies or groundwater, EBMUD would also need to dedicate some capacity in Mokelumne Aqueducts to convey 16 MGD of replacement water supplies to the East Bay conventional treatment plants. During this time, EBMUD would solely rely on Mokelumne Aqueduct 3 to convey the Mokelumne River supply of 214 MGD. However, the pumped capacity for Mokelumne Aqueduct 3 (at nearly 172 MGD) is below the 214 MGD of water supplies available from the Mokelumne. Therefore, Mokelumne Aqueducts 1 and 2 can only be dedicated to convey replacement water supplies for a short period of time. EBMUD would need to determine the best option and most energy efficient operation to minimize the duration of pumping and to ensure availability of Mokelumne Aqueduct capacity to deliver the replacement water supplies when needed.

2.6 Alternatives Considered but Rejected

State CEQA Guidelines Section 15126.6 requires that an EIR identify alternatives that were considered by the lead agency but rejected as infeasible during the scoping process. An EIR also must briefly explain the reasons that the prospective alternatives were rejected. EBMUD identified the following water supply alternatives, but eliminated these from further consideration based on their inability to meet the project objectives and other factors affecting feasibility.

- Extension to the Year 2025 Alternative
- Extension to the Year 2060 Alternative
- Additional CVP Contract Supplies Alternative
- Additional Demand Management Measures Alternative

The Project includes the extension of EBMUD's existing Permit 10478 to the year 2040 to serve existing and projected demands. Each of these alternatives examines either an alternative to extend the permit to 2040 or alternate ways of meeting existing and projected demand. The last two rejected alternatives presume that the Project is not undertaken and, thus, similar to the actions described above under the No-Project Alternative, are consequences of a decision not to extend Permit 10478. All of these alternatives have been rejected because of both infeasibility and inability to satisfy the underlying objectives of the Project.

Each alternative that was considered but rejected is described in the following sections. Table 2-2 at the end of this chapter summarizes the ability of the rejected alternatives to meet project objectives and needs.

2.6.1 Extension to the Year 2025 Alternative

EBMUD analyzed a limited Extension to the Year 2025 Alternative because this could possibly lessen one or more environmental impacts, although it would fail to fully meet the identified project objectives. Under the Extension to the Year 2025 Alternative, EBMUD could seek a time extension only to the year 2025 to apply the waters obtained under Permit 10478 to beneficial use.

Under the Extension to the Year 2025 Alternative, EBMUD would continue to rely on its Mokelumne River water rights to meet service area demand to the year 2025. Using the same approach as described for the Project, the adjusted demand after incorporating water savings from cumulative conservation and recycling is expected to reach 224 MGD in 2025.

EBMUD water demands in the service area would continue to increase beyond 2025 as development proceeds consistent with the land use plans of the respective communities served by EBMUD. As noted in Section 1.4.1, in 2008 EBMUD undertook a study to determine the projected demand in its service area to year 2040. In 2012, EBMUD finalized its long-range (to the year 2040), supplemental water supply program. At this time, it is not possible to look at water demands beyond 2040 with any degree of specificity given that local land use agencies have not yet developed planning documents. Thus, EBMUD's petition for a 40-year time extension is consistent with its long range water planning documents.

The Extension to the Year 2025 Alternative fails to meet the project objective of ensuring the continued ability for EBMUD to reliably meet water demands in the service area to the year 2040 because it could require EBMUD to file another extension petition in just a few years, well short of 2040. Further, this alternative fails to meet the project objective of ensuring EBMUD's ability to meet demands in the most cost-effective manner, because it requires a significant expenditure of time, effort and resources to apply for a time extension, prepare related documentation, and undergo the water rights process. This cost is an additional reason EBMUD applied for a 40-year extension, making it a more cost-effective and efficient use of limited public resources, both for EBMUD as well as for regulatory agencies. The 2025 Alternative fails to meet this project objective.

Under the Extension to the Year 2025 Alternative, EBMUD would need to request another extension in a short period of time or obtain replacement water supplies after year 2025 to replace waters that were available from the Mokelumne River under Permit 10478 so that it could continue to fulfill its statutory mission. The Extension to the Year 2025 Alternative does not ensure that EBMUD can continue to serve demands in the most cost effective manner beyond 2025. This alternative also fails to ensure the continued full availability of water supplies authorized by Permit 10478. If there were

no further extensions of the permit, an additional 6 MGD would be needed to meet the year 2040 average annual demand of 230 MGD and would lead to further shortages in the future beyond 2040.

It would be speculative to attempt to identify specific non-dry year replacement water supplies that could potentially meet future EBMUD service area demands under this scenario; however, for purposes of this evaluation of the Extension to the Year 2025 Alternative, it is assumed that any additional replacement surface water supplies would likely be generated from water users in the Sacramento Valley and that the existing FRWP facilities would be used to convey water to the Mokelumne Aqueducts and then to EBMUD's service area. It is also assumed that because, similar to the current FRWP, water supplies would be diverted from the Sacramento River above the Delta using existing facilities, that no new facilities would be needed. Water transfers could also come from Delta water; however, because of regulatory and infrastructure constraints, impacts from this potential water source were not evaluated.

As noted above, if Permit 10478 is only extended to year 2025, EBMUD would need to request another extension in year 2025, or obtain replacement water supplies after year 2025 to replace waters that were available from the Mokelumne River under Permit 10478 so that it could continue to fulfill its statutory mission. This alternative, thus, has the potential to result in similar impacts as those identified for the Project or, alternatively, impacts similar to those identified in the discussion for the No-Project Alternative in Chapter 5, Alternatives Analysis. As noted, this alternative fails to meet the project objective of meeting future demands in the most cost-effective manner.

2.6.2 Extension to the Year 2060 Alternative

As noted in Chapter 1, Objective and Need for the Permit 10478 Time Extension Project, EBMUD is a municipal utility charged with serving the water demands in its service area. The Project reviewed in this EIR is the extension of Permit 10478 to the year 2040 to allow EBMUD additional time to apply Permit 10478 waters to beneficial use. EBMUD selected the year 2040 because the timeframe corresponds with the maximum extent of the planning documents and information available for the cities and counties in EBMUD's service area. It is difficult to look forward beyond year 2040 with any degree of specificity in analyzing water demands and usage patterns, as doing so involves a significant amount of speculation and is subject to a number of variables. Nonetheless, population will continue to increase in EBMUD's service area beyond year 2040. Department of Finance projections of growth in Contra Costa County and Alameda County from 2040 to 2060 indicate that population would increase by more than 6% during this time frame.

As a potential alternative to the Project, EBMUD considered petitioning to extend Permit 10478 to the year 2060. Projections indicate that EBMUD's average annual demand in the service area would be 244 MGD at this time. Although the estimate of demand for this year is based on available information, coupled with a straight line methodology to derive demand projections, it is considered to be highly speculative. It is not known whether this level of demand will be reached at some time before 2060, or at a later date. EBMUD has elected to petition for an extension to year 2040 because the available land-use planning documents from the communities that EBMUD serves allow for a reasonable estimation of demand at that point in the future, and EBMUD is able to reasonably estimate the impacts of using Permit 10478 to meet its planned demand. For those reasons, EBMUD elected to request an extension to year 2040 instead of year 2060 because estimating future demand and service area growth patterns with any specificity is not possible for this future time increment.

It is still important to have Permit 10478 supplies available beyond 2040, particularly in light of the expected growth of the population by 2060. Given the regulatory, environmental, and other uncertainties affecting the resources of the watershed and service area, EBMUD has determined that the State Water Board and trustee agencies would be better able to act on the petition as requested, although, it is important to recognize that the full Permit 10478 water supplies are necessary for EBMUD to fulfill its mission.

Table 2-2 summarizes the Extension to the Year 2060 Alternative's ability to meet project objectives and needs. While the alternative would provide sufficient supplies to meet water demands, and thus satisfies the Project objective and needs, this alternative does not lessen potentially significant impacts associated with extending the use of Permit 10478.

2.6.3 New Central Valley Project Contract Alternative

EBMUD and Reclamation executed a contract (the CVP contract) that allows EBMUD to schedule a defined quantity of water only in dry years, when total system storage declines beyond a defined level. During droughts when Mokelumne River supplies are insufficient, EBMUD will use its CVP contract and the FRWP facilities to take delivery of CVP supplies, according to current limitations. Under its current CVP contract, EBMUD is limited to a total delivery of 165,000 acre-feet over any consecutive 3-year dry period.

Under the New CVP Contract Alternative, if EBMUD did not extend Permit 10478, EBMUD could seek a new contract with Reclamation to obtain an additional 16 MGD of water to meet average annual demands by 2040 during non-dry years. Similar to other replacement waters sought under the No-Project Alternative, EBMUD would use FRWP conveyance facilities over a period of 3 to 4 months in the winter and spring to route the diverted water to EBMUD's conventional treatment plants. As explained in the prior sections, to maximize efficient operations EBMUD typically operates these treatment plants in the summer and early fall months. However, because of the difference in the quality of water from sources other than the Mokelumne River, EBMUD would need to extend operation of these facilities into the winter and spring months, resulting in additional use of chemicals, energy, labor, and other operational impacts.

There are significant institutional barriers to using the CVP as a supply instead of the existing Permit 10478 water supply. Although EBMUD originally obtained a CVP contract in 1970, a series of regulatory, legal, and institutional hurdles resulted in delays of nearly 40 years to obtain the dry-year CVP supplies that EBMUD currently has available. Actual deliveries in the defined dry years are subject to curtailment because of CVP water shortage conditions. Recognizing the potential impacts on other CVP contractors and the environment, EBMUD likely would have difficulty obtaining an additional CVP contract for water supplies to replace the Mokelumne supplies. Potential operational and environmental impacts also make the additional CVP supplies an infeasible replacement supply. Moreover, use of FRWP facilities for delivery of replacement water involves high startup and operating costs, in addition to the capital and operation and maintenance costs for the water, and, therefore, is infeasible from a cost perspective and fails to meet the project objectives.

Table 2-2 illustrates the New CVP Contract Alternative's ability to meet project objectives and needs. The New CVP Contract Alternative would not be a reliable alternative to support demands during a curtailment of Mokelumne River supplies. Even under non-urgency conditions, deliveries are subject to curtailment due to CVP water shortage conditions. The New CVP Contract Alternative would

marginally support fishery obligations by allowing more water to remain in the Mokelumne River for temperature and flow management; however, impacts would be shifted to other river systems resulting in little net benefit.

2.6.4 Additional Demand Management Measures Alternative

The components of the Additional Demand Management Alternative include additional conservation measures, expanded recycled water development, and increased levels of water rationing by customers during multiple-year drought events

Recently, EBMUD adopted the WSMP 2040 that includes a portfolio of measures to meet the future need for water to achieve savings of an additional 39 MGD from conservation programs. EBMUD's calculated water use reduction from 1995 to 2008 from its existing Water Conservation Master Plan (WCMP) program was 22.5 MGD. The achievement of an additional 39 MGD of WCMP conservation water savings results in a total program goal of 62 MGD by 2040.

During the preparation of the WSMP 2040, EBMUD used a screening process recommended by the *American Water Works Association Water Conservation Planning Manual*, M-52 to screen and rank water conservation measures. Measures were prioritized based on a number of factors, including market-tested technology, independent third-party performance testing, water savings, cost of implementation, market saturation, remaining conservation potential, and consumer acceptance. Fifty-three selected conservation measures were further analyzed and grouped into multiple component programs of increasingly higher water savings and implementation costs. The conservation savings estimates were derived from targeted market saturation levels for voluntary adoption of conservation technology and practices, plus mandatory savings from adopted codes and ordinances.

After engaging in this water conservation screening process, as part of its approval of the WSMP 2040, EBMUD adopted a portfolio of conservation measures to achieve an additional 39 MGD of conservation savings. EBMUD chose not to adopt the higher 41 MGD conservation target as a project alternative because of its unjustifiable cost and modest additional savings as compared to the 39 MGD program. Furthermore, the 41 MGD maximized water conservation measure would add only 2 MGD of water savings toward meeting the 16 MGD need. For these reasons, expanding the conservation targets beyond EBMUD's existing conservation goals is not feasible.

Recycled water is used in place of potable water for primarily irrigation and industrial processes. Recycled water use reduces demand for potable water and potentially reduces the need for rationing during droughts. Recipients of EBMUD recycled water include an oil refinery, golf courses, parks, school grounds, office parks, and roadway landscaping. As part of its efforts during the 2-year study period preceding adoption of WSMP 2040, EBMUD conducted an exhaustive look at potential recycled water projects that could feasibly provide supplies of recycled water in addition to its already existing and planned recycled water projects. As a result of these efforts, EBMUD developed a range of potential recycled water projects that could be developed within the 2040 planning horizon, with a maximum of 11 MGD of additional recycled water projects. As part of its approval of the WSMP 2040, EBMUD adopted the maximum 11 MGD of additional recycled water projects, for a total recycled water program yield of 20 MGD by 2040.

Building recycled water projects and expensive distribution systems in an urban environment is difficult. Potential recycled water projects require proximity to existing recycled water pipelines and wastewater treatment plants, adequate recycled water volume for the project, topography that

allows reasonable cost for pumping recycled water, and future land uses that could utilize the recycled water. In some instances, in order to meet EBMUD's recycled water targets, new recycled water distribution pipelines are required, and in most cases, treatment facilities must be expanded or created. Where new treatment facilities are required, it is desirable to co-locate them with an existing wastewater treatment plant. For all these reasons, expanding the recycled water targets beyond EBMUD's existing recycled water targets is not feasible.

Table 2-2 shows the ability of the Additional Demand Management Measures to meet project objectives and needs. While replacing the Mokelumne supplies with a greater water conservation component could provide a small contribution toward fulfilling 2040 demands, this could only be done at significant additional costs. Instituting the Additional Demand Management Measures in the event of a decision by EBMUD not to extend the Permit, fails to meet most of the operational needs of the Project, and it is not cost effective.

Table 2-2. Ability of the Alternatives Considered but Rejected to Meet Project Objective and Need

Objective and Need	Alternatives Considered but Rejected				
	Permit 10478 Time Extension Project ^a	Extension to the Year 2025 Alternative ^a	Extension to the Year 2060 Alternative ^a	New Central Valley Project Contract Alternative ^a	Additional Demand Management Measures Alternative ^a
Project Objective					
Serve service area demand in the most cost effective manner	Yes	No	Yes	No	No
Maintain high quality water sufficient for treatment using existing facilities	Yes	Partial	Yes	Uncertain	Not Applicable
Maintain operational flexibility	Yes	Partial	Yes	Uncertain	No
Need to Maintain Operational Flexibility					
Have sufficient supplies to meet projected increases in demand for water in EBMUD's service area	Yes	Partial	Uncertain	Uncertain	No
Have sufficient supplies to meet peak summer demands	Yes	Partial	Uncertain	Uncertain	No
Ensure that demands will continue to be met in the event of Mokelumne River water supply outages or following a drought or catastrophic event	Yes	Partial	Uncertain	Uncertain	No
Meet water quality and flow commitments in the Mokelumne River to protect the ecosystem and anadromous fish	Yes	Yes	Yes	Yes	Yes

^a The terms used in this table have the following meanings:

- *Yes* means that the alternative would fully meet the objective or need at a level equivalent to the Permit 10478 Time Extension Project.
- *No* means that the alternative would not meet the objective or need at a level equivalent to the Permit 10478 Time Extension Project.
- *Partial/Uncertain* means that questions remain as to water supply availability and reliability, cost, or regulatory and permitting issues, or the participation of other entities.

Chapter 3

Impacts and Mitigation Measures

Chapter 3 presents the organization of the impacts analysis associated with implementing the Permit 10478 Time Extension Project (Project). The following discussion describes the significance criteria used to evaluate physical changes in the environmental setting to determine potential impacts associated with the Project, and identifies feasible mitigation measures for potentially significant impacts. This chapter also presents a brief discussion on resource areas that are not addressed in the EIR and describes the assumptions used for the impact analyses.

3.0 Organization of Impact Analysis

The following sections describe the significance criteria used to determine potential impacts, characterization of impact significance, analytical approach, presentation of potential impacts and mitigation, resource topics not analyzed in this EIR, and potentially significant impacts associated with the Project.

3.0.1 Significance Criteria

As defined by State California Environmental Quality Act (CEQA) Guidelines 15064.7(a), a threshold of significance is an identifiable quantitative, qualitative, or performance standard for a particular environmental effect. EBMUD used significance criteria to determine the potential impacts and their level of significance for each of the scenarios evaluated. They are presented prior to the evaluation of potential effects for each environmental topic and are based primarily on the CEQA Checklist (Appendix G of the State CEQA Guidelines).

3.0.2 Characterization of Impact Significance

CEQA defines significance as a “substantial or potentially substantial adverse change to the environment” (Section 15382). The determination of significance by the lead agency is based on threshold criteria specific to each resource category. Under CEQA, a significance threshold identifies the point at which the severity of an impact changes from less than significant to significant, with or without mitigation. The following terms are used in this EIR to characterize impacts.

- **No Impact:** No adverse environmental impacts would occur.
- **Less than Significant:** Environmental impacts would not exceed the significance criteria.
- **Less than Significant with Mitigation:** Adverse environmental impacts could occur (impacts would exceed the significance criteria or threshold defined for each environmental issue), but mitigation measures would be implemented to reduce adverse impacts to less-than-significant levels.
- **Significant:** Adverse environmental impacts could occur, and no mitigation measures are identified to reduce impacts to levels below the significance criteria.

- **Beneficial:** No adverse environmental effects would occur, and one or more environmental baseline conditions would improve as a result of the Project.

State CEQA Guidelines Section 15126.4[a] states that, “an EIR shall describe feasible measures which could minimize significant adverse impacts...and [that are] fully enforceable through permit conditions, agreements, or other legally binding instruments.” A mitigation measure is intended to do one or more of the following:

- avoid the impacts altogether by not taking a certain action or parts of an action;
- minimize impacts by limiting the degree or magnitude of the action and its implementation;
- rectify the impact by repairing, rehabilitating, or restoring the affected environment;
- reduce or eliminate the impact over time through preservation and maintenance operations during the life of the action; or
- compensate for the impact by replacing or providing substitute resources or environments.

Significant impacts that cannot be mitigated to less-than-significant levels may be unavoidable.

3.0.3 Analytical Approach

A project such as a time extension for an existing permit under which existing facilities have been constructed and in use for decades cannot be meaningfully analyzed under a typical CEQA assessment process of comparing baseline conditions to the future with-project conditions. Under current conditions (baseline), EBMUD is permitted to divert, and has on occasion diverted, at the maximum rate allowed under Permit 10478 and has diverted to storage virtually the entire maximum annual amount (352,000 acre-feet out of a maximum 353,000 acre-feet) allowed under Permit 10478 (see Chapter 2, Project Description, Baseline, and Alternatives, for a description of the Project and baseline). In the future (with-project conditions), EBMUD would continue to use Permit 10478 to divert the maximum quantities authorized in the permit. Under the future with-project conditions, operations of Pardee and Camanche Reservoirs would change gradually over time as more water is drafted off the Mokelumne River.

To derive more meaningful and comparative results for CEQA purposes, EBMUD has developed modeling parameters, such as average annual demand, to illustrate the potential differences and impacts between baseline conditions and future with-project conditions. The project being considered in this document is the extension of the existing Permit 10478 to the year 2040. Variances in modeling parameters are merely an analytical device used to provide a comparative basis to assess impacts of the Project.

As noted in Chapter 2, Project Description, Baseline, and Alternatives, the baseline used to assess potential impacts in this EIR includes an average annual demand of 214 million gallons per day (MGD), while an average annual demand of 230 MGD in the year 2040 is used to assess potential impacts of the Project. Actual demand is expected to grow gradually over the decades from the present to 2040 and would vary year to year. Nevertheless, the modeling conducted to assess impacts assumes 230 MGD demand would occur immediately under the Project, thus potentially overstating impacts from the Project in the immediate and intermediate future.

Various chapters of this EIR describe the impact analysis conducted for baseline, no-project, and Project scenarios. Appendix E, the Modeling Technical Appendix, provides the modeling tools and

the modeling assumptions used under various scenarios to assess impacts, if any, on the environmental resources.

3.0.4 Presentation of Potential Impacts and Mitigation

The potential impacts and mitigation measures for this EIR are presented for the following environmental resources:

- water,
- fish,
- vegetation, wetlands, and wildlife,
- agriculture,
- recreation, and
- visual.

Additionally, cumulative impacts (Chapter 4), climate change (Chapter 7), and other CEQA analyses, including growth inducement impacts (Chapter 8), are analyzed in this EIR.

3.0.5 Resource Topics Not Analyzed in This Environmental Impact Report

Certain topics have been eliminated from further analysis in this EIR. EBMUD, as lead agency, determined that the Project would not result in adverse impacts on the following resources:

- air quality,
- cultural resources,
- geology and soils,
- hazards and hazardous materials,
- land use and planning,
- mineral resources,
- noise,
- population and housing,
- public services,
- transportation and traffic, and
- utilities and service systems.

These resources are not analyzed separately in the EIR and are briefly described in Chapter 1, Objective and Need for the Permit 10478 Time Extension Project, Section 1.7.

3.0.6 Potentially Significant Impacts Identified in this Environmental Impact Report

The evaluation presented in Chapter 3 describes the impacts of the Project on water; fish; vegetation, wetland, and wildlife; agricultural; recreation; and visual resources. Because EBMUD's increased average annual demand from the baseline to 2040 (16 MGD) is small compared to the total flows in the Mokelumne River watershed, EBMUD's modeling results indicate that a majority of the time almost no detectable changes would occur to Pardee Reservoir and Camanche Reservoir storage levels and flows in the lower Mokelumne River. Analysis indicates that no significant impacts were identified for water resources; vegetation, wetlands, and wildlife resources; recreational resources; or visual resources.

Significant impacts were identified for fish resources and agricultural resources. The potentially significant impacts identified for fish resources would be related to reduced adult migration habitat for fall-run Chinook salmon and steelhead. Implementing mitigation measure FISH-1 will reduce this impact to a *less-than-significant* level.

Potentially significant impacts identified for agricultural resources are related to senior water rights holder Jackson Valley Irrigation District's (JVID's) ability to physically obtain water from Pardee Reservoir when water surface elevation at Pardee Reservoir falls below a certain threshold due to the Project. Implementing mitigation measure AG-1 will reduce this impact to a *less-than-significant* level.

3.1 Water Resources

This section describes water resources in the project area and assesses the significance of impacts on water resources associated with implementing the Permit 10478 Time Extension Project (Project). The analysis concludes there would be no significant impacts on water resources as a result of implementing the Project.

Some project-related changes in hydrologic conditions do not directly affect water resources but could affect other resources such as fisheries or agriculture. These potential changes are discussed here, but their significance is discussed elsewhere in this document. For example, potential changes in water temperature are discussed here, but the potential significance of changes in water temperature is discussed in Section 3.2, Fish Resources.

In addition to the text presented here, several appendices are referenced in the following sections that contain information about Mokelumne River hydrology and water quality:

- Appendix D: Lower Mokelumne River Project, Federal Energy Regulatory Commission (FERC) Project No. 2916-004, Joint Settlement Agreement (JSA) and Ten-Year Review
- Appendix E: Modeling Technical Appendix
- Appendix F: Comparison of End-of-Month Water-Surface Elevations at Camanche Reservoir to Average Water Temperature at Station McIntire for October 1974 to December 2009
- Appendix G: Monthly Graphs of Baseline and Project EBMUDSIM Results for Pardee Reservoir Storage, Camanche Reservoir Storage, Camanche Release Flows, and Flows below Woodbridge
- Appendix H: Evaluation of the Distribution of Baseline and Project EBMUDSIM Hydrologic Results, and
- Appendix L: Allocations to the North San Joaquin Water Conservation District under Baseline and Project Conditions

3.1.1 Environmental Setting

This section describes water resources in the project area, including an overview of the Mokelumne River, EBMUD's water supply structures, EBMUD Mokelumne River water rights, other Mokelumne River entitlements and uses, and EBMUD flood-control requirements. This section also includes a description of Mokelumne River hydrology and streamflow, as well as water quality in the river and Delta.

3.1.1.1 Mokelumne River Overview

The Mokelumne River watershed upstream of Camanche Dam covers an area of approximately 627 square miles. The eastern portion of the watershed is relatively narrow and steep, beginning at an elevation of 10,364 feet above sea level at Round Top and dropping to 235 feet above sea level at Camanche Reservoir spillway crest. The primary tributaries are the North, Middle, and South Forks of the Mokelumne River. Smaller tributaries include Summit Creek, Bear Creek, Cole Creek, Moore Creek, Blue Creek, Tiger Creek, Panther Creek, Forest Creek, Licking Fork, and Murphy Creek below Camanche Dam. The North Fork watershed is the largest tributary at 370 square miles and contributes 85% of Mokelumne River flow.

The upper Mokelumne River basin is located on the western slope of the Sierra Nevada in Alpine, Amador, and Calaveras Counties (Figure 1-2). 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.

There are two primary water developments on the Mokelumne River—Pacific Gas and Electric Company's (PG&E's) Mokelumne River Project and EBMUD's lower Mokelumne Project facilities. PG&E's facilities include multiple reservoirs and powerhouses upstream of Pardee Reservoir (described in more detail below). EBMUD's facilities consist of Pardee and Camanche Reservoirs and other appurtenant facilities (described in more detail in Chapter 1, Objective and Need for the Permit 10478 Time Extension Project, and below).

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 tidal influence in the lowest 37.5 miles of the river.

3.1.1.2 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. EBMUD's water supply system is described in greater detail in Chapter 1, Objective and Need for the Permit 10478 Time Extension Project. Pardee and Camanche Reservoirs are summarized below.

Pardee Dam and Reservoir

Pardee Reservoir is located on the mainstem 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. As described in Chapter 1, Objective and Need for the Permit 10478 Time Extension Project, 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 as described in Chapter 1, Objective and Need for the Permit 10478 Time Extension Project, 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.

Reservoir Objectives

As noted in Chapter 1, Objective and Need for the Permit 10478 Time Extension Project, EBMUD operates Pardee and Camanche Reservoirs together as an integrated system to deliver municipal water supply of up to 325 million gallons per day (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 (Corps) flood-control requirements. Consistent with all other operating objectives and obligations, releases from the two reservoirs also are planned to provide hydropower benefits.

3.1.1.3 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 [AFY]). EBMUD water rights are described in detail in Chapter 1, Objective and Need for the Permit 10478 Time Extension Project.

3.1.1.4 Other Mokelumne River Entitlements and Uses

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. Figure 1-4 in Chapter 1, Objective and Need for the Permit 10478 Time Extension Project, provides a general overview of the Mokelumne River diversions and conceptually illustrates how the river's flow is allocated among the various users and uses.

Upstream Diversions and Uses

Streamflow in the Mokelumne River is modified by upstream diversions and regulated by reservoir storage operations for hydroelectric power generation and water supply (Table 3.1-1). Upstream reservoirs have altered the pattern of flows entering Pardee and Camanche Reservoirs. The following text briefly describes the extensive hydrologic infrastructure on the Mokelumne River as context for evaluating project effects on water resources.

Table 3.1-1. Reservoirs and Diversion Facilities above Pardee Reservoir

Facility	Dam		Capacity	Elevation
	Height (ft)	Length (ft)	Acre-Feet	Feet above msl
Upper Blue Lake ^a	31	837	7,300	8,134
Lower Blue Lake ^a	40	1,063	5,091	8,085
Twin Lake ^a	22	1,520	1,270	8,144
Meadow Lake ^a	77	775	5,656	7,774
Upper Bear River ^a	77	760	7,306	5,878
Lower Bear River ^a	249	979	52,025	5,822
Salt Springs Dam ^a	328	1257	141,857	3,834
Tiger Creek Forebay ^a	33	900	42	3,539
Tiger Creek Regulator ^a	100	486	533	3,483
Schaads Reservoir ^b	95	600	1,740	2,935
Tiger Creek Afterbay ^a	100	448	2,607	2,400
Electra Diversion Dam ^a	26	188	65	2,089
Lake Tabeaud ^a	123	636	1,259	1,965

^a Pacific Gas and Electric Company
^b Calaveras Public Utility District
ft = feet; msl = mean sea level

Pacific Gas and Electric Company Facilities

PG&E's facilities are located on the Mokelumne River, North Fork Mokelumne River (NFMR), Bear River, and associated tributaries in Alpine, Amador, and Calaveras Counties, California. PG&E project (FERC Hydroelectric Project 137) features extend over a wide range of elevations from over 8,100 feet (Twin Lake) to less than 800 feet (Electra Powerhouse). Portions of the PG&E project occupy lands in the Stanislaus National Forest and the El Dorado National Forest, as well as lands managed by the U.S. Department of the Interior's Bureau of Land Management (BLM). The PG&E project consists of 12 dams and reservoirs, four powerhouses, and numerous diversions and conduits. Total PG&E storage capacity in the Mokelumne River watershed is 225,000 acre-feet. PG&E facilities are described below in more detail to further indicate the extent to which inflow to Pardee Reservoir has deviated from unimpaired conditions. PG&E facilities upstream of Pardee Reservoir are discussed below.

- Salt Springs Development.** Includes three storage reservoirs: Salt Springs Reservoir on the NFMR, and Upper Bear River Reservoir and Lower Bear River Reservoir on Bear River. Water stored in Salt Springs Reservoir is diverted through Salt Springs Powerhouse Unit No.1, located immediately below Salt Springs Reservoir Dam. Upper and Lower Bear River reservoirs divert water from the Bear River drainage through a tunnel and penstock for use

at Salt Springs Powerhouse Unit No. 2. Water is also diverted from upper Cole Creek into this tunnel, where the tunnel crosses under the creek.

- **Tiger Creek Development.** At Salt Springs Powerhouse tailrace, discharges from both units are made directly into the upper section of the Tiger Creek Canal and transported 17.8 miles to Tiger Creek Regulator Reservoir. Diversions on three small tributary streams (Cole Creek, Bear River, and Tiger Creek) feed additional water into Tiger Creek Canal along its course. From Tiger Creek Regulator, water travels 2.5 miles in the lower section of Tiger Creek Canal to Tiger Creek Forebay and ultimately to Tiger Creek Powerhouse.
- **West Point Development.** The West Point Development is located just downstream from the Tiger Creek Development. The water discharged through Tiger Creek Powerhouse is returned to the NFMR and impounded in Tiger Creek Afterbay for diversion into the West Point Tunnel. Water diverted into this tunnel feeds West Point Powerhouse, 2.6 miles downstream.
- **Electra Development.** The Electra Development receives diversion flows from West Point Powerhouse Tailrace and water diverted by the Electra Diversion Dam, located immediately upstream from the West Point Powerhouse. The combined flows enter the Electra Tunnel for transport to the Electra Powerhouse forebay (Lake Tabeaud) for use at Electra Powerhouse, located on the mainstem of the Mokelumne River 11.5 miles downstream of Electra Diversion Dam.

Other Upstream Diversions

The Amador Water Agency diverts Mokelumne River water through the Amador Canal and from the Tiger Creek Afterbay to its Central Amador Water Project. JVID receives water from Pardee Reservoir at the Jackson Creek spillway. Calaveras Public Utility District owns and operates Schaads Reservoir on the Middle Fork and diverts water into Jeff Davis Reservoir for treatment and distribution to customers. Calaveras County Water District diverts from Bear Creek, approximately 6 miles above the confluence with the Middle Fork, near the town of Westpoint.

Mokelumne River Flow and Diversions between Camanche Dam and the Delta

As noted in Chapter 1, Objective and Need for the Permit 10478 Time Extension Project, 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 described in detail in Section 3.2, Fish Resources. 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 5. 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 (Table 3.1-2). 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

As described in Chapter 1, Objective and Need for the Permit 10478 Time Extension Project, 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), described more fully in Section 3.2, Fish Resources, specifies that the water of the hypolimnion should be less than 16.4 degrees Celsius (°C) (61.5 degrees Fahrenheit [°F]).

Table 3.1-2. Summary of Camanche Release Requirements Specified in the Joint Settlement Agreement

Period	Life Stage	Year Type and Releases							
		Normal and Above Normal		Below Normal		Dry		Critically Dry	
		Camanche Release (cfs)	Below Woodbridge Dam (cfs)	Camanche Release (cfs)	Below Woodbridge Dam (cfs)	Camanche Release (cfs)	Below Woodbridge Dam (cfs)	Camanche Release (cfs)	Below Woodbridge Dam (cfs)
Oct 1–15	Adult migration	325	100	250	100	220	80	100	15
Oct 16–31	Spawning/incubation	325	100	250	100	220	80	130	75
Nov 1–Mar 31 ^a	Spawning—fry rearing	325	100	250	100	220	80	130	75
Apr 1–30	Fry rearing	325 ^b	150	250 ^b	150	220	150	130	75
May 1–31	Fry and juvenile rearing	325 ^b	300	250 ^b	200	220	150	100 ^c	15
Jun 1–30	Outmigration	325 ^b	300	250 ^b	200	100 ^c	20	100 ^c	15
Jul 1–Sep 30	Oversummer	100	25	100	20	100	20	100	15

^a Approximate period when Woodbridge Dam boards are out and Lodi Lake is empty. When the boards are out, it is expected that flow downstream of Woodbridge Dam would be at least as high as the value shown, but EBMUD would not be required to release more than the specified amount from Camanche Reservoir. During the other periods, Camanche releases must be sufficient to meet the specified flow below Woodbridge Dam.

^b For normal, above normal, and below normal years, extra flows would be released from Camanche Reservoir during April–June depending on the combined Pardee and Camanche storage for the end of the prior month as follows:
 < 10 TAF below maximum allowable storage (BMAS), additional release is 200 cfs for subsequent month.
 10 TAF ≤ BMAS < 20 TAF, additional release is 150 cfs for subsequent month.
 20 TAF ≤ BMAS < 30 TAF, additional release is 100 cfs for subsequent month.
 30 TAF ≤ BMAS < 40 TAF, additional release is 50 cfs for subsequent month.

^c Outmigrating smolts would be trapped, tagged, and transported around the Delta.

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. As described in Section 3.4, Agricultural Resources, NSJWCD has a temporary water right permit that was issued pursuant to Water Code Section 1462, which authorizes the granting of a permit for temporary appropriation of water that is excess to the needs of a municipality. The temporary permit 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 has an agreement with EBMUD to store water in Camanche Reservoir, when water is available under NSJWCD's junior water right, for later release to NSJWCD. NSJWCD historically has used as much as 9,488 AFY under Permit 10477, and in the last 10 years, diversions have declined to between 2,000 and 4,000 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).

3.1.1.5 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.

3.1.1.6 Hydrology and Streamflow

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. Annual precipitation averages 15 inches in the valley near the Cosumnes River and 60 inches at the higher elevations. Runoff is generally dominated seasonally by snowmelt, with the highest flows in April through June of wet years. Figure 1-1 in Chapter 1, Objective and Need for the Permit 10478 Time Extension Project, illustrates the annual streamflow variability on the Mokelumne River.

Figure 3.1-1 shows the distribution of historical monthly inflow to Pardee Reservoir measured at Mokelumne Hill during water years 1928 through 2011. 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).

Although the PG&E facilities upstream of Pardee Reservoir are used primarily for nonconsumptive hydroelectric purposes, the facilities have generally changed the timing of peak flows downstream of Salt Springs Reservoir, which now occur later in the year than under estimated natural conditions (Federal Energy Regulatory Commission 1996).

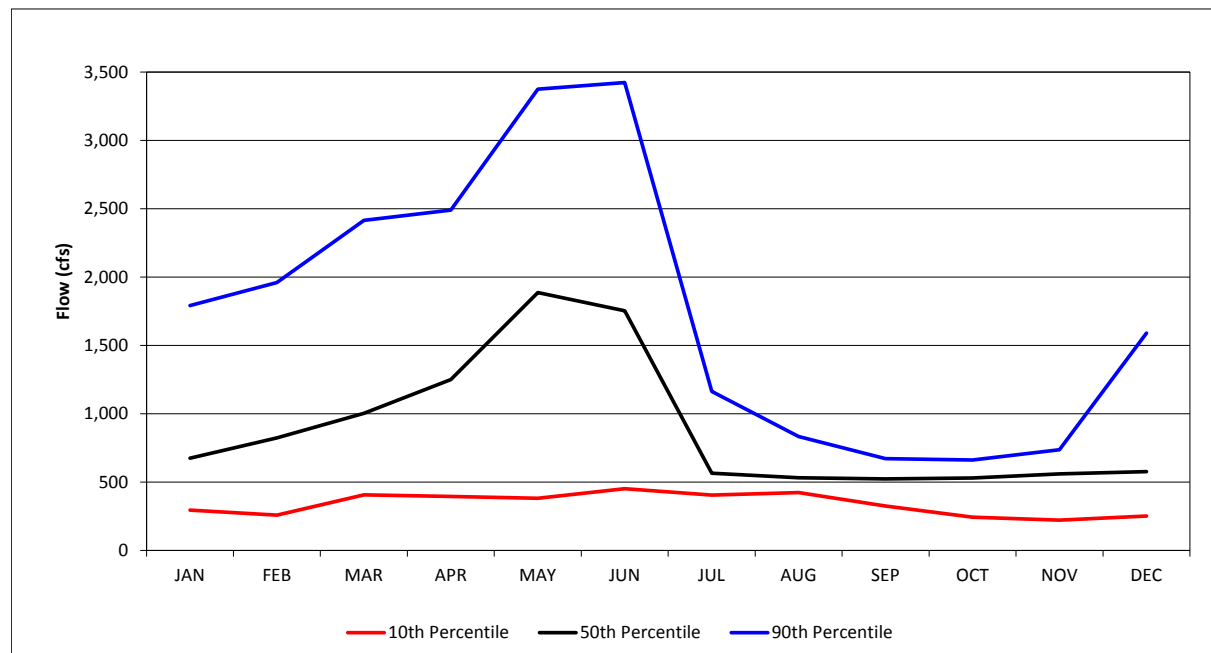


Figure 3.1-1
Average Monthly Flow Measured at Mokelumne Hill for
Water Years 1928 through 2011

Pardee and Camanche Reservoirs

Figures 3.1-2 and 3.1-3 show historical end-of-month storage in 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. The coordinated operational procedures for maintaining coldwater supply are discussed under Water Temperature.

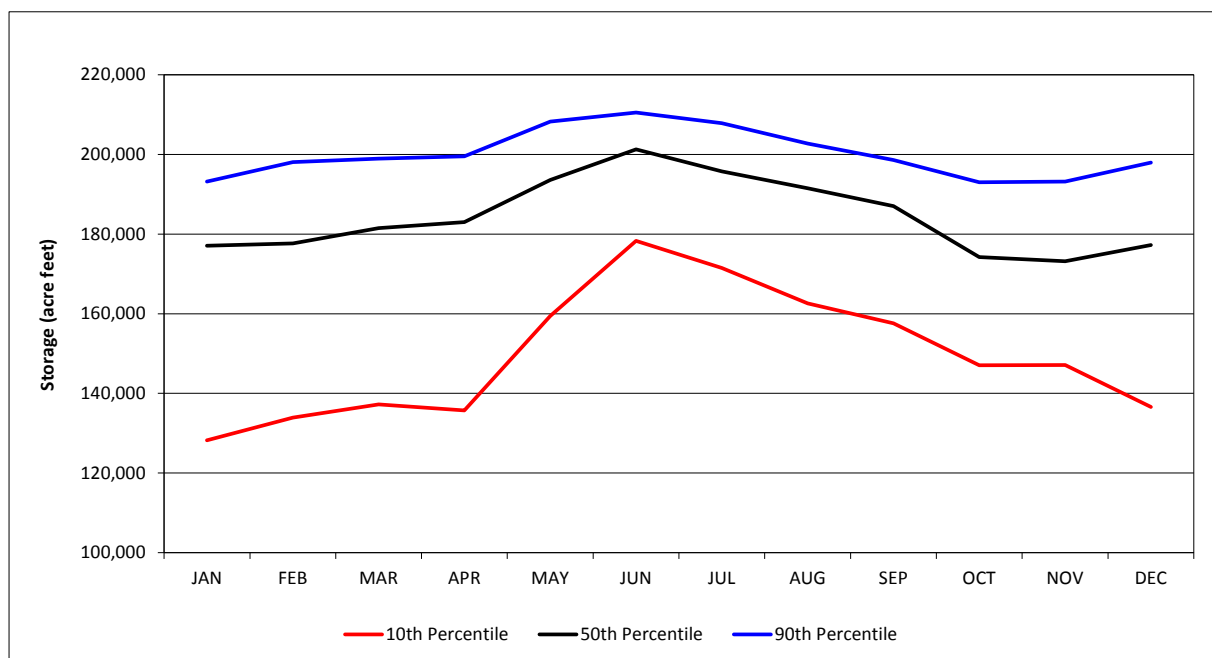


Figure 3.1-2
Average Monthly End-of-Month Storage at Pardee Reservoir for
Water Years 1931 through 2012

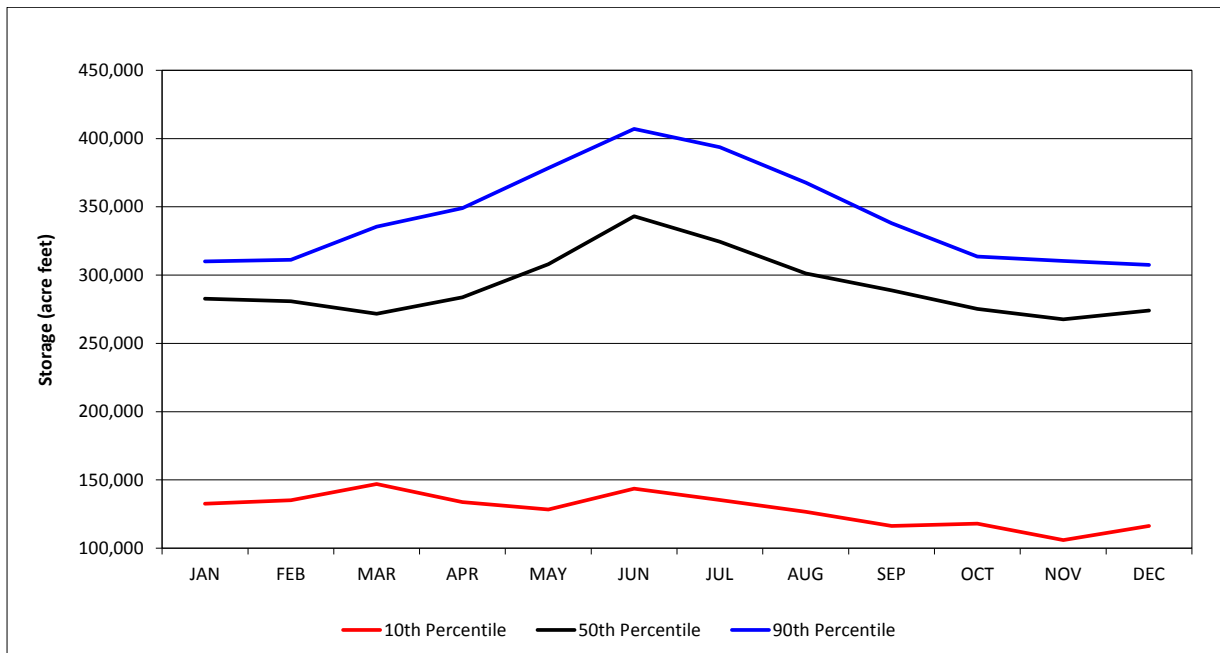


Figure 3.1-3
Average Monthly End-of-Month Storage at Camanche Reservoir for
Water Years 1966 through 2012

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 3.1-4. 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 3.1-4).

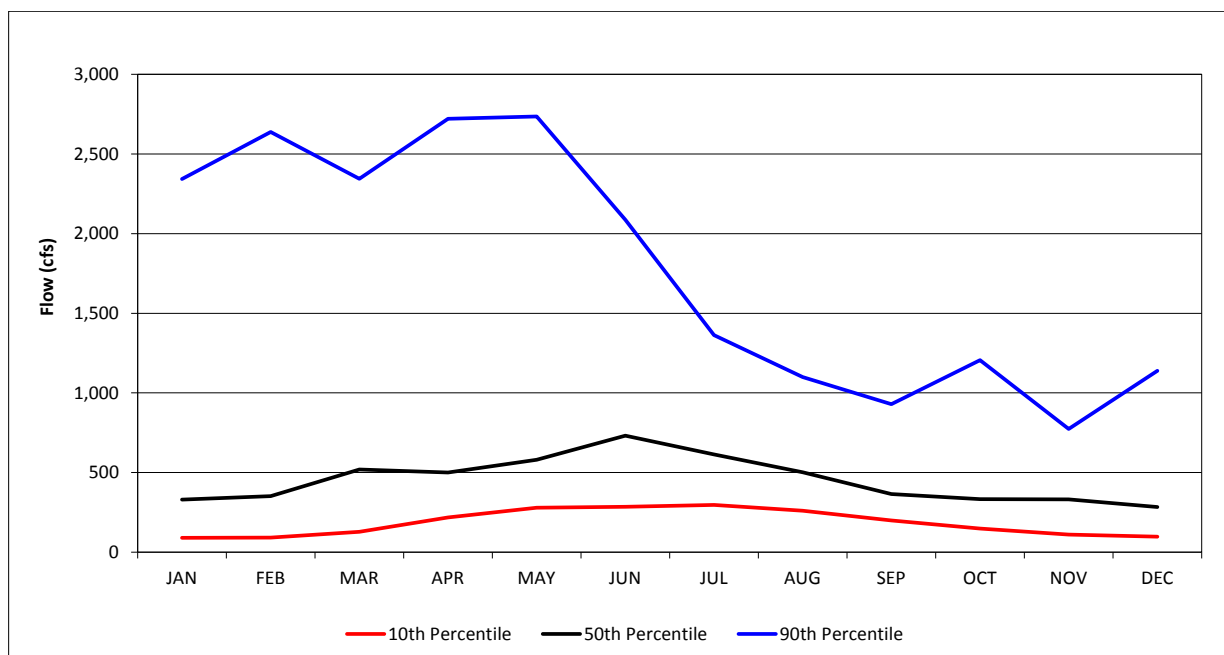


Figure 3.1-4
Average Monthly Flow Releases from Camanche Reservoir for
Calendar Years 1966 through 2012

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 rooted aquatic vegetation from spawning gravel, providing access to seasonally inundated floodplain habitat, and aiding migration (see Section 3.2, Fish Resources). In addition, overbank flow may help recruitment of riparian vegetation. In contrast, overbank flow also could damage agricultural lands, property, and structures.

The floodplain downstream of Camanche Dam has been modified greatly by human activities that have included urbanization and construction of levees and dams. Peak flows have been diminished by the presence of dams and by Corps flood-control requirements. Connectivity between the river and its floodplain has been broken by the presence of levees. As a result, flows high enough to cause the river to spill out of its banks have become less common. When flows are high enough to allow overbank flow, the amount of floodplain habitat generally is restricted by the presence of levees (Florsheim and Mount 2003). In the lower Mokelumne River, studies 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 with the Cosumnes River and Tracy Lake (Florsheim and Mount 2003). Approximately 32% of water years 1966 through 2012 had 10 or more days with daily flows that equaled or exceeded 3,000 cfs below Camanche Dam (Figure 3.1-5).

Research along the lower Mokelumne River has indicated that flows of 2,000 cfs or more may improve gravel quality (Merz et al. 2008). In the Mokelumne River, rooted aquatic vegetation was found to colonize and grow to cover up to 70% of some spawning gravel sites within 2 years of stable low flows. When flows reach 2,000 cfs, a level predicted to mobilize surface bed material, some of the aquatic vegetation is removed (Merz et al. 2008). Approximately 43% of water years

1966 through 2012 had 10 or more days with daily flows that equaled or exceeded 2,000 cfs below Camanche Dam (Figure 3.1-6). However, there have been dry periods longer than 2 years when flows did not exceed 2,000 cfs because of dry hydrology.

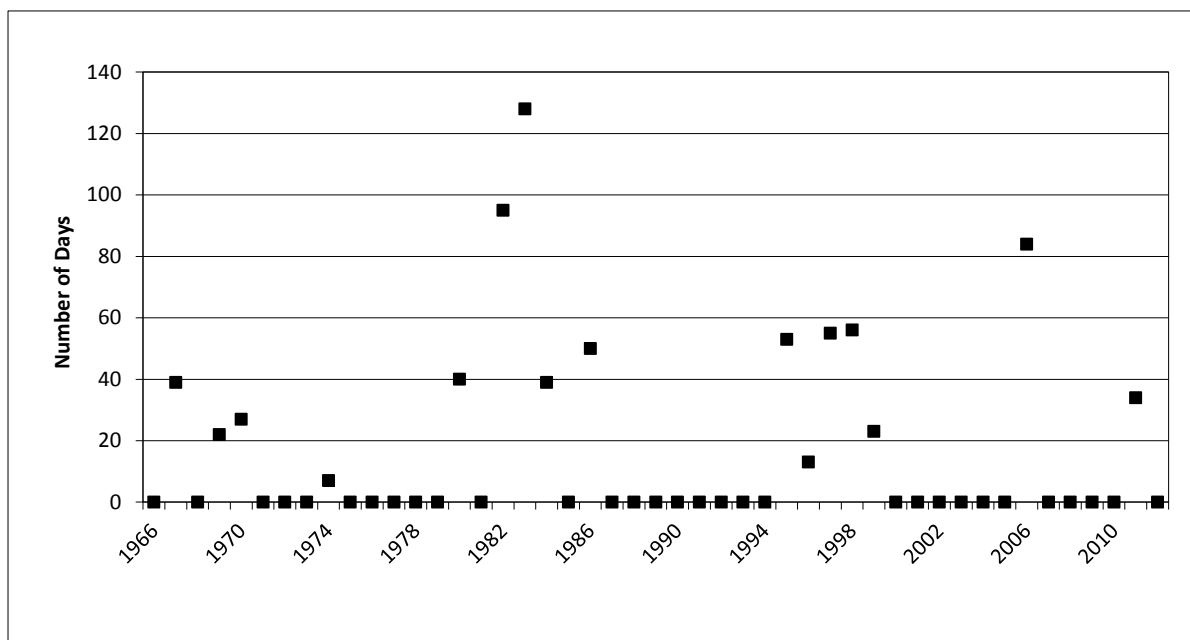


Figure 3.1-5

Number of Days When Flows below Camanche Dam Were $\geq 3,000$ cfs during Water Years 1966 through 2012

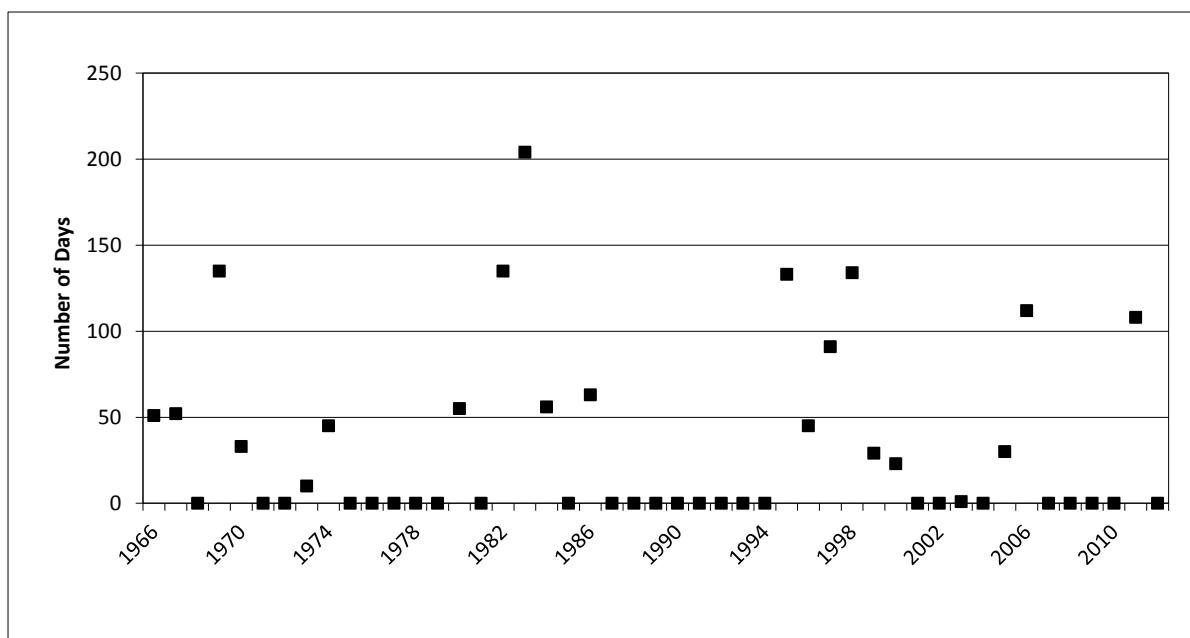


Figure 3.1-6

Number of Days When Flows below Camanche Dam Were $\geq 2,000$ cfs during Water Years 1966 through 2012

3.1.1.7 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.

Pursuant to Section 303(d) of the Clean Water Act (CWA), California is required to develop a list of water bodies requiring action to achieve and maintain water quality standards. Water bodies that do not meet established water quality standards and are listed on a state's 303(d) list are considered impaired. An impaired water body is a water body that has concentrations of pollutants or contaminants that exceed the threshold to support its beneficial uses. 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 (Central Valley Regional Water Quality Control Board 2009a). 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 with potential to be affected by the Project. The following sections describe coldwater releases, monitoring locations along the lower Mokelumne River, Camanche release temperatures, and water temperature in the lower Mokelumne River.

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

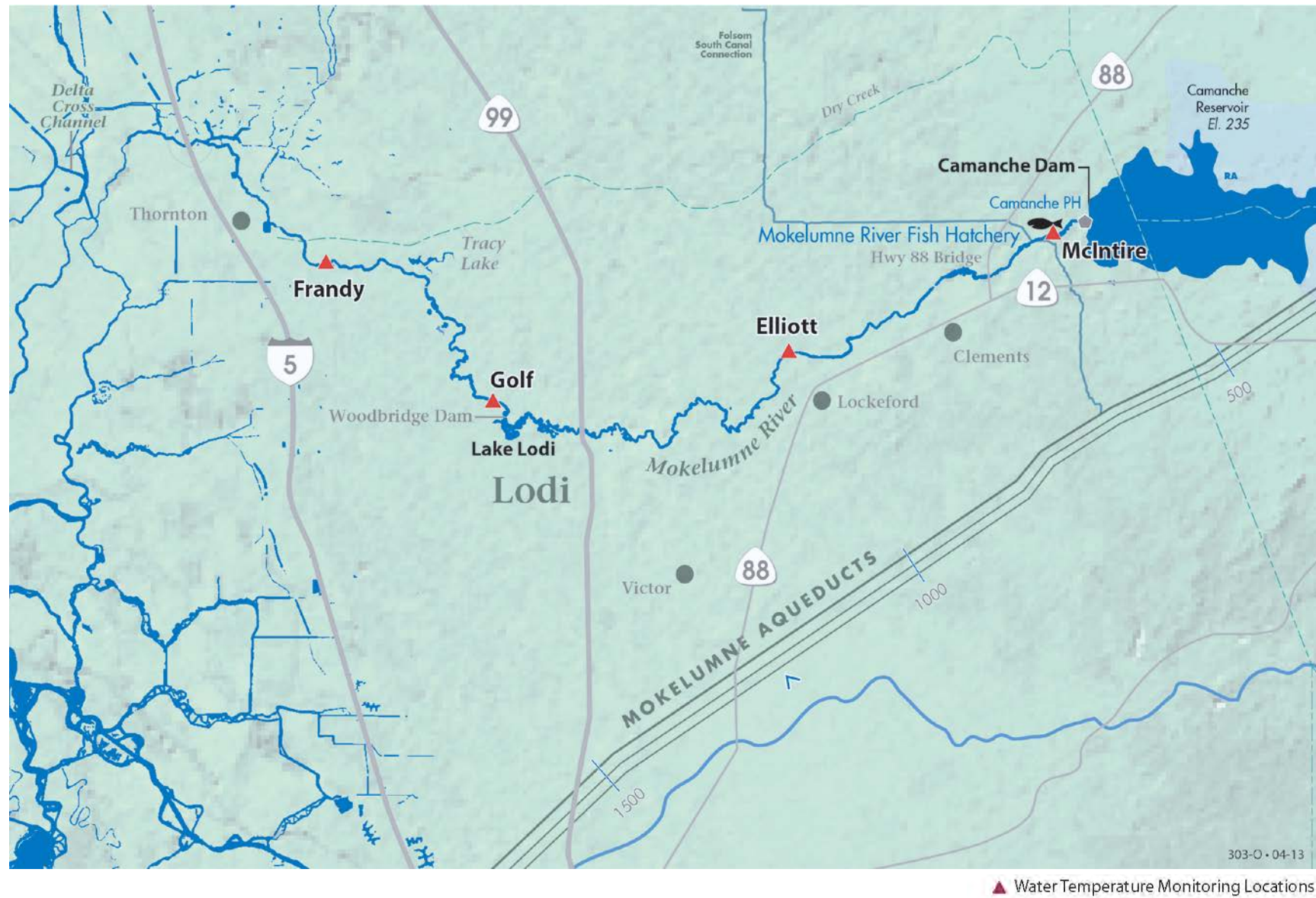
EBMUD operates Camanche Reservoir and Pardee Reservoir in an integrated manner to maintain low temperatures for fish migration, spawning, egg incubation, and juvenile rearing. This is done by preserving when feasible the coldwater pool (i.e., hypolimnion) in the lower depths of Pardee and Camanche Reservoirs 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. For further details, see Chapter 1, Objective and Need for the Permit 10478 Time Extension Project.

Water Temperature Monitoring

This EIR focuses on water temperatures at four monitoring stations downstream of Camanche Reservoir: McIntire, Elliott, Golf, and Frandy (Figure 3.1-7). 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. 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 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.

Water temperature has been measured at these four locations since 1994. The monthly average temperatures and monthly average of the daily maximum temperatures (referred to as monthly maximum temperatures) are used here to show historical water temperature conditions. Summer water temperature patterns downstream of Camanche Dam are influenced by flow, solar radiation, shade, air temperature, channel geometry, humidity, and wind speed.

Figure 3.1-8 shows the monthly average and monthly maximum temperatures for the 1994 through 2012 measurement period. Water temperatures at Station McIntire do not peak until fall because releases from Camanche Dam are dominated by withdrawals from the hypolimnion, which peaks in temperature immediately before the reservoir stratification breaks down in late fall or early winter. Meteorological conditions have a more immediate effect on the water in rivers than in reservoirs. As a result, water temperatures farther downstream from the Camanche release peak earlier in the year corresponding to the warmest meteorological conditions, which occur in July and August. For most of the year, the Camanche release temperatures are cooler than the downstream temperatures. However, in the late fall and early winter, cool meteorological conditions cause the river often to be cooler than the reservoir release. Temperatures for each of the four monitoring locations are discussed in more detail below.

**Figure 3.1-7****Lower Mokelumne River Monitoring Stations Downstream of Camanche Dam**

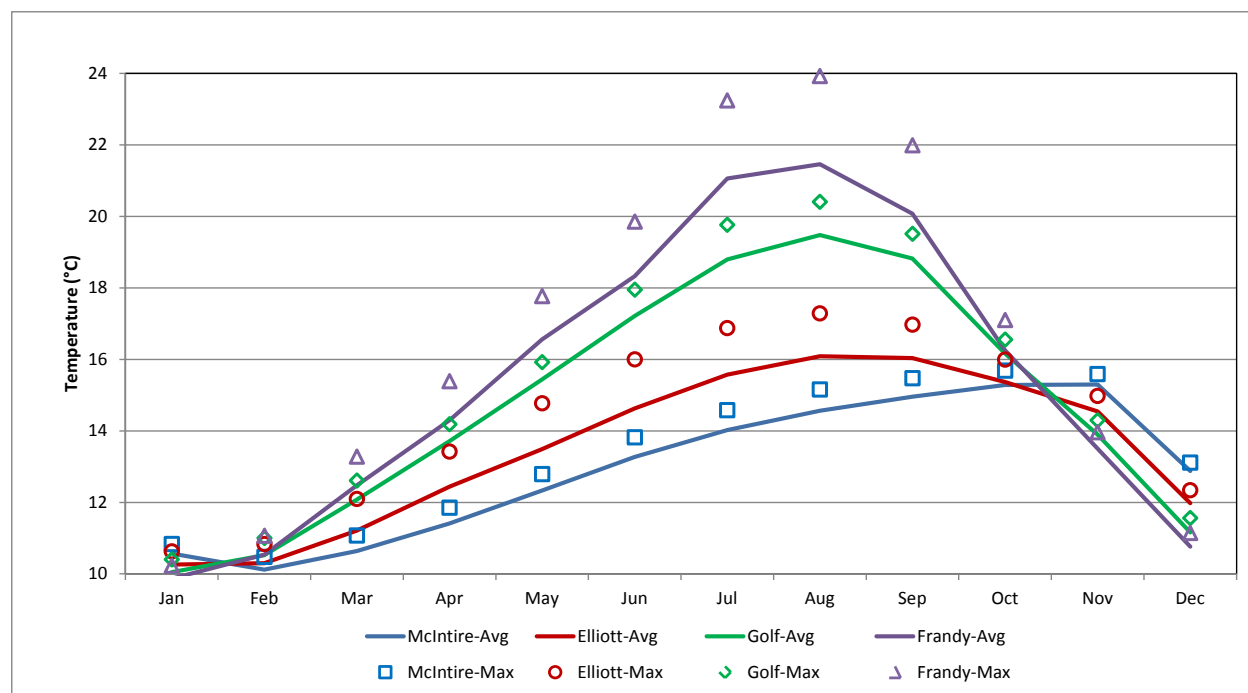


Figure 3.1-8
Temperatures in the Lower Mokelumne River
Average of Daily Average and Daily Maximum Temperatures during 1994–2012

Station McIntire Temperatures

Station McIntire is used to assess water temperature just downstream of Camanche Dam. The monthly average temperatures measured at Station McIntire during the winter months (December through February) from 1994 to 2012, ranged from about 9.1 to 14.3°C (48.4 to 57.8°F). Temperatures gradually increase over the year during the transition from winter to spring to summer and reach a maximum monthly average sometime during September through November (Figure 3.1-9). As stated above, temperatures at Station McIntire are generally cooler from March through October than downstream stations because the water released from Camanche Dam is mainly from the colder hypolimnion of Camanche Reservoir. Because water temperature at the bottom of the reservoir does not exhibit diurnal fluctuations, the monthly maximum temperatures at Station McIntire are not much greater than the monthly averages.

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—see Chapter 1, Objective and Need for the Permit 10478 Time Extension Project, for specific definition) is variable, there is no consistent, precise reservoir elevation threshold for affecting release temperatures. An elevation of 190 feet appears to be the highest elevation at which release temperatures might be affected by low storage levels. This is discussed in more detail in Appendix E, Modeling Technical Appendix.

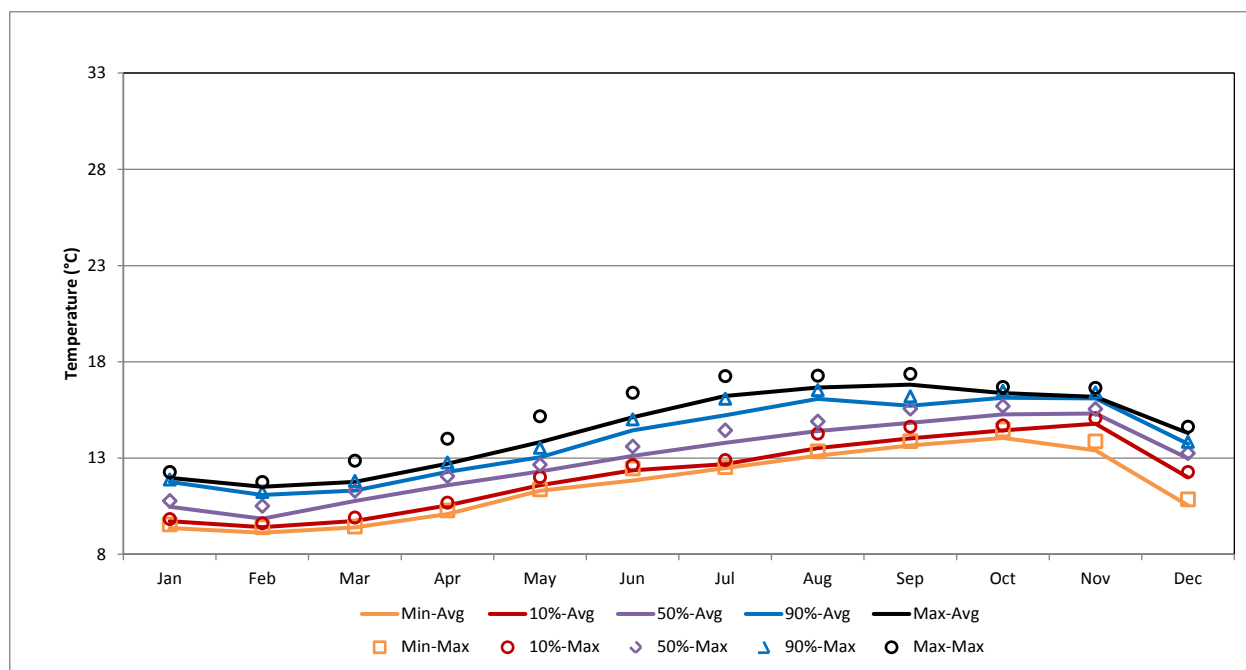


Figure 3.1-9
Distribution of Monthly Average and Average Maximum
Temperatures at Station McIntire during 1994–2012

Station Elliott Temperatures

Station Elliott is used to assess water temperature just downstream of Camanche Dam to the Elliott Road Bridge. This reach of the lower Mokelumne River typically includes the vast majority of fall-run Chinook salmon and steelhead spawning and rearing habitat.

Station Elliott is far enough downstream of Camanche Dam that meteorological conditions can affect water temperature. Meteorological effects can be seen in the increased difference between the monthly average and monthly maximum temperatures and in the tendency for the peak temperatures to occur earlier in the year. However, the range of variation in the monthly temperatures at Station Elliott (about 2 to 4°C [4 to 7°F]), which is an indication of the effect meteorological conditions, is not much larger than the range for Station McIntire.

The average temperature at Station Elliott during the winter months (December through February) ranged from 9.1 to 14.3°C (48.4 to 57.7°F). Temperatures gradually increase through the year, and the highest measured average monthly temperature was 18.0°C (64.4°F) during July (Figure 3.1-10). However, peak temperatures generally occur in August in most years and can occur as late as September in a few cases. The variation in timing of peak temperatures is reflective of the degree of warming due to meteorological effects as water flows downstream from Station McIntire. For example, less warming due to cooler conditions will tend to result in later peak temperatures in September much like that seen for Station McIntire, whereas relatively warmer conditions in summer or lower flows associated with drier year types can lead to a greater meteorological influence shifting the peak temperatures for Station Elliot to earlier in the year.

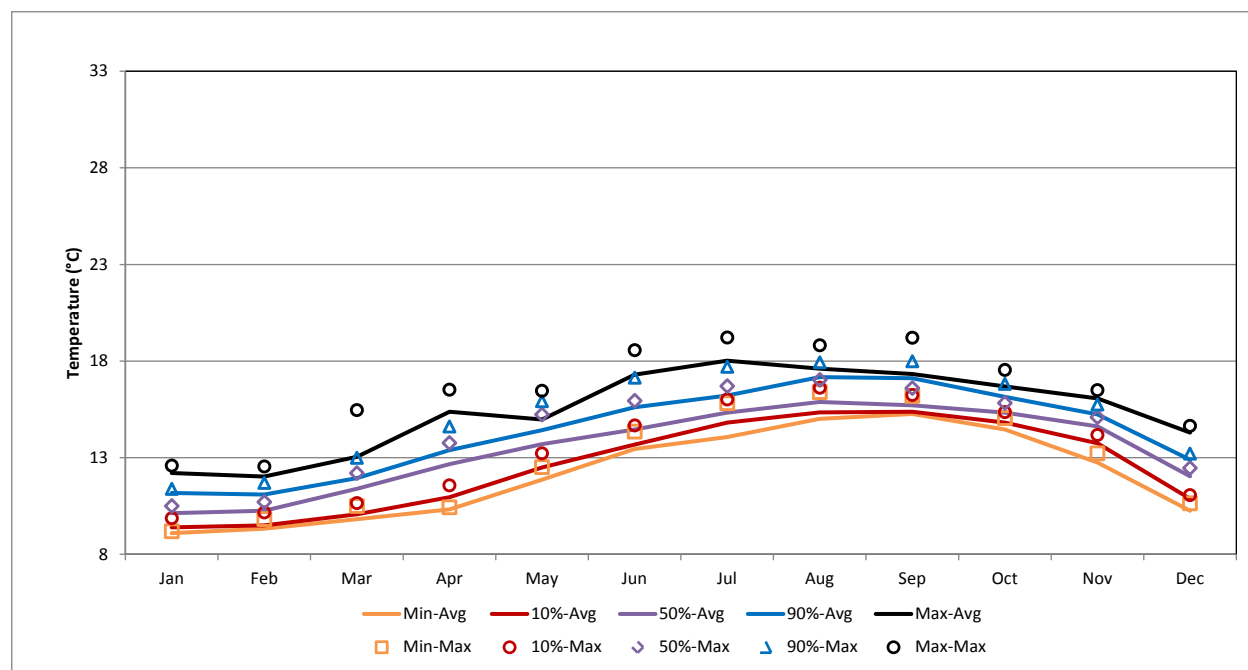


Figure 3.1-10
Distribution of Monthly Average and Average Maximum
Temperatures at Station Elliott during 1994-2012

Station Golf Temperatures

Station Golf is used to assess water temperature between the Elliott Road Bridge and Woodbridge Dam. This reach of the lower Mokelumne River above Woodbridge Dam typically experiences higher flows over the summer months than the reach below Woodbridge Dam and also supports rearing habitat for fall-run Chinook salmon and steelhead.

The average monthly water temperature at Station Golf during the winter months (December through February) ranged from about 8.5 to 13.1°C (47.3 to 55.6°F). Temperatures gradually increase through the spring, and the highest measured average monthly temperature was 23.3°C (73.9°F) during July (Figure 3.1-11).

Temperature data for Station Golf shows an increased spread between the minimum and maximum of the average monthly temperatures relative to upstream stations. The overall maximum difference between minimum and maximum of the average monthly temperatures equal to 9.2°C (16.5°F) occurs in July. The tendency of maximum values of the monthly temperatures to occur earlier in the year (e.g., August instead of September) at Station Golf relative to upstream Station Elliott and Station McIntire is due to several factors. One factor is simply a stronger meteorological effect due to the longer travel times and, therefore, environmental exposure of the water flowing downstream from Camanche Dam. Also Lodi Lake serves to slow down the flow increasing contact time with potentially warmer environmental conditions. Furthermore, as the water flows downstream, diversions and losses to seepage and evapotranspiration diminish the quantity of flow and lower flows are more susceptible to meteorological influence.

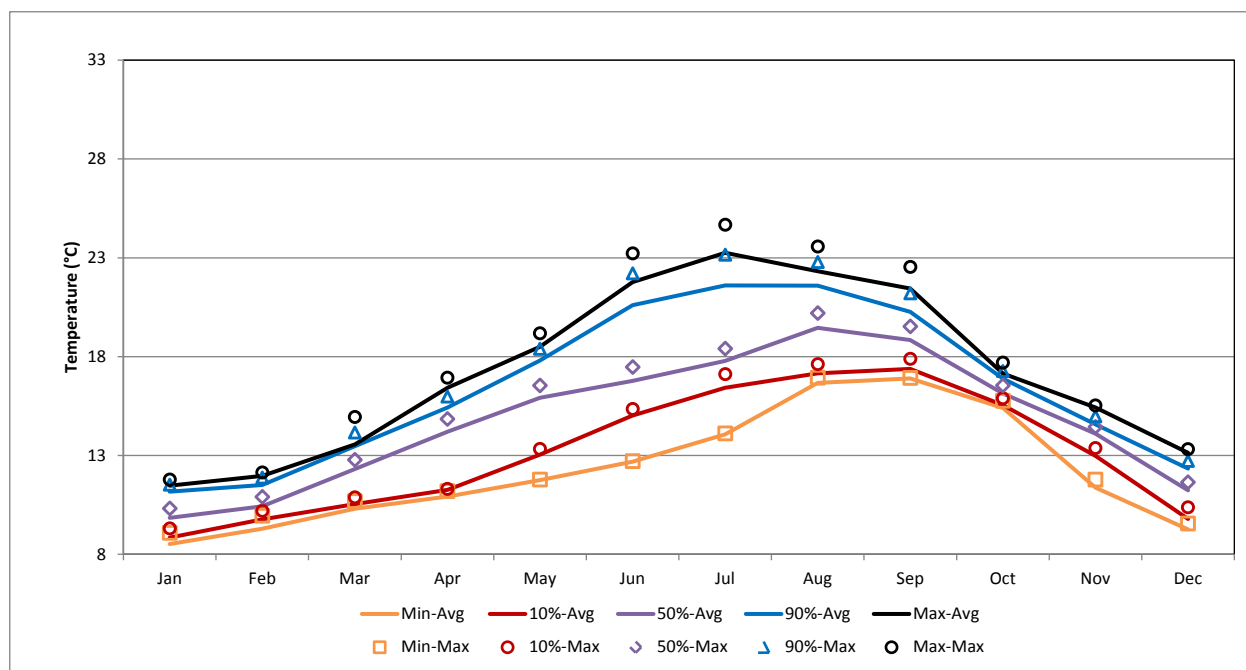


Figure 3.1-11
Distribution of Monthly Average and Average Maximum
Temperatures at Station Golf during 1994–2012

Station Frandy Temperatures

The monthly distribution of temperatures at Station Frandy shows the degree of warming and the variability in temperatures that occur in the most downstream portions of the river (Figure 3.1-12). While temperatures at Station Frandy are similar to the reservoir release temperatures during the winter months (8.2 to 12.6°C [46.7 to 54.7°F]), the summer temperatures are much warmer, with a maximum average temperature of 28.0°C (82.4°F) measured during July. During the summer, there is a very large spread of monthly average temperatures at Station Frandy (spread of 11.4°C [20.5°F] in July). As a result, the medians of the monthly average temperatures during the summer are much less than the maximums of the monthly average temperatures (e.g., 19.3°C [66.7°F] versus 28.0°C [82.4°F] in July). Comparing the monthly average temperatures to the monthly maximum temperatures (i.e., the average of the daily maximums) (Figure 3.1-12) gives a sense of the large diurnal swings that can occur at Station Frandy. Relatively large diurnal temperature swings at Station Frandy can occur when meteorological conditions are relatively warm and/or station stage (water depth) is low.

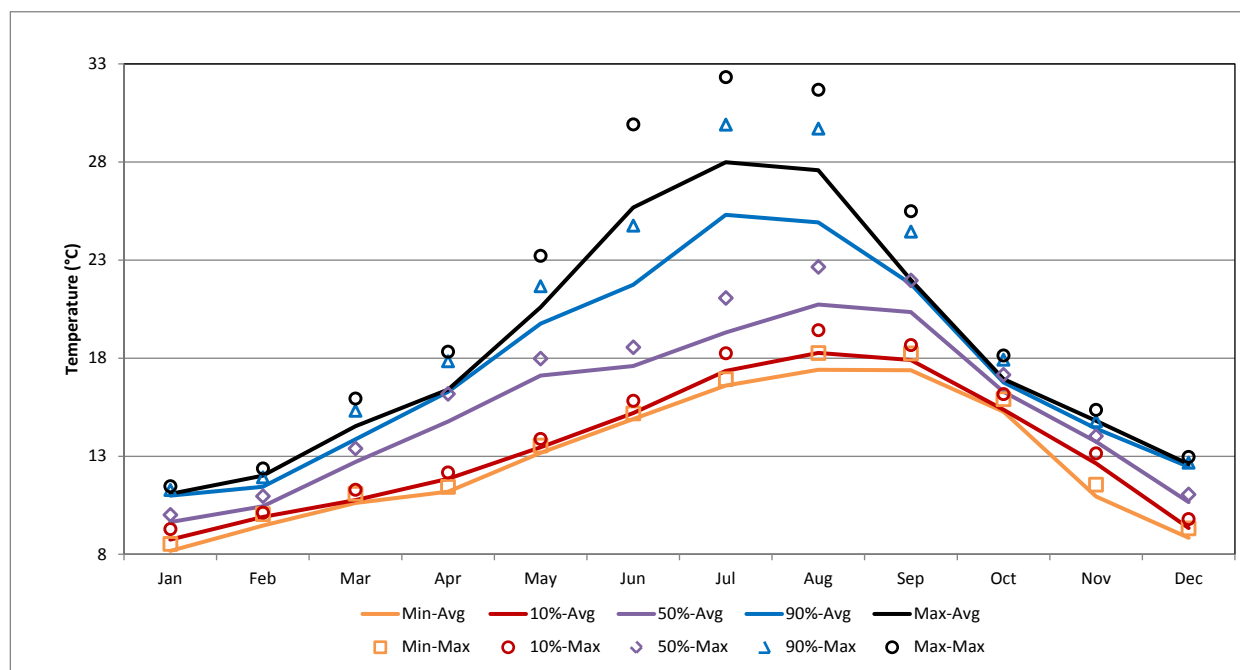


Figure 3.1-12
Distribution of Monthly Average and Average Maximum Temperatures at
Station Frandy during 1994–2012

The large range of temperatures that occurs at Station Frandy during the summer months is related only partly to variability in meteorological conditions. Stage (water depth) is also an important determinant in Station Frandy temperatures (Figure 3.1-13). Flow records are not maintained for Station Frandy due to tidal influence; however, high stage can be generally associated with high flows and and/or high tides and low stage with lower flows and/or low tides. Therefore, at higher flows, travel time is shortened and the water does not have as much time to warm toward thermal equilibrium. In addition, the increased volume of water is less affected by air temperatures and solar radiation. At the highest flows, there is relatively less warming of the Camanche release; however, at the lowest flows, meteorological conditions can cause the water to warm significantly. These temperature effects also are modified by tidal influence at Station Frandy. At higher tides and lower flows, temperatures are influenced by Delta waters.

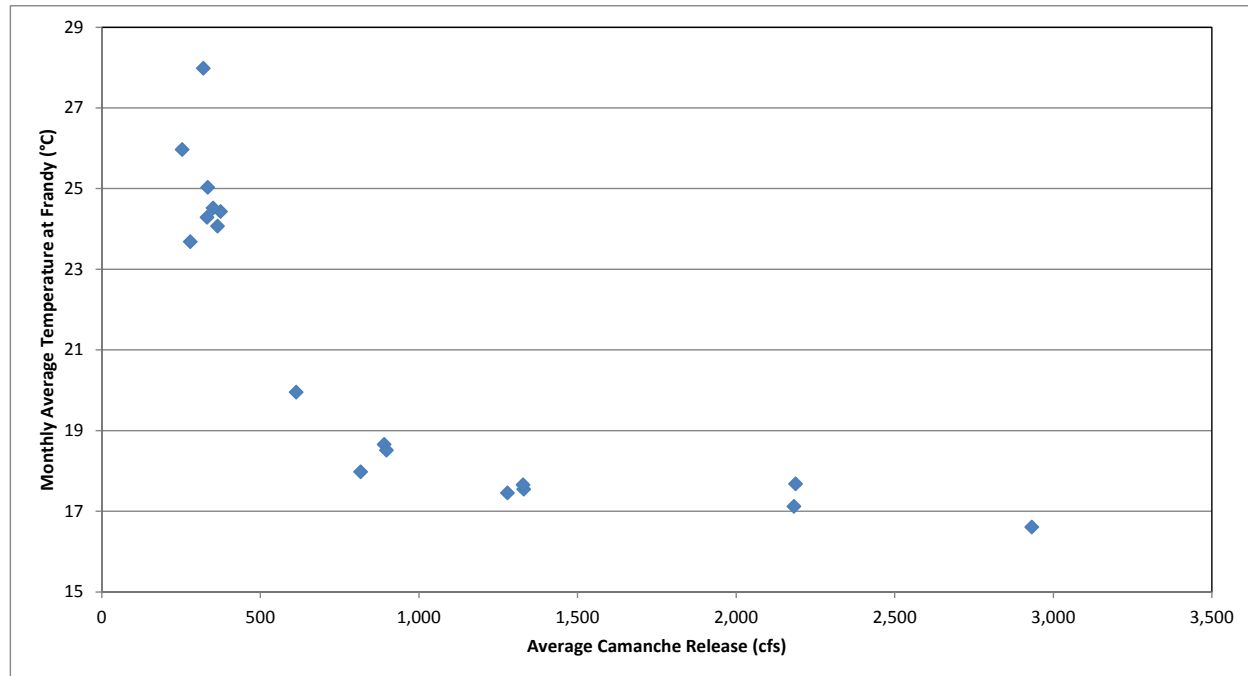


Figure 3.1-13
Effect of Flow on Average July Water Temperature at
Station Frandy during 1994–2011

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. Camanche Dam has buffered the lower river from high metal concentrations by diluting the runoff during low-flow periods, trapping metals in the reservoir, and storing metals over the long term in the sediment behind Camanche Dam. Although EBMUD never owned or operated Penn Mine, in the early 1960s it acquired a portion of the mine tailings and surface water drainage as part of the development of Camanche Reservoir. 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.

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) (California Regional Water Quality Control Board 2011). Dissolved oxygen objectives for fish are discussed in Section 3.2, Fish Resources.

Periodic releases of water containing hydrogen sulfide from the low-oxygen bottom water stratum of Camanche Dam historically caused problems in the operation of the Mokelumne River Fish Hatchery and lower river. 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. The JSA specifies that the HOS should be used to maintain dissolved oxygen and reduce

hydrogen sulfide levels in the Camanche Reservoir hypolimnion. The WQRMP specifies that this should occur whenever oxygen levels drop to 2 parts per million (ppm) (2 mg/L) or below during May through October in Camanche Reservoir. Since 1998, the system typically has operated from July/August through mid-November, and no hydrogen sulfide has developed near the reservoir outlet.

Figure 3.1-14 depicts the average monthly dissolved oxygen concentrations (mg/L) measured in 1) the Camanche Reservoir hypolimnion (January 1998 through June 2012); 2) the lower Mokelumne River at Station 11, about 0.50 mile downstream of Camanche Dam (January 1998 through June 2012); and 3) in the lower Mokelumne River at Elliott Road, about 10 miles downstream of Camanche Dam (January 2000 through June 2012). The summary provides median, spread (first and third quartiles) and range (minimum and maximum values) of the measured values. Also shown is the WQCP criteria for dissolved oxygen concentrations (dashed horizontal line = 7.0 mg/L).

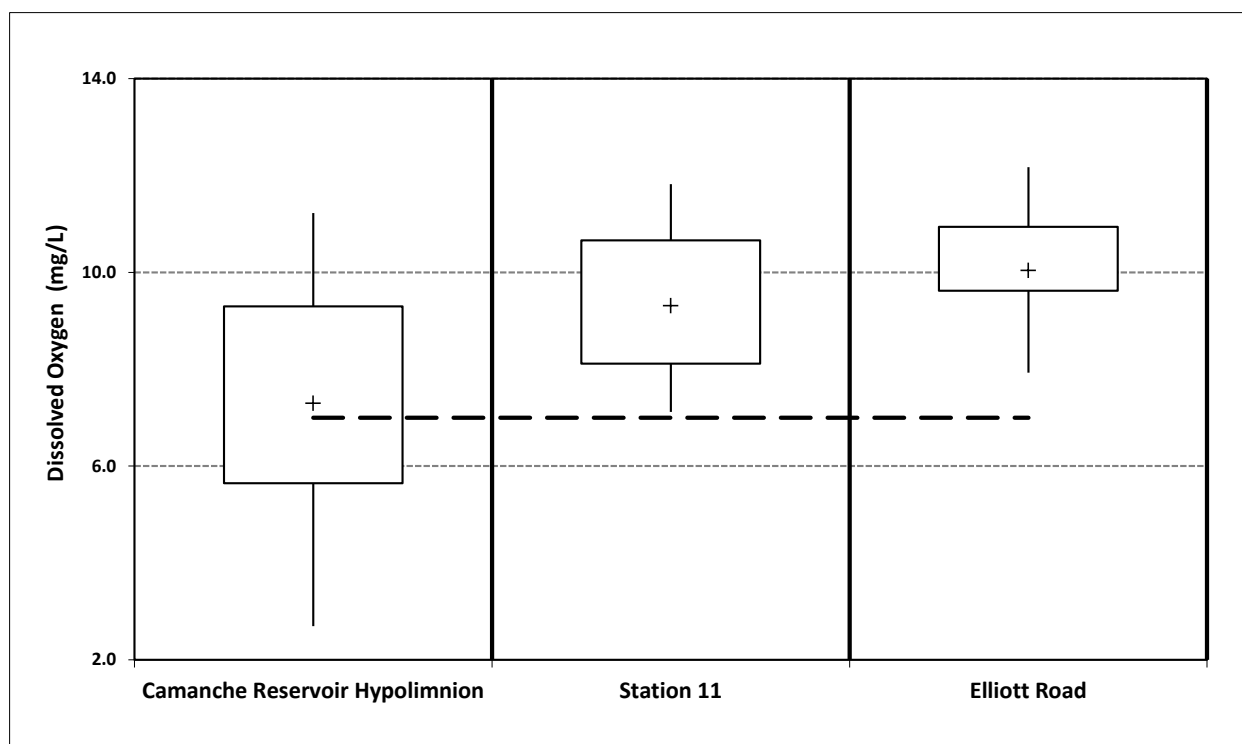


Figure 3.1-14
Summary of Average Monthly Dissolved Oxygen Concentrations in
Camanche Reservoir and the Lower Mokelumne River

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. The longest recorded shutdown duration of 65 days occurred in 1997 when severe storms and a landslide created high turbidity in Pardee Reservoir. Service area water demand was met by drawing down the local terminal reservoirs. Episodic events such as these necessitate expeditious refilling of the East Bay local terminal reservoirs.

3.1.1.8 Sacramento–San Joaquin River Delta

The North Fork and South Fork of the lower Mokelumne River are part of the Delta. Delta-specific beneficial uses protected through water quality objectives are municipal and domestic water supply, agricultural supply, industrial supply (process and service), recreation (water contact and non-contact), freshwater habitat (warm- and coldwater), fish migration (warm- and coldwater), fish spawning (warmwater fish), commercial and sport fishing, wildlife habitat, and navigation. Because of the high economic and environmental value of the Delta, flow and water quality in the Delta are controversial issues.

There are many water quality constituents of concern in the Delta. Regulations to improve Delta water quality (Total Maximum Daily Load restrictions [TMDLs]) have been established for diazinon, chlorpyrifos, pathogens (for Stockton urban waterways), low dissolved oxygen (Stockton Deep Water Ship Channel [DWSC]) and methylmercury. The Delta portion of the Mokelumne River has been listed as impaired for chlorpyrifos, copper, mercury, dissolved oxygen, and unknown toxicity.

The largest diversions from the Delta are the Central Valley Project (CVP) and the State Water Project (SWP). The Central Delta is roughly regarded as those waterways surrounding the San Joaquin River from Stockton westward to Webb Tract and Twitchell Island. These waterways include the mainstem of the lower San Joaquin River itself, the lower Mokelumne River complex and its associated waterways (i.e., Potato, Disappointment, and Fourteen mile Sloughs as well as other channels), and the lower reaches of Old River and Middle River with their interconnecting waterways and channels. Under natural hydrologic conditions, net flow in these waterways typically would have been in a downstream direction toward the ocean.

The DCC was constructed by Reclamation in the early 1950s to direct Sacramento River water southward through the central Delta to the CVP pumps at Tracy. Currently, Reclamation operates the DCC to improve the transfer of water from the Sacramento River to the export facilities at the SWP and CVP Pumping Plants, improve water quality in the southern Delta, and reduce saltwater intrusion rates in the western Delta. Closures of the DCC typically occur from November 1 through June 15 to reduce entrainment of juvenile salmonids and green sturgeon from the Sacramento River to the central Delta.

Under current CVP and SWP operating conditions, flow in many channels is toward the CVP and SWP pumps. When the DCC gates are open, the channel conveys Sacramento River water into Snodgrass Slough and subsequently into the Mokelumne River system. This water eventually discharges into the San Joaquin River near river mile 22.

3.1.2 Regulatory Setting

This section describes the regulations and policies relevant to water resources affected by the Project. Because the Project would not involve significant and adverse physical change to the environment from construction, many federal, state, and local regulations that are typically relevant to a water resources analysis in an EIR are not applicable. The discussion below focuses only on those regulations that are potentially relevant to the Project.

3.1.2.1 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 CWA), 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.

2011 Water Quality Control Plan for the Central Valley

The Central Valley WQCP (Central Valley Regional Water Quality Control Board 2011) contains water quality objectives for the region that includes the Mokelumne River. The objectives most Project are those for water temperature. 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 (EPA), 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. The basic objectives relating to water quality, Delta outflow, and fish protection are listed below.

- **Delta Salinity Objectives.** Several Delta locations have specified salinity objectives for protecting aquatic habitat, agricultural diversions in the Delta, and municipal water supply.
- **X2 Objective.** X2 is the location at which the water in the Delta changes from fresh, river-influenced to salty, ocean-influenced. It is more strictly defined as the Delta location where water has a salinity of 2 parts per thousand (ppt). Delta flows are regulated to ensure that objectives for the X2 location are met during February through June.
- **Maximum Export/Inflow (E/I) Ratios.** D-1641 includes a maximum E/I ratio objective to limit the fraction of Delta inflows that is exported from the CVP Jones and SWP Banks Pumping Plants. This objective was developed to generally protect fish species by reducing entrainment losses.
- **Delta Outflow Requirements.** The minimum monthly Delta outflow objectives protect the salinity range for the estuarine aquatic habitat and are included in D-1641.
- **Delta Cross Channel Gate Closures.** Closures of the DCC are governed by State Water Board D-1641 water right requirements and specific actions prescribed by NMFS (2009) to protect listed fish species.

3.1.2.2 Antidegradation Policy

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.

3.1.3 Assessment of Impacts

This section summarizes the baseline hydrologic conditions and changes in these conditions that are expected to occur under project conditions (that is, with the projected increase in average annual demand of 16 MGD in the EBMUD service area in 2040). This section also includes a description of the methods, assumptions, and results for each type of analysis, as well as the criteria for determining the significance of impacts. The modeling methods and results that are summarized in this water resources section also were used to evaluate project effects for other resources, particularly fish.

To evaluate potential changes in hydrology associated with the increase in average annual demand of 16 MGD (i.e., from 214 MGD in 2005 to 230 MGD in 2040) under project conditions, reservoir storage and river flow were simulated with EBMUD’s hydrologic model, EBMUDSIM. Potential changes in water temperature were simulated with the Stream Segment Temperature (SSTEMP) model and empirically derived equations. These modeling efforts are discussed briefly here, and in more detail in Appendix E, Modeling Technical Appendix. Potential effects of the Project on Delta flows and Delta water quality were assessed by comparing historical Delta flows to the incremental change in Delta inflow associated with the Project and by estimating the maximum potential increase in saltwater intrusion that may be associated with the Project.

These same methods (EBMUDSIM, SSTEMP, empirically derived regressions, and Delta assessment) were also used to assess cumulative impacts, discussed in Chapter 5, Cumulative Impacts, and Chapter 6, Programmatic Evaluation of Use Beyond 2040.

3.1.3.1 EBMUDSIM Modeling

EBMUDSIM 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 primary purpose of EBMUDSIM is to determine the ability of EBMUD's water supply system to meet customer demands. Accordingly, model studies were prepared to simulate baseline hydrologic conditions and conditions with the increase in average annual demand of 16 MGD described above. Although the increased demand would rise over decades and would vary from year to year, the hydrologic and water temperature modeling evaluated this increased demand as an immediate and consistent change. Several agencies, including the State Water Board and FERC, have relied on EBMUDSIM modeling to assess hydrologic conditions in the Mokelumne River. See Appendix E, Modeling Technical Appendix, for specific details regarding EBMUDSIM.

EBMUDSIM Results

EBMUDSIM results for the baseline and project scenarios are summarized below. Additional information can be found in Appendices G and H.

- Appendix G: Monthly Graphs of Baseline and Project EBMUDSIM Results for Pardee Reservoir Storage, Camanche Reservoir Storage, Camanche Release Flows, and Flows below Woodbridge
- Appendix H.1: Comparison of Baseline and Project EBMUDSIM Results as Illustrated with Percentile Plots and Tables
- Appendix H.2: Joint Settlement Agreement Year Type Classifications as Simulated by EBMUDSIM
- Appendix H.3: Evaluation of when End-of-Month Camanche Elevation Falls below 190 Feet

Aqueduct Flows

As expected, the EBMUDSIM results indicate that increasing the EBMUD service area demand by 16 MGD for the Project would result in increased flows in the Mokelumne Aqueducts (Appendix H.1). The long-term average increase in aqueduct flow was about 21.3 cfs (approximately 13.8 MGD) due to implementation of demand management measures. During most years, the full 16 MGD was available for diversion. During the aqueduct outage scenario (described in Appendix E), or when the aqueducts were already at capacity under baseline conditions, diversions could not be increased.

Because the aqueduct capacity is limited to a maximum of 325 MGD, or about 500 cfs, there was little to no increase in the maximum aqueduct flows. Under both the 3-year drought planning sequence (DPS) (described in Appendix E) and aqueduct outage scenario, it would be necessary to take maximum aqueduct diversions to recover terminal reservoir storage. In both the baseline and project scenarios, aqueduct flows were close to the maximum level during spring and summer of 1979 (after the DPS) and from spring 1982 to spring 1983 (after the simulated aqueduct outage).

During 1968 and 1978, the simulated project aqueduct flows were actually lower than those of the baseline aqueduct flows. For 1968, this reduction occurred because of FRWP deliveries. During this year, the Project caused a reduction in storage that was sufficient to trigger FRWP deliveries. As a result, less water was diverted from the Mokelumne River. During 1978 (the end of the DPS), storage was very low and there was less water available for diversion under the project scenario compared to the baseline scenario.

Camanche Release and Flow in the Lower Mokelumne River

The increased diversions to meet EBMUD's increased average annual demand by 2040 translate almost directly into a reduction in Camanche Reservoir releases. The overall average reduction in Camanche Reservoir release flows was 13.5 MGD. Because of the ability to store water in the reservoirs, the simulated reduction in river release did not always occur at the same time as the increase in aqueduct flow (Appendix H.1). In general, the Project translated into a relatively small percent reduction in flow. For the entire simulation period, average Camanche release was reduced 3.2% and flows below Woodbridge Dam were reduced about 4.3% under project conditions (Figures 3.1-15 and 3.1-16).

Reservoir Storage

Increased aqueduct diversions result in reduced storage in Pardee Reservoir. This is most pronounced when storage volumes are above 100 TAF (Figure 3.1-17 and Appendix H.1). Storage volume reductions in Camanche Reservoir are most pronounced when storage is below 250 TAF because water must be released to meet downstream needs and the requirements of the JSA (Figure 3.1-18).

North San Joaquin Water Conservation District and Other Diversions

Under project conditions, EBMUD would continue to meet obligations to senior water rights holders before meeting EBMUD diversions. However, there is some potential that the senior water rights held by JVID could be affected by a reduced water surface elevation in Pardee Reservoir if the reservoir level falls below 550 feet, which is the elevation of the JVID intake. This potential impact is discussed in Section 3.4, Agricultural Resources.

The NSJWCD is an irrigation district that diverts water from the lower Mokelumne River below Camanche Dam. NSJWCD's water right to divert this water is junior to EBMUD's Permit. Baseline EBMUDSIM results indicate that NSJWCD's water deliveries would be available from the Mokelumne River in 49 of the 89 years modeled, with one of these years being less than the full 20,000 acre-feet delivery. Under the project scenario, NSJWCD's water deliveries from the Mokelumne River would be available from the Mokelumne River in 47 of the 89 years modeled, with two of these years being less than the full 20,000 acre-feet delivery (see Appendix L). Potential impacts associated with these reductions in deliveries are discussed in more detail in Section 3.4, Agricultural Resources.

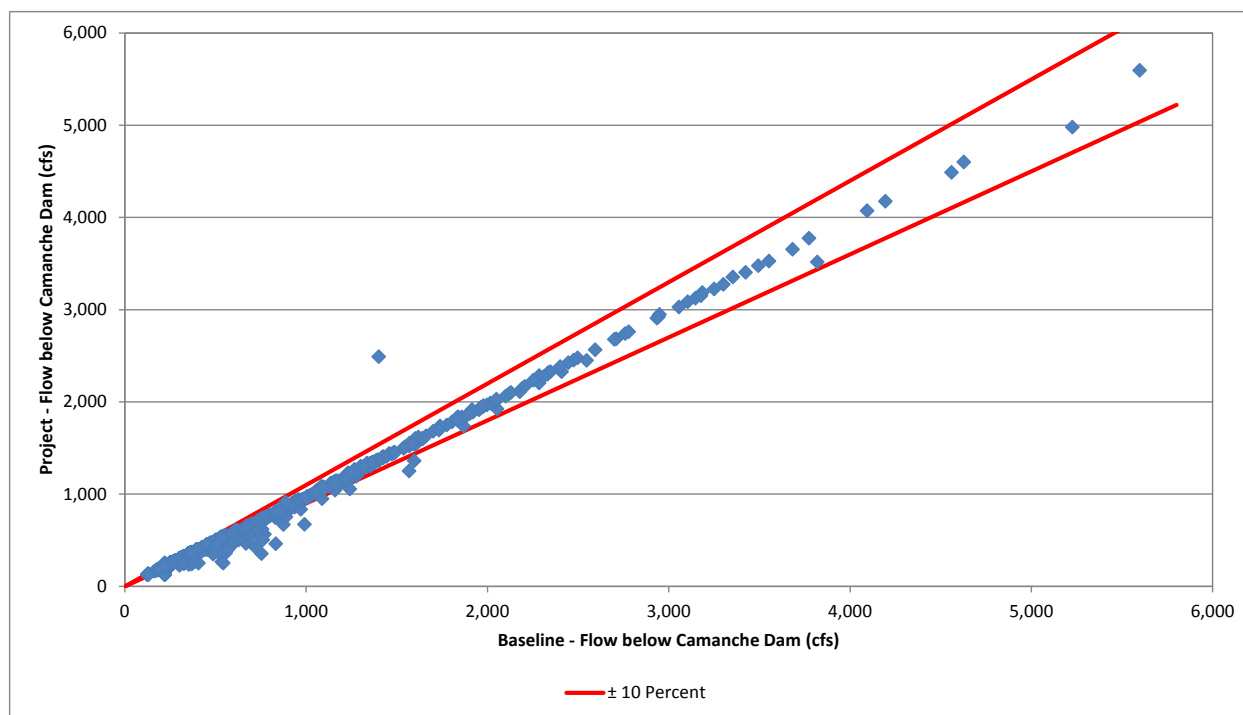


Figure 3.1-15
Comparison of Baseline and Permit 10478 Time Extension Project Camanche Reservoir Flow Releases for Calendar Year 1921 through 2009 Hydrology

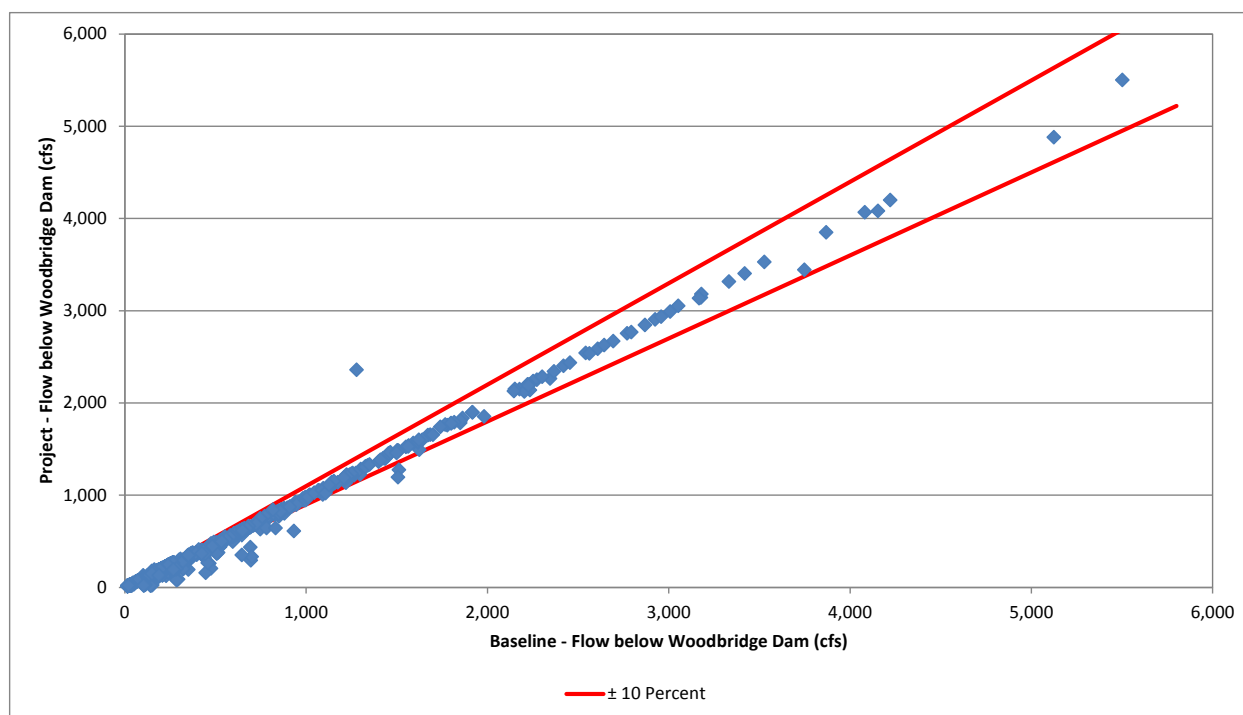


Figure 3.1-16
Comparison of Baseline and Permit 10478 Time Extension Project Flows below Woodbridge Dam for Calendar Year 1921 through 2009 Hydrology

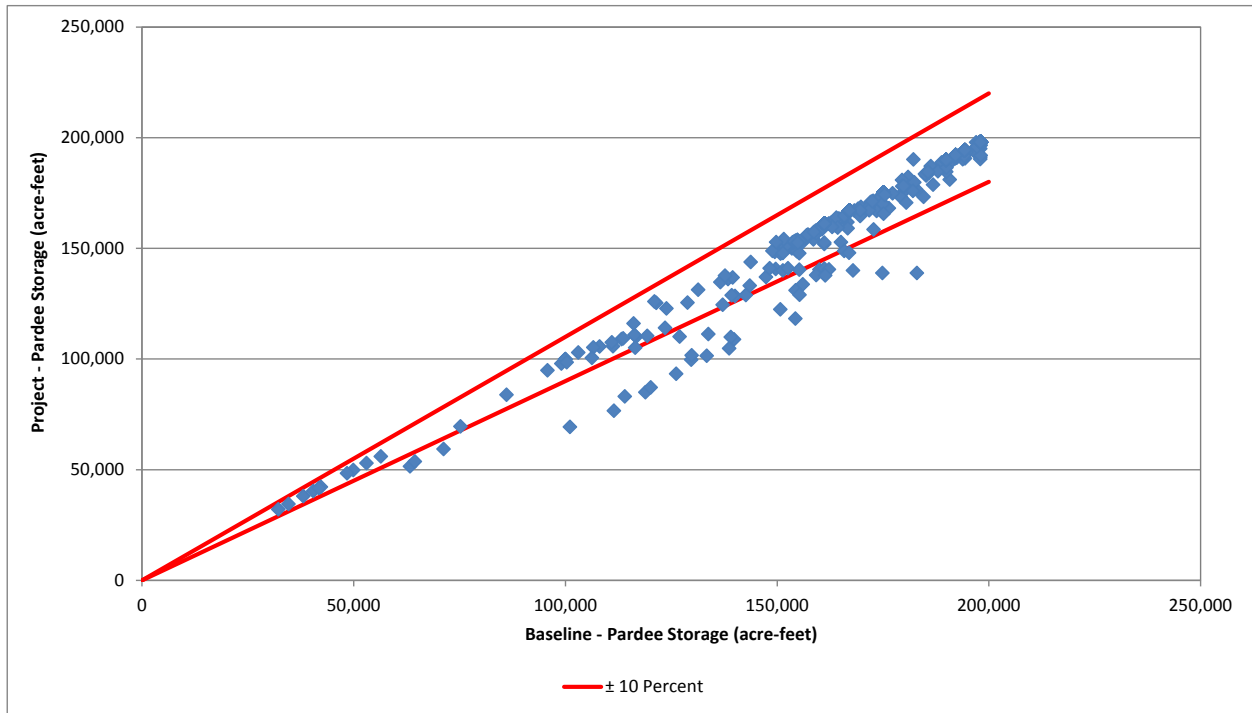


Figure 3.1-17
Comparison of Baseline and Permit 10478 Time Extension Project
Pardee Reservoir Storage for Calendar Year 1921 through 2009 Hydrology

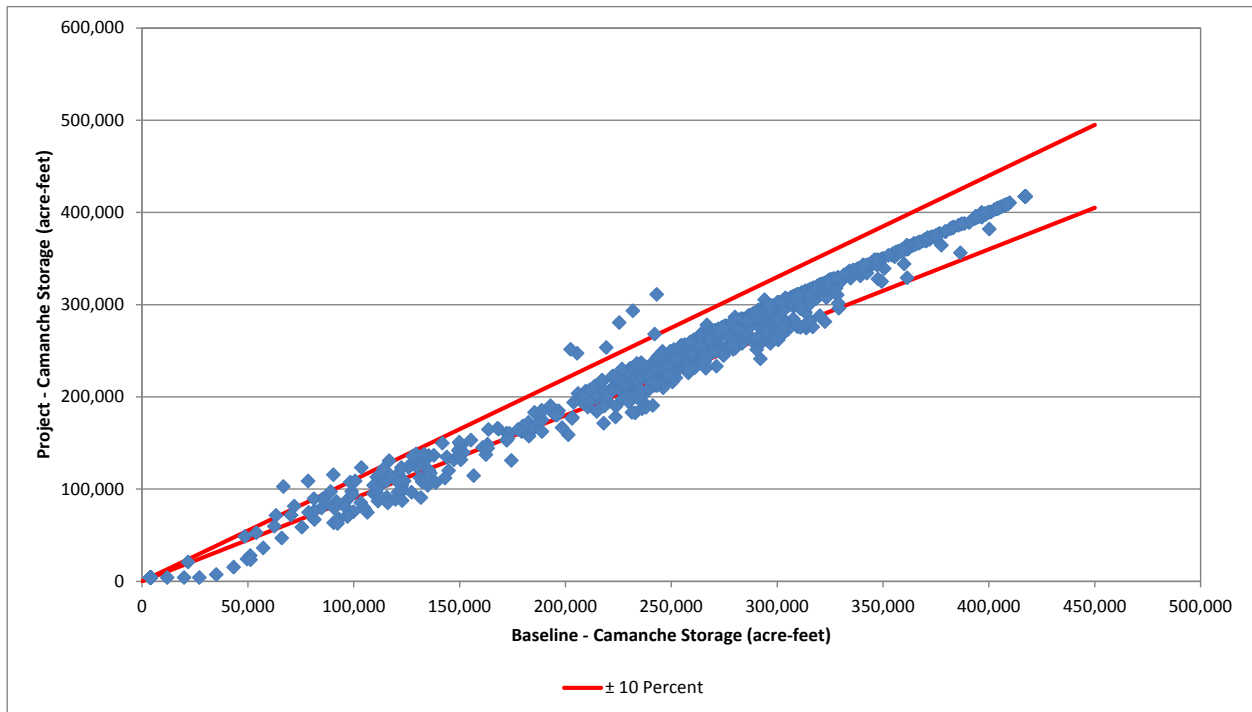


Figure 3.1-18
Comparison of Baseline and Permit 10478 Time Extension Project
Camanche Reservoir Storage for Calendar Year 1921 through 2009 Hydrology

3.1.3.2 1921–2009 Water Temperature Modeling for Impact Assessment

Project-related water temperature effects were estimated using equations to estimate reservoir release temperatures and the SSTEMP model for temperatures in the lower Mokelumne River below Camanche Dam. The inputs were Camanche Reservoir elevation, Camanche release flows, and Woodbridge flows simulated by EBMUDSIM for 1921–2009. Meteorological conditions were represented by an annual repeating sequence of long-term average data measured at Stockton (Western Regional Climate Center 2012). See Appendix E, Modeling Technical Appendix, for specific details related to the temperature modeling.

Methods

Reservoir Release Temperatures (Station McIntire)

As described above and in Section 3.2, Fish Resources, Camanche Reservoir release temperatures could be affected by reservoir storage when the elevation of Camanche Reservoir is below 190 feet (about 146,700 acre-feet). To simulate any potential project effects associated with causing a decrease in reservoir elevation, an equation was developed to estimate average monthly temperatures at Station McIntire as a function of Camanche elevation when elevation was less than 190 feet. Because low reservoir elevations cause negligible increases (and sometimes a decrease) in release temperatures during November through February, the equation was developed and applied for the March through October period.

The release temperature equation was developed by comparing reservoir elevation to the monthly average water temperature at Station McIntire. The procedure for creating the equation is more fully described in Appendix E. To increase the range of data used to develop the equation, the Station McIntire dataset of measured water temperatures (1994 through 2011) was extended back in time by using water temperature measured at the Mokelumne River Fish Hatchery. (The hatchery uses water from Camanche Reservoir and is located immediately downstream of Camanche Dam adjacent to the lower Mokelumne River.) Appendix E contains a description of the procedure used to reconstruct the October 1974 through December 1993 Station McIntire temperatures from hatchery records. The reconstruction of the Station McIntire record back to October 1974 encompasses all water year types and enables a more complete evaluation of the relationship between Camanche Reservoir water surface elevation and release temperatures. Appendix F shows the month-by-month comparisons of Camanche Reservoir elevation to Station McIntire temperatures.

SSTEMP Modeling

The SSTEMP model was used to simulate monthly average water temperatures in the Mokelumne River downstream of Camanche Reservoir. The SSTEMP model is a one-dimensional stream segment model developed by USGS (2009).

The model for the Mokelumne River was composed of three segments:

- Station McIntire to Station Elliott,
- Station Elliott to Station Golf, and
- Station Golf to Station Frandy.

This model and its performance are described in detail in Appendix E, Modeling Technical Appendix.

Model inputs for the baseline and project scenarios were identical except for river flow and Station McIntire temperature (both monthly time series are the key input for model segment 1). The model requires mean monthly temperature values as input to the upstream end of a segment. The mean temperature output from segment 1 was used as input to segment 2, and the mean temperature output from segment 2 was used as input to segment 3. River flows were based on the baseline and project EBMUDSIM simulations.

For most months, the mean temperature inputs for segment 1 were set equal to the average monthly values from the 1974 through 2011 reconstructed temperature record for Station McIntire. However, if reservoir elevation was less than 190 feet during March through October for the baseline or project EBMUDSIM simulations, the release temperature equation was used to adjust the assumed reservoir release temperature assigned to Station McIntire. As a result, monthly input temperatures for the two scenarios used the same average value, unless Camanche elevations fell below 190 feet and were different. Table 3.1-3 indicates the relatively small effect of the Project on the occurrence of months with Camanche Reservoir storage below 190 feet. The table data are provided as both percent and number of years out of the 89-year simulation period.

Table 3.1-3. Occurrence of Camanche Elevation Less than 190 Feet

Month	Baseline		Permit 10478 Time Extension Project	
	Years	Percent (%)	Years	Percent (%)
March	9	10.1	10	11.2
April	8	9.0	10	11.2
May	8	9.0	9	10.1
June	8	9.0	9	10.1
July	9	10.1	10	11.2
August	10	11.2	10	11.2
September	10	11.2	10	11.2
October	9	10.1	9	10.1

This approach to the water-temperature analysis provides an estimate of the average project-related temperature effects in response to estimated changes in reservoir storage and flow for each of the 89 years simulated by EBMUDSIM.

Monthly Maximum of the 7-Day Moving Average of the Maximum Daily Water Temperatures

In Section 3.2, Fish Resources, the temperature parameter used to assess water temperature suitability for fish is the monthly maximum of the 7-day moving average of the daily maximum water temperatures (MM7DADM). The SSTEMP model, however, simulates the mean monthly water temperature. The SSTEMP temperatures were converted to MM7DADM values using equations developed from measured temperatures. These equations are based on regression relationships between mean monthly and MM7DADM water temperatures. Separate sets of monthly equations were developed for monitoring stations Elliott, Golf, and Frandy. The development of the equations for converting mean monthly temperatures to MM7DADM temperatures is described in more detail in Appendix E. The estimated project effects on MM7DADM temperatures are discussed in Section 3.2, Fish Resources.

Water Temperature Modeling Results

Simulated average monthly temperature effects are discussed briefly for stations McIntire, Elliott, Golf, and Frandy. In general, temperature effects were small as expected due to the relative consistency in Camanche storage and water-surface elevation (Table 3.1-3). Temperature effects of the Project at Station McIntire were solely the result of changes in Camanche water-surface elevation. Project temperature effects at locations downstream of Station McIntire were caused by the combination of changes in flow and water-surface elevation. For months when there are no project-related changes in flow, any temperature effects at Station McIntire would tend to dissipate as the water moves downstream. In contrast, temperature effects caused by a change in flow would be expected to increase as water moves downstream.

Simulated project effects on average monthly water temperature are shown in two ways:

1. Graphs that show 50th percentile, 99th percentile, and maximum water temperatures for each month at each of the monitoring locations (Figures 3.1-19 through 3.1-22). Because the modeling used average meteorological conditions and because most of the Station McIntire temperatures used to start the SSTEMP simulations had the same value (unless reservoir elevation fell below 190 feet), most of the monthly temperatures are very similar. As a result, lines and symbols representing percentiles other than 50th, 99th, and 100th are not shown because they would be indistinguishable from the lines and symbols representing the 50th percentiles.
2. A table that shows the distribution of simulated project temperature effects in increments of 0.5°C (Table 3.1-4). The graphs do not clearly show the simulated temperature effects because the temperatures effects are generally small (<0.5°C). The frequency table shows temperature effects more clearly.

Station McIntire

The Station McIntire temperatures used as input for the SSTEMP model were the same for each month unless the simulated Camanche water-surface elevation during March through October fell below 190 feet. Most of the temperatures varied between about 10°C (January and February) and 15°C (September through November). However, temperatures were estimated to become much higher during some years with low reservoir storage (estimated 99th percentile temperature reached approximately 18.5 to 19.5°C, and maximum temperatures reached 23.7°C).

Estimated project-related temperature effects were infrequent and were generally less than 1°C. Some of the largest estimated temperature effects occurred during July through October in association with the DPS (1977 through 1978) and are roughly illustrated by the 99th percentile line in Figure 3.1-19.

The 99th percentile temperatures for March through June are somewhat unusual because the large temperature increase in March and April is followed by a decrease in May and June. The 99th percentile temperatures for March through June are partway between the 1978 and 1979 values. The 1978 values increase steadily through the spring, which is typical of reservoir release temperatures. The 1979 values, however, decrease between April and May and then again between May and June. During this time, the simulated Camanche elevation was less than 190 feet as a result of the DPS. The decrease in Station McIntire temperature is related to the increase in simulated Camanche Reservoir storage during this time in both the baseline and project case. When Camanche elevation is less than 190 feet, higher elevations produce lower release temperatures.

Station Elliott

By the time water reaches Station Elliott, some of the simulated temperature effects associated with changes in reservoir elevation have dissipated as illustrated by the 99th percentile line in Figure 3.1-20 and the reduction in the occurrence of the larger temperature effects ($>1^{\circ}\text{C}$) in the frequency table. Project-related changes in flow produced small increases and decreases in water temperature that are not apparent graphically but can be seen in the frequency tables. During October through February, the percentage of time with small temperature decreases ($<0.5^{\circ}\text{C}$) is estimated to be larger than the percentage of time with small temperature increases.

Station Golf

By the time water reaches Station Golf, the simulated temperature effects associated with change in reservoir storage have dissipated further, but more of the months show small ($<0.5^{\circ}\text{C}$) temperature increases associated with changes in flow. As described earlier, upstream diversions and channel losses due to seepage and evapotranspiration reduce the magnitude of the discharge as water flows downstream from Camanche Dam. The increased exposure time to atmospheric conditions coupled with the reductions in discharge explain why there is a higher frequency of small ($<0.5^{\circ}\text{C}$) temperature changes at Station Golf. These small increases are apparent graphically in the 50th percentile values (Figure 3.1-21).

Station Frandy

By the time water reaches Station Frandy, there is even more of a temperature effect associated with flow, although for most months, the project-related change in temperature is still less than 0.5°C . Station Frandy has the largest percentage of project-related temperature effects that are greater than 1°C , 7% in July, i.e., 6 out of the 89 years (Table 3.1-4). At Station Frandy, the effect of reservoir drawdown on temperature is still apparent, but the simulated project effects associated with drawdown are mostly gone (i.e., elevated temperatures associated with the high reservoir release temperatures during the DPS are still present, but the baseline and project temperatures are elevated by about the same amount) (Figure 3.1-22).

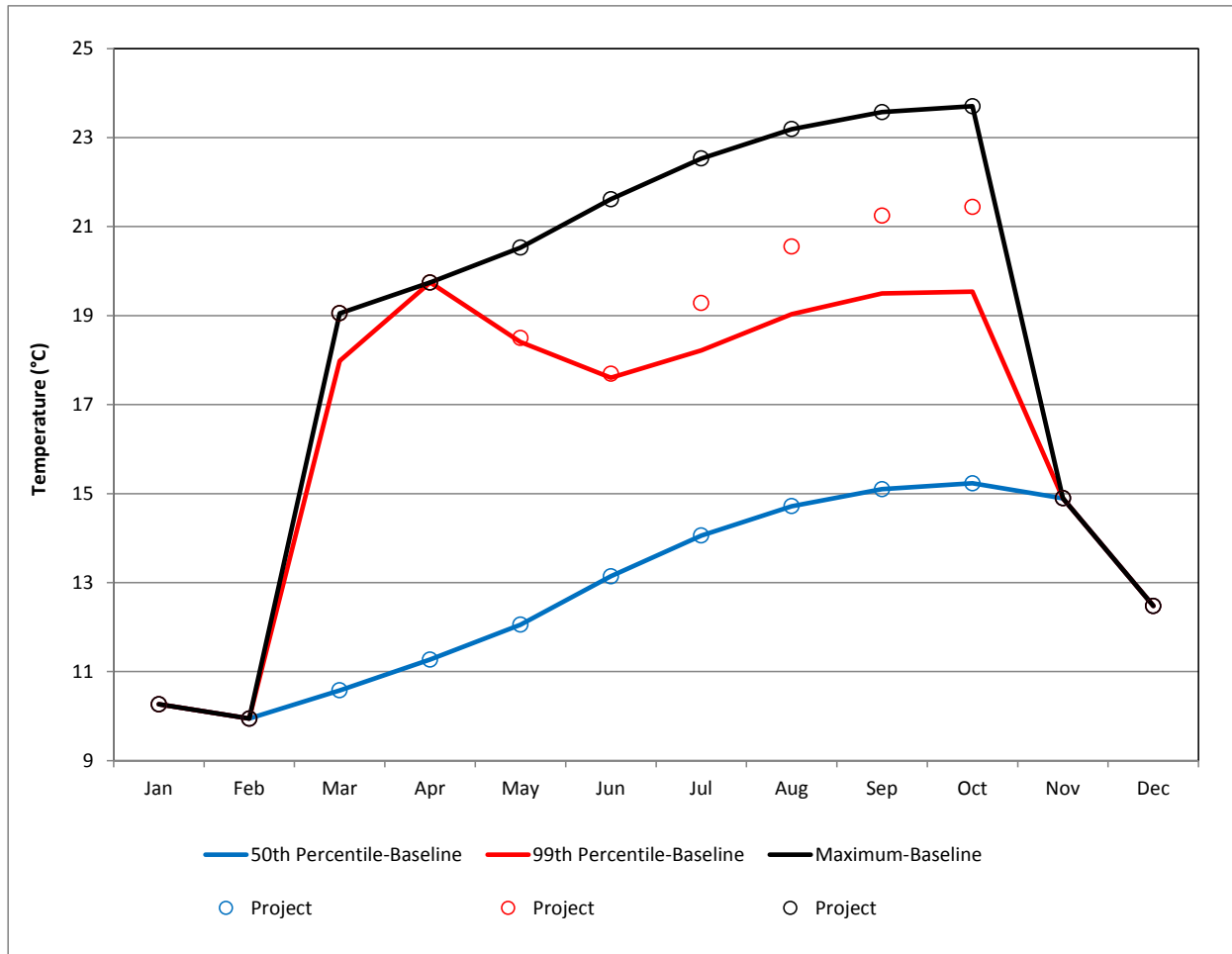


Figure 3.1-19
Monthly Average Temperatures at Station McIntire Simulated for Baseline and Permit 10478 Time Extension Project Conditions for 1921 through 2009 Using EBMUDSIM Hydrology and Average Meteorological Conditions

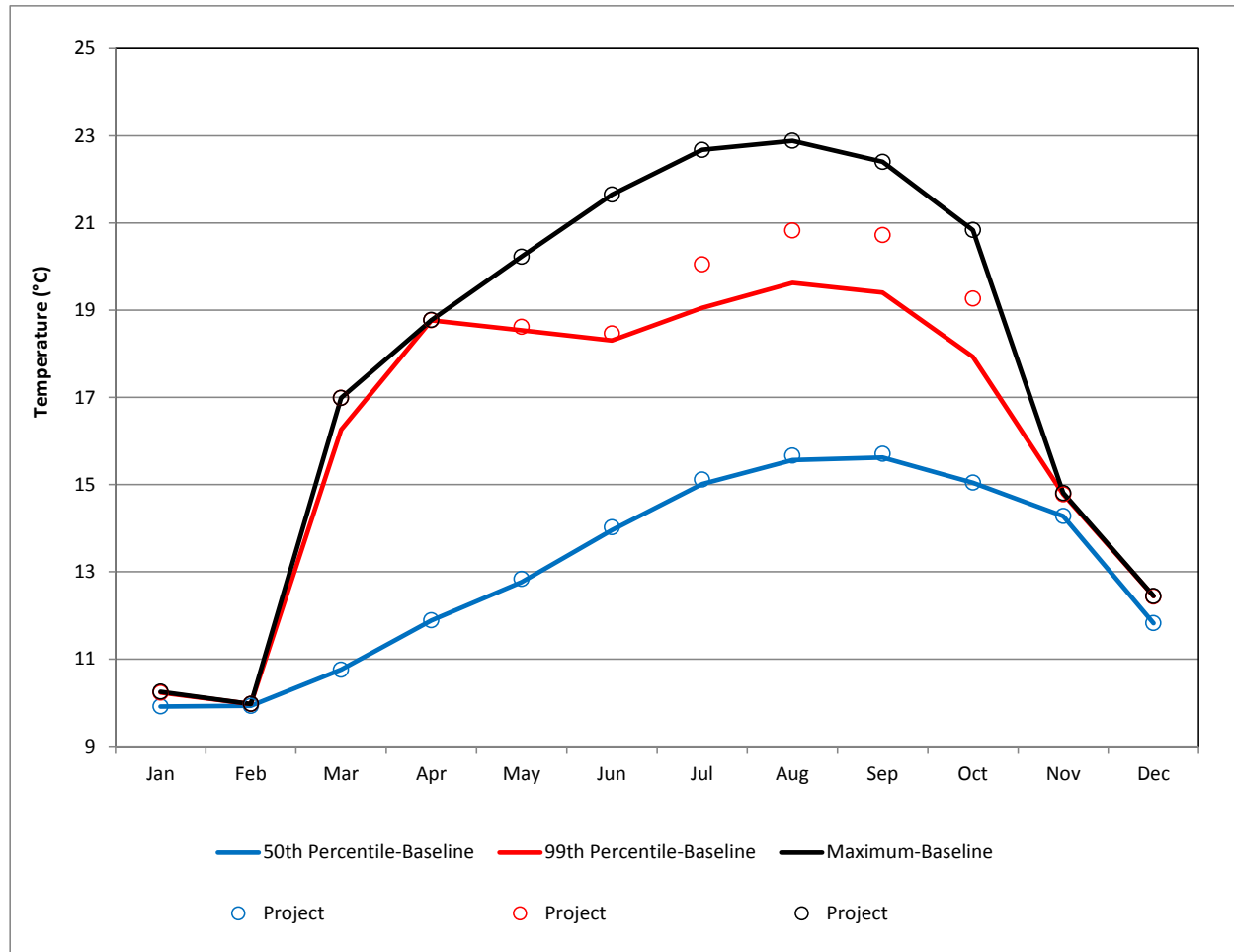


Figure 3.1-20
Monthly Average Temperatures at Station Elliott Simulated for Baseline and Permit 10478 Time Extension
Project Conditions for 1921 through 2009 Using EBMUDSIM Hydrology and Average Meteorological
Conditions

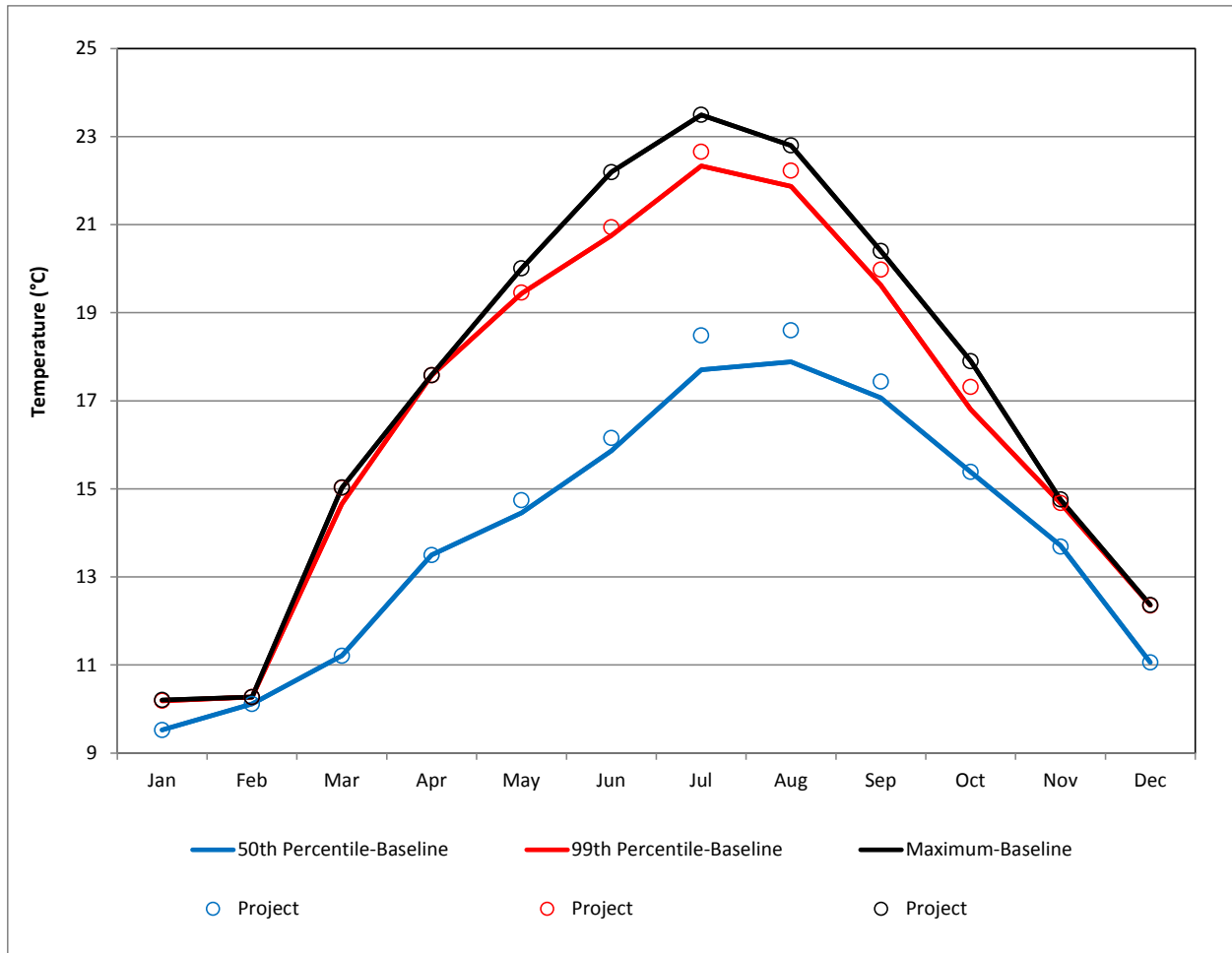


Figure 3.1-21
Monthly Average Temperatures at Station Golf Simulated for Baseline and Permit 10478 Time Extension Project Conditions for 1921 through 2009 Using EBMUDSIM Hydrology and Average Meteorological Conditions

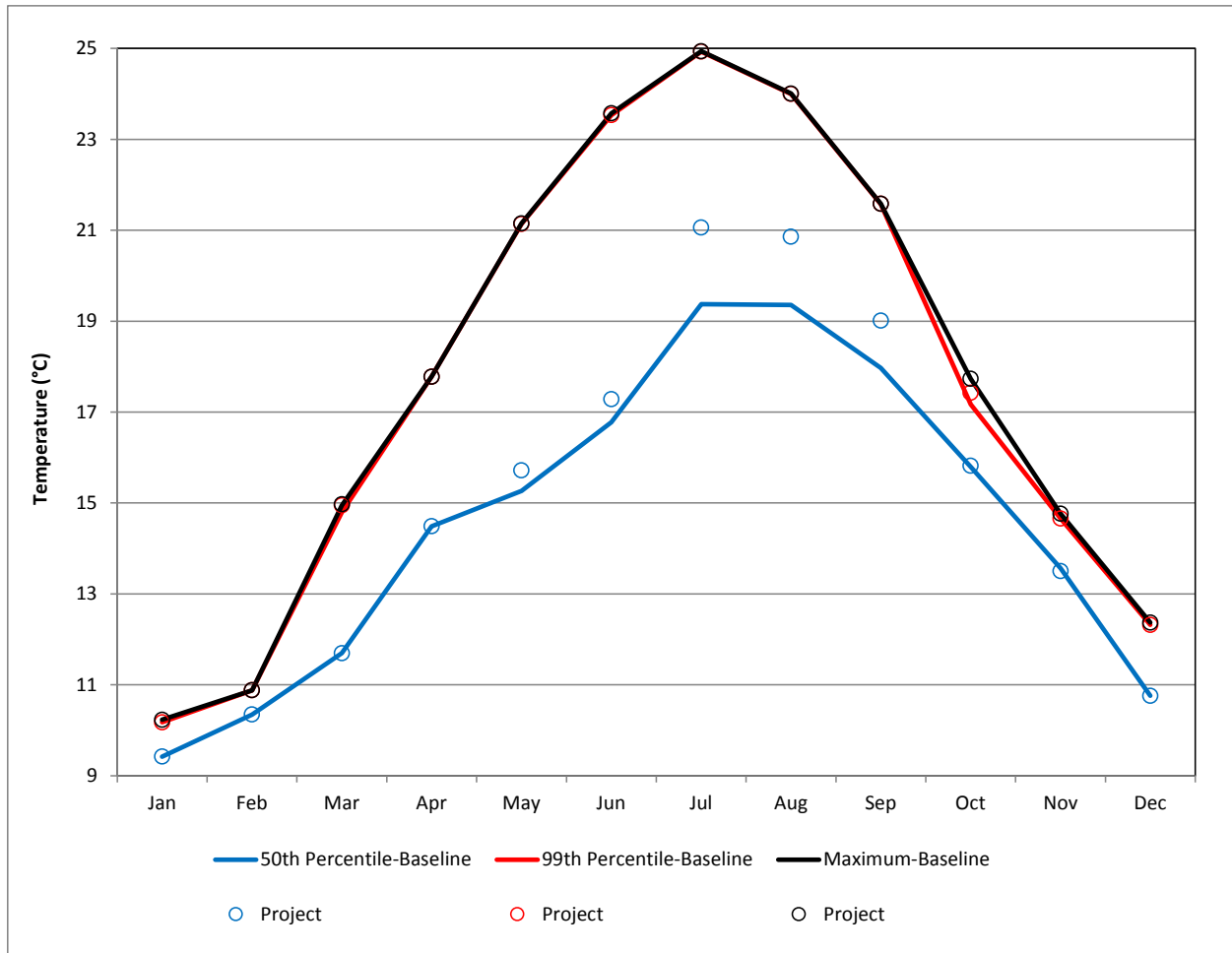


Figure 3.1-22
Monthly Average Temperatures at Station Frandy Simulated for Baseline and Permit 10478 Time Extension
Project Conditions for 1921 through 2009 Using EBMUDSIM Hydrology and Average Meteorological
Conditions

Table 3.1-4. Distribution of Project Temperature Effects Shown as Number of Years of Simulated Changes in Average Monthly Temperature (°C)

Month	<-1.0	<-0.5 and >=-1.0	<-0.05 and >=-0.5	>-0.05 and <0.05	>0.05 and <=0.5	>0.5 and <=1.0	>1.0 and <=1.5	>1.5 and <=2.0	>2.0 and <=2.5	>2.5 and <=3.0	>3.0	Total >1.0	Total
Station McIntire													
Jan	0	0	0	89	0	0	0	0	0	0	0	0	89
Feb	0	0	0	89	0	0	0	0	0	0	0	0	89
Mar	1	0	1	80	2	3	2	0	0	0	0	2	89
Apr	0	0	1	81	3	3	1	0	0	0	0	1	89
May	0	0	1	81	5	2	0	0	0	0	0	0	89
Jun	0	0	0	82	5	0	2	0	0	0	0	2	89
Jul	0	0	0	80	7	0	2	0	0	0	0	2	89
Aug	0	0	1	82	2	2	1	1	0	0	0	2	89
Sep	0	0	2	81	2	2	1	1	0	0	0	2	89
Oct	0	0	2	81	2	2	1	0	1	0	0	2	89
Nov	0	0	0	89	0	0	0	0	0	0	0	0	89
Dec	0	0	0	89	0	0	0	0	0	0	0	0	89
Station Elliott													
Jan	0	0	7	82	0	0	0	0	0	0	0	0	89
Feb	0	0	0	89	0	0	0	0	0	0	0	0	89
Mar	1	0	1	77	7	3	0	0	0	0	0	0	89
Apr	0	0	1	83	2	2	1	0	0	0	0	1	89
May	0	0	0	79	8	1	1	0	0	0	0	1	89
Jun	0	0	0	75	12	2	0	0	0	0	0	0	89
Jul	0	0	0	74	13	1	1	0	0	0	0	1	89
Aug	0	0	0	75	10	3	1	0	0	0	0	1	89
Sep	0	0	2	75	8	3	1	0	0	0	0	1	89
Oct	0	0	3	81	1	3	0	1	0	0	0	1	89
Nov	0	0	13	75	1	0	0	0	0	0	0	0	89
Dec	0	0	13	75	1	0	0	0	0	0	0	0	89
Station Golf													
Jan	0	0	13	75	1	0	0	0	0	0	0	0	89
Feb	0	0	0	83	6	0	0	0	0	0	0	0	89
Mar	0	1	1	69	18	0	0	0	0	0	0	0	89
Apr	0	0	1	77	10	1	0	0	0	0	0	0	89
May	0	0	0	63	23	2	0	1	0	0	0	1	89
Jun	0	0	0	60	26	3	0	0	0	0	0	0	89
Jul	0	0	0	42	41	3	1	2	0	0	0	3	89
Aug	0	0	0	51	33	2	1	2	0	0	0	3	89
Sep	0	0	2	57	27	1	2	0	0	0	0	2	89
Oct	0	0	1	83	4	1	0	0	0	0	0	0	89
Nov	0	2	12	74	1	0	0	0	0	0	0	0	89
Dec	0	2	14	72	1	0	0	0	0	0	0	0	89

Month	<-1.0	<-0.5 and >=-1.0	<-0.05 and >=-0.5	>-0.05 and <0.05	>0.05 and <=0.5	>0.5 and <=1.0	>1.0 and <=1.5	>1.5 and <=2.0	>2.0 and <=2.5	>2.5 and <=3.0	>3.0	Total >1.0	Total
Station Frandy													
Jan	0	0	15	72	2	0	0	0	0	0	0	0	89
Feb	0	0	0	76	13	0	0	0	0	0	0	0	89
Mar	0	0	1	66	21	0	1	0	0	0	0	1	89
Apr	0	0	2	74	12	0	1	0	0	0	0	1	89
May	0	0	0	57	28	3	0	0	0	0	1	1	89
Jun	0	0	0	52	33	3	1	0	0	0	0	1	89
Jul	0	0	0	42	37	4	2	1	0	1	2	6	89
Aug	0	0	0	48	34	4	0	0	0	1	2	3	89
Sep	0	0	0	52	31	3	0	1	0	1	1	3	89
Oct	0	0	3	69	17	0	0	0	0	0	0	0	89
Nov	0	2	15	70	2	0	0	0	0	0	0	0	89
Dec	2	0	17	68	2	0	0	0	0	0	0	0	89

3.1.3.3 Dissolved Oxygen Analysis

Evaluation of flow releases from Camanche Dam, water temperatures below Camanche Dam, and Camanche Reservoir surface elevations from January 1998 through October 2012 show a significant relationship ($P < 0.001$) with water column dissolved oxygen concentrations below Camanche Dam. Flow, temperature, and reservoir surface elevations explain about 57% of the variability of water column dissolved oxygen at Station 11, about 0.50 mile below Camanche Dam (Figure 3.1-23). This regression relationship was used along with EBMUDSIM and water temperature model results to estimate changes in dissolved oxygen downstream of Camanche Dam that could result from the Project. Based on these results (Figure 3.1-24), the Project would have only a small effect on dissolved oxygen in the Mokelumne River. In this water resources section, potential changes in dissolved oxygen are compared to the WQCP minimum dissolved oxygen objective of 7.0 mg/L. In Section 3.2, Fish Resources, potential changes in dissolved oxygen are compared to dissolved oxygen objectives for salmonid life stages.

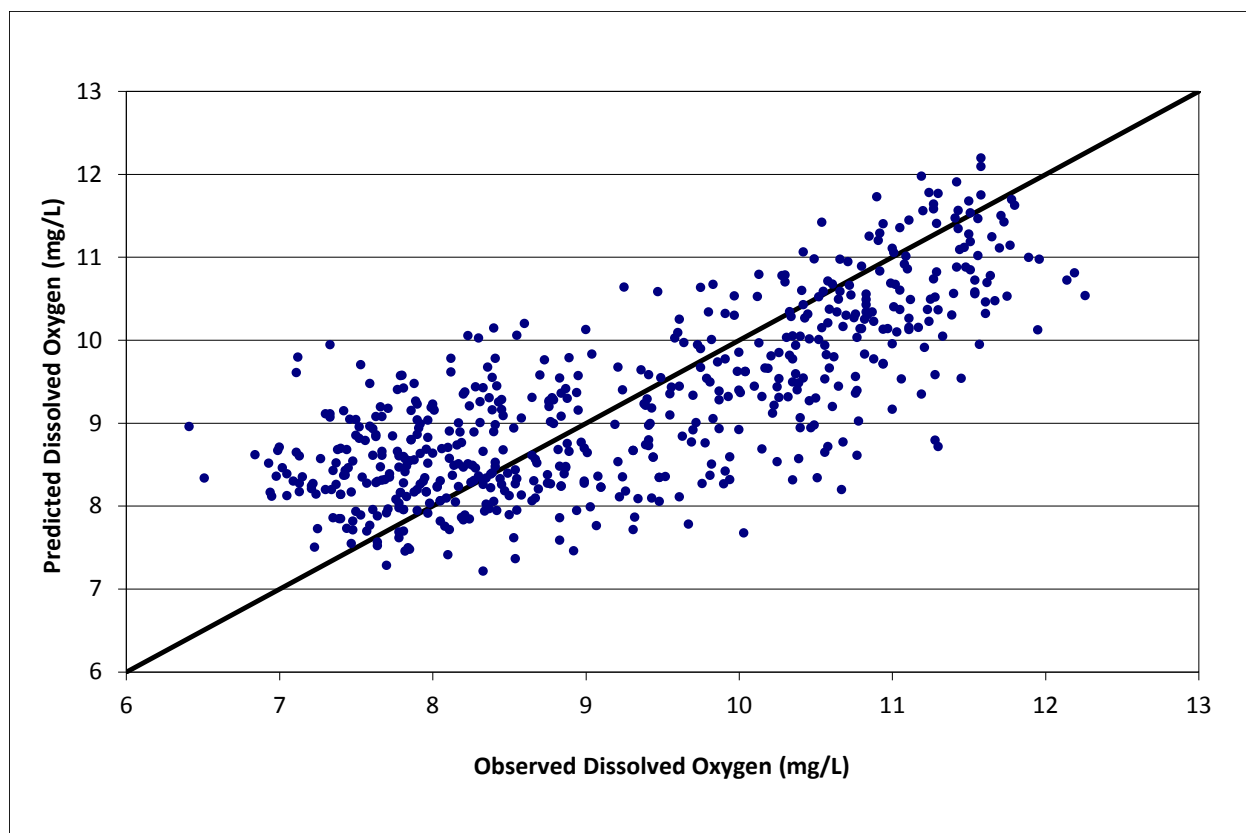


Figure 3.1-23
Comparison of Measured and Predicted Dissolved Oxygen Concentrations at Station 11
in the Lower Mokelumne River

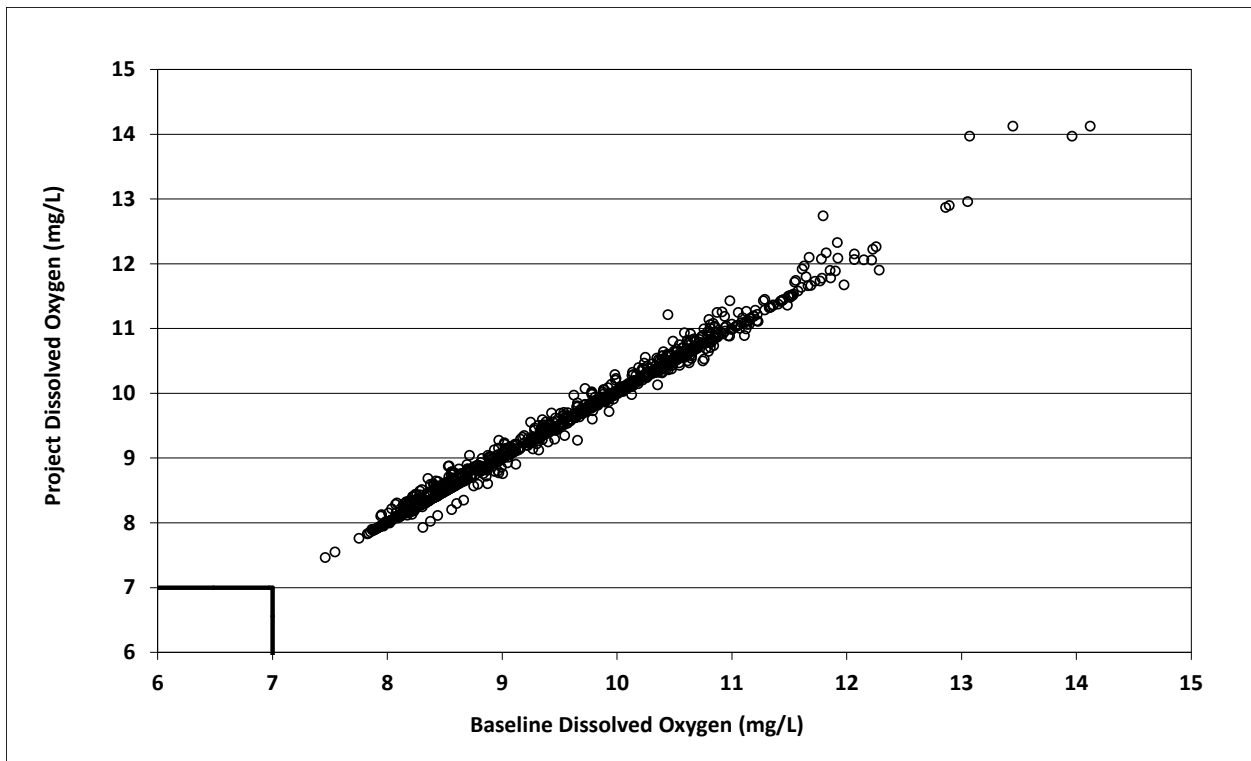


Figure 3.1-24

Comparison of Estimated Baseline and Permit 10478 Time Extension Project Monthly Dissolved Oxygen Concentrations below Camanche Dam (1921-2009 Hydrology)

3.1.3.4 Delta Analysis

DWR keeps records of the major inflows and outflows of the Delta in its DAYFLOW program. The DAYFLOW data were used in conjunction with the EBMUDSIM results to estimate project effects on the Delta. Project effects on the Delta were evaluated for the period January 1970 (shortly after Banks Pumping Plant was constructed) through December 2009 (the end of the EBMUDSIM simulation period).

Inflow to the Delta is large. Table 3.1-5 compares Mokelumne River inflow to the Delta to total inflow to the Delta on a monthly basis. DAYFLOW data indicate that for water years 1970 through 2009, monthly average Delta inflow has varied between monthly average flow as low as 4,700 cfs (November) and monthly average flow as high as 267,000 cfs (March), with monthly median flows ranging between about 16,000 cfs (October and November) and 43,000 cfs (February) (Table 3.1-5). The majority of Delta inflow reaches the ocean as outflow. A substantial amount of water is also exported at the SWP Banks and CVP Jones pumping facilities.

Table 3.1-5. Comparison of Historic Total Delta Inflow to Mokelumne River Flows

Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Distribution of Historic Delta Inflows (cfs) (DAYFLOW data for 1970–2009)													
Minimum	9,894	8,833	7,150	6,199	7,609	7,007	8,409	7,828	7,030	4,749	7,151	8,767	7,552
5th	10,919	13,285	15,073	11,281	8,851	9,629	10,266	10,211	10,743	8,806	8,348	10,373	10,649
10th	13,977	14,949	16,567	13,646	11,927	11,585	13,308	13,288	11,773	9,385	9,065	12,400	12,656
50th	35,228	43,009	41,887	23,839	19,816	17,779	20,435	18,901	18,129	15,610	15,555	21,295	24,290
90th	122,819	126,168	107,192	97,135	66,842	41,993	25,875	24,416	28,778	22,853	32,573	84,510	65,096
95th	152,737	184,285	170,006	123,180	87,787	58,895	41,889	26,389	31,709	24,855	43,795	91,760	86,441
Maximum	262,855	227,303	266,621	181,499	104,088	80,632	53,428	35,542	37,543	36,150	71,675	154,696	126,003
Distribution of Historic Mokelumne River Inflow to Delta (cfs) (DAYFLOW data for 1970–2009)													
Minimum	33	20	9	9	8	8	9	7	5	2	23	39	14
5th	43	38	26	20	17	14	18	15	17	34	47	41	27
10th	49	43	34	22	28	24	28	26	30	47	75	49	38
50th	256	301	373	273	287	317	181	72	101	176	281	247	239
90th	2,161	2,419	2,317	2,515	1,766	1,902	989	691	564	721	688	976	1,476
95th	2,471	2,705	2,852	3,033	2,966	2,252	1,996	950	886	919	1,398	1,883	2,026
Maximum	4,746	4,285	4,799	4,181	3,875	3,505	2,561	1,462	1,172	1,285	1,979	2,825	3,056
Distribution of Historic Mokelumne River Inflow to Delta as Percent of Total Delta Inflow (DAYFLOW data for 1970–2009) ^a													
Minimum	0.08	0.08	0.02	0.05	0.10	0.08	0.10	0.07	0.07	0.04	0.24	0.23	0.10
5th	0.18	0.17	0.12	0.12	0.14	0.12	0.11	0.10	0.13	0.22	0.29	0.31	0.17
10th	0.30	0.24	0.15	0.14	0.22	0.20	0.16	0.17	0.23	0.45	0.47	0.35	0.26
50th	1.02	0.84	0.78	1.13	1.36	1.47	0.88	0.39	0.55	1.38	1.72	1.05	1.05
90th	1.94	2.12	2.64	2.98	3.40	4.67	3.95	2.98	2.60	3.57	2.98	1.98	2.98
95th	2.03	2.21	2.89	3.22	4.50	4.86	4.48	3.81	2.92	4.31	3.66	2.20	3.42
Maximum	2.37	3.53	3.90	4.95	6.01	6.06	5.91	4.43	4.04	4.71	3.87	2.64	4.37

^a The values in this third table were not obtained by dividing the values in the first table by the values in the second table. This distribution of percent was generated by dividing the Mokelumne River inflow by the total Delta inflow for each month of each year for 1970 through 2009 (and multiplying by 100). This table shows the distribution of these results.

DAYFLOW data indicate that for water years 1970 through 2009, monthly average Mokelumne River inflow to the Delta has varied between monthly average flow as low as 2 to cfs (October) and as high as 4,800 cfs (March), with the median of the monthly flows ranging between about 70 cfs (August) and 370 cfs (March). The contribution of the Mokelumne River to Delta inflow is relatively small. For water years 1970 through 2009, the monthly average Mokelumne River contribution to Delta inflow varied between values as low as 0.02% (March) and values as high as 6.1% (June) (Table 3.1-5), with an overall average of 1.4%. The DAYFLOW program uses Mokelumne River flow measured at Woodbridge. Actual Delta inflow from the Mokelumne River may be less during periods of low to moderate flow (because of channel losses downstream of Woodbridge) and could be more during the rainy season (because of accretions downstream of Woodbridge).

The effect of the Project on Delta inflow was estimated by comparing the DAYFLOW Delta inflow values to the reduction in flow at Woodbridge estimated to be caused by the Project as simulated with EBMUDSIM. This evaluation was performed by converting the monthly change in flow at Woodbridge to daily values for each month. These daily changes were then used to adjust the DAYFLOW values, and the results are presented in terms of monthly averages for comparative purposes. Note that for this analysis and the analysis of Delta outflow and X2 (described below), the

assessment was based on changes relative to historic DAYFLOW values. For most other analyses of project effects, project conditions were compared to baseline conditions based on EBMUDSIM modeling results. However, in this case, there was no separate calculation or modeling of baseline conditions in the Delta. Modeling of Delta inflow, outflow, and X2 was not performed because it would have required an estimate of how the Delta may have been operated differently under baseline conditions. Because the Mokelumne River inflow is so small compared to total Delta inflow, it is not necessary to create a new baseline simulation for the Delta to understand potential effects of the Project on Delta conditions.

The effect of the Project on Delta inflow would be very small (Table 3.1-6). The Project is expected to result in a less than 0.7% reduction in monthly Delta inflows in most years (95%), assuming 1970 through 2009 hydrology. The estimated median reduction in monthly Delta inflow represented zero to 0.06% of the total (Table 3.1-6). The small reduction in inflow associated with the Project would cause a reduction in Delta outflow (to the ocean), a reduction in evapotranspiration or seepage, or a reduction in Delta exports or diversions, depending on Delta operations and regulations. From a habitat perspective, the largest effects would occur if all reductions in Mokelumne River flow resulted in an equal reduction in Delta outflow. Using this worst-case assumption, the effect of the Project on Delta outflow was estimated to be less than 2.2% in most years (95%). The estimated median reduction in monthly Delta outflow was zero to 0.13% (Table 3.1-6). Because Delta outflow to the ocean is less than Delta inflow, the maximum possible percent reduction in Delta outflow is greater than the percent reduction in Delta inflow, although it is still very small.

Table 3.1-6a. Estimated Percent Decrease in Delta Inflow Associated with the Permit 10478 Time Extension Project for 1970-2009

Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Minimum	-0.01	0.00	0.00	-0.02	0.00	0.00	0.00	0.00	0.00	-0.02	-0.02	-0.20	-0.02
5th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	-0.02	-0.02	-0.01
10th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	0.00
50th	0.00	0.00	0.00	0.00	0.02	0.02	0.04	0.05	0.06	0.00	0.00	0.00	0.02
90th	0.06	0.13	0.05	0.11	0.21	0.40	0.24	0.22	0.21	0.02	0.13	0.07	0.15
95th	0.15	0.46	0.08	0.28	0.42	0.55	0.42	0.51	0.65	0.26	0.26	0.09	0.34
Maximum	0.63	0.89	0.19	0.66	1.67	0.63	0.60	0.57	0.72	0.89	0.71	0.65	0.74

Note: Negative values represent an increase in Delta inflow and outflow

Table 3.1-6b. Estimated Maximum Potential Percent Decrease in Delta Outflow to the Ocean Associated with the Permit 10478 Time Extension Project (Assuming No Reduction in Exports or Diversions from the Delta) for 1970-2009

Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Minimum	-0.01	0.00	0.00	-0.03	0.00	0.00	0.00	0.00	0.00	-0.09	-0.08	-0.39	-0.05
5th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.05	-0.03	-0.01
10th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.01	-0.01
50th	0.00	0.00	0.00	0.00	0.03	0.02	0.04	0.08	0.13	0.00	0.00	0.00	0.03
90th	0.07	0.13	0.06	0.12	0.34	0.71	0.50	0.66	0.79	0.07	0.21	0.09	0.31
95th	0.18	0.54	0.10	0.43	0.53	1.04	1.28	1.47	2.20	0.86	0.48	0.15	0.77
Maximum	2.50	1.41	0.23	1.20	3.90	1.61	1.63	1.97	3.54	2.99	1.61	1.24	1.99

Note: Negative values represent an increase in Delta inflow and outflow

The estimated maximum effect of the Project on Delta outflow can be translated into a salinity effect by estimating the position of X2, the Delta location where water has a salinity of 2 parts per thousand (ppt). X2 is frequently used to assess the occurrence of freshwater habitat in the Delta. X2 can be estimated with the following equation that is used by the DAYFLOW program:

$$X2_t = X2_{t-1} * 0.945 + 10.16 - 1.487 * \text{Log}(\text{OUT})$$

Where:

X2 = Distance (in km) between the Golden Gate Bridge and the location of salinity of 2 ppt

OUT = Delta outflow in cfs; for calculation purposes, this is not allowed to be less than 100 cfs

t = current day (and t-1 = the previous day)

The standard error of this equation has been estimated to be 1.3 kilometers (km) (Kimmerer and Monismith 1992), which is fairly good considering that tidal excursion may be 5 to 10 km (Jassby et al. 1995).

This equation was used to calculate change in X2 position associated with the Project. The estimated change in X2 associated with the Project was very small. Based on DAYFLOW data for 1970 through 2009, X2 has ranged from about 41 km (March) to about 97 km (September) (Table 3.1-7). X2 is typically larger (farther inland) in the late summer and early fall when Delta outflow is low. The estimated maximum potential effect of the Project on monthly average X2 position (assuming a direct translation between a reduction in Delta inflow and a reduction in Delta outflow) would be unchanged or shifted upstream by less than 0.25 km in most years (95% of the time), well within the 1.3 km standard of error (Table 3.1-7), with the median effect for each month being equal to or very close to zero (less than or equal to 0.01 km or approximately 33 feet). The largest estimated potential increases occur when there is a rare co-occurrence of low Delta outflow and moderate project-related effects on flow in the Mokelumne River. The overall estimated median increase in the monthly X2 values was a nominal 0.001 km (4 feet). Note that estimated project effects on X2 are presented as a change in distance because the distance has a direct correspondence to amount of freshwater habitat. In contrast, project effects on flow are given as a percent because a change in flow is relevant only if it represents a significant percent of the total flow.

Actual project effects on X2 would be less than those presented here because these calculations make the assumption that all of the project-related reduction in flow would be translated directly into a reduction in Delta outflow. This assumption was made to evaluate maximum potential project effects on water quality and fish (see Section 3.2, Fish Resources). In reality, much of the water from the Mokelumne River never reaches the ocean; it is lost to diversions, evapotranspiration, and probably some seepage between Woodbridge and Station Frandy; however, it is difficult to estimate how much of the Mokelumne River flow is lost between Woodbridge and the San Pablo Bay.

Table 3.1-7. Estimated Maximum Potential Effect of the Permit 10478 Time Extension Project on X2 Position (Assuming No Reduction in Exports or Diversions from the Delta)

Historic X2 Position (kilometers) (DAYFLOW data for 1970 – 2009)													
Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Minimum	46.51	44.81	40.89	44.14	48.18	51.74	56.19	63.70	63.91	62.85	60.31	50.48	52.81
5th	50.30	46.86	46.93	47.59	49.65	54.98	61.45	70.92	68.99	69.26	67.04	56.99	57.58
10th	53.44	50.67	49.69	49.28	52.94	59.82	69.10	74.51	70.53	71.57	69.78	60.45	60.98
50th	69.30	64.57	62.53	67.40	72.32	76.92	81.55	82.51	84.43	85.21	83.95	78.61	75.77
90th	83.10	84.23	77.70	80.93	85.26	87.47	88.62	90.08	92.94	91.85	89.31	85.90	86.45
95th	86.12	85.12	87.87	82.98	87.03	88.12	90.08	91.22	93.68	93.56	89.57	86.73	88.51
Maximum	87.08	90.88	91.65	91.47	90.44	93.29	91.77	91.81	96.96	94.73	91.00	89.19	91.69

Maximum Potential Increase in X2 (kilometers) for 1970-2009 Associated with the Permit 10478 Time Extension Project ^a													
Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	0.00
5th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50th	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
90th	0.02	0.03	0.02	0.02	0.03	0.07	0.08	0.07	0.09	0.09	0.04	0.03	0.05
95th	0.03	0.04	0.03	0.03	0.04	0.10	0.15	0.17	0.25	0.20	0.14	0.07	0.10
Maximum	0.24	0.25	0.14	0.11	0.37	0.19	0.17	0.22	0.35	0.23	0.31	0.32	0.24

^a This distribution of potential increases in X2 is based on individual increases for each month of each year for 1970 through 2009. The values in this second table do not necessarily align with those in the first table. For example, the 90th percentile increase in X2 of 0.08 km for July under the Permit 10478 Time Extension Project did not occur at the same time as the 90th percentile X2 value of 88.62 km.

3.1.3.5 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 the Project would not involve any construction of new facilities, nor would any existing facilities be modified, only those criteria that are relevant to this analysis are listed below. Impacts on hydrology and water quality may be considered significant if the Project would

- violate any water quality standards or waste discharge requirements;
- 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.

3.1.3.6 Impact Discussion

The primary impact mechanisms for water resources are changes in lower Mokelumne River flow, which could affect groundwater recharge, reduce flooding, or affect water quality in the Delta. Significant and less-than-significant impacts on water resources associated with these changes are described in the following sections. Project-related effects of hydrology on fish resources; vegetation, wetland, and wildlife resources; agricultural resources; recreational resources; and visual resources are described in Sections 3.2, 3.3, 3.4, 3.5, and 3.6, respectively.

Significant Impacts

As explained below under Less-Than-Significant Impacts, changes in lower Mokelumne River flow associated with the Project 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 Project is unlikely to have much effect on channel shape because reduction in flow would be small (overall reduction of 3.2% of flow below Camanche Dam as described above).

Based on EBMUD's stage/discharge data for the streamflow stations in the lower Mokelumne River near Lockford (Elliott) and at Woodbridge Dam (Golf), at low flows (less than 325 cfs at Elliott Road Bridge, about midway between Camanche Dam and Lodi Lake) a 10% flow reduction results in a reduction in river stage height of less than 2 inches. At higher flows (1,000 to 2,000 cfs at Elliott Road Bridge) a 10% reduction in flows results in a river stage height reduction of 5 to 9 inches.

In EBMUDSIM, channel losses (including seepage to groundwater) are modeled as being dependent on flow. However, the model predicts little change in channel losses associated with the Project. Under both baseline and project scenarios, annual modeled channel losses would range from a maximum of 120,000 AFY to a minimum of 56,000 AFY, with medians equal to 56,000 AFY (i.e., more than half the values are equal to the minimum). Average annual channel losses would be 63,700 acre-feet and 63,200 acre-feet under baseline and project conditions, respectively reflecting an average annual reduction of about 500 acre-feet.

The Project would have a negligible effect on groundwater recharge, and there would be no substantial depletion of groundwater supplies. This impact is considered *less than significant*. No mitigation is necessary.

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

As described in Section 3.1.1, Environmental Setting, a flow of 3,000 cfs could produce floodplain inundation (and potentially flood-related damage) downstream of Woodbridge Dam. Because EBMUDSIM works on a monthly time scale, a comparison of monthly average to the monthly maximum of the daily flows was used to estimate monthly average flows that would indicate a daily flow greater than 3,000 cfs. Based on measured flow data from the lower Mokelumne River at Woodbridge Dam, a month with average flow of 1,900 cfs is likely to have at least 1 day with flow exceeding 3,000 cfs.

Floodplain inundation is generally beneficial for fish resources and is, therefore, evaluated from a different perspective in Section 3.2, Fish Resources. Whereas flood damage can occur with 1 day of flooding, fish benefit mostly from relatively prolonged inundation of the floodplain. As a result, the EBMUDSIM monthly average flow threshold used in the fish assessment was higher (3,000 cfs).

Project-related flow reductions in the lower Mokelumne River have the potential to reduce flooding, which is considered a beneficial effect. For the 89-year hydrologic period evaluated by EBMUDSIM (1921 through 2009), the baseline scenario was simulated to have 43 months with average flow exceeding 1,900 cfs, whereas the project scenario was simulated to have 41 months with average flow exceeding 1,900 cfs.

The frequency of flows that are greater than 1,900 cfs would be only slightly reduced under the project scenario; therefore, this is considered to be a *less-than-significant* impact. No mitigation is necessary.

Impact WR-3: Potential for changes in Camanche Reservoir storage and Mokelumne River flow to affect water quality in the Mokelumne River (Less than Significant)

The only water quality constituents with potential to be negatively affected by the Project are dissolved oxygen and water temperature. The potential effects of the Project on water temperature and dissolved oxygen are discussed from a fish perspective in Section 3.2, Fish Resources. Section 3.2 presents the predicted effects of the Project on dissolved oxygen in the Mokelumne Rivers as estimated using the regression relationship between dissolved oxygen and Camanche release flows, Camanche release temperatures, and Camanche water-surface elevation that is described above in Section 3.1.3.3. Based on these results (Figure 3.1-24), the Project would have only a small effect on dissolved oxygen in the Mokelumne River and it would not cause dissolved oxygen concentration in the Mokelumne River to fall below the 7.0 mg/L objective of the CVRWQCB. This impact is considered to be *less-than-significant*. No mitigation is necessary.

Impact WR-4: Potential for changes in Mokelumne River flow to affect water quality in the Delta (Less than Significant)

The Mokelumne River generally has good water quality with the exception of some toxics (see the water quality discussion above under Section 3.1.1, Environmental Setting). If flow in the Mokelumne River is reduced, there is some potential for water quality in the Delta to be affected by minor water temperature increases and reduced dilution of pollutants present in the Delta. However, the Mokelumne River contributes very little water to the Delta. Based on DAYFLOW data for water years 1970 through 2009, the average contribution of the Mokelumne River to total Delta inflow was only 1.4% (see Section 3.1.3.4, Delta Analysis, above). Because the majority of water in

the Delta does not originate from the Mokelumne River and because the flow effects associated with the Project would be small, it is unlikely that the Project could noticeably affect water quality in the Delta.

For the period of overlap (1970 through 2009) between the EBMUDSIM results and the DAYFLOW data that were evaluated for the Delta assessment (Tables 3.1-5, 3.1-6, and 3.1-7), the Project would be expected to result in a less than 0.7% reduction in monthly Delta inflows in most years (95%), assuming 1970 through 2009 hydrology. The median monthly reductions in Delta inflow was zero for most months and less than 0.1% for the other months (i.e., undetectable).

To assess maximum potential saltwater intrusion effects associated with this reduction, the reduction in inflow was assumed to have a direct effect on Delta outflow (as opposed to a reduction in Delta diversions). This estimated maximum possible reduction in Delta outflow was used to estimate maximum possible effects on X2, an indicator of saltwater intrusion. The estimated maximum potential effect of the Project on monthly average X2 position (assuming a direct translation between a reduction in Delta inflow and outflow) would be unchanged or shifted upstream by less than 0.25 km in most years (95% of the time) (Table 3.1-7). The overall estimated maximum effect of the Project on the median of all the monthly X2 values is an immeasurable increase of 0.001 km (4 feet). This increase is much less than the standard error of the X2 equation, which has been estimated to be 1.3 km (Kimmerer and Monismith 1992).

Because the Project would have minimal effects on Delta inflow and, therefore, minimal effects on Delta water quality, potential effects associated with the Project on Delta water quality are considered to be *less than significant*. No mitigation is necessary.

3.2 Fish Resources

This section describes fish resources in the project area and assesses the significance of the impacts associated with implementing the Permit 10478 Time Extension Project (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. Other fish, including delta smelt (*Hypomesus transpacificus*), green (*Acipenser medirostris*) and white sturgeon (*Acipenser transmontanus*), hardhead (*Mylopharodon conocephalus*), hitch (*Lavinia exilicaudia*), longfin smelt (*Spirinchus thaleichthys*), Pacific lamprey (*Lampetra tridentate*), prickly sculpin (*Cottus asper*), Sacramento blackfish (*Orthodon microlepidotus*), Sacramento pikeminnow (*Ptychocheilus grandis*), Sacramento splittail (*Pogonichthys macrolepidotus*), Sacramento sucker (*Catostomus occidentalis*), and tule perch (*Hysterocarpus traski*) are discussed because they are native species that have been observed or may occur in the lower Mokelumne River. Striped bass (*Morone saxatilis*) and American shad (*Alosa sapidissima*), which typically occur below the Woodbridge Irrigation District (WID) Dam (Woodbridge Dam) in the lower Mokelumne River, are described because of their recreational importance. This section also describes potential impacts on recreational fisheries (rainbow trout [*Oncorhynchus mykiss*], kokanee salmon [*O. nerka*], and black bass [*Micropterus spp.*]) in Pardee and Camanche Reservoirs.

This analysis concludes that the Project would not result in significant impacts on fish resources after implementing mitigation measures.

3.2.1 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 (Table 3.2-1). 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) 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.

Six native and 17 introduced fish species have been observed in Pardee and Camanche Reservoirs (Table 3.2-2). The principal game species in these reservoirs are rainbow trout; kokanee (Pardee Reservoir); largemouth bass (*M. salmoides*), spotted bass (*M. punctulatus*), and smallmouth bass (*M. dolomieu*); crappie (*Pomoxis spp.*); sunfish (*Lepomis spp.*); and catfish (*Ameiurus spp.*).

3.2.1.1 Lower Mokelumne River

The lower Mokelumne River extends about 72.5 miles from Camanche Dam to its confluence with the San Joaquin River (Figure 3.2-1). 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 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.

Table 3.2-1. Fish Species Observed in the Lower Mokelumne River

Family	Common Name	Scientific Name	Distribution
Petromyzontidae: Lamprey Family	Pacific lamprey	<i>Lampetra tridentata</i>	Native
Acipenseridae: Sturgeon Family	White sturgeon	<i>Acipenser transmontanus</i>	Native
	Green sturgeon	<i>Acipenser medirostris</i>	Native
Clupeidae: Herring Family	Threadfin shad	<i>Dorosoma pretenense</i>	Introduced
	American shad	<i>Alosa sapidissima</i>	Introduced
Cyprinidae: Minnow Family	Hitch	<i>Lavinia exilicaudia</i>	Native
	Sacramento splittail	<i>Pogonichthys macrolepidotus</i>	Native
	Sacramento blackfish	<i>Orthodon microlepidotus</i>	Native
	Sacramento pikeminnow	<i>Ptychocheilus grandis</i>	Native
	Hardhead	<i>Mylopharodon conocephalus</i>	Native
	Golden shiner	<i>Notemigonus crysoleucas</i>	Introduced
	Goldfish	<i>Carassius auratus</i>	Introduced
	Common carp	<i>Cyprinus carpio</i>	Introduced
Catostomidae: Sucker Family	Sacramento sucker	<i>Catostomus occidentalis</i>	Native
Ictaluridae: Catfish Family	Black bullhead	<i>Ameiurus melas</i>	Introduced
	Brown bullhead	<i>Ameiurus nebulosus</i>	Introduced
	White catfish	<i>Ameiurus catus</i>	Introduced
	Channel catfish	<i>Ictalurus punctatus</i>	Introduced
Osmeridae Smelt Family	Delta smelt	<i>Hypomesus transpacificus</i>	Native
	Wakasagi	<i>Hypomesus nipponensis</i>	Introduced
Salmonidae: Salmon and Trout Family	Chinook salmon	<i>Oncorhynchus tshawytscha</i>	Native
	Chum salmon	<i>Oncorhynchus keta</i>	Native
	Kokanee	<i>Oncorhynchus nerka</i>	Native
	Steelhead/rainbow trout	<i>Oncorhynchus mykiss</i>	Native

Family	Common Name	Scientific Name	Distribution
Atherinopsidae: Siversides Family	Inland silversides	<i>Menidia beryllina</i>	Introduced
Poeciliidae: Livebearers	Western mosquitofish	<i>Gambusia affinis</i>	Introduced
Cottidae: Sculpin Family	Prickly sculpin	<i>Cottus asper</i>	Native
Moronidae: Striped Bass Family	Striped bass	<i>Morone saxatilis</i>	Introduced
Centrarchidae: Sunfish Family	Bluegill	<i>Lepomis macrochirus</i>	Introduced
	Pumpkinseed	<i>Lepomis gibbosus</i>	Introduced
	Redear sunfish	<i>Lepomis microlophus</i>	Introduced
	Warmouth	<i>Lepomis gulosus</i>	Introduced
	Green sunfish	<i>Lepomis cyanellus</i>	Introduced
	White crappie	<i>Pomoxis annularis</i>	Introduced
	Black crappie	<i>Pomoxis nigromaculatus</i>	Introduced
	Largemouth bass	<i>Micropterus salmoides</i>	Introduced
	Smallmouth bass	<i>Micropterus dolomieu</i>	Introduced
	Redeye bass	<i>Micropterus coosae</i>	Introduced
	Spotted bass	<i>Micropterus punctulatus</i>	Introduced
Percidae: Perch Family	Bigscale logperch	<i>Percina macrolepida</i>	Introduced
Embiotocidae: Surfperch Family	Tule perch	<i>Hysterocarpus traski</i>	Native
Gobiidae: Goby Family	Yellowfin goby	<i>Acanthogobius flavimanus</i>	Introduced
Source: EBMUD data			

Table 3.2-2. Fish Species Observed in Pardee and Camanche Reservoirs

Family	Common Name	Scientific Name	Distribution	Reservoir	
Clupeidae: Herring Family	Threadfin shad	<i>Dorosoma pretenense</i>	Introduced	C	
Cyprinidae: Minnow Family	Hitch	<i>Lavinia exilicaudia</i>	Native	C	
	Sacramento blackfish	<i>Orthodon microlepidotus</i>	Native	C	
	Sacramento pikeminnow	<i>Ptychocheilus grandis</i>	Native	P	C
	Golden shiner	<i>Notemigonus crysoleucas</i>	Introduced	P	C
	Goldfish	<i>Carassius auratus</i>	Introduced	C	
	Common carp	<i>Cyprinus carpio</i>	Introduced	P	C
Catostomidae: Sucker Family	Sacramento sucker	<i>Catostomus occidentalis</i>	Native	P	C
Ictaluridae: Catfish Family	Black bullhead	<i>Ameiurus melas</i>	Introduced	C	
	White catfish	<i>Ameiurus catus</i>	Introduced	P	C
	Channel catfish	<i>Ictalurus punctatus</i>	Introduced	P	C
Salmonidae: Salmon and Trout Family	Kokanee	<i>Oncorhynchus nerka</i>	Introduced	P	C
	Rainbow trout	<i>Oncorhynchus mykiss</i>	Native	P	
Poeciliidae: Livebearers	Western mosquitofish	<i>Gambusia affinis</i>	Introduced	C	
Cottidae: Sculpin Family	Prickly sculpin	<i>Cottus asper</i>	Native	P	C
Centrarchidae: Sunfish Family	Bluegill	<i>Lepomis macrochirus</i>	Introduced	P	C
	Redear sunfish	<i>Lepomis microlophus</i>	Introduced	P	C
	Green sunfish	<i>Lepomis cyanellus</i>	Introduced	P	C
	White crappie	<i>Pomoxis annularis</i>	Introduced	C	
	Black crappie	<i>Pomoxis nigromaculatus</i>	Introduced	P	C
	Largemouth bass	<i>Micropterus salmoides</i>	Introduced	P	C
	Smallmouth bass	<i>Micropterus dolomieu</i>	Introduced	P	C
	Spotted bass	<i>Micropterus punctulatus</i>	Introduced	C	
P = Pardee Reservoir; C = Camanche Reservoir Source: EBMUD data					

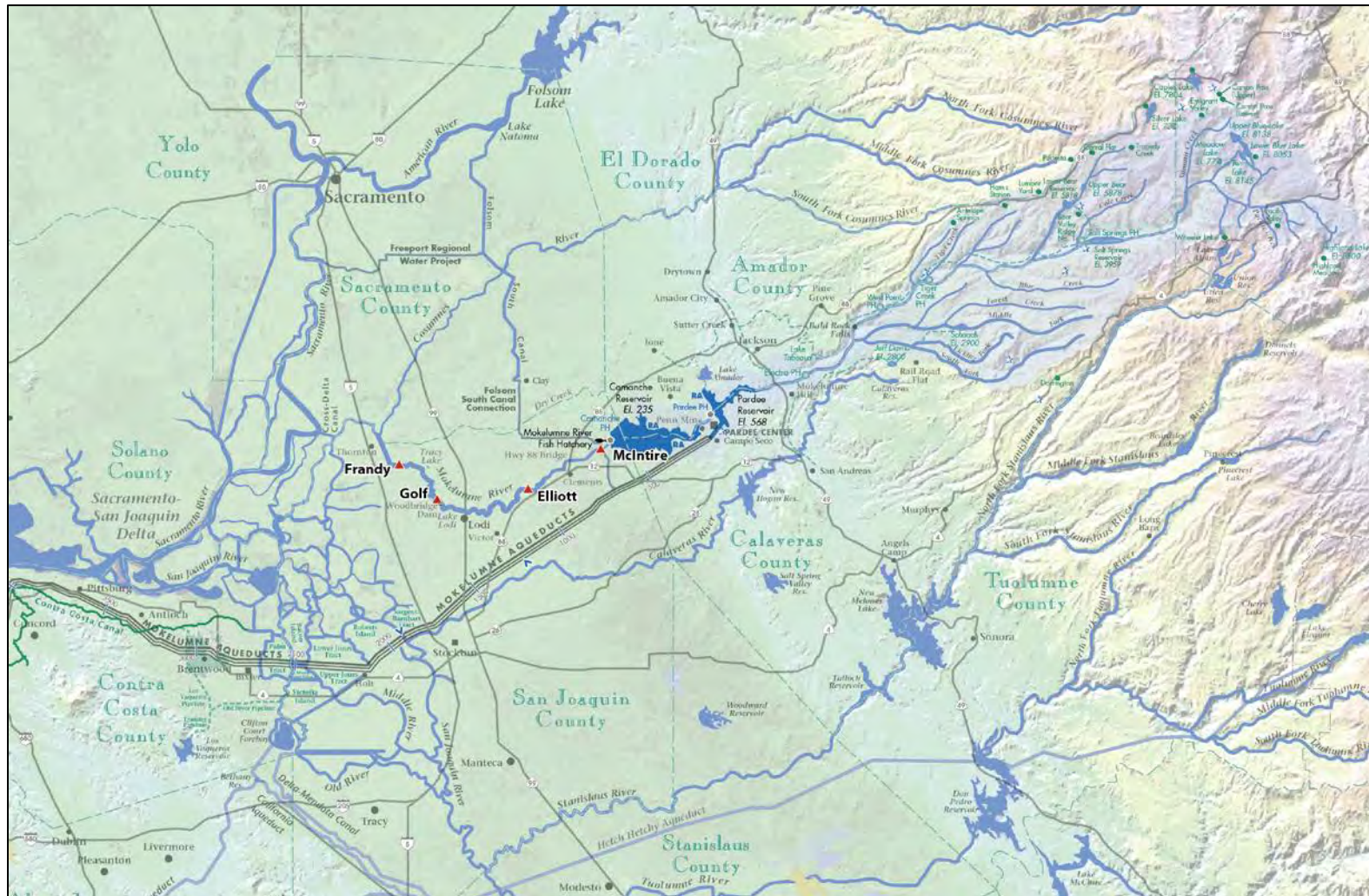


Figure 3.2-1

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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

The National Marine Fisheries Service (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 3.2-3). 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 (Figure 3.2-1).

Chinook salmon spawn in the lower Mokelumne River typically from October through December (Table 3.2-3), 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 3.2-3).

Table 3.2-3. 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.												

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.

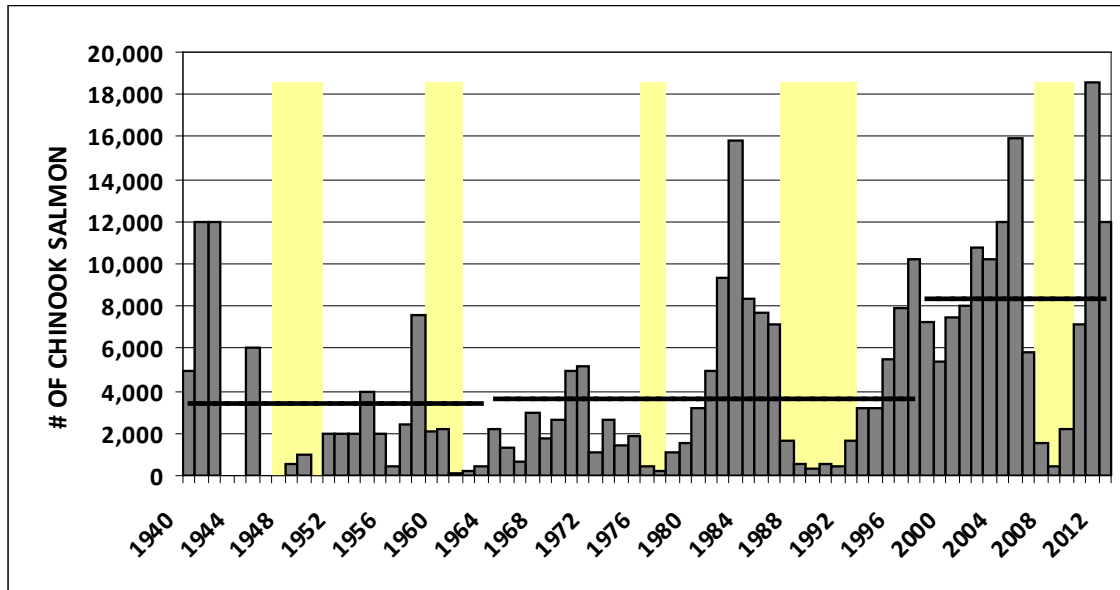
Optimal temperatures for Central Valley fall-run Chinook salmon fry growth and survival are 13 to 18 degrees Celsius (°C), although throughout their range, positive growth is experienced at temperatures of 5 to 19°C (Moyle 2002). Major mortality occurs at 22 to 23°C and maximum embryo survival temperatures 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 3.2-2). 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 (JSA), which contains a suite of comprehensive flow and non-flow measures to protect and enhance the Mokelumne fishery. (See Appendix D for a summary of the JSA.) Chinook salmon escapement from 1993 through 2006 averaged over 8,000 annually. The adult return to the river in 2007–2009 was, however, 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 3.2-2.)

Chinook salmon production in the lower Mokelumne River is supplemented by hatchery fish reared at the Mokelumne River Fish Hatchery. Since 1998, the California Department of Fish and Wildlife (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).



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 3.2-2
Estimated Annual Spawning Escapement of Fall-Run Chinook Salmon
in the Lower Mokelumne River since 1940

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 3.2-3).

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).

NMFS is in the process of developing a recovery plan for Central Valley salmonids, including steelhead. The Central Valley steelhead recovery priority for the Mokelumne River population is Core 3 (National Marine Fisheries Service 2009). Core 3 populations are present on an intermittent basis and are characterized as being dependent on other nearby populations for their existence.

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—are discussed in Appendix I because they are native species that 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 described in

Appendix I because of their recreational importance. Table 3.2-4 summarizes the native and recreationally important species that typically occur in the lower Mokelumne River.

Table 3.2-4. Native and Recreationally Important Fish Species Occurrence in the Lower Mokelumne River

Species/Primary Location	January	February	March	April	May	June	July	August	September	October	November	December
American shad (Woodbridge Dam to Delta)												
Delta smelt (Mokelumne Forks to Delta)												
Hardhead (Camanche Dam to Delta)												
Hitch (Camanche Dam downstream to Delta)												
Pacific lamprey (Camanche Dam to Delta)												
Prickly sculpin (Camanche Dam to Delta)												
Sacramento blackfish (Woodbridge Dam to Delta)												
Sacramento pikeminnow (Camanche Dam to Delta)												
Sacramento splittail (Camanche Dam to Delta)												
Sacramento sucker (Camanche Dam to Delta)												
Striped bass (Woodbridge Dam to Delta)												
Tule perch (Camanche Dam to Delta)												

Note: Darker shading indicates primary spawning period.

Source: Appendix I and EBMUD data

3.2.1.2 Pardee and Camanche Reservoirs

Pardee and Camanche Reservoirs support recreational fisheries for rainbow trout; kokanee (Pardee Reservoir only); largemouth, spotted, and smallmouth bass; sunfish; crappie; and catfish. Most game species are introduced (nonnative) and maintained by natural production or hatchery plants (e.g., kokanee and rainbow trout). Other species include native Sacramento sucker and pikeminnow and nonnative carp, golden shiner, inland silversides, and threadfin shad.

Warmwater game species, such as largemouth bass, sunfish, and catfish, spawn in Camanche and Pardee Reservoirs primarily from March through June. These species spawn in littoral habitat (shallow nearshore areas) within or adjacent to cover (e.g., rocks, woody debris, vegetation). This

habitat also provides important rearing habitat of juveniles through the spring and summer. Consequently, the availability and stability of littoral habitat through the spring and summer generally determines the reproductive success of bass and other warmwater fishes.

Coldwater game species, such as trout and kokanee, use pelagic habitat (deeper, colder offshore areas) where they concentrate during the summer months. The coldwater fisheries in Pardee and Camanche Reservoirs are maintained by annual stocking of hatchery rainbow trout and limited natural production of trout and kokanee (Pardee Reservoir only).

3.2.1.3 History of Salmon and Steelhead Populations in the Mokelumne River

For more than 150 years, California's Central Valley rivers have experienced major disruptions. The Mokelumne River is no exception. Since the mid-1800s, mining, winery and cannery operations, agriculture, and water diversions have adversely affected the Mokelumne River.

Historically, the Mokelumne River supported fall- and spring-run Chinook salmon, and Yoshiyama et al. (2001) suggest that a late-fall run also may have occurred, at least until the mid-19th century. There is debate as to whether indigenous steelhead naturally existed in the Mokelumne River prior to releases of out-of-basin hatchery stocks in the 20th century (Cramer et al. 1995; McEwan and Jackson 1996).

Historical river flows suggest that spring-run Chinook salmon were probably the dominant run until the mid-1800s because fall flows were relatively low and naturally occurring high water temperatures may have created a migratory barrier in the lower river. Bald Rock Falls (about 7 miles upstream of Pacific Gas and Electric Company's (PG&E's) Electra Powerhouse) is a natural fish passage barrier and was the upstream limit for anadromous salmonids according to Woodhall (1946). The conversion of the Mokelumne River Chinook salmon population from a spring run-dominated population to one dominated by fall run appears to have occurred prior to the construction of Pardee and Camanche Reservoirs. Spring-run populations declined in the mid- to late 1800s as a result of mining activities in the Mokelumne River (described below) such that by 1884 it was reported that

This [San Joaquin River] is a very good stream for the fall run of salmon, the ascent being not very steep, and the current, especially the first seventy-five miles, not very strong. The different branches form fine spawning grounds, providing the fish could reach their headwaters (California State Board of Fish Commissioners 1884).

Collins (1892) reported that

Salmon do not run into the San Joaquin River in large numbers. In the fall, when the fishery is at its best, fishermen go a few miles up to the Mokelumne, a small stream that empties into the San Joaquin, about 20 miles above Black Diamond.

Pollution from mining, winery and cannery operations, construction of dams, and water diversions has resulted in loss of habitat, physical barriers, and direct mortality. Fish populations have been affected by changes in species introductions, hatchery practices, water flow, chemistry, and temperatures during critical periods of migration, spawning, emergence, and rearing. As a result, fish populations have fluctuated substantially, and fish communities have changed.

Mining

Dramatic degradation of the Mokelumne River began with the discovery of gold in 1848. By 1850, so much water was diverted for gold mining that the riverbed periodically was left dry (Taylor 1850). Gold production peaked in 1854 and declined steadily until the turn of the century (Central Valley Regional Water Pollution Control Board 1952). Aggregate mining along the Mokelumne River is documented as early as 1931 (Clark 1955). Sand and gravel were actively mined for about 30 years from numerous sites in the lower Mokelumne River from roughly the town of Clements upstream to what is now the base of Camanche Dam.

Copper was discovered in 1861 along the Mokelumne River at Penn Mine, near the upper end of what is now Camanche Reservoir, and mined intensively between 1899 and 1919. By 1926 the mine shafts were filled with water. Penn Mine was one of the four largest copper mines in California. Mining techniques and the lack of restrictions on waste disposal resulted in lethal heavy metal concentrations in the Mokelumne River (California Department of Fish and Game 1956). The discharge of water from Penn Mine caused many documented fish losses. In 1937, a shaft of Penn Mine was drained so that mining operations could be resumed. The water was discharged directly into the river, eliminating all aquatic life in the river for 96 kilometers downstream (Shaw and Tower 1937; Finlayson and Rectenwald 1978).

The federal government operated Penn Mine during World War I and World War II. In 1943, Penn Mine was completely drained; water was pumped from the mine directly into the river and eliminated all downstream aquatic life, including steelhead, from 1943 to 1944 (California Department of Fish and Game 1956). Other incidents of pollution occurred from 1943 to 1946, and fish did not return to the upper river until 1949 (California Department of Fish and Game 1956). The site was mined intensively through 1949 and periodically through 1956. In 1952, heavy metal concentrations in the river were near or exceeded lethal limits for fish even though the mine was barely operational (Paul 1952).

The mine was abandoned in 1956, but the heavy metal-laden ore deposits and settling ponds continued to cause widespread fish kills along the Mokelumne River (Finlayson and Rectenwald 1978). Although EBMUD never owned or operated Penn Mine, in the early 1960s it acquired a portion of the mine tailings and surface water drainage as part of the development of Camanche Reservoir. In 2003, EBMUD and the Central Valley Regional Water Quality Control Board (CVRWQCB) completed cleanup of the Penn Mine site and were successful in returning the site to a natural "pre-mining" condition.

Winery and Cannery Waste

Wineries began discharging organic waste into the lower Mokelumne River in about 1933. Organic waste harms aquatic life because it depletes dissolved oxygen as it decomposes. By 1935, more than 475,500 gallons of winery waste were being dumped into the river each day (San Joaquin County Health District 1935). In 1937, dissolved oxygen levels in the river fell below that needed to support fish life, resulting in fish losses downstream of the wineries and a blockage of upstream passage (California Division of Fish and Game 1937). In 1939, low levels of dissolved oxygen again resulted in the loss of several hundred salmon and blocked upstream migration (Hatton 1940). Most of the wineries were closed between 1940 and 1943, but resumed releasing effluent directly into the river in 1943. By 1945 the salmon runs had virtually disappeared (California Department of Fish and Game 1956).

Canneries also discharged organic waste into the river. In 1948, discharges from the Thornton Cannery reduced oxygen levels in the river to almost zero. By 1952, both winery and cannery discharges were being treated to comply with state regulations.

Dams

Construction of dams in the Mokelumne River watershed has hindered fish migration since at least 1891, when a dam was constructed near the present site of the Woodbridge Dam. This dam had no fish ladder. In 1910, the wooden dam was replaced with a 164-foot-wide flashboard dam that was in place from April through October during the irrigation season. The dam had no fish ladder until 1925. The first fish ladder was constructed in 1925 and was replaced in 1948 with a more effective structure. This ladder was washed out in 1950 when flows were over 25,000 cubic feet per second (cfs). A new fish ladder was built in 1955 and an additional Denil fishway was installed in 1972 to aid fish passage. Water is diverted at Woodbridge Dam through the WID canal, which has a maximum capacity of 415 cfs and usually operates from March through October. Fry and Petrovich (1970) concluded that for decades, the lack of a fish screen on the canal was a major block to the rehabilitation of Mokelumne River salmon runs. CDFW built a fish screen across the WID canal in 1968 to prevent further loss of outmigrating salmon and steelhead; however, the mesh size of the screen was inadequate to prevent outmigrating salmon smaller than 1.6 inches from passing through the screen into the canal (Vogel 1992).

EBMUD has worked cooperatively with WID since 1998 to support WID's Lower Mokelumne River Restoration Program (LMRRP) to improve fish passage at Woodbridge Dam while maintaining WID's access to its water rights. In 2004 to 2005, WID replaced the existing Woodbridge Dam with a new adjustable weir dam immediately upstream. Modern fish passage facilities also were constructed at Woodbridge Dam, with improved design to attract fish to the ladders. Improvements to downstream fish passage facilities included construction of a new fish screen at WID's diversion canal, a new bypass pipeline to transport fish from the fish screen to a location below the dam, and modifying the tailwater portion of the dam and riverbed to reduce holding areas for predatory fish.

In 1897, the Blue Springs Electra Powerhouse was constructed by the predecessor to PG&E about 2 miles upstream from Middle Bar. Within a year, it was replaced with a new Electra Powerhouse several miles upstream (Marvin et al. 2007). These facilities did not impede fish passage. In 1928, Pardee Dam was constructed upstream from Woodbridge Dam. The concrete dam is 345 feet high and has no means of fish passage. As a result of the PG&E dams and Pardee Dam, river flows in the spring are reduced, and from July through November flows are increased over historical natural flow.

Camanche Dam was completed in 1964 and has no fish passage. The construction of Camanche Dam inundated most of the remaining steelhead and salmon spawning habitat on the Mokelumne River (California Department of Fish and Game 1959; Fry and Petrovich 1970). As mitigation for those habitat losses, CDFW required EBMUD to construct the Mokelumne River Fish Hatchery. EBMUD built the hatchery, which CDFW continues to operate. The operation of Camanche Dam results in further reductions in spring flows compared to historical natural flow and a slight additional increase in summer and fall flows below Camanche Dam.

Because Camanche Dam prevents downstream transport of sediment and because spawning habitat had been identified as a limiting factor for Mokelumne River Chinook salmon and steelhead reproduction (California Department of Fish and Game 1991), a spawning gravel augmentation and monitoring program was initiated by EBMUD to increase total available spawning habitat and

improve the quality of existing habitat below Camanche Dam. More than 45,000 cubic yards of gravel have been placed since 1990. About 55% of Chinook salmon spawning currently occurs in these enhancement sites (Merz et al. 2008). Recent studies have demonstrated substantial improvements in the quality of the intergravel environment, and in the survival of Chinook salmon and steelhead embryos at the enhanced sites (Merz et al. 2004; Merz and Setka 2004).

Diversions

Water supply and other diversions in the Mokelumne River are described in detail in Section 3.1, Water Resources.

The largest diversions below Camanche Dam that affect Mokelumne River salmonids are the CVP, the SWP, and the Delta Cross Channel (DCC). The Central Delta is roughly regarded as those waterways surrounding the San Joaquin River from Stockton westward to Webb Tract and Twitchell Island. These waterways include the mainstem of the lower San Joaquin River itself, the lower Mokelumne River complex and its associated waterways (Potato, Disappointment, and Fourteen Mile Sloughs as well as other channels), and the lower reaches of Old River and Middle River with their interconnecting waterways and channels. Under natural hydrological conditions, net flow in these channels usually would have been in a downstream direction toward the ocean.

Under current CVP and SWP export operations, net flow in many of these channels is toward the pumps (referred to as reverse flows), particularly when river flows are low and pumping rates are high. When the DCC gates are open, the channel conveys Sacramento River water into Snodgrass Slough and subsequently into the Mokelumne River system. Burau et al. (2007) estimated that when the DCC gates are open, approximately 45% of the Sacramento flow at Freeport is redirected into the Delta interior through the DCC and Georgiana Slough. This water eventually discharges into the San Joaquin River below the confluence of the North and South forks of the Mokelumne River and is then available to be drawn southward toward the CVP and SWP pumps in the south Delta.

Numerous studies indicate that transiting the Delta interior is a very risky undertaking for juvenile salmonids exiting from the San Joaquin River basin or from the Mokelumne and Calaveras River basins (National Marine Fisheries Service 2009). The probability of ending up at the Delta export facilities or remaining in the interior Delta waterways increases with increased export pumping, particularly for those fish in the San Joaquin River system (National Marine Fisheries Service 2009).

Agricultural diversion pumps have been used on the Mokelumne River since the 1890s for irrigation and have adversely affected salmon and steelhead populations for more than a century. By 1928, approximately 60 pumps were diverting a total of about 4 thousand acre-feet (TAF) of water per year from the river during the irrigation season (U.S. Geological Survey 1929). By 1950, 66 pumps were drawing about 15 TAF of water between Thornton and Clements (about 40 miles of the river). Pumped irrigation diversions reached about 34 TAF annually in 1972 but since have declined to less than 15 TAF.

The effect of these unscreened riparian pumps on steelhead and salmon survival has not been quantified, but may result in considerable mortality during the period when the pumps are operated and juvenile salmonids are present. As part of its commitments under the JSA, EBMUD is assisting the USFWS Anadromous Fish Restoration Program to identify riparian diversions that could be screened to reduce entrainment of juvenile salmon and steelhead. EBMUD completed a preliminary assessment of 62 riparian diversions from Camanche Dam to Station Frandy (Figure 3.2-1) and submitted a prioritized list of existing unscreened diversions to USFWS in 2007.

Water Quality

In 1977, 1988, and 1989, hydrogen sulfide concentrations in the water supply to the Mokelumne River Fish Hatchery resulted in losses of more than 350,000 steelhead at the hatchery. To address this problem, EBMUD conducted studies of hydrogen sulfide formation and ways to prevent it. Those studies found that when pure oxygen is added to Camanche Reservoir's anoxic hypolimnion during the late spring, summer, and early fall, hydrogen sulfide production in the oxygenated area is eliminated. The hypolimnion is the dense bottom layer of water in a thermally stratified lake or reservoir. Typically the hypolimnion is the coldest layer of a lake in summer and the warmest layer during winter. In response to these studies, EBMUD designed, installed, and began operating in 1993 a Hypolimnetic Oxygenation System (HOS) to add pure oxygen to the Camanche Reservoir hypolimnion. There have been no hydrogen sulfide problems in the reservoir, hatchery water supply, or lower Mokelumne River since EBMUD began operating the HOS.

Levees

Floodplains provide rearing habitat for salmonids and promote enhanced growth and survival relative to mainstream river channels (California Department of Fish and Game 2010). Levee construction on the Mokelumne River began in 1907 and fixed the multiple channels in the area of the confluence of the Mokelumne River, Cosumnes River and Dry Creek into their present-day positions. Progressive construction of levees following the turn of the century concentrated flow from multiple channels to a single channel and limited river-floodplain connectivity and floodplain sedimentation (Florsheim and Mount 2003). Construction of levees generally prevented floodplain sedimentation except during floods that overtopped the levees or during accidental breaches. Completion of the levee system by the 1920s changed the hydrogeomorphology of the lowland flood basing by reducing floodplain flood stages and inundation duration. Levees limited transport of sediment, water, and nutrients from the channel onto the adjacent floodplain except during accidental breaches.

Hatcheries

Williamson and May (2005) assessed the population genetic structure and temporal stability of genetic diversity of fall-run Chinook salmon in California's Central Valley. The lack of genetic distinction and temporal differences in allele frequencies between hatchery and naturally spawning fish indicates that considerable gene flow occurs between fall-run Chinook salmon throughout the Central Valley. Because of the prevalence of off-site releases of hatchery-reared juveniles and the history of interbasin hatchery transfers and stocking in the Central Valley, homogenization of Central Valley fall-run populations is most likely the result of hatchery practices over the past 140 years.

Prior to the establishment of the Mokelumne River Fish Hatchery there were numerous releases of steelhead to the San Joaquin River Basin from the Mount Shasta, Mount Whitney, Basin Creek, Fern Creek, Kaweah, and Mormon Creek hatcheries (West Coast Steelhead Biological Review Team 1998). Because there is no documentation of egg collections from San Joaquin River basin sources, the exact origin of the released steelhead is unknown (West Coast Steelhead Biological Review Team 1998).

EBMUD is working collaboratively with CDFW and NMFS to develop a Hatchery Genetics Management Plan (HGMP) for the operations and management of the Mokelumne River Fish Hatchery. The HGMP is designed to improve the genetics management, production, and release of

fall-run salmon and steelhead produced in the hatchery in a manner that supports and is compatible with the protection and recovery of listed salmonids in the Central Valley.

Flooding

Streamflow on the lower Mokelumne River normally results from winter rainfall and spring snowmelt. Approximately 40% of the watershed lies between the elevations of 5,000 to 10,000 feet, which causes the hydrology of the lower Mokelumne River to be influenced heavily by snowmelt. Completion of Camanche Dam in 1964, and to a lesser extent Pardee Dam in 1929, reduced flooding that historically had occurred on the Mokelumne River. Upstream reservoirs have altered the pattern of flows entering Pardee and Camanche Reservoirs. PG&E's Mokelumne Hydroelectric Project has also altered the flow patterns in the Mokelumne River, reducing the volume of spring flows and increasing summer and fall flows.

Streamflow records in the Mokelumne River below Camanche Dam (U.S. Geological Survey Gage #11323500) provide a perspective of flow conditions unregulated by EBMUD reservoirs on the Mokelumne River from 1904 to 1928; regulated flow conditions by Pardee Reservoir from 1929 to 1963; and regulated flow conditions by Pardee and Camanche Reservoirs from 1964 to date. While Pardee Reservoir provides some flood storage capacity, it was not until the completion of Camanche Dam that the lower Mokelumne River received significant flood protection. In fact, providing additional flood control on the Mokelumne River was one of the interests advocated by parties in San Joaquin County in the 1955–1956 water rights hearing that resulted in the State Water Board's granting Permit 10478 to EBMUD. The floods of 1950 and 1955 were cited as arguments in favor of the need for flood control. This local interest in flood control is one of the reasons that the State Water Board, in Permit 10478, included a condition requiring EBMUD to allow those local interests an opportunity to participate financially in the construction of the proposed Camanche Dam for flood-control purposes, or to secure federal participation therein. EBMUD met this condition by reaching a flood-control agreement in 1962 with the U.S. Army Corps of Engineers (Corps) for the operation of Camanche Reservoir to accommodate, together with the existing Pardee Reservoir, the reservation of flood-control space for the protection of downstream areas in San Joaquin County. Camanche Reservoir was oversized to provide some of the flood-control space required by the Corps.

Table 3.2-5 shows peak flow events for pre- and post-Pardee/Camanche conditions. No major floods in the lower Mokelumne River have occurred since completion of Camanche Dam in 1964. The importance of Camanche Reservoir's flood regulation capacity was demonstrated in 1997, when peak inflow into Pardee Reservoir reached 41,300 cfs. This was the highest flow of record for this gage. However, the peak flow below Camanche Dam reached only 5,440cfs.

Table 3.2-5. Peak Floodflow Events in the Lower Mokelumne River since 1900

Date	Peak Flow (cfs)
March 1907	25,500
January 1911	18,900
March 1928	25,600
Pardee Dam Completed 1929	
March 1943	9,360
November 1950	28,800
December 1955	27,300
April 1958	8,220
February 1963	5,920
Camanche Dam Completed 1964	
January 1969	4,940
January 1970	5,130
February 1980	4,550
May 1982	4,080
July 1983	4,640
December 1983	4,160
February 1986	6,060
June 1995	3,960
January 1997	5,440
April 2006	5,150

Source: Robertson-Bryan, Inc. 2006a

November–December 1950

The storms that hit the Sierra Nevada between November 18, 1950 and December 10, 1950, inundated bottomlands on both sides of the Mokelumne River, from where the river enters the Central Valley all the way to the Delta. These storms created a then-record peak flow of 28,800 cfs and inundated 22,100 acres of land (U.S. Army Corps of Engineers 1991). Adjacent agricultural lands were inundated to a depth of 8 feet and the town of Lodi to a depth of 5 feet. At the confluence of the Cosumnes River, Dry Creek, and the Mokelumne River, floodwaters created a lake of about 8,700 acres, which is referred to as the Franklin Pond (U.S. Army Corps of Engineers 1991). All levees along the river were overtopped except those protecting the town of Thornton. Total flood damages were estimated at \$1.7 million (based on 1950 dollar value).

December 1955

The peak flow during the December 1955 storm reached 27,300 cfs and inundated approximately 19,300 acres of the floodplain. Areas on both sides of the Mokelumne River were inundated to a depth of 8 feet from 1 mile above the SR 88 Bridge crossing to the mouth of the river. Total damages to agriculture, utilities, roads, bridges, and levees were estimated at \$1.3 million (based on 1955 dollar value).

February 1986

The storm of February 12–20, 1986, caused widespread flooding throughout northern California. The Cosumnes River experienced a peak flow of 45,100 cfs and a 3-day volume of 198 TAF. Approximately 21,700 acres along the Cosumnes River were inundated, causing \$1.6 million in damages, based on dollar values at the time of the flood. The 1986 storm occurred when all the Mokelumne River basin reservoirs were relatively empty. As a result, there was very little damage in the Mokelumne floodplain. The majority of the damage was a result of uncontrolled flows in the Cosumnes River, which in turn, caused some minor damage in the Mokelumne floodplain. Camanche and Pardee Reservoirs impounded 168 TAF of water with an additional 64 TAF impounded upstream at PG&E's Lower Bear and Salt Springs Reservoirs. Peak discharge from Camanche Dam reached 6,060 cfs. About 59,000 acres were inundated in the combined Cosumnes and Mokelumne floodplains, causing an estimated \$20 million dollars in damage, based on dollar values at the time of the flood (U.S. Army Corps of Engineers 1991).

January 1997

The 1997 storm was a rain-on-snow event, melting the snowpack in the central Sierra Nevada and causing large flows for all rivers in the region. But similar to the 1986 storm, the system of reservoirs on the Mokelumne River dampened the stormwater runoff to only 5,440 cfs on the lower Mokelumne River. Although extensive flooding occurred in the lower reaches of the Mokelumne River near the confluence with the Cosumnes River, the flood control provided by Camanche Dam reduced flood damages, resulting in limited localized downstream flooding. According to the Corps annual Flood Damages Report for 1997, Camanche Dam prevented approximately \$20 million of flood damages.

3.2.2 Regulatory Setting

In addition to the State CEQA Guidelines, select local agreements and programs influence the protection of biological resources in the project area. This section describes those agreements and programs relevant to fish resources in the lower Mokelumne River. Specifically, this section describes the JSA (Appendix D.1) and also includes a description of the Water Quality and Resource Management Plan (WQRMP) that defines goals, measures, performance criteria and responsive actions associated with implementation of the JSA. Some key findings of the 10-year review of the JSA (Appendix D.2) are also provided below.

Because the Project would not involve any physical disturbance to the environment such as construction of facilities or structures, the discussion below focuses only on those regulations that are *potentially* relevant to the Project.

3.2.2.1 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 joint settlement agreement (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 (Appendix D.1).

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 United States Fish and Wildlife Service (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.

Components of the JSA are described in more detail below, and the JSA is included as Appendix D.

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 (Appendix D). 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.

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 than 45,000 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 June 2012, the Partnership Fund has earned about \$810,000, has received about \$170,000 in grants, and has spent about \$800,000 on projects in the lower Mokelumne River. 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) 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 2012).

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.

3.2.2.2 Water Quality and Resource Management Program

One of the first tasks of the steering committee for the Lower Mokelumne River Partnership was to develop the WQRMP to define reasonable goals, measures, performance criteria and responsive actions associated with implementing the JSA. The WQRMP was prepared by the Partnership, submitted to FERC in June 1999, and approved by FERC in May 2001. The goals of the WQRMP are as follows.

- Provide, to the extent feasible, habitat quality and availability in the lower Mokelumne River to maintain fishery, wildlife, and riparian resources in good condition.

- Contribute toward the state and federal fishery restoration goals as defined in the California Salmon, Steelhead Trout, and Anadromous Fisheries Program Act (AFRP) and Central Valley Project Improvement Act (CVPIA).
- Sustain the long-term viability of the salmon and steelhead fishery while protecting the genetic diversity of naturally produced populations of Chinook salmon and steelhead in the lower Mokelumne River.

Many of the action items described in the WQRMP are similar to those included in the JSA; however, the WQRMP presents additional details, actions, and monitoring measures.

3.2.2.3 10-Year Review of Joint Settlement Agreement Accomplishments

The Lower Mokelumne River Partnership steering committee (CDFW, USFWS, and EBMUD) conducted a 10-year review of the JSA in 2008 (East Bay Municipal Utility District et al. 2008) (Appendix D.2). The committee found that most of the goals and actions described in the JSA and WQRMP continue to be pursued in one form or another. Some actions, such as meeting minimum flow requirements, are continuing unchanged. Other actions have been modified to enhance the successful attainment of JSA objectives. Several JSA objectives, as previously described in this EIR, were successfully completed:

- improvement of the fish bypass at Woodbridge canal;
- collaboration with WID to improve fish passage at Woodbridge Dam;
- modification of the channel downstream of Woodbridge Dam to reduce predation; and,
- expansion and improvement of the Mokelumne River Fish Hatchery.

The 10-year review included some new or modified actions recommended by the steering committee that are being implemented:

- develop an integrated reservoir/stream temperature model to predict water temperatures and operate reservoirs to optimize water temperatures for all salmonid life stages;
- work with landowners to implement the practices described in the San Joaquin County Resource Conservation District's Lower Mokelumne River Conservation Handbook;
- depending on funding, implement the Mokelumne River Day Use Area Recreation and Resource Management Plan;
- use the Spawning Habitat Integrated Rehabilitation Approach for annual gravel supplementation;
- create an HGMP for the Mokelumne River Fish Hatchery in cooperation with NMFS and CDFW; and,
- continue constant fractional marking of hatchery fish.

3.2.3 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 Project.

3.2.3.1 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 temperature simulation modeling to quantitatively evaluate the magnitude and frequency of project changes in reservoir storage, flows, and water temperatures compared to baseline conditions; and,
- assessing potential changes in habitat conditions from the Project compared to simulated baseline 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.

3.2.3.2 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 Project on fish resources.

Significant impacts on fish resources may occur if the Project 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 Project 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 (East Bay Municipal Utility District et al. 2008). Consequently, the assessment of project 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 throughout the proposed extension of Permit 10478 entitlements.

3.2.3.3 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 in Section 3.2.1.1, Lower Mokelumne River. 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 fines (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

The Project would not alter the operation of EBMUD's local terminal reservoirs (Briones, Chabot, Lafayette, San Pablo, and Upper San Leandro); therefore, no effects on fish populations in these reservoirs are anticipated.

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. Figure 3.2-3 shows the monthly differences in water temperature 2012. 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.

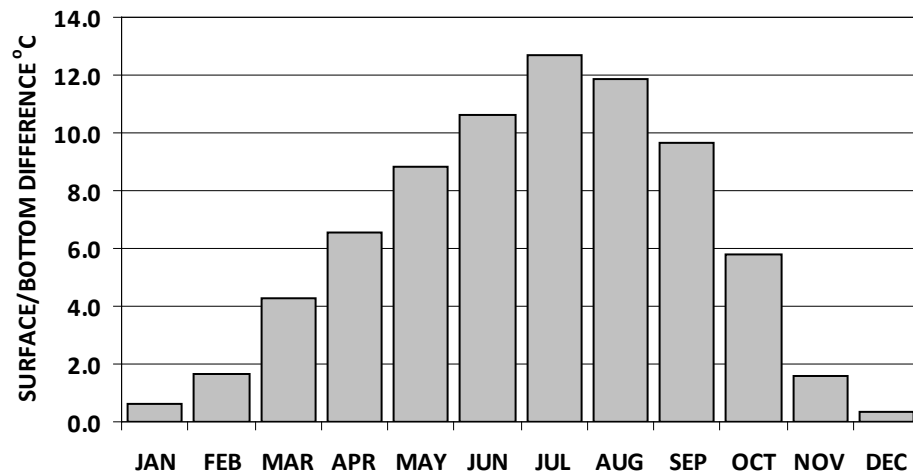


Figure 3.2-3
Thermal Stratification in Camanche Reservoir
 (Source Data 1988 through 2012)

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.

Chronic exposure to water temperatures outside the optimum range (i.e., sublethal temperatures) for a particular species and life stage can indirectly influence fish survival by causing a number of adverse physiological and developmental effects, including impaired viability and development of early life stages, reduced feeding and growth of juveniles, and increased susceptibility of juveniles

and adults to predators, disease, and pollutants. Temperatures also can influence behavior, which, in turn, can affect fish survival. For example, adults may avoid elevated water temperatures during their spawning migration, causing migration delays or blockage to upstream spawning areas.

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).

3.2.3.4 Impact Assessment

Quantitative assessment of project effects on fish resources was based on monthly hydrologic and water temperature modeling results presented in Section 3.1, Water Resources. Modeling is based in part on EBMUD's projected increase in average annual demand from 214 million gallons per day (MGD) to 230 MGD. Although the increased demand would increase over decades, and would vary from year to year, the hydrologic and water temperature modeling evaluated this increased demand as an immediate and consistent change.

This EIR focuses on Pardee and Camanche Reservoir storage and surface water elevations, as well as flow and water temperatures at four monitoring stations downstream of Camanche Reservoir: McIntire, Elliott, Golf, and Frandy (Figure 3.2-1). These sites are located approximately 1, 10, 24, and 33 miles downstream of Camanche Dam, respectively. Station McIntire serves as a measure of the flow and temperatures from the Camanche Dam releases. 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 downstream end of the primary rearing habitat for Chinook salmon and steelhead. The Frandy site is located downstream where the river is tidally influenced. During low-flow conditions, water temperatures and flow at Frandy are influenced by tidal action and Delta water temperatures.

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, water temperature simulation modeling, historical water quality and biological monitoring data, and selected biological criteria to quantitatively evaluate the magnitude and frequency of project effects on key habitat variables in Camanche and Pardee Reservoirs, lower Mokelumne River, and Bay-Delta estuary. For more information, the methods are also described in Section 3.1, Water 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 throughout the proposed extension of Permit 10478 (Section 3.2.2, Regulatory Setting). The following impact assessment focuses on fish impacts related to the following topics:

- flow
- reservoir storage
- water quality
- temperature
- Delta habitat

Each impact identified in the following discussion relates to one or more of the significance criteria listed above under Section 3.2.3.2, Significance Criteria.

Flow

Project 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 simulated baseline and project conditions. On average, project conditions would result in an annual reduction in flow below Camanche Dam of about 3.2% and about 4.3% below Woodbridge Dam.

Adult Salmonid Migration

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

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.

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. Tidal action may affect flow velocities and depths, particularly in the most downstream areas. Instream flows and tidal action influence water depths and upstream salmonid migration.

The majority of adult fall-run Chinook salmon migration in the lower Mokelumne River occurs from September through December, and adult steelhead migration occurs primarily from September through February. Since 1990, upstream migrating adult fall-run Chinook salmon and steelhead have been observed over a range of low flows at Woodbridge Dam. 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 project flow conditions below Woodbridge Dam relative to the baseline condition are shown in Table 3.2-6. Under project conditions, flows may preclude passage of upstream migrating adult Chinook salmon and steelhead. These impacts are considered *significant*. See Section 3.2.3.5 for a summary describing this impact, as well as recommended mitigation measures.

Table 3.2-6. 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)

	Baseline Conditions					Project Conditions				
	Normal	Below Normal	Dry	Critical	Total	Normal	Below Normal	Dry	Critical	Total
September	0	9	23	10	42	0	12	22	11	45
October	0	0	0	6	6	0	0	0	8	8
November	0	0	0	6	6	0	0	0	8	8
December	0	0	0	6	6	0	0	0	8	8
January	0	0	1	6	7	0	0	1	8	9
February	0	0	0	5	5	0	0	0	7	7

Salmonid Spawning and Rearing Habitat

Impact FISH-2: Reduced spawning and rearing habitat for fall-run Chinook salmon and steelhead (Less than Significant)

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 baseline conditions and project 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 evaluated spawning, fry, and juvenile habitat for fall-run Chinook salmon and steelhead in the lower Mokelumne River using the Physical Habitat Simulation (PHABSIM) (California Department of Fish and Game 1991). The PHABSIM estimates changes in physical microhabitat as a function of flow. The output from PHABSIM is WUA. This habitat measure is a combination of physical microhabitat quantity and quality. WUA is expressed in units of microhabitat area per unit distance along a stream (square feet per 1,000 feet of stream). CDFW simulated habitat-discharge relationships over a range of flows from 100 to 1,000 cfs. Much of the lower Mokelumne River is bankfull at 900 to 1,000 cfs where flows greater than this begin to spread out over adjacent riparian vegetation and pasture land (California Department of Fish and Game 1991).

Since the CDFW study was conducted in 1986 and 1987, the JSA Partnership (EBMUD, CDFW, and USFWS) has made significant salmonid habitat improvements in the lower Mokelumne River stream channel for approximately 2 miles downstream of Camanche Dam. This was accomplished by placing and configuring over 45,000 yds³ of suitable-sized spawning gravel in the stream channel, and the construction of a juvenile salmonid rearing channel. This has significantly improved the depth, velocity and substrate for all life stages of salmonids in the lower Mokelumne River.

Escobar-Arias and Pasternak (2011) used a functional flow model to evaluate gravel-bed riffle functionality for fall-run Chinook salmon in the lower Mokelumne River. They found that river rehabilitation (gravel augmentation) increased the number of days with functional flows (discharge values that serve ecological uses) on the lower Mokelumne River. Although channel conditions in the lower Mokelumne River have changed as a result of extensive gravel augmentation since

implementation of the JSA, the evaluation of WUA based on CDFW's 1991 approach is a useful tool for quantitatively assessing changes in flows as a result of project conditions.

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).

Project conditions relative to baseline conditions were assessed to determine impacts of potential flow changes on salmonid life stage habitat availability. Flow increases below the flow range that maximizes WUA (e.g., 300 to 500 cfs for fall-run Chinook spawning) increase available habitat and flow increases above the flow range that maximizes WUA decrease available habitat (California Department of Fish and Game 1991). Increases in flows above 1,000 cfs are considered to have a negligible effect.

Figure 3.2-4 (fall-run Chinook salmon) and Figure 3.2-5 (steelhead) depict the monthly WUA values for baseline and project conditions (values simulated using hydrologic conditions for 1921 through 2009). The summary presents the central value (median), spread (first and third quartiles), and range (minimum and maximum values) of the modeled values. Also shown are the maximum values (California Department of Fish and Game 1991) for the various life stages (horizontal dashed line). The months used for the fall-run Chinook evaluation were October through March for spawning and incubation, January through April for fry rearing, and January through June for juvenile rearing. For steelhead, the months used for the evaluation were December through May for spawning and incubation, February through June for fry rearing, and year-round for juvenile rearing.

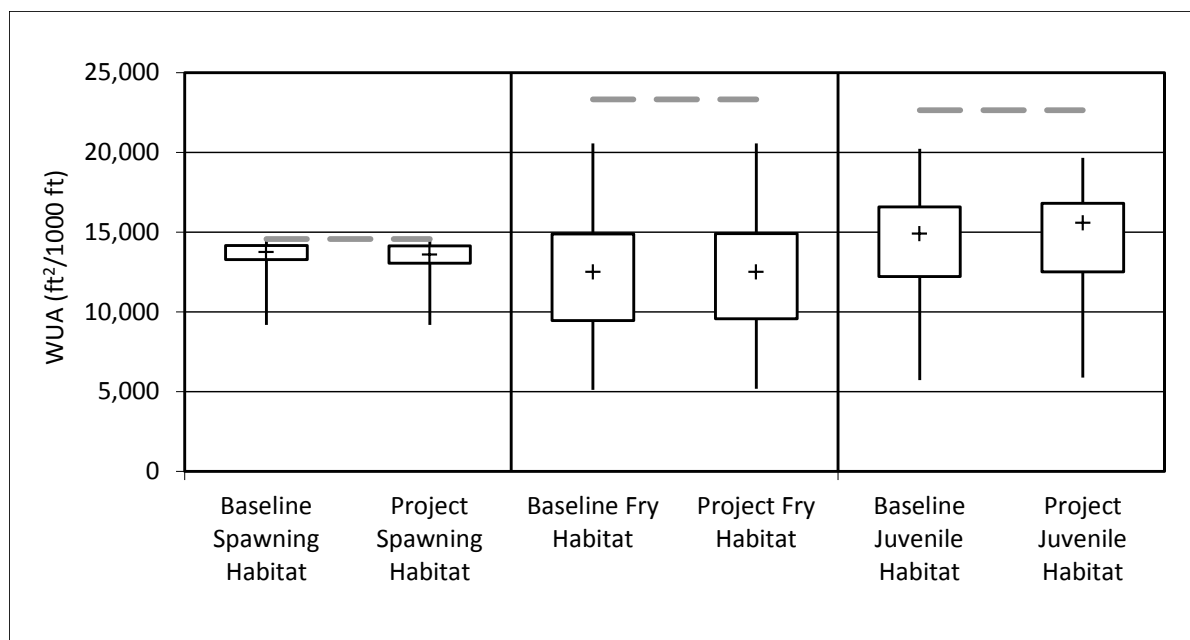


Figure 3.2-4
Summary of Modeled Annual Fall-run Chinook Salmon WUA in the Lower Mokelumne River (1921–2009 Hydrology)

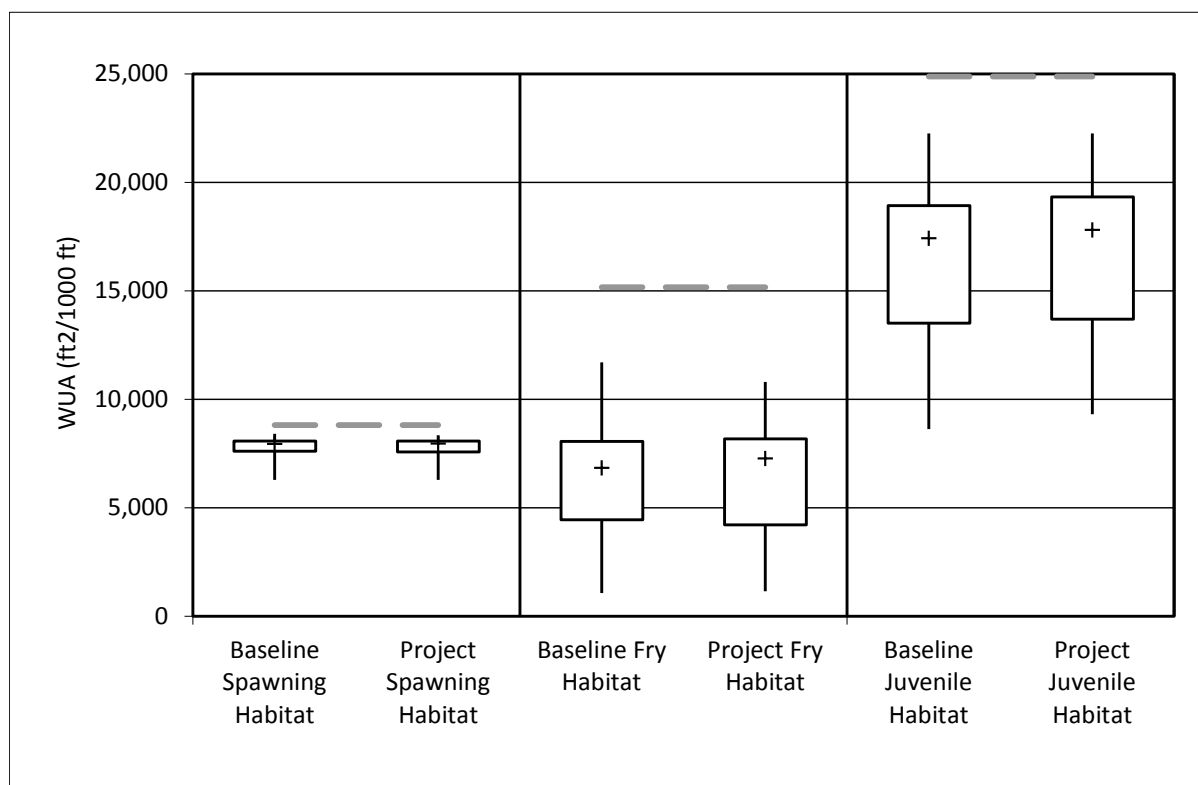


Figure 3.2-5
Summary of Modeled Annual Steelhead WUA in the Lower Mokelumne River (1921–2009 Hydrology)

Project conditions are anticipated to result in a minor decrease in fall-run Chinook salmon and steelhead spawning and incubation WUA and minor increases in Chinook salmon and steelhead fry and juvenile rearing WUA (Table 3.2-7). These impacts are considered *less than significant*.

Table 3.2-7. Average Annual WUA (ft²/1000 ft of river) and Percent Change for Salmonid Life Stages Based on JSA Year Type

	Spawning and Incubation			Fry Rearing			Juvenile Rearing		
	Baseline	Project	Percent	Baseline	Project	Percent	Baseline	Project	Percent
Fall-Run Chinook Salmon									
Normal	7866	7248	-7.9	4746	4429	-6.7	4756	4437	-6.7
Below Normal	2908	2489	-14.4	3177	2869	-9.7	3651	3433	-6.0
Dry	1923	2594	34.9	2832	3432	21.2	4176	4534	8.6
Critical	698	933	33.7	1767	2269	28.4	2199	2620	19.1
Total	13395	13264	-1.0	12522	12999	3.8	14782	15024	1.6
Steelhead									
Normal	3290	3072	-6.6	1798	1680	-6.6	5675	5299	-6.6
Below Normal	2074	1884	-9.2	1588	1570	-1.1	4234	4055	-4.2
Dry	1699	1967	15.8	2194	2284	4.1	4608	4986	8.2
Critical	699	840	20.2	1233	1458	18.3	2339	2774	18.6
Total	7762	7763	0	6813	6992	2.6	16856	17114	1.5

Salmonid Juvenile Outmigration

Impact FISH-3: Reduced outmigration for juvenile fall-run Chinook salmon and steelhead (Less than Significant)

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 ($R^2=0.09$) 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 ($R^2=0.49$, $P<0.001$) 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).

Of the 89 simulated years, the frequency of average January through March flows above 800 cfs below Camanche Dam are the same with project conditions and baseline conditions; therefore, no impacts are anticipated (Figure 3.2-6 and Table 3.2-8).

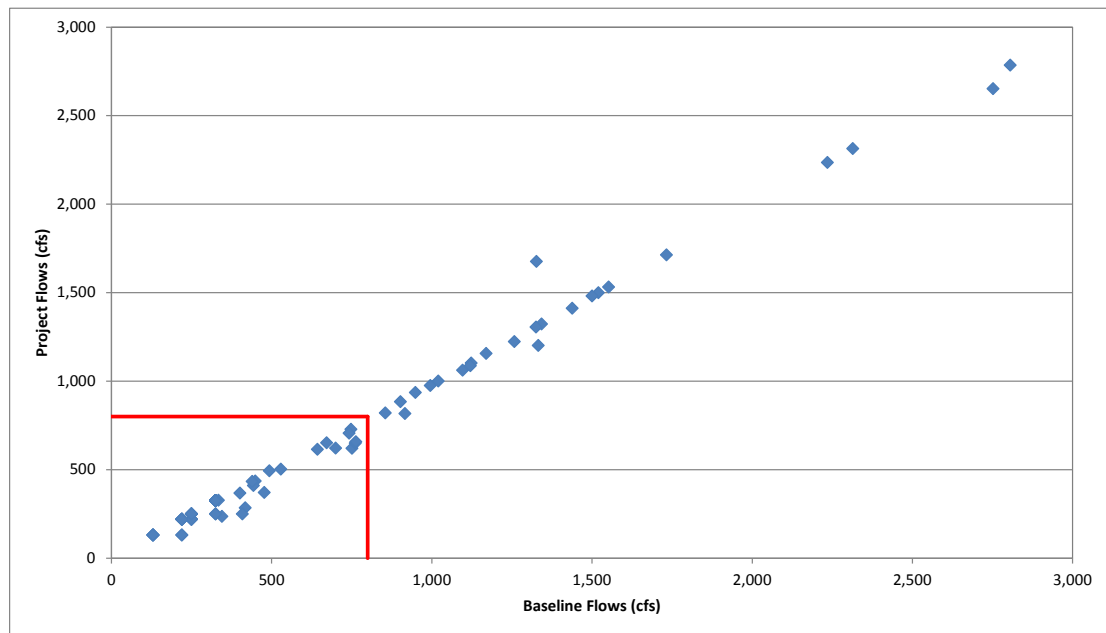


Figure 3.2-6

**Annual Average January through March Flows Below
Camanche Dam (1921–2009 Hydrology)**

Table 3.2-8. Number of Modeled Years When Flows below Camanche Dam May Influence Juvenile Fall-run Chinook Salmon Outmigration Based on JSA Year Type (when Average Flow during January through March Exceeds 800 cfs)

	Baseline Conditions	Project Conditions
Norm	17	17
Below Normal	4	4
Dry	3	3
Critical	0	0
Total	24	24

CDFW indicated that in normal water years, a flow of 350 cfs in March, 400 cfs in April, 450 cfs in May, and 400 cfs in June below Woodbridge Dam would facilitate the outmigration of young salmonids to the Delta (California Department of Fish and Game 1991). Flows below Woodbridge Dam were modeled for 1921–2009 hydrology under baseline and project conditions. Compared to baseline conditions, project conditions reduce flows below CDFW's recommendation in 1 year in March and 5 years in May and 4 years in June (Table 3.2-9). Because this occurs so infrequently (<3%), the impact is considered *less than significant*.

Table 3.2-9. Number of Modeled Years When Flows below Woodbridge Dam May Impede Juvenile Salmonid Migration Based on JSA Year Type

	March (350 cfs)		April (400 cfs)		May (450 cfs)		June (400 cfs)	
	Baseline	Project	Baseline	Project	Baseline	Project	Baseline	Project
Normal	29	27	13	13	0	2	0	1
Below Normal	13	11	28	28	13	16	12	15
Dry	11	14	23	22	23	22	23	22
Critical	5	7	10	11	10	11	10	11
Total	58	59	74	74	46	51	45	49

Floodplain Habitat

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

As discussed in Section 3.2.3.3, Impact Mechanisms, 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 [Section 3.1, Water Resources, Figure 3.1-5]). 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 89 simulated years, the frequency of flows exceeding 3,000 cfs in March, April, and/or May below Woodbridge Dam are infrequent (5 years) but are the same with project conditions and baseline conditions; therefore, *no impacts* are anticipated (Table 3.2-10).

Table 3.2-10. Number of Modeled Years When Flows below Woodbridge Dam May Support Floodplain Habitat Maintenance Based on JSA Year Type (when Average Monthly Flow for March, April, or May Exceeded 3,000 cfs)

	Baseline Conditions			Project Conditions		
	March	April	May	March	April	May
Normal	1	2	3	1	2	3
Below Normal	0	0	0	0	0	0
Dry	0	0	0	0	0	0
Critical	0	0	0	0	0	0
Total	1	2	3	1	2	3

Note: While the total number months with Woodbridge flow greater than 3,000 cfs during March through May was 6, the total number of years with flow greater than 3,000 cfs during March through May was only 5 for both the baseline and project scenarios because the year with the 1983 hydrology had flow exceeding 3,000 cfs during both March and May.

Salmonid Spawning Habitat Maintenance

Impact FISH-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 [Section 3.1, Water Resources, Figure 3.1-6]). 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. Compared to baseline conditions, project conditions result in 1 less year (23 years) when an annual flow event more than 2,000 cfs occurs downstream of Camanche Dam (Table 3.2-11). Because this occurs so infrequently, the impact is considered *less than significant*.

Table 3.2-11. Number of Modeled Years When Flows below Camanche Dam May Support Salmonid Spawning Habitat Maintenance Based on JSA Year Type (when One or More Months of the Year Have Average Flow Exceeding 2,000 cfs)

	Baseline Conditions	Project Conditions
Normal	20	20
Below Normal	4	4
Dry	3	3
Critical	0	0
Total	24*	23*

Note: Total differs from sum of water year types because more than one water year type may occur during a calendar year.

Native Fishes Habitat

Impact FISH-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

Project 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 reservoir water surface elevations under simulated baseline and project conditions. Published literature and general reservoir habitat relationships were used to evaluate the results (Appendix J).

Warmwater Fish Species

Impact FISH-7: Substantial short or long-term losses of habitat quantity or quality for warmwater fish species (Less than Significant)

Mitchell (1982) studied the relationship between largemouth bass reproduction and water levels in Lake Millerton, California, and determined a water level rise tolerance limit of 10.6 inches per day. Lee (1999) suggests that a spawning nest survival rate of at least 20% is necessary to maintain the long-term population levels of highly fecund, warmwater fish, such as black bass. Nest survival curves developed by Lee (1999) illustrate that reductions of approximately 4.3 and 9 inches per day would result in 20% nest survival of largemouth and smallmouth bass, and spotted bass, respectively. Water levels in Camanche Reservoir fluctuate more than in Pardee Reservoir, but past fish sampling by EBMUD has shown that both reservoirs support relatively large numbers of warmwater fish. These species also benefit from the flooding of vegetation that grows along the exposed shoreline during prolonged dry periods.

Black bass use the littoral zones of Pardee and Camanche reservoirs during the primary spawning (March through June) and early rearing (March through September) periods. Criteria used to assess impacts of project conditions on warmwater reservoir fish are daily reservoir surface increases of less than 10.6 inches per day (Mitchell 1982) and daily reservoir surface decreases of less than 4.3 inches per day from March through September (Lee 1999).

For warmwater species that use the littoral zones of Pardee and Camanche Reservoirs (e.g., catfish, black bass and sunfish, some minnows), spawning and rearing success decreases with reservoir drawdowns (water surface elevation declines) during the primary spawning and early rearing periods. Under both baseline and project conditions, Pardee Reservoir fills in December through July and gradually declines from August through November; Camanche Reservoir fills from February through June, declines through September and is recharged in October to provide cold water for downstream releases.

The average daily reservoir surface elevation fluctuations from March through September are typically less than those identified by Mitchell (1982) and Lee (1999). The frequency of fluctuations in Camanche Reservoir exceeding 10.6 inches (increase) and 4.3 inches (decrease) per day from

March through September are the same (0.3%) under project conditions and baseline conditions; therefore, no impacts are anticipated (Table 3.2-12). Fluctuations in Pardee Reservoir exceed the criteria about 0.8% of the time under baseline conditions and would exceed the criteria about 1.1% of the time under project conditions. Because the effects under baseline and project conditions were similar and infrequent, this impact is considered *less than significant*.

Table 3.2-12. Number of Modeled Years When Average Daily Reservoir Fluctuation Exceeds Criteria (+10.6 or -4.3 inches/day) based on JSA Year Type

Month	Baseline Conditions					Project Conditions				
	Normal	Below Normal	Dry	Critical	Total	Normal	Below Normal	Dry	Critical	Total
Pardee Reservoir										
March	0	0	0	1	1	0	0	0	2	2
April	0	0	0	1	1	0	1	0	1	2
May	0	0	0	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0
August	0	0	0	1	1	0	0	0	1	1
September	1	0	0	1	2	1	0	0	1	2
Camanche Reservoir										
March	0	0	0	0	0	0	0	0	0	0
April	1	0	0	0	1	1	0	0	0	1
May	1	0	0	0	1	1	0	0	0	1
June	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0	0	0
September	0	0	0	0	0	0	0	0	0	0

Coldwater Fish Species

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

Potential impacts on coldwater species (kokanee and rainbow trout in Pardee Reservoir, and rainbow trout in Camanche Reservoir) were based on the availability of coldwater habitat during the summer and early fall (July through November), when coldwater 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). Using a threshold of 15°C in Pardee Reservoir and 18°C in Camanche Reservoir, the volume of water providing suitable temperatures was modeled for 1921 through 2009 hydrology in each reservoir under baseline and project conditions.

Based on the temperature-depth profile modeling (Appendix J), there were 6 months where the simulated baseline Camanche Reservoir depth was below the minimum depth threshold necessary to provide suitable water temperatures (less than 18°C): the consecutive months of June through November 1978. There were 7 months where the simulated project case Camanche Reservoir depth was below the minimum depth threshold necessary to provide suitable water temperatures:

November 1977 and the consecutive months of June through November 1978. For both the baseline and project simulations of Pardee Reservoir, there were only 2 months in which simulated Pardee Reservoir depth was less than the minimum threshold depth necessary to provide suitable water temperatures (less than 15°C): the consecutive months of October and November of 1978.

Table 3.2-13 shows these data.

Because the Project case resulted in only one more month (November 1977) where conditions were considered unsuitable for coldwater species and 1977 and 1978 were the driest years of the analysis period, this impact is considered *less than significant*.

Table 3.2-13. Number of Modeled Years When Minimum Coldwater Pool Exceeds Criteria (<18°C in Camanche, <15°C in Pardee) based on JSA Year Type

Month	Baseline Conditions				Project Conditions			
	Normal	Below Normal	Dry	Critical	Normal	Below Normal	Dry	Critical
Pardee Reservoir								
May	0	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0
September	0	0	0	0	0	0	0	0
October	0	0	0	1	0	0	0	1
November	0	0	0	1	0	0	0	1
December	0	0	0	0	0	0	0	0
Camanche Reservoir								
May	0	0	0	0	0	0	0	0
June	0	0	0	1	0	0	0	1
July	0	0	0	1	0	0	0	1
August	0	0	0	1	0	0	0	1
September	0	0	0	1	0	0	0	1
October	0	0	0	1	0	0	0	1
November	0	0	0	1	0	0	0	2
December	0	0	0	0	0	0	0	0

Water Quality

Impact FISH-9: Reduction in water quality (dissolved oxygen, pH, and turbidity) for fall-run Chinook salmon and steelhead (No Impact)

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.

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 milligrams per liter (mg/L) (California Regional Water Quality Control Board 2011). The U.S. Environmental Protection Agency

(EPA) developed ambient water quality criteria for dissolved oxygen in salmonid waters (U.S. Environmental Protection Agency 1986). Those criteria are summarized in Table 3.2-14.

Table 3.2-14. Dissolved Oxygen Concentrations (mg/L) and Their Effects on Salmonid Life Stages

Level of Effect	Embryo and larval Stages	All Other Life Stages
No Production Impairment	11	8
Slight Production Impairment	9	6
Moderate Production Impairment	8	5
Severe Production Impairment	7	4
Limit to Avoid Acute Mortality	6	3

Source: U.S. Environmental Protection Agency 1986.

According to EPA (1986), production impairment levels are subjective and provide convenient divisions of the range of dissolved oxygen concentrations between acute mortality and no production impairment. Slight production impairment represents a high level of protection of fish resources, risking only a slight (10%) impairment of production; moderate production impairment protects the persistence of the existing fish populations but causes considerable (20%) loss of production; and severe production impairment provides a low level of protection of production and results in a 40% reduction in production.

Dissolved oxygen concentrations (mg/L) measured in the lower Mokelumne River about 0.50 mile downstream of Camanche Dam were examined to determine if flow releases from Camanche Reservoir, water surface elevation in Camanche Reservoir, and water temperatures of the Camanche flow release could be used to predict project effects on dissolved oxygen concentrations in the river. A linear regression model of flow, temperature and reservoir surface elevations (N=576) explained about 57% ($P < 0.001$) of the variability of water column dissolved oxygen. This relationship was used to analyze the effects of the Project compared to the baseline conditions.

Figure 3.2-7 depicts the monthly dissolved oxygen data for the baseline and project conditions (values simulated using hydrologic conditions for 1921 through 2009). The figure presents the central value (median), spread (first and third quartiles) and range (minimum and maximum values) of the modeled values. Also shown are the EPA criteria for dissolved oxygen concentrations (dotted horizontal line = slight impairment, dashed horizontal line = moderate impairment, solid horizontal line = severe impairment). Spawning and incubation months (October through March for fall-run Chinook, and December through May for steelhead) were assessed differently from the rest of the year because of the higher dissolved oxygen requirements for this life stage.

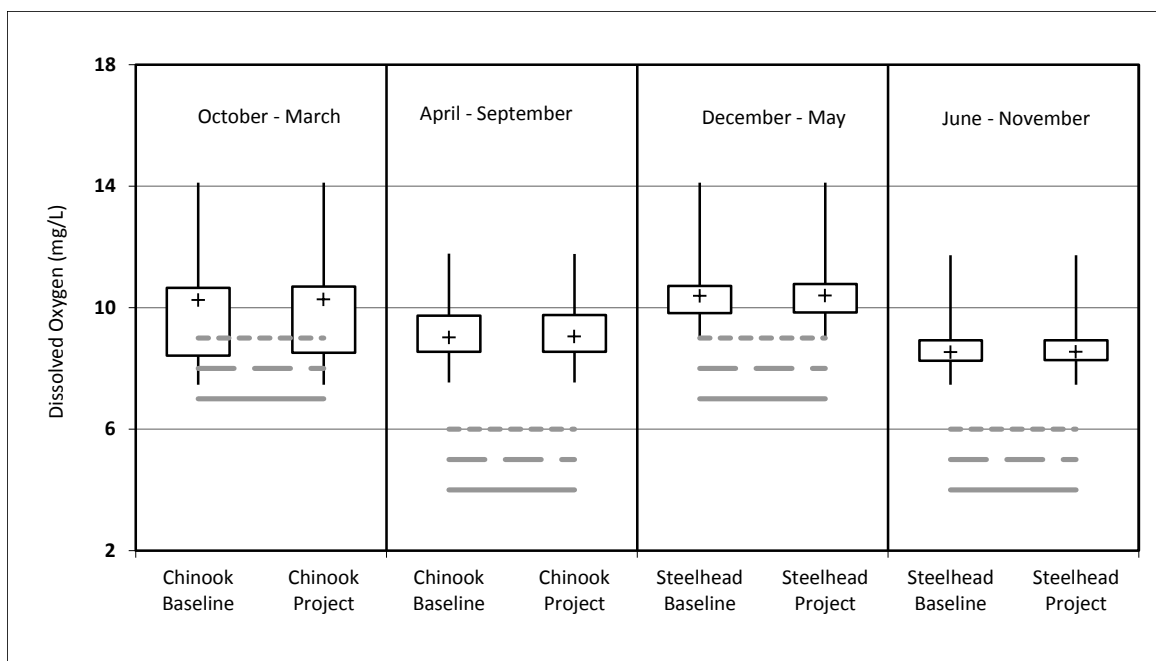


Figure 3.2-7
Summary of Modeled Monthly Dissolved Oxygen Concentrations in the
Lower Mokelumne River (1921–2009 Hydrology)

Under baseline conditions, slight impairment occurs about 12% of the time and moderate impairment about 3% of the time for fall-run Chinook salmon. All of this impairment occurs during the primary spawning and incubation period (October–March). There is no impairment for steelhead under baseline conditions. There is almost no difference between the baseline conditions and project conditions in predicted water column dissolved oxygen impairment in the lower Mokelumne River (Table 3.2-15); therefore, *no impacts* are anticipated.

Table 3.2-15. Percent of Modeled Years When Dissolved Oxygen Levels below Camanche Dam May Impact Salmonid Life Stages Based on JSA Year Type

	Severe Impairment		Moderate Impairment		Slight Impairment	
	Baseline	Project	Baseline	Project	Baseline	Project
Fall-Run Chinook Salmon						
Normal	0	0	2.9	2.6	6.5	6.0
Below Normal	0	0	0	0.1	3.6	3.1
Dry	0	0	0	0	1.9	2.5
Critical	0	0	0.1	0.2	0.5	0.6
Total	0	0	3.0	2.9	12.4	12.2
Steelhead						
Normal	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0
Dry	0	0	0	0	0	0
Critical	0	0	0	0	0	0
Total	0	0	0	0	0	0

Little information is available addressing salmonid tolerance to changes in pH, but effects on rainbow trout appear to show that pH levels between 5.0 and 9.0 are acceptable (Deas and Orlob 1999). Monthly samples collected over a range of flows and temperatures by EBMUD in the lower Mokelumne River at the Elliott Road Bridge from January 2000 through September 2012 showed that pH ranged from 6.37 to 8.03 (mean 7.07).

Robertson-Bryan Inc. (2006b) concluded that suspended solids concentrations below 20 to 25 mg/L would result in few, if any, measurable effects on fish populations and communities. Possible exceptions include egg and larvae mortality and reduced growth rates in salmonids at lower levels (10 to 20 mg/L) (Newcombe and Jenson 1996). 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).

Based on these data, dissolved oxygen, pH and turbidity/suspended solids are not problematic water quality parameters on the lower Mokelumne River; however, water temperature is the most relevant water quality parameter (National Marine Fisheries Service 2009) associated with the Project. The water temperature assessment was based on simulated Camanche Reservoir storage, and flows in the lower Mokelumne River, both of which can influence water temperatures below Camanche Dam.

Water Temperature

Reservoir Storage Effects

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 project-related changes in reservoir water surface elevation on Camanche

release temperatures whenever simulated reservoir levels fell below 190 feet (Section 3.1, Water Resources; Appendix E).

Downstream Effects

Temperatures were modeled downstream from Camanche Dam to Frandy using the Stream Segment Temperature Model (Bartholow 2002), incorporating the reservoir storage effects, EBMUDSIM flows, and a statistical approximation of the 7-day average of the daily maximum temperature (Appendix E). Lower Mokelumne River temperature effects were evaluated under baseline and project conditions for the entire 1921–2009 historical basin hydrology.

Cold water is critical to the protection of salmon, steelhead, and other native fish species in the lower Mokelumne River—these fish need cold water throughout their various life stages. The appropriate water temperature is a critical part of habitat needed by salmon. Temperature in rivers and streams varies with the seasons, over the course of 24 hours, and over the length of a river. Maximum daily water temperatures can vary as much as 1.5°C (at Station Elliott) to 6°C (at Station Frandy) from day to day, and as much as 5°C (at Station Elliott) to 11°C (at Station Frandy) over the course of a month.

A water quality standard for temperature is critical to ensuring rivers and streams are cold enough to support these fish. To address these concerns, EPA Region 10 (Pacific Northwest) developed regional temperature criteria guidance for the Pacific Northwest that would be protective of salmonids. EPA recognized that because of the inherent variability of Pacific Northwest rivers and streams, there are likely to be situations where the recommended temperature criteria would be unattainable or inappropriate. Because the California populations of steelhead and Chinook salmon reside at the southernmost limit of these species' distributions, one can expect the fish to show significantly different responses to environmental conditions compared with more northern populations (Cech and Myrick 1999).

Cech and Myrick (1999) demonstrated that temperatures up to 19°C are not a problem for Nimbus Hatchery–origin juvenile Chinook salmon, provided that food and oxygen availability are not restricted and disease problems do not arise. They also showed that Nimbus Hatchery–origin juvenile steelhead preferred temperatures between 17 and 20°C, irrespective of ration level or rearing temperature (Cech and Myrick 1999). Laboratory experiments by Marine and Cech (2004) demonstrated that Sacramento River juvenile Chinook salmon can readily survive and grow at temperatures up to 24°C. However, juveniles reared at 21 to 24°C experienced significantly decreased growth rates, impaired smoltification indices, and increased predation vulnerability compared with juveniles reared at 13 to 16°C. Fish reared at 17 to 20°C experienced similar growth, variable smoltification impairment, and higher predation vulnerability compared with fish reared at 13 to 16°C.

Conclusive studies of the thermal requirements of Chinook salmon and steelhead in Central Valley streams are limited (Myrick and Cech 2001), but for the purposes of this impact assessment, the EPA Region 10 temperature criteria guidance for the Pacific Northwest (U.S. Environmental Protection Agency 2003) was used to evaluate the effects of the Project relative to baseline conditions. These criteria are conservative, in that they were developed for the cooler Pacific Northwest region, not the warmer California Central Valley. The EPA Region 10 temperature criteria were used despite their limitations. To determine the significance of temperature changes, the frequency of EPA criteria exceedance at Station Elliott, Station Golf, and Station Frandy for the project conditions was compared to baseline conditions.

Table 3.2-16 shows the water temperature criteria (7-day average of the daily maximum values [MM7DADM]) for fall-run Chinook salmon and steelhead life stages for key months and locations in the lower Mokelumne River, based on the EPA Region 10 guidance). Based on the information presented in Section 3.2.1.1, Lower Mokelumne River, including the literature-based temperature requirements, these temperatures should be protective of the other native fish species that occur in the lower Mokelumne River (see Appendix I for temperature requirements of native fish species).

Table 3.2-16. Water Temperature Criteria for Fall-Run Chinook Salmon and Steelhead in the Lower Mokelumne River

Species/Life Stage	Critical Months	Critical Location (Station)	Temperature Criteria (°C)
Chinook Salmon Adult Migration	September–December	Frandy	18
Chinook Salmon Spawning/Incubation	October–March	Elliott	13
Chinook Salmon Juvenile Rearing	January–June	Golf	16
Chinook Salmon Smoltification	April–June	Golf	15
Chinook Salmon Emigration	January–June	Frandy	18
Steelhead Adult Migration	September–February	Frandy	18
Steelhead Spawning/Incubation	December–May	Elliott	13
Steelhead Juvenile Rearing	January–December	Golf	16
Steelhead Smoltification	February–June	Golf	14
Steelhead Emigration	February–June	Frandy	18

Note: Criteria are based on a 7-day average of the daily maximum values (MM7DADM).

Table 3.2-17 provides the percent of time when water temperatures exceeded the salmonid life stage EPA criteria by JSA year type. Of the modeled months that exceeded the EPA criteria, water temperatures decreased, were unchanged, or increased less than 1°C 95% to 100% of the time, depending on salmonid life stage. The months and years when temperature increases exceeded 1°C are shown in Table 3.2-18. The monthly temperatures used for the evaluation were those specified in Table 3.2-16.

Table 3.2-17. Percent of Time When Water Temperatures Exceed Salmonid Life Stage EPA Criteria Based on JSA Year Type

	Adult Migration		Spawning And Incubation		Juvenile Rearing		Smolting		Emigration	
	Baseline	Project	Baseline	Project	Baseline	Project	Baseline	Project	Baseline	Project
Fall-Run Chinook Salmon										
Normal	40.9	41.4	50.0	49.5	11.8	12.3	65.5	66.7	0.8	0.9
Below Normal	55.3	57.0	50.0	51.5	29.8	34.1	83.3	84.5	18.4	22.0
Dry	58.1	53.4	57.7	53.9	43.5	37.6	100.0	100.0	44.4	39.3
Critical	57.1	54.3	58.3	62.5	50.0	49.1	100.0	100.0	66.7	61.4
Total	48.6	48.6	51.7	51.9	26.4	27.2	83.9	84.6	20.2	21.0
Steelhead										
Normal	26.1	26.4	41.2	41.7	35.2	36.0	45.2	46.7	1.1	1.1
Below Normal	38.2	40.5	56.8	60.3	51.4	54.7	68.9	72.4	21.3	25.0
Dry	40.9	36.4	66.3	58.0	59.7	54.3	75.8	68.0	50.5	46.0
Critical	40.0	37.3	65.9	66.7	62.5	60.5	76.2	73.5	76.2	71.4
Total	32.4	32.4	51.7	51.9	46.9	47.3	61.1	61.1	24.3	25.2

Table 3.2-18. Modeled Months and Years When Project Condition Water Temperatures Exceed Baseline Water Temperatures by More than 1°C

Year	Month	Year Type	Baseline Temp (°C)	Project Temp (°C)	Project Temp Increase (°C)
ADULT MIGRATION					
2003	SEP	BNORM	21.1	26.9	5.8
2009	SEP	BNORM	21.8	26.9	5.1
1935	SEP	BNORM	19.7	22.6	2.9
1929	SEP	DRY	25.5	26.9	1.4
1925	SEP	BNORM	19.8	21.0	1.1
1957	SEP	BNORM	20.8	21.8	1.1
SPAWNING AND INCUBATION					
1992	MAR	CRIT	14.0	16.1	2.1
1978	MAR	CRIT	24.8	26.8	1.9
1932	MAR	CRIT	12.8	14.5	1.7
1992	MAY	DRY ¹	14.9	16.3	1.4
1977	OCT	CRIT	19.4	20.7	1.3
1988	MAR	DRY	13.0	14.1	1.1
1977	MAR	DRY	15.6	16.7	1.1
JUVENILE REARING					
2009	JUL	BNORM	20.0	21.7	1.7
2003	JUL	BNORM	19.7	21.4	1.7
2003	AUG	BNORM	19.9	21.5	1.6
2009	AUG	BNORM	20.1	21.7	1.5
1935	JUL	BNORM	18.9	20.2	1.3
1992	MAY	DRY ¹	17.4	18.6	1.2
2003	SEP	BNORM	19.1	20.3	1.2
1935	AUG	BNORM	19.2	20.4	1.2
2009	SEP	BNORM	19.3	20.4	1.1
SMOLTING					
1992	MAY	DRY	17.4	18.6	1.2
EMIGRATION					
1992	MAY	DRY ¹	20.4	25.1	4.7
1992	APR	DRY ¹	18.1	19.9	1.8
1935	JUN	BNORM	18.4	20.1	1.7
2003	JUN	BNORM	19.5	21.0	1.5
2009	JUN	BNORM	19.8	21.2	1.4
2003	MAY	BNORM	17.4	18.5	1.1

¹ Critically Dry Year Type during Project Conditions

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

Impact FISH-10: 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. Water temperatures from Camanche Dam downstream to Frandy (where the lower Mokelumne River is affected by tidally influenced water temperatures) during September through December are considered in the analysis of project temperature effects on adult Chinook salmon migration habitat. Typically, the highest water temperatures during this period occur at Frandy; therefore, the Frandy gaging station was selected as the critical location to analyze temperature effects. Of the 89 simulated years, project conditions exceeded EPA criteria for adult migrating fall-run Chinook salmon at the same frequency as baseline conditions; therefore, impacts would be considered *less than significant*.

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. Water temperatures from Camanche Dam downstream to Station Elliott (where most fall-run Chinook salmon spawning occurs in the lower Mokelumne River) during October through March were analyzed. Of the 89 simulated years, project conditions exceeded EPA criteria for fall-run Chinook salmon spawning and incubation 0.2% more frequently than baseline conditions; therefore, impacts would be considered *less than significant*.

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

Impact FISH-11: 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). Water temperatures from Camanche Dam downstream to Woodbridge Dam (where the majority of fall-run Chinook salmon rearing and smolting occur in the lower Mokelumne River) are considered in the analysis of project temperature effects on juvenile Chinook salmon rearing and smolting habitat. 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. Therefore, the analysis of project temperature effects on juvenile Chinook salmon emigration habitat considered Frandy (where the lower Mokelumne River is affected by tidally influenced water temperatures) as a critical location.

Of the 89 simulated years, project conditions exceeded EPA criteria for fall-run Chinook salmon juvenile rearing 0.8% more frequently than baseline conditions; therefore, impacts would be considered less than significant. EPA criteria exceedance for fall-run Chinook salmon smolts occurs 0.7% more frequently under project conditions compared to baseline conditions; therefore, impacts would be considered less than significant. EPA criteria exceedance for fall-run Chinook emigration occurs 0.8% more frequently under project conditions compared to baseline conditions; therefore, impacts would be considered *less than significant*.

Steelhead Adult Migration, Spawning, and Incubation

Impact FISH-12: 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. Water temperatures from Camanche Dam downstream to Frandy (where the lower Mokelumne River is affected by tidally influenced water temperatures) during September through February are considered in the analysis of project temperature effects on adult steelhead migration habitat. Typically the highest water temperatures during this period occur at Frandy; therefore, the Frandy gaging station was selected as the critical location to analyze temperature effects. Of the 89 simulated years, project conditions exceeded EPA criteria for steelhead adult migration at the same frequency as baseline conditions; therefore, impacts are considered to be *less than significant*.

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 project temperature effects on adult steelhead spawning and incubation habitat. EPA criteria exceedance for steelhead spawning and incubation would occur 0.2% more frequently under project conditions compared to baseline conditions, therefore impacts would be *less than significant*.

Steelhead Juvenile Rearing, Smolting, and Emigration

Impact FISH-13: 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; therefore, water temperatures at Station Golf are considered in the analysis of project temperature effects on steelhead rearing and smolting habitat. 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. Therefore, the analysis of project temperature effects on juvenile steelhead emigration

habitat considered Frandy (where the lower Mokelumne River is affected by tidally influenced water temperatures) a critical location.

Of the 89 simulated years, project conditions exceeded EPA criteria for steelhead juvenile rearing 0.4% more frequently than baseline conditions; therefore, impacts would be considered less than significant. EPA criteria exceedance for steelhead smolts was the same under project conditions and baseline conditions; therefore, no impacts are anticipated. EPA criteria exceedance for steelhead emigration would occur 0.9% more frequently under project conditions compared to baseline conditions; therefore, impacts would be *less than significant*.

Delta Habitat

Impact FISH-14: Reduction in survivability and habitat for anadromous and estuarine fish species (Less than Significant)

Fish species that may occur seasonally in the lower Mokelumne River below Woodbridge Dam, but primarily in the Delta and estuary, include American shad, delta smelt, green sturgeon, white sturgeon, longfin smelt, Sacramento splittail, and striped bass. In addition to fall-run Chinook salmon and steelhead, other salmonids that may be affected by the Project include federally and state-listed winter-run and spring-run Chinook salmon, which use the Delta and estuary as a migration corridor during their migrations to and from spawning and rearing areas in the Sacramento River system.

Alterations of Delta hydrodynamics and pumping-related losses of fish at the CVP and SWP export facilities (e.g., entrainment, predation, and salvage mortality) have been identified as major stressors for Central Valley fish species, and contributing factors in the decline of anadromous salmonids and other native fish populations in recent decades (Moyle 2002).

For juvenile salmonids, survival through the Delta is a function of the complex interaction of freshwater inflows, tidal action, pumping rates, and gate operations (e.g., DCC gate operations) (National Marine Fisheries Service 2009). Hydraulic modeling and tagging studies indicate that juvenile salmon and steelhead are adversely affected by reductions in Delta inflows and increased export pumping through increases in net flow toward the pumps and associated increases in entrainment and exposure to other sources of mortality (e.g., predators) in the channels leading to the pumps. In general, these studies indicate that survival can be substantially lower in the channels of the central and south Delta than in the Sacramento River. Salmon and steelhead that enter the Delta from the San Joaquin River, Calaveras River, Mokelumne River, or Sacramento River (via the DCC or Georgiana Slough) are generally at highest risk because of their proximity to the export pumps. Although similar studies have not been conducted for other fish species, most species that occur in this portion of the Delta are subject to entrainment, which potentially can increase with decreases in freshwater inflows to the Delta.

Species with pelagic larval stages that are dependent on the Delta and estuary for spawning and early rearing are especially vulnerable to changes in freshwater inflows and direct and indirect pumping-related mortality. Potential impacts of the Project on the pelagic fish community were evaluated based on predicted changes in estuarine habitat conditions for three representative

species (delta smelt, longfin smelt, and striped bass), as indexed by X2¹. X2 is used in the following analysis as the primary variable for evaluating the effects of flow on estuarine fish species because of its direct relationship to outflow and its demonstrated link to annual variation and long-term trends in abundance of several species, including federally and state-listed delta smelt and longfin smelt (Jassby et al. 1995; Kimmerer 2002).

X2 measures the effect of hydrologic conditions (i.e., outflow) on the salinity distribution and the physical habitat of estuarine fish species and their prey and can be used as a general indicator of habitat conditions in the spring and fall. In general, upstream shifts in X2 during the spring and fall are associated with reductions in outflows that can adversely affect delta smelt and other species through direct effects on larval transport and availability of suitable habitat, and potential indirect effects on turbidity, food availability, contaminants, predation rates, and entrainment risk. While the specific mechanisms linking flow effects with species survival and abundance are not well understood, X2 provides a useful indicator of estuarine fish habitat based on the general negative relationships between this variable and annual abundance indices of a number of fish species and their principal prey (calanoids, mysids) (Mac Nally et al. 2010, in press; Kimmerer et al. 2009). Although the X2 responses of some species changed following the introduction of the overbite clam *Corbula amurensis* in 1986, most species that historically exhibited an X2 relationship continue to show statistically significant relationships between abundance or early life stage survival and X2 position.

Methods

For the purposes of this assessment, it is assumed that project effects on Delta inflows would translate directly to changes in Delta outflow (i.e., no changes in Delta exports or diversions are assumed). Because this does not account for water management and regulatory actions that typically would occur to maintain Delta water quality and ecosystem protection standards (including potential export restrictions), the results represent the maximum potential project effect on net flow through the Delta and total outflow.

Potential project effects on Chinook salmon, steelhead, and other anadromous species in the Delta were evaluated qualitatively based on the percent change in inflow during the primary migration and rearing periods in the Delta (September through June). It was assumed that proportional changes in Delta inflow provide a general indicator of the magnitude of potential flow-related effects on survival and migration in the Delta. For Chinook salmon and steelhead, these effects include changes in water quality, straying, and entrainment risk.

Potential project effects on estuarine fish species were evaluated using monthly X2 values computed from historical DAYFLOW and EBMUDSIM outflow data, as described in Section 3.1, Water Resources. The analysis focuses on two seasonal periods, winter-spring (January through June) and fall (September through December). The winter-spring period corresponds to the larval rearing periods of longfin smelt, striped bass, and a number of other estuarine fish species that historically have exhibited negative relationships with winter-spring X2 values (i.e., increasing abundance with increasing outflow or seaward position of X2) (Kimmerer et al. 2009). To evaluate potential project effects, the following post-1986 relationships (from Kimmerer et al. 2009) were used to compute

¹ The parameter X2 (i.e., the distance in kilometers [km] of the 2-parts per thousand [ppt] isohaline from the Golden Gate Bridge) has been used to manage flows in the Delta since 1995 and serves as an indicator of potential effects of Delta outflow on physical habitat conditions in the upper San Francisco estuary.

abundance or survival indices from the simulated monthly outflow and X2 values under project (EBMUDSIM data) and baseline (historical 1970-2006 DAYFLOW data) conditions:

Longfin smelt: $MWT = 10^{(6.19 - 0.05(X2))}$

MWT = annual abundance index based on fall midwater trawl survey catch data

X2 = average of monthly X2 values for January–June

Striped bass: $TNS = 10^{(3.81 - 0.025(X2))}$

TNS = annual survival index based on summer townet survey catch data

X2 = average of monthly X2 values for April–June

Delta smelt abundance historically has not shown a consistent relationship with winter-spring X2 values. However, X2 is correlated with the amount of suitable habitat (defined by water clarity and salinity) for pre-spawning adults during the fall and, since 1987, has been shown to contribute to the prediction of delta smelt abundance the following summer (Feyrer et al. 2011). The following equation (derived from the data presented by Feyrer et al. (2011) was used to compute estimates of annual fall habitat area (habitat index) for delta smelt under project (EBMUDSIM data) and baseline (historical 1970–2009 DAYFLOW data) conditions:

$A = 1.156(X2)^3 - 274.74(X2)^2 + 21393(X2) - 539798$

A = fall habitat index or area of suitable habitat (hectares)

X2 = average of monthly X2 values for September–December

This equation estimates the total area of suitable habitat for Delta smelt for X2 values ranging from 67 to 90 kilometers (km) inland from the Golden Gate Bridge (Figure 3.2-8). Note that the largest change in suitable habitat area occurs at X2 values between 70 and 85 km and that the data does not extend beyond X2 values of 67 and 90 km. Therefore, for the purposes of this impact assessment, it was assumed that there would be little change in the habitat index with X2 positions less than 67 km or greater than 90 km.

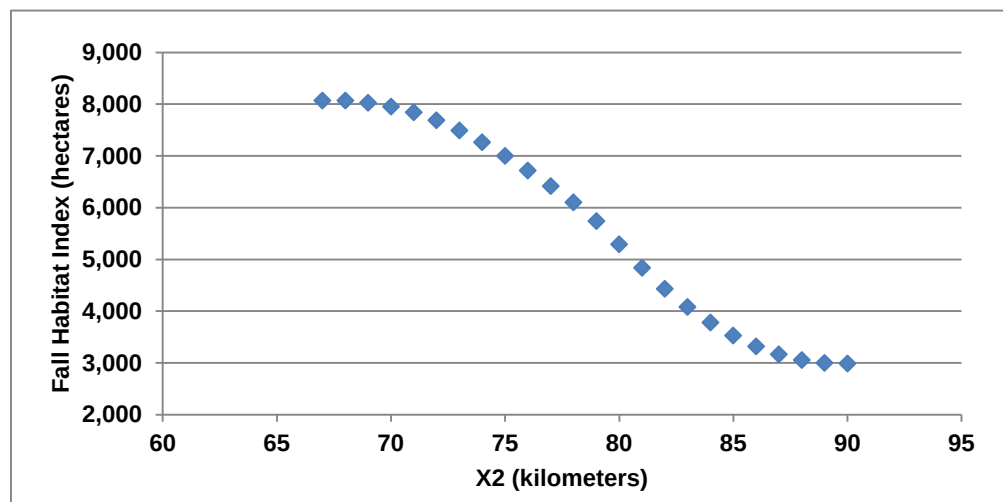


Figure 3.2-8
Fall Habitat Index for Delta Smelt in Relation to X2

Results

Based on the analysis described in Section 3.1, Water Resources, the Project would be expected to result in a less than 0.7% reduction in monthly Delta inflows during September–June in most years (95% of the time), assuming 1970 through 2009 hydrology. These small reductions in Delta inflows would have correspondingly small effects on flow patterns and habitat conditions in the Delta. Based on available information on the relationships between Delta inflows, export pumping rates, and fish survival and entrainment in the Delta, the Project would result in slight increases in entrainment risk but would have no measurable long-term population effects on Chinook salmon, steelhead, or other anadromous fish species.

Based on maximum potential changes in Delta outflow associated with the Project, the effects of the project would be limited to slight shifts in the position of X2 during September through June relative to historical X2 values (Section 3.1, Water Resources, Table 3.1-7). During the primary spawning and larval rearing periods of longfin smelt (January–June) and striped bass (April–June), the position of X2 would be unchanged or shifted upstream by less than 0.1 km in most years (95% of the time), resulting in little or no measurable effects on estuarine habitat conditions. Potential changes in annual abundance or survival indices for longfin and striped bass would be less than 0.5% in most years (Table 3.2-19). During September through December, the position of X2 would be unchanged or shifted upstream by less than 0.25 km in most years (Section 3.1, Water Resources, Table 3.1-7). Corresponding reductions in suitable fall habitat area for delta smelt would be unchanged or less than 1% in most years (Table 3.2-14). Therefore, the Project would have *less-than-significant* effects on anadromous and estuarine fish species and habitat.

Table 3.2-19. Distribution of Annual Abundance Indices (Longfin Smelt), Survival Indices (Striped Bass), and Fall Habitat Areas (Delta Smelt) Based on Seasonal X2 Values under Historical and Project Conditions (Assuming No Reduction in Exports or Diversions from the Delta)

	Baseline (Historical)			With Project			Difference (%) ^a		
	Longfin Smelt Abundance Index	Striped Bass Survival Index	Delta Smelt Habitat Area (hectares)	Longfin Smelt Abundance Index	Striped Bass Survival Index	Delta Smelt Habitat Area (hectares)	Longfin Smelt Abundance Index	Striped Bass Survival Index	Delta Smelt Habitat Area
Minimum	48.2	33.8	2,895.7	48.2	33.8	2,895.7	-1.3	-1.3	-1.2
5 th Percentile	87.7	45.4	2,898.2	87.7	45.4	2,898.2	-0.4	-0.2	-0.8
10 th Percentile	132.6	49.7	2,905.9	131.4	49.6	2,905.7	-0.3	-0.2	-0.3
50 th Percentile	806.2	98.0	4,239.8	804.2	97.9	4,235.5	-0.1	-0.1	0.0
90 th Percentile	3,011.2	298.9	8,033.8	3,007.1	298.9	8,033.4	0.0	0.0	0.0
95 th Percentile	3,455.7	346.6	8,040.2	3,455.6	346.5	8,040.2	0.0	0.0	0.0
Maximum	6,299.7	406.9	8,069.0	6,296.8	406.7	8,069.0	0.0	0.0	0.0

^a The distribution of the differences was generated by subtracting the baseline values from the with-project values for each year of the period of record (1970-2009).

3.2.3.5 Summary of Significant Impacts and Mitigation Measures

Potentially significant impacts on fish resources resulting from implementation of the Project are described below.

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

EBMUD has been subject to the Corps flood-control requirements since the early 1960s. These requirements mandate that EBMUD maintain sufficient reservoir space in Pardee and Camanche Reservoirs to capture potential flood waters beginning in the fall and running through spring and early summer of some years. Except in dry years, these requirements mean that EBMUD must release sufficient water from Camanche Reservoir to the lower Mokelumne River so that it has vacated enough reservoir space to meet the flood-control requirements beginning in the fall. In such years, there may be an opportunity to optimize the releases of flood-control water to provide habitat benefits to the lower Mokelumne River salmonids. This opportunity would be dependent on appropriate hydrology, reservoir storage, and required release conditions to maintain the Corps flood-control requirements and avoid risk of water supply shortage.

During early November through spring, floodflow releases are governed by the Corps rainflood drawdown requirement to mitigate varying weather conditions, which affect watershed runoff and river flows. EBMUD makes controlled releases to manage river flows and meet flood-control requirements.

During spring through October, however, as Corps drawdown requirements relax and river flows become more predictable, there is more flexibility to optimize floodflow releases for salmonid habitat benefits. During spring through October, the objective of EBMUD's release scheduling is to maintain coldwater pools for release in the fall and maximize the benefits of required releases while ensuring that it has vacated sufficient flood control space by the key November 5th deadline.

The protection of fish resources in the lower Mokelumne River also depends on EBMUD's ability to continue to meet the JSA flow requirements and successfully implement other elements of the JSA throughout the proposed extension of Permit 10478 entitlements (Section 3.2.2, Regulatory Setting).

As described in Section 3.2.3.4, Impact Assessment, low flows along the migration routes of adult salmon and steelhead can impede or delay their migration to spawning areas. During the primary fall-run Chinook salmon and steelhead immigration period (September through February), adequate water depths are required in the lower Mokelumne River to provide unimpeded passage downstream of Woodbridge Dam. Under project conditions, flows below Woodbridge Dam from September through December may impede adult salmonid migration if it results in inadequate water depths. This impact would be *significant* if it precludes passage of upstream migrating adult fall-run Chinook salmon and steelhead. *Implementation of the following mitigation measure would reduce this significant impact to less-than-significant levels.*

Mitigation Measure FISH-1: If expected flows below Woodbridge Dam impair adult salmonid migration from September through February, one of the following measures will be implemented depending on EBMUD reservoir carryover storage conditions and water year runoff.

- 1) EBMUD will release from Camanche Dam up to a total of 2,000 acre-feet of additional water above required releases during the September through February period in Below Normal and Dry water years to facilitate adult salmonid fish passage below Woodbridge Dam.
- 2) During Critically Dry water years, EBMUD will survey the reach below Woodbridge Dam prior to spawning season to identify any significant blockages or obstructions to instream passage. Adequate water depths of sufficient width are necessary to promote passage of adult salmonids at critical passage sites. At least 25% of the entire width of a potential passage impediment will be reconfigured to provide at least 0.9 foot in water depth. If a blockage is identified EBMUD will work with the appropriate entity to remove or reduce the impediment, to ensure that there is a depth of at least 0.9 foot to facilitate adult salmonid fish passage.

The magnitude, frequency, and duration of the additional flows set forth in number 1) above, are to be determined by the JSA Partnership Steering Committee based on Camanche cold water storage, and water temperatures below Woodbridge Dam. Instream passage improvements are to be determined by the JSA Partnership Steering Committee based on EBMUD assessment of potential passage impediments from Woodbridge Dam downstream to tidal influence during July or August of current (April through September) or anticipated (October through March) Critically Dry water years.

3.3 Vegetation, Wetland, and Wildlife Resources

This section presents information on vegetation, wetlands, other waters of the United States, and wildlife resources (collectively referred to as *biological resources*) located in the project area. Fish resources are evaluated in Section 3.2, Fish Resources, of this EIR. This section includes a discussion of the environmental setting, a summary of the regulatory requirements, and an analysis of project effects on biological resources. The analysis concludes there would be no significant impacts on biological resources as a result of implementing the Permit 10478 Time Extension Project (Project).

3.3.1 Environmental Setting

For the purposes of this discussion, the project region for the analysis on vegetation, wetland, and wildlife resources is a 2-mile buffer around the project area, which comprises Pardee Reservoir, upstream to the Middle Bar Bridge; Camanche Reservoir; and the lower Mokelumne River between Camanche Dam spillway and the Woodbridge Irrigation District (WID) intake near the town of Woodbridge. The project area is in the following U.S. Geological Survey (USGS) 7.5-minute quadrangles: Valley Springs, Wallace, Clements, Lockeford, Lodi North, and Jackson (Figure 1-2).

3.3.1.1 Methods

The analysis in this section is based on review of existing and available information, extensive field studies conducted along the lower Mokelumne River, and a reconnaissance survey of the project region. This information consists of field surveys of the project area, as well as literature and database searches.

Biological Field Studies

Over the past decade a significant amount of biological information has been collected during field studies on the lower Mokelumne River and reported by EBMUD Fisheries and Wildlife Division staff as part of the JSA compliance and Lower Mokelumne River Partnership studies. These studies include:

- Lower Mokelumne River Riparian Bird Surveys (Smith 2004).
- Lower Mokelumne River Amphibian and Reptile Survey (Workman and Smith 2004).
- Survey of Falcon, Kites, Hawks and Owls in the Lower Mokelumne River Watershed in Sacramento and San Joaquin Counties (Reeves and Smith 2004).
- Lower Mokelumne River Small Mammal Inventory (Reeves and Jones 2004a).
- Terrestrial Vegetation Communities along the Lower Mokelumne River (Reeves and Jones 2004b).
- Non-native Invasive Plant Communities along the Lower Mokelumne River (Reeves and Jones 2004c).
- Mokelumne River Watershed Master Plan (East Bay Municipal Utility District 2008a).

Literature and Database Searches

In addition to the information identified above, ICF International biologists reviewed the following information to identify vegetation, wetland, and wildlife resources that could occur in the project area:

- Freeport Regional Water Project Environmental Impact Report/Environmental Impact Statement (Jones & Stokes 2003a).
- California Department of Fish and Wildlife (CDFW) Natural Diversity Database (CNDDB) (California Department of Fish and Game 2012b) (Figures 3.3-1 and 3.3-2).
- California Native Plant Society (CNPS) Inventory of Rare and Endangered Plants of California (California Native Plant Society 2013).
- Species list of federally listed wildlife and plants for the Valley Springs, Wallace, Clements, Lockeford, Lodi North, and Jackson USGS 7.5-minute quadrangles (U.S. Fish and Wildlife Service 2013).
- *San Joaquin County Multi-Species Habitat Conservation and Open Space Plan* (SJMSCP Steering Committee 2000).
- San Joaquin County 2010 General Plan Public Review Draft Background Report for Natural Resources (July 2009).
- *Calaveras County General Plan* (1996).
- Personal observation information from an EBMUD biologist (Jones pers. comm.).
- Breeding Riparian Songbird Monitoring along the Lower Mokelumne River, 2004–2010 (Howell et al. 2011).
- Tricolored Blackbird Portal (Tricolored Blackbird Working Group 2013).
- eBird: Online Database of Bird Distribution and Abundance (eBird 2013).

This information was used to develop lists of special-status species and other sensitive biological resources with potential to occur in the project region. Special-status species were included in these lists if they were known to occur in the project region (as shown on Figures 3.3-1 and 3.3-2) and if their habitats could occur in the project region. Special-status plants and wildlife identified as present or having the potential to occur in the project region are shown in Tables 3.3-1 and 3.3-2, respectively. For plants, the database search included the surrounding quadrangles (i.e., the standard “nine-quad search.” No protocol-level biological surveys for special-status species have been conducted because the Project would not involve any ground-disturbing activities.

Field Visit

In addition to the numerous field surveys conducted by EBMUD biologists, ICF International biologists conducted a reconnaissance-level field visit on April 9, 2009. This field visit consisted primarily of visual observations from roads and other publicly accessible areas. For those portions of the project area that could not be accessed or observed directly from public roads, information on vegetation and wetland resources was obtained from analysis of existing information and recent aerial photographs.

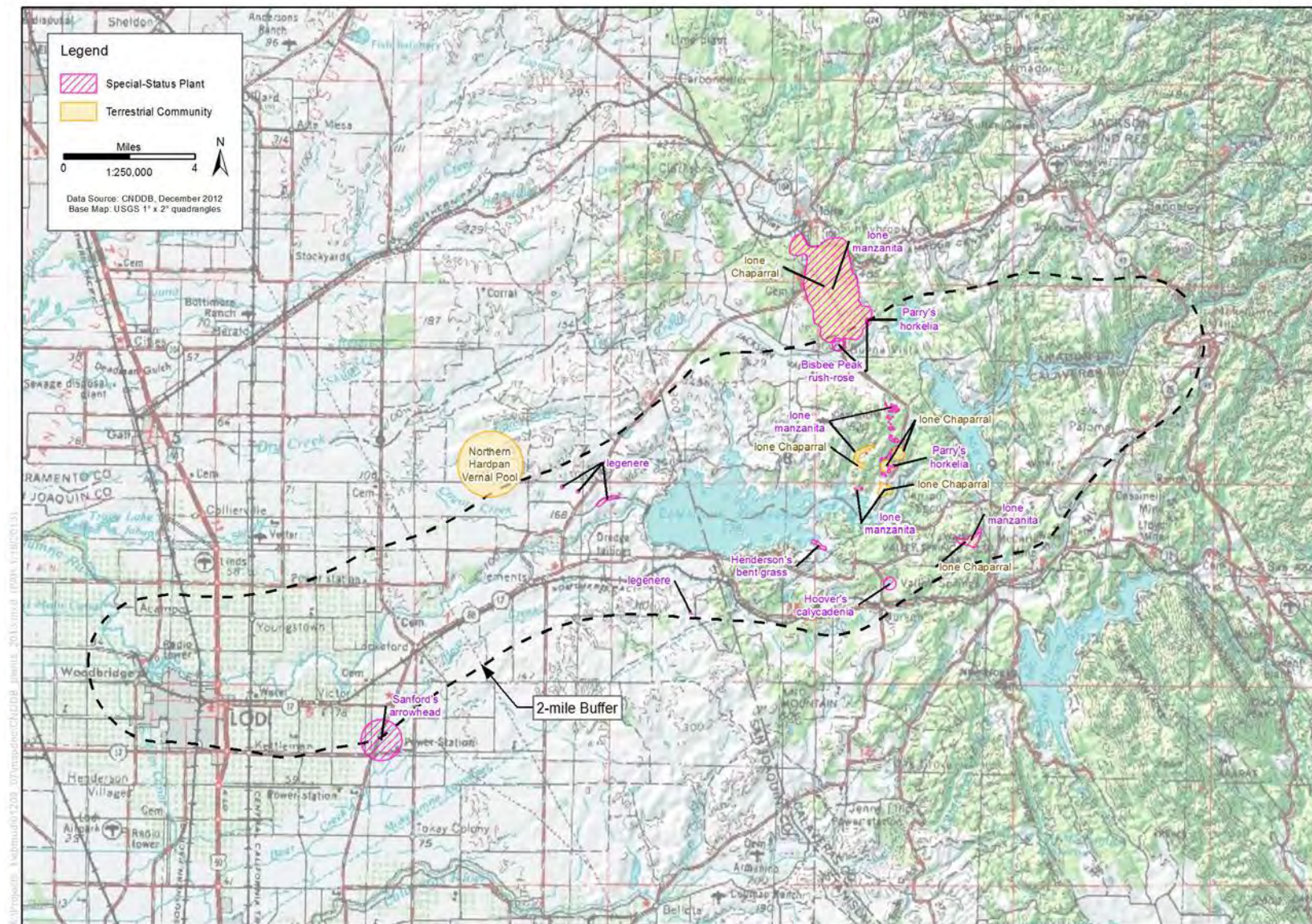


Figure 3.3-1
Special-Status Plant Occurrences Documented in the Project Region

Figure 3.3-2

Table 3.3-1. Special-Status Plant Species Known to Occur in the Project Region^a

Common Name	Scientific Name	Status (Fed/State/ CRPR) ^b	Blooming Period ^c	Habitat	Potential to Occur in the Project Component Region ^d		
					PR	CR	LMR
Ahart's dwarf rush	<i>Juncus leiospermus</i> var. <i>ahartii</i>	--/--/1B.2	Mar–May	Mesic areas in valley and foothill grassland; 30–229 meters	L	L	L
Bisbee Peak rush-rose	<i>Helianthemum suffrutescens</i>	--/--/3.2	Apr–Jun	Ultramafic, gabbroic, or lone soils in chaparral	Known	Known	N
Bogg's Lake hedge hyssop	<i>Gratiola heterosepala</i>	--/E/1B.2	Apr–Aug	Marshes and swamps along lake margins, vernal pools on clay soils; 10–2,375 meters	L	L	L
Bolander's water-hemlock	<i>Cicuta maculata</i> var. <i>bolanderi</i>	--/--/2.1	Jul–Sep	freshwater or brackish marshes and swamps; below 200 meters	L	L	L
bristly sedge	<i>Carex comosa</i>	--/--/2.1	May–Sep	Lake margins, annual grassland; below 625 meters	M	M	L
Congdon's lomatium	<i>Lomatium congdonii</i>	--/--/1B.2	Mar–Jun	serpentinic soils in chaparral and oak woodland; 300–2,100 meters	N	N	N
Delta button-celery	<i>Eryngium racemosum</i>	--/E/1B.1	Jun–Oct	Mesic clay depressions in riparian scrub; 3–30 meters	N	N	L
Dwarf downingia	<i>Downingia pusilla</i>	--/--/2.2	Mar–May	Vernal pools and mesic areas in grassland; below 445 meters	L	L	M
Ewan's larkspur	<i>Delphinium hansenii</i> ssp. <i>ewanianum</i>	--/--/4.2	Mar–May	Rocky substrates in cismontane woodland or grassland; 60–600 meters	M	M	L
Henderson's bentgrass	<i>Agrostis hendersonii</i>	--/--/3.2	Apr–Jun	Mesic valley and foothill grassland, vernal pools; 0–305 meters	M	Known	L
Hoover's calycadenia	<i>Calycadenia hooveri</i>	--/--/1B.3	Jul–Sep	Rocky substrates in cismontane woodland and grassland; 65–300 meters	M	Known	L
Lone buckwheat	<i>Eriogonum apricum</i> var. <i>apricum</i>	E/E/1B.1	Jul–Oct	Openings in chaparral on lone soils	H	N	N
Lone manzanita	<i>Arctostaphylos myrtifolia</i>	T/--/1B.2	Nov–Mar	Acidic lone formation soils in chaparral and cismontane woodland	Known	Known	N
Irish Hill buckwheat	<i>Eriogonum apricum</i> var. <i>prostratum</i>	E/E/1B.1	Jun–Jul	Openings in chaparral on lone soils	M	M	N

Table 3.3-1. Continued

Common Name	Scientific Name	Status (Fed/State/ CRPR) ^b	Blooming Period ^c	Habitat	Potential to Occur in the Project Component Region ^d		
					PR	CR	LMR
Legenere	<i>Legenere limosa</i>	--/--/1B.1	Apr–Jun	Vernal pools; below 880 meters	L	H	Known
Mariposa cryptantha	<i>Cryptantha mariposae</i>	--/--/1B.3	Apr–Jun	Rocky or serpentine soils in chaparral; 200–650 meters	M	M	N
Parry's horkelia	<i>Horkelia parryi</i>	--/--/1B.2	Apr–Sep	Ione formation soils in chaparral and oak woodland; 80–1035 meters	Known	Known	L
Pincushion navarretia	<i>Navarretia myersii</i> ssp. <i>myersii</i>	--/--/1B.1	May	Vernal pools, often acidic; 20–330 meters	L	L	L
Prairie wedge grass	<i>Sphenopholis obtusata</i>	--/--/2.2	Apr–Jul	Mesic meadows and openings in oak woodland; 300–2000 meters	M	M	N
Red hills soaproot	<i>Chlorogalum grandiflorum</i>	--/--/1B.2	May–Jun	Serpentine, gabbroic, and other soils in chaparral, oak woodland, and lower montane coniferous forest; 245–1240 meters	N	N	N
Sacramento Orcutt grass	<i>Orcuttia viscida</i>	E/E/1B.1	Apr–Jul	Vernal pools	L	L	L
Sanford's arrowhead	<i>Sagittaria sanfordii</i>	--/--/1B.2	May–Oct	Marshes, ponds, and swamps; roadside ditches; below 650 meters	M	M	Known
Side-flowering skullcap	<i>Scutellaria lateriflora</i>	--/--/2.2	Jul–Sep	Mesic meadows; marshes	N	N	L
Succulent owl's-clover	<i>Castilleja campestris</i> ssp. <i>succulenta</i>	T/E/1B.2	Apr–May	Vernal pools and swales, often on acidic soils; 50–750 meters	L	L	L
Tuolumne button-celery	<i>Eryngium pinnatisectum</i>	--/--/1B.2	May–Aug	Vernal pools and mesic sites in oak woodland, lower montane coniferous forest; 70–915 meters	L	L	L
Watershield	<i>Brasenia schreberi</i>	--/--/2.3	Jun–Sep	Freshwater marshes and swamps; 30– 2200 meters	M	M	M
Woolly rose-mallow	<i>Hibiscus lasiocarpus</i>	--/--/1B.2	Jun–Sep	Freshwater marshes and swamps; below 120 meters	N	N	M

Table 3.3-1. Continued

Common Name	Scientific Name	Status (Fed/State/ CRPR) ^b	Blooming Period ^c	Habitat	Potential to Occur in the Project Component Region ^d		
					PR	CR	LMR
^a <i>Region</i> is defined for the purposes of the database searches as the project area quadrangles and all surrounding quadrangles (standard “9-quad search,” see text), as distinct from the project component region, defined as a 2-mile buffer around the project area. Plant list generated from searches of the California Natural Diversity Database (CNDDDB) (California Department of Fish and Game 2012) and the CNPS’s online <i>Inventory of Rare and Endangered Plants</i> (California Native Plant Society 2013). Table includes state and federal listed plants, and CRPR Lists 1B, 2, and 3. Plants on Lists 3 and 4 may be included as special-status species on the basis of local significance or recent biological information, e.g., Ewan’s larkspur is included because the project area is at the extreme north end of its distribution.							
^b Plant status definitions and governing agencies are as follows: - = No listing Federal (U.S. Fish and Wildlife Service) T = Threatened E = Endangered State (California Department of Fish and Wildlife) E = Endangered California Rare Plant Rank (CRPR) 1B = Plants rare, threatened, or endangered in California and elsewhere. 2 = Plants rare, threatened, or endangered in California, but more common elsewhere. 3 = Plants for which more information is needed. 4 = Plants with limited distribution, a watch list. CRPR Threat Ranks .1 = Seriously endangered in California. .2 = Fairly endangered in California. .3 = Not very endangered in California.							
^c Blooming Period refers to the expected flowering period, when the plant is expected to be evident and identifiable, and, is considered a guide for the best time to survey for the species; however, some plants may be identifiable at other growth stages.							
^d The project component regions are defined as: Pardee Reservoir (PR), Camanche Reservoir (CR), and Lower Mokelumne River (LMR). The project region includes the project area and a 2-mile buffer.							
Definitions of occurrence levels: Known: Plant known to occur within 2 miles of the project region (CNDDDB 2012). High: Known occurrence in region from CNDDDB or other documents; or presence of suitable habitat conditions and suitable microhabitat conditions. Moderate: Known occurrence of plant in region from CNDDDB or other documents; but suitable microhabitat conditions are not present. Low: Plant not known to occur in the region from CNDDDB or other documents; habitat conditions of poor quality. None: Plant not known to occur in the region from CNDDDB or other documents; suitable habitat not present in any condition.							

Table 3.3-2. Special-Status Wildlife Species with Potential to Occur in the Project Region

				Potential to Occur in Each Project Component Region ^c		
Common Name (<i>Scientific Name</i>)	Status Fed/State ^a	Habitat	Occurrence in Project Region ^b	PR	CR	LMR
Invertebrates						
Rudolph's cave harvestman (<i>Banksula rudolphi</i>)	-/S1	A cave obligate that is known only from Chrome Cave, a small cave in a limestone outcrop surrounded by serpentine with a high relative humidity and mean temperature.	There is one CNDDDB occurrence in Chrome Cave approximately 0.5 miles north of the Channel Arm of Pardee Reservoir.	X		
Conservancy fairy shrimp (<i>Branchinecta conservatio</i>)	E/--	Large, deep vernal pools in annual grasslands.	There are no observations in the project region. There is suitable habitat in the project region.		X	X
Vernal pool fairy shrimp (<i>Branchinecta lynchi</i>)	T/--	Vernal pools and ephemeral pools in sandstone rock outcrops, grass swales, or basalt flows.	There is one CNDDDB occurrence approximately 2 miles north of Camanche Reservoir.		X	X
Midvalley fairy shrimp (<i>Branchinecta mesovallensis</i>)	-/S2	Vernal pools; may occur in small, relatively short-lived pools.	There are five CNDDDB occurrences within 4 miles of Lodi.		X	X
Vernal pool tadpole shrimp (<i>Lepidurus packardii</i>)	E/--	Vernal pools and ephemeral ponds, usually in grasslands.	There are two CNDDDB occurrences: one approximately 1 mile west of the City of Lodi, and one approximately 5 miles north of Clements at the Florence Lake Vernal Pool Preserve.		X	X
Valley elderberry longhorn beetle (<i>Desmocerus californicus dimorphus</i>)	T/--	Elderberry shrubs in riparian and oak savanna communities.	There are six CNDDDB occurrences in the project region, including one location on the lower Mokelumne River and one location close to the south shore of Camanche Reservoir.	X	X	X
Leech's skyline diving beetle (<i>Hydroporus leechi</i>)	--/S1	Shallow water along pond shorelines.	There is one CNDDDB occurrence near Mokelumne Hill.	X	X	X

Table 3.3-2. Continued

Common Name (<i>Scientific Name</i>)	Status Fed/State ^a	Habitat	Occurrence in Project Region ^b	Potential to Occur in Each Project Component Region ^c		
				PR	CR	LMR
Amphibians						
California tiger salamander (<i>Ambystoma californiense</i>)	T/T	Breeds in seasonal ponds in grassland and oak woodlands; uses underground burrows in upland habitats for summer dormancy.	There are 13 CNDDDB occurrences and numerous observations in the project region and critical habitat occurs north of CR in the northeast corner of San Joaquin County.	X	X	X
Western spadefoot (<i>Spea hammondi</i>)	--/SSC	Occurs primarily in grassland habitats but can be found in valley-foothill hardwood woodlands. Vernal pools are essential for breeding and egg-laying.	There are two CNDDDB occurrences in the project region: one located approximately 2 miles west of the Camanche Reservoir and one covering an area of several slow-moving creeks approximately 2 miles southeast of Wallace.		X	
California red-legged frog (<i>Rana aurora draytonii</i>)	T/SSC	Ponds with emergent vegetation and quiet pools in permanent streams.	This species has been recorded approximately 1.5 miles from EBMUD lands. Critical habitat occurs 1.4 miles south of PR in Calaveras County. The species could occur in tributaries to both reservoirs and the river; however, it is incompatible with predatory bullfrog (<i>Rana catesbeiana</i>) that is common along LMR (Workman and Smith 2004) and predatory fish in both PR and CR (Jones pers. comm.).	X	X	X
Reptiles						
Western pond turtle (<i>Actinemys marmorata</i>)	--/SSC	Ponds, marshes, streams and irrigation canals with aquatic vegetation in woodland and grassland communities.	There are two CNDDDB occurrences: one south of Camanche Reservoir and one occurrence north of Lockeford. Numerous observations occur within the project region. The reservoirs and river provide suitable habitat.	X	X	X

Table 3.3-2. Continued

Common Name (<i>Scientific Name</i>)	Status Fed/State ^a	Habitat	Occurrence in Project Region ^b	Potential to Occur in Each Project Component Region ^c		
				PR	CR	LMR
Coast-horned lizard (<i>Phrynosoma blainvillii</i>)	-/SSC	Sacramento Valley, including foothills, south to southern California; Coast Ranges south of Sonoma County; below 4,000 feet in northern California; grasslands, brushlands, woodlands, and open coniferous forest with sandy or loose soil; requires abundant ant colonies for foraging.	There are no observations in the project region. There is suitable habitat in the project region.	X	X	X
Giant garter snake (<i>Thamnophis gigas</i>)	T/T	Freshwater marshes, sloughs, and canals with emergent vegetation; requires high ground above water for winter dormancy.	There are no CNDDDB occurrences in the project region. There is suitable habitat in the lower Mokelumne River.			X
Birds						
American white pelican (<i>Pelecanus erythrorhynchos</i>)	--/SSC (Nesting)	Freshwater lakes with islands for breeding; inhabits river sloughs, freshwater marshes, salt ponds, and coastal bays during the rest of the year.	There are no CNDDDB nesting occurrences in the project region but there have been numerous observations in the project region (Smith 2004; eBird 2013). Historically, nested at large lakes throughout California; but no longer nests in San Joaquin Valley	X	X	X
Great blue heron (<i>Ardea herodias</i>)	-/CDF Sensitive (Nesting colony)	Found throughout much of North America and into Central and South America; rookeries occur in tall trees near a variety of wetland habitat types. Isolated areas that discourage predation and human disturbance are preferred.	There are no CNDDDB occurrences in the project region but there have been numerous observations in the project region (Smith 2004; Howell et al. 2011). Suitable nesting habitat exists in the project region.	X	X	X
Great egret (<i>Ardea albus</i>)	-/CDF Sensitive (Nesting colony)	Throughout California except for high mountains and deserts; feeds and rests in fresh and saline emergent wetlands; along the margins of estuaries, lakes, and slow-moving streams; on mudflats and salt ponds; and in irrigated croplands and pastures. Nests colonially in large trees.	There are no CNDDDB occurrences in the project region but there have been numerous observations in the project region (Reeves and Smith 2004; Howell et al. 2011). Suitable nesting habitat exists in the project region.	X	X	X

Table 3.3-2. Continued

Common Name (<i>Scientific Name</i>)	Status Fed/State ^a	Habitat	Occurrence in Project Region ^b	Potential to Occur in Each Project Component Region ^c		
				PR	CR	LMR
Swainson's hawk (<i>Buteo swainsonii</i>)	--/T (Nesting)	Nests in deciduous trees in riparian areas; forages in grasslands and agricultural fields.	There are two CNDDDB nest occurrences in the project region. There is potential nesting habitat in the project region.		X	X
Northern harrier (<i>Circus cyaneus</i>)	--/SSC (Nesting)	Grasslands, meadows, marshes, and seasonal and agricultural wetlands.	There are no CNDDDB occurrences in the project region, but there have been numerous observations in the project region (Smith 2004; Howell et al. 2011). Suitable nesting and foraging habitat are present throughout the project region.			X
White-tailed kite (<i>Elanus leucurus</i>)	--/FP (Nesting)	Valley grasslands, oak savanna, riparian areas or marshes near open grassland.	There are no CNDDDB occurrences in the project region but there have been numerous observations in the project region (Reeves and Smith 2004, Howell et al. 2011). Suitable nesting and foraging habitat throughout the project region.	X	X	X
Bald eagle (<i>Haliaeetus leucocephalus</i>)	--/E	Forages in lakes, bays, rivers, and other open water; nests and roosts in large trees near water.	Nests located at both Pardee and Camanche Reservoirs since 2004; wintering populations occur on both reservoirs, with up to 40 individuals at Camanche Reservoir (Jones pers. comm.). Areas of regular use include the middle Mokelumne River below Pardee Dam, the upper Mokelumne River near Middle Bar, and several locations around the reservoirs.	X	X	X
Burrowing owl (<i>Athene cunicularia</i>)	--/SSC (Burrow sites and some wintering sites)	Lowlands throughout California, including the Central Valley, northeastern plateau, southeastern deserts, and coastal areas. Rare along south coast; level, open, dry, heavily grazed or low-stature grassland or desert vegetation with available burrows.	There are no CNDDDB occurrences in the project region, but the species has been observed in the project region (Reeves and Smith 2004). Suitable habitat exists in the project region.	X	X	X

Table 3.3-2. Continued

Common Name (<i>Scientific Name</i>)	Status Fed/State ^a	Habitat	Occurrence in Project Region ^b	Potential to Occur in Each Project Component Region ^c		
				PR	CR	LMR
Loggerhead shrike (<i>Lanius ludovicianus</i>)	-/SSC (Nesting)	Resident and winter visitor in lowlands and foothills throughout California; rare on coastal slope north of Mendocino County, occurring only in winter; prefers open habitats with scattered shrubs, trees, posts, fences, utility lines, or other perches	There are no CNDDDB occurrences in the project region but there have been numerous observations in the project region (Howell et al. 2011; eBird 2013). Suitable habitat exists in the project region.	X	X	X
California yellow warbler (<i>Dendroica petechia brewsteri</i>)	--/SSC (Nesting)	Breeds in lowland riparian woodlands and isolated willow stands.	There is one CNDDDB nesting occurrence along the lower Mokelumne River and there have been several observations in the project region (Smith 2004; Howell et al. 2011). Suitable nesting habitat exists in the area around Middle Bar (Jones & Stokes 1999).	X	X	X
Yellow-breasted chat (<i>Icteria virens</i>)	--/SSC (Nesting)	Coastal, valley foothill riparian and desert riparian habitats; nests in dense shrubs along a river or stream.	There is one CNDDDB nesting occurrence along Mokelumne River between Camanche and Pardee Reservoirs. Suitable nesting habitat exists in the Upper Mokelumne River, near Middle Bar (Jones & Stokes 1999).	X	X	X
Tricolored blackbird (<i>Agelaius tricolor</i>)	-/SSC (Nesting colony)	Nests in dense colonies in marshes or moist upland sites with dense vegetation; forages in marshes, pastures, and fields.	Documented nesting in six locations in the project region, including in a marsh near the southern shore of Camanche Reservoir (CNDDDB 2012; Tricolored Blackbird Working Group 2013). May also occur in the vicinity of the lower Mokelumne River.		X	X

Table 3.3-2. Continued

				Potential to Occur in Each Project Component Region ^c		
Common Name (<i>Scientific Name</i>)	Status Fed/State ^a	Habitat	Occurrence in Project Region ^b	PR	CR	LMR
Mammals						
American badger (<i>Taxidea taxus</i>)	–/SSC	In California, badgers occur in a wide variety of open, arid habitats but are most commonly associated with grasslands, savannas, mountain meadows, and open areas of desert scrub; the principal habitat requirements for the species appear to be sufficient food (burrowing rodents), friable soils, and relatively open, uncultivated ground.	There are no CNDDDB occurrences in the project region. Suitable habitat exists in the project region.	X	X	X
Riparian brush rabbit (<i>Sylvilagus bachmani riparius</i>)	E/E	Native valley riparian habitats with large clumps of dense shrubs, low-growing vines, and some tall shrubs and trees.	There are no CNDDDB occurrences in the project region. Suitable habitat exists in the project region. The only known populations are confined to Caswell Memorial State Park on the Stanislaus River, Durham Ferry on the San Joaquin River, and to a region in the South Delta near Lathrop, and (Kelly et al. 2011).			X
Pallid bat (<i>Antrozous pallidus</i>)	–/SSC/High priority	Occurs throughout California, except the High Sierra, from Shasta to Kern Counties and along the northwest coast, primarily at lower and middle elevations; occurs in a variety of habitats from desert to coniferous forest. Most closely associated with oak, yellow pine, redwood, and giant sequoia habitats in northern California and oak woodland, grassland, and desert scrub in southern California. Relies heavily on trees for roosts.	There are no CNDDDB occurrences in the project region. Suitable habitat exists in the project region.	X	X	X

Table 3.3-2. Continued

Common Name (<i>Scientific Name</i>)	Status Fed/State ^a	Habitat	Occurrence in Project Region ^b	Potential to Occur in Each Project Component Region ^c		
				PR	CR	LMR
Townsend's big-eared bat (<i>Corynorhinus townsendii</i>)	-/SSC/-	Klamath Mountains, Cascades, Sierra Nevada, Central Valley, Transverse and Peninsular Ranges, Great Basin, and the Mojave and Sonora Deserts; mesic habitats; gleans insects from brush or trees and feeds along habitat edges.	There are no CNDDB occurrences in the project region. Suitable habitat exists in the project region.	X	X	X
Western red bat (<i>Lasiurus blossevillii</i>)	-/-/High priority	Scattered throughout much of California at lower elevations; found primarily in riparian and wooded habitats. Occurs at least seasonally in urban areas. Day roosts in trees within the foliage. Found in fruit orchards and sycamore riparian habitats in the Central Valley.	There are no CNDDB occurrences in the project region. Suitable habitat exists in the project region.	X	X	X
Hoary bat (<i>Lasiurus cinereus</i>)	-/SSC/-	Occurs throughout California from sea level to 13,200 feet; found primarily in forested habitats. Also found in riparian areas and in park and garden settings in urban areas. Day roosts within foliage of trees.	There are no CNDDB occurrences in the project region. Suitable habitat exists in the project region.	X	X	X
Fringed myotis (<i>Myotis thysanodes</i>)	-/-/High priority	Found from coastal region to at least 6,400 feet in elevation in the Sierra Nevada in California; habitat varies from low desert scrub to high-elevation coniferous forest. Roosts in mines, caves, trees, and buildings.	There are no CNDDB occurrences in the project region. Suitable habitat exists in trees in the project region.	X	X	X
Yuma myotis (<i>Myotis yumanensis</i>)	-/-/Low-medium priority	Found throughout California, from lower elevations to 5,000 feet; Inhabits a variety of habitats from the coast to mid-elevation. Roosts in buildings, trees, mines, caves, bridges, and rock crevices.	There are no CNDDB occurrences in the project region. Suitable habitat exists in the project region.	X	X	X

Table 3.3-2. Continued

Common Name (<i>Scientific Name</i>)	Status Fed/State ^a	Habitat	Occurrence in Project Region ^b	Potential to Occur in Each Project Component Region ^c		
				PR	CR	LMR
Western mastiff bat (<i>Eumops perotis</i>)	-/SSC/High priority	Occurs along the western Sierra Nevada, primarily at low to middle elevations, and widely distributed throughout the south Coast Range. Found in a wide variety of habitats from desert scrub to montane conifer. Roosts and breeds in deep, narrow rock crevices but may also use crevices in trees, buildings, and tunnels.	There are no CNDDDB occurrences in the project region. Suitable habitat exists in the project region.	X	X	X

^a Wildlife status definitions and agencies are as follows:

Federal (U.S. Fish and Wildlife Service)

- E = listed as Endangered under the Federal Endangered Species Act
- T = listed as Threatened under the Federal Endangered Species Act
- C = candidate for listing as Threatened or Endangered

State (California Department of Fish and Wildlife)

- E = listed as Endangered under the California Endangered Species Act
- T = listed as Threatened under the California Endangered Species Act
- C = candidate for listing under the California Endangered Species Act
- SSC = California Department of Fish and Wildlife Special Concern Species
- FP = California Department of Fish and Wildlife Fully Protected Species
- S1 = CNDDDB Conservation Status Rank = Critically Imperiled; which may meet the definitions of rare or endangered under CEQA (State CEQA Guidelines Section 15380[b], [c], or [d])
- S2 = CNDDDB Conservation Status Rank = Imperiled; which may meet the definitions of rare or endangered under CEQA (State CEQA Guidelines Section 15380[b], [c], or [d]) Western Bat Working Group (WBWG). 2012.

High priority = Species are imperiled or at high risk of imperilment.

Moderate priority = This designation indicates a level of concern that should warrant closer evaluation, more research, and conservation actions of both the species and possible threats. A lack of meaningful information is a major obstacle in adequately assessing these species' status and should be considered a threat.

Low priority = While there may be localized concerns, the overall status of the species is believed to be secure.

^b Project region is defined as the project area and a 2-mile buffer.

^c Project Component Region = Pardee Reservoir (PR), Camanche Reservoir (CR), and lower Mokelumne River (LMR).

3.3.1.2 Overview of Existing Conditions

Pardee Reservoir

While the water surface elevation of Pardee Reservoir fluctuates through the year, it is generally at an elevation of approximately 560 feet and is surrounded by annual grassland, oak woodland, foothill pine woodland, ponderosa pine, and chaparral that are largely in a natural state, with little development. Developed areas include the dam and its associated facilities and Pardee Recreation Area.

Camanche Reservoir

Biological communities surrounding Camanche Reservoir are similar to those surrounding Pardee Reservoir. Vegetation varies from oak woodland, chaparral, and foothill pine (*Pinus sabiniana*) at the eastern end of the reservoir to nonnative annual grassland at the western end of Camanche Reservoir. The water surface of the reservoir is typically at an elevation of approximately 215 feet. There is more development around Camanche Reservoir than around Pardee Reservoir; however, most of the area surrounding Camanche Reservoir is undeveloped. Higher levels of recreational use, as described in Section 3.5, Recreational Resources, of this EIR, typically occur in summer, thereby reducing the value of open water habitat for wildlife. During the fall, winter, and spring, when there is less recreational activity, Camanche Reservoir provides high-quality open-water habitat for migratory birds, particularly spring migrants, and nesting and wintering bald eagles.

Lower Mokelumne River

The lower Mokelumne River is defined as the river reach between the Camanche Dam spillway and the WID intake at the town of Woodbridge, approximately 18 miles downstream of the Camanche Dam. The elevation of this reach ranges from approximately 115 feet at the base of the spillway to 40 feet at Woodbridge. The lower Mokelumne River historically supported a riparian corridor connecting the higher elevation foothill grasslands and oak woodlands to the Delta. Agriculture, ranching, urban development, and other activities associated with human development have eliminated much of the historical riparian habitat along the lower Mokelumne River, although substantial areas of riparian habitat remain. Agricultural uses in the area include orchards, vineyards, grains, irrigated pasture, and row crops. In the lower reaches, there are oxbows and meanders with adjacent riparian habitat. Nonnative annual grassland areas with seasonal wetlands occur near Camanche Reservoir. Although the riparian habitat along the lower Mokelumne River has been reduced in both acreage and quality, it still is considered a significant wildlife resource.

3.3.1.3 Biological Communities

This section provides an overview of existing conditions and a description of the biological communities that occur in the project region.

Nonnative Annual Grassland

Nonnative annual grassland is common throughout the foothill and valley portions of the project region. Annual grassland provides habitat for a variety of native terrestrial vertebrates. Grasslands support insects, amphibians, reptiles, raptors, and mammals, including the red-tailed hawk (*Buteo jamaicensis*), American kestrel (*Falco sparverius*), great-horned owl (*Bubo virginianus*), California

vole (*Microtus californicus*), deer mice (*Peromyscus* spp.), California ground squirrel (*Spermophilus beecheyi*), American badger (*Taxidea taxus*), and coyote (*Canis latrans*) (Reeves and Jones 2004a; Reeves and Smith 2004; Workman and Smith 2004).

Nonnative annual grassland consists of dense to sparse cover of nonnative annual grasses in association with a variety of showy annual forbs (both native and nonnative). Germination occurs with the onset of the late fall rains. Growth, flowering, and seed-set occur from winter through spring. Plants typically are senescent through the summer and fall dry season. Typical annual grasses are wild oats (*Avena* spp.), bromes (*Bromus* spp.), fescues (*Festuca* spp.), and ryegrass (*Festuca perennis*). Associated forbs are a mix of nonnatives such as mustards (*Brassica* spp.), filarees (*Erodium* spp.), clovers (*Trifolium* spp.), burclovers (*Medicago* spp.), and natives such as goldfields (*Lasthenia* spp.), lupines (*Lupinus* spp.), poppies (*Eschscholzia* spp.), and brodiaeas (*Brodiaea* spp.), (Reeves and Jones 2004b). Nonnative annual grassland also forms the understory in open oak woodlands in the project region. Small pockets of remnant native perennial grassland remain, but this formerly widespread type dominated by needlegrass species (*Stipa* spp., formerly *Nassella*), now covers less than 1% of the lower Mokelumne River (Reeves and Jones 2004b).

Annual grassland habitat adjacent to the lower Mokelumne River is more disturbed than the grassland around the reservoirs and may contain more nonnative, invasive plant species, especially yellow star-thistle (*Centaurea solstitialis*) (Reeves and Jones 2004c).

Chaparral Communities

Chaparral communities occur in the foothills primarily in the Pardee Dam component region on shallow or rocky soils and integrate with forest communities as elevation increases. The chaparral community is a mosaic of subtypes varying based on soil type and depth, slope, aspect, and disturbance regime. Chamise chaparral is common around the reservoirs. Toyon (*Heteromeles arbutifolia*) and whiteleaf manzanita (*Arctostaphylos viscida*) share dominance with chamise (*Adenostoma fasciculatum*) in the cooler, moister microsites of ravines.

Sierran black sage (*Salvia mellifera*) scrub is uncommon in the Sierra Nevada floristic province but occurs in a patchy distribution at scattered locations on south-facing slopes downstream of Pardee Dam, where monodominant stands of black sage occur in a mosaic with chamise and bush monkeyflower (*Mimulus aurantiacus*). Ione chaparral is a sensitive plant community (California Department of Fish and Game 2010b) dominated by the federally listed shrub, Ione manzanita (*Arctostaphylos myrtifolia*). Ione chaparral occurs in the project region intermittently in a narrow band on clay soils running roughly northwest-southeast south of Pardee Dam (Figure 3.3-1).

Chaparral is a diverse habitat type that provides moderately high value for wildlife. The varied composition of chaparral vegetation provides foraging and nesting habitat for a variety of reptiles, birds, and small mammals. Typical chaparral birds of the Sierra foothills are wrentit (*Chamaea fasciata*), Bewick's wren (*Thryomanes bewickii*), California thrasher (*Toxostoma redivivum*), and spotted towhee (*Pipilo maculata*). Common mammals of these habitat types are rodents, such as California ground squirrels, California mouse, and brush mouse (*Peromyscus boyleyi*).

Oak Woodland and Savanna Communities

In the project region, woodland and savanna communities occur around the two reservoirs and in the floodplain of the river. These communities are dominated by a variety of oaks depending on soil type, aspect, and slope. Valley oak (*Quercus lobata*) woodland occurs in deep soils of the valley floor

that may be intermittently flooded or seasonally saturated, and is found mostly along Reach 2 of the lower Mokelumne River; it is typically an open savanna with valley oak the dominant canopy tree and blue oak (*Quercus douglasii*), California sycamore (*Platanus racemosa*), interior live oak (*Quercus wislizeni*), and Oregon ash (*Fraxinus latifolia*) often present in the subcanopy (Reeves and Jones 2004b). Interior live oak woodland occurs on shallow soils that are moderately to excessively drained; it is the dominant canopy tree, and valley oak and blue oak may be present (Reeves and Smith 2004b). Blue oak woodland occurs in the foothills of the Pardee Dam and Camanche Reservoir region and consists of open to savanna-like stands of blue oak trees in a mosaic with nonnative annual grassland. In some areas, foothill pine occurs as a codominant with the oak trees. Shrub species vary with the type of oak community and elevation and generally include varying associations of blackberry (*Rubus* spp.), coffee berry (*Frangula* spp.), poison-oak (*Toxicodendron diversilobum*), manzanita (*Arctostaphylos* spp.), buck brush (*Ceanothus cuneatus*), coyote brush (*Baccharis pilularis*), mountain mahogany (*Cercocarpus betuloides*), and toyon. The understory in most oak woodland types is dominated by nonnative annual grassland species (described above).

Oak woodland and savanna communities in the project region provide valuable foraging and nesting habitat for a variety of birds, including acorn woodpecker (*Melanerpes formicivorus*), white-breasted nuthatch (*Sitta carolinensis*), oak titmouse (*Baeolophus inornatus*), and western scrub-jay (*Aphelocoma californica*). Mammals commonly found in these habitats are mule deer (*Odocoileus hemionus*), western gray squirrel (*Sciurus griseus*), and deer mouse. The abundant acorn crop produced by blue oaks provides an important food source for rodents and birds. In more dense woodland areas, the shade and leaf litter provide favorable habitat for amphibians and reptiles.

In addition to providing important wildlife habitat, oak woodland and savannas are important for soil development and watershed protection.

Riparian Communities

A variety of riparian communities occur along the reservoir edges, Mokelumne River, and tributary drainages in the project region. The two most common general types of riparian communities in the project region are riparian woodland and forest and riparian scrub. Each of these communities is described below.

Riparian communities are some of the richest in terms of structural and biotic diversity of any plant community found in California. Riparian vegetation provides three important functions in addition to wildlife habitat: Riparian vegetation 1) acts as a movement corridor for wildlife between the river and adjacent uplands; 2) filters out pollutants, thus protecting water quality; and 3) helps reduce the severity of floods by stabilizing riverbanks.

Despite widespread disturbances resulting from urbanization, agricultural conversion, and grazing, riparian communities remain important wildlife resources because of their scarcity regionally and statewide and because riparian communities are used by a large variety of wildlife species. Wildlife species use riparian habitats for food, protection from the elements, escape from predators, dispersal and migration corridors, and as a reliable water source.

Riparian Woodland and Forest

A diversity of riparian woodland and forest community subtypes occur along the reservoirs and the lower Mokelumne River. At the southern arm of Pardee Reservoir, a mature community of valley

oak woodland riparian occurs on deep, well-developed soils that are infrequently inundated by a permanent spring.

Approximately 1,600 acres of riparian habitat occur along the lower Mokelumne River (Reeves and Jones 2004b: Table A-2). Distribution of riparian woodland and forest communities is a function of the fluvial geomorphology of the Mokelumne River. In low-gradient areas where sediment deposits are relatively deep, a diverse forest dominated by Fremont cottonwood (*Populus fremontii*), Gooding's black willow (*Salix gooddingii*), and red willow (*Salix laevigata*) with a dense understory of California grape (*Vitis californica*) is present. Associated subcanopy and understory trees include white alder (*Alnus rhombifolia*), box elder (*Acer negundo*), Oregon ash, walnut (*Juglans* spp.), and California sycamore, and the shrub layer is often diverse, with elderberry (*Sambucus* spp.), coyote brush, poison-oak, and California rose (*Rosa californica*) (Reeves and Jones 2004b). In areas frequently disturbed by high flow, white alders colonize the cobble and bedrock substrates in a narrow strip along the water's edge. Oregon ash black willow, and red willow are present in the areas less frequently disturbed by high flows. The invasive woody vine, Himalayan blackberry (*Rubus armeniacus*), may be locally dominant in the understory (Reeves and Jones 2004c).

Riparian woodland and forest communities support a greater diversity of plant species than do other habitat types in the region. They provide a variety of foods and microhabitat conditions for wildlife species. For this reason, riparian forests have the most diverse wildlife communities in the project region. They provide nesting habitat for species such as Swainson's hawk (*Buteo swainsoni*) and red-shouldered hawk (*Buteo lineatus*), warbling vireo (*Vireo gilvus*), western wood-pewee (*Contopus sordidulus*), and yellow-breasted chat (*Icteria virens*) and winter foraging habitat for species such as, ruby-crowned kinglet (*Regulus calendula*) and yellow-rumped warbler (*Dendroica coronata*) (Reeves and Smith 2004; Smith 2004; Howell et al. 2011; eBird 2013). They also provide nesting habitat for cavity-dependent species such as Nuttall's woodpecker (*Picoides nuttallii*), house wren, and tree swallow (*Tachycineta bicolor*) (Smith 2004; Howell et al. 2011).

Introduced riparian forest is found primarily along the lowest reach of the lower Mokelumne River and is dominated by nonnative invasive tree species, black locust (*Robinia pseudoacacia*) and tree-of-heaven (*Ailanthus altissima*) (Reeves and Jones 2004b, 2004c).

Riparian Scrub

Areas along the river that are subject to frequent inundation and high rates of scour support an early-seral shrub community of predominantly sandbar willow (*Salix exigua*). This community generally occurs on gravel bars within the river corridor. Away from the scour zone, native riparian scrub occurs in the floodplains along streams and rivers and is more diverse, with willows, elderberry, coyote brush, California rose, and poison-oak. Scattered patches of blackberry scrub occur, dominated by the native California blackberry (*Rubus ursinus*) or the introduced Himalayan blackberry. In the lowest reach of the lower Mokelumne River, introduced riparian scrub dominated by Himalayan blackberry occurs (Reeves and Jones 2004b).

Blackberry scrub provides foraging habitat and cover for multiple species. Several species that occur in the project region, including northern mockingbird (*Mimus polyglottos*), spotted towhee, gray fox (*Urocyon cinereoargenteus*), and striped skunk (*Mephitis mephitis*) (Reeves and Jones 2004a), forage on blackberries and the insects associated with the shrubs. The dense shrubs also provide cover for California quail (*Callipepla californica*), spotted towhee, song sparrow (*Melospiza melodia*), and

snakes such as the sharp-tailed snake (*Contia tenuis*) (Reeves and Smith 2004; Smith 2004; Howell et al. 2011; Workman and Smith 2004).

Willow scrub provides moderate to dense cover and foraging habitat. Beavers (*Castor canadensis*) feed on young willow shoots, and many small birds and mammals feed on willow seeds. Birds that often use this habitat for foraging and nesting include the black-headed grosbeak (*Pheucticus melanocephalus*), yellow warbler (*Dendroica petechia*), warbling vireo, Wilson's warbler (*Wilsonia pusilla*), orange-crowned warbler (*Vermivora celata*), and song sparrow (Smith 2004; Howell et al. 2011).

Wetland Communities

Wetlands are ecologically productive habitats that support a rich variety of plant and animal life. The Corps defines wetlands as “areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions” (33 Code of Federal Regulations [CFR] 328.3[b], 40 CFR 230.3). For a wetland to qualify as a jurisdictional aquatic site, and therefore, be subject to regulation under Section 404 of Clean Water Act (CWA), the site must support a prevalence of hydrophytic vegetation, hydric soils, and wetland hydrology. This determination is made on a site-specific basis.

The definition of wetlands used by CDFW was developed by USFWS and defines wetlands as “lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is covered by shallow water,” and they exist where any one of the following conditions is present:

- predominantly undrained hydric soils (soils with low concentrations of oxygen in the upper layers during the growing season);
- a predominance, at least periodically, of hydrophytic plants (plants that have adapted to the low availability of oxygen and others stresses in saturated soils); or
- a nonsoil substrate (such as a rocky shore) that is saturated with water or covered by shallow water each year at some point during the growing season.

Under normal circumstances, the federal definition of wetlands requires all three wetland identification parameters to be met, whereas the CDFW definition requires the presence of at least one of these parameters.

In the project region, Corps jurisdictional wetlands and state-regulated wetlands include marshes and seasonal wetland communities that are hydrologically connected to drainages and other bodies of water (e.g., ponds and reservoirs on drainage systems). Hydrologically isolated wetlands, such as some vernal pools and seasonally inundated depressions and swales, and ponds or reservoirs without drainage systems, may not be subject to regulation under Section 404 of CWA but are considered wetlands by CDFW and USFWS. In the project region, many of these isolated wetlands provide habitat for a variety of special-status species.

Wetland communities occur in all project component regions. Several types of wetland communities have been identified along the lower Mokelumne River: natural seasonal wetland, managed seasonal wetland, nontidal freshwater emergent wetland and tidal freshwater emergent wetland (Reeves and Jones 2004b). The wetland communities that could be affected by the Project include seasonal wetland, emergent wetland, and open water, as described below.

Seasonal Wetland Communities

Seasonal wetlands typically occur in swales or concave topographic depressions that are seasonally inundated by rainwater. They generally are dominated by annual facultative wetland vegetation species (species that grow in wetland conditions 67 to 99% of the time). Seasonal wetlands also may occur along the shores of the two reservoirs and along the lower Mokelumne River floodplain.

Seasonal wetland communities are dominated by a variety of annual grass and forb species. The plant association varies depending on the frequency and depth of flooding, soil type, and elevation. There are several subtypes of seasonal wetlands (including vernal pools) in the project region and associated plants include perennial ryegrass, crisp dock (*Rumex crispus*), smartweeds (*Polygonum* spp.), and California mugwort (*Artemisia douglasiana*). Managed seasonal wetlands have been identified in Reach 3 and are associated with irrigation water; they are seasonally flooded with fresh or saline water and are dominated by spikerush (*Eleocharis* spp.), pickleweed, sedges, bulrush (*Scirpus pungens*) and cattails (*Typha* spp.) (Reeves and Jones 2004b). Frequent inundation along the high-water mark of the reservoirs also promotes the establishment of a fringe of the hydrophytic plant Baltic rush (*Juncus balticus*) in gently sloping areas.

Vernal pools are a specific type of seasonal wetland; they are defined as seasonally flooded landscape depressions, usually closed, and are developed over a subsurface impermeable layer that restricts drainage (Holland and Jain 1988). Their formation requires an unusual combination of soil conditions, including a Mediterranean climate (i.e., winter rainfall and summer drought), topography, and hydrology. They support characteristic flora and fauna, including special-status species. In the project region, vernal pools provide habitat for the special-status plant legumere (Figure 3.3-1) and the listed invertebrates vernal pool fairy shrimp (*Branchinecta lynchi*) and vernal pool tadpole shrimp (*Lepidurus packardii*) (Figure 3.3-2).

Seasonal wetlands and vernal pools in grassland areas provide foraging and breeding habitat for a variety of wildlife species. Bird species found within and in the immediate vicinity of seasonal wetlands include great blue heron (*Ardea herodias*), great egret (*Ardea alba*), snowy egret (*Egretta thula*), killdeer (*Charadrius vociferus*), greater yellowlegs (*Tringa melanoleuca*), and Wilson's snipe (*Gallinago delicata*). Mammals, amphibians, and reptiles associated with seasonal wetlands are California vole, deer mouse, western harvest mouse, Pacific chorus frog (*Pseudacris regilla*), western toad (*Bufo boreas*), Pacific ring-necked snake (*Diadophis punctatus amabilis*), and western terrestrial gartersnake (*Thamnophis elegans*).

Emergent Wetland Communities

In the project region, emergent wetland communities develop where frequent flooding provides an anaerobic environment necessary for the establishment and root growth of emergent wetland vegetation. Perennial plants such as bulrush and cattails usually dominate this habitat type, and may reach heights of more than 6 feet.

Permanent marsh in the project region is dominated by cattails and common tule (*Schoenoplectus acutus*), with other wetland plants such as three-square bulrush. There are narrow strips of marsh habitat along the riverbank and on islands in the river channel. Permanent marsh may be interspersed with willow scrub, blackberry scrub, and riparian forest.

Wet meadow occurs along the lower Mokelumne River and is dominated by Santa Barbara sedge (*Carex barbarae*), Bermuda grass (*Cynodon dactylon*), and spikerush and rushes (*Juncus* spp.).

Tidal emergent wetlands occur along the lowest reach of the lower Mokelumne River and are permanently flooded with tidally influenced fresh or saline water (Reeves and Jones 2004b).

Emergent wetlands provide important habitat for a large proportion of the birds that follow the Pacific Flyway. Large numbers of wading birds, shorebirds, and waterfowl use wetland habitats as breeding grounds, migratory stopovers, and wintering grounds. Birds known to be present in these habitats include egrets, great blue heron, killdeer, greater yellowlegs, mallard (*Anas platyrhynchos*), and northern pintail (*Anas acuta*). Additionally, wetlands support many species of amphibians and reptiles, which attract raptor species throughout the year but particularly during the winter months. Common amphibian and reptile species found in this community are Pacific chorus frog, bullfrog (*Bufo marina*), and valley gartersnake (*Thamnophis sirtalis fitchii*).

Open Water

The open water portions of the reservoirs and river support a diversity of waterfowl and waterbirds that use the reservoir as wintering or nesting habitat. Common species occurring in the project region include mallard, common merganser (*Mergus merganser*), American coot (*Fulica americana*), pied-billed grebe (*Podilymbus podiceps*), western grebe (*Aechmophorus occidentalis*), California gull (*Larus californicus*) and ring-billed gull (*Larus delawarensis*) (eBird 2013). Canada goose (*Branta canadensis*) and double-crested cormorant (*Phalacrocorax auritus*) were observed on the reservoir during the reconnaissance survey. The reservoirs serve as a migratory stopover for other waterfowl and other aquatic birds.

Beavers are common along the lower Mokelumne River, where they construct dams and lodges and feed on aquatic vegetation and young willows, cottonwoods, and Oregon ash. Many species of water birds also use the open-water areas. Herons and egrets feed on small fish, crayfish, and amphibians along the banks and in shallow water. Waterfowl, such as mallard, wood duck (*Aix sponsa*), common merganser, bufflehead (*Bucephala albeola*), and common goldeneye (*Bucephala clangula*), forage and rest in the water.

Vineyards and Other Agricultural Lands

Vineyards and other agricultural lands are located adjacent to the lower Mokelumne River. Highly cultivated fields such as vineyards are often of low value to wildlife because they provide very little cover and food. Pesticides applied in vineyards tend to reduce prey populations (insects and other invertebrates) and herbicides are applied to reduce herbaceous plants (cover), although in fall many birds will feed on grapes. Birds observed in vineyards along the lower Mokelumne River include northern flicker (*Colaptes auratus*), northern mockingbird, western scrub-jay, yellow-billed magpie (*Pica nuttallii*), American robin (*Turdus migratorius*), European starling (*Sturnus vulgaris*), yellow-rumped warbler, and house finch (*Carpodacus mexicanus*) (Smith 2004).

Fruit and nut orchards provide food and cover for wildlife as well as roosting and nesting sites for some species. Many species of birds feed on fruits and nuts, including northern flicker, American crow (*Corvus brachyrhynchos*), yellow-billed magpie, western scrub jay, American robin, Bullock's oriole (*Icterus bullockii*), and black-headed grosbeak (Smith 2004).

3.3.1.4 Special-Status Species

Special-status species are plant and animal species that are legally protected under the federal Endangered Species Act (ESA), California Endangered Species Act (CESA), or other regulations, as

well as species considered sufficiently rare by the scientific community to qualify for such listing. Special-status species are those species (species, subspecies, or varieties) that meet any of the criteria listed below.

- Listed or proposed for listing as threatened or endangered under the ESA (50 CFR 17.12 [listed plants]; 50 CFR 17.11 [listed animals]; various notices in the *Federal Register* [FR] [proposed species]).
- Candidates for possible future listing as threatened or endangered under ESA (77 FR 69994–70060, November 21, 2012);
- Listed or proposed for listing by the State of California as threatened or endangered under CESA (14 CCR 670.5).
- Plants listed as rare under the California Native Plant Protection Act (California Fish and Game Code Section 1900 *et seq.*).
- Meet the definitions of rare or endangered under CEQA (State CEQA Guidelines Section 15380[b], [c], and [d]), species that may meet this definition include:
 - plants ranked as “rare, threatened, or endangered in California” (California Rare Plant Rank [CRPR] 1B and 2¹); and
 - plants and animals that may warrant consideration on the basis of local significance or recent biological information (State CEQA Guidelines Section 15380[d]), that may include species with CNDDDB Natural Heritage Ranks of S1 (Critically Imperiled) and S2 (Imperiled) and CRPR 3 (plants about which more information is needed to determine their status) and CRPR 4 (plants of limited distribution) and
 - some species included on the *California Natural Diversity Database* (CNDDDB) *Special Plants, Bryophytes, and Lichens List* and *Special Animals List* (current lists available: <http://www.dfg.ca.gov/biogeodata>).
- Animals fully protected in California (California Fish and Game Code, Section 3511 [birds], 4700 [mammals], and 5050 [reptiles and amphibians]); or
- Animal species of special concern to CDFW (Shuford and Gardali 2008 [birds]; Williams 1986 [mammals]; Jennings and Hayes 1994 [amphibians and reptiles]).

Special-status natural communities are communities that are of limited distribution statewide or within a county or region. The most current version of CDFW’s *List of California Terrestrial Natural Communities* indicates which natural communities are of special status (California Department of Fish and Game 2010).

Special-Status Plants

A review of existing information identified 27 special-status plants as known to occur in the project region, defined for the purposes of the database searches as the project area quadrangles and all surrounding quadrangles (i.e., the standard “nine-quad search”) (Table 3.3-1); the table does not include plants of brackish or freshwater habitats in the Delta known only from the quadrangle(s)

¹ California Department of Fish and Wildlife recently changed *CNPS Rank* to *California Rare Plant Rank*; the name change does not change the definitions or the review and rank assignment process.

west of the project area, such as Mason's lilaeopsis (*Lilaeopsis masonii*), Delta mudwort (*Limosella subulata*), Delta tule pea (*Lathyrus jepsonii*), and Suisun marsh aster (*Symphyotrichum lentum*), because suitable habitat for these species does not occur along the lower Mokelumne River in the project area. According to the CNDDDB (2012), seven of these species have been recorded in the project region (Figure 3.3-1), and an eighth species, lone buckwheat (*Eriogonum apricum* var. *apricum*), occurs very close to the project region boundary. These species are associated with chaparral (lone manzanita, Parry's horkelia [*Horkelia parryi*], lone buckwheat, and Bisbee Peak rushrose [*Helianthemum suffrutescens*]), woodland and grassland (*Hoover's calycadenia*), and seasonal wetlands, vernal pool, or marsh (Henderson's bentgrass [*Agrostis hendersonii*], legenere [*Legenere limosa*], and Sanford's arrowhead [*Sagittaria sanfordii*]) habitats surrounding the reservoirs and river habitats. One occurrence of lone manzanita is within a few dozen feet above the high water mark of the eastern edge of Camanche Reservoir. One occurrence of Henderson's bentgrass near Camanche Reservoir is historical (i.e., it has not been seen since 1935) and is considered possibly extirpated, according to the CNDDDB, because it is believed that its habitat is now under water from when the reservoir was first impounded. No other special-status plants have been documented directly in the reservoirs and none have been recorded along the Mokelumne River.

Special-Status Natural Communities

Two special-status natural communities have been recorded in the project region: lone chaparral and Northern hard pan vernal pool (Figure 3.3-1) (California Department of Fish and Game 2012b). No special-status natural communities have been documented directly within the reservoirs or river.

Special-Status Wildlife

A review of existing information, observation information from an EBMUD biologist (Jim Jones), and observations made by ICF International during the field visit resulted in the identification of 35 special-status wildlife species that may occur in the project region (Table 3.3-2). Twenty-two of these species have been recorded or observed in the project region, including valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), great blue heron, great egret, Swainson's hawk, northern harrier, white-tailed kite, bald eagle, burrowing owl, loggerhead shrike, willow flycatcher, bank swallow, California yellow warbler, yellow-breasted chat, and tricolored blackbird. Nine of the species observed in the project region require vernal pools, seasonal wetland habitats, or other aquatic habitats, including conservancy fairy shrimp (*Branchinecta conservatio*), vernal pool fairy shrimp, midvalley fairy shrimp, vernal pool tadpole shrimp, Leech's skyline diving beetle (*Hydroporus leechi*), California tiger salamander, California red-legged frog, western spadefoot toad, and western pond turtle. One of the observed species, Rudolph's cave harvestman, is a cave obligate. The remaining species have not been reported in the project region but could occur in areas with suitable habitat (Table 3.3-2).

3.3.2 Regulatory Setting

Because the Project would not involve any physical disturbance, many regulations that are typically relevant to biological resource impact analysis in an EIR are not applicable. The discussion below focuses only on those regulations that are *potentially* relevant to the Project.

3.3.2.1 Federal Endangered Species Act

The ESA protects fish and wildlife species, and their habitats, identified by USFWS or the National Marine Fisheries Service (NMFS) as endangered or threatened. *Endangered* refers to species, subspecies, or distinct population segments that are at risk of extinction through all or a significant portion of their range. *Threatened* refers to those that are likely to become endangered in the near future. The ESA is administered by USFWS and NMFS. In general, NMFS is responsible for protection of ESA-listed marine species and anadromous fish, while other listed species are under USFWS jurisdiction.

3.3.2.2 Section 9: Federal Endangered Species Act Prohibitions

ESA Section 9 prohibits the take of any fish or wildlife species listed under the ESA as endangered. Take of threatened species also is prohibited under Section 9 unless otherwise authorized by federal regulations.² *Take*, as defined by ESA, means “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.” *Harm* is defined as “any act that kills or injures the species, including significant habitat modification.” In addition, Section 9 prohibits removing, digging up, cutting, and maliciously damaging or destroying federally listed plants on sites under federal jurisdiction. Section 9 does not prohibit take of federally listed plants on sites not under federal jurisdiction.

3.3.2.3 California Endangered Species Act

California implemented CESA in 1984. The act prohibits the take of endangered and threatened species; however, habitat destruction is not included in the state’s definition of take. Section 2090 of CESA requires state agencies to comply with endangered species protection and recovery and to promote conservation of these species. CDFW administers the act and authorizes take through Section 2081 agreements (except for species designated as fully protected). CDFW can adopt a federal biological opinion as a state biological opinion under California Fish and Game Code, Section 2095. In addition, CDFW can write a consistency determination for species that are both federally and state listed if CDFW determines that the avoidance, minimization, and compensation measures will ensure no take of species.

Regarding rare plant species, CESA defers to the California Native Plant Protection Act of 1977, which prohibits importing rare and endangered plants into California, taking rare and endangered plants, and selling rare and endangered plants. State-listed plants are protected mainly in cases where state agencies are involved in projects under the California Environmental Quality Act (CEQA). In these cases, plants listed as rare under the California Native Plant Protection Act of 1977 are not protected under CESA but can be protected under CEQA.

3.3.2.4 California Fish and Game Code

Section 3503 of the California Fish and Game Code prohibits the killing, possession, or destruction of bird eggs or of bird nests. Sections 3503.5 and 3513 prohibit the killing, possession, or destruction of all nesting birds (including raptors and passerines). Section 3513 prohibits the take or possession

² In some cases, exceptions may be made for threatened species under ESA Section 4[d]. In such cases, USFWS or NMFS issues a “4[d] rule” that describes protections for the threatened species and specifies the circumstances under which take is allowed.

of any migratory nongame birds designated under the federal Migratory Bird Treaty Act (MBTA). Section 3800 prohibits take of nongame birds. Some mammals are protected under Section 4700.

3.3.2.5 San Joaquin County Multi-Species Habitat Conservation and Open Space Plan

The San Joaquin County Multi-Species Habitat Conservation and Open Space Plan (SJMSCP) was developed in 2000 with assistance from the San Joaquin County Transportation Authority, the City of Tracy, and the City of Lathrop. The purpose for the SJMSCP is to:

- provide a strategy for balancing the need to conserve open space and the need to convert open space to non-open space uses while protecting the region's agricultural economy;
- preserve landowner property rights;
- provide for the long-term management of plant, fish, and wildlife species, especially those that are currently listed or may be listed in the future, under the federal ESA or the California ESA;
- provide and maintain multiple-use open spaces, which contribute to the quality of life for the residents of San Joaquin County; and
- accommodate a growing population while minimizing costs to project proponents and the society at large.

The SJMSCP encompasses all of San Joaquin County (except federally-owned lands), and includes the project region. San Joaquin County's past and future growth has affected and will continue to affect 97 special-status plant, fish, and wildlife species in 52 vegetative communities scattered throughout the county. In accordance with the federal ESA and California ESA incidental take permits, the SJMSCP provides compensation for the conversion of open space to non-open space uses, which affect the plant, fish, and wildlife species covered by this plan. Additionally, the SJMSCP provides some compensation to offset the impacts of open space land conversions on non-wildlife related resources, such as recreation, agriculture, scenic values, and other beneficial open space uses.

3.3.2.6 Programmatic Safe Harbor Agreement for the Lower Mokelumne River Watershed

The *Programmatic Safe Harbor Agreement for the Lower Mokelumne River Watershed* was entered into in 2006 between the California Association of Resource Conservation Districts and USFWS. The purpose for this agreement is to

- promote ecosystem restoration, including the conservation of endangered species, through the voluntary restoration, enhancement, and management of native riparian habitat in the lower Mokelumne River watershed;
- provide certain regulatory assurances to landowners participating in such restoration, enhancement, and management activities; and
- accomplish the foregoing without negatively affecting farming practices.

The Programmatic Safe Harbor Agreement covers Valley elderberry longhorn beetle, a federally listed species. Lands subject to this agreement include non-federal lands in the lower Mokelumne River Watershed in San Joaquin County and generally consist of those lands from the confluence with the Cosumnes River, upstream to the Camanche Dam, and exclusive of lands within the watershed of Dry Creek upstream of its crossing with Highway 99. Implementation of this

agreement is expected to provide a net conservation benefit to the Valley elderberry longhorn beetle because the collective management activities performed by the program participants are expected to provide an increase in the covered species' population and/or enhance, restore, or maintain the covered species' habitat. In 2007, EBMUD entered into a Cooperative Agreement under the *Programmatic Safe Harbor Agreement for the Lower Mokelumne River Watershed* to restore, enhance, and manage riparian habitat for the Valley elderberry longhorn beetle.

3.3.2.7 Safe Harbor Agreement

In June 2009, USFWS and EBMUD entered into a *Safe Harbor Agreement for East Bay Municipal Utility District Lands in San Joaquin, Amador, and Calaveras Counties* (Safe Harbor Agreement) (Appendix K). This action fulfills a recommendation of the *2008 Mokelumne Watershed Master Plan* (East Bay Municipal Utility District 2008a). Under the 30-year agreement, EBMUD will protect existing habitat and create new high-quality habitat for California red-legged frog, California tiger salamander, and valley elderberry longhorn beetle on EBMUD watershed lands in San Joaquin, Amador, and Calaveras Counties and provides certain regulatory assurances to EBMUD. Based on the agreement, USFWS issued EBMUD an enhancement of survival permit pursuant to the appropriate provisions of the federal ESA. The agreement combined with the permit will allow incidental taking of California red-legged frog, California tiger salamander, and valley elderberry longhorn beetle associated with the enhancement and conservation management of these species' habitat and other lawful uses of the property.

About 28,000 acres are covered by the Safe Harbor Agreement, including Pardee Dam and Reservoir, Camanche Dam and Reservoir, and adjacent lands. The agreement requires that EBMUD maintain on the property at least as much habitat for the covered species as was present when the agreement was signed (i.e., the baseline) and as documented in Exhibit 2 of the agreement. Based on the agreement, USFWS is issuing EBMUD an enhancement of survival permit under the federal ESA. By means of this permit, USFWS acknowledges in advance that incidental take may be caused by routine EBMUD practices, such as work needed to prevent and fight fires, prevent floods, deliver water supplies, graze animals, grow cover crops, operate the Mokelumne fish hatchery, treat wastewater, and provide recreation opportunities.

Implementation of the agreement is expected to provide a "net conservation benefit" to the three covered species, as the covered activities should provide an increase in populations as a result of an increase in habitat. Covered habitats include vernal pool complexes, breeding pond habitat for California tiger salamander and California red-legged frog, and elderberry bushes.

Conservation management activities described by the agreement include:

- develop additional elderberry habitat,
- limit pesticide and herbicide use,
- remove nonnative invasive species,
- protect elderberry shrubs from prescribed burns,
- reintroduce California red-legged frogs,
- maintain vernal pool complexes,
- develop new shallow water habitat,
- restore and maintain existing constructed ponds,

- enhance red-legged frog breeding habitat,
- control nonnative predators,
- enhance and/or maintain existing suitable upland dispersal and aestivation habitat,
- manage livestock as prescribe in the agreement, and
- prohibit discing or grading in existing suitable upland habitats as described in the agreement.

A copy of the Safe Harbor Agreement is provided as Appendix K.

3.3.3 Assessment of Impacts

This section describes the operation-related impacts on biological resources that could occur under the Project, including a description of the methods and assumptions used to conduct the analysis and the criteria for determining the significance of impacts.

3.3.3.1 Methods and Assumptions

The Project would not involve constructing, improving, or eliminating any facilities; therefore, there would be no temporary or permanent impacts on biological resources resulting from construction. The following assumptions were also made regarding project-related impacts on biological resources:

- project conditions would entail no physical activities that would interfere with migratory wildlife corridors, the movement of resident or migratory wildlife species, or native wildlife nursery sites; and
- project conditions would not have significant direct or indirect impacts on annual grassland, chaparral, and oak woodland and savanna communities because those communities are not affected by changes in reservoir water-surface elevation or flows in the river.

The analysis of the effects of the Project on vegetation and wildlife resources emphasizes impacts on riparian and wetland habitats, which were assessed by determining changes in Pardee and Camanche water-surface elevations and changes in lower Mokelumne River flows. EBMUDSIM modeling used 89 years of historical hydrology data to simulate flows in the lower Mokelumne River, storage volumes in Pardee and Camanche Reservoirs, and the corresponding changes in reservoir surface elevations under project conditions. Projected changes in reservoir-surface elevations and river flow were then compared against baseline conditions to determine potential impacts, including changes in habitat accessible to special-status species. Although the demand would increase over decades, and would vary from year to year, the hydrologic and water temperature modeling evaluated this increased demand as an immediate and consistent change. EBMUDSIM modeling results are presented in Appendix E, Modeling Technical Appendix.

Pardee and Camanche Reservoirs

Vegetation along the shores of Pardee and Camanche Reservoirs, as well as birds and other wildlife that may use the reservoirs, are accustomed to fluctuations in reservoir elevation that occur under baseline conditions. EBMUDSIM results for baseline conditions indicate that for most years there are large fluctuations in water-surface elevations in Pardee and Camanche Reservoirs. The median difference between the minimum and maximum elevations over the 89-year historic record was 18 feet for Pardee Reservoir and 20 feet for Camanche Reservoir. Year to year fluctuation related to the

difference between minimum and maximum reservoir water-surface elevation is large, with Pardee Reservoir fluctuating from 13 to 93 feet and Camanche Reservoir fluctuating from 4 to 75 feet. Because biological resources associated with the reservoirs have been exposed to historically large changes in the reservoirs' water-surface elevation that occur as part of normal reservoir operations, small changes in reservoir elevations are unlikely to affect these biological resources.

The effect on riparian and wetland habitats associated with Pardee and Camanche Reservoir elevations was conducted by comparing end-of-month water-surface elevations for baseline conditions, to end-of-month water-surface elevations for project conditions.

Lower Mokelumne River

Riparian zones are critical areas in the landscape that connect and sustain river and terrestrial ecosystems. Riparian trees stabilize streambanks, filter nutrients and pollutants, cool nearby air and waters, contribute nutrients from leaf litter and large woody debris to the aquatic ecosystem, and provide migration corridors and vertical habitat for birds and wildlife. Periodic flooding is a fundamental characteristic of floodplain and riparian ecology. The timing, frequency (recurrence interval), and duration of flooding are important factors in regulating species composition and riparian vegetation establishment and maintenance (Griggs 2008). Winter peak flows deposit fine sediment, spring snowmelt flows promote germination and early root growth, and summer base flows support seedling survival and root growth (Stillwater Sciences 2006).

Channel maintenance flows provide conditions conducive to creating or maintaining stream morphology and habitat, including creating conditions for replenishing streamside vegetation to maintain long-term riparian functions (Richter and Richter 2000). Channel maintenance flows, depending on channel gradient, confinement, and streambed, vary from 80% of the "bankfull flow" to a streamflow that occurs only once every 2 years or more (Robison 2007). Bankfull flow has been identified as the flow at which channel maintenance is the most effective (Schmidt and Potyondy 2004; State Water Resources Control Board 2010).

The determination of bankfull flow can vary depending on the estimation metric. Estimates range from a recurrence interval (the frequency at which the annual maximum instantaneous peak stream flow is expected to occur) of 1.4 years (Castro and Jackson 2001) to 2 years (Robison 2007). CDFW (1991) determined that much of the lower Mokelumne River was bankfull at 900 to 1,000 cubic feet per second (cfs). Based on EBMUDSIM modeling, a monthly average flow of 1,000 cfs has a recurrence interval of about 2 years.

The effect on riparian and wetland habitats in the lower Mokelumne River was conducted by comparing the frequency of channel maintenance flows during the spring (April through June) for project conditions relative to baseline conditions.

3.3.3.2 Significance Criteria

The criteria used for determining the significance of an impact on vegetation, wetland, and wildlife resources are based on Appendix G (a model environmental checklist) of the State CEQA Guidelines and professional standards and practices. Appendix G suggests that impacts on vegetation, wetland, and wildlife resources may be considered significant if the Project would:

- have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFW or USFWS;
- have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, or regulations, or by the CDFW or USFWS;
- have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the CWA (including marshes, vernal pools, coastal wetlands) through direct removal, filling, hydrological interruption, or other means;
- interfere substantially with the movement of any native resident or migratory wildlife species or with established native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites;
- conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance; or
- conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan.

These impacts were taken into consideration to the extent they are applicable to the Project, in developing the following significance criteria. As explained under Methods and Assumptions (Section 3.3.3.1 above), impacts on biological resources may be considered significant if implementation of the Project would specifically:

- cause reservoir water-surface elevation fluctuations of sufficient magnitude to result in a substantial adverse effect on any sensitive species, riparian habitat or sensitive natural community, or federally protected wetland; or
- reduce the frequency of channel maintenance flows in the lower Mokelumne River sufficiently to result in a substantial adverse effect on any sensitive species, riparian habitat or sensitive natural community, or federally protected wetland.

3.3.3.3 Impact Discussion

The primary impact mechanisms for biological resources are changes in reservoir water-surface elevations and changes in flows in the lower Mokelumne River, which could affect special-status species, their habitat, or other sensitive habitat types. Significant and less-than-significant impacts on biological resources associated with these changes are described in the following sections.

Significant Impacts

As explained below under Less-Than-Significant Impacts, changes in reservoir water-surface elevations and changes in flows in the lower Mokelumne River are not great enough under project conditions compared to baseline conditions to significantly affect special-status species, their habitat, or other sensitive habitat types. As a result, there would be no significant impacts on biological resources.

Less-than-Significant Impacts

Impact BIO-1: Potentially adverse effect on special-status plants and special natural communities, directly or through habitat modification, caused by increased reservoir water-surface fluctuations and reduced frequency of river maintenance flows (No Impact)

The Project would not have a significant impact on special-status plants caused by reservoir water-surface fluctuations and/or reduced frequency of river maintenance flows compared to baseline conditions. Most species listed in Table 3.3-1 are found in chaparral, woodland, grassland, seasonal wetland, vernal pool, and slough habitats, which are not located in areas that would experience changes in water-surface elevations at Pardee or Camanche Reservoirs or changes in the frequency of maintenance flows in the lower Mokelumne River and, therefore, would not be affected by implementing the Project. One special-status plant, Henderson's bentgrass, has been recorded in the Camanche Reservoir footprint, but the record dates from 1935 and it is believed to have been extirpated when the reservoir was first impounded. Lone manzanita and lone chaparral occur adjacent to the eastern end of Camanche Reservoir but above the high water mark and, therefore, would not be affected by water fluctuations in the reservoirs. No additional special-status plants or special natural communities have been documented directly in or adjacent to Pardee and Camanche Reservoirs and none are known to occur along the lower Mokelumne River (Figure 3.3-1). As a result, there would be *no impact* from changes in reservoir water-surface elevations or river flows on special-status plants as a result of implementing the Project. No mitigation is necessary.

Impact BIO-2: Potentially adverse effect on special-status wildlife, riparian communities, and federally protected wetlands caused by increased reservoir water-surface fluctuations and reduced frequency of river maintenance flows (Less than Significant)

A variety of special-status wildlife species have the potential to occur in the project region (Table 3.3-2), and several special-status wildlife species have been recorded in the project region (Reeves and Smith 2004; Smith 2004; Howell et al. 2011; California Department of Fish and Game 2012b; eBird 2013; Tricolored Blackbird Working Group 2013; Jones pers. comm.). Implementing the Project could affect special-status wildlife species as a result of habitat modification, specifically riparian and wetland habitat effects resulting from reservoir water-surface fluctuations and flow changes. These potential impacts are described below.

Pardee and Camanche Reservoirs

Although the Project would not cause large changes in reservoir surface-water elevation compared to baseline conditions, project conditions may result in system operations that alter storage and surface elevations at Pardee and Camanche Reservoirs. Historically, fluctuations at these reservoirs, in response to day-to-day operations and changes in runoff patterns, affected vegetation that established at or near the water surface and within the drawdown zone. Similarly, vegetation that periodically established in the drawdown zone or near the waters' edge was commonly inundated and lost during prolonged periods of high storage, while plants that established during periods of high storage could be lost during periods of reduced reservoir storage or drought. Compared to baseline conditions, project conditions would result in minor changes in reservoir storage. Fluctuations in reservoir elevation would be similar to those experienced under baseline conditions (Figures 3.3-3 and 3.3-4) and vegetation would experience a similar cycle of establishment, inundation, and loss, as water elevations rise and fall seasonally and in response to precipitation and flood-control requirements. Therefore, the impact of implementing the Project on reservoir

vegetation, as well as on special-status wildlife species that inhabit these areas, would be *less than significant*. No mitigation is necessary.

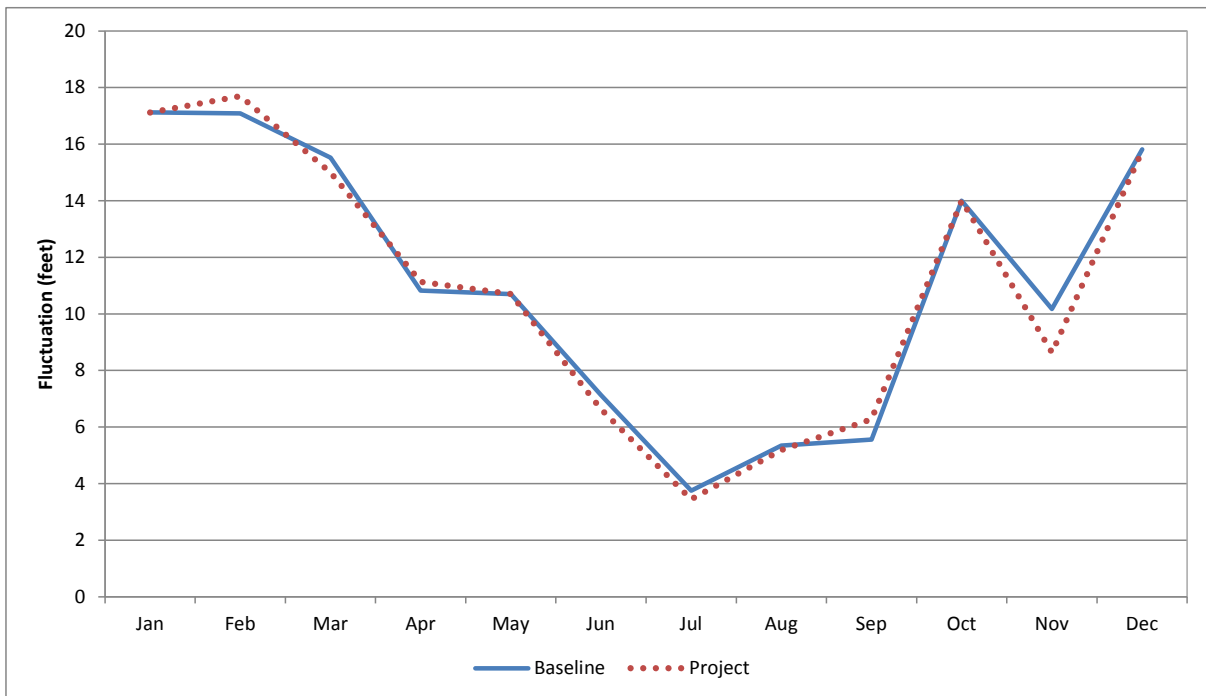


Figure 3.3-3
Month to Month Fluctuations (95th Percentile of Modeled Years) in Pardee Reservoir

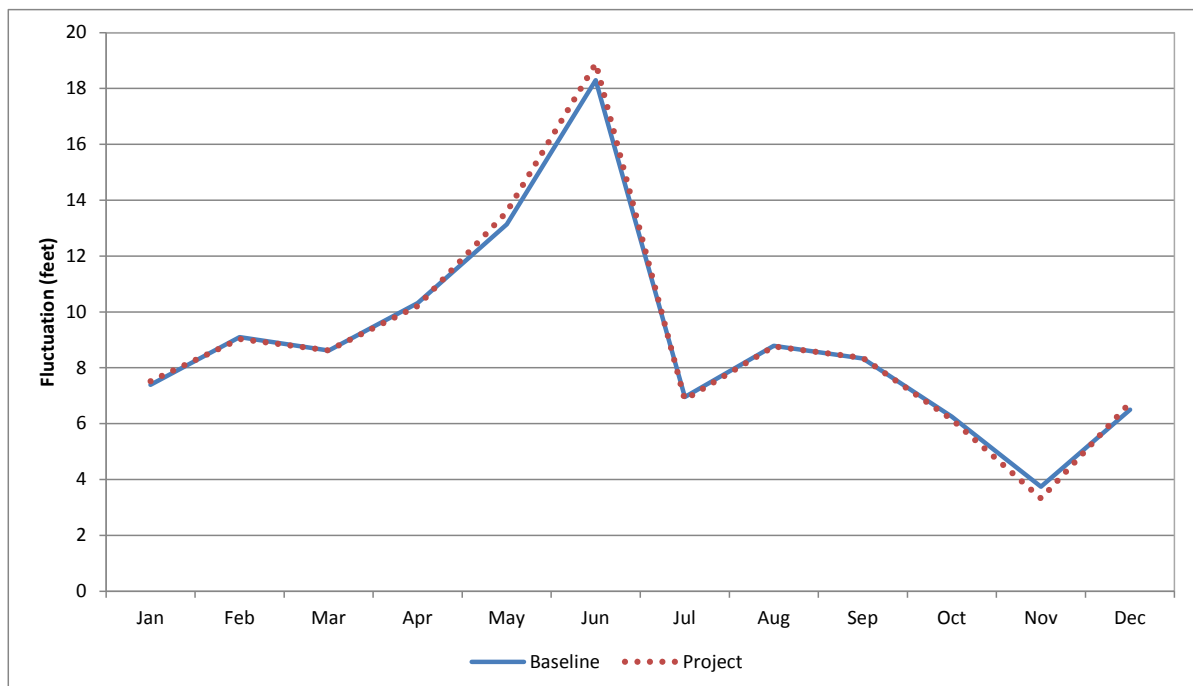


Figure 3.3-4
Month to Month Fluctuations (95th Percentile of Modeled Years) in Camanche Reservoir

Lower Mokelumne River

EBMUDSIM hydrologic modeling results for mean monthly flows downstream of Camanche Dam are used to evaluate impacts from project conditions on the lower Mokelumne River. Average monthly flows exceeding 1,000 cfs (bankfull flow) in the lower Mokelumne River during the spring (April through June) are assumed to provide channel maintenance flows (California Department of Fish and Game 1991; Schmidt and Potyondy 2004; State Water Resources Control Board 2010).

Relative to baseline conditions, project conditions would result in 5 fewer years (out of 89 years simulated) when channel maintenance flows between Camanche Dam and Woodbridge Dam would be less than 1,000 cfs during April through June (Table 3.3-3). During these years, if the flows had been only slightly higher, 49 cfs in May 1993, 24 cfs in June 1923 and 1951, and 8 cfs in May 1937 and 1984, monthly average flows of 1,000 cfs would have been attained. These infrequent and minor reductions in flows would not have a significant effect on channel maintenance flows in the lower Mokelumne River. Therefore, the impacts of operations associated with implementing the Project on lower Mokelumne River vegetation, as well as on special-status wildlife species that inhabit these areas, would be *less than significant*. No mitigation is necessary.

Table 3.3-3. Number of Modeled Years When Lower Mokelumne River Channel Maintenance Flows Exceed 1,000 cfs

	Camanche Dam to Woodbridge Dam	
	Baseline	Project
April	10	10
May	33	30
June	37	35

Impact BIO-3: Potential conflicts with the provisions of an adopted habitat conservation plan, natural community conservation plan, or other approved local, regional, or state habitat conservation plan. (Less than Significant)

Portions of the project area are addressed in the *San Joaquin County Multi-Species Habitat Conservation and Open Space Plan* (San Joaquin County 2000). The plan covers all of San Joaquin County (approximately 900,000 acres), including EBMUD lands, and was developed to provide for the long-term management of 97 plant, fish, and wildlife species, especially those that are currently listed or may be listed in the future, under the federal and California ESAs.

The *Programmatic Safe Harbor Agreement for the Lower Mokelumne River Watershed* (California Association of Resource Conservation Districts and U.S. Fish and Wildlife Service 2006) encompasses lands in San Joaquin County in the lower Mokelumne River watershed from Camanche Dam downstream to the confluence of the Cosumnes River and covers the valley elderberry longhorn beetle. EBMUD has an existing Cooperative Agreement (2007) under the Lower Mokelumne River Programmatic Safe Harbor Agreement to restore, enhance, and manage riparian habitat for the Valley elderberry longhorn beetle on EBMUD lands in the lower Mokelumne River Watershed.

In 2009, EBMUD entered into a Safe Harbor Agreement with USFWS to protect existing habitat and create new high-quality habitat for special-status species, including California red-legged frog, California tiger salamander, and valley elderberry longhorn beetle on EBMUD watershed lands in

San Joaquin, Amador, and Calaveras Counties (see Appendix K for more information on the Safe Harbor Agreement).

While implementing the Project, EBMUD would continue to comply with the *San Joaquin County Multi-Species Habitat Conservation and Open Space Plan*, EBMUD's Cooperative Agreement under the *Programmatic Safe Harbor Agreement for the Lower Mokelumne River Watershed*, and EBMUD's Safe Harbor Agreement with USFWS. The Project, therefore, would not conflict with provisions of these habitat conservation plans. This impact is considered to be *less than significant*. No mitigation is necessary.

3.4 Agricultural Resources

This section describes existing agricultural resources in the lower Mokelumne River and assesses the significance of impacts on agricultural resources associated with implementing the Permit 10478 Time Extension Project (Project). The analysis concludes that implementing the Project would not result in significant impacts on agricultural resources after implementing mitigation measures.

3.4.1 Environmental Setting

For the purposes of this discussion, the project area includes Pardee and Camanche Reservoirs and the lower Mokelumne River, which refers to the portion of the Mokelumne River between the Camanche Dam spillway and Woodbridge Irrigation District (WID)'s intake on the Mokelumne River near the town of Woodbridge. Because Calaveras County's and Amador Water Agency's diversions are located upstream of Pardee Reservoir and are not affected by Permit 10478, they are not discussed in detail in this section. Jackson Valley Irrigation District (JVID) in Amador County receives supplies from senior water rights on the Mokelumne River and because there is the potential for agricultural lands in JVID's area to be affected by the Project, JVID's use is discussed below. Additionally, a junior water rights holder in San Joaquin County that diverts water from the lower Mokelumne River for agricultural use (when water is available) could also be affected by the Project; therefore, agricultural land use in San Joaquin County is also discussed.

3.4.1.1 Agricultural Land Use in Amador County

In recent years, Amador County has experienced increased urbanization and decreased farming and agriculture, though continued agriculture and preservation of agriculture lands is encouraged by the county. Primary farming commodities in the Amador County include wine grapes and cattle. Grazing on public lands is still a custom and part of the county's culture. Large land holdings for timber harvesting of softwood forests exist in areas designated as Timberland Preservation Zones, but significant urbanization pressures continue.

Agricultural Production

According to the California Department of Conservation (CDC), Amador County contains an estimated 198,000 acres of agricultural land, including approximately 188,000 acres of grazing land (California Department of Conservation 2011).

The gross value of agricultural production in Amador County for 2011 was \$29,777,623. This is an increase of 25.52% from the 2010 gross production values. The primary farming commodities in the county are wine grapes (\$11,675,766), livestock and poultry (\$9,725,756), and field crops (consisting of hay/alfalfa, hay/grain, hay/other, pasture irrigated, pasture and range, sudan grass, and corn for food) (\$5,323,544). (Amador County 2011)

Agricultural Water Demand

Amador County makes use of both surface water and groundwater for agricultural production. JVID is the primary supplier of agricultural water in Amador County. JVID was organized in 1956 and has a service area of 12,800 acres in Jackson Valley along Jackson Creek in Amador County (RMC Water

and Management 2006). JVID has water rights to divert 3,850 acre-feet per year (AFY) from the Mokelumne River, at Pardee Reservoir, for agricultural irrigation. However, in the future, as water demand increases at points upstream of JVID's point of diversion within Amador County, JVID's allocation may be reduced by 1,050 acre-feet to serve that water demand.

Amador County's population of approximately 38,000 residents is expected to grow to roughly 44,000 by the year 2040 (California Department of Finance 2012). The county is also expecting growth of industrial, agricultural, and raw water use, and is expecting a total demand of 6,562 AFY by 2035, an approximate 50% increase from the 2010 demand of 3,129 AFY (Amador Water Agency 2011).

3.4.1.2 Agricultural Land Use in San Joaquin County

Much of the open space along the 40-mile reach of the lower Mokelumne River in San Joaquin County is in agricultural production. Lands adjacent to the river are used primarily for pasture, hay, grape, and vegetable crops, as well as orchards.

General land use trends include significant development of rural and agricultural areas, primarily around the urban centers of Lodi and Stockton. In particular, San Joaquin County is experiencing a shift from grazing to viticulture and from viticulture to residential development.

Agricultural Production

According to CDC, San Joaquin County contains an estimated 754,000 acres of agricultural land, including approximately 139,000 acres of grazing land (California Department of Conservation 2011).

The gross value of agricultural production in San Joaquin County for 2011 was \$2,238,688,000. This is an increase of 14.2% from the 2010 estimated production value of \$1,960,086,000. The primary farming commodities in the county are milk (\$452,880,000), grapes (\$286,728,000), walnuts (\$278,857,000), almonds (\$187,748,000), and tomatoes (\$107,844,000). These major agricultural commodities are produced primarily near Stockton, Tracy, Lodi, Manteca, Lathrop, and Escalon. (San Joaquin County 2011)

Agricultural Water Demand

San Joaquin County makes use of both surface and groundwater. Groundwater is used to make up the difference between surface water supply and actual demand; however, the amount of annual groundwater recharge is not sufficient to compensate for the pumping needed. San Joaquin County is currently in a severe overdraft situation. The San Joaquin County *Water Management Plan* (San Joaquin County 2001) recognizes and anticipates that most current surface water supplies will not increase and likely will decrease because of the increasing demands of upstream senior water right holders.

San Joaquin County's population of approximately 700,000 residents is expected to nearly double by the year 2040 (California Department of Finance 2012). This growth is expected to be focused in urban areas with a corresponding conversion of agricultural lands to urban uses. According to the San Joaquin County *Water Management Plan*, the last 30 years has seen an increase in vineyards, orchards, and urban areas and a decrease in farmstead crops and pasture. Although urban growth will result in an increase in urban water use, the corresponding decrease in agricultural water use as

a result of converting agricultural land to urban uses is expected to offset the additional demand for water for new urban development because agricultural land uses generally require more water per acre than typical urban uses. By 2030, agricultural water use is expected to decrease by 132,000 acre-feet; whereas, urban water use is expected to increase by 146,600 acre-feet. Therefore, overall water demands in the county are projected to remain relatively constant into the future. (San Joaquin County 2001)

3.4.1.3 Mokelumne River Agricultural Water Use

Senior Water Rights Holders

EBMUD releases water from Pardee Reservoir for use directly by Jackson Valley Irrigation District (JVID). EBMUD also releases water from the Mokelumne Project to meet obligations to senior agricultural water rights holders such as WID located downstream of Camanche Reservoir. EBMUD must make releases to meet the water rights of riparian rights holders as well. These obligations are codified in the various agreements between EBMUD and senior water rights holders.

Senior water rights include rights held by riparian landowners and water users whose entitlements must be met prior to EBMUD diversions. See Figure 1-3 in Chapter 1, Objective and Need for the Permit 10478 Time Extension Project, for the location of Mokelumne River diverters; Figure 1-4 from Chapter 1 depicts the river's flow divided among the various uses. The most senior water rights on the Mokelumne River are those of riparian landowners who may divert water from the natural flow of the river for use on riparian lands only. The second-most senior water rights are those of prior appropriators and those who hold pre-1914 appropriative rights.

JVID is a senior water right holder that diverts Mokelumne River water to Lake Amador via Pardee Reservoir and the Jackson Creek Spillway, located on the north arm of Pardee Reservoir. JVID supplies water for domestic and irrigation uses to customers in portions of Amador County located below Lake Amador. Pursuant to an agreement between JVID and EBMUD, water diversion releases to JVID are made through a release valve and a two-foot diameter outlet pipe at the base of the spillway (with an intake elevation of 550 feet). During drought years, or when Pardee Reservoir level drops below elevation 550 feet, diversions by JVID are greatly reduced or discontinued. EBMUD determines the quantity of water available to JVID from the flow of the Mokelumne River entering Pardee Reservoir, as regulated by the existing upstream reservoirs of PG&E and as diminished by the demands of other diverters with priorities earlier than JVID's priority date of July 30, 1927. JVID diverts up to its maximum entitlement rate of 50 cfs in the months of April through October from Pardee Reservoir when water is available; however, if the level of Pardee Reservoir drops below elevation 550 feet or if there is no water available in the river under the 1927 priority date, then no water is available to JVID from Pardee Reservoir. JVID currently diverts approximately its full annual entitlement of 3,850 acre-feet from the Mokelumne River whenever water is available under its 1927 priority date. However, for modeling purposes, it is assumed that JVID diversions are 3,400 acre-feet by year 2005 and that 450 acre-feet of JVID's water allocation was re-allocated to meet other water demands in Amador County, upstream of Pardee Reservoir.

Downstream of the Camanche Dam spillway, WID, riparian landowners and other senior downstream appropriators have priorities that are senior to EBMUD's water right Permit 10478. Pursuant to agreements between WID and EBMUD, EBMUD is obligated to release a maximum of 60 thousand acre-feet (TAF) in normal and wet years, and 39 TAF in dry years for diversion by WID. While WID's senior water entitlements are dependent on climate and the overall availability of

Mokelumne River water, WID's water supply is made more reliable by the agreements entered into with EBMUD.

Riparian landowners and other individuals with appropriative rights on the lower Mokelumne River that predate EBMUD's water rights include the owners of ranches, vineyards, and farms. These downstream rights are senior to EBMUD's and total approximately 21 TAF in normal runoff years and 16 TAF in dry years.

Under the Project, EBMUD would continue to meet its obligations to senior water rights holders before meeting EBMUD diversions.

Junior Water Rights Holders

The North San Joaquin Water Conservation District (NSJWCD) is an irrigation district that diverts water from the lower Mokelumne River below Camanche Dam. NSJWCD provides both groundwater and surface water for agricultural irrigation.

NSJWCD's temporary water right Permit 10477, issued pursuant to Water Code Section 1462, authorizes the granting of a permit for temporary appropriation of water that is excess to the needs of a municipality, and allows NSJWCD to divert directly to use or store from December 1 to July 1. NSJWCD, which has no storage facilities of its own, has an agreement with EBMUD, entered into in 1963 and amended in 1969, under which EBMUD stores up to 20 TAF of Permit 10477 water for NSJWCD when capacity is available in EBMUD's Mokelumne reservoirs so that NSJWCD can receive its supplies after July 1. The State Water Board subsequently amended Permit 10477 to allow storage of that water in Camanche Reservoir. In years when water is available to NSJWCD under the agreement, EBMUD uses a portion of its Camanche Reservoir capacity to store and release water for diversion by NSJWCD during the irrigation season. After November 5, the Corps requires EBMUD to provide flood-control space in Pardee and Camanche Reservoirs; therefore, by November 5, EBMUD must release the unused excess water remaining in storage.

NSJWCD's maximum entitlement under its junior water right is 20,000 AFY. This represents 1.6% of the wet year surface water resources available to San Joaquin County (San Joaquin County 2001). However, NSJWCD's diversions have been less than this amount. In dry and critically dry years, when there is no stored water surplus to EBMUD's municipal needs, NSJWCD typically receives no water under its entitlement. Historically, NSJWCD has used up to 9,488 AFY under its Permit 10477, and in the last 10 years, diversions have declined to between 2,000 and 4,000 AFY.

The Project, and EBMUD's continued growth in its water use under Permit 10478, could affect the availability of supplies for NSJWCD under its junior Permit 10477. Consequently, EBMUD undertook the analysis in this section to determine whether the Project would have a significant impact.

3.4.2 Regulatory Setting

This section describes the state and county regulations relevant to agricultural resources potentially affected by the Project. The Project is not subject to any federal regulations relevant to agricultural resources.

3.4.2.1 Williamson Act

The California Land Conservation Act (CLCA) of 1965, also known as the Williamson Act, is intended to preserve agricultural and open space lands by discouraging their premature conversion to urban uses. CLCA enables cities and counties to designate agricultural preserves and tax them according to their value in agricultural use, rather than on the property's assessed market value. In return for receiving the preferential tax rate, the agricultural landowner is required to sign a contract with the city or county agreeing not to develop the land for a minimum 10-year period. Contracts are automatically renewed annually unless the landowner files for nonrenewal or petitions for cancellation. Permissible land uses under Williamson Act contracts are governed by Government Code Section 51238.1. Cities and counties may determine land uses that are compatible with CLCA.

The majority of the land adjacent to the lower Mokelumne River from the Camanche Dam spillway southwest to the City of Lodi is predominantly in agricultural use.

3.4.2.2 Amador County General Plan

The Amador County General Plan is currently under revision. The most current version of the General Plan's Land Use, Open Space, Conservation, Scenic Highways Elements section was last revised in 2001; however, most of the General Plan's text dates to the 1973 revision of the original 1967 plan. Given that this section contains text that is mostly 30 years old, it does not provide information on recent land use, growth, or intended direction of Amador County. The General Plan states that agriculture has been a large economic presence in Amador County since 1854, and contains the related objective: "to strengthen the area economy through expanded commercial and industrial activity, protection and expansion of agricultural and forestry and increased local processing of their raw materials" (Amador County 1973). The General Plan also discusses the compatibility of different land uses:

Compatibility of land uses, i.e., urban, residential, industrial, agricultural and recreational, will be fostered and encouraged. All future reservoir sites, prime farmland or commercial grade timber land, or areas of outstanding scenic or recreational significance shall be preserved against subdivision or other urban development, and zoned to preserve their present use and value. (Amador County 1973)

3.4.2.3 San Joaquin County General Plan

The *San Joaquin County General Plan* supports continued agricultural uses in the county. However, it also recognizes that current trends include increased conversion of areas to nonagricultural or urban uses. Therefore, one of the objectives of the plan is "to minimize the effect on agricultural lands and other environmental resources while providing for orderly growth." (San Joaquin County 1992.)

The general plan includes several policies and implementation guidelines that relate to when and how agricultural land can be converted to urban or rural community uses. The general plan places an emphasis on infill projects over expansion of community boundaries and encourages communities to expand their boundaries only when needed, and in a way that ensures services are provided and that does not increase potential land use conflicts. The general plan discourages leapfrog development. (San Joaquin County 1992.)

In June 2008, San Joaquin County began updating its 1992 General Plan. In particular, San Joaquin County used the information gathered as part of the Farmland Mapping and Monitoring Program

(FMMP) (described below) to assist in updating its county farmland maps. (San Joaquin County 2009.)

3.4.2.4 Farmland Mapping and Monitoring Program

The FMMP, under jurisdiction of the California Department of Conservation, produces maps and statistical data used for analyzing changes to California's agricultural land inventory. Agricultural land is rated according to soil quality and irrigation status; the best-quality land is called *Prime Farmland*. Important Farmland¹ maps are updated every 2 years with the use of a computer mapping system, aerial imagery, and field reconnaissance. These maps show the relationship between the quality of soils for agricultural production and the land's use for agricultural, urban, or other purposes. FMMP tracks conversion of farmland to urban use and fallowing.

The maps use soil data from the U.S. Department of Agriculture, Natural Resource Conservation Service. Existing maps are compared to new aerial photos to detect land use changes that have occurred in the 2 years between updates. Notes from prior mapping or from outside reviewers are used to document the nature of changes, and field verification is conducted where needed.

San Joaquin County's Prime Farmland totaled approximately 438,000 acres in 1990, representing 55% of the agricultural land in the county (approximately 796,000 acres in 1990). In 2010, San Joaquin County's Prime Farmland inventory had declined to approximately 385,000 acres, representing 51% of the agricultural land in the county (approximately 754,000 acres in 2010). (California Department of Conservation 2011)

Lands surrounding Pardee and Camanche Reservoirs are designated as grazing land. There is no Prime Farmland, Unique Farmland, or Farmland of Statewide Importance within 1 mile of either Pardee or Camanche Reservoir.

From approximately 1 mile south of Camanche Dam, all of the land immediately adjacent to both banks of the lower Mokelumne River is designated as Prime Farmland, Unique Farmland, or Farmland of Statewide Importance.

3.4.3 Assessment of Impacts

This section describes the operation-related impacts on agricultural resources that could occur under the Project, including a description of the methods and assumptions used to conduct the analysis and the criteria for determining the significance of impacts.

3.4.3.1 Methods and Assumptions

The Project would not involve the construction, improvement, or alteration of any facilities; therefore, there would be no temporary or permanent impacts, including the loss of agricultural resources, on agricultural resources resulting from construction.

The effects of the Project on agricultural resources were assessed by determining how EBMUD's increased diversions from the Mokelumne River might change the amount of water available for

¹ Important Farmland includes *Prime Farmland*, *Farmland of Statewide Importance*, *Unique Farmland*, and *Farmland of Local Importance*. Prime Farmland, the best-quality agricultural land, is defined as land that has the best combination of physical and chemical characteristics for producing crops. (California Department of Conservation 2011)

agricultural use. Hydrologic modeling using EBMUDSIM was used to simulate annual diversions to NSJWCD, the primary supplier of surface water for irrigation to lower Mokelumne River agriculture holding a right junior to EBMUD's Permit 10478, under both project conditions and baseline conditions. Modeling simulations assumed that required instream fishery conservation releases would continue as required under the JSA described in Chapter 1, Objective and Need for the Permit 10478 Time Extension Project, and Section 3.2, Fish Resources, of this EIR. Although the demand for water would increase over decades, and would vary from year to year, the hydrologic and water temperature modeling evaluated this increased demand as an immediate and consistent change. EBMUDSIM modeling results are presented in Appendix E, Modeling Technical Appendix.

3.4.3.2 Significance Criteria

The criteria used for determining the significance of an impact on agricultural resources are based on Appendix G (a model Environmental Checklist) of the State CEQA Guidelines and professional standards and practices. Appendix G suggests that impacts on agricultural resources may be considered significant if implementation of the Project would:

- convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (collectively *Farmland*), as shown on the maps prepared pursuant to the FMMP of the California Resources Agency, to nonagricultural use;
- conflict with existing zoning for agricultural use, or a Williamson Act contract; or
- involve other changes in the existing environment, which, because of their location or nature, could result in substantial conversion of Farmland to nonagricultural use or substantial loss of production value of specific crops relative to the total production value in the project area.

Because the primary impact mechanisms for agricultural resources are reduced flows available in the lower Mokelumne River for agricultural use by downstream water rights holders, an additional significance criterion is considered. Impacts on agricultural resources may be considered significant if implementation of the Project would substantially reduce surface water supplies to Mokelumne River water rights holders that supply water for agricultural land use.

3.4.3.3 Impact Discussion

The primary impact mechanisms for agricultural resources are reduced flows available in the Mokelumne River for agricultural use by senior water rights holders and downstream water rights holders. The Project would not convert Farmland to nonagricultural use; conflict with existing zoning for agricultural use, or a Williamson Act contract; or involve other changes in the existing environment that could result in substantial conversion of Farmland to nonagricultural use. Significant and less-than-significant impacts are described in the following sections.

Significant Impacts

Impact AG-1: Potential reduction of surface water supply for agricultural use by senior water rights holders (Significant/Less than Significant with Mitigation)

JVID water rights on the Mokelumne River are senior to EBMUD's water right Permit 10478. As stated earlier, JVID diverts water from Pardee Reservoir at the Jackson Creek Spillway Facility, to supply water for domestic and irrigation uses to customers in portions of Amador County. Compared to baseline conditions, water-surface elevations at Pardee Reservoir under the Project

would drop below 550 feet for 13 additional months—between the months of April through October—out of the 89-year hydrologic record, as simulated using EBMUDSIM. These simulated drops correspond to 1961 (July through October), 1976 (April), 1988 (May through August), 1989 (August), and 1990 (July through September) (Appendix E). When the water-surface elevation at Pardee Reservoir falls below 550 feet, even though the supply itself is not impacted because of its seniority, releases cannot physically be made for JVID through its release valve. To ensure that JVID could continue to divert its senior water right at Pardee when it is available under its water right priority, EBMUD will implement the following mitigation measure.

Mitigation Measure AG-1: Work with JVID to help JVID divert water under its water right

During periods when the water-surface elevation of Pardee Reservoir is below 550 feet, and water is available to JVID under its water right priority, EBMUD will work with JVID on the installation of a submersible pump in Pardee Reservoir for JVID to divert water into its diversion facility and pipeline. Implementing Mitigation Measure AG-1, and assisting JVID to divert its allocated water during such periods, would reduce Impact AG-1 to a *less-than-significant* level with mitigation.

Less-than-Significant Impacts

Impact AG-2: Potential reduction of surface water supply for agricultural use by junior water rights holders (Less than Significant)

The Project could affect surface water supply provided to downstream junior water rights holders. NSJWCD's maximum entitlement under its junior water right is 20,000 AFY. However, as described above, NSJWCD has historically diverted less than this amount. Under baseline conditions, in dry and critically dry years when there is no stored water surplus to EBMUD's municipal needs, NSJWCD typically receives no water under its entitlement.

The amount of Mokelumne River water available to NSJWCD may be reduced under project conditions because EBMUD would need to divert additional water from the Mokelumne River to meet future demands. EBMUDSIM modeling results (Appendix E) indicate that under baseline conditions, water is available to NSJWCD from the Mokelumne River in 49 of the 89 years modeled, with one of these years being less than the full 20 TAF delivery. Under project conditions, water would be available to NSJWCD from the Mokelumne River in 47 of the 89 years modeled, with two of these years being less than the full 20 TAF delivery (see Appendix L). The number of years when NSJWCD allocations would not be met under project conditions is an increase of approximately 2% compared to baseline conditions.

Under baseline conditions, Mokelumne River is available to NSJWCD under its Permit 10477 nearly 55% of time. Under project conditions, surface water supplies available to NSJWCD from the Mokelumne River under Permit 10477 are expected to be available nearly 53% of the time. Given the slight reduction in reliability and reduction in the volume of water in 2 out of 89 years (i.e., less than 5%), the changes to NSJWCD's allocations under project conditions are considered a *less-than-significant* impact as related to lower Mokelumne River agricultural resources. No mitigation is necessary.

3.5 Recreational Resources

This section describes recreational opportunities at Pardee and Camanche Reservoirs, as well as along the lower Mokelumne River, and assesses the significance of the impacts, if any, on recreation as a result of implementing the Permit 10478 Time Extension Project (Project). The analysis concludes there would be no significant impacts on recreational resources as a result of implementing the Project.

3.5.1 Environmental Setting

For the purposes of this discussion, the project area includes recreational opportunities at Pardee Reservoir up to the Middle Bar Bridge, at Camanche Reservoir, and along the lower Mokelumne River. The lower Mokelumne River refers to the portion of the Mokelumne River between Camanche Dam spillway and WID's intake on the Mokelumne River near the town of Woodbridge.

3.5.1.1 Pardee Reservoir

Pardee Reservoir extends over an area of nearly 2,200 surface acres (3 square miles) and 37 miles of shoreline. Because Pardee Reservoir is used principally as a domestic drinking water supply, water-contact recreational activities are prohibited by state law. Pardee Reservoir provides both water-dependent and water-enhanced recreational opportunities. Water-dependent recreation includes boating and fishing. Water-enhanced recreation includes camping, picnicking, hiking, and recreational vehicle use. The number of visitors to Pardee Reservoir for recreational access fluctuates substantially according to weather conditions and the surface elevation of the reservoir.

Middle Bar Bridge

Middle Bar Bridge is situated at the upper end of Pardee Reservoir. Cast fishing is popular from the bridge. Upstream of Middle Bar Bridge is a boating take-out developed by EBMUD in 2003, which river kayakers along the Upper Mokelumne River use before reaching Pardee Reservoir. Picnic tables and restrooms are available at this take-out.

Pardee Recreation Area

The Pardee Recreation Area is located on the west shore of the reservoir's northern edge and provides day-use and overnight facilities. The recreation area is owned by EBMUD and operated by a private concessionaire. Recreational activities at the reservoir include fishing, boating, recreational vehicle use, camping, and short-term and seasonal recreational vehicle facilities. Pardee Recreation Area is open from mid-February through early November. Restricted areas are located on the west side of the reservoir at the recreation area floating pumps platform, along the spillway, and in the vicinity of the outlet tower.

The Pardee Recreation Area attracts approximately 100,000 visitor-days annually (Leong pers. comm.). The highest use of the Pardee Recreation Area generally occurs from March through July and then tapers off through the beginning of November, when the recreation area closes.

Mokelumne Coast to Crest Trail

The Mokelumne Coast to Crest Trail (MCCT), most of which is still in the planning stages, is envisioned to extend from San Francisco Bay to the Sierra Nevada just south of Lake Tahoe. The 29-mile-long segment of the MCCT on EBMUD lands in the Mokelumne River was completed in 2012. The Pardee trail segment, an equestrian and hiking trail, extends along the south side of Pardee Reservoir, beginning at the Campo Seco staging area and ending at the Middle Bar takeout. The Camanche trail segment extends along the south shore of Camanche Reservoir beginning at the Camanche South Shore staging area and ending at the Campo Seco staging area. The entire trail is available to hikers and horseback riders. The trail and staging areas are open year-round. (Mokelumne Coast to Crest Trail 2013)

3.5.1.2 Camanche Reservoir

Camanche Reservoir is located immediately downstream of Pardee Reservoir and has a water surface area of 7,768 acres (more than 12 square miles) and 62 miles of shoreline. Popular recreational activities include swimming, boating (including water- and jet-skiing), fishing, hiking, camping and recreational vehicle use.

Camanche Reservoir Recreation Areas

Recreational facilities include two major recreation areas owned by EBMUD: the Camanche Reservoir North Shore Recreation Area and the Camanche Reservoir South Shore Recreation Area. Both recreation areas are operated by a concessionaire. The areas provide a variety of day and overnight recreational facilities that are operated continuously throughout the year. The two recreation areas attract an average of 400,000 visitor-days annually. In 2008, the two areas together accommodated almost 366,000 visitor-days (Leong pers. comm.).

Camanche Hills Hunting Preserve

The Camanche Hills Hunting Preserve is located 25 miles east of Lodi via State Route (SR) 88 and Liberty Road. Facilities at the preserve include 1500 acres of hunting areas, a clubhouse, restaurant, and trap range; amenities provided include dog rental and training and pheasant, chukar, goose, and duck hunting. Special services at the preserve include game processing, sale of hunting supplies, and hunter safety courses. The hunting season runs from the first week of October through the end of March, 6 days per week.

3.5.1.3 Lower Mokelumne River

The lower Mokelumne River extends nearly 73 miles from Camanche Dam to its confluence with the San Joaquin River. Tidal influence from the Delta typically extends to the town of Thornton but can reach as far upstream as Woodbridge Dam. Public access to the river is limited because the majority of land along the Mokelumne River is privately owned and trespassing is prohibited.

EBMUD's Mokelumne River Day Use Area (MRDUA), located at the base of Camanche Dam, is a popular access point to the Mokelumne River and for visitors to the Mokelumne River Fish Hatchery. Popular activities at the Mokelumne River Day Use Area include picnicking, hiking, fishing, wading, and swimming. Additionally, the park affords rafting access to the lower Mokelumne River. On average, 40,000 visitors come to the MRDUA annually (Leong pers. comm.). The Mokelumne

River Fish Hatchery is located on McIntire Road at the base of Camanche Dam and is open to the public 7 days a week.

Stillman Magee County Park (near the town of Clements) provides access to the Mokelumne River downstream of the Mokelumne River Day Use Area. Past SR 99 two river parks, Woodbridge Regional Park and Woodbridge Regional Wilderness Area, provide river access. Popular water-dependent activities on the lower Mokelumne River are wading, swimming, canoeing, kayaking, rafting, tubing, and fishing. These activities are so popular that the lower Mokelumne River is often congested on summer weekends. Important game fish include, rainbow trout, steelhead, and Chinook salmon. (Jones & Stokes Associates 1999)

At the town of Lodi, the flow of the Mokelumne River is impounded seasonally by WID's diversion dam, which creates Lodi Lake. Lodi Lake Park, a 114-acre recreation area adjacent to the Mokelumne River, includes a nature area in the floodplain of the Mokelumne River, as well as recreational facilities such as a boat ramp, boat rentals, picnic facilities, amphitheater, recreational vehicle area, swimming beach, hiking and biking trails, and a 58-acre nature area. Farther downstream, also in the river's floodplain, San Joaquin County has acquired approximately 15 acres of wooded area adjacent to the community of Woodbridge.

3.5.1.4 Local Terminal Reservoirs (East Bay)

EBMUD provides recreational opportunities at some of its local service area reservoirs, in accordance with the *East Bay Watershed Master Plan* (EBWMP) (East Bay Municipal Utility District 1999). Lafayette Recreation Area is a year-round day-use area ideal for hiking, jogging, fishing, boating, and picnicking, located off of Highway 24 near the west end of Lafayette. Chabot Recreation Area is also open year-round and supports hiking, jogging, fishing, boating, and picnicking. Chabot Recreation Area is located off of SR 580 in Castro Valley. The San Pablo Reservoir provides no-contact recreation (i.e., no swimming), including boating, fishing, picnicking, hiking, and kayaking. The reservoir is located off San Pablo Dam road between the city of Orinda and unincorporated El Sobrante and is open from February through November. Recreation is not allowed in Upper San Leandro and Briones Reservoirs.

Water in Lafayette Reservoir is supplied by local runoff in the surrounding watershed. Water in San Pablo Reservoir is a combination of local runoff and water imported from the Mokelumne River, while water in Chabot is primarily from local runoff and occasional releases from Upper San Leandro Reservoir.

3.5.2 Regulatory Setting

In addition to the State CEQA Guidelines, several local plans and policies promote recreational resources in the project area. This section describes the local plans and policies that are relevant to recreational resources in the project area. Because the Project would not involve any physical disturbance, many regulations that are typically relevant to this impact analysis in an EIR are not applicable to this Project. The discussion below focuses only on those plans and policies that are *potentially* relevant to the Project.

3.5.2.1 EBMUD Policy 9.04

The EBMUD Board of Directors last amended Policy 9.04 in 2012. Among the principles that it sets out is the intent to manage watershed lands in accordance with applicable environmental laws and

regulations. To that end, EBMUD allows public use of district land/watersheds for purposes of education, recreation, and fishing, if such uses are consistent with the District's potable water service mission. Policy 9.04 specifically provides that:

- EBMUD will permit only those uses that can be adequately monitored and managed by the District.
- EBMUD will maintain and operate recreation areas at its terminal reservoirs consistent with the EBWMP.
- Recreation areas will be developed and operated by District staff, qualified public agencies or private concessionaires as determined by the Board. Non-District operation of recreation areas must conform to District-adopted performance standards.
- EBMUD will obtain public input on District watershed management by inviting public participation, through citizen advisory committees or other means.

3.5.2.2 East Bay Watershed Master Plan

EBMUD's Board of Directors adopted the EBWMP in 1996. The master plan concerns the watershed surrounding the terminal reservoirs in the service area but does not include the upcountry reservoir areas. Among the master plan's provisions are statements of Watershed Management Area Direction, which include direction for developed recreation and trail access for each reservoir watershed area. For certain locations, management direction considers reducing or limiting currently permitted recreational activities in light of environmental sensitivities, or where such limitations are necessary to preserve water quality.

3.5.2.3 Mokelumne Watershed Master Plan

The *Mokelumne Watershed Master Plan* (MWMP) (East Bay Municipal Utility District 2008a) was adopted by the EBMUD Board of Directors in April 2008. It encompasses EBMUD-owned lands along the Mokelumne River and around Pardee and Camanche Reservoirs in Calaveras, Amador, and San Joaquin Counties. The MWMP provides guiding principles for the management of facilities and property. Section 3.3.9 of the MWMP calls for the preparation of a *Mokelumne Watershed Recreation Management Plan* to outline recreation opportunities in the watershed, and desired future recreation amenities. That plan was completed in 2010.

3.5.2.4 Amador County General Plan

The *Amador County General Plan* (Amador County 1969) contains several objectives and policies that call for the maintenance and provision of high-quality recreational facilities. The plan encourages recreational development and calls for the protection of the varied resources for public recreation in scenic and historical areas, hunting and fishing areas, lakes and waterways, forests and wilderness, and urban open spaces.

3.5.2.5 Calaveras County General Plan

The open space element of the *Calaveras County General Plan* (Calaveras County 1996) includes a recreational resources section that contains many recreation-related goals and policies. The general plan addresses support for recreational uses and open space management (Goal V-7) and support for public and private entities in their efforts to maintain and improve recreational facilities

(Goal V-9). It is Calaveras County policy to conserve national, state, and regional recreational areas (Policy V-7A), to preserve portions of the County's rivers and streams as a local recreation resource, to balance water resources development with the preservation of streams and rivers in their natural state, and to protect public access to streams and rivers.

3.5.2.6 San Joaquin County General Plan

The *San Joaquin County General Plan* (San Joaquin County 1992, 2009) contains specific objectives and policies that address recreation. In general, under a Community Development Element are several objectives that call for the provision of parks and recreation facilities, the promotion of the County's recreation potential, and the protection and preservation of the County's unique recreation resources, such as waterways. These objectives are to:

- serve the recreation needs of the County population by providing regional and local parks and recreational facilities;
- protect the diverse resources upon which recreation is based, such as waterways, marsh lands, wildlife habitats, unique land and scenic features, and historical and cultural sites;
- ensure the preservation of the Delta and the opportunity for the public to learn about and enjoy this unique recreational resource; and
- promote the recreational potential of San Joaquin County.

The entire stretch of the lower Mokelumne River from Camanche Dam to Woodbridge is classified by the *San Joaquin County General Plan* as a Significant Resource Area for Recreation. The *San Joaquin County General Plan* also identifies the following recreational activities as being provided by the Mokelumne River: fishing, rafting and tubing, canoeing, and nature study.

3.5.2.7 City of Lodi General Plan

The Parks, Recreation, and Open Space Element of the *City of Lodi General Plan* (City of Lodi 2010) contains goals and policies that outline measures to preserve significant open-space resources, such as the lower Mokelumne River Corridor. Policy 9 of the Parks, Recreation, and Open Space Element is applicable to the Project and states that:

The city shall support improvements along the Mokelumne River in consultation and cooperation with the County and with creek restoration and design professionals.

3.5.3 Assessment of Impacts

This section describes the operation-related impacts on recreational opportunities that could occur under the Project, including a description of the methods and assumptions used to conduct the analysis and the criteria for determining the significance of impacts.

3.5.3.1 Methods and Assumptions

The Project does not involve constructing, improving, or eliminating any facilities; therefore, there would be no temporary or permanent impacts, on recreational resources resulting from construction.

The effects of the Project on recreational opportunities were assessed by determining if change in reservoir surface water elevations or flows in the lower Mokelumne River might significantly impair

access to, or the quality of, water-dependent and water-enhanced activities at Pardee Reservoir, Camanche Reservoir, the lower Mokelumne River, and San Pablo and Chabot Reservoirs.

EBMUD used the hydrologic model EBMUDSIM to simulate reservoir storage and river flow under baseline conditions and project conditions (Appendix E). EBMUDSIM modeling used 89 years of historical hydrology to simulate flows in the lower Mokelumne River, storage volumes in Pardee and Camanche Reservoirs, and the corresponding changes in reservoir surface elevations under project conditions (see Section 3.1, Water Resources, and Appendix E for more information regarding the EBMUDSIM simulations). Although the increased demand would increase over decades, and would vary from year to year, the hydrologic and water temperature modeling evaluated this increased demand as an immediate and consistent change. Reservoir surface elevations and river flow under project conditions were compared to baseline conditions to determine potential impacts.

Pardee and Camanche Reservoirs

The primary recreational activity at Pardee and Camanche Reservoirs that could be affected by the Project is boating. Other water-dependent or water-enhanced activities such as camping may be affected by fluctuating water surface elevations. Changes in water surface elevations at the reservoirs could affect boating and other activities if the water service elevation was to fall below the elevation of the boat ramps.

Project effects on recreational opportunities at the reservoirs were assessed by using EBMUDSIM results to estimate if the Project would change the frequency at which the reservoir water-surface elevations would fall below the boat ramp elevations during the months when the ramps are in use. For this analysis, if the Project limits monthly boat launch access at Pardee and Camanche Reservoirs by more than 10% compared to baseline conditions, this would be considered a significant impact.

Lower Mokelumne River

The primary recreational activities along the lower Mokelumne River include wading, swimming, fishing, and slow-water boating and inner tubing.

A drop in river flow generally has a detrimental effect on recreational opportunities only if there is a substantial decrease in river flow when flows are moderately low. Small changes in low-to-moderate flow levels are unlikely to be noticed and changes at higher flow levels are unlikely to harm boat use. To evaluate project-related effects on recreation along the lower Mokelumne River, a reduction in flow was evaluated by comparing baseline releases and Project releases from Camanche Reservoir. A 30% reduction in flows from 325 cfs results in less than a 3-inch change in water surface elevation at Stillman Magee Park (rafting takeout). For analytical purposes, it was assumed that when project or baseline flows are 325 cfs or below, a decrease in flow of more than 20% could have a significant impact on recreation if it were to occur more than 10% of the time (i.e., for more than 107 months out of the 89-year hydrologic record [1,068 months] as simulated using EBMUDSIM).

3.5.3.2 Significance Criteria

The criteria used for determining the significance of an impact on recreational resources are based on Section I of Appendix G (a model Environmental Checklist) of the State CEQA Guidelines and professional standards and practices. Appendix G suggests that impacts on both water-dependent

and water-enhanced recreational opportunities may be considered significant if implementation of the Project would:

- substantially diminish availability of existing recreation opportunities;
- cause an increase in the use of existing neighborhood and regional parks or other recreation facilities such that substantial physical deterioration of the facility would occur or be accelerated; or
- include recreation facilities or require the construction or expansion of recreation facilities that might have an adverse physical effect on the environment.

As explained in Section 3.5.3.1, Methods and Assumptions, impacts on recreational opportunities may be considered significant if implementation of the Project would specifically:

- limit monthly boat launch access at Pardee and Camanche Reservoirs by more than 10% compared to baseline conditions, as simulated using EBMUDSIM; or
- reduce moderate to low flows (i.e., less than 325 cfs) in the lower Mokelumne River by more than 20% for more than 10% of the time over the 89-year hydrologic record, as simulated using EBMUDSIM.

3.5.3.3 Impact Discussion

The primary impact mechanisms for recreational resources are:

- lowered water-surface elevations at the boat launches for the Pardee Recreation Area during the spring and summer months (i.e., from February through November when the Pardee Recreation Area is open to the public);
- lowered water-surface elevations year-round at the boat launches for the Camanche Reservoir North Shore and South Shore Recreation Areas; and
- reduced flows in the lower Mokelumne River.

Table 3.5-1 shows water-surface elevations, reservoir storage, and the number of months in which the reservoir surface elevations would be affected by the Project relative to baseline. Most other recreational facilities at Pardee and Camanche Reservoirs are not dependent on minimum water surface elevations; however, when the water levels are particularly low, shore fishing also may be affected.

Table 3.5-1. Boat Launch Operations Affected Under Permit 10478 Time Extension Project Conditions Relative to Baseline Conditions

Boat Launch	Lowest Operational Water Surface Elevation (ft msl)	Reservoir Storage (AF)	Increased Limited Access Relative to Baseline ^a	
			Number of Months	Percent of Time (%)
Pardee Recreation Area				
Main Boat Launch	540	142,420	14	1.7
Low Water Boat Launch	495	75,480	1	0.1
Camanche Reservoir North Shore Recreation Area				
Main Ramp (full 8 lanes)	210	247,231	54	5.1
Main Ramp (Reduced 2 lanes)	194	164,370	8	0.7
Main Ramp, Low-Water Ramp	160	54,246	2	0.2
Camanche Reservoir South Shore Recreation Area				
Main Ramp	205	219,265	50	4.7
Main Ramp, Low-Water Ramp	175	91,528	16	1.5
Main Ramp, Very-Low-Water Ramp	160	54,246	2	0.2

^a Data reflected here represents the increased amount of time in which boat launch operations would be affected under project conditions relative to baseline conditions. This data was calculated from EBMUDSIM modeling results (Appendix E), which used 89 years of historical data (1921 to 2009) to model baseline and project conditions (Appendix M). The total number of months that the Pardee Recreation Area boat launches are open to the public is 801 months during this time frame (February through October from 1921 to 2009). The total number of months that the Camanche Reservoir Recreation Area boat launches are open to the public is 1,068 months during this time frame (year-round or 12 months out of the year from 1921 to 2009).

AF = acre feet; ft msl = feet above mean sea level.

Significant and less-than-significant impacts on recreational opportunities associated with lowered reservoir water surface elevations and reduced Mokelumne River flows are described in the following sections.

Significant Impacts

As explained below under Less-Than-Significant Impacts, changes in reservoir water surface elevations and changes in flows in the lower Mokelumne River would not be great enough under project conditions compared to baseline conditions to significantly affect the lower boat launches at Pardee and Camanche Reservoirs and recreational opportunities along the lower Mokelumne River. As a result, there would be no significant impacts on recreational resources.

Less-than-Significant Impacts

Impact REC-1. Diminished recreational boating access as a result of lowered water surface levels in Pardee Reservoir (Less than Significant)

While only recreational boating access impacts are described here, other effects that are tied to reservoir levels would be affected to a comparable degree. These effects would include a temporary decrease in operating hours, a temporary closure of some facilities, changes in access to shoreline fishing, decreased revenues and visitors, and increases in navigational hazards in the reservoir. The

increases in these effects would mimic those on boating access and would occur for the same months as reduced boating access.

Boat launching at the Pardee Reservoir Recreation Area is permitted only at designated launch ramps. As Table 3.5-1 illustrates, the utility of both the eight-lane main boat launch and the two-lane low-water boat launch are affected by *decreased* water-surface elevations. The reservoir elevation required for full use of the main boat launch must be greater than 540 feet above mean sea level (ft msl). At 540 ft msl, only two of the eight launch lanes would remain in service. At 535 ft msl and below, none of the eight lanes would be operational. Therefore, 540 ft msl has been established as the impact threshold for use of the main launch ramp. (Bolton pers. comm.)

The reservoir elevation of 495 ft msl is required for full use of the low-water boat launch, and is therefore, set as the impact threshold for use of this boat launch. Above 535 ft msl surface elevation, the low-water ramp is inundated. (Bolton pers. comm.)

Recreational boating access at Pardee Reservoir may be summarized as follows:

- Above elevation 540 ft msl: full access at main boat launch ramp;
- Elevation 540 ft to 495 ft msl: no access at main boat launch ramp, limited access at low-water boat launch ramp; and
- Below elevation 495 ft msl: no launching service.

EBMUDSIM modeling results were used to calculate the total number of months during which the boat launches would be affected during the 89-year hydrologic record for the time period when the boat launches are open to the public (February through October).

As shown in Table 3.5-1, 14 additional months of limited access or non-access would occur at the main boat launch under project conditions, representing a 1.7% increase of monthly limited access compared to baseline conditions. Similarly, 1 additional month of non-access would occur at the low-water boat launch under project conditions, representing a 0.1% increase of monthly limited access compared to baseline conditions.

The small increment of additional months when Pardee Reservoir boating access would be limited under project conditions (i.e., less than 10%) is *less than significant*. No mitigation is necessary.

Impact REC-2. Diminished recreational boating access as a result of lowered water surface levels in Camanche Reservoir (Less than Significant)

While only recreational boating access impacts are described here, other effects that are tied to reservoir levels would be affected to a comparable degree. These effects would include a temporary decrease in operating hours, a temporary closure of some facilities, changes in access to shoreline fishing, decreased revenues and visitors, and increases in navigational hazards in the reservoir. The increases in these effects would mimic those on boating access and would occur for the same months as reduced boating access.

Similar to the Pardee Reservoir Recreation Area, boat launching at the Camanche Reservoir North Shore and South Shore Recreation Areas is permitted only at designated launch ramps. Water surface elevations below 210 ft msl in Camanche Reservoir at any time of the year would affect access to boat ramps. The water levels needed for access to facilities on Camanche Reservoir are summarized as follows (Bolton pers. comm.):

- above elevation 210 ft msl: full use of North Shore main boat launch ramp;
- above elevation 205 ft msl: full use of South Shore main boat launch ramp;
- below elevation 205 ft msl: fueling service suspended at North Shore, 2 lanes open;
- below elevation 194 ft msl: main ramp unusable;
- below elevation 175 ft msl: South Shore low-water launch ramp inoperable; and
- below elevation 160 ft msl: North Shore low-water launch ramp for the main boat launch ramp inoperable, South Shore very low-water ramp for the main boat launch ramp inoperable.

EBMUDSIM modeling results were used to calculate the total number of months during which boat launches would be affected during the 89-year hydrologic record.

As shown in Table 3.5-1, the Project would limit access to the Main Ramp at the North Shore Recreation Area by 54 additional months, representing a 5.1% increase of monthly limited access compared to baseline conditions. The Project would limit access to the main ramp at the South Shore Recreation Area by 50 additional months, representing a 4.7% increase of monthly limited access compared to baseline conditions.

For the lowest boat launches at both the North Shore Recreation Area and the South Shore Recreation Area, the boat launch facilities are out of service 2 additional months under project conditions, representing a 0.2% increase of monthly limited access compared to baseline conditions.

The small increment of additional months when Camanche Reservoir boating access would be limited under project conditions (i.e., less than 10%) is *less than significant*. No mitigation is necessary.

Impact REC-3. Diminished recreation opportunities as a result of reduced flows in the lower Mokelumne River (Less than Significant)

The majority of the land along the lower Mokelumne River between Camanche Dam and the town of Woodbridge is privately owned, and most access to the river is prohibited. The principal points of access to lower Mokelumne River recreational opportunities occur at public facilities, including EBMUD's Mokelumne River Day Use Area, the Mokelumne River Fish Hatchery, Stillman Magee County Park, and Lodi Lake Park.

Table 3.5-2 shows EBMUDSIM results for the number of months when low or moderate flows (i.e., less than 325 cfs) were reduced by more than 20% under project conditions compared to baseline conditions. As noted earlier, a 30% reduction in flows from 325 cfs results in less than a 3 inch reduction in surface elevation at Stillman Magee Park. Although flows in the lower Mokelumne River are simulated to be somewhat lower under project conditions compared to the baseline conditions, this reduction in flows should not significantly affect recreation resources along the river because over the 89-year hydrologic record used by EBMUDSIM modeling, only 38 months out of 1,068 months (approximately 3.6% of the time) had a 20% reduction in low-to-moderate flows. The highest frequency for any given month was 7.9% (February). Nearly 75% of the recreation in the lower Mokelumne River takes place from March through October.

This reduction in low-to-moderate flows would not significantly affect water-dependent recreational opportunities along the lower Mokelumne River because these reduced flows would occur rarely during the prime recreational months between April and September. Over the 89-year record used for the EBMUDSIM simulations, only 4 months out of 534 prime recreational months (approximately 0.7% of the time) had more than a 20% reduction of low or moderate flows under project conditions compared to baseline conditions (Table 3.5-2).

For the reasons stated above, the potential effect of the Project on recreational opportunities along the lower Mokelumne River is considered to be *less than significant*. No mitigation is necessary.

Table 3.5-2. Occurrence when Low to Moderate Lower Mokelumne River Flows Were Reduced by More than 20% under Permit 10478 Time Extension Project Conditions Relative to Baseline Conditions

Month	Number of Months ^a	Percent Occurrence (%) ^a
January	5	5.6
February	7	7.9
March	5	5.6
April	1	1.1
May	1	1.1
June	0	0.0
July	0	0.0
August	0	0.0
September	2	2.2
October	6	6.7
November	6	6.7
December	5	5.6
Total	38	3.6 (average)

^a Number of months and percent occurrence over the 89-year hydrologic record (1068 months) simulated by EBMUDSIM

Impact REC-4. Reduced or lost recreation opportunities as a result of lower reservoir levels in Lafayette, Chabot, or San Pablo Reservoirs (Less than Significant)

Lafayette Reservoir water levels would not be affected by the Project because the reservoir is not connected to the Mokelumne River supply, is filled only with local runoff, and is used as a back-up emergency supply. Therefore, operations and associated elevations are not expected to change. As a result, there would be no impacts on recreational resources at Lafayette Reservoir. No mitigation is necessary.

Chabot Reservoir serves as an emergency potable water supply and a seasonal non-potable supply for two adjacent golf courses. The source of supply for Chabot Reservoir is primarily local runoff, with occasional releases from Upper San Leandro Reservoir. Operations and associated surface elevations at Chabot Reservoir are not expected to change as a result of the Project; therefore, there would be *less-than-significant* impacts on recreational resources at Chabot Reservoir. No mitigation is necessary.

San Pablo Reservoir is filled to capacity between December 1 and July 1 each year, at which point minimal deliveries via the Mokelumne Aqueducts supply additional water. However, summer demand in the EBMUD service area generally results in the drawdown of the reservoir to its minimal operating range. The management of San Pablo Reservoir would not change under the Project. Under the Project, San Pablo Reservoir would continue to be filled to capacity between December 1 and July 1 and would continue to be drawn down during the summer months as under current operations. As such, there would be *less-than-significant* impacts on recreational resources at San Pablo Reservoir. No mitigation is necessary.

Recreation is not allowed at the Briones and Upper San Leandro Reservoirs.

3.6 Visual Resources

This section describes visual resources at Pardee and Camanche Reservoirs, as well as along the lower Mokelumne River, and assesses the significance of the impacts, if any, on visual resources as a result of implementing the Permit 10478 Time Extension Project (Project). The analysis concludes there would be no significant impacts on visual resources as a result of implementing the Project.

3.6.1 Environmental Setting

For the purposes of this discussion, the project area includes visual resources at Pardee Reservoir, up to the Middle Bar Bridge; at Camanche Reservoir; as well as from public viewing areas along the lower Mokelumne River. The lower Mokelumne River refers to the portion of the Mokelumne River between Camanche Dam spillway and WID's intake on the Mokelumne River near the town of Woodbridge.

3.6.1.1 Concepts and Terminology for Visual Analysis

Identifying and evaluating a project's visual resources involves three steps:

1. Objectively identifying the visual features (visual resources) of the landscape.
2. Assessing the character and quality of those resources relative to overall regional visual character.
3. Determining the importance to people, or sensitivity, of views of visual resources in the landscape.

The aesthetic value of an area is a measure of its visual character and quality, considered in terms of concern for a particular viewshed and the overall sensitivity of the viewer (U.S. Forest Service 1995; Federal Highway Administration 1988).

Viewer response is a combination of viewer exposure and viewer sensitivity. Viewer exposure is a function of the number of viewers, number of views seen, distance of the viewers, and viewing duration. Viewer sensitivity is based on the visibility of resources in the landscape, proximity of viewers to the visual resource, elevation of viewers relative to the visual resource, frequency and duration of views, number of viewers, and type and expectations of individuals and viewer groups.

- Both natural and artificial landscape features contribute to the visual character of an area or view. Visual character is influenced by geologic, hydrologic, botanical, wildlife, recreational, and urban features (such as roads, utilities, and other human-made structures). The appearance of a landscape is described in terms of the dominance of the form, line, color, and texture of landscape components.
- Visual quality is evaluated based on the relative degree of vividness, intactness, and unity. High-quality views are highly vivid and relatively intact and exhibit a high degree of visual unity.
- Vividness is the visual power or memorability of landscape components as they combine in striking and distinctive visual patterns.
- Intactness is the visual integrity of the natural and human-built landscape and its freedom from encroaching elements. This factor can be present in well-kept urban and rural landscapes, and in natural settings.

- Unity is the visual coherence and compositional harmony of the landscape considered as a whole; it frequently attests to the careful design of individual components in the landscape.
- A vista is a confined view that is seen through a passageway (e.g., a row of buildings or vegetation, canyon walls) and often focuses on a specific landscape feature; a vista can be human created and can be influenced by design. (U.S. Forest Service 1995)

3.6.1.2 Regional Visual Character

Pardee Reservoir

Pardee Reservoir lies in the rolling foothills of the Sierra Nevada. The reservoir encompasses approximately 37 miles of shoreline with three main arms extending north, east, and south. The reservoir's surroundings comprise annual grassland, oak woodland, foothill pine woodland, and chaparral that are largely in a natural state. The built environment surrounding the reservoir is limited, consisting of roads, the main dam, auxiliary dams, and recreational facilities. The reservoir facilities are located along the western shoreline of the reservoir's north and south arms. Also located to the west, Pardee Dam Road/Sandretto Road extends along the entire length of the reservoir. Scattered throughout the eastern arm and eastern shoreline of the reservoir are several unimproved dirt roads and trails.

Pardee Reservoir is a significant visual feature in the regional landscape. The lake and shoreline contrast sharply with the nearby rolling wooded foothills. Visual quality is highest in the late spring and early summer when reservoir levels are high. This period corresponds with the highest level of viewer exposure because the Pardee Recreation area is open to the public only from February through October. As summer progresses into winter, reservoir drawdown typically exposes a ring of bare soil along the shoreline, negatively affecting visual quality.

Vistas available to residents and visitors to the watershed are typical of those found in the lower Sierra foothills, including rolling hills, water bodies surrounded by rising hills, and views of the Sierra Nevada. Higher elevations on EBMUD and private properties in the watershed offer scenic views of distant hills and valleys and, from some locations, the Sierra Nevada rising to the east. Contrasts between the surface water of the reservoirs, the variation in near and distant terrain and vegetation, and the expanse of the sky enhance the quality of these vistas. From lower elevations, vistas consist of views across the reservoirs or across the rolling landscape surrounding the reservoirs. Because of elevation differences, some near-shore locations also offer longer vistas beyond the reservoirs.

The reservoir and nearby facilities occupy the foreground of the various viewsheds around the lake and adjacent areas. Major viewer groups associated with the reservoir and reservoir facilities include the residents of nearby areas, recreationists using the reservoir and trails, users of Pardee Dam/Sandretto Road, and facility staff members. For these viewer groups, exposure and sensitivity are relatively high.

Downstream of Pardee Reservoir, the Mokelumne River flows from Pardee Dam southwest into Camanche Reservoir. The Pardee powerhouse is located at the toe of Pardee Dam, with transmission lines from the existing powerhouse substation and other overhead utility lines that stretch from north to south through this area. South of Pardee Dam, the spillway occupies the foreground of the Mokelumne River/upper Camanche Reservoir viewshed from an observation point, Pardee Dam Road, and adjacent facilities.

Overall, views associated with the reservoir are vivid because they are not typical of the roadside scenery in the region; are intact because the area is rural and the open space environment is free from encroaching elements; and are unified because the existing landscape is congruent and harmonious in terms of scale, color, and form.

Camanche Reservoir

The landscape surrounding Camanche Reservoir is similar to Pardee Reservoir in that it is a scenic, vista-rich environment. The dominant vegetation is grassland, chaparral, oak woodland, and foothill pine.

Vistas at Camanche Reservoir occur from higher elevations on EBMUD and private properties in the drainage. Similar to Pardee Reservoir, these vantages offer scenic views of distant hills and valleys and provide a scenic contrast between the surface water of the reservoir, the variation in near and distant terrain and vegetation, and the expanse of the sky. From lower elevations, vistas consist of views across the reservoirs or across the rolling landscape surrounding the reservoirs. Because of elevation differences, some near-shore locations also offer longer vistas beyond the reservoirs.

Lower Mokelumne River

The lower Mokelumne River is characterized by rolling hills and small valleys, with occasional rock outcrops. The dominant natural vegetation is annual grassland and native oak woodlands, occurring in varying densities. The tree canopy cover and species diversity increases in small draws and valley bottoms where water is more readily available. The contrasts in form, color, and texture of this vegetation add visual variety and interest to the landscape. The area is a rural, pastoral landscape of rangeland and open space, with residences scattered throughout the region. Public access to the Mokelumne River in the lower Mokelumne River segment is limited because most land is owned privately.

Because of the releases from Pardee and Camanche Reservoirs, flows are present year-round in the lower Mokelumne River.

3.6.2 Regulatory Setting

3.6.2.1 Federal, State, and Local Scenic Routes

There are no federal or state designated scenic roadways or corridors in the project area.

Highway 49 is an Eligible State Scenic Highway and a Calaveras County scenic roadway from Mokelumne Hill south to Angels Camp (Calaveras County 1996). SR 88 and Liberty Road are San Joaquin County scenic routes (San Joaquin County 1992). Although these roads are in the vicinity of Pardee and Camanche Reservoirs, the viewpoints from these roads are not in the project area and the reservoirs cannot be seen from these roadways. SR 88 crosses the lower Mokelumne River approximately 2.5 miles downstream of the Camanche Reservoir; however, views of the lower Mokelumne River from this roadway are minimal.

3.6.2.2 Local General Plans

Amador County General Plan

The *Amador County General Plan* (Amador County 1973) Policy 15 (General Plan Appendix, Section V) may be relevant to the project area because it indicates areas of aesthetic importance in the County.

Special consideration and care should be devoted to the aesthetics, architecture and visual appearance of proposed development in the following areas: 1) Land within sight of Highway 49 between Central House and Sutter Creek; 2) Land within sight of Highway 88 between Pine Grove and the National Forest; 3) Areas within a half-mile of the shore of Camanche Reservoir; 4) The land within 1 mile of the shore of Camanche Reservoir; 5) The area within 1 mile of Daffodil Hill; 6) The scenic areas along Highway 49; 7) Private lands in the National Forest; 8) Nashville Reservoir area; 9) Highway 124 near Irish Hill Reservoir; and 10) Other areas having outstanding scenic or historic interest, upon request of the residents or owners.

Calaveras County General Plan

The *Calaveras County General Plan* (Calaveras County 1996) has several objectives, goals, and policies that may be applicable for the visual resources analysis, including those objectives, goals, and policies addressing scenic highways and cultural, historic, and scenic resources. The Open Space Element of the general plan includes the following policies related to visual resources:

- Goal V-6: To preserve and protect the scenic qualities of the County.
- Policy V-6A: Proposed new development shall consider the scenic qualities of the natural resources in the design of the project.
- Implementation Measure V-6A-1: New development shall be encouraged to avoid extreme topographic modification, and may be required to restore natural contours and vegetation of the land after grading or other land disturbances.
- Implementation Measure V-6A-2: Cluster development with preservation of open space of scenic quality shall be encouraged.
- Implementation Measure V-6A-3: New development shall be encouraged to be designed in a manner which is sensitive to available natural resources.

San Joaquin County General Plan

The *San Joaquin County General Plan* (San Joaquin County 1992) has several objectives, goals, and policies that may be applicable for the visual resources analysis of the Project, including those objectives, goals, and policies addressing community development (e.g., growth accommodation, industrial development, utility corridors), open space, water resources and quality, vegetation, and fish and wildlife habitat.

The following objectives and policies related to aesthetics from the *San Joaquin County General Plan* were considered in this analysis:

IV. Community Development,

E. Public Facilities, 1. Recreation Policies

23. Scenic corridors along the recreation trailways and scenic routes shall be protected from unsightly development.

VI. Resources

A. Open Space

Objectives

1. To preserve open space land for the continuation of commercial agricultural and productive uses, the enjoyment of scenic beauty and recreation, the protection and use of natural resources, and for protection from natural hazards.

Policies

10. Views of waterways, hilltops, and oak groves from public land and public roadways shall be protected.
11. Outstanding scenic vistas shall be preserved and public access provided to them whenever possible.
12. The County should recognize the roads shown in Figure VI-2 as scenic routes and as valuable in enhancing the recreational experience for County residents and non-residents. Criteria for selection of additional routes should specify that the route:
1. leads to a recreational area,
 4. provides a representative sampling of the scenic diversity in the County,
 5. exhibits unusual natural or man-made features of interest,
 6. provides opportunities to view the Delta waterways, and
 7. links two scenic routes or connects with scenic routes of cities or other counties.
 8. State Route 88 and Liberty Road are San Joaquin County scenic routes.
13. Development proposals along scenic routes shall not detract from the visual and recreational experience.
- F. Water Resources and Quality
5. To recognize the surface waters of San Joaquin County as resources of State and national significance for which environmental and scenic values must be protected.

3.6.3 Assessment of Impacts

This section describes the operational-related impacts on visual resources that could occur under the Project, including a description of the methods and assumptions used to conduct the analysis and the criteria for determining the significance of impacts.

3.6.3.1 Methods and Assumptions

The Project would not involve constructing, improving, or eliminating any facilities; therefore, there would be no temporary or permanent impacts, on visual resources resulting from construction.

The effects on visual resources in the project area were assessed by determining how the potential change in reservoir surface water elevations or flows in the lower Mokelumne River might adversely affect visual resources at each location. Hydrologic modeling conducted by EBMUD using EBMUDSIM was used to generate estimates of how the Project would affect storage levels in Pardee and Camanche Reservoirs and flows in the lower Mokelumne River. The modeling was performed using 89 years (1921–2009) of basin runoff data. (See Section 3.1, Water Resources, and Appendix E for more information regarding the EBMUDSIM simulations.)

Pardee and Camanche Reservoirs

Visitors to Pardee and Camanche Reservoirs are accustomed to the annual fluctuations in reservoir elevation that occur under baseline conditions. The baseline EBMUDSIM results indicate that for most years there are large fluctuations in water-surface elevations in Pardee and Camanche Reservoirs. The median difference between the minimum and maximum baseline elevations was 18 feet for Pardee Reservoir and 20 feet for Camanche Reservoir. Year-to-year variation in the fluctuation in elevation is large, with the Pardee fluctuation ranging from 13 to 93 feet and the Camanche fluctuation ranging from 2 to 75 feet. Because visitors are accustomed to the large changes in reservoir elevation that occur as part of normal reservoir operations (i.e., baseline operations), small changes in reservoir elevations due to Project operations (as compared to the baseline conditions) would be unlikely to affect the visual quality of the reservoirs.

An assessment of project effects on visual resources at Pardee and Camanche Reservoirs was conducted by comparing end-of-month water-surface elevations under baseline conditions to end-of-month water surface elevations under project conditions. If more than 10% of the months had a project-related drop in water surface elevation of more than 10 feet compared to baseline conditions, visual impacts at a reservoir would be considered significant.

Lower Mokelumne River

A drop in river flow generally has a detrimental visual effect only if there is a substantial decrease in river flow when flows are moderately low. Small changes in low-to-moderate flow levels (10%) are unlikely to be noticed and changes at higher flow levels are unlikely to be visually disturbing. To evaluate Project-related visual effects along the Lower Mokelumne River, a reduction in flow was evaluated by simulating the months where Project or baseline flows were projected to be less than 325 cubic feet per second (cfs). This rate was selected because 325 cfs is the median flow value for October through March (median flows are higher for the other months; see Camanche Reservoir Releases to the Mokelumne River in Appendix H.1).

A 30% reduction in flows below 325 cfs would result in less than a 3-inch change in water surface elevation at Stillman Magee Park (rafting takeout). For analytical purposes, it was estimated that when Project or baseline flows are below 325 cfs, a decrease in flow of more than 20% in the project case could have a significant impact on recreation if it were to occur more than 10% of the time (i.e., for more than 107 months out of the 89-year hydrologic record [1,068 months] as simulated using EBMUDSIM).

3.6.3.2 Significance Criteria

The criteria used for determining the significance of an impact on visual resources are based on Section I of Appendix G (a model Environmental Checklist) of the State CEQA Guidelines and professional standards and practice. Appendix G suggests that impacts on visual resources may be considered significant if implementation of the Project would:

- have a substantial adverse effect on a scenic vista;
- substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway;
- substantially degrade the existing visual character or quality of the site and its surroundings; or
- create a new source of substantial light or glare that would adversely affect day or nighttime public views.

Because of the subjective nature of evaluating visual impacts, federal and professional standards of visual assessment methods have been used to determine potential impacts on aesthetic values of the project area. According to professional standards, a project may be considered to have a significant impact on visual resources if it would significantly:

- conflict with local guidelines or goals related to visual quality;
- alter the existing natural viewsheds, including changes in natural terrain;
- alter the existing visual quality of the region or eliminate visual resources;
- increase light and glare in the project vicinity;
- result in backscatter light into the nighttime sky;
- result in reduction of sunlight or introduction of shadows in community areas;
- obstruct or permanently reduce visually important features; or
- result in long-term (persisting for 2 years or more) adverse visual changes or contrasts to the existing landscape as viewed from areas with high visual sensitivity.

As explained above under Methods and Assumptions, impacts on visual resources may be considered significant if implementation of the Project would specifically:

- cause reservoir water-surface elevations to drop by more than 10 feet for more than 10% of the time over the 89-year hydrologic record, as simulated using EBMUDSIM; or
- reduce moderate to low flows (i.e., less than 325 cfs) in the lower Mokelumne River by more than 20% for more than 10% of the time over the 89-year hydrologic record, as simulated using EBMUDSIM.

3.6.3.3 Impact Discussion

The primary impact mechanisms for visual resources are:

- lowered water surface elevations in Pardee and Camanche Reservoirs, and
- reduced flows in the lower Mokelumne River.

Significant and less-than-significant impacts on visual resources associated with lowered reservoir water-surface elevations and reduced Mokelumne River flows are described in the following sections.

Significant Impacts

As explained below under Less-Than-Significant Impacts, changes in reservoir water-surface elevations and changes in flows in the lower Mokelumne River are not great enough under Project conditions compared to baseline conditions to significantly affect visual resources at Pardee and Camanche Reservoirs and along the lower Mokelumne River. As a result, there would be no significant impacts on visual resources.

Less-than-Significant Impacts

Impact VIS-1: Adversely affect a scenic vista, or degrade the existing visual character or quality, of Pardee and Camanche Reservoirs and their surroundings (Less than Significant)

Seasonal and permanent scenic vistas exist from the Pardee and Camanche Reservoirs, nearby roadways, hiking trails, and the river shoreline. Under baseline conditions, water levels at the reservoirs retreat periodically such that soil normally submerged around the shoreline are exposed. (This is sometimes referred to as the “bathtub rings” effect.) Under project conditions, this effect would increase slightly in frequency, duration, and extent.

The Project would not cause large changes in reservoir water-surface elevation compared to baseline conditions, as shown in Table 3.6-1. The modeling for Table 3.6-1 was performed using 89 years (1921 through 2009) of basin runoff data. (See Section 3.1, Water Resources, and Appendix E for more information regarding the EBMUDSIM simulations.) Table 3.6-1 shows the effect of project conditions on reservoir elevations as assessed by looking at the number of months simulated by EBMUDSIM to have a drop in water surface elevation by more than 10 feet during a month compared to baseline conditions. For Pardee Reservoir, only 2.8% of all months simulated showed a surface water elevation drop by more than 10 feet, and the highest frequency for any given month was 3.4% (January, February, March, September, October, November, and December). For Camanche Reservoir, only 1.4% of all the months simulated showed a drop of more than 10 feet, and the highest frequency for any given month was 3.4% (March).

These relatively infrequent changes in watersurface elevations (i.e., less than 10% of the time) are not expected to be significantly noticeable from public viewing areas. The potential effect of the Project on visual resources is considered to be *less than significant*. No mitigation is necessary.

Table 3.6-1. Occurrence when Reservoir Elevations Dropped by More than 10 Feet under Permit 10478 Time Extension Project Conditions Relative to Baseline Conditions

Month	Pardee Reservoir		Camanche Reservoir	
	Number of Months	Percent Occurrence (%)	Number of Months	Percent Occurrence (%)
January	3	3.4	2	2.2
February	3	3.4	2	2.2
March	3	3.4	3	3.4
April	2	2.2	1	1.1
May	1	1.1	0	0.0
June	2	2.2	0	0.0
July	2	2.2	1	1.1
August	2	2.2	1	1.1
September	3	3.4	1	1.1
October	3	3.4	1	1.1
November	3	3.4	1	1.1
December	3	3.4	2	2.2
Total	30	2.8 (average)	15	1.4 (average)

Impact VIS-2: Adversely affect a scenic vista, or degrade the existing visual character or quality, along the lower Mokelumne River and its surroundings (Less than Significant)

Table 3.6-2 shows EBMUDSIM results for the number of months when low or moderate flows (less than 325 cfs) were reduced by more than 20% under Project conditions compared to baseline conditions. The modeling for Table 3.6-2 was performed using 89 years (1921 through 2009) of basin runoff data. (See Section 3.1, Water Resources, and Appendix E for more information regarding the EBMUDSIM simulations.) Although flows in the lower Mokelumne River are simulated to be somewhat lower under the Project compared to the baseline scenario, this reduction in flows should not significantly affect the visual quality along the river because over the 89-year hydrologic record used by EBMUDSIM modeling, only 38 months out of 1,068 months (approximately 3.6% of the time) had a 20% reduction in low to moderate flows. The highest frequency for any given month was 7.9% (February). The potential effect of the Project on recreation opportunities along the lower Mokelumne River is considered to be *less than significant*. No mitigation is necessary.

Table 3.6-2. Occurrence when Low to Moderate Lower Mokelumne River Flows Were Reduced by More than 20% under Permit 10478 Time Extension Project Conditions Relative to Baseline Conditions

Month	Number of Months ^a	Percent Occurrence (%) ^a
January	5	5.6
February	7	7.9
March	5	5.6
April	1	1.1
May	1	1.1
June	0	0.0
July	0	0.0
August	0	0.0
September	2	2.2
October	6	6.7
November	6	6.7
December	5	5.6
Total	38	3.6 (average)

^a Number of months and percent occurrence over the 89-year hydrologic record simulated for Permit 10478 Time Extension Project conditions compared to baseline conditions.

Chapter 4

Cumulative Impacts

This chapter analyzes the cumulatively significant impacts associated with the Permit 10478 Time Extension Project (Project). 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).

4.1 Approach to Cumulative Impact Analysis

4.1.1 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 EIR.

4.1.2 Methods and Assumptions

This analysis describes significant impacts associated with future cumulative conditions in the Mokelumne River system and the Delta, particularly the cumulative impact of the Project diversions in combination with other reasonably foreseeable diversions from the Mokelumne River. Where the analysis indicates that the cumulative impacts are potentially significant, the Project's contribution to the potentially significant cumulative impact is evaluated to determine whether it is cumulatively considerable. Where the contribution of the Project is found to be cumulatively considerable, mitigation measures to reduce that contribution are also described.

For most of the analyses described below, results are presented as a comparison between baseline conditions and cumulative conditions. This enables the reader to see the full cumulative effect. In some cases, the incremental difference between the project conditions and the cumulative conditions is discussed to better understand how much of the cumulative effect is attributable specifically to the Project.

The cumulative analysis assumes that upstream water users on the Mokelumne River (Amador and Calaveras Counties) would be using their full senior water-right entitlement of 47,000 acre-feet per year (AFY) as compared to the 27,000 AFY of use identified in the baseline analysis (see Chapter 1, Objective and Need for the Permit 10478 Time Extension Project, Figure 1-4). Thus, the cumulative analysis assumes an additional take of 20,000 AFY by upstream diverters with senior rights. As a result of this increased use, there would be less water available for diversion downstream, which could impact flows and water temperature. This full use of the senior entitlements combined with the Project diversions were assumed in EBMUDSIM to simulate cumulative effects on reservoir inflows, storage volumes, and releases under 1921 through 2009 hydrologic conditions. As discussed in Appendix B, recently EBMUD finalized the Water Supply Management Program (WSMP) 2040 which identified options for meeting EBMUD's dry year needs in the future. The cumulative analysis assumes that by 2040, EBMUD would have secured or otherwise obtained some of the additional dry-year supplies identified in WSMP 2040.

Climate change also has the potential to affect the Mokelumne River hydrology in the future. See Chapter 7, Climate Change, for a discussion of this issue.

The cumulative analysis for water and fish resources includes a discussion of the minor potential effects of the Project on the Delta. Many future actions and projects could affect the Delta, but it is difficult to envision a single future for the Delta with any certainty for use in a cumulative assessment. Potential changes in the Delta include actions that would likely improve conditions, and other actions that may degrade existing conditions.

4.1.3 Other Mokelumne River or Delta Projects and Programs

This section briefly describes projects and management programs that were considered likely to contribute to cumulative effects on water quality and fish resources in the Mokelumne River and the Delta. However, cumulative impacts on the Delta resources would be limited by the requirements of existing regulatory measures such as the D-1641 objectives and the Regional Water Quality Control Board (RWQCB) basin plans. In addition, there are existing regulatory mechanisms (e.g., actions required under the federal Endangered Species act [ESA], California Endangered Species Act [CESA], and the Bay-Delta Water Quality Control Plan [WQCP]) that are intended to prevent future changes in the Delta that could adversely affect fish and water quality.

4.1.3.1 U.S. Fish and Wildlife Service Biological Opinion for Central Valley Project/State Water Project Operations Criteria and Plan

The U.S. Fish and Wildlife Service (USFWS) (2008) determined that a Reasonable and Prudent Alternative (RPA) is necessary to protect Delta smelt under the CVP-SWP Operations Criteria and Plan (OCAP). The RPA includes measures to prevent or reduce entrainment of delta smelt at Jones and Banks Pumping Plants; provide suitable habitat conditions for delta smelt migration, spawning, and rearing in the Bay-Delta; and monitor delta smelt abundance and distribution through continued sampling programs. These measures, which would be implemented by the California Department of Water Resources (DWR) and U.S. Bureau of Reclamation (Reclamation), are intended to ensure that operations of the Central Valley Project (CVP) and State Water Project (SWP) do not jeopardize this species, and are expected to significantly improve conditions for this species compared to previous operational scenarios. Additional information is available at <<http://www.fws.gov/sfbaydelta/cvp-swp/cvp-swp.cfm>>.

4.1.3.2 National Marine Fisheries Service Biological Opinion for Central Valley Project/State Water Project Operations Criteria and Plan

The National Marine Fisheries Service (NMFS) (2009) determined that an RPA is necessary for the protection of salmon, steelhead, and green sturgeon under the CVP-SWP OCAP. The RPA includes measures to improve habitat, reduce entrainment, and improve salvage through both operational and physical changes in the system. These measures would be implemented by DWR and Reclamation. The RPA is intended to avoid jeopardizing listed species or adversely modifying their critical habitat, but not necessarily to achieve recovery. NMFS amended the RPA in 2011 to include updates to respond to an Independent Review Panel (IRP) report, acknowledge, and highlight efforts to improve operations, highlight how current studies will influence real time management, and highlight the need for Reclamation to explore options to avoid non-compliance with the RPA. Additional information is available at <<http://swr.nmfs.noaa.gov/ocap.htm>>.

4.1.3.3 Ecosystem Restoration Program

The Ecosystem Restoration Program (ERP) is administered by the California Department of Fish and Wildlife (DFW). 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 sediment quality to better support ecosystem health. ERP actions contribute to cumulative benefits on fish and wildlife species, habitats, and ecological processes. Additional information is available at <<http://www.dfg.ca.gov/ERP>>.

4.1.3.4 Bay-Delta Conservation Plan

The Bay-Delta Conservation Plan (BDCP) is a proposed plan to address impacts to endangered and sensitive species and their habitats in the Delta. Alternatives being evaluated to mitigate impacts of water diversions include using through-Delta and isolated conveyance facility options, or a combination of both strategies. Restoration actions under consideration include various degrees of habitat restoration in the Delta and Suisun Marsh, particularly, additional tidal habitat conversion along the lower Mokelumne and Cosumnes Rivers. The Delta Habitat Conservation and Conveyance Plan (DHCCP) is the CEQA analysis associated with BDCP. The entities involved in developing the BDCP and associated environmental analysis have indicated that any potential impacts to Mokelumne River fisheries including potential impacts to migration will be mitigated or avoided. The final plan and the environmental impact statement/environmental impact report (EIS/EIR) are expected to be completed in 2013. The BDCP would be implemented by DWR, Reclamation, and local water agencies. Additional information is available at <<http://baydeltaconservationplan.com/default.aspx>>.

4.1.3.5 San Joaquin River Restoration Program

The San Joaquin River Restoration Program (SJRRP) is a comprehensive long-term effort to restore flows to the San Joaquin River below Friant Dam and restore self-sustaining Chinook salmon populations (spring-run and fall-run) in the river, while reducing or avoiding adverse water supply impacts. This program will change San Joaquin River flows and fish migration through the Delta (past the Mokelumne River mouth). The program is a direct result of a settlement agreement reached in September 2006, between the United States and CVP Friant Division contractors. The San Joaquin River Restoration Settlement Act, enacted in March 2009, authorizes and directs the Secretary of the Interior to fully implement the settlement. The program management team includes representatives from Reclamation, USFWS, NMFS, DFW, and DWR. Additional information is available at <<http://www.restoresjr.net/>>.

4.1.3.6 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 with and without changes to the environment that may occur as the result of current planning efforts such as the BDCP.

4.1.3.7 North Delta Flood Control and Ecosystem Restoration Project

Under the North Delta Flood Control and Ecosystem Restoration Project, DWR would implement flood-control improvements in the northeast Delta in a manner that would benefit aquatic and terrestrial habitats, species, and ecological processes. The North Delta project area includes the North and South Fork Mokelumne Rivers and adjacent channels downstream of Interstate 5 (I-5)

and upstream of the San Joaquin River. Although this is only a planning study, it represents a potential “blueprint” for restoration of riparian floodplain and tidal wetlands habitat along the lower Mokelumne and Cosumnes Rivers. Project elements include bridge replacement, setback levees, dredging, island bypass systems, island detention systems, and ecosystem restoration. The final EIR was prepared in 2010.

4.1.3.8 City of Stockton Delta Water Supply Project

In 2012, the City of Stockton completed construction on the Delta Water Supply Project, which diverts water from the Delta for use as a supplemental water supply for the Stockton Metropolitan Area. The finished project replaces declining surface water resources, protects groundwater supplies, and provides for current and future water needs. Water from the San Joaquin River is pumped through miles of underground pipeline to a new state-of-the-art surface water treatment plant. The water is treated to the highest drinking water standards and distributed to Stockton residents and businesses. The initial phase of the project allows 30 MGD of water to be treated and delivered, therefore meeting approximately one-third of Stockton’s water needs. At final buildout (estimated in 2050), the water treatment plant will have the capacity to treat up to 160 MGD. (<http://deltawatersupplyproject.com/index.htm>)

4.1.3.9 Inter-Regional Conjunctive Use Projects

San Joaquin County has initiated planning efforts for the Integrated Conjunctive Use Program (ICUP). The project would address San Joaquin County’s (SJC) groundwater basin overdraft concerns. It would include new groundwater storage and extraction facilities, and would use existing water supply features (such as reservoirs and conveyance pipelines) on the Mokelumne River. Stored groundwater also would provide conjunctive use opportunities for water agencies during drought periods. A 2004 Reconnaissance Study suggested that an intake be constructed at Pardee or Camanche to capture flood flows at a proposed off-stream reservoir (Duck Creek Reservoir). Water would then be sent to aquifer storage and recovery facilities. It is anticipated that such a project would provide water supply benefits under all hydrologic scenarios (from wet years through dry years). This proposal has the potential to impact Mokelumne River fisheries and EBMUD’s water supply operations. CEQA documentation on the proposed project will need to be completed and potentially significant impacts would have to be addressed.

Similarly, initial planning of an inter-regional conjunctive use project (IRCUP) involving a broader range of entities has been proposed in the past, primarily as spearheaded through the Mokelumne River Forum, a consortium of local and regional agencies and stakeholders of the Mokelumne River. The IRCUP was seen as a means to not simply address the water supply needs of San Joaquin County, but also the needs of other water agencies that rely on the Mokelumne River for all or a portion of their water supply. Potential IRCUP components included proposed new groundwater banking facilities, use of existing conveyance and reservoir systems, and water rights elements. The IRCUP efforts have yet to move past the initial planning stage due to various institutional and political barriers. It is anticipated, however, that if these efforts move forward, they will be undertaken without resulting in any additional impacts to Mokelumne River fisheries.

At present, the Northeast San Joaquin County Groundwater Banking Authority (GBA) together with the Upper Mokelumne River Watershed Authority (UMRWA) are embarking upon a feasibility study to determine if there are opportunities to jointly develop projects or programs along the Mokelumne Watershed that offer water supply as well as environmental benefits. That feasibility study, termed

the Mokelumne Watershed Interregional Sustainability Evaluation Program (MokeWISE), will commence in the spring of 2013 and be completed by the spring of 2015.

4.2 Cumulative Impact Analysis

Cumulative effects were evaluated using the same techniques that were used for evaluating effects of the Project in Chapter 3, Impacts and Mitigation Measures. As described in Section 3.1, Water Resources, hydrologic and water quality effects were evaluated quantitatively using EBMUDSIM, SSTEMP, statistical regressions, and DAYFLOW data for the Delta. The primary difference between the simulations for the cumulative conditions and the project conditions is that the cumulative conditions includes increased senior water rights diversions upstream of Pardee Reservoir and dry-year supplemental supplies identified in WSMP 2040 for EBMUD. Some potential future projects, however, could not be evaluated quantitatively because of uncertainty and a lack of quantitative detail. Cumulative effects of these projects were assessed qualitatively.

Increased water use upstream of Pardee Reservoir would have various downstream effects. Under cumulative conditions, flow into Pardee Reservoir would be reduced by 20,000 AFY compared to the Project. The increased upstream demand under cumulative conditions had the effect of triggering the use of supplemental supplies via FRWP facilities for 8 additional years out of the 89-year simulation period compared to baseline conditions, and 7 additional years compared to project conditions.

Under cumulative conditions, water use by North San Joaquin Water Conservation District (NSJWCD), a junior water rights holder, would be reduced in some years (compared to both the baseline and project scenarios).

This cumulative analysis also assumes that by 2020, Jackson Valley Irrigation District (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 as with project conditions (see Section 3.4, Agricultural Resources). However, should JVID continue to divert the full 3,850 acre-feet at Pardee Reservoir through year 2040, there could be intermittent limitations as a result of low water surface elevations at Pardee Reservoir under cumulative conditions. To ensure that JVID could continue to divert its senior water right at Pardee when it is available under its water right priority, EBMUD will work with JVID on the installation of a submersible pump in Pardee Reservoir for JVID to divert water into its diversion facility and pipeline, as described in Section 3.4.3.3.

Under cumulative conditions, water use by the Woodbridge Irrigation District (WID) generally would remain the same as under existing or baseline conditions. However, there would be some years (5 years in the 89-year simulation period) when increased diversions upstream of Pardee Reservoir would reduce Pardee inflow to such a degree as to curtail the WID allotment.

This EIR analyzes cumulative impacts on the following resource areas:

- water resources (hydrology, water supply, and water quality);
- fish resources,
- vegetation, wetland, and wildlife resources;
- agricultural resources;

- recreational resources; and
- visual resources.

The cumulative impacts of climate change and greenhouse gas emissions are discussed in Chapter 7, Climate Change. For the following resource areas, EBMUD, as lead agency, determined that the Project would not contribute to adverse cumulative impacts on the following resources:

- air quality,
- cultural resources,
- geology and soils,
- hazards and hazardous materials,
- land use and planning,
- mineral resources,
- noise,
- population and housing,
- public services,
- transportation and traffic, and
- utilities and service systems.

Chapter 3, Impacts and Mitigation Measures, explains why the resources listed above are not analyzed in this EIR and, as a result, these resources are not analyzed in the following cumulative impact discussion.

4.2.1 Water Resources

This section describes cumulative hydrologic conditions based on results from the cumulative EBMUDSIM simulation and other considerations. EBMUDSIM hydrologic results for the cumulative conditions are summarized here and are presented in more detail in the following appendices:

- Appendix H.2: Joint Settlement Agreement Year Type Classifications as Simulated by EBMUDSIM.
- Appendix H.3: Evaluation of when End-of-Month Camanche Elevation Falls below 190 Feet.
- Appendix N: Monthly Graphs of Baseline and Cumulative EBMUDSIM Results for Pardee Reservoir Storage, Camanche Reservoir Storage, Camanche Release Flows, and Flows below Woodbridge.
- Appendix O: Comparison of Baseline and Cumulative EBMUDSIM Results as Illustrated with Percentile Plots and Tables.
- Appendix P: Allocations to the North San Joaquin Water Conservation District under Baseline and Cumulative Conditions.

Cumulative impacts on reservoir storage, Camanche releases and flows in the lower Mokelumne River, water temperature, groundwater recharge, reduced flooding, Delta water quality, and Delta

exports are described in the following sections. Potential impacts associated with a reduction in water available for the NSJWCD are discussed below under agricultural resources.

4.2.1.1 Reservoir Storage

Future increases in upstream demand are likely to reduce the amount of water stored in Pardee and Camanche Reservoirs. As discussed in Section 3.1, Water Resources, when the water surface elevation in Camanche Reservoir falls below 190 feet during the months of March through October, it is possible that the temperature of water released from the reservoir could rise.

The Project was estimated by EBMUDSIM to have a minimal effect on the number of months when the Camanche elevation would fall below 190 feet (Section 3.1, Water Resources). For the months of March through October, each month had no more than 2 additional years when storage fell below 190 feet with the Project (e.g., for the month of April there was a 2.2% greater occurrence of months with low storage between baseline and project conditions out of the 89-year simulation period) (Table 4-1).

The number of low storage months for the cumulative conditions occurred up to four additional times for each of the months of March through October during the 89-year simulation period compared to baseline conditions (e.g., for the month of August there was a 10% greater occurrence of low storage between baseline and cumulative conditions) (Table 4-1).

Potential impacts associated with the increase in the number of months with low reservoir storage under the cumulative conditions are discussed below under fish resources. In addition, potential effects associated with lower reservoir water surface elevations are discussed below for vegetation, wetland, and wildlife resources; agricultural resources; recreational resources; and visual resources.

Table 4-1. Effect of Cumulative Conditions on Camanche Elevation Occurring Less than 190 Feet^a

Month	Baseline		Permit 10478 Time Extension Project		Cumulative		Increase (Cumulative vs. Baseline)	
	Years	Percent (%)	Years	Percent (%)	Years	Percent (%)	Years	Percent (%)
March	9	10.1	10	11.2	9	10.1	0	0
April	8	9.0	10	11.2	9	10.1	1	12.5
May	8	9.0	9	10.1	7	7.9	0	0
June	8	9.0	9	10.1	8	9.0	0	0
July	9	10.1	10	11.2	9	10.1	0	0
August	10	11.2	10	11.2	11	12.4	1	10.0
September	10	11.2	10	11.2	11	12.4	1	10.0
October	9	10.1	9	10.1	10	11.2	1	11.1

^a Provided both as the number of years when these conditions would occur and percent occurrence out of the 89-year EBMUDSIM simulation period.

4.2.1.2 Camanche Release and Flow in the Lower Mokelumne River

The increased upstream demand of the cumulative conditions, which lessens flow into Pardee Reservoir, results in a reduction in Camanche Reservoir releases. Average release flows for the entire 89-year EBMUDSIM simulation were 645 cfs for the baseline conditions and 611 cfs for the

cumulative conditions, an overall average reduction in flow of 5.3%. Based on the EBMUDSIM results, approximately half of this reduction, 3.2%, would be caused by the Project. Average flows at Woodbridge for the entire 89-year EBMUDSIM simulation were 450 cfs for the baseline conditions and 418 cfs for the cumulative conditions, an overall average reduction in flow of 7.1%. Based on the EBMUDSIM results, approximately half of this reduction, 4.3%, would be caused by the Project. The reductions in Mokelumne River flows are not spread evenly over all months and years (Table 4-2; Appendix Q).

Potential impacts associated with a cumulative reduction in Mokelumne River flow are discussed below under fish resources; vegetation, wetland, and wildlife resources; agricultural resources; recreational resources; and visual resources.

Table 4-2. Percent Reductions in Average Lower Mokelumne River Flows Associated with the Permit 10478 Time Extension Project and Cumulative Conditions Compared to Baseline Conditions, as Simulated with EBMUDSIM

Month	Camanche Release		Flow below Woodbridge Dam	
	Reduction between Baseline and Project (%)	Reduction between Baseline and Cumulative (%)	Reduction between Baseline and Project (%)	Reduction between Baseline and Cumulative (%)
January	0.7	3.2	0.6	3.3
February	6.2	7.4	6.8	7.9
March	3.1	4.8	3.6	5.7
April	1.3	1.7	1.6	2.9
May	2.9	4.8	3.6	6.5
June	2.9	5.1	4.3	8
July	3.8	6.9	7.9	14.6
August	4.1	7.5	8.2	15.1
September	4.9	9	8.2	15.2
October	2.7	2.3	4.3	2
November	2.8	4.7	3.2	5.3
December	3.1	4.2	3.5	4.6
Annual	3.2	5.1	4.3	7.6

4.2.1.3 Water Temperature

The increase in the number of months when Camanche storage is below 190 feet mean sea level (msl) (Table 4-1) is indicative of the number of months when Camanche release temperatures could become elevated. In addition, the flow reductions simulated for the cumulative conditions (Table 4-2) likely would cause temperatures to increase at locations downstream of Camanche Reservoir, with flow effects on water temperature increasing with distance from Camanche Dam when the river is warming downstream of Camanche Dam (April through October). The cumulative temperature effects likely would be a combination of greater increases in temperature and more frequent increases in temperature compared to baseline conditions.

Potential impacts associated with cumulative increases in water temperature are discussed below under fish resources.

4.2.1.4 Groundwater Recharge

Under cumulative conditions, withdrawals from the groundwater aquifer beneath the Mokelumne River would continue and potentially increase as demand in the area increases. A reduction in groundwater supply is considered to be a potentially significant cumulative impact, although implementation of projects like IRCUP could eliminate this impact.

As described in Section 3.1, Water Resources, a decrease in Mokelumne River flow has by itself a potential to cause only small decreases in groundwater recharge. Under cumulative conditions, the reduction in flow would be somewhat greater, thereby potentially causing slightly greater reductions in groundwater recharge. However, a cumulative lowering of the water table could cause the opposite effect by increasing seepage from the Mokelumne River and requiring higher releases from Camanche Reservoir to meet downstream requirements. As groundwater levels drop, the amount of water seeping from the Mokelumne River to groundwater could increase despite slight reductions in Mokelumne River flow into Pardee Reservoir resulting from increased upstream diversions. Because there is potential for groundwater recharge from the river to increase rather than decrease under cumulative conditions, the cumulative impact on groundwater recharge would be *less than significant*. Because there would be no cumulative impact associated with groundwater recharge, the contribution of the Project would not be considerable. No mitigation is necessary.

4.2.1.5 Reduced Flooding

Project-related flow reductions in the lower Mokelumne River have the potential to reduce flooding, which would be considered a beneficial effect. As described in Section 3.1, Water Resources, a month with an average flow of 1,900 cfs at Woodbridge Dam is considered to have at least 1 day that could produce floodplain inundation (and potentially flood-related damage) downstream of Woodbridge Dam. For the 89-year hydrologic period evaluated by EBMUDSIM (1921 through 2009), the number of months simulated to have average flow exceeding 1,900 cfs was 43 months for the baseline scenario, 41 months for the Project, and 42 months for the cumulative scenario. Based on the EBMUDSIM modeling, there would be no difference between the project and cumulative effects on flooding. Under cumulative conditions, however, a conjunctive use project (recharge groundwater with flood water) such as IRCUP could potentially reduce flooding. Reduction in floodflows is considered to be a *less-than-significant* cumulative impact because the effect would be small and beneficial. Because there would be no cumulative impact associated with reduced floodflows, the contribution of the Project would not be considerable. No mitigation is necessary.

Floodplain inundation is generally beneficial for fish and vegetation resources and is, therefore, evaluated from a different perspective below in the sections for fish and vegetation resources.

4.2.1.6 Water Quality in the Delta

If flow in the Mokelumne River at Woodbridge is reduced, there is some potential for water quality in the Delta to be affected by small water temperature increases and reduced dilution of pollutants present in the Delta. However, this cumulative impact is considered *less than significant* for the following reasons:

1. Numerous regulations are in place to protect water quality in the Delta (e.g., X2 regulations, Delta salinity standards, wastewater treatment plant discharge requirements, and Total Maximum Daily Load [TMDL] limits); therefore, water quality conditions in the Delta are not likely to worsen in the future.

- Although flow in the Mokelumne River would be slightly reduced under the cumulative scenario, this reduction would be minimal compared to the total Delta inflow and would be unlikely to cause water quality in the Delta to fall below water quality thresholds (Table 4-3).

Table 4-3. Estimated Potential Effect of Mokelumne River Cumulative Conditions on Delta Inflow

Distribution of Historic Mokelumne River Inflow to Delta as Percent (%) of Total Delta Inflow (DAYFLOW data for 1970–2009)													
Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
Minimum	0.08	0.08	0.02	0.05	0.10	0.08	0.10	0.07	0.07	0.04	0.24	0.23	0.10
5th	0.18	0.17	0.12	0.12	0.14	0.12	0.11	0.10	0.13	0.22	0.29	0.31	0.17
10th	0.30	0.24	0.15	0.14	0.22	0.20	0.16	0.17	0.23	0.45	0.47	0.35	0.26
50th	1.02	0.84	0.78	1.13	1.36	1.47	0.88	0.39	0.55	1.38	1.72	1.05	1.05
90th	1.94	2.12	2.64	2.98	3.40	4.67	3.95	2.98	2.60	3.57	2.98	1.98	2.98
95th	2.03	2.21	2.89	3.22	4.50	4.86	4.48	3.81	2.92	4.31	3.66	2.20	3.42
Maximum	2.37	3.53	3.90	4.95	6.01	6.06	5.91	4.43	4.04	4.71	3.87	2.64	4.37
Estimated Percent (%) Reduction in Total Delta Inflow Associated with Project Conditions for 1970–2009 Simulation ^a													
Minimum	-0.01	0.00	0.00	-0.02	0.00	0.00	0.00	0.00	0.00	-0.02	-0.02	-0.20	-0.02
5th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	-0.02	-0.02	-0.01
10th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	0.00
50th	0.00	0.00	0.00	0.00	0.02	0.02	0.04	0.05	0.06	0.00	0.00	0.00	0.02
90th	0.06	0.13	0.05	0.11	0.21	0.40	0.24	0.22	0.21	0.02	0.13	0.07	0.15
95th	0.15	0.46	0.08	0.28	0.42	0.55	0.42	0.51	0.65	0.26	0.26	0.09	0.34
Maximum	0.63	0.89	0.19	0.66	1.67	0.63	0.60	0.57	0.72	0.89	0.71	0.65	0.74
Estimated Percent (%) Reduction in Total Delta Inflow Associated with Cumulative Conditions for 1970–2009 Simulation ^a													
Minimum	-0.16	-0.31	-0.06	-0.01	0.00	0.00	0.00	0.00	0.00	-0.34	-0.05	-0.03	-0.08
5th	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.05	-0.03	-0.02	-0.01
10th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.03	-0.01	-0.01	0.00
50th	0.00	0.00	0.01	0.00	0.05	0.09	0.17	0.20	0.19	0.00	0.00	0.00	0.06
90th	0.13	0.24	0.09	0.11	0.44	0.44	0.41	0.44	0.44	0.01	0.25	0.15	0.26
95th	0.34	0.67	0.11	0.14	0.49	0.60	0.43	0.49	0.46	0.22	0.69	0.21	0.40
Maximum	0.63	1.50	0.26	0.34	0.68	0.89	0.54	0.51	0.65	0.89	0.71	1.60	0.77

^a This analysis is an estimate of how the historic values might have changed under the Permit 10478 Time Extension Project or cumulative conditions based on the EBMUDSIM simulations. As a result, the analysis is limited to the period after the major Central Valley Project and State Water Project facilities were constructed, 1970–2009.

Potential effects of cumulative changes in Mokelumne River flow on saltwater intrusion (from reduced Delta outflow) were evaluated using the same approach that was used in Section 3.1, Water Resources (Table 3.1-7). The flow reductions under the cumulative conditions were subtracted from estimated historical Delta outflow to estimate the maximum possible effect of the cumulative conditions on Delta outflow. The estimated maximum effect of the cumulative conditions on Delta outflow was translated into a salinity effect by estimating the position of X2 (the Delta location where water has a salinity of 2 parts per thousand [ppt]) as a function of Delta outflow. X2 frequently is used to assess the occurrence of freshwater habitat in the Delta.

The estimated maximum potential effect of the cumulative reduction in Mokelumne River flow on monthly average X2 position (i.e., assuming no compensatory reduction in exports or diversions

from the Delta) ranged from a slight decrease to a rare increase of up to 0.33 kilometer (km) (Table 4-4).

The median effect of the Mokelumne River cumulative scenario on X2 for each month was equal to or very close to zero (with an increase of up to 0.04 km in August) (Table 4-4). While this Mokelumne River effect would be small, Delta water quality and X2 could also be affected by reductions in Delta inflow from future projects and increased diversions along other Delta tributaries. However, existing regulations to protect water quality in the Delta would be expected to minimize these impacts. Therefore, the cumulative effect on water quality in the Delta is considered to be *less than significant*. Furthermore, because the Project would contribute very little to any water quality effects in the Delta (see Section 3.1, Water Resources), the contribution of the Project would not be considerable. No mitigation is necessary.

Table 4-4. Estimated Maximum Potential Effect of Mokelumne River Cumulative Conditions on X2 Position^a

X2 Position (kilometers) for 1970–2009 Historical Record													
Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
Minimum	46.51	44.81	40.89	44.14	48.18	51.74	56.19	63.70	63.91	62.85	60.31	50.48	52.81
5th	50.30	46.86	46.93	47.59	49.65	54.98	61.45	70.92	68.99	69.26	67.04	56.99	57.58
10th	53.44	50.67	49.69	49.28	52.94	59.82	69.10	74.51	70.53	71.57	69.78	60.45	60.98
50th	69.30	64.57	62.53	67.40	72.32	76.92	81.55	82.51	84.43	85.21	83.95	78.61	75.77
90th	83.10	84.23	77.70	80.93	85.26	87.47	88.62	90.08	92.94	91.85	89.31	85.90	86.45
95th	86.12	85.12	87.87	82.98	87.03	88.12	90.08	91.22	93.68	93.56	89.57	86.73	88.51
Maximum	87.08	90.88	91.65	91.47	90.44	93.29	91.77	91.81	96.96	94.73	91.00	89.19	91.69
Potential Project-Related Increase in X2 (kilometers) for 1970–2009 Simulation ^b													
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	0.00
5th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50th	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
90th	0.02	0.03	0.02	0.02	0.03	0.07	0.08	0.07	0.09	0.09	0.04	0.03	0.05
95th	0.03	0.04	0.03	0.03	0.04	0.10	0.15	0.17	0.25	0.20	0.14	0.07	0.10
Maximum	0.24	0.25	0.14	0.11	0.37	0.19	0.17	0.22	0.35	0.23	0.31	0.32	0.24
Potential Mokelumne River Cumulative Increase in X2 (kilometers) for 1970–2009 Simulation ^a													
Minimum	-0.02	-0.07	-0.03	-0.01	0.00	0.00	0.00	0.00	0.00	-0.07	-0.05	-0.01	-0.02
5th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	0.00
10th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50th	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.04	0.03	0.02	0.00	0.00	0.01
90th	0.03	0.04	0.03	0.03	0.04	0.10	0.13	0.15	0.17	0.10	0.05	0.06	0.08
95th	0.06	0.10	0.06	0.03	0.05	0.11	0.17	0.17	0.21	0.15	0.19	0.09	0.11
Maximum	0.24	0.25	0.14	0.05	0.06	0.17	0.25	0.22	0.26	0.23	0.31	0.33	0.21

^a Data assumes no compensatory reduction in exports or diversions from the Delta.

^b This analysis is an estimate of how the historic values might have changed under the Project or cumulative conditions based on the EBMUDSIM simulations. As a result, the analysis is limited to the period after the major Central Valley Project and State Water Project facilities were constructed, 1970–2009.

4.2.1.7 Delta Exports

Future increased diversions upstream of Pardee Reservoir are likely to cause a small reduction in Delta inflow. Because Delta regulations protect water quality and fish (outflow objectives), reductions in Delta inflow could impact Delta exports made by the CVP and SWP in some months. Because there are multiple regulatory constraints that limit Delta exports, the effect on Delta exports of a reduction in inflow would depend on which parameter is limiting the exports. If exports are limited by reverse flow in Old and Middle Rivers, then a change in Mokelumne River inflow will not change exports. However, if exports are controlled by Delta outflow, the export to inflow ratio, or the X2 position, then a reduction in inflow would potentially impact exports.

Because the amount of inflow that the Mokelumne River contributes to total Delta inflow is very small (median monthly contribution of 1.05%) (Table 4-3), the cumulative impact of a reduction in Delta exports resulting from reduced Mokelumne flow would be minimal. Under project conditions, the change in the median monthly inflow would be 0.02%. Under the Mokelumne River cumulative scenario, the change in total Delta inflow is also small; the median monthly decrease in total Delta inflow would be 0.06% (Table 4-3). When other actions that might affect the Delta inflows and outflow requirements are considered, a reduction in Delta exports for south-of-Delta water users could be a potentially significant cumulative impact. The contribution of the Project to this impact, however, would not be cumulatively considerable (as explained above) and, therefore, would be *less than significant*. No mitigation is necessary.

4.2.2 Fish Resources

This section describes cumulative conditions for fish resources based on results from the cumulative EBMUDSIM hydrologic simulation and other considerations described above under water resources. EBMUDSIM results for analyzing cumulative impacts on fish resources are summarized below and are presented in more detail in the following appendices:

- Appendix G: Monthly Graphs of Baseline and Permit 10478 Time Extension Project EBMUDSIM Results for Pardee Reservoir Storage, Camanche Reservoir Storage, Camanche Release Flows, and Flows below Woodbridge.
- Appendix H.1: Comparison of Baseline and Permit 10478 Time Extension Project EBMUDSIM Results as Illustrated with Percentile Plots and Tables.
- Appendix N: Monthly Graphs of Baseline and Cumulative EBMUDSIM Results for Pardee Reservoir Storage, Camanche Reservoir Storage, Camanche Release Flows, and Flows below Woodbridge.
- Appendix O: Comparison of Baseline and Cumulative EBMUDSIM Results as Illustrated with Percentile Plots and Tables.

Cumulative impacts on fish in Pardee and Camanche Reservoirs, the lower Mokelumne River, and the Delta and estuary are described in the following sections. Cumulative impacts were evaluated using the same assessment methods that were described in Sections 3.2.3.3 and 3.2.3.4 in Section 3.2, Fish Resources.

4.2.2.1 Lower Mokelumne River

Projected cumulative increases in water demands could affect fish resources through changes in reservoir inflows, storage, and releases to the lower Mokelumne River (i.e., lower Mokelumne River flow). Changes in lower Mokelumne River water quality and water temperature could also affect fish resources. These effects are described in the following sections.

Flow

Cumulative effects on the magnitude and frequency of Mokelumne River 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 simulated baseline and cumulative conditions. On average, cumulative conditions result in an annual reduction in flow below Camanche Dam of about 5.1% and about 7.6% below Woodbridge Dam (Table 4-2).

Adult Salmonid Migration

Based on the threshold flows that may impede upstream migration of adult salmon and steelhead in the lower Mokelumne River, cumulative impacts on migration of fall-run Chinook salmon may occur 18% more frequently during the September through December migration period (Table 4-5). Under cumulative conditions, steelhead migration may be impaired 24% more frequently during the September through February migration period. Because increases in the frequency of flows that potentially impede migration could adversely affect overall production of Chinook salmon and steelhead, this cumulative impact is considerable. Implementing Mitigation Measure FISH-1, presented in Section 3.2, Fish Resources, would reduce the Project's contribution to this cumulatively significant impact to *less-than-significant* levels.

Table 4-5. 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)

	Baseline Conditions					Cumulative Conditions				
	Normal	Below Normal	Dry	Critical	Total	Normal	Below Normal	Dry	Critical	Total
September	0	9	23	10	42	1	13	23	10	47
October	0	0	0	6	6	0	0	0	8	8
November	0	0	0	6	6	0	0	0	8	8
December	0	0	0	6	6	0	0	0	8	8
January	0	0	1	6	7	0	0	1	8	9
February	0	0	0	5	5	0	0	1	7	8

Salmonid Spawning and Rearing Habitat

As described under Section 3.2.3.3 in Section 3.2, Fish Resources, potential project impacts on salmon and steelhead spawning and rearing habitat was evaluated using the flow-habitat relationships developed by DFW under 1986-1987 channel conditions (California Department of Fish and Game 1991). The assessment was based on predicted changes in Weighted Usable Area (WUA) as a function of flow.

Figure 4-1 (fall-run Chinook salmon) and Figure 4-2 (steelhead) depict the monthly WUA values for baseline and cumulative conditions (values simulated using hydrologic conditions for 1921 through 2009). The summary provides the central (median), spread (first and third quartiles), and range (minimum and maximum values) of the modeled values. Also shown are the maximum values (California Department of Fish and Game 1991) for the various life stages (dashed horizontal line). The months used for the fall-run Chinook evaluation were October through March for spawning and incubation, January through April for fry rearing, and January through June for juvenile rearing. For steelhead, the months used for the evaluation were December through May for spawning and incubation, February through June for fry rearing, and year-round for juvenile rearing.

Cumulative conditions are anticipated to result in minor decreases in fall-run Chinook salmon and steelhead spawning and incubation WUA and minor increases in Chinook salmon and steelhead fry and juvenile rearing WUA, as summarized in Table 4-6. Therefore, cumulative impacts on spawning and rearing habitat are considered *less than significant*. Because there would be no cumulative impact on salmonid spawning and rearing habitat, the contribution of the Project would not be considerable. No mitigation is necessary.

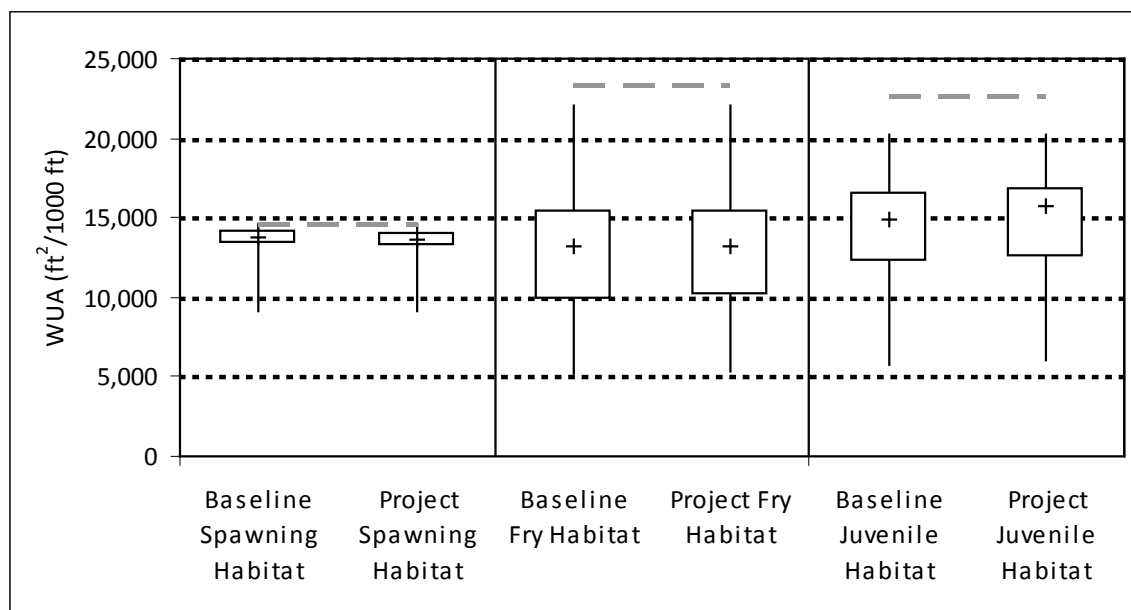


Figure 4-1
Summary of Modeled Annual Fall-run Chinook Salmon WUA in the
Lower Mokelumne River (1921–2009 Hydrology)

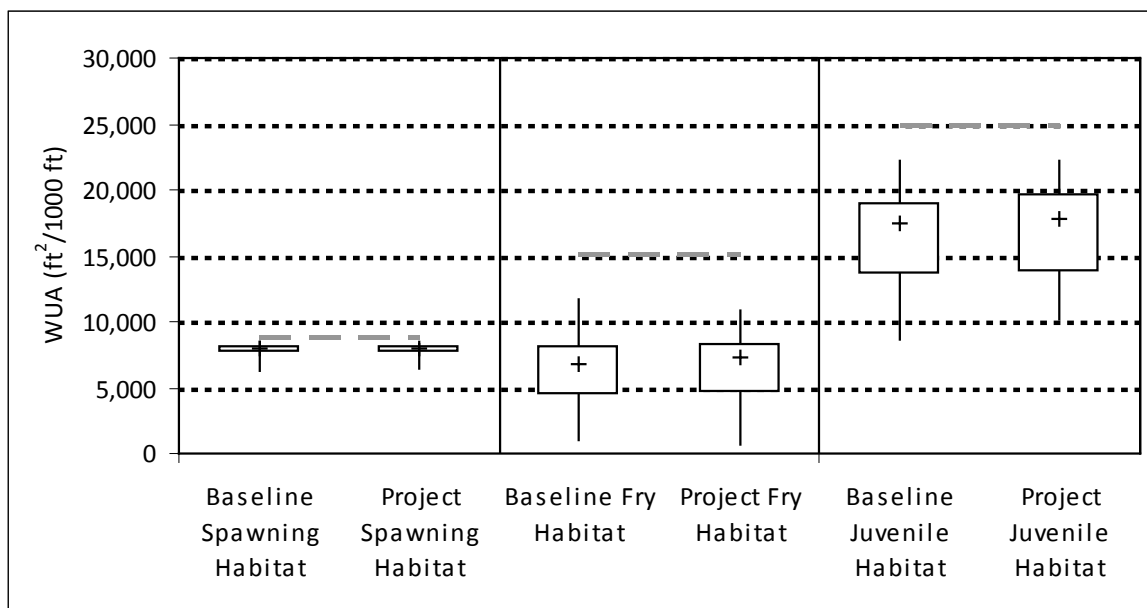


Figure 4-2
Summary of Modeled Annual Steelhead WUA in the
Lower Mokelumne River (1921–2009 Hydrology)

Table 4-6. Average Annual WUA (ft²/1000 ft of river) and Percent Change for Salmonid Life Stages Based on JSA Year Type

	Spawning and Incubation			Fry Rearing			Juvenile Rearing		
	Baseline	Cumulative	Percent	Baseline	Cumulative	Percent	Baseline	Cumulative	Percent
Fall-Run Chinook Salmon									
Normal	7,866	7,464	-5.1	4,746	4,805	-3.5	4,756	4,601	-3.3
Below Normal	2,908	2,371	-18.5	3,177	2,829	-13.5	3,651	3,352	-8.2
Dry	1,923	2,491	29.6	2,832	3,614	22.5	4,176	4,642	11.2
Critical	698	953	36.5	1,767	2,360	25.3	2,199	2,479	12.7
Total	13,395	13,279	-0.9	12,522	13,609	4.0	14,782	15,074	2.0
Steelhead									
Normal	3,290	3,157	-4.0	1,798	1,747	-2.8	5,675	5,479	-3.5
Below Normal	2,074	1,824	-12.2	1,588	1,530	-3.7	4,234	4,019	-5.1
Dry	1,699	1,981	16.6	2,194	2,349	7.0	4,608	5,045	9.5
Critical	699	812	16.2	1,233	1,362	10.4	2,339	2,605	11.3
Total	7,762	7,774	0.2	6,813	6,987	2.5	16,856	17,148	1.7

Salmonid Juvenile Outmigration

As described under Section 3.2.3.3 in Section 3.2, Fish Resources, evaluation of project 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, average flows exceeding 800 cfs occurred in 2 fewer years than under project and baseline conditions (Table 4-7), with a shortfall of 23 cfs with the 1958 hydrology and 125 cfs with the 1973 hydrology. 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 Project would not be considerable. No mitigation is necessary.

Table 4-7. Number of Modeled Years When Flows below Camanche Dam May Influence Juvenile Fall-run Chinook Salmon Outmigration Based on JSA Year Type (when Average flow during January through March Exceeds 800 cfs)

	Baseline Conditions	Cumulative Conditions
Norm	17	16
Below Normal	4	5
Dry	3	1
Critical	0	0
Total	24	22

DFG (1991) indicated that in normal water years, a flow of 350 cfs in March, 400 cfs in April, 450 cfs in May, and 400 cfs in June below Woodbridge Dam would facilitate the outmigration of young salmonids to the Delta. Flows below Woodbridge Dam were modeled for 1921 through 2009 hydrology under baseline and cumulative conditions. Compared to baseline conditions, cumulative conditions would reduce flows below DFW's recommended flows in 3 years in March, 1 year in April, and 5 years in May and June (Table 4-8). Because the reduced flows would occur so infrequently (4%), cumulative impacts on outmigration are considered *less than significant*. Because there would be no cumulative impact on the outmigration of young salmonids to the Delta, the contribution of the Project would not be considerable. No mitigation is necessary.

Table 4-8. Number of Modeled Years when Flows below Woodbridge Dam May Impede Juvenile Salmonid Migration Based on JSA Year Type

	March (350 cfs)		April (400 cfs)		May (450 cfs)		June (400 cfs)	
	Baseline	Cumulative	Baseline	Cumulative	Baseline	Cumulative	Baseline	Cumulative
Normal	29	30	13	14	0	2	0	1
Below Normal	13	12	28	28	13	16	12	16
Dry	11	12	23	23	23	23	23	23
Critical	5	7	10	10	10	10	10	10
Total	58	61	74	75	46	51	45	50

Floodplain Habitat

As discussed under Section 3.2.3.3 in Section 3.2, Fish Resources, 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 (see Figure 3.1-5 in Section 3.1, Water Resources). Flows of this magnitude occurred in 5 of the 89 years simulated for baseline, Project, and cumulative conditions (Table 4-9), therefore no impacts are anticipated under cumulative conditions. No mitigation is necessary.

Table 4-9. Number of Modeled Years When Flows below Woodbridge Dam May Support Floodplain Habitat Maintenance Based on JSA Year Type (when Average Monthly Flow for March, April, or May Exceeded 3,000 cfs)

	Baseline Conditions			Cumulative Conditions		
	March	April	May	March	April	May
Normal	1	2	3	1	2	3
Below Normal	0	0	0	0	0	0
Dry	0	0	0	0	0	0
Critical	0	0	0	0	0	0
Total	1	2	3	1	2	3

Note: While the total number months with Woodbridge flow greater than 3,000 cfs during March through May was 6, the total number of years with flow greater than 3,000 cfs during March through May was only 5 for both the baseline and cumulative scenarios, because the year with the 1983 hydrology had flow exceeding 3,000 cfs during both March and May.

Salmonid Spawning Habitat Maintenance

As discussed under Section 3.2.3.3 in Section 3.2, Fish Resources, 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. Both baseline and cumulative conditions would result in 24 years with flows of 2,000 cfs or greater (Table 4-10). Therefor no impact is anticipated. No mitigation is necessary.

Table 4-10. Number of Modeled Years When Flows below Camanche Dam May Support Salmonid Spawning Habitat Maintenance Based on JSA Year Type (when One or More Months of the Year Have Average Flow Exceeding 2,000 cfs)

	Baseline Conditions	Cumulative Conditions
Normal	20	20
Below Normal	4	7
Dry	3	1
Critical	0	0
Total	24 ^a	24 ^a

^a Total differs from sum of water year types because more than one water year type may occur during a calendar year.

4.2.2.2 Pardee and Camanche Reservoirs

Cumulative impacts of the Project 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 reservoir water surface elevations under simulated baseline and cumulative conditions. The assessment methods and criteria for assessing potential habitat effects are described in Section 3.2.3.4 in Section 3.2, Fish Resources.

Warmwater Fish Species

Potential impacts on warmwater fish species were based on the frequency of monthly flow fluctuations exceeding 10.6 inches/day (increase) and 4.3 inches/day (decrease) during the spring and summer spawning and rearing season (March through September). In Pardee reservoir, fluctuations exceeding these thresholds occur about 0.8% of the time under baseline conditions and about 1.3% of the time under cumulative conditions (Table 4-11). In Camanche Reservoir, the frequency of fluctuations exceeding these thresholds is 0.3% under baseline conditions and cumulative conditions (Table 4-11). Because the effects under baseline and cumulative conditions are similar and infrequent, cumulative impacts on warmwater fish species are considered *less than significant*. Because there would be no cumulative impact, the contribution of the Project would not be considerable. No mitigation is necessary.

Table 4-11. Number of Modeled Years When Average Daily Reservoir Fluctuation Exceeds Criteria (+10.6 or -4.3 inches/day) based on JSA Year Type

Month	Baseline Conditions					Cumulative Conditions				
	Normal	Below Normal	Dry	Critical	Total	Normal	Below Normal	Dry	Critical	Total
Pardee Reservoir										
March	0	0	0	1	1	0	0	0	2	2
April	0	0	0	1	1	0	0	0	1	1
May	0	0	0	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0
August	0	0	0	1	1	0	0	0	2	2
September	1	0	0	1	2	1	0	0	2	3
Camanche Reservoir										
March	0	0	0	0	0	0	0	0	0	0
April	1	0	0	0	1	1	0	0	0	1
May	1	0	0	0	1	1	0	0	0	1
June	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0	0	0
September	0	0	0	0	0	0	0	0	0	0

Coldwater Fish Species

Potential impacts on coldwater fish species (kokanee and rainbow trout in Pardee Reservoir, and rainbow trout in Camanche Reservoir) were based on the availability of coldwater habitat during the summer and early fall (July through November). In Pardee Reservoir, the minimum depth threshold necessary to provide suitable water temperatures (less than 15°C) was exceeded in 2 consecutive months under baseline conditions and cumulative conditions (October and November 1978) (Table 4-12). In Camanche Reservoir, simulated reservoir depths exceeded the minimum depth threshold necessary to provide suitable water temperatures (less than 18 °C) in 6 consecutive months under baseline conditions (June through November 1978) and 7 months under cumulative conditions (November 1977 and June through November 1978) (Table 4-12). Because reservoir depths exceeded the criteria only in the fall of 1977 and 1978, and these 2 years were the driest

years of the simulation period, cumulative impacts on coldwater fish species are considered *less than significant*. Because there would be no cumulative impact, the contribution of the Project would not be considerable. No mitigation is necessary.

Table 4-12. Number of Modeled Years When Minimum Coldwater Pool Exceeds Criteria (<18°C in Camanche, <15°C in Pardee) based on JSA Year Type

Month	Baseline Conditions					Cumulative Conditions				
	Normal	Below Normal	Dry	Critical	Total	Normal	Below Normal	Dry	Critical	Total
Pardee Reservoir										
May	0	0	0	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0	0	0
September	0	0	0	0	0	0	0	0	0	0
October	0	0	0	1	1	0	0	0	1	1
November	0	0	0	1	1	0	0	0	1	1
December	0	0	0	0	0	0	0	0	0	0
Camanche Reservoir										
May	0	0	0	0	0	0	0	0	0	0
June	0	0	0	1	1	0	0	0	1	1
July	0	0	0	1	1	0	0	0	1	1
August	0	0	0	1	1	0	0	0	1	1
September	0	0	0	1	1	0	0	0	1	1
October	0	0	0	1	1	0	0	0	1	1
November	0	0	0	1	1	0	0	0	2	2
December	0	0	0	0	0	0	0	0	0	0

4.2.2.3 Water Quality

As discussed under Section 3.2.3.4 in Section 3.2, Fish Resources, dissolved oxygen downstream of Camanche Dam was estimated using simulated values for Camanche Reservoir water surface elevation, release flows, and water temperatures.

Figure 4-3 depicts the monthly dissolved oxygen values for the baseline and cumulative conditions (values simulated using hydrologic conditions for 1921 through 2009). The figure presents the central value (median), spread (first and third quartiles) and range (minimum and maximum values) of the modeled values. Also shown are the EPA criteria for dissolved oxygen concentrations (dotted horizontal line = slight impairment, dashed horizontal line = moderate impairment, solid horizontal line = severe impairment). Spawning and incubation months (October through March for fall-run Chinook and December through May for steelhead) were assessed differently from the rest of the year because of the higher dissolved oxygen requirements for this life stage.

Cumulative conditions would cause almost no change to the frequency of dissolved oxygen levels associated with moderate, slight, and no impairment (U.S. Environmental Protection Agency 1986) relative to baseline conditions (Table 4-13). As discussed under Section 3.2.3.4 in Section 3.2, Fish Resources, no adverse effects on dissolved oxygen, pH, and suspended solids in the lower

Mokelumne River are anticipated under project conditions. Therefore, there would be no cumulative impact on water quality. No mitigation is necessary.

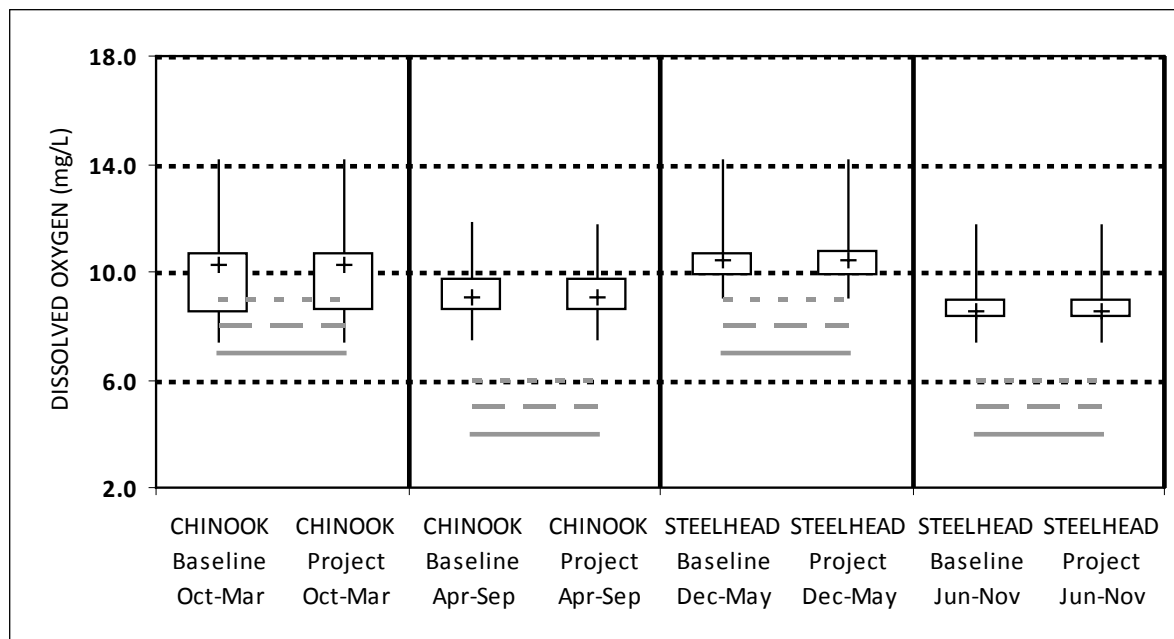


Figure 4-3
Summary of Modeled Monthly Dissolved Oxygen Concentrations in the
Lower Mokelumne River (1921–2009 Hydrology)

Table 4-13. Percent of Modeled Years When Dissolved Oxygen Levels below Camanche Dam May Impact Salmonid Life Stages Based on JSA Year Type

	Severe Impairment		Moderate Impairment		Slight Impairment	
	Baseline	Cumulative	Baseline	Cumulative	Baseline	Cumulative
Fall-Run Chinook Salmon						
Normal	0	0	2.9	2.6	6.5	6.2
Below Normal	0	0	0	0	3.6	3.2
Dry	0	0	0	0	1.9	2.3
Critical	0	0	0.1	0.1	0.5	0.7
Total	0	0	3.0	2.7	12.5	12.4
Steelhead						
Normal	0	0	0	0	0	0
Below Normal	0	0	0	0	0	0
Dry	0	0	0	0	0	0
Critical	0	0	0	0	0	0
Total	0	0	0	0	0	0

Water Temperature

Based on water temperature modeling results and water temperature criteria for fall-run Chinook salmon and steelhead (Table 3.2-16 in Section 3.2, Fish Resources), project conditions had minor effects on the frequency of predicted 7 DADM water temperatures exceeding the EPA criteria for each of the life stages of concern in the lower Mokelumne River.

The percent changes in the frequency of 7-DADM water temperatures exceeding the EPA criteria for each life stage are shown in Table 4-14. Of the modeled months that exceeded the EPA criteria, water temperatures decreased, were unchanged, or increased less than 1°C 95%-100% of the time, depending on salmonid life stage. The months and years when temperature changes exceeded 1°C are shown in Table 4-15.

These results indicate that potential cumulative increases in the frequency of stressful water temperatures are not likely to substantially affect Chinook salmon and steelhead populations in the lower Mokelumne River. Therefore, cumulative impacts on water temperature are considered less than significant. No mitigation is necessary.

Table 4-14. Percent of Time When Water Temperatures Exceed Salmonid Life Stage EPA Criteria Based on JSA Year Type

	Adult Migration		Spawning And Incubation		Juvenile Rearing		Smolting		Emigration	
	Baseline	Cumu-lative	Baseline	Cumu-lative	Baseline	Cumu-lative	Baseline	Cumu-lative	Baseline	Cumu-lative
Fall-Run Chinook Salmon										
Normal	40.9	41.9	50.0	49.5	11.8	13.0	65.5	66.7	0.8	1.3
Below Normal	55.3	57.0	50.0	51.5	29.8	34.1	83.3	84.5	18.4	22.0
Dry	58.1	54.9	57.7	53.1	43.5	40.2	100	100.0	44.4	41.0
Critical	57.1	52.9	58.3	62.5	50.0	46.3	100	100.0	66.7	59.3
Total	48.6	48.9	51.7	51.7	26.4	27.5	83.9	84.6	20.2	21.0
Steelhead										
Normal	26.1	26.7	41.2	41.4	35.2	36.2	45.2	46.2	1.1	1.6
Below Normal	38.2	40.5	56.8	60.3	51.4	54.7	68.9	72.4	21.3	25.0
Dry	40.9	37.9	66.3	59.1	59.7	56.4	75.8	70.3	50.5	47.5
Critical	40.0	36.0	65.9	65.4	62.5	58.3	76.2	71.7	76.2	69.6
Total	32.4	32.6	51.7	51.7	46.9	47.5	61.1	61.1	24.3	25.2

Table 4-15. Modeled Months and Years When Cumulative Condition Water Temperatures Exceed Baseline Water Temperatures by More than 1°C

Year	Month	Year Type	Baseline Temp (°C)	Cumulative Temp (°C)	Cumulative Temp Increase (°C)
ADULT MIGRATION					
1935	SEP	BNORM	19.7	26.9	7.2
1957	SEP	BNORM	20.8	26.2	5.5
2009	SEP	BNORM	21.8	26.9	5.0
2003	SEP	BNORM	21.1	23.2	2.1
1925	SEP	BNORM	19.8	21.4	1.6
1997	SEP	NORM	20.8	22.2	1.4
1929	SEP	DRY	25.5	26.7	1.2
1951	SEP	NORM	20.6	21.8	1.2
1970	SEP	NORM	20.2	21.3	1.1
SPAWNING AND INCUBATION					
1932	MAR	CRIT	12.8	14.4	1.6
1977	MAR	DRY	15.6	17.0	1.4
1977	OCT	CRIT	19.4	20.4	1.1
1988	MAR	DRY	13.0	14.1	1.1
JUVENILE REARING					
1935	JUL	BNORM	18.9	21.6	2.7
1935	AUG	BNORM	19.2	21.6	2.4
1935	SEP	BNORM	18.6	20.4	1.7
2009	JUL	BNORM	20.0	21.7	1.7
2009	AUG	BNORM	20.1	21.6	1.5
1957	JUL	BNORM	19.5	21.0	1.5
1957	AUG	BNORM	19.7	21.1	1.4
2009	SEP	BNORM	19.3	20.4	1.1
1957	SEP	BNORM	19.0	20.0	1.0
EMIGRATION					
1935	JUN	BNORM	18.4	21.1	2.7
1935	MAY	BNORM	16.6	18.6	2.0
1957	JUN	BNORM	19.3	20.7	1.5
2009	JUN	BNORM	19.8	21.1	1.3
1957	MAY	BNORM	17.2	18.3	1.1
1925	JUN	BNORM	18.6	19.6	1.1

4.2.2.4 Sacramento–San Joaquin River Delta and Estuary

Reductions in freshwater inflows to the Sacramento–San Joaquin River estuary and modifications of the seasonal distribution and routing of freshwater flows in the Delta are among the many factors that have contributed to historical declines of native fish populations in the Sacramento–San Joaquin River basin (National Marine Fisheries Service 2009; U.S. Fish and Wildlife Service 2008). The future of the Bay-Delta ecosystem is uncertain although existing and future regulatory requirements and ecosystem recovery actions may limit further environmental degradation and potentially reverse declines in native fish populations. Currently, protective measures outlined in the Reasonable and Prudent Alternatives of the NMFS's (2009) and USFWS's (2008) OCAP biological opinions are expected to improve conditions for Delta fish species. If implemented as currently proposed, the BDCP is expected to provide additional measures that may help conserve native species. However, because of substantial degradation of environmental conditions in the Delta and estuary under current conditions, the increasing demand for water, and uncertain future of the Bay-Delta ecosystem, the cumulative impact of upstream water users on Delta fish resources is potentially *significant*.

As discussed under Section 3.2.3.4, Delta Habitat, in Section 3.2, Fish Resources, potential effects of the Project on Delta inflows would be very small (total inflow would be reduced by less than 0.7% in most years, 95% of time; see Table 4-3), resulting in little or no measurable effect on Delta flows and estuarine habitat conditions. Under cumulative conditions, changes in total inflow would be similar (less than 0.7% in most years) (Table 4-3). These changes are not expected to limit the ability of the CVP, SWP, and other water users to meet current or reasonably foreseeable ecosystem and fish protection measures in the Delta and estuary, including current and potential future restrictions on reverse flows and exports. Therefore, there is no cumulatively significant impact on fish resources in the Sacramento–San Joaquin River estuary. No mitigation is necessary.

4.2.3 Vegetation, Wetland, and Wildlife Resources

Increased demands under cumulative conditions would not result in the cumulative loss of identified sensitive biological resources. This cumulative impact was determined by using the same significance criteria used to assess the Project's effects in Section 3.3, Vegetation, Wetland, and Wildlife Resources.

In addition, project conditions would not have significant direct or indirect cumulative impacts on annual grassland, chaparral, oak woodland, and savanna communities and associated habitat for special-status species because these communities are not affected by changes in reservoir surface water elevation or a reduction of flows in the river.

Cumulative impacts on vegetation, wetland, and wildlife resources at Pardee and Camanche Reservoirs and along the lower Mokelumne River are described in the following sections.

4.2.3.1 Special-Status Plant and Special Natural Communities

Similar to project conditions, cumulative conditions would not have a significant impact on special-status plants caused by reservoir water-surface fluctuations and/or reduced frequency of river maintenance flows compared to baseline conditions because most special-status plants identified in the project area (see Table 3.3-1 in Section 3.3, Vegetation, Wetland, and Wildlife Resources) are found in chaparral, woodland, grassland, seasonal wetland, vernal pool, and slough habitats. These

habitats are not located in areas that would experience changes in water-surface elevations at Pardee or Camanche Reservoirs or changes in the frequency of maintenance flows in the lower Mokelumne River and, therefore, would not be affected under the Project or cumulative conditions. No special-status plants or special natural communities have been documented directly in or adjacent to Pardee and Camanche Reservoirs and none are known to occur along the lower Mokelumne River (see Figure 3.3-1 in Section 3.3, Vegetation, Wetland, and Wildlife Resources). As a result, there would be *no impact* from changes in reservoir water-surface elevations or river flows on special-status plants under cumulative conditions. No mitigation is necessary.

4.2.3.2 Special-Status Wildlife Species

A variety of special-status wildlife species have the potential to occur in the project region (see Table 3.3-2 in Section 3.3, Vegetation, Wetland, and Wildlife Resources), and several special-status wildlife species have been recorded in the project region (Reeves and Smith 2004; Smith 2004; Howell et al. 2011; California Department of Fish and Game 2012b; eBird 2013; Tricolored Blackbird Working Group 2013; Jones pers. comm.). Cumulative conditions could potentially impact special-status wildlife species as a result of habitat modification, specifically riparian and wetland habitat effects resulting from reservoir water-surface fluctuations and flow changes. These potential impacts are described below.

Pardee and Camanche Reservoirs

Cumulative conditions could result in system operations that alter storage and water-surface elevations at Pardee and Camanche Reservoirs. Historically, fluctuations at these reservoirs, in response to day-to-day operations and changes in runoff patterns, affected vegetation that established at or near the water surface and within the drawdown zone. Similarly, vegetation that periodically established in the drawdown zone or near the waters' edge was commonly inundated and lost during prolonged periods of high storage, while plants that established during periods of high storage could be lost during periods of reduced reservoir storage or drought. Compared to baseline conditions, cumulative conditions would result in minor changes in reservoir storage (Figures 4-4 and 4-5). Fluctuations in reservoir water-surface elevation would be similar to those experienced under baseline conditions and vegetation would experience a similar cycle of establishment, inundation, and loss, as water elevations rise and fall seasonally and in response to precipitation and flood-control requirements as compared to baseline conditions. Therefore, cumulative impacts on reservoir vegetation, as well as on special-status wildlife species that inhabit these areas, would be *less than significant*. Because there would be no cumulative impact on wildlife species that inhabit the area immediately surrounding the Pardee and Camanche Reservoirs, no mitigation is necessary.

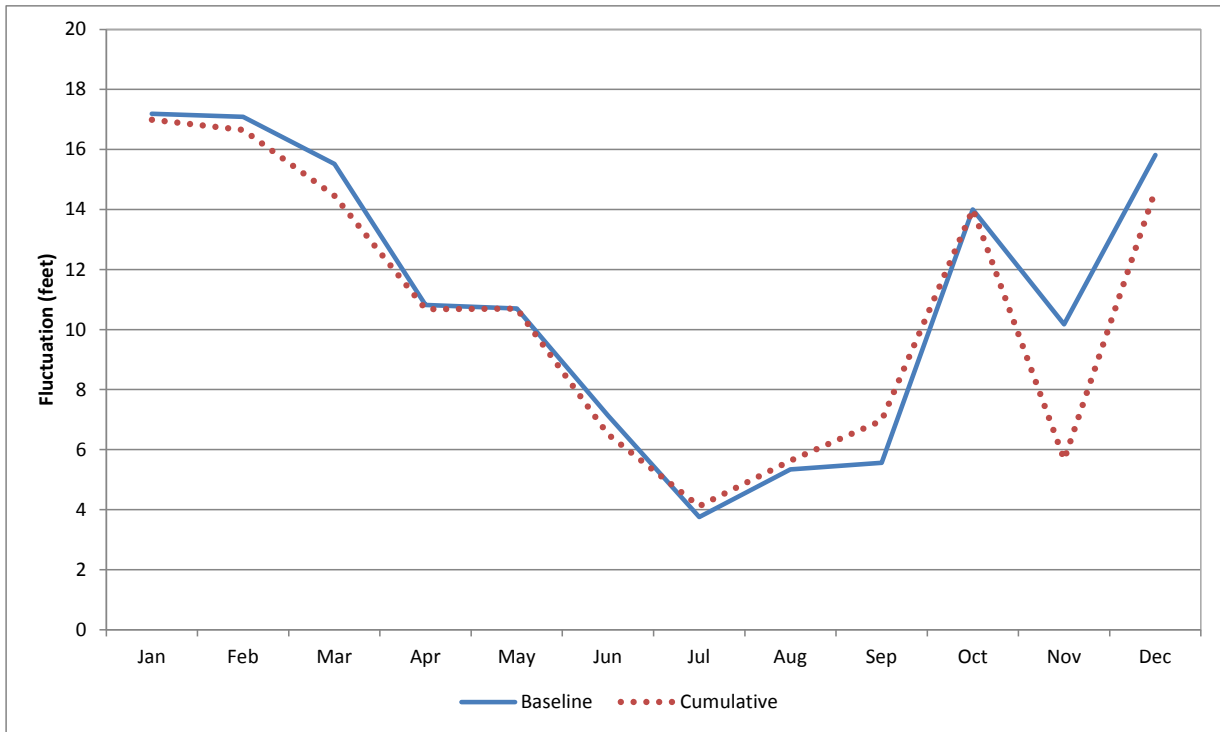


Figure 4-4
Month to Month Fluctuations (95th Percentile of Modeled Years)
in Pardee Reservoir

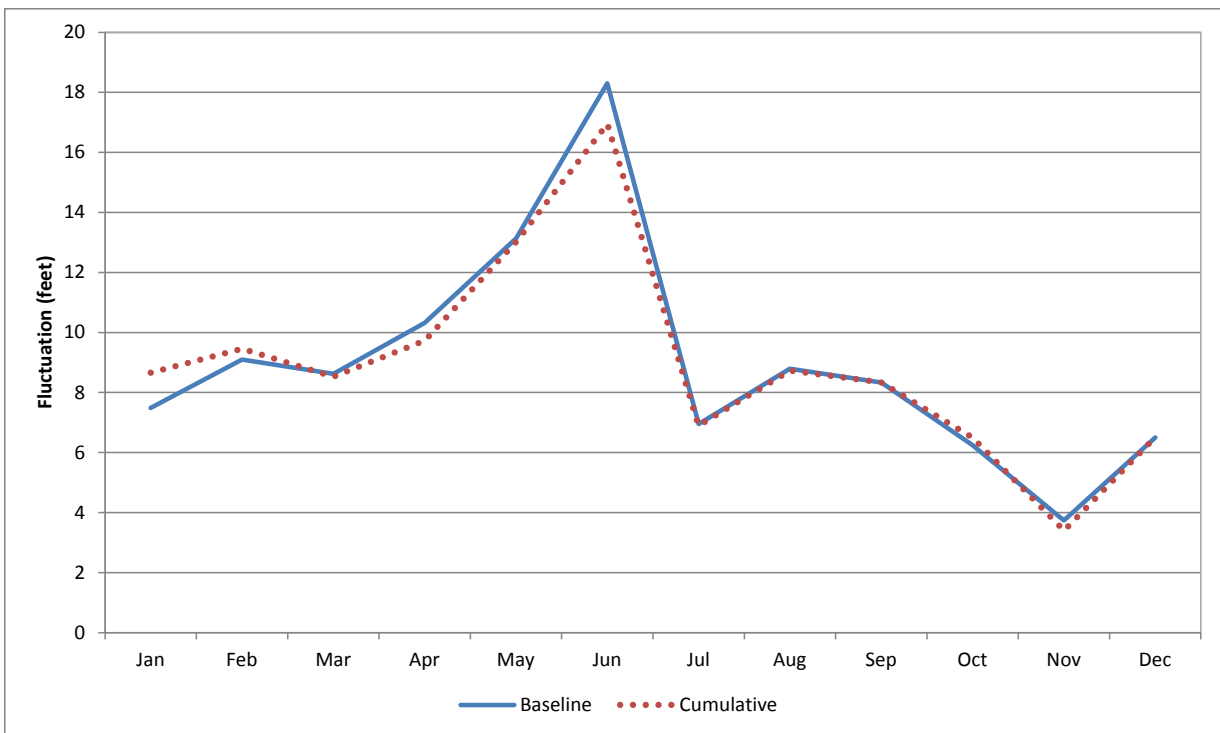


Figure 4-5
Month to Month Fluctuations (95th Percentile of Modeled Years)
in Camanche Reservoir

Lower Mokelumne River

Similar to the methodology used to evaluate impacts from project conditions on the lower Mokelumne River, EBMUDSIM hydrologic modeling results for mean monthly flows downstream of Camanche Dam are also used to evaluate cumulative impacts on the lower Mokelumne River. Average monthly flows exceeding 1,000 cfs (bankfull flow) in the lower Mokelumne River during the spring (April through June) are assumed to provide channel maintenance flows.

Relative to baseline conditions, cumulative conditions would result in 2 fewer years (out of 89 years simulated) when channel maintenance flows would occur below Camanche Dam. This infrequent reduction in flows would not have a significant effect on channel maintenance flows in the lower Mokelumne River. Therefore, cumulative impacts on lower Mokelumne River vegetation, as well as on special-status wildlife species that inhabit these areas, would be *less than significant*. Because there is no cumulative impact on wildlife species that inhabit the area along the lower Mokelumne River, no mitigation is necessary.

4.2.4 Agricultural Resources

This section describes cumulative conditions for agricultural resources based on results from the EBMUDSIM hydrologic simulation for cumulative conditions and other considerations (Section 4.2.2, Water Resources). EBMUDSIM results for analyzing cumulative impacts on agricultural resources are summarized below and are presented in more detail in the following appendices:

- Appendix L: Allocations to the North San Joaquin Water Conservation District under Baseline and Permit 10478 Time Extension Project Conditions.
- Appendix P: Allocations to the North San Joaquin Water Conservation District under Baseline and Cumulative Conditions.

As discussed above under Section 4.2, there would be no impacts on WID under cumulative conditions; therefore, impacts on this agency are not discussed further under this analysis.

As described in Section 4.2 above, this cumulative analysis assumes that by 2020, JVID, a senior water rights holder, would be supplied with water from AWA, so it would no longer be subject to intermittent limitations as a result of low water surface elevations in Pardee Reservoir as with project conditions (Section 3.4, Agricultural Resources). Therefore, JVID diversions are not expected to change under future cumulative conditions. However, should JVID continue to divert the full 3,850 acre-feet at Pardee Reservoir through year 2040, there could be intermittent limitations as a result of low water surface elevations at Pardee Reservoir under cumulative conditions. To ensure that JVID could continue to divert its senior water right at Pardee Reservoir when water is available under its water right priority, EBMUD will work with JVID on the installation of a submersible pump in Pardee Reservoir for JVID to divert water into its diversion facility and pipeline, as described in Section 3.4.3.3.

As described in Section 3.4, Agricultural Resources, NSJWCD's temporary water right Permit 10477, which was issued pursuant to Water Code Section 1462, authorizes the granting of a permit for temporary appropriation of water that is excess to the needs of a municipality. EBMUDSIM results for baseline conditions indicate that water is available to NSJWCD in 49 of the 89 years modeled, with one of these years being less than the full 20,000 acre-feet delivery. Under the Project, water would be available to NSJWCD from the Mokelumne River in 47 of the 89 years modeled, with two of these years being less than the full 20,000 acre-feet delivery (Appendix L). The number of years

when NSJWCD allocations would not be met under project conditions (i.e., 2 additional years) is an increase of approximately 2% compared to baseline conditions. Therefore, although the Project may reduce the amount of water available to NSJWCD, the reduction would not be significant compared to baseline conditions (Section 3.4, Agricultural Resources).

Under cumulative conditions, similar to the Project, water would be available to NSJWCD from the Mokelumne River in 47 of the 89 years modeled with two of these years being less than the full delivery (Appendix P) 20,000 acre-feet.

In summary, under cumulative conditions, water available to NSJWCD would be reduced by three additional years compared to baseline out of the 89-year hydrologic record modeled. Under baseline conditions, Mokelumne River water is available to NSJWCD under its Permit 10477 nearly 55% of the time; under cumulative conditions, surface water supplies available to NSJWCD from the Mokelumne River under Permit 10477 are expected to be available nearly 53% of the time. This change of 2% is not expected to significantly impact agricultural resources. For the reasons stated here, this cumulative impact is considered to be *less than significant*. Because there would be no cumulative impact on agricultural resources, no mitigation is necessary.

4.2.5 Recreational Resources

This section describes cumulative conditions for recreational opportunities based on results from the EBMUDSIM simulation for cumulative conditions and other considerations. EBMUDSIM results for the cumulative conditions are summarized here and are presented in more detail in the following appendices:

- Appendix M: Number of Months when Reservoir Storage Falls below Recreation Opportunity Thresholds under Baseline and Permit 10478 Time Extension Project Conditions.
- Appendix Q: Number of Months when Reservoir Storage Falls below Recreation Opportunity Thresholds under Baseline and Cumulative Conditions.

Cumulative impacts on recreational opportunities at Pardee and Camanche Reservoirs and along the lower Mokelumne River are described in the following sections.

4.2.5.1 Pardee and Camanche Reservoirs

Similar to the analysis presented in Section 3.5, Recreational Resources, which compared the Project and baseline conditions, recreation opportunities at Camanche and Pardee Reservoirs are unlikely to be significantly affected under cumulative conditions. In dry years, there would be some additional months when both Camanche and Pardee Reservoirs are too low to support the higher boat launches; however, there also would be very few additional months under the cumulative conditions when the reservoir water levels would be low enough to affect the lower boat launches.

Compared to EBMUDSIM results for baseline conditions, the cumulative conditions had 1 less month at Pardee Reservoir (total of 9 months) and 3 additional months at Camanche Reservoir (total of 27 months) when lake elevations would fall below the lower boat ramps out of the simulated 89-year hydrologic record (Table 4-16). The change in the number of months when the lower boat ramps would be affected under the cumulative conditions represents a 0.1% decrease out of the 89-year simulation period compared to baseline conditions when the boat ramps are open at Pardee Reservoir (boat ramps at Pardee Reservoir are open 9 months out of the year), and a 0.3% increase

out of the 89-year simulation period compared to baseline conditions for the boat ramps at Camanche Reservoir (boat ramps at Camanche Reservoir are open year-round).

Because the total number of months when Pardee and Camanche Reservoirs' lower boat launches would be inoperable under the cumulative conditions is relatively small (less than a 1% increase compared to baseline conditions), this cumulative impact is considered *less than significant*. Because there would be no cumulative impact on recreation at Pardee and Camanche Reservoirs, no mitigation is necessary.

Table 4-16. Water Surface Elevations and Number of Months in Which Boat Launches Are Affected under Project Conditions and Cumulative Conditions Relative to Baseline

Boat Launch	Lowest Operational Water Surface Elevation (ft msl)	Baseline Number of Months Affected	Increased Limited Access Compared to Baseline Conditions ^a In Months (percent)	
			Project Conditions	Cumulative Conditions
Pardee Recreation Area				
Main Boat Launch	540	40	14 (1.7)	-5 (-0.6)
Low Water Boat Launch	495	10	1 (0.1)	-1 (-0.1)
Camanche Reservoir North Shore Recreation Area				
Main Ramp (full 8 lanes)	210	310	54 (5.1)	46 (4.3)
Main Ramp (reduced 2 lanes)	194	129	8 (0.7)	15 (1.4)
Main Ramp, Low- Water Ramp	160	24	2 (0.2)	3 (0.3)
Camanche Reservoir South Shore Recreation Area				
Main Ramp	205	202	50 (4.7)	51 (4.8)
Main Ramp Low- Water Ramp	175	44	16 (1.5)	4 (0.4)
Main Ramp Very- Low-Water Ramp	160	24	2 (0.2)	3 (0.3)

^a Data calculated from EBMUDSIM modeling results (Appendix E), which used 89 years of historical runoff data (1921 to 2009) to model baseline, Permit 10478 Time Extension Project, and cumulative conditions (Appendices M and Q). The total number of months that the Pardee Recreation Area boat launches are open to the public is 801 months during this time frame (February through October from 1921–2009). The total number of months that the Camanche Reservoir Recreation Area boat launches are open to the public is 1,068 months during this time frame (year-round from 1921–2009).

ft msl = feet above mean sea level.

4.2.5.2 Lower Mokelumne River

The primary recreational activity along the lower Mokelumne River is slow-water boating and inner tubing. As such, only relatively large reductions in flow would harm recreational use of the lower Mokelumne River. A 30% reduction in flows below 325 cfs generally equates to a 3-inch or more reduction in water surface elevation at Stillman Magee Park. For purposes of this analysis, a more conservative threshold of 20% reduction in flows was used.

Flow effects were assessed by using EBMUDSIM results to determine the number of months and percent of time when low or moderate flows (i.e., less than or equal to 325 cfs) under baseline or cumulative conditions were reduced by more than 20%. Table 4-13 shows that flows released from Camanche Reservoir to the lower Mokelumne River were sometimes lower in the EBMUDSIM simulated cumulative conditions compared to baseline conditions.

EBMUDSIM simulations for the cumulative conditions resulted in low or moderate flows that were reduced by more than 20% approximately 4.6% of the time (Table 4-17). These reductions in flows would not significantly affect water-dependent recreational opportunities along the river because these reduced flows would occur rarely during the prime recreational months of April through September. Over the 89-year record used for modeling, only 8 out of 534 prime recreation months (approximately 1.5% of the time between April and September) had more than a 20% reduction of low or moderate flows between baseline and cumulative conditions (Table 4-17).

Because this reduction in flows occurred less than 10% of the time during the 89-year record simulated for cumulative conditions, and only 1.5% of the time for the prime recreation months, this cumulative impact is considered to be *less than significant*. Because there would be no cumulative impact on recreation in the lower Mokelumne River, no mitigation is necessary.

Table 4-17. Occurrence when Low to Moderate Lower Mokelumne River Flows Were Reduced by More than 20% under Permit 10478 Time Extension Project and Cumulative Conditions Relative to Baseline Conditions

Month	Project Conditions		Cumulative Conditions	
	Number of Months ^a	Percent Occurrence (%) ^a	Number of Months ^a	Percent Occurrence (%) ^a
January	5	5.6	7	7.9
February	7	7.9	10	11.2
March	5	5.6	5	5.6
April	1	1.1	0	0
May	1	1.1	0	0
June	0	0.0	0	0
July	0	0.0	5	5.6
August	0	0.0	5	5.6
September	2	2.2	9	10.1
October	6	6.7	6	6.7
November	6	6.7	8	9.0
December	5	5.6	5	5.6
Total	38	3.6 (average)	49	5.6 (average)

^a Number of months and percent occurrence over the 89-year (1,068 months) hydrologic record simulated for Permit 10478 Time Extension Project and cumulative conditions compared to baseline conditions.

4.2.6 Visual Resources

This section describes cumulative effects on scenic vistas based on results from the EBMUDSIM hydrologic simulation for cumulative conditions for the 89-year period of record. Cumulative visual conditions were evaluated using the same process used to evaluate visual conditions for the Project in Section 3.6, Visual Resources.

Cumulative impacts on visual resources at Pardee and Camanche Reservoirs and along the lower Mokelumne River are described in the following sections.

4.2.6.1 Pardee and Camanche Reservoirs

Seasonal and permanent scenic vistas exist from the Pardee and Camanche Reservoirs, nearby roadways, hiking trails, and the river shoreline. Section 3.6, Visual Resources, presents the analysis between Project and baseline conditions. Similar to the analysis presented in Section 3.6, Table 4-18 shows the number and percent of months when cumulative reservoir water surface elevations dropped more than 10 feet below baseline elevations. Under simulated cumulative conditions, this decrease in water surface elevations would occur less than 10% of the time at Pardee Reservoir (6.5%) and Camanche Reservoir (2.4%).

Water level fluctuations at both Pardee and Camanche Reservoirs would be similar to the fluctuations that occur under baseline conditions and therefore would not create an adverse effect on scenic views. This cumulative impact is considered to be *less than significant*. Because there would be no cumulative impact on scenic views from Pardee and Camanche Reservoirs, no mitigation is necessary.

Table 4-18. Occurrence when Reservoir Elevations Dropped by More than 10 Feet under Cumulative Conditions Relative to Baseline Conditions

Month	Pardee Reservoir		Camanche Reservoir	
	Number of Months ^a	Percent Occurrence (%) ^a	Number of Months ^a	Percent Occurrence (%) ^a
January	1	1.1	3	3.4
February	1	1.1	3	3.4
March	0	0	3	3.4
April	0	0	2	2.2
May	0	0	0	0
June	0	0	0	0
July	1	1.1	2	2.2
August	1	1.1	3	3.4
September	1	1.1	3	3.4
October	1	1.1	2	2.2
November	1	1.1	2	2.2
December	1	1.1	3	3.4
Annual	8	0.7 (average)	26	2.4 (average)

^a Number of months and percent occurrence over the 89-year (1,068 months) hydrologic record simulated for Permit 10478 Time Extension Project and cumulative conditions compared to baseline conditions.

4.2.6.2 Lower Mokelumne River

Flow effects were assessed by using EBMUDSIM results to determine the number of months and percent of time when low or moderate flows under baseline or cumulative conditions were reduced by more than 20%. Table 4-17 shows that flows released from Camanche Reservoir to the lower Mokelumne River were sometimes lower in the EBMUDSIM simulated cumulative conditions compared to baseline conditions.

EBMUDSIM simulations for the cumulative conditions resulted in low or moderate flows that were reduced by more than 20% approximately 4.6% of the time. Over the 89-year record used for modeling, only 8 out of 534 prime recreation months (approximately 1.5% of the time between April and September) had more than a 20% reduction of low or moderate flows between baseline and cumulative conditions (Table 4-17).

These reductions in flows should not significantly affect visual resources along the lower Mokelumne River. As noted earlier, a 30% reduction in flows below 325 cfs generally equates to a 3" or more reduction in water surface elevation at Stillman Magee Park (rafting takeout site). The river most often is viewed as part of water-dependent recreation activities that occur primarily during April through September. Additionally, the majority of the land along the lower Mokelumne River between Camanche Dam and the town of Woodbridge is privately owned, and most access to the river is prohibited; therefore, public viewpoints along the lower Mokelumne River are limited.

Regardless of limited public viewpoints along the lower Mokelumne River, because this reduction in flows occurred less than 10% of the time during the 89-year record simulated for cumulative conditions and only 1.5% of the time for the prime recreation months, this cumulative impact is considered to be *less than significant*. Because there would be no cumulative impact on visual resources along the lower Mokelumne River, the contribution of the Project would not be considerable. No mitigation is necessary.

4.3 Conclusions

In summary, the Project's contribution to cumulative impacts on water resources; vegetation, wetland, and wildlife resources; recreational resources; and visual resources would not be considerable. Potentially significant cumulative impacts are described below.

As noted above in Section 4.1.2, the cumulative analysis assumed that upstream water users on the Mokelumne River (Amador and Calaveras Counties) would be using their full water-right allotment of 47,000 AFY instead of the 27,000 AFY assumed for baseline and Project conditions. The cumulative analysis also assumes that by 2040, EBMUD would have secured or otherwise obtained some of the additional dry-year supplies identified in WSMP 2040. These assumptions along with the Project level diversions, were used in EBMUDSIM to simulate cumulative effects on reservoir inflows, storage volumes, and releases under 1921 through 2009 hydrologic conditions including the DPS.

EBMUD, USFWS, and DFW 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. Consequently, the assessment of cumulative 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 throughout the proposed extension period of Permit 10478 entitlements.

Cumulative Impact FISH-1: The Permit 10478 Time Extension Project would contribute to cumulatively significant impacts on fish resources (Potentially Significant/Less than Significant with Mitigation). Cumulatively significant impacts on fish resources include impacts on lower Mokelumne River flows that could impede upstream migration of adult salmon and steelhead. Because increases in the frequency of flows that potentially impede migration could adversely affect overall production of Chinook salmon and steelhead, this cumulative impact is considered potentially significant. To address this cumulative impact on fish resources in the lower Mokelumne River, EBMUD will implement Mitigation Measure FISH-1. *Implementation of the following mitigation measure would reduce this significant impact to less-than-significant levels*

Mitigation Measure FISH-1: If expected flows below Woodbridge Dam impair adult salmonid migration from September through February, one of the following measures will be implemented depending on EBMUD reservoir carryover storage conditions and water year runoff.

- 1) EBMUD will release from Camanche Dam up to a total of 2,000 acre-feet of additional water above required releases during the September through February period in “Below Normal” and “Dry” water year types to facilitate adult salmonid fish passage below Woodbridge Dam.
- 2) During “Critically Dry” water year types, EBMUD will survey the reach below Woodbridge Dam prior to spawning season to identify any significant blockages or obstructions to instream passage. Adequate water depths of sufficient width are necessary to promote passage of adult salmonids at critical passage sites. At least 25% of the entire width of a potential passage impediment will be reconfigured to provide at least 0.9 foot in water depth. If a blockage is identified EBMUD will work with the appropriate entity to remove or reduce the impediment, to insure that there is a depth of at least 0.9 foot to facilitate adult salmonid fish passage.

The magnitude, frequency, and duration of the additional flows set forth in 1) above, are to be determined by the JSA Partnership Steering Committee based on Camanche cold water storage, and water temperatures below Woodbridge Dam. Instream passage improvements, are to be determined by the JSA Partnership Steering Committee based on EBMUD assessment of potential passage impediments from Woodbridge Dam downstream to tidal influence during July or August of current (APR-SEP) or anticipated (OCT-MAR) “Critically Dry” water year types.

Cumulative Impact AG-1: The Permit 10478 Time Extension Project could contribute to cumulatively significant impacts on surface water supply for agricultural use by senior water rights holders (Potentially Significant/Less than Significant with Mitigation)

JVID water rights on the Mokelumne River are senior to EBMUD’s water right Permit 10478. As described in Section 4.2 above, under cumulative conditions, it is expected that JVID will be supplied water by 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 the full 3,850 acre-feet at Pardee Reservoir through year 2040, there could be intermittent limitations as a result of low water surface elevations at Pardee Reservoir under cumulative conditions. To ensure that JVID could continue to divert its senior water right at Pardee when it is available under its water right priority, EBMUD will implement the following mitigation measure.

Mitigation Measure AG-1: Work with JVID to help JVID divert water under its water right

During periods when the water-surface elevation of Pardee Reservoir is below 550 feet, and water is available to JVID under its water right priority, EBMUD will work with JVID on the installation of a submersible pump in Pardee Reservoir for JVID to divert water into its diversion facility and pipeline. Implementing Mitigation Measure AG-1, and assisting JVID to divert its allocated water during such periods, would reduce Impact AG-1 to a *less-than-significant* level with mitigation.

Chapter 5

Alternatives Analysis

This environmental impact report (EIR) for the Permit 10478 Time Extension Project (Project) examines a single alternative, the No-Project Alternative. Other potential alternatives that were considered for examination in the EIR, but rejected, are discussed in Chapter 2, Project Description, Baseline, and Alternatives. This chapter presents an analysis of the No-Project Alternative.

As noted in the description of the No-Project Alternative presented in Chapter 2, Project Description, Baseline, and Alternatives, the No-Project Alternative would result in other actions if EBMUD does not pursue a permit extension. This is because under the No-Project Alternative, while water available under the permit would continue to be available on an average annual basis up to 214 million gallons per day (MGD), to meet any future growth in average annual demand in excess of 214 MGD, EBMUD would need to obtain additional supplies to replace Permit 10478 water that would otherwise be used to meet this demand.

Table 5-1 evaluates the No-Project Alternative's ability to meet the objective and need of the Project. As shown in the table, the No-Project Alternative does not fully meet several of the fundamental project objectives. EBMUD would not have sufficient supplies to reliably meet service area demands including peak summer demands. Additionally, EBMUD's ability to meet demands while quickly and fully replenishing the terminal reservoirs after a prolonged drought or water supply disruptions could be compromised. EBMUD would need to find and develop replacement water sources such as transfers, desalination, or groundwater supplies instead of relying more on the existing Permit 10478 water. The ability to obtain replacement waters is uncertain and is dependent on a number of factors such as water quality, timing, and coordination with other entities.

5.1 Ability of Alternatives to Meet Project Objectives and Needs

Table 5-1 compares the Project and No-Project Alternative in terms of the ability to meet the project objectives and need as described in Chapter 1, Project Objective and Need for the Permit 10478 Time Extension Project. The California Environmental Quality Act (CEQA) does not require the No-Project Alternative to meet project objectives. The following sections go beyond the basic requirements of CEQA by comparing the Project to the No-Project Alternative.

Table 5-1. Ability of the Alternatives to Meet Project Objective and Need^a

Objective and Need	Permit 10478 Time Extension Project	No-Project Alternative
Project Objective		
Serve service area demand in the most cost-effective manner	Yes	No
Maintain high-quality water sufficient for treatment using existing facilities	Yes	Uncertain
Maintain operational flexibility	Yes	Uncertain
Need to Maintain Operational Flexibility		
Have sufficient supplies to meet projected increases in demand for water in EBMUD's service area	Yes	Uncertain
Have sufficient supplies to meet peak summer demands	Yes	Uncertain
Ensure that demands will continue to be met in the event of Mokelumne River water supply outages or following a drought or catastrophic event	Yes	Uncertain
Meet water quality and flow commitments in the Mokelumne River to protect the ecosystem and anadromous fish	Yes	Yes
^a The terms used in this table have the following meanings: • <i>Yes</i> means that the alternative would fully meet the objective or need at a level equivalent to the Permit 10478 Time Extension Project. • <i>No</i> means that the alternative would not meet the objective or need at a level equivalent to the Permit 10478 Time Extension Project. • <i>Uncertain</i> means that questions remain as to water supply availability and reliability, cost, or regulatory and permitting issues, or the participation of other entities.		

5.2 Environmental Impacts of the No-Project Alternative

As noted in Chapter 1, Project Objective and Need for the Permit 10478 Time Extension Project, coordinated operation of Pardee and Camanche Reservoirs allows EBMUD to deliver municipal water supplies of up to 325 MGD from Pardee Reservoir to the EBMUD service area in the most energy-efficient manner, while meeting all other operating goals, objectives, and requirements.

Under the No-Project Alternative, it would be necessary to obtain up to 16 MGD (18,000 acre-feet per year [AFY]) in replacement supplies to meet EBMUD's future average annual demand by year 2040. For purposes of evaluation, the No-Project Alternative assumes that replacement supplies could be obtained via water transfers (surface water and/or groundwater sources), and/or a new desalination plant of up to 16 MGD to meet EBMUD's future average annual demand by year 2040. Additional supplies would also be needed beyond year 2040. Diversions from other sources would reduce the effects of additional diversions from the Mokelumne River, but may result in potential impacts on other water bodies and associated resources.

The following sections describe impacts associated with the No-Project Alternative, particularly the impacts of obtaining replacement water supplies and transporting these supplies to EBMUD's service area.

5.2.1 Impacts Associated with Diverting Water from the Mokelumne River

Under the No-Project Alternative, EBMUD diversions from the Mokelumne River would be limited to the baseline amounts, including an annual average diversion of 214 MGD. As described below, there would be impacts associated with obtaining and conveying the 16 MGD of replacement water to EBMUD's service area.

5.2.2 Impacts Associated with Obtaining Water from Other Sources in Non-Dry Years

As noted in Chapter 2, Project Description, Baseline, and Alternatives, to serve demand in EBMUD's service area up to year 2040, the No-Project Alternative entails the acquisition of water supplies to replace the additional 16 MGD of water currently needed from Permit 10478 through the year 2040. The programmatic analysis in Chapter 6, Programmatic Evaluation of Use of Beyond 2040, further notes that the need for replacement water supplies would continue to increase beyond year 2040 as EBMUD's customer demands continue to increase.

The ability to obtain these replacement supplies is not certain. It would be speculative to identify specific water sources that could be obtained to meet replacement water supplies under the No-Project Alternative. However, for purposes of this evaluation, it is generally assumed that replacement waters would likely be generated from either water users in the Sacramento River watershed, from groundwater basins near existing EBMUD facilities, or from a newly constructed desalination project located adjacent to the Bay Delta. A water transfer or groundwater-sourced water supply would be conveyed to EBMUD's service area through the use of the existing Freeport Regional Water Project (FRWP) facilities and through the Mokelumne Aqueducts. Conveyance of replacement waters would require additional pumping, treatment, and potential construction of new facilities to divert and convey waters to EBMUD's conventional treatment plants. To minimize pumping at FRWP and other associated facilities, EBMUD would seek to obtain replacement supplies within a compressed 3-to-4-month period and would need to adjust operations to accommodate this schedule. Raw water quality in the East Bay could be affected by additional non-Mokelumne supplies since the water would be of a different quality than existing high-quality Mokelumne River supplies diverted by EBMUD under Permit 10478. The resulting extended operation of conventional treatment plants would result in increased use of chemicals, additional electrical consumption, and an increase in the generation of greenhouse gases (GHGs) and emissions.

Water that is now conveyed to the East Bay from the Mokelumne Project facilities, using gravity benefits provided by these facilities, would instead be replaced with water pumped from another source under the No-Project Alternative. The No-Project Alternative would involve the replacement of existing supplies—which have lower-energy usage and lower-GHG production—with new supplies that involve energy-intensive pumping (in the case of water transfers or groundwater supplies) or energy-intensive treatment (in the case of desalination) that would result in increased energy consumption and increased generation of GHG emissions compared to baseline conditions. This would not be consistent with California state policy, including the California State Water Resources Control Board (State Water Board)'s own policies. Principle 7 of Resolution 2008-0030 directs State Water Board staff to coordinate with other government agencies to encourage sustainable resource management in the administration of State Water Board regulatory activities. Strategy IV stated in the May 2008 *Status Report on Climate Change Activities*, in response to the

Governor's Executive Order S-3-05, would require the State Water Board and the California Department of Water Resources (DWR) to implement measures to reduce the magnitude and intensity of energy usage in the state's water delivery systems.

The development of replacement water supplies with water from transfers (surface water and/or groundwater sources) and/or desalination may also result in additional construction-related and operational impacts. Depending on the specific supply source arrangements, this could potentially result in both short-term and long term impacts such as crop idling on agricultural land, increased reliance on groundwater, air quality issues, fishery impacts, geology, landuse and other secondary impacts such as economic impacts from crop idling on the farming community.

Replacement of Mokelumne Project Permit 10478 water with water from water transfers (surface water and/or groundwater sources), or desalination could require EBMUD to develop complex partnership agreements, operational coordinating agreements, and cost-sharing arrangements with numerous stakeholders. In effect, the No-Project Alternative could require these complex arrangements and agreements in order for EBMUD to develop new water supplies to replace waters that have long been, and are currently, available under its permit.

Development and construction of a desalination facility may require EBMUD to develop partnership agreements with various entities. The need for and the complexity of the partnership agreement (s) would be dependent on the location of the desalination facility and other factors. If the facility is located upstream along the Bay Delta, a regional desalination effort would be more appropriate.

It would also be necessary to file change petitions, in partnership with other agencies, to obtain the 16 MGD of additional water to replace water currently available under Permit 10478, to add place of use and purpose of use under others' existing water rights in order to implement water transfers. Additionally, recent court decisions on the biological opinions associated with the Central Valley Project (CVP)/State Water Project (SWP) operations and Sacramento–San Joaquin River Delta (Delta) water quality have altered operations with respect to the Delta, which could affect projects to replace Mokelumne River water with other sources.

Should EBMUD seek to obtain additional replacement water supplies through water transfers (surface water and/or groundwater sources) and/or desalination at some future date, a project-level analysis of the potential environmental effects associated with the replacement water supply would be undertaken under CEQA.

The following sections present a general analysis of impacts associated with obtaining replacement water supplies under the No-Project Alternative. The analysis for the replacement water supplies is based, in part, on the analysis conducted under EBMUD's Water Supply Management Program (WSMP) 2040 programmatic environmental impact report (PEIR), certified by EBMUD on April 24, 2012. It included a portfolio of supplemental supplies to meet dry-year demands through the year 2040. The future supplies identified in the program would supplement—but not replace—EBMUD's existing water rights and supply from the Mokelumne River.

5.2.2.1 Water Resources

As described in the FRWP Environmental Impact Report/Environmental Impact Statement (EIR/EIS) (Jones & Stokes 2003a), any diversions that could be made through the FRWP facilities (at a rate of less than 300 cubic feet per second [cfs]) represent a very small percentage of river flow given that Sacramento River flows at this location are typically more than 5,000 cfs, even during

low-flow events. The following potential water resources impacts are considered to be *less than significant, or less than significant with mitigation*.

Impact WR-1(No-Project Alternative [NP]): Potential reduction in groundwater supply resulting from increased groundwater pumping (Potentially Significant/Less than Significant with Mitigation)

Under the No-Project Alternative, replacement water supplies might be obtained from water transfers (surface water and/or groundwater sources). Transfers of surface waters could result in increased groundwater pumping if these transferred surface supplies are replaced by the seller with groundwater. The degree to which the use of surface supplies to replace Mokelumne River supplies would affect groundwater is unknown.

If EBMUD acquired the additional water needed for the No-Project Alternative from a groundwater source that is not a groundwater bank, the acquisition of this water could directly result in the further depletion of the groundwater source.

Any increases in groundwater pumping that might be associated with the use of surface supplies to replace Permit 10478 Mokelumne River supplies under the No-Project Alternative would likely occur within one of the 18 contiguous (non-isolated) subbasins of the Sacramento Valley groundwater basin (California Department of Water Resources 2003). In general, the Sacramento Valley groundwater basin is currently being used in a sustainable manner. Much of the groundwater pumping in the basin is not measured, but total average annual groundwater pumping has been estimated to average between 1.4 million acre-feet (Faunt et al. 2009) and 2.7 million acre-feet (California Department of Water Resources 2003)¹, much larger than the 17,900 acre-feet (i.e., 16 MGD or 0.0179 million acre-feet) that EBMUD would need for the No-Project Alternative.

Because the details of the replacement supplies under the No-Project Alternative are not known, there is some potential for increased groundwater use associated with the No-Project Alternative to have local groundwater effects, particularly if the basin from which the groundwater was obtained is experiencing an overall decline. This impact is considered to be potentially *significant*, although it could be reduced to *less than significant with mitigation*.

Mitigation Measure WR-1 (NP): Mitigations noted in the WSMP 2040 PEIR include monitoring groundwater levels by those organizations that would increase groundwater pumping, to determine if the increased groundwater withdrawals would cause a reduction in groundwater levels and adversely impact neighboring groundwater users.

Impact WR-2(NP): Potential reduction in water quality downstream of the FRWP (Less than Significant)

Under the No-Project Alternative, in non-dry years, replacement water supplies of 16 MGD (18,000 AFY) might be obtained from water transfers conveyed through the FRWP facilities to the Mokelumne Aqueducts. As described in the FRWP EIR/EIS, the FRWP diversions of 185 MGD (i.e., 85 MGD in non-dry years and 185 MGD in dry years) have a minimal effect on the dilution of the Sacramento Regional Wastewater Treatment Plant (SRWWTP) effluent. The small amount by which the No-Project Alternative might result in an increase in the currently planned diversions at the

¹ The California Department of Water Resources estimate is higher than the Faunt et al. estimate partially because it includes a larger area and some smaller basins that were not part of the estimate provided by Faunt et al.

FRWP would not cause any significant effect on dilution of the SRWWTP effluent, particularly in the years in which this would be expected to occur. This impact would be *less than significant* because existing adopted water quality standards would not be exceeded, and no substantive effect on public health or environmental receptors would be produced. No mitigation is required.

Impact WR-3(NP): Increased frequency or duration of taste and odor events from EBMUD terminal reservoirs (Less than Significant)

Under the No-Project Alternative, replacement water supplies might be obtained from water transfers (surface water and/or groundwater sources). Conveyance of such surface supplies from the Sacramento River to EBMUD's terminal reservoirs in the years in which this would be done has the potential to result in elevated levels of total dissolved solids, total hardness, turbidity, pathogens, total organic carbons, and biostimulatory nutrients in the terminal reservoirs compared to the existing water quality. Increased inorganic mineral content and nutrients could incrementally increase the frequency or duration of adverse taste and odor events in EBMUD terminal reservoirs. Because the conventional treatment plants which are fed by water from the terminal reservoirs have treatment processes (i.e., ozonation) to reduce taste and odor compounds, this impact would be *less than significant*.

Impact WR-4(NP): Changes to Folsom South Canal water quality (Less than Significant)

Under the No-Project Alternative, replacement water supplies might be obtained from water transfers (surface and/or groundwater sources). The replacement water supplies would be diverted at the FWRP and delivered to the Folsom South Canal (FSC) approximately at its midpoint and conveyed about 15 miles to the terminus of the FSC and the Clay Station Pumping Plant. The water in the FSC from the discharge point to the terminus of the canal would contain a blend of Sacramento River water and American River water. Currently, the Sacramento Municipal Utility District (SMUD) is the only consistent user of water from this portion of the FSC.

The concentrations of some physical and chemical constituents in Sacramento River water are generally higher than in American River water that is presently in the FSC. Consequently, there could be a change in the quality of water delivered to SMUD when replacement water deliveries to EBMUD are occurring. In general, the blended Sacramento River water and American River water would be very low in all constituents and would not adversely affect existing beneficial uses or preclude the use of FSC water for any other beneficial uses. Transport of suspended sediment in the form of total suspended solids (TSS) and turbidity could increase. A large majority of sediment introduced from the Sacramento River would settle within the forebay at the FRWP intake facility and within the FSC. If fine sediment material remains in suspension and is transported to downstream users (i.e., SMUD), there are presently treatment facilities in place to address this potential change in water quality.

For these reasons, the increase in Sacramento River water in the FSC that might result from transporting replacement water through the FSC would result in a *less-than-significant* impact.

Impact WR-5(NP): Pipeline operation effect on surface drainage (Less than Significant)

Under the No-Project Alternative, replacement water supplies might be obtained from water transfers (surface water and/or groundwater sources). Replacement supplies would be diverted at the FRWP intake facilities and conveyed via FRWP pipeline to the Mokelumne Aqueducts. To minimize the duration of pumping at FRWP and other associated facilities, EBMUD would seek to

obtain replacement water within a compressed 3-to-4-month period. When the pipeline is not being used, it would need to be emptied at the completion of each diversion period. As described in the FRWP EIR/EIS, draining of the pipeline would require authorization through the Regional Water Quality Control Board (RWQCB) General Order for dewatering and other low threat discharges to surface waters and would not significantly affect local water quality or drainage. For these reasons, this impact would be *less than significant*. No mitigation is required.

Impact WR-6(NP): Changes in Delta inflow, Delta outflow, and Delta water quality (Less than Significant)

Under the No-Project Alternative, replacement water supplies might be obtained from water transfers (surface water and/or groundwater sources). If the replacement supplies are obtained from a surface water source that would otherwise flow into the Delta, no net change in the overall Delta inflow, outflow or water quality is expected because the total volume of upstream diversions would remain the same.

If the replacement water is met through groundwater or a source that does not flow to the Delta, there is a potential for a small change in Delta inflow, although this would be *less than significant* because replacement supply of 16 MGD (18,000 AFY) is 0.06% of the average annual Delta inflow of 27 million acre-feet. Therefore, this impact would be *less than significant*.

Impact WR-7(NP): Potential construction-related impacts on soils, water quality, drainage and flooding patterns (Less than Significant with Mitigation)

Under the No-Project Alternative, replacement water supplies would be obtained from water transfers (surface and/or groundwater sources) and/or desalination facilities. The WSMP 2040 PEIR identified several potential construction-related impacts on water quality, soils, and changes to existing drainage patterns from generation of stormwater runoff, removal of vegetation, grading, excavation and other typical construction activities related to obtaining water for dry-year needs. Similarly, development of replacement water supplies for non-dry years could result in potential short-term construction impacts and long-term operational impacts.

Construction impacts related to the development of facilities for desalination and water transfers such as wells, ponds, pump stations, recharge basins and treatment plants could result in potentially significant impacts on water quality and changes in existing drainage patterns. Implementation of a mitigation measures such as best management practices and other regulatory and permit requirements would lessen the impacts to *less-than-significant* levels.

Impact WR-8(NP): Potential impacts on water quality from the operation of a desalination plant (Less than Significant with Mitigation)

Under the No-Project Alternative, replacement water supplies might be obtained from desalination. Operation of a desalination facility would result in the production of a waste discharge with increased salt content (brine), as well as solids and other debris collected at the intake, which would require disposal at a landfill. Disposal of solids at a landfill is not expected to result in a significant impact. The potential effects of brine discharge on the section of the Bay Delta receiving waters is dependent on a number of environmental variables, including variations in salinity and temperature of the receiving waters, freshwater inflow and tidal and wind actions in the mixing and dispersal of the discharge. The brine discharge could exceed established water quality objectives and numerical standards identified for the receiving water body.

Impacts of a desalination project on water quality could be considered potentially significant. However, hydrodynamic modeling studies would be used to evaluate the variables affecting salinity and used in designing the outfall to minimize impacts on the receiving waters. Implementation of these design measures could likely reduce the potentially significant impacts on water quality to *less than significant with mitigation*.

Impact WR-9(NP): Potential effects on other intakes and outfalls from the operation of a desalination plant (Less than Significant with Mitigation)

Under the No-Project Alternative, replacement water supplies might be obtained from desalination. Analysis conducted as part of the WSMP 2040 PEIR indicated that operation of a desalination facility intake could affect neighboring intakes and outfalls. If, for example, localized flow patterns that formed around the new intake could alter flow patterns around existing intakes such that the rate of intake decrease and/or the quality of water diverted changes, impacts of a desalination project on nearby intakes or outfalls could be considered potentially significant. However, implementation of mitigation would reduce these potential impacts to less than significant. For mitigation, EBMUD (along with a partner agency if present) would conduct numerical modeling of the desalination facility design. Modeling would consider local intakes and outfalls within a certain distance from the proposed facility that may affect the project or, in turn, be affected by the project, in terms of both hydraulics and water quality. The specific distance would be defined during the project's environmental review stage. The results of the numerical modeling would be used in the design to minimize both impacts from the project on existing intakes/outfalls, and from these sources on the project's intake structure.

5.2.2.2 Geology, Soils and Seismicity

Impact GSS-1(NP): Potential for geology, soil and seismicity-related impacts on groundwater, desalination or water transfer facilities (Less than Significant with Mitigation)

Under the No-Project Alternative, replacement water supplies would need to be obtained from water transfers (surface and/or groundwater sources) and/or desalination projects. Proposed facilities developed as part of these replacement supplies would include treatment plants, wells, pump stations, recharge ponds, etc. are dependent on the specific project and the ultimate design. The specific location of the proposed facilities relative to faults has not yet been determined. These facilities would be located in a variety of urban and rural settings. Site-specific impacts related to geologic and seismic hazards would depend on selection of the sites and the design of the facilities. State laws require that the design and construction of facilities include incorporating appropriate practices for identification of adverse geologic hazards and seismic conditions and implementation of appropriate engineering measures compatible with relevant seismic zones.

Impacts related to geology, soils, and seismicity would be considered potentially significant. Implementation of mitigation measures to include prudent geotechnical engineering control measures during the design of the facilities would reduce potential impacts to *less-than-significant* levels.

5.2.2.3 Fish Resources

Under the No-Project Alternative, replacement water supplies would be obtained from water transfers (surface and/or groundwater sources) and/or desalination plants. Water transfers might be diverted at the FRWP for conveyance to the EBMUD service area. As described in the FRWP EIR/EIS, water diversions made through the FRWP facilities (up to 286 cfs) represent a very small percentage of river flow given that Sacramento River flows at this location are typically more than 5,000 cfs, even during low-flow events. The diversion rate of replacement supplies from transfers would not exceed the diversion rate of FRWP intake facilities.

Per the FRWP EIR/EIS, the diversions from the FRWP facilities would not significantly affect water levels or flow volumes, hence the diversions at FRWP associated with conveying replacement water obtained from water transfers are anticipated to have a *less-than-significant* impact on fish in upstream waters. Potential impacts on fish resources from desalination facilities were identified in the WSMP 2040 PEIR and were assessed to be *less than significant with mitigation*.

Impact FISH-1 (NP). Entrainment at the FRWP facility (Less than Significant)

Under the No-Project Alternative, replacement water supplies might be obtained from water transfers. Water transfers might be diverted at the FRWP for conveyance to the EBMUD service area. In the FRWP EIR/EIS, fish entrainment at the FRWP intake facility diversions (up to the maximum diversion rate of 286 cfs) was considered to be *less than significant*. The FRWP facility also includes a state-of-the-art fish screen that minimizes potential impacts on aquatic resources. Because diversion rate of replacement supplies from transfers would not exceed the diversion rate of FRWP intake facilities, this impact would remain *less than significant*.

Impact FISH-2 (NP). Potential entrainment of special-status fish into pumps/intake pipes as constructed for desalination facilities (Less than Significant with Mitigation)

Under the No-Project Alternative, replacement water supplies might be obtained from desalination. Desalination facilities require diversion mechanisms to divert water from rivers, bays or other water bodies. Such systems have the potential to entrain fish, larvae, juveniles, and adults, including special-status species. Losses to diversions depend on the timing, size, design, and location (geography and position in the channel) of individual diversions relative to the seasonal and diurnal distribution and abundance of fish. Egg, larval, and juvenile life stages are most susceptible to entrainment. Potential entrainment of fish, including special-status species, intake pumps and intake pipes would be a potentially significant impact. Implementation of mitigation measures can reduce the impact level to *less than significant*.

As mitigation, fish screens would be designed and installed over any potential new diversion intake(s). The screens would be designed consistent with the California Department of Fish and Wildlife and the National Marine Fisheries Service (NMFS) criteria for screen mesh size, water velocity approach, etc.

Impact FISH-3(NP). Effect on fish in the Delta (Less than Significant)

Under the No-Project Alternative, replacement water supplies would be obtained from water transfers (surface and/or groundwater sources) and/or desalination plants. As noted earlier, if the replacement supplies are obtained from a source that would otherwise flow to the Delta, there would be no net change in Delta inflow, outflow, or water quality. If the additional replacement

water is met through groundwater or a source that does not flow to the Delta, there is potential for a change in Delta inflow, although this would be insignificant. The insignificant changes in Delta inflow or water quality are not expected to reduce survivability and habitat for anadromous and estuarine fish species in the Delta. Therefore, this impact is *not significant*.

As discussed earlier, water quality of the desalination plant discharge is anticipated to be potentially significant. However, hydrodynamic modeling studies would be used to evaluate the variables affecting salinity and utilized in designing the outfall to minimize impacts on the receiving waters. Implementation of these design measures could likely reduce the potentially significant impacts on fish to *less than significant*.

Impact FISH-4(NP). Construction-related impacts on fish and aquatic species (Less than Significant with Mitigation)

Under the No-Project Alternative, replacement water supplies would be obtained from water transfers (surface water and/or groundwater sources) and/or desalination projects. Construction-related activities associated with proposed facilities needed for replacement water supplies could result in erosion or disturbance of sediments and soils, temporarily increase turbidity and sedimentation downstream of the construction sites if soils are transported in river flows or stormwater runoff. Construction-related increases in sediments, turbidity, water temperature, and contaminants could temporarily impact nearby aquatic habitats and fish populations in the vicinity of the project construction activities. This impact could be potentially significant. Compliance with appropriate permit requirements including general construction permit requirements, best management practices, spill prevention control would reduce these impacts to *less than significant with mitigation*.

5.2.2.4 Vegetation, Wetland, and Wildlife Resources

The primary impact mechanisms for vegetation, wetland, and wildlife resources are changes in upstream reservoir water-surface elevations and changes in flows in upstream water bodies, which could affect special-status species, their habitat, or other sensitive habitat types. Construction-related impacts during the development of surface water transfers and use of groundwater supplies and desalination facilities could also result in adverse impacts. Should EBMUD seek to acquire replacement supplies at some future date, project-level analysis of the potential environmental effects associated with the Project would be undertaken under CEQA.

Impact BIO-1(NP): Potentially adverse effect on special-status plants and special natural communities, directly or through habitat modification, caused by development of transfers, groundwater supplies and desalination facilities (Less than Significant with mitigation)

Under the No-Project Alternative, replacement water supplies would be obtained from water transfers (surface water and/or groundwater sources) and/or desalination projects. Development and utilization of surface water transfers could result in slight alterations to reservoir water-surface elevations. Changes in water-surface elevation have the potential to affect special-status plants and special natural communities that grow along the shoreline of reservoirs, as outlined in Chapter 7 of the FRWP EIR/EIS. These plants and natural communities, however, are accustomed to water-surface fluctuations, which are a frequent occurrence in these reservoirs under baseline conditions. Additionally, changes in water-surface elevations associated with providing replacement supplies to EBMUD are anticipated to be minimal. For these reasons, frequent water-level fluctuations in

upstream reservoirs associated with the No-Project Alternative would have a *less-than-significant* impact on special-status plants and special natural communities.

Construction and operational activities associated with the development of desalination facilities could disturb, affect, or eliminate special-status plants, protected trees and/or sensitive plant communities resulting in potentially significant impacts. However, mitigation measures such as conducting appropriate habitat assessments, tree surveys prior as part of facility design to avoid special status plants if possible could reduce the impacts to *less than significant with mitigation*.

Impact BIO-2(NP): Potentially adverse effect on special-status wildlife and their critical habitat, special-status mammals, including special status bat species, special-status reptiles and amphibians, nesting birds, riparian communities, special- status invertebrates or their habitat, special-status mammals, including federally protected wetlands caused by development of replacement water supplies (Less than Significant with mitigation)

Under the No-Project Alternative, replacement water supplies would be obtained from water transfers (surface water and/or groundwater sources) and/or desalination plants. Depending on the source of surface water transfers, there could be slight changes to water surface elevations of any associated reservoirs or river stretches downstream of the surface water source. Fluctuations in reservoir water-surface elevations would generally mimic those experienced under baseline conditions, and vegetation would experience a similar cycle of establishment, inundation, and loss, as water elevations rise and fall seasonally and in response to precipitation and flood-control requirements. Alterations in water-surface elevations associated with the No-Project Alternative would be minimal, and as such would have a *less-than-significant* impact on special-status wildlife, special-status invertebrates and their habitat, riparian communities, or federally protected wetlands.

Construction and operational activities associated with the development of desalination could have the potential to increase erosion and/or contribute sediments to wetlands or waters of the United States resulting in a potentially significant impact. These activities may have a potential to adversely affect special-status wildlife and their critical habitat, special-status mammals, including special status bat species, special-status reptiles and amphibians, nesting birds, riparian communities, and special- status invertebrates or their habitat. Formal consultation with appropriate agencies are required prior during the development of the facilities. Implementation of appropriate mitigation measures as delineations and surveys by qualified personnel as required under the consultation guidelines or permit requirements would reduce the impacts to *less than significant with mitigation*.

Impact BIO-3: Potential conflicts with the provisions of an adopted habitat conservation plan, natural community conservation plan, or other approved local, regional, or state habitat conservation plan (Less than Significant)

Under the No-Project Alternative, EBMUD would not undertake actions that are inconsistent with the *San Joaquin County Multi-Species Habitat Conservation and Open Space Plan*, EBMUD's Cooperative Agreement under the Programmatic Safe Harbor Agreement for the Lower Mokelumne River Watershed, and EBMUD's Safe Harbor Agreement with the U.S. Fish and Wildlife Service (USFWS). The No-Project Alternative, therefore, would not conflict with provisions of these habitat conservation plans. This impact is considered to be *less than significant*.

5.2.2.5 Air Quality

Obtaining replacement supplies from transfers of surface water sources could result in a reduction in the amount of water applied to irrigated land, which could, in turn, result in drying of the land and associated canals and drains. These retired lands have the potential to become sources of fugitive dust, causing negative impacts on air quality. The extent to which fugitive dust would increase is dependent on the nature of the transaction, and it is difficult to determine the amount of land, if any, that would be idled, the condition of the idled land, and the amount of fugitive dust that would be generated. Resulting impacts on air quality could be significant, but could be reduced to *less than significant with mitigation*.

Replacement supplies obtained through water transfers (surface water and/or groundwater sources) and desalination plants, if viewed as a whole, would occur in one (or more) of three separate air basins, which in turn are regulated by three separate local air districts (i.e., the Bay Area Air Quality Management District [BAAQMD], San Joaquin Valley Air Pollution Control District [SJVAPCD], and the Sacramento Metropolitan Air Quality Management District [SMAQMD]). Construction and operational activities associated with a given project would occur within areas under the jurisdiction of one of the three air districts. Prior to development of a particular project, an analysis would be performed according to the recommended methodologies of the applicable air district to determine the significance of specific air quality impacts associated with implementation.

Impact AIR-1(NP): Increase fugitive dust as a result of reduced irrigation (Less than Significant with Mitigation Measures)

Under the No-Project Alternative, replacement water supplies might be obtained from water transfers (surface water and/or groundwater sources). Surface water transfers could reduce the amount of water applied to irrigated land, which could cause a drying of the land and associated canals and drains. Retired lands would increase the amount of vacant land, which could become a potential fugitive dust source during high wind events. Windblown fugitive dust could cause a variety of respiratory health problems, reduce visibility on roadways, add nutrients and sediments to waterways, and damage property.

The potential increase in wind erosion associated with the No-Action Alternative would depend on:

- **The amount of land that would become idle as a result of a water transfer.** Idle land resulting from water transfer would be dependent on whether the transferred water was originally used for agriculture or whether the water was replaced with groundwater, as well as the water application rate before and after a water transfer. If the water was made available by conservation or reservoir reoperation, the transfer would not result in crop idling.
- **The condition of land that is idled.** If land is idled, then the amount of fugitive dust would depend on soil type, vegetation, and wind speeds. In general, soil type in the Sacramento Valley is not highly susceptible to wind erosion (U.S. Bureau of Reclamation 2010). Furthermore, if cover crops are planted, it is unlikely that dust would be a problem. Eventually, permanently idled land would probably convert to ruderal grassland, which would prevent wind erosion.
- **The amount of fugitive dust generated prior to implementation of the No-Project Alternative.** Current agricultural activities could release fugitive dust as a result of planting, tillage, and off-road vehicle travel (e.g., tractors). Fugitive dust production also is related to travel along dirt roads throughout the farmland areas. If baseline dust generation is large, then crop idling would probably not cause a significant increase in fugitive dust.

The amount of replacement supplies that would be needed under the No-Project Alternative is equivalent to approximately 18,000 AFY in year 2040 and would continue to increase after that date. The transfer of this amount of water could result in crop idling on thousands of acres of agricultural land. If water is made available for transfer by crop idling on agricultural land, the amount of water that can be transferred is based on the evapotranspiration of the applied water (ETAW). ETAW depends on meteorological conditions and type of crop. In the Sacramento Valley, rice is the most frequent type of crop that is idled for water transfer purposes (U.S. Bureau of Reclamation 2010). DWR and the U.S. Bureau of Reclamation have recommended that an ETAW of 3.3 acre-feet/acre be assumed for rice (California Department of Water Resources and U.S. Bureau of Reclamation 2012). Assuming this value for ETAW, approximately 5,400 acres of rice would need to be idled to generate 18,000 AFY of water for transfer.

Because the specifics of the replacement supplies are unknown and because a large number of acres could be involved, an increase in fugitive dust is considered to be a potentially significant (but probably temporary) impact if the soil type of the idled land is susceptible to wind erosion. This potentially significant impact could be reduced to *less than significant with mitigation*. For mitigation, the formation of fugitive dust would be minimized by the land owner planting a cover crop or, if the land is to be permanently retired from agriculture, by assisting land conversion to grassland by planting appropriate vegetation.

Impact AIR-2(NP): Potential to conflict with, or obstruct implementation of, applicable air quality plans and creation of objectionable odors affecting a substantial number of people (Less than Significant)

The State Implementation Plan (SIP) describes how the State of California will achieve the national ambient air quality standards by specified dates. This SIP is a broad-level air quality plan based on population growth levels and distribution identified in local community plans combined with the cumulative impacts from approved and proposed development projects.

Under the No-Project Alternative, replacement water supplies would be obtained from water transfers (surface water and/or groundwater sources) and/or desalination projects. Possible components of these replacement supplies could involve the operation of pumping stations, extraction wells, injection wells, and treatment facilities. Because these facilities are typically electric-powered and have back-up diesel generators that are only operated during emergencies and for periodic testing, they would not regularly generate emissions on-site. Permits to operate and test the backup generators would be required by the respective air district and, therefore, the emissions produced by each generator would be accounted for in the emissions inventory of the local air basin. Moreover, because backup generators are only operated during emergencies and for periodic testing, their addition to the emissions inventory would be nominal.

It is expected that implementation of any of the replacement water supply projects would be consistent with the existing land use designations of the surrounding communities and therefore would not directly result in an increase in population, employment, or vehicle miles traveled (VMT) beyond that already assumed and approved for development, and accounted for in the emissions budgets of the SIP. Thus, there would not be a substantial increase in VMT or associated mobile-source emissions that would result in a significant adverse incremental effect on the region's ability to attain or maintain state and national ambient air quality standards.

Thus, implementation of water transfer schemes, groundwater projects or desalination projects would not conflict with or obstruct implementation of the applicable air quality efforts of the BAAQMD, SJVAPCD, or SMAQMD. As a result, this impact would be *less than significant*.

The occurrence and severity of odor impacts depend on numerous factors including the nature, frequency and intensity of the source, windspeed and direction and the presence of sensitive receptors. Odors associated with the No-Project Alternative could include exhaust odors, process emissions from EBMUD facilities. Implementation of best management practices to minimize odors, such as dust control, coatings etc. during construction and operations of replacement water supplies would likely reduce the impact to *less than significant*.

Impact AIR-3(NP): Potential to violate an air quality standard or contribute substantially to an existing or projected air quality violation during construction and operations of replacement water supplies (Potentially Significant)

Under the No-Project Alternative, replacement water supplies would be obtained from water transfers (surface water transfers and/or groundwater sources) and/or desalination plants. Construction-related activities would have the potential to generate a temporary increase in emissions that could violate air quality standards or contribute substantially to an existing or projected air quality violation. As a result, this would be a potentially significant impact. Further site-specific analysis would be required to estimate the mass emission levels associated with the construction of a particular project's components to determine its potential effects on air quality. EBMUD would implement appropriate dust control measures as stipulated by the applicable air districts to reduce the potentially significant impact to *less than significant with mitigation*.

Operations-related activities resulting from the replacement water supplies could have the potential to violate air quality standard or contribute substantially to an existing or project air quality violation. Should EBMUD pursue replacement supplies at some future date, EBMUD would be required to complete project-specific environmental documentation. At that time EBMUD would obtain appropriate permits and would be required by the applicable air districts to implement mitigation measures to minimize long-term adverse impacts on air quality. It is likely that operations of replacement water supplies such as the use of desalination facilities will result in *potentially significant* impacts on air quality.

Impact AIR-4(NP): Potential exposure of sensitive receptors to substantial pollutant concentrations (Potentially Significant)

Under the No-Project Alternative, replacement water supplies would be obtained, such as water transfers (surface water and/or groundwater source) and/or desalination facilities. These replacement water supplies could potentially expose sensitive receptors such as schools, residences, and hospitals to substantial concentrations of common air pollutants that exceed State or national ambient air quality standards and/or toxic air contaminants that may cause or contribute to an increase in mortality or serious illness, or that may pose a hazard to human health. As noted earlier, should EBMUD pursue replacement supplies at some future date, EBMUD would be required to complete project specific environmental documentation. At that time, EBMUD would obtain appropriate permits and would be required by the applicable air districts to implement mitigation measures to minimize impacts on air quality. It is likely that the development of replacement water supplies would result in *potentially significant* impacts on air quality.

5.2.2.6 Noise

Development of replacement water supplies could potentially result in exposure to noise levels in excess of ambient noise standards.

Impact NOI-1(NP): Potential exposure of sensitive receptors to noise levels in excess of the applicable noise standards and/or result in a noticeable increase in ambient noise levels from short-term construction activities. (Potentially Significant)

Under the No-Project Alternative, replacement water supplies would be obtained from water transfers (surface water and/or groundwater sources) and/or desalination plants. Proposed facilities for replacement water supplies could include treatment plants, wells, pump stations, recharge ponds, a desalination plant, pipelines and ancillary facilities. They would be located in a variety of urban and rural settings. Although the exact locations of many of these facilities have not been identified, it is assumed that to the extent possible pipelines would be located along existing roadways and easements.

Noise levels associated with construction-related activities are expected to fluctuate and would likely be short-term. These impacts are likely potentially significant. As noted earlier, should EBMUD pursue development of replacement supplies at some future time, EBMUD would be required to obtain appropriate permits from applicable entities and would be required to implement mitigation measures to minimize noise levels. Mitigation measures that would be employed involve avoiding the siting of projects or proposed construction activities in close proximity to noise-sensitive land uses. If avoidance is not possible, EBMUD shall site these construction activities as far from noise-sensitive land uses as possible.

Impact NOI-2(NP): Potential exposure of noise-sensitive receptors to noise levels in excess of the applicable noise standards and/or result in a noticeable increase in ambient noise levels from long-term operational activities (Potentially Significant)

Under the No-Project Alternative, replacement water supplies would be obtained from water transfers (surface water and/or groundwater source) and/or desalination plants. Some of the proposed replacement facilities (e.g., desalination / treatment plants and pumping stations) could generate operational-related noise levels. Buried pipelines and recharge ponds would not likely result in any long-term operational noise impacts. Noise sources could take the form of fans, pumps, air compressors, chillers, turbines, or cooling towers. Noise levels from proposed facility operational equipment may vary significantly depending on unit efficiency, size, and location. Operational requirements have not yet been developed for the above components. Some stationary sources could generate a noise level of 80 decibels (dB) equivalent continuous sound level (Leq) at a distance of 50 feet. Existing receptors may be located within 50 feet of proposed stationary source activities that could exceed non-transportation noise standards (e.g., 50 dB Leq for daytime and 45 dB Leq for nighttime) at receptor locations.

For the purposes of this analysis, if an area is designated as noise sensitive and is in close proximity to proposed noise-generating operational facilities, then the potential exists for the proposed operations of the components to expose sensitive receptors to noise levels in excess of the applicable noise standards and/or result in a noticeable increase in ambient noise levels. As a result, operational stationary noise impacts would be *potentially significant*. While implementation of mitigation measures would reduce potential impacts, it is not known whether the measures would reduce potential impacts to less-than-significant levels. Further site-specific analysis would be

needed to determine the potential effects of operational noise at the noise-sensitive land uses in close proximity of proposed facilities.

Impact NOI-3(NP): Potential for noticeable increase in traffic noise (3 dB or greater) along roadways designated for hauling construction materials (Less than Significant with Mitigation)

Under the No-Project Alternative, replacement water supplies would be obtained from water transfers (surface water and/or groundwater sources) and/or desalination plants. Construction-generated traffic volumes would depend on material requirements and availability and project phase. As such, all materials would be transported over designated haul routes on the local roadway network, thus increasing traffic volumes along affected roadway segments. Existing traffic volumes on local roadway networks would vary depending on individual No-Project Alternative component construction locations. For urban areas, local roadway networks would be expected to consist of high existing traffic volumes, resulting in high existing traffic noise levels. In these instances, an increase of daily traffic volumes due to construction traffic would not be expected to result in a substantial increase in existing traffic noise levels. Typically, a doubling of traffic volumes would be required to increase existing traffic noise levels by 3 dB due to construction traffic.

Rural areas generally have lower existing traffic volumes, resulting in lower existing traffic noise levels. While construction-related traffic increases would be expected to increase existing traffic noise levels, increases would be site specific and require specific traffic analysis when details are available.

For the purposes of this analysis, if noise-sensitive uses are on a local roadway, adjacent to the designated haul route, then the proposed construction-related traffic volume increases may expose noise-sensitive receptors to a noticeable increase in ambient noise levels. As a result, construction-related traffic noise impacts would be potentially significant. Further site-specific analysis would be needed to determine the potential effects of increased traffic noise at the noise-sensitive land uses. Implementation of mitigation measures would reduce these potential impacts to *less-than-significant* levels.

As mitigation, EBMUD would avoid designating construction haul routes on local roadways with adjacent noise-sensitive land uses. If avoidance is not possible, EBMUD shall designate construction haul routes with the fewest possible adjacent noise-sensitive land uses.

As additional mitigation, EBMUD would implement measures to reduce construction-generated traffic noise levels at existing noise-sensitive receptors. Implementation of the measures would reduce the exposure of sensitive receptors to increased project-generated traffic source noise levels; therefore, potential impacts would be *less than significant*.

Impact NOI-4(NP): Potential exposure of sensitive receptors to excessive ground-borne noise and vibration levels (e.g., exceed FTA, Caltrans, and local guidelines) (Potentially Significant).

Under the No-Project Alternative, replacement water supplies would be obtained from water transfers (surface water and/or groundwater source) and/or desalination plants. Construction activities associated with the replacement water supplies would have the potential to result in varying degrees of temporary groundborne vibration, depending on the specific construction equipment used and operations involved. Groundborne vibration levels associated with various types of construction equipment are summarized in the table below. Based on the representative vibration levels identified for various construction equipment types, sensitive receptors located in

close proximity to construction activities could be exposed to groundborne vibration levels exceeding the recommended Federal Transit Administration (FTA) and Caltrans guidelines of 80 velocity decibels (VdB) and 0.2 inches per second (in/sec) peak particle velocity (PPV), respectively. These groundborne noise and vibration levels could result in annoyance or architectural/structural damage and would be *potentially significant*.

Construction induced vibration impacts would be potentially significant. While implementation of mitigation measures would reduce potential impacts, it is not known whether these measures would reduce potential impacts to *less-than-significant* levels. As mitigation, EBMUD would avoid siting proposed construction activities in close proximity to vibration-sensitive land uses. If avoidance is not possible, EBMUD would site these construction activities as far from vibration-sensitive land uses as possible. Implementation of reduction measures (which may include, but are not limited to, designating a preservation director to manage complaints; recording the pre-existing condition of all buildings in close proximity to construction activities; conducting vibration monitoring during pile-driving operations; providing protective coverings for nearby historic features; and using alternative pile-driving methods) would reduce the exposure of sensitive receptors to project-generated vibration levels; however, potential impacts would be *potentially significant*.

5.2.2.7 Climate Change

Under the No-Project Alternative, replacement water supplies would be obtained from transfers (surface water and/or groundwater sources) and/or desalination plants. Operation of FRWP and associated facilities to convey replacement waters from the Sacramento River at FRWP intake to the Folsom South Canal and on to the Mokelumne Aqueducts for use in the East Bay would require additional pumping relative to the project conditions. Operation of desalination facilities would also require additional pumping and result in higher greenhouse gas emissions. Anticipated increases in greenhouse gas emissions due to the operation and use of the replacement water supplies would be offset by EBMUD's and Pacific Gas and Electric Company (PG&E)'s plans to increase its renewable energy sources. As a result, this impact would be *less than significant*.

Impact GHG-1(NP): Increase in GHG emissions resulting from additional pumping to move water (Less than Significant)

Under the No-Project Alternative, replacement supplies might be obtained through water transfers (surface water and/or groundwater sources). To convey waters from the Sacramento River FRWP intake to the East Bay would require pumping at three locations in addition to the Walnut Creek Pumping Plant: 1) from the Sacramento River at Freeport to the FSC, 2) through the FSC at Clay Station Pumping Plant, and 3) at Camanche Pumping Plant to pump the water into the Mokelumne Aqueducts to overcome the pressure (head) of water already in the aqueducts that was diverted upstream at Pardee Reservoir.

As described in Chapter 7, Climate Change, 77% of EBMUD's GHG emissions on an annual basis are due to electricity purchases, primarily from PG&E. The carbon content of PG&E's electricity would decline over time as electricity providers in California comply with the California Renewables Portfolio Standard (RPS) (SB 1078, SB 107 and SBX 1-2).

The GHG emissions associated with the No-Project Alternative are greater than under project conditions due to a larger electricity demand from the development of replacement supplies. Largely due to increasing levels of renewable power in PG&E's power portfolio, as well as EBMUD's energy efficiency programs, increased use of onsite renewables, greening of EBMUD's fleet, and

other sustainability efforts, the resulting emissions from the No-Project Alternative would be less than baseline conditions. As a result, the GHG impact associated with the No-Project Alternative is expected to be *less than significant*.

5.2.2.8 Agricultural Resources

Under the No-Project Alternative, replacement water supplies would be obtained from water transfers (surface water and/or groundwater source) and/or desalination plant. The use of either surface water source or groundwater source could affect the amount of water available for agricultural resources; however, as explained below, this impact would be *less than significant*.

Impact AG-1(NP): Potential reduction of surface water supply for agricultural use by upstream water rights holders (Less than Significant)

As described above under Impact AIR-1(NP), obtaining replacement water supplies under the No-Project Alternative could result in a reduction in water available for agricultural use by upstream water rights holders. Depending on the specifics of the transfer transactions, thousands of acres of idled farmland could be idled. Because the specifics of the replacement supplies are unknown and because a large number of acres could be involved, the reduction of water supply for agricultural use would be potentially significant. Although the decision to enter into a transfer agreement is voluntary, other actions such as planting cover crops or converting to less water intensive crops or grasslands may reduce the impacts to *less than significant*.

5.2.2.9 Recreational Resources

As described in Section 5.2.2.1, Water Resources, water from replacement sources would represent a small percentage of overall Sacramento River flow and, as such, water levels would only be slightly affected. Additionally, the use of additional groundwater supplies would not have any impact on recreational resources. For these reasons, the following potential impact on recreational resources would be *less than significant*.

Impact REC-1(NP): Change in water-dependent and water-enhanced recreation opportunities on source water bodies (Less than Significant)

Under the No-Project Alternative, replacement water supplies would be obtained from water transfers (surface water and/or groundwater source) and/or desalination plants. For replacement waters obtained from a surface water source, alterations to water levels in upstream water bodies as a result of the diversion of replacement supplies at the FRWP are assumed to be minimal. Depending on the surface water source, small changes to water-surface elevations might occur in the associated reservoirs, as well as in the river stretches downstream of the reservoirs. However, these impacts would most likely be *less than significant*.

5.2.2.10 Visual Resources

Visual resources could be affected by water transfers from the Sacramento River via the FRWP intake facility through small changes in water-surface elevations in upstream reservoirs and the river stretches downstream of the reservoirs. However, as described in Section 5.2.2.1, Water Resources, the water needed for replacement supplies would not be expected to significantly affect overall Sacramento River flow and, as such, water levels would only be slightly affected. For this reason, the following potential impact on visual resources would be *less than significant*.

Impact VIS-1(NP): Adversely affect a scenic vista, or degrade the existing visual character or quality, of upstream reservoirs, rivers, and their surroundings (Less than Significant)

Under the No-Project Alternative, replacement water supplies would be obtained from water transfers (surface water and/or groundwater sources) and/or desalination plants. Depending on the specific surface water source seasonal and permanent scenic vistas exist from upstream reservoirs, nearby roadways, hiking trails, and the river shoreline. Under baseline conditions, water levels at upstream reservoirs retreat periodically such that soil normally submerged around the shoreline is exposed. This is often referred to as the “bathtub ring” effect. Under the No-Project Alternative, the bathtub ring effect could be altered very slightly due to the diversion of replacement water supplies. Changes to the bathtub ring effect in upstream water bodies would likely be minimal, although this is difficult to determine without an identification of the source, and would not be expected to cause a significant effect on the visual character of upstream water bodies and surrounding areas. This impact would most likely be *less than significant*.

5.3 Growth Inducement

As described in Chapter 8, Other CEQA Analyses, of this EIR, the Project would continue to provide water supplies from the Mokelumne River to support demand in the EBMUD service area communities. The No-Project Alternative includes actions EBMUD would undertake to obtain replacement supplies to support the same demand in the EBMUD service area communities. The land-use agencies have evaluated the potentially significant effects of growth in their respective general plans and related environmental impact reports. These analyses found that there are significant, and in some cases unavoidable, impacts that would result from planned growth. The level of growth would be similar to that identified for the Project and discussed in Section 8.2 of this EIR.

5.4 Environmentally Superior Alternative

CEQA Guidelines Section 15126.6(e)(2) states that “[i]f the environmentally superior alternative is the ‘no project’ alternative, the EIR shall also identify an environmentally superior alternative among the other alternatives.” As discussed in Section 2.6, there are no feasible alternatives to the Project. Therefore, the requirement to identify an environmentally superior alternative does not apply to this EIR. Nevertheless, note that, as described below, the Project is the environmentally superior alternative.

As evaluated under project conditions, potentially significant impacts on fish resources (adult fish migration habitat) and agricultural resources (diversions by Jackson Valley Irrigation District, senior water rights holder) were identified. Both potentially significant impacts were determined to be *less than significant with mitigation*.

Under the No-Project Alternative, the impacts on the Mokelumne River basin would be slightly reduced, but these impacts could shift to other water bodies and other watersheds from which the replacement supplies would originate. Use of replacement water supplies such as desalination plants and water transfers from surface water and/or groundwater sources could result in the

construction of new facilities, new operational scenarios, additional pumping with potentially significant impacts on air quality and noise.

Both the Project and No-Project Alternative would generally require pumping of deliveries above 200 MGD. Under the Project, approximately 30 MGD would be pumped through the Mokelumne Aqueducts using the Walnut Creek Pumping Station. Under the No-Project Alternative, approximately 14 MGD would be pumped through the Mokelumne Aqueducts and 16 MGD would be pumped from the Sacramento River via the FRWP intake facility to the Mokelumne Aqueducts. Deliveries from the Sacramento River have higher energy intensity (kilowatts per hour [kwh]/MGD) than deliveries from Pardee reservoir, due to the longer distance and additional pumping required to deliver the water from the lower elevation.

The No-Project Alternative could increase the frequency of use of FRWP facilities from dry years to all year types, thereby creating additional operational and maintenance issues and increasing pumping. The No-Project Alternative would require more pumping to not only convey replacement supplies a greater distance from their sources, but also require more pumping to overcome a higher gradient as compared to the Project. Additional pumping that would be needed at the lower elevation facilities would result in greater GHG emissions.

The availability of replacement supplies is uncertain and is dependent on a number of factors including water quality, timing, and coordination with other entities. If replacement supplies are available, the use would require complex partnership agreements and operational coordination agreements with numerous shareholders. EBMUD would have to overcome significant institutional hurdles.

Under the Project, EBMUD would continue to use existing facilities and would continue to operate in an environmentally superior manner by using gravity flow to the maximum extent possible. As a result, the Project would be the environmentally superior alternative.

Programmatic Evaluation of Use of Permit 10478

This programmatic evaluation discusses how EBMUD would continue to use Permit 10478 to meet customer demands beyond 2040 for the Permit 10478 Time Extension Project (Project). As noted in Chapter 1, Objective and Need of the Permit 10478 Time Extension Project, and Chapter 2, Project Description, Baseline, and Alternatives, of this EIR, water demands in the EBMUD service area are expected to continue to grow beyond year 2040 as population grows and businesses develop. Because most planning documents for the communities that EBMUD serves do not extend beyond 2040, it would be speculative to estimate the details of use beyond 2040 with any degree of certainty. Nevertheless, it is prudent to assume that demand will continue to increase beyond 2040. EBMUD has included a programmatic assessment of impacts beyond 2040 in this EIR with the recognition that continuing the availability of the full entitlement of Permit 10478 will be necessary to ensure that EBMUD has a sufficient supply of water available to meet existing and future demands in EBMUD's service area.

The potential future water needs are discussed along with the potential environmental impacts associated with the continued use of Permit 10478. Because it is not possible to accurately project future population growth, density, and environmental conditions far into the future, the analysis makes numerous assumptions as to what conditions might be in the future based on current and historical trends and existing readily available information such as the Department of Finance growth projections for Alameda and Contra Costa Counties.

This evaluation includes a general, program-level evaluation of the continuing use of the Permit 10478 water supplies beyond year 2040. Under this scenario, similar to current conditions, EBMUD could use supplemental water supplies from other sources including water transfers and conjunctive use programs to meet dry-year needs. In the future, prior to undertaking any of these supplemental supply programs, EBMUD would complete project-level CEQA analysis of the potential environmental impacts.

6.1 Water Use Beyond 2040

As described in Chapter 1, Objective and Need of the Permit 10478 Time Extension Project, due to a variety of factors, including EBMUD's aggressive conservation and recycling efforts, EBMUD has not yet used the maximum volumes of water allowed under Permit 10478, although EBMUD has diverted at the maximum diversion rate of 325 million gallons per day (MGD) numerous times in the past.

As noted, forecasting demand and developing planning-level scenarios beyond 2040 requires numerous assumptions to be made regarding technical, environmental, regulatory, political, financial, and economic factors that are too uncertain and speculative to determine with confidence at this time. It is nonetheless reasonable to assume that demands in the EBMUD service area would continue to rise beyond the year 2040 as population growth in the Bay Area continues. In the future, as the year 2040 approaches and demand and environmental conditions can be ascertained with a higher degree of certainty, EBMUD would adjust its water supply tools and portfolios as needed to meet demands beyond 2040.

Based on recent California State Department of Finance population projections to the year 2060 for Alameda and Contra Costa Counties, EBMUD calculated a 25% increase in population from years 2010 to 2060 in EBMUD's service area (EBMUD's service area generally encompasses 57% of Alameda County and 48% of Contra Costa County). By assuming a linear growth rate, EBMUD estimates that its service area population would be over 1.9 million residents toward the end of this century. As a result, rough estimates indicate that EBMUD's water demand could be expected to reach an average annual demand of 275 MGD toward the end of this century. While acknowledging that the extended estimate is necessarily based on numerous assumptions, this data forms the most reasonable information available at this time on which to base this programmatic-level analysis.

At 275 MGD average annual demand, EBMUD would divert up to its full permitted quantity of 325 MGD from the Mokelumne River, when it is hydrologically available, for immediate use in the East Bay and to bank the remaining diversions (up to 50 MGD) in a groundwater basin for later use. An average annual demand of 275 MGD would be met through a combination of demand-management measures along with surface supplies from the Mokelumne River when diverted in accordance with EBMUD's existing water supply authorizations, as well as various supplemental supplies when surface water supplies from the Mokelumne River alone are not sufficient to meet demand.

Under this general evaluation, in normal and wet years, EBMUD would rely completely on its Mokelumne River surface water entitlements to meet service area demand, i.e., EBMUD would divert up to 325 MGD from the river to meet service area demand and to bank the remaining supplies for later use in drier years. When Mokelumne River flow is not sufficient to meet EBMUD service area demands, similar to the current conditions, EBMUD would rely on supplemental supplies to help meet its needs and obligations. These supplemental supplies could include EBMUD's existing Central Valley Project (CVP) contract, new long-term water transfers (via existing Freeport Regional Water Project [FRWP] facilities), and previously banked groundwater from available basins. For this programmatic evaluation, EBMUD has developed a number of assumptions regarding the various water supply components that could be implemented to ensure that EBMUD can meet both its statutory and regulatory obligations. These assumptions are briefly described below.

6.2 Water Supply Programs to Meet Future EBMUD Service Area Needs

This programmatic analysis examines the use of the full quantities available under Permit 10478 to serve anticipated future demand beyond 2040. While EBMUD has already diverted water at the maximum rate allowed under Permit 10478 at certain times, its annual demands to date have not required the full use of the permit on an average annual basis. With an average annual demand of 275 MGD, EBMUD would expect to fully use Permit 10478 in normal and wet years when sufficient quantities are available. This analysis also discusses other options available to EBMUD, based on existing knowledge and information, to supplement supplies from the Mokelumne River in drier years to ensure that EBMUD can reliably meet a future service area average annual demand of 275 MGD and its downstream release obligations. While it is speculative and not feasible to specifically identify how increased demands might be met or the mix of programs that could be implemented to meet this demand in every year, the Water Supply Management Program (WSMP) 2040 provides a basic framework for a program-level discussion of EBMUD's need for use of Mokelumne supplies beyond 2040.

6.2.1 Continued Use of Permit 10478 under Existing Terms

When water is available under Permit 10478 (generally normal and wet years) in the Mokelumne River in accordance with the established water rights priorities, water rights entitlements, and regulatory requirements, including the existing Joint Settlement Agreement (JSA), EBMUD would continue to divert, consistent with its existing entitlements, the volume of water necessary to meet service area demands. No additional infrastructure or operational changes would be necessary to maintain the continued operation under Permit 10478 to meet EBMUD's service area demands.

In drier years, similar to current conditions, EBMUD would require additional supplies to supplement its Mokelumne River surface water supplies. The following is a brief discussion of the efforts EBMUD could possibly undertake to supplement its Mokelumne River supplies to ensure that EBMUD's water supply needs can continue to be met in drier years while continuing to meet all statutory and regulatory obligations.

6.2.1.1 Mokelumne River—Groundwater Banking/Conjunctive Use

EBMUD could develop a conjunctive use program in partnership with other agencies to help meet its below normal and dry year needs by using the Mokelumne River and other supplies as appropriate, when sufficient surface water is available. In wetter years, additional water in excess of what is needed to meet customer demands could be diverted for groundwater banking. *Groundwater banking* is using dewatered aquifer space to store surface water supplies during years when surplus surface water is available, i.e., during normal to wet years. Based on an assumed average annual demand of 275 MGD, EBMUD could bank up to 50 MGD of Mokelumne River water in years with flood-control releases (i.e., normal and wet years).

In drier years, when Mokelumne River flow is not sufficient to meet all of EBMUD's demands, EBMUD would extract and release a portion of the banked groundwater into the Mokelumne Aqueducts to meet customer demand. The precise amount of water extracted would depend on the regional partnership agreements, pretreatment capabilities, as well as aqueduct availability and demands in EBMUD service area.

It is assumed for this analysis that the maximum annual amount that could be banked is 50 MGD, while 25 MGD would be the maximum that could be extracted in any one year.

6.2.1.2 Water Transfers

During dry years, when EBMUD's Mokelumne River surface supplies and groundwater supplies are not sufficient to meet demand, EBMUD would need to acquire supplemental supplies, and could do this through a series of water transfers in 25 MGD increments, up to 50 MGD, to meet demands during multiyear droughts. At this time, EBMUD has not yet identified the source of water transfers to meet these demands. For purposes of this programmatic assessment, it is assumed that EBMUD would seek water transfers with partners in the Sacramento Valley, or with partners who have supplies that originate north of the Sacramento–San Joaquin River Delta (Delta). It is also assumed that EBMUD would utilize the FRWP facilities and the Mokelumne Aqueducts to convey the transferred water to EBMUD's service area. Additional pumping would be required to convey the transferred water to the East Bay.

6.2.2 Camanche Reservoir and Mokelumne Aqueduct Connection

When EBMUD applied for Permit 10478 (Application 13156), the application included among the facilities listed a direct connection from Camanche Reservoir to the Mokelumne Aqueducts. To date, EBMUD has not yet needed to construct this connection because it has developed an environmentally superior method of operation that relies on gravity to the maximum extent practicable to convey water from Pardee Reservoir through the aqueducts to the service area. In the future, well beyond year 2040, as EBMUD demands continue to grow it may be desirable for EBMUD to have the flexibility to draw water directly from Camanche Reservoir to meet both its service area needs and regulatory requirements. Permit 10478 allows waters to be stored and withdrawn from both the upstream Pardee Reservoir and Camanche Reservoir. Water is presently diverted to the Mokelumne Aqueducts at Pardee Reservoir, which is at a higher elevation. With the existing infrastructure, through year 2040 with an estimated average annual demand of 230 MGD, EBMUD can continue to operate the Pardee and Camanche Reservoirs in a coordinated manner to meet service area demands and other obligations. In the future, as demands grow, a direct connection at Camanche Reservoir could provide EBMUD with greater operational flexibility by allowing the withdrawal of water from either Pardee or Camanche Reservoir. Establishing a direct connection from Camanche Reservoir to the Mokelumne Aqueducts could involve construction of the following facilities:

- new intake structure for the Camanche Reservoir outlet works,
- new pipeline, and
- new pumping plant, and other appurtenant facilities.

See Section 6.3.3, Possible Environmental Effects Associated with Constructing a Camanche Reservoir and Mokelumne Aqueduct Connection, for a qualitative assessment of impacts.

6.3 Assessment of Impacts

This programmatic assessment of impacts describes potential impacts on environmental resources that could occur as a result of the continued use of the supplies available under Permit 10478 to meet EBMUD's demand beyond 2040. This assessment recognizes that the permitted quantities would likely be fully used on an annual basis in wet and normal years when EBMUD's average annual demand is 275 MGD. A brief generalized discussion of impacts is also included for the potential direct connection between Camanche Reservoir and the Mokelumne Aqueducts. In the future, EBMUD would complete the appropriate project-level CEQA analysis of a direct connection when demand increases and if it is determined by EBMUD that a direct connection is needed.

6.3.1 Methods and Assumptions

This programmatic evaluation associated with meeting future EBMUD water demands beyond 2040 includes

- a qualitative evaluation of potential environmental effects on the Mokelumne River system associated with aqueduct diversions to meet a future EBMUD service area average annual

demand of 275 MGD, as met by the continued use of Permit 10478 under its existing terms and conditions; and

- a discussion of possible environmental effects associated with the construction and use of a connection between Camanche Reservoir and the Mokelumne Aqueducts to divert water directly from Camanche Reservoir and send this water to EBMUD's service area.

A qualitative evaluation of potential environmental effects related to the continued use of Permit 10478 is based on potential changes in hydrology associated with the increase in average annual demand of approximately 61 MGD (i.e., from 214 MGD in 2005 [baseline conditions] to 275 MGD in the future [assumed programmatic conditions]). Due to the speculative nature of programmatic conditions, a qualitative evaluation of potential environmental effects is presented below.

The discussion of possible environmental effects associated with the construction and use of a Camanche Reservoir/Mokelumne Aqueducts connection is based on existing, readily available information, coupled with a general understanding of the impacts that would be expected to occur during the construction and operation of the connection, and professional judgment. As noted earlier, in the future EBMUD would complete appropriate project-level CEQA analysis of the direct connection if it is determined that a direct connection is needed.

Each assessment is described below under Sections 6.3.2, and 6.4.4, respectively. Assumptions related to each assessment are described under each applicable impact discussion.

6.3.1.1 Significance Criteria

Similar to the assessment of impacts presented for the Project in Chapter 3, Impacts and Mitigation Measures, the criteria used for determining the significance of an impact on a resource for this programmatic evaluation were generally based on Appendix G, Model Environmental Checklist, of the State CEQA Guidelines and professional standards and practices. Chapter 3, Impacts and Mitigation Measures, presents specific significance criteria, as well as the regulatory and environmental settings, for water; fish; vegetation, wetlands, and wildlife; agricultural; recreational; and visual resources.

6.3.1.2 Limitations of this Programmatic Evaluation

Because it is not possible to accurately project environmental conditions far into the future, this programmatic evaluation makes numerous assumptions as to what conditions might exist in the latter part of this century when the full use of Permit 10478 is anticipated to be reached. The impact assessments described in the following sections are based on current and historical trends and existing, readily available information. Although significance conclusions are presented for each impact, it is not known with certainty what actually would occur under future conditions.

In the event EBMUD finds it necessary in 2040 to petition the State Water Board to extend the terms of Permit 10478 beyond 2040, EBMUD will be required to undertake a similar CEQA analysis for the Project at that time, and the State Water Board would then review the proposed extension based on the facts and circumstances existing at that time.

6.3.2 Potential Environmental Effects Associated with Continued Use of Permit 10478 Beyond 2040

6.3.2.1 Assumptions

Certain operational assumptions have been developed to analyze the continued use of Permit 10478 beyond year 2040. These operational assumptions are dependent on many factors including operating agreements with regional partners, engineering design, regulatory conditions, and other factors. Actual operations under this scenario cannot be determined because such operations would be dependent on numerous factors that cannot be accurately predicted at this time, such as the timing and availability of other water supplies, actual growth in demand, and climate conditions, among others. The following analysis is included to provide a discussion of possible impacts of future operations on the Mokelumne River system to meet EBMUD service area demand beyond 2040.

6.3.2.2 Impact Discussion

This programmatic evaluation of continued use of Permit 10478 beyond 2040 examines EBMUD's full use of Permit 10478 to divert 325 MGD from the river. For analytical purposes, the evaluation assumes EBMUD would do this to meet a service area demand of 275 MGD. The estimated increase in demand of 61 MGD from baseline to programmatic conditions is approximately four times the increase of 16 MGD expected to occur from baseline to project conditions.

Because the Mokelumne River system cannot meet this level of demand in drier years, similar to the project-level analysis, this analysis also assumes the implementation of one or more programs that would provide necessary supplemental water supplies to meet that level of demand in all years. This impact discussion describes potential environmental effects associated with the continued use of Permit 10478.

This impact discussion is limited to the potential impacts related to the following:

- Water quality,
- Fish resources,
- Vegetation, wetlands, and wildlife resources,
- Agricultural resources,
- Recreational resources, and
- Visual resources.

The following sections present a qualitative discussion of environmental effects on the resources listed above.

Water Resources

Under programmatic conditions, minimum flows in the Mokelumne River would still be maintained as required by the JSA; however, on average, flows would be lower than under project conditions. In addition, programmatic conditions could result in greater fluctuations or decreased storage in Camanche Reservoir. Programmatic conditions could result in reduced peak flows, reduced

groundwater recharge, reduced levels of dissolved oxygen, increased water temperature, and reduced inflow to the Delta.

The potential impacts on water resources that were discussed in Chapter 3 for the Project included reduced groundwater recharge, reduced flooding, reduced levels of dissolved oxygen, and reduced water quality in the Delta. These impacts could be greater under programmatic conditions; however, the impacts on groundwater recharge, dissolved oxygen, and Delta water quality would be so small or negligible under project conditions that it is unlikely these potential impacts would be of concern under programmatic conditions. As a result, these potential impacts under programmatic conditions are considered to be *less than significant*.

It is possible that programmatic conditions could significantly reduce flooding along the lower Mokelumne River. This would be considered a beneficial effect, although high flows are important for other resources, such as riparian and wetland habitats and spawning habitat for anadromous fish. As discussed in the following sections, hydrologic effects associated with the programmatic scenario could affect other resources. For example, increased water temperature could affect fish, increased reservoir drawdown and reduced peak flows could affect recreation, and reduced floodplain inundation could affect habitat for fish and wildlife. These potential impacts are evaluated below.

Fish Resources

Potential fish impacts associated with diverting water from Pardee Reservoir are listed below.

Potential Effects Related to a Reduction in River Flow

- Reduced migration habitat for adult fall-run Chinook salmon and steelhead
- Reduced spawning and rearing habitat for fall-run Chinook salmon and steelhead
- Reduced outmigration habitat for juvenile fall-run Chinook salmon and steelhead
- Reduced floodplain habitat for native fish species
- Reduced mobilization of substrate for salmonid spawning habitat maintenance
- Reduced flows that support native fish species habitat

Potential Effects Caused by Changes in Reservoir Storage

- Short or long-term losses of habitat quantity or quality for warmwater fish species
- Short or long-term change of water temperature for coldwater fish species

Potential Effects on Delta Habitat

- Reduction in survivability and habitat for anadromous and estuarine fish species

Potential Effects on Water Quality that Could Affect Fish

- Reduction in water quality (dissolved oxygen, pH, and turbidity) for fall-run Chinook salmon and steelhead
- Reduction in suitable water temperatures for fall-run Chinook salmon or steelhead

Under project conditions, only one potential effect on fish from those listed above was determined to be significant: *Reduced migration habitat for adult fall-run Chinook salmon and steelhead in the lower Mokelumne River*. Other potential impacts on fish resources were considered *less than significant*.

Under Programmatic conditions, the impact “Reduced migration habitat for adult fall-run Chinook salmon and steelhead in the lower Mokelumne River” would be considered *significant*. Compared to baseline conditions, this impact would occur in 9 more years during September and 3 additional years during October through February under programmatic conditions.

Implementation of Mitigation Measure FISH-1, as proposed in Chapter 3, Impacts and Mitigation Measures, would reduce this impact to *less than significant with mitigation*. Analysis of programmatic conditions projected flows below Woodbridge dam confirms the feasibility of the proposed mitigation. To provide 100 cfs flow below Woodbridge dam for the month of September, projected floodflow or JSA adaptive management releases in the previous May and June can be reduced by 4% to 20% without significantly impacting salmonid life stages. During critically dry years when floodflow or JSA adaptive management releases are unavailable, flows below Woodbridge dam range from 45 to 73 cfs. Although adult fall-run Chinook salmon and steelhead have been observed passing Woodbridge dam at flows less than 45 cfs, to ensure adult salmonid fish passage during these rare events, instream habitat improvements will be implemented to eliminate any impediments from Woodbridge dam downstream to tidal influence.

The difference between the baseline and programmatic conditions regarding warmwater fish species habitat is one additional year where fluctuations exceed warmwater fish criteria during August (2 years instead of 1 year) in Pardee Reservoir and one additional year in Camanche Reservoir during May (2 years instead of 1 year). This impact would be considered *less than significant*.

The difference between the baseline and programmatic conditions regarding coldwater fish species habitat is one additional year where elevations exceed coldwater fish criteria during September, October and November (2 years instead of 1 year) in Camanche Reservoir and no difference in Pardee Reservoir. This impact would be considered *less than significant*.

Other potential impacts on fish resources were considered *less than significant*.

Vegetation, Wetlands, and Wildlife Resources

Special-Status Plants

The continued use of Permit 10478 beyond 2040 would not have a significant impact on special-status plants caused by reservoir water-surface fluctuations and/or reduced frequency of river maintenance flows compared to baseline conditions because most special-status plants are presently not located in areas that already experience changes in water-surface elevations at Pardee or Camanche Reservoirs or changes in the frequency of maintenance flows in the lower Mokelumne River under baseline conditions (see Section 3.3, Vegetation, Wetlands, and Wildlife Resources, for more information on special-status plants in the area), nor is it anticipated that special-status plants would be present in areas that would experience changes in hydrology under programmatic conditions. As a result, there would be *no impact* from changes in reservoir water-surface elevations or river flows on special-status plants as a result of implementing the continued use of Permit 10478 beyond 2040. No mitigation is necessary.

Special-Status Wildlife, Riparian Communities, and Wetland Habitats

Continued use of Permit 10478 beyond 2040 could affect special-status wildlife species as a result of habitat modification, specifically riparian and wetland habitat effects resulting from reservoir water-surface fluctuations and flow changes. These potential impacts are described below.

Pardee and Camanche Reservoirs

The continued use of Permit 10478 beyond 2040 could result in changes in reservoir storage at Pardee and Camanche Reservoirs. Historically, fluctuations at these reservoirs, in response to day-to-day operations and changes in runoff patterns, affected vegetation that established at or near the water surface and within the drawdown zone. Similarly, vegetation that periodically established in the drawdown zone or near the waters' edge was commonly inundated and lost during prolonged periods of high storage, while plants that established during periods of high storage could be lost during periods of reduced reservoir storage or drought. Fluctuations in reservoir elevation under the programmatic scenario would be similar to those experienced under baseline conditions, and vegetation would continue to experience a similar cycle of establishment, inundation, and loss, as water elevations rise and fall seasonally and in response to precipitation and flood-control requirements. Therefore, the impact of implementing the continued use of Permit 10478 beyond 2040 on reservoir vegetation, as well as on special-status wildlife species that inhabit these areas, would most likely to be *less than significant*. No mitigation is necessary.

Lower Mokelumne River

Implementing the continued use of Permit 10478 beyond 2040 could affect flow in the lower Mokelumne River; however, these affects are anticipated to be infrequent and minor reductions in flows, which would most likely not have a significant effect on channel maintenance flows in the lower Mokelumne River. Therefore, the impacts of operations associated with implementing the continued use of Permit 10478 beyond 2040 on lower Mokelumne River vegetation, as well as on special-status wildlife species that inhabit these areas, would most likely be *less than significant*. No mitigation is necessary.

Agricultural Resources

The continued use of Permit 10478 beyond 2040 would not affect senior agricultural water rights holders because EBMUD would continue to manage its water to meet obligations to senior agricultural water rights holders, such as the Jackson Valley Irrigation District (JVID) and Woodbridge Irrigation District (WID).

The assessment presented for the Project in Section 3.4, Agricultural Resources, determined that the Project would have a significant impact on JVID, which diverts water off Pardee Reservoir for agricultural and municipal uses in 1 year of the 89-year period, due to changes in Pardee water surface elevation. However, that potentially significant impact would be reduced to less than significant by the implementation of Mitigation Measure AG-1 described in Section 3.4. In addition, for this programmatic evaluation JVID is expected to be able to obtain water from the Amador Canal by the year 2020, 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 the full 3,850 acre-feet at Pardee Reservoir, there could be intermittent limitations as a result of low water surface elevations at Pardee Reservoir under programmatic conditions. To ensure that JVID could continue to divert its senior water right at Pardee Reservoir when it is available under its water right priority,

EBMUD will work with JVID on the installation of a submersible pump in Pardee Reservoir for JVID to divert water into its diversion facility and pipeline as described in Section 3.4.3.3. Therefore, under programmatic conditions, the impact on JVID is assumed to be *less than significant with mitigation*.

EBMUD's obligations to WID are set forth in a series of agreements between the two agencies. EBMUD's obligations under these agreements are determined by inflow to Pardee Reservoir. Inflow to Pardee Reservoir is not expected to change under programmatic conditions. Therefore no impact on WID is expected.

The full use of Permit 10478 on an average annual basis would affect the surface water supplies provided to North San Joaquin Water Conservation District (NSJWCD) pursuant to its permit issued under Water Code Section 1462, which allows for the temporary appropriation of water in excess of the quantity used by EBMUD under Permit 10478. NSJWCD historically has used up to 9,488 acre-feet per year (AFY) under its Permit 10477, and in the last 10 years, diversions have declined to between 2,000 and 4,000 AFY. When EBMUD makes full use, there would be no excess available for temporary appropriation.

However, notwithstanding the nature of NSJWCD's existing right, the amount of surface water available to NSJWCD under programmatic conditions would be dependent on potential future groundwater banking agreements between EBMUD, NSJWCD and other entities in San Joaquin County. Under programmatic conditions, EBMUD anticipates the possible development of conjunctive use projects in San Joaquin County. While it is speculative to anticipate the terms of these arrangements, EBMUD could continue to provide surface water storage to NSJWCD in years when water is available under NSJWCD's water right. Moreover NSJWCD could derive other potential benefits such as increased reliability of groundwater supplies and changing groundwater levels from participation in a conjunctive use project.

Under baseline conditions, NSJWCD receives surface supplies up to its full entitlement of 20 thousand acre-feet (TAF) in 48 years out of the 89-year period of record (53% of the time) and a reduced amount of 13 TAF in 1 year. During the years when water is not available (nearly 47% of the time under baseline conditions), NSJWCD relies on use of groundwater supply or other rights. Under programmatic conditions, EBMUD assumes that NSJWCD would receive surface supplies up to its full entitlement of 20 TAF in 43 out of 89 years (48% of the time) and a slightly reduced amount of 19 TAF in an additional year. Therefore, under programmatic conditions, NSJWCD would need to rely on groundwater or other supplies nearly 52% of the time, an increase of nearly 6% from baseline conditions. The temporary nature of NSJWCD's Permit 10477 water right combined with NSJWCD's ongoing operations to use other water sources would reduce the impact on agricultural resources to *less than significant*.

Recreational Resources

The continued use of Permit 10478 beyond 2040 could potentially have impacts on recreational resources at Camanche Reservoir. In particular, access to the main boat launches at both the Camanche North Shore Recreation Area and the Camanche South Shore Recreation Area could be affected. According to EBMUDSIM modeling results (Appendix E), and as demonstrated in Table 6-1, limited access to these boat launches could increase by approximately 10% under programmatic conditions relative to baseline conditions. Considering that limited access to these boat launches would not generally increase by more than 10.3% of the time under programmatic conditions

compared to baseline conditions, and that future conditions under the programmatic scenario are highly speculative, these impacts are considered to be *less than significant*.

Table 6-1. Boat Launch Operations Affected under Programmatic Conditions Relative to Baseline Conditions

Boat Launch	Lowest Operational Water Surface Elevation (ft msl)	Reservoir Storage (AF)	Increased Limited Access Relative to Baseline ^a	
			Number of Months	Percent of Time (%)
Pardee Recreation Area				
Main Boat Launch	540	142,420	10	1.2
Low Water Boat Launch	495	75,480	1	0.1
Camanche Reservoir North Shore Recreation Area				
Main Ramp (full 8 lanes)	210	247,231	107	10
Main Ramp (reduced 2 lanes)	194	164,370	32	3
Main Ramp, Low-Water Ramp	160	54,246	5	0.5
Camanche Reservoir South Shore Recreation Area				
Main Ramp	205	219,265	110	10.3
Main Ramp, Low-Water Ramp	175	91,528	-1	-0.1
Main Ramp, Very-Low-Water Ramp	160	54,246	5	0.5

Notes:

^a Data reflected here represents the increased amount of time in which boat launch operations would be affected under continued use of Permit 10478 beyond 2040 conditions relative to baseline conditions. This data was calculated from EBMUDSIM modeling results (Appendix E), which used 89 years of historical data (1921 to 2009) to model baseline and programmatic conditions (Appendix M). The total number of months that the Pardee Recreation Area boat launches are open to the public is 801 months during this time frame (February through October from 1921 to 2009). The total number of months that the Camanche Reservoir Recreation Area boat launches are open to the public is 1,068 months during this time frame (year-round or 12 months out of the year from 1921 to 2009).

AF = acre feet; ft msl = feet above mean sea level.

As shown in Table 6-2, impacts on recreational resources on the Lower Mokelumne River would be expected to be less than significant. A 30% reduction in flows below 325 cfs generally equates to a 3-inch or more reduction in water surface elevation at Stillman Magee Park. A 20% reduction in flows would result in even less of a reduction in water surface elevation at Stillman Magee Park. According to EBMUDSIM modeling results, the average percent occurrence when low to moderate lower Mokelumne River flows were reduced by more than 20%, increased by 7% under programmatic conditions relative to baseline conditions (i.e., less than the 10% threshold). For these reasons, this impact is considered to be *less than significant*.

Table 6-2. Occurrence when Low to Moderate Lower Mokelumne River Flows Were Reduced by More than 20% under Programmatic Conditions Relative to Baseline Conditions

Month	Number of Months ^a	Percent Occurrence (%) ^a
January	11	12.4
February	12	13.5
March	8	9.0
April	2	2.2
May	0	0.0
June	0	0.0
July	0	0.0
August	0	0.0
September	8	9.0
October	11	12.4
November	12	13.5
December	11	12.4
Total	75	7.0 (average)

^a Number of months and percent occurrence over the 89-year (1,068 months) hydrologic record simulated by EBMUDSIM

Visual Resources

The continued use of Permit 10478 beyond 2040 could potentially have impacts on visual resources at the Camanche Reservoir. According to EBMUDSIM modeling results, and as shown in Table 6-3, the average occurrence for Camanche Reservoir water-surface elevations to drop by more than 10 feet could increase by approximately 10% under programmatic conditions compared to baseline conditions. Considering that the frequency at which the elevation for Camanche Reservoir would drop by more than 10 feet would not increase by more than 10.3% of the time under programmatic conditions compared to baseline conditions, and those future conditions under the programmatic scenario are highly speculative, this impact is considered to be *less than significant*.

As shown in Table 6-3 and Table 6-4, impacts on visual resources at Pardee Reservoir and along the lower Mokelumne River would occur well below the 10% threshold of significance, and therefore, are also considered to be *less than significant*.

Table 6-3. Occurrence when Reservoir Elevations Dropped by More than 10 Feet under Programmatic Conditions Relative to Baseline Conditions

Month	Pardee Reservoir		Camanche Reservoir	
	Number of Months	Percent Occurrence (%)	Number of Months	Percent Occurrence (%)
January	5	5.6	9	10.1
February	4	4.5	11	12.4
March	4	4.5	10	11.2
April	2	2.2	9	10.1
May	1	1.1	8	9.0
June	2	2.2	7	7.9
July	2	2.2	7	7.9
August	3	3.4	10	11.2
September	3	3.4	11	12.4
October	5	5.6	9	10.1
November	5	5.6	10	11.2
December	6	6.7	9	10.1
Total	42	3.9 (average)	110	10.3 (average)

Table 6-4. Occurrence when Low to Moderate Lower Mokelumne River Flows Were Reduced by More than 20% under Programmatic Conditions Relative to Baseline Conditions

	Number of Months ^a	Percent Occurrence (%) ^a
January	11	12.4
February	12	13.5
March	8	9.0
April	2	2.2
May	0	0.0
June	0	0.0
July	0	0.0
August	0	0.0
September	8	9.0
October	11	12.4
November	12	13.5
December	11	12.4
Total	75	7.0 (average)

^a Number of months and percent occurrence over the 89-year (1,068 months) hydrologic record simulated for continued use of Permit 10478 beyond 2040 conditions compared to baseline conditions.

6.3.3 Possible Environmental Effects Associated with Constructing a Camanche Reservoir and Mokelumne Aqueduct Connection

6.3.3.1 Assumptions

As explained above under Section 6.2.2, Camanche Reservoir and Mokelumne Aqueduct Connection, in the future, it may be desirable for EBMUD to draw water directly out of Camanche Reservoir to the Mokelumne Aqueducts. Section 6.2.4 identifies some of the new facilities that would need to be constructed if EBMUD determines that the Camanche Reservoir/Mokelumne Aqueduct connection is necessary. As with any future program, key engineering details for these new facilities, such as the exact location for the construction site, are unknown and cannot be determined at this time. Because of the lack of project-specific information, any specific analysis of the potential impacts of the connection would be largely speculative. Addition of new infrastructure to EBMUD's Mokelumne Project could result in new operational rules and scenarios. Specific operational studies would be performed in the future if EBMUD determines it is desirable to draw water directly out of Camanche Reservoir to the Mokelumne Aqueduct. For purposes of this evaluation, EBMUD assumed that under programmatic conditions, diversions to the Mokelumne Aqueduct directly from Camanche Reservoir would typically occur during July through November, and that total aqueduct diversions and releases below Camanche Reservoir would remain the same as without a direct connection. The following impact assessment provides a general discussion of the types of potential environmental effects that might be expected to occur if the Camanche Reservoir/Mokelumne Aqueduct connection is undertaken.

6.3.3.2 Impact Discussion

The following presents a discussion of possible effects associated with constructing and operating a connection between Camanche Reservoir and the Mokelumne Aqueducts. At this time, operational scenarios have not been developed and it would be speculative how EBMUD would operate its Mokelumne River facilities with a direct connection. In the future, should EBMUD determine that this connection be desirable, EBMUD would be required to undertake a complete project-level analysis of the potential environmental effects associated with the new infrastructure, as required by CEQA. The following is a brief and general discussion of some of the potential impacts on resources from construction and operation of the Camanche Reservoir/Mokelumne Aqueduct connection.

- Water quality,
- Fish resources,
- Vegetation, wetlands, and wildlife resources,
- Air quality,
- Cultural resources,
- Noise,
- Recreational resources,
- Traffic, and
- Visual resources.

A general discussion of potential impacts on each resource is presented below.

Water Quality

Construction of the Camanche Reservoir and the Mokelumne Aqueducts connection could cause short-term reductions in water quality because some construction would need to occur in and adjacent to Camanche Reservoir. Construction activities could cause soil disturbance, vegetation removal, and releases of construction-related contaminants into the reservoir. Construction-related impacts on water quality could be significant. However, because construction activities that could affect water quality would be subject to regulations under the federal Clean Water Act and other state and local laws and regulations intended to minimize potential water quality impacts, complying with and implementing the regulatory measures would most likely reduce the potentially significant construction-related impacts on water quality to *less-than-significant* level.

Operation of a new intake facility at Camanche Reservoir could have a long-term effect on water temperature in the reservoir; however, multiple inlet levels would allow EBMUD the flexibility to draw water from the warmer reaches of the reservoir, thereby helping to maintain or preserve the coldwater pool. The flexibility in operations would allow EBMUD to adaptively manage its statutory and regulatory obligations to meet downstream requirements while continuing to meet its increased water supply needs. Future, more specific, operational and temperature studies would be needed to optimize operations of EBMUD's Mokelumne River facilities if additional infrastructure is added. If needed, implementing adaptive management measures to preserve the coldwater pool such as supplementing with additional water supplies would be expected to reduce potentially significant impacts on water quality to *less than significant with mitigation*.

Fish Resources

Fish resources could be affected by the potential reduction in water quality, temporary harmful noise levels and higher turbidity levels in the reservoir resulting from construction. If construction activities were to cause significant noise or turbidity problems in the water, measures required by state and federal laws and regulations, such as turbidity curtains, air bubble curtains, isolation casings, and cushion blocks would be used to reduce impacts. Therefore, impacts would be expected to be *less than significant with mitigation*.

Diverting water directly from Camanche Reservoir could result in some fish in the reservoir being entrained in the new intake structure; however, the project design would incorporate measures, such as fish screens on the intake structure, which would most likely prevent fish from becoming entrained in the new structure. Implementing appropriate mitigation measures to prevent fish entrainment in the intake structure and adaptively managing the operations with supplemental water supplies to maintain water quality and preserving the coldwater pool would minimize impacts on fish resources to *less-than-significant* level. Diversions to the Mokelumne Aqueduct from Camanche Reservoir are assumed to occur during July through November. This diversion would most likely result in lower water-surface elevations in Camanche Reservoir compared to baseline conditions. This reduction in water-surface elevation during the spawning period for warmwater fish species may have significant impacts on spawning habitat that exist in shallow water. Adaptively managing the rate of diversions from Camanche Reservoir to the Mokelumne Aqueducts to avoid significant reductions in water-surface elevations would most likely reduce these operations-related impacts on *less than significant with mitigation*.

Vegetation, Wetlands, and Wildlife Resources

The diversion of water directly from Camanche storage would most likely result in lower water-surface elevations in Camanche Reservoir than baseline conditions. This additional reduction in water-surface elevation may have significant impacts on vegetation and natural communities that exist along the drawdown zone or near the water's edge. However, implementing applicable mitigation measures, such as adaptively managing the diversions from Camanche Reservoir to the Mokelumne Aqueducts to avoid significant reductions in water-surface elevations, would most likely reduce these operations-related impacts to *less than significant with mitigation*.

Impacts related to construction of a connection from the Camanche Reservoir to the Mokelumne Aqueducts could include affect vegetation, wetlands, and wildlife located within the construction footprint. If construction activities were likely to cause significant impacts on vegetation, wetlands and wildlife resources, measures required by state and federal laws and regulations such as avoiding special-status plants, sensitive habitats would be used to reduce impacts. Therefore, impacts would most likely be *less than significant with mitigation*.

Air Quality

As explained above in earlier sections, in the future, EBMUD may draw water from the Mokelumne River directly out of Camanche Reservoir to the Mokelumne Aqueducts. Because these intakes would be at a lower elevation than the Pardee intakes, more pumping would be required to move water to EBMUD's service area. Additional indirect GHG emissions associated with increased electricity use for increased pumping at the Camanche Reservoir/Mokelumne Aqueduct connection could create a significant impact on air quality; however, because the full use of Permit 10478 would occur during the latter half of this century, it is difficult to determine what California's electricity portfolio would be that far into the future and how much of that portfolio would include the use of renewable resources. California currently has a renewables portfolio standard (Senate Bill [SB] 1078, SB 107, and SB X1-2) that mandates all investor-owned utilities, electric service providers, and community choice aggregators to procure 33% of power from eligible renewable sources by 2020. Although it is expected that the state will continue to increase procurement of renewable power beyond the 2020 target date of SB 1078, SB 107, and SB X1-2, it is unknown at this time the amount of electricity supplied to California customers—including EBMUD—that would be derived from renewable sources in 2090. The current trend for energy use in the state of California is to increase the use of renewable resources. By the latter half of this century, it is likely that a larger portion of California's energy would be obtained from renewable resources relative to today and, therefore, would have minimal GHG emissions, even if electricity required to deliver the water is higher. (See Chapter 7, Climate Change, for additional information related to GHG emissions and the increased use of renewable resources.) As a result, this operations-related impact on air quality would most likely be *less-than-significant*. No mitigation is necessary.

Construction activities related to construction of a Camanche Reservoir/Mokelumne Aqueduct connection could result in emissions associated with construction equipment and fugitive dust, which is similar to most other construction projects. However, because construction activities that could affect air quality would be subject to state and local regulations intended to minimize potential impacts, implementation of the pertinent regulatory measures would most likely reduce the impacts to *less than significant with mitigation*.

Cultural Resources

Diversion of water directly from the Camanche Reservoir to the Mokelumne Aqueducts is not expected to impact cultural resources in the Mokelumne River area. Construction activities are likely limited to areas adjacent to or near the existing public right-of way. Like other similar construction projects federal and state laws and regulations regarding cultural resources are intended to minimize impacts on cultural resources. Implementing applicable mitigation measures required by these regulations would reduce the potential impacts to *less than significant with mitigation*.

Noise

As discussed above under Air Quality, operating the new Camanche Reservoir/Mokelumne Aqueduct connection would require additional pumping to send water to the EBMUD service area. The new pumping plant could generate noise while in operation; however, using appropriate sound-proofing materials and other mitigation measures could minimize the noise levels to *less than significant with mitigation*.

Like other similar construction projects, a temporary increase in noise would be expected. Construction activities are subject to federal and state laws and regulations. Implementing standard mitigation measures such as noise reduction techniques and other measures to reduce construction noise would likely reduce noise-related impacts to *less than significant with mitigation*.

Recreational Resources

Diverting water directly from Camanche Reservoir could result in an increase in the frequency of fluctuations of the reservoir's water-surface elevations, which could diminish recreational boating access. This impact could, however, be reduced to a *less-than-significant* level by adaptively managing the time period of the diversions from Camanche Reservoir and constructing boat ramps that could be accessed at lower reservoir water-surface elevations. Therefore, operations-related impacts on recreational resources would most likely be *less than significant with mitigation*.

Construction-related activities may temporarily limit the recreational use of the Camanche Reservoir, which would be limited to the general, immediate area surrounding the construction site. Water-dependent recreational uses near the construction site could be disrupted and land-based recreational activities, such as hiking, may need to be diverted to areas away from construction activities. Such disruptions to recreational resources, however, most likely would only be temporary and limited to the construction area, which should be relatively small compared to the overall size of the Camanche Reservoir recreational area. Therefore, construction-related impacts on recreational resources would most likely be *less than significant*. No mitigation is required.

Similarly, diverting water directly from Camanche Reservoir could increase the frequency of reduced flows in the lower Mokelumne River, which could, therefore, affect water-dependent recreation along the river. A 30% reduction in flows below 325 cfs generally equates to a 3-inch or more reduction in water surface elevation at Stillman Magee Park. As noted in Section 6.3.2.2, the average percent occurrence when low to moderate lower Mokelumne River flows were reduced by more than 20%, increased by 7% under programmatic conditions relative to baseline conditions (i.e., less than the 10% threshold). For these reasons, this impact is considered to be *less than significant*.

Traffic

Like other similar construction projects, construction activities associated with developing infrastructure for the Camanche Reservoir/Mokelumne Aqueduct connection would result in a temporary increase in traffic. Construction activities may interfere with local traffic in the area. Implementation of applicable standard mitigation measures such as traffic plans would likely reduce the impacts on traffic to *less than significant with mitigation*.

Once the Camanche Reservoir/Mokelumne Aqueduct connection is operational, occasional traffic could result from facility operations and maintenance. Traffic related to facility operations is anticipated to be minimal and, therefore, would most likely have a *less-than-significant* impact on local traffic.

Visual Resources

Similar to other construction projects, visual resources may be temporarily affected by the equipment, signage and other related materials typical of construction sites. Mitigation measures to reduce the visual resources could likely reduce these impacts to *less than significant with mitigation*.

Diverting water directly from Camanche Reservoir could increase the frequency of water-level fluctuations at the reservoir. The “bathtub ring” effect, however, is a fairly common feature for most reservoirs and viewers expect Camanche Reservoir to show exposed soil around the shoreline. Once operational, the connection from Camanche Reservoir to the Mokelumne Aqueducts most likely would be designed to have a minimal impact on scenic views in the area; therefore, this impact would most likely be *less than significant*.

7.1 Introduction

Climate change is the cumulative effect of increasing concentrations of greenhouse gases (GHGs) in the earth's atmosphere over hundreds of years. Climate change is a global problem and certain GHGs are considered global pollutants. Higher atmospheric concentrations of GHGs increase the globally averaged temperature, which in turn initiates changes to the global climate system. Changes to the global climate system manifest differently in different regions of the world. Accordingly, this chapter describes the Permit 10478 Time Extension Project's (Project's) impact on climate change in light of the level of its contribution of GHG emissions expressed as carbon dioxide equivalent (CO₂e) emissions. If the Project's contribution is not greater than existing conditions, or can be mitigated to a level that does not exceed existing conditions, then its contribution is not "considerable" (i.e., significant).

This chapter also discusses the impacts of climate change on the Mokelumne River watershed and EBMUD's water and energy supply, although the purpose of an EIR is to address the significant effects of a project on the environment, not the significant effects of the environment or changes in the environment on a project. Section 7.2 addresses the Project's contribution to GHG emissions, and Section 7.3 briefly addresses the impacts of climate change on the Mokelumne River watershed and EBMUD's water system.

7.2 Greenhouse Gas Emissions

This section includes a discussion of the environmental setting, regulatory setting, existing thresholds, methods for determining significance, and impacts of the Project on GHG emissions.

7.2.1 Environmental Setting

While the Project alone would not create a measurable incremental change in the global climate, legislation and executive orders on climate change in California have established a statewide context for GHG emissions, and an enforceable cap on those emissions. An important part of California's plan to reduce GHG emissions is using renewable power, including certain types of hydroelectric power generation. The project area for this analysis is northern California, inclusive of the following subregions: the Mokelumne River Basin; the Central Valley in the vicinity of the Freeport Regional Water Project, which encompasses Sacramento County as well as the Sacramento and American River watersheds; and the EBMUD service area.

7.2.1.1 Greenhouse Gases

State CEQA Guidelines Section 15364.5 states that GHGs include, but are not limited to, carbon dioxide (CO₂), nitrous oxide (N₂O), methane (CH₄), ozone (O₃), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride.¹ Characteristics of these GHGs are listed in Table 7-1.

Table 7-1. Characteristics of Significant Greenhouse Gases

Gas	Primary Global Sources	GWP (100 years) ^{a,b}	Lifetime (years) ^c	2005 Atmospheric Abundance (ppm) ^d	2005 % of Global Emissions
Carbon Dioxide (CO ₂)	Fossil fuel use, cement production, deforestation, and decay of biomass.	1	5–200	379	77
Methane (CH ₄)	Livestock, rice cultivation, fossil fuel combustion and coal mining.	21	9–15	1.7	15
Nitrous Oxide (N ₂ O)	Agriculture, industrial processes, fossil fuel combustion (transportation).	310	120	0.32	7
Sulfur Hexafluoride (SF ₆)	Insulation in power distribution infrastructure, semi-conductor industry.	23,900	3,200	5.6x10 ⁻⁶	<1
Hydrofluorocarbons					
Fluoroform (HFC-23)	Refrigerant	11,700	264	1.8 x 10 ⁻⁵	<1
1,1,1,2-Tetrafluoroethane (HFC -134a)	Propellant, refrigerant, ODS substitute.	1,300	14.6	3.5x 10 ⁻⁵	<1
1,1,1,2-Tetrafluoroethane (HFC-152a)	Refrigerant, ODS substitute	140	1.5	3.9x10 ⁻⁶	<1
Perfluorocarbons					
Carbon tetrafluoride (PFC-14)	Refrigerant, propellant, industrial solvent and cleaner, grain fumigant,	6,500	50,000	7.4x10 ⁻⁵	<1
Hexafluoroethane (PFC-116)	Semi-conductor manufacturing,	9,200	10,000	2.9x10 ⁻⁶	<1

Sources: Intergovernmental Panel on Climate Change 1996, 2001, 2007; World Resources Institute 2005.

¹cf. Health and Safety Code §38505(g). Water vapor, although the most abundant GHG, is not included in this analysis or identified by Health and Safety Code §38505(g) because natural concentrations and fluctuations far outweigh anthropogenic influences.

Notes: CF₄ and C₂F₆ are PFCs.

- ^a GWP = global warming potential is a measure of a gas' heat-absorbing capacity relative to a reference gas, CO₂, which is defined as having a GWP of 1. It is assessed in the present-day atmosphere with its effect integrated over a period of 100 years, relative to CO₂.
 - ^b The GWP values presented above are based on the IPCC Second Assessment Report (SAR) and UNFCCC reporting guidelines (Intergovernmental Panel on Climate Change 1996; United Nations 2006). Although the IPCC Fourth Assessment Report (AR4) presents different GWP estimates, the current inventory standard relies on SAR GWPs to comply with reporting standards and consistency with regional and national inventories (U.S. Environmental Protection Agency 2010).
 - ^c The atmospheric residence time of a gas, or lifetime, is equal to the total atmospheric abundance of the gas divided by its rate of removal.
 - ^d ppm = parts per million.
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7.2.1.2 East Bay Municipal Utility District Greenhouse Gas Inventory (2005)

A GHG inventory is a depiction of GHG emissions and sinks within a selected physical or economic boundary. Sinks² of CO₂ include uptake by vegetation and dissolution into the ocean. GHG inventories can be performed on a large scale (for global and national entities) or on a small scale (for a particular building or person).

Following the methods and reporting protocols of the California Climate Action Registry (CCAR)³, EBMUD began taking annual inventories of GHG emissions resulting from its operations in 2000. EBMUD uses the year 2000 as its GHG baseline for internal GHG reduction planning⁴. As explained in Chapter 2, Project Description, Baseline, and Alternatives⁵, this document uses the normalized average annual demand from the year 2005 as baseline, which is, therefore, also considered for the GHG emissions baseline. EBMUD's emissions inventory for year 2005 is shown in Table 7-2 and Figure 7-1.

²A carbon dioxide sink is a resource that absorbs and stores CO₂ from the atmosphere. The classic example of a sink is a forest in which vegetation absorbs CO₂ and produces oxygen through photosynthesis.

³ The California Climate Action Registry (CCAR) was established by statute in 2000 as a non-profit voluntary GHG registry. CCAR developed protocols to assist member agencies in calculating, reporting and verifying GHG emissions from a variety of emissions sources and entity types, including public water utilities. The protocols provide rigorous emissions reporting standards that are consistent across jurisdictions and with international standards. The CCAR officially closed in December 2010.

⁴ The July 2010 Strategic Plan (Strategy 4) establishes a goal to reduce GHG emissions (net) by 10% below the 2000 baseline by 2015.

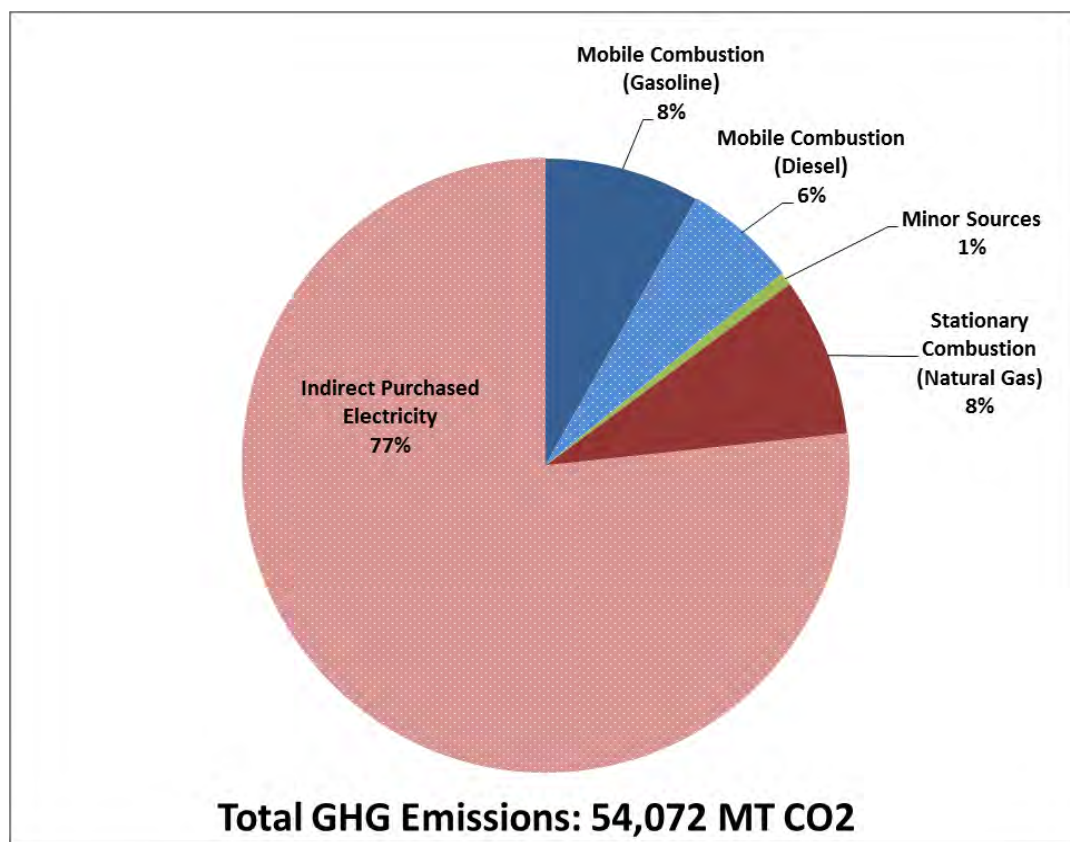
⁵As discussed in Chapter 2, Project Description, Baseline, and Alternatives, in 2007, EBMUD undertook a comprehensive, multiyear study to determine projected demand for the year 2040. The study selected calendar year 2005 as the base year for defining existing land uses and as the starting point for projecting future water demands. The demand analysis concluded that normalized average annual demand in year 2005 was 214 million gallons per day (MGD). This EIR uses the 214 MGD average annual demand figure as its baseline for analytic purposes. Year 2005 was selected as the base year for the Demand Study because it was the last year of complete data availability that did not experience distribution system anomalies.

Table 7-2. East Bay Municipal Utility District 2005 Greenhouse Gas Inventory⁶

Gas	CO ₂ (MT)
Direct Mobile Combustion (Gasoline – vehicles and portable equipment)	4,483
Direct Mobile Combustion (Diesel – vehicles and portable equipment)	3,218
Minor Sources ^a	370
Direct Stationary Combustion (Natural Gas – microturbines etc.)	4,541
Indirect Purchased Electricity (PG&E and Western Area Power Administration)	41,460
Total	54,072

MT = metric tons

^a Includes direct mobile combustion (propane–forklifts), direct stationary combustion (diesel–generators) and direct stationary combustion (propane–generators).

**Figure 7-1. EBMUD 2005 GHG Inventory**

⁶ EBMUD's 2005 GHG inventory only includes CO₂ carbon dioxide and does not account for other GHGs. This is due to the following: 1) Consistency with earlier GHG inventories that addressed only CO₂ and 2) Collection of all data necessary to account for all gases was not possible 3) CO₂ emissions likely represent 90% to 97% of EBMUD's total emissions.

Total GHG emissions resulting from EBMUD's operations in 2005 were 54,072 metric tons (0.0541 million metric tons [MMT]) CO₂, the majority of which were associated with electricity purchases. EBMUD estimates that 3% of emissions are a result of raw water operations (water intake and transport to a facility), 51% a result of water treatment and distribution, 15% a result of building operations, 19% a result of fleet, and 12% resulting from wastewater operations. Diversions of Permit 10478 water through the Mokelumne Aqueducts require pumping but are assisted by gravity flow, thereby reducing the energy intensity (and consequent GHG intensity) of these water deliveries relative to other sources. As seen in Table 7-2 and Figure 7-1, 77% of EBMUD's GHG emissions are associated with purchased electricity.

EBMUD's normalized average annual demand in 2005 (i.e., baseline) was 214 million gallons per day (MGD) for a total of 78,100 million gallons (MG). Combined with data presented in Table 7-2 and Figure 7-1, EBMUD's system-wide GHG intensity factor was 0.69 MT CO₂/MG in 2005. This accounts for GHG emissions that result from all EBMUD operations, not only energy for water pumping in the Mokelumne Aqueducts. Since GHG emissions associated with water supply, distribution, and treatment are primarily a result of electricity consumption (as opposed to other GHG sources such as fleet), it is also useful to present an energy intensity factor. In 2005, the energy intensity of pumping at the Walnut Creek pumping plant was 3,244 kilowatt-hours/million gallons (kWh/MG). The overall energy intensity factor was 1,454 kWh/MG⁷.

Several factors influence the GHG intensity factor and the energy intensity factor for water provided by EBMUD, including water demand in the service area and consequent electricity demand by EBMUD, and Pacific Gas and Electric Company's (PG&E's) GHG emission factor in any given year. The intensity factor fluctuates because of water demand and hydropower production throughout the west. Fluctuations in the GHG intensity factor and energy intensity factor are expected on a year-to-year basis even if overall these values may be trending up or down.

As discussed in EBMUD's *2011 Climate Change Monitoring and Response Plan* (East Bay Municipal Utility District 2011a), GHG or electricity intensity factors of different operational sectors have different characteristics. For instance, emissions from water treatment/distribution and wastewater depend strongly on production, whereas, buildings and fleet have little or no relationship to production. For these reasons, EBMUD tracks several metrics in measuring progress toward its GHG reduction goals, including total GHG emissions, electricity intensity and GHG intensity. For example, EBMUD tracks the GHG intensity of water treatment/distribution and the absolute emissions of buildings and fleet operations. EBMUD has little control over emissions in the raw water sector (controlled by supply) and has not established either an intensity or absolute emissions target.

7.2.2 Regulatory Setting

Emissions of the six GHGs (or classes of GHGs) in Table 7-1 are regulated as air contaminants at the federal and state levels. The Project is subject to air quality regulations developed and implemented at the federal, state, and local levels. At the federal level, the U.S. Environmental Protection Agency (EPA) is responsible for implementation of the Clean Air Act (CAA).

Responsibility for attaining and maintaining air quality in California, including attaining GHG reduction goals mandated by Assembly Bill 32 (AB 32), is divided between the California Environmental Protection Agency's Air Resources Board (ARB) and regional air quality districts.

⁷ Based on a total electricity consumption of 16,477 MWh and an average annual pumping demand of 14 MGD.

Areas of control for the regional districts are set by ARB, which divides the state into air basins. The Bay Area Air Quality Management District (BAAQMD) and the San Joaquin Valley Air Pollution Control District (SJVAPCD), which are relevant to the Project, have developed CEQA guidance for GHGs. The BAAQMD Guidance is not currently in effect; however, it provides general direction for GHG impact analysis. In the AB 32 Scoping Plan, the ARB has outlined a plan for achieving the GHG reduction goals of AB 32. The Scoping Plan (California Environmental Protection Agency's Air Resources Board 2008) includes several independent rules and regulations that apply to the Project and/or have implications for EBMUD's overall GHG emissions inventory. Plans, policies, and regulations relevant to the Project are discussed below.

7.2.2.1 Federal Plans, Policies and Regulations

Mandatory Greenhouse Gas Reporting Rule (2009)

On September 22, 2009, EPA released its final Greenhouse Gas Reporting Rule (Reporting Rule, Title 40, Code of Federal Regulations (CFR), Part 98). The Reporting Rule is a response to the fiscal year (FY) 2008 Consolidated Appropriations Act (H.R. 2764; Public Law 110-161), which required EPA to develop "mandatory reporting of greenhouse gasses above appropriate thresholds in all sectors of the economy..." The Reporting Rule applies to most entities that emit 25,000 metric tons of CO₂e or more per year. Facility owners are required to submit an annual GHG emissions report with detailed calculations of facility GHG emissions. The Reporting Rule also mandates recordkeeping and administrative requirements for EPA to verify annual GHG emissions reports. EBMUD's main wastewater treatment plant is required to report GHG emissions and submitted its first facility level report in 2012 to the EPA.

Environmental Protection Agency Endangerment Finding and Cause and Contribute Finding (2009)

On December 7, 2009, EPA signed the Endangerment and Cause or Contribute Findings for Greenhouse Gases under Section 202(a) of the CAA. Under the Endangerment Finding, EPA found that current and projected concentrations of the six key well-mixed GHGs—CO₂, CH₄, N₂O, PFCs, SF₆, and HFCs—in the atmosphere threaten the public health and welfare of current and future generations. Under the Cause or Contribute Finding, EPA finds that the combined emissions of these well-mixed GHGs from new motor vehicles and new motor vehicle engines contribute to the GHG pollution that threatens public health and welfare. These findings do not themselves impose any requirements on industry or other entities. However, this action is a prerequisite to finalizing EPA's proposed new corporate average fuel economy standards for light-duty vehicles, which EPA proposed in a joint proposal including the Department of Transportation's proposed corporate average fuel-economy standards.

Council on Environmental Quality Draft NEPA Guidance (2010)

On February 19, 2010, the Council on Environmental Quality (CEQ) issued draft National Environmental Policy Act (NEPA) guidance on the consideration of the effects of climate change and GHG emissions. This guidance advises federal agencies to consider opportunities for reducing GHG emissions caused by federal actions, adapt their actions to climate change effects throughout the NEPA process, and address these issues in their agency NEPA procedures. Where applicable, the scope of the NEPA analysis should cover the GHG emissions effects of a proposed action and alternative actions, as well as the relationship of climate change effects on a proposed action or

alternatives. The CEQ guidance is still considered draft as of the writing of this document and is not an official CEQ policy document (Council on Environmental Quality 2010).

7.2.2.2 State Plans, Policies, and Regulations

Executive Order S-3-05 (2005)

Signed by Governor Arnold Schwarzenegger on June 1, 2005, Executive Order S-3-05 asserts that California is vulnerable to the effects of climate change. To combat this concern, Executive Order S-3-05 established the following GHG emissions reduction targets for state agencies.

- By 2010, reduce GHG emissions to 2000 levels.
- By 2020, reduce GHG emissions to 1990 levels.
- By 2050, reduce GHG emissions to 80% below 1990 levels.

Executive orders are binding only on state agencies. Accordingly, Executive Order S-03-05 guides state agencies' efforts to control and regulate GHG emissions but has no direct binding effect on local government or private actions. The Secretary of the California Environmental Protection Agency is required to report to the Governor and state legislature biennial on the impacts of global warming on California, mitigation and adaptation plans, and progress made toward reducing GHG emissions to meet the targets established in this executive order.

Assembly Bill 32, California Global Warming Solutions Act (2006)

In September 2006, the California State Legislature adopted Assembly Bill 32, the California Global Warming Solutions Act of 2006 (AB 32). AB 32 establishes a cap on statewide GHG emissions and sets forth the regulatory framework to achieve the corresponding reduction in statewide emission levels. Under AB 32, ARB is required to take the following actions.

- Adopt early action measures to reduce GHGs.
- Establish a statewide GHG emissions cap for 2020 based on 1990 emissions.
- Adopt mandatory reporting rules for significant GHG sources.
- Adopt a scoping plan indicating how emission reductions would be achieved through regulations, market mechanisms, and other actions.
- Adopt regulations needed to achieve the maximum technologically feasible and cost-effective reductions in GHGs.

State California Environmental Quality Act Guidelines

The State CEQA Guidelines require lead agencies to describe, calculate, or estimate the amount of GHG emissions that would result from a project. Moreover, the State CEQA Guidelines emphasize the necessity to determine potential climate change effects of a project and propose mitigation as necessary. The State CEQA Guidelines confirm the discretion of lead agencies to determine appropriate significance thresholds, but require the preparation of an EIR if "there is substantial evidence that the possible effects of a particular project are still cumulatively considerable notwithstanding compliance with adopted regulations or requirements" (Section 15064.4).

State CEQA Guidelines Section 15126.4 includes considerations for lead agencies related to feasible mitigation measures to reduce GHG emissions, which may include, among others, measures in an existing plan or mitigation program for the reduction of emissions that are required as part of the lead agency's decision; implementation of project features, project design, or other measures that are incorporated into the project to substantially reduce energy consumption or GHG emissions; off-site measures, including offsets that are not otherwise required, to mitigate a project's emissions; and measures that sequester carbon or carbon-equivalent emissions.

Senate Bills 1078/107/X1-2 and Executive Order S-14-08—Renewable Portfolio Standard (2002, 2006, 2011)

Senate Bills (SB) 1078 and 107, California's Renewable Portfolio Standard (RPS), obligates investor-owned utilities (IOUs), energy service providers (ESPs), and Community Choice Aggregations (CCAs) to procure an additional 1% of retail sales per year from eligible renewable sources until 20% is reached, no later than 2010. The California Public Utilities Commission (CPUC) and California Energy Commission (CEC) are jointly responsible for implementing the program. Executive Order S-14-08 sets forth a longer-range target of procuring 33% of retail sales by 2020. SB X1-2 (2011) requires an RPS of 33% by 2020. Senate Bill X1-2 expands the RPS to include all publicly-owned utilities (POUs).

California Mandatory Reporting Rule

The California Mandatory Reporting Rule (MRR) (title 17, California Code of Regulations [CCR], Sections 95100-95157) requires industrial facilities, suppliers (of natural gas, CO₂, liquefied petroleum gas and transportation fuels), and electric power entities to report GHG emissions or transactions annually to ARB and have the report verified by a certified third party. Each entity has unique categories that determine rule applicability. The California MRR incorporates by reference aspects of EPA's MRR. Certain types of facilities are required to report annual emissions regardless of threshold. Other facilities with combustion emissions greater than 10,000 MT CO₂e or total emissions from all sources greater than 25,000 MT CO₂e are required to report emissions to ARB. Fuel suppliers and electricity retailers are required to report inter- and intra-state transactions. These reports also require third-party verification. The reporting program supports California's cap-and-trade system (see below). Not all facilities required to report have a compliance obligation under the cap. EBMUD's main wastewater treatment plant is required to report GHG emissions under the California MRR and submitted its first facility level report in 2009 to ARB.

Greenhouse Gas Cap-and-Trade Program

On October 20, 2011, ARB adopted the final cap-and-trade program for California. The California cap-and-trade program creates a market-based system with an overall emissions limit for affected sectors. The program regulates more than 85% of California's emissions and staggers compliance requirements according to the following schedule: 1) electricity generation and large industrial sources (2012), and 2) fuel combustion and transportation (2015). EBMUD does not have a compliance obligation for 2012 under the cap.

7.2.2.3 Local Plans, Policies, and Regulations

Bay Area Air Quality Management District CEQA Guidelines

The BAAQMD, which is the local agency responsible for air quality management in the San Francisco Bay Area, adopted significance thresholds for operations-related GHG emissions in June 2010. According to BAAQMD significance thresholds, land use development projects (other than stationary sources) are considered to have a less than significant impact on air quality if they comply with the following standards:

- Comply with a qualified GHG reduction strategy.
- Emit less than 1,100 metric tons of CO₂e per year.
- Emit less than 4.6 MT CO₂e/service population/year (residents + employees).

For stationary source projects, the threshold is 10,000 metric tons of CO₂e per year. BAAQMD does not recommend a construction GHG emissions threshold, but encourages implementing best management practices (BMPs) (Bay Area Air Quality Management District 2010).

The guidance is part of an update to the BAAQMD guidance that was challenged in court in 2012. The court found that BAAQMD should have prepared a CEQA document prior to adopting the Guidelines and that a decision is currently under appeal. In the interim, BAAQMD has recommended that lead agencies determine their own threshold of significance based on substantial evidence in the record.

San Joaquin Valley Air Pollution Control District CEQA Guidelines

The San Joaquin Valley Air Pollution Control District (SJVAPCD) has adopted the *Guidance for Valley Land-Use Agencies in Addressing GHG Emissions Impacts for New Projects under CEQA* and the policy *Addressing GHG Emissions Impacts for Stationary Source Projects under CEQA* to assist lead agencies in addressing GHG emissions resulting from their projects (San Joaquin Valley Air Pollution Control District 2009a, 2009b). The guidance policy is directed to projects with construction and not specifically to the operations of a public utility. The guidance does not limit a lead agency from determining its significance criteria. Further, the guidance allows for individual projects to show consistency with a larger GHG reduction plan when the plan has been adopted in a public process that includes CEQA.

Sacramento Metropolitan Air Quality Management District CEQA Guidelines

The Sacramento Metropolitan Air Quality Management District (SMAQMD) Guide to Air Quality Assessment in Sacramento County establishes analysis expectations with regard to GHG emissions in CEQA documents (Sacramento Metropolitan Air Quality Management District 2009). The district recommends that an analysis of potential impacts of project-generated GHG emissions include a description of GHGs, summary of existing regulations, and discussion of GHG emissions sources in the project area. The guidelines further state that the analysis quantify the mass emissions associated with project construction and operations. Although the guidelines recommend that GHG emissions be quantified, they do not establish set emissions thresholds. Rather, they state that the CEQA lead agency should determine a threshold appropriate to the project using either thresholds adopted by other agencies or their own. SMAQMD guidelines state that CEQA documents make a

conclusion as to the significance of project-related GHG emissions and identify feasible mitigation measures.

7.2.2.4 East Bay Municipal Utility District's Internal Climate Change Procedures

Climate Change Monitoring and Response Plan

In 2007, EBMUD established an agency-wide management strategy to address climate change, led by a climate change committee that included members from the Operations and Maintenance Department, Engineering and Construction Department, Wastewater Department, Natural Resources Department, Water Conservation Division, Office of General Manager, and Office of General Counsel. This plan was updated in July 2010 and July 2011. EBMUD prepares annual reports on GHG emissions (East Bay Municipal Utility District 2011a) and incorporates this information into strategic planning and budgeting. EBMUD has established a goal to reduce GHG emissions by 10% from the 2000 baseline by 2015. In 2011, EBMUD's GHG emissions were 39,024 MT CO₂e, which was 28% below 2005 levels and 30% below 2000 levels (East Bay Municipal Utility District 2011c).

Renewable Energy Policy

In support of its Strategic Plan (East Bay Municipal Utility District 2012), EBMUD developed a Renewable Energy Policy (Policy 7.07) to encourage and promote the cost-effective use and generation of renewable energy. EBMUD is continuing its efforts to reduce GHG emissions both through energy efficiency and alternative fuels and annually produces an Energy Management Plan and Energy Report (East Bay Municipal Utility District 2011b and 2011c). In 2011, EBMUD had approximately 55 MW of renewable power generation facilities including hydro and solar power purchase agreements. Only a small portion of this generation offsets EBMUD purchases from PG&E. Much of this power is sold (along with the Renewable Energy Certificate) on the wholesale power market. EBMUD's 2011 Energy Management Plan specifies 14 planned projects designed to minimize energy use and nine projects designed to diversify energy supplies.

7.2.3 Impacts of the Permit 10478 Time Extension Project on Greenhouse Gas Emissions

7.2.3.1 Methods for Determining Significance

In response to SB 97 (2007), the Natural Resources Agency amended the State CEQA Guidelines on December 31, 2009, to include Section 15064.4 requiring the determination of impact significance from GHG emissions. These amendments became effective on March 18, 2010.

Section 15064.4(a) (2) allows the lead agency to rely on qualitative analysis or performance-based standards to assess the significance of impacts from GHG emissions on the environment. State CEQA Guidelines §15064.4(b) allows the lead agency to determine significance by comparing project GHG emissions to the standards adopted by local regulatory agencies for GHG emissions reduction. Furthermore, State CEQA Guidelines §15064.4(b) allows the lead agency the discretion to set its own threshold of significance for GHG emissions.

Rather than establish such a threshold, EBMUD has considered in this analysis how the Project may increase or reduce GHG emissions compared to the base year environmental setting and base year

performance standards. This approach is also recognized under §15064.4(b) and is consistent with BAAQMD, SMAQMD, and SJVAPCD CEQA guidance that allow lead agencies discretion in determining their own threshold.

For the purposes of a cumulative impact analysis, a project would have a significant effect if it makes a “considerable” contribution to the cumulative impact. A project’s contribution can be reduced to a less-than-significant level if it complies with a program for the reduction of GHG emissions or would otherwise not result in a net contribution to GHGs. The impact of the Project would be considered significant if resulting GHG emissions increased EBMUD’s overall GHG emissions above current levels, thereby impeding the state’s goal to reduce GHG emissions. The impact of the Project would also be considered significant if EBMUD’s performance metric (MT CO₂e/MG) increases relative to current conditions.

7.2.3.2 Greenhouse Gas Emissions of the Permit 10478 Time Extension Project

The Project is a time extension and does not propose to change the amount of water currently permitted under Permit 10478. However, although EBMUD has, at times, diverted at the maximum rate allowed under Permit 10478 and collected to storage virtually all of the permitted maximum quantity (352 of 353 thousand acre-feet [TAF] allowed), EBMUD’s annual water usage is such that it has not yet diverted the maximum amounts allowed to be diverted annually under Permit 10478. This analysis assumes an average annual demand by year 2040 of 230 MGD (future diversion) and a 2005 normalized baseline demand of 214 MGD (baseline diversion). The GHG emissions evaluated here are those associated with the increase from the 2005 baseline diversion to the 2040 future diversions associated with the Project.

Average annual demand in 2040 would result in an additional 16 MGD diversion relative to baseline conditions. Under project conditions, the 16 MGD would be diverted through the Mokelumne Aqueducts and pumped via the Walnut Creek Pumping Station. Table 7-3 shows the annual water and electricity demands, the carbon intensity of PG&E-supplied electricity (with RPS), and the resulting GHG emissions associated with the additional diversion of 16 MGD under project conditions as compared to the baseline diversion of 214 MGD.

Electricity use at the Walnut Creek Pumping Station is projected to be 27,092 megawatt hours (MWh) (Table 7-3). Baseline electricity use is 16,477 MWh. In the baseline year, approximately 86% of EBMUD’s electricity was sourced from PG&E and the average GHG intensity of PG&E supplied electricity at this time was 553.4 pounds of carbon dioxide (lbs. CO₂)/MWh. In compliance with California Renewable Portfolio Standard (SB 1078, SB 107 and SB X1-2) PG&E estimates that the GHG intensity of its electricity in 2020 would be 290 lbs CO₂/MWh due to an increase in the amount of renewable power in PG&E’s portfolio. Assuming that a similar percentage of electricity will be sourced from PG&E (86%) under Project conditions as baseline conditions, and that EBMUD’s electricity use (outside of the Walnut Creek Pumping Station) would increase proportionally with overall level of service, total GHG emissions for EBMUD operations are expected to *decline* under project conditions, even though EBMUD’s total electricity demand would increase. Electricity demand at the Walnut Creek Pumping Station would increase by 65% commensurate with the increase in diversion from 14 MGD to 30 MGD via the Mokelumne Aqueducts. Electricity use at other facilities would increase by a much smaller amount over the period from year 2005 to year 2040. As previously shown in Section 7.2.1.2, East Bay Municipal Utility District Greenhouse Gas Inventory (2005), approximately 77% of EBMUD’s emissions are attributable to power purchased from PG&E

and Western Area Power Administration (WAPA). In 2005, approximately 12.1% of PG&E's power was from RPS-eligible renewable sources. In response to the RPS (SB 1078, SB 107, SB X1-2) PG&E will be required to achieve 33% of total procurement from renewable sources by 2020. Because a large fraction of EBMUD's emissions are due to PG&E-supplied electricity, PG&E's compliance with the RPS alone would result in a reduction in EBMUD's total GHG emissions from 54,072 MT CO₂e in 2005 to a projected level of 48,050 in 2040 under project conditions, even when taking into account an increase in electricity demand. EBMUD has already seen a decline in total GHG emissions over the period from 2005 to 2011, approximately 25% which is largely due to the decrease in carbon content of PG&E-supplied electricity (East Bay Municipal Utility District 2011a).

Table 7-3 assumes that the relative percentages of power procured from PG&E and WAPA are constant and that the proportion of non-electricity GHG emissions sources to total emissions sources in the future is the same as in 2005 (i.e., 77% of EBMUD emissions due to purchased electricity). Table 7-3 shows that even if EBMUD does nothing further to increase energy efficiency (kWh/MG) or increase its own internal energy supply, and if WAPA does nothing to reduce the carbon content of its non-hydro power, EBMUD can still meet the 2040 projected demand of 230 MGD while simultaneously reducing overall GHG emissions and the GHG intensity of water deliveries.

Table 7-3. Greenhouse Gas Emissions Metrics of EBMUD Operations under Baseline and Projected Conditions

Metric	2005 Baseline Diversion	2040 Project Diversion
Estimated Daily Demand(MGD)	214	230
Pumping Demand (MGD)	14	30
Annual Walnut Creek Pumping Demand (MWh) ^a	16,477	27,092
Annual Total Electricity Purchases (MWh) ^b	113,607	131,486
Walnut Creek Pumping Plant Energy Intensity (MWh/MG)	3.2	2.5
Portion Electricity Purchased from PG&E (%)	86	86
PG&E GHG Emission Factor ^c	553.4	290.0
GHG Emissions (Electricity) Walnut Creek Pumping Plant (MT CO ₂ e)	6,049	7,162
GHG Emissions ² (Electricity) Other Facilities (MT CO ₂ e)	35,657	27,597
Other GHG Emissions (Fleet, Stationary Combustion etc.) (MT CO ₂ e) ^b	12,366	13,290
Total GHG Emissions (MT CO ₂ e)	54,072	48,050
Overall GHG Intensity (MT CO ₂ e/MG)	0.69	0.57

^a Provided by EBMUD.

^b Provided by EBMUD for 2005; Projected for 2040 using GHG inventory data.

^c Pacific Gas and Electric Company 2012.

MGD = million gallons per day; MWh = megawatts per hour; MG = million gallons; MT CO₂e = million metric tons of carbon dioxide equivalent.

The future projection of EBMUD's total GHG emissions and GHG intensity is a very conservative estimate since it relies solely on the reduction in the GHG intensity of PG&E supplied electricity and does not account for EBMUD's internal efforts to reduce GHG emissions through energy efficiency, alternative energy and fleet improvements.

Since 2005 (baseline scenario) EBMUD has already completed lighting retrofits, a PV installation at Sobrante and the Mokelumne WS HQ retrofit yielding electricity savings of 1,140 MWh. EBMUD completed five PV power purchase agreement projects in 2011 and has another 17 projects (efficiency, renewables, demand response or other) slated for the near future (East Bay Municipal Utility District 2011b). Although these projects and many others will be completed by EBMUD between now and 2040, they have not been accounted for in this analysis because they are not yet complete and unlike PG&E which has a legislative mandate to comply with the RPS, EBMUD is not required by law to complete these projects. EBMUD has established a goal (July 2008 Strategic Plan Strategy 4) to reduce net GHG emissions from EBMUD facilities over 2000 baseline by 10% by 2015. Toward achieving this goal EBMUD has already converted to a hybrid fleet and installed microturbine cogeneration systems at the Administration Building and Adeline Maintenance Center. EBMUD is increasing energy and water efficiency, has plans to further decarbonize its fleet and is considering the purchase of offsets accomplished through conservation easements and afforestation or reforestation.

7.2.3.3 Significance Determination

Under project conditions, Permit 10478 would be extended to year 2040 to allow EBMUD additional time to apply the water obtained under Permit 10478 to beneficial use. As noted in Chapter 1, Objective and Need for the Permit 10478 Time Extension Project, EBMUD's raw water system relies on gravity for most of an average year. Pumping is required when flows through the Mokelumne Aqueduct exceed about 200 MGD (depending on Pardee's water surface elevation). Additional waters drafted from the Mokelumne River to meet demands in 2040 would require pumping (additional electricity), but would not result in a substantial increase in GHG emissions as compared to baseline levels due to the generally decreasing GHG emissions factor for electricity provided by PG&E to EBMUD in the future. Table 7-3 shows that EBMUD can still meet projected demand in non-drought conditions and decrease the system-wide GHG intensity factor and overall GHG emissions, assuming PG&E meets its RPS requirements pursuant to SB 1078, SB 107, and SB X1-2. EBMUD's GHG intensity factor and overall GHG emissions would likely decrease even further as a result of its own efforts to increase efficiency and on-site renewable power, as outlined in the 2011 Energy Management Strategy (East Bay Municipal Utility District 2011b) combined with PG&E's efforts.

The Project's GHG emissions impacts would be less than significant because the Project would not result in a net increase in EBMUD's total operational GHG emissions and it would not cause EBMUD's GHG intensity factor or the Walnut Creek Pumping Station electricity intensity factor to increase. In addition, the Project would not hinder EBMUD from achieving its GHG reduction or renewable energy goals. Overall operational GHG emissions are projected to decline over time and EBMUD is supporting the state's ability to meet the goals of AB 32.

7.3 Impacts of Climate Change on the Permit 10478 Time Extension Project

This section describes EBMUD's activities to address the likely impacts of climate change on the Mokelumne River watershed and EBMUD's operations and planning. The purpose of this EIR is to identify significant effects associated with implementing the Project. CEQA does not require an analysis of the impacts climate change would have on the Project, but this discussion explains EBMUD's strategy for incorporating climate change into its planning and decision-making.

7.3.1 Changes to Climate in the Sierra Nevada

Evidence of warming is already apparent in winter temperatures in the Sierra Nevada, with an increase of almost 2 degrees Celsius (°C) observed in the second half of the twentieth century (Dettinger and Cayan 1995). With no decrease in GHGs, an additional incremental increase of 2°C is projected for the next half century (East Bay Municipal Utility District 2009). Recent reviews of climate modeling predictions indicate that California will experience a continuing warming trend, with most models predicting a rise in average annual temperatures between 3.6 degrees Fahrenheit (°F) and 9°F by 2100 (California Natural Resources Agency 2009).

Variation in annual precipitation also is expected to increase, potentially increasing the frequency and intensity of winter storms (and flood events) and critically dry years. Modeling of climate change published to date projects that overall precipitation in California would decrease between 12% and 35% by the year 2050, depending on the model and future emissions scenario (California Natural Resources Agency 2009).

Additionally, a long-term shift in the seasonal pattern of runoff is expected to continue, with peaks occurring earlier in the year because of declines in the proportion of precipitation falling as snow and earlier spring snowmelt (California Natural Resources Agency 2009). This is expected to reduce summer and fall runoff from Sierra Nevada streams, potentially resulting in significant reductions in the availability of water by late summer (California Natural Resources Agency 2009).

Research on and planning for climate impacts specific to California is being led by the California Natural Resources Agency (CNRA) and CEC. In addition, other agencies have conducted studies and preparation regarding their specific operations, including the California Department of Water Resources (DWR) (California Department of Water Resources 2012) and EBMUD (East Bay Municipal Utility District 2011a).

DWR projects that the impacts of climate change will gradually increase in severity during this century and beyond (California Department of Water Resources 2009b). The principal impact categories of interest in this EIR include:

- reduced water supply because of substantial decreases in Sierra Nevada snowpack,
- increased flooding threats from higher flood peaks and sea level rise,
- increased Delta salinity and damage to Delta levees, and
- diminished water quality and fish habitat because of reduced stream flows and warming waters.

Each of the impacts above is discussed further in Section 7.3.3, Assessment of Climate Change Impacts on the Permit 10478 Time Extension Project, specifically in the context of EBMUD's water

supply and operations. Discussion is based on the *2011 Climate Change Monitoring and Response Plan* (East Bay Municipal Utility District 2011a).

There is substantial uncertainty associated with climate change projections on regional and watershed scales. This uncertainty stems from the complexity of climate and ecosystem processes and modeling imperfections, and uncertainty about future trends in GHG emissions. EBMUD is continually monitoring the latest research and recommendations from the state of California as the state updates its preparedness plans.

7.3.2 Regulatory Setting

At present, there is no federal or state regulation that establishes a threshold for determining significance of climate change impacts on a project; however, recent regulatory action at state and national levels underscores the importance of this issue. Federal and state regulations, plans, and policies related to climate change impacts on the Project are described below. Significance of climate change impacts on the Project is not determined, but impacts and vulnerabilities of EBMUD's systems are disclosed below for informational purposes only.

7.3.2.1 Federal Plans, Policies, and Regulations

Council on Environmental Quality Draft NEPA Guidance (2010)

As previously stated, the CEQ issued on February 19, 2010, draft NEPA guidance on the consideration of the effects of climate change and GHG emissions. This guidance advises federal agencies to consider opportunities for reducing GHG emissions caused by federal actions, adapt their actions to climate change effects throughout the NEPA process, and address these issues in their agency NEPA procedures. Where applicable, the scope of the NEPA analysis should cover the GHG emissions effects of a proposed action and alternative actions, as well as the relationship of climate change effects on a proposed action or alternatives. The CEQ guidance is still considered to be in draft form as of the writing of this document and is not an official CEQ policy document (Council on Environmental Quality 2010).

7.3.2.2 State Plans, Policies, and Regulations

Governor's Executive Order S-13-08 (2008)

Executive Order S-13-08 directs state agencies to plan for sea level rise and climate impacts through coordination of the state Climate Adaptation Strategy (see the following section).

California Climate Adaptation Strategy (2009)

Adopted in 2009, the California Climate Adaptation Strategy (CAS) uses downscaled climate models to evaluate the impacts of climate change statewide. The CAS summarizes the impacts and makes recommendations for adaptation strategies (prepare, prevent, and respond) in the sectors of Public Health, Biodiversity and Habitat, Oceans and Coastal Resources, Water, Agriculture, Forestry, and Transportation and Energy. The CAS is routinely updated with the latest scientific studies, guidance and adaptation efforts throughout California. The next update to the CAS is expected in 2013.

State California Environmental Quality Act Guidelines

Section 15126.2 (a) of the CEQA Guidelines has been revised by the Resources Agency to direct lead agencies to evaluate the impacts of locating development in areas susceptible to hazardous conditions, including hazards potentially exacerbated by climate change. Locating state projects in such areas may require additional guidance that, in part, depends on planning tools such as Cal-adapt and others developed by state agencies.

7.3.2.3 East Bay Municipal Utility District's Internal Climate Change Procedures

Climate Change Monitoring and Response Plan

As explained in Section 7.2.2.4, in 2007 EBMUD established an agency-wide climate change committee and strategy to address climate change. EBMUD has prepared annual reports on both GHG emissions and vulnerabilities within its system (East Bay Municipal Utility District 2011a) and incorporates this information into strategic planning and budgeting. In addition to establishing a GHG reduction goal, the committee routinely monitors climate change science and uses the best science to develop scenarios of temperature, precipitation, sea level rise, snowpack, and runoff, and uses these scenarios to identify critical infrastructure and vulnerabilities.

7.3.3 Assessment of Climate Change Impacts on the Permit 10478 Time Extension Project

Based on global and regional climate change predictions, EBMUD evaluated climate change effects in the EBMUD service area and the Mokelumne River watershed as part of the Water Supply Management Program 2040 (WSMP 2040) (East Bay Municipal Utility District 2009). As part of long-term planning, EBMUD examines potential changes in supply that could arise from several sources, including climate change.

EBMUD conducted a climate change sensitivity analysis that evaluated potential climate change impacts on its water supply system; a “bottom-up” approach based on historical hydrology was used to evaluate impacts. The analysis was used to help develop a preferred portfolio that would respond to a range of possible future climate scenarios to guide water supply planning. A summary of the potential impacts and consequences on operations and services is provided in Table 7-4. Table 7-4 was taken from the *2011 Climate Change Monitoring and Response Plan* (East Bay Municipal Utility District 2011a).

To further examine the impacts and consequences outlined in Table 7-4, EBMUD examined the sensitivity of its operations to several key parameters assuming a customer demand response to a 4°C temperature increase by 2040, runoff timing change in the Mokelumne basin for various temperature increases by 2040, and reductions in Mokelumne runoff if precipitation decreased by 10% to 20% by 2040. The results of EBMUD's sensitivity analysis are summarized below. A complete description can be found in the *2011 Climate Change Monitoring and Response Plan* (East Bay Municipal Utility District 2011a).

Table 7-4. Potential Climate Change Impacts and Consequences on EBMUD Operations and Services

Potential Impacts	Expected Consequences	
	Operations and Services	Expected Consequences
Increased temperatures and heat wave days	Demand - Non-residential	Increases in commercial landscape irrigation (golf courses, outdoor commercial usages such as golf courses, cemeteries, etc.) and commercial and industrial cooling Changes in season demand patterns (food processing, irrigation)
	Demand - Residential	Increases in water demand (due to increased net evapotranspiration) Changes in seasonal demand patterns (primarily irrigation)
Increased ratio of rain to snow, delayed onset of the snow season accelerated rate of spring snowmelt and shortened overall snowfall season Increased evaporation Long-term changes in watershed vegetation Change in the timing, intensity, location, and amount of precipitation	Sources	Loss of annual water supply from the Sierra snowpack Increase in drought frequency Increase in potential for invasive species Increase in adverse changes in water quality (physical and biological) Increase in erosion/sedimentation
Increased temperatures and heat wave days Long-term changes in watershed vegetation Increased frequency and intensity of wildfires Increased ratio of rain to snow, delayed onset of the snow season, accelerated rate of spring snowmelt, and shortened overall snowfall season Change in the timing, intensity, location, and amount of precipitation	Watershed Management	Increase in flooding incidence Increase in need to balance between flood protection and water supply Increase in difficulty maintaining instream flows Increase in environmental water demand for instream temperature control Increased difficulty in maintaining recreational quality
Increased temperatures and heat wave days Increased ratio of rain to snow, delayed onset of the snow season, accelerated rate of spring snowmelt, and shortened overall snowfall season Increased water temperatures Increased frequency and intensity of wildfires Change in water quality Increased evaporation Change in the timing, intensity, location, and amount of precipitation Sea level rise	Operations	Greater challenges for reservoir management and balancing the competing concerns of flood protection and water supply
Source: East Bay Municipal Utility District 2011a.		

Water Supply. Carryover storage in reservoirs would be reduced because of an increased need for flood protection and reservoir drawdown in winter. The earlier runoff has a greater impact on carryover storage. Although warmer temperatures also create conditions of earlier runoff, reductions in average annual precipitation of 10% to 20% are most important to carryover storage, resulting in 12% to 24% reduced carryover storage in 70% of the years analyzed by EBMUD.

Demand. Warmer temperatures increase both residential and non-residential water demand. EBMUD estimates an increase of approximately 10 MGD by 2040 for a 4°C increase in temperature.

Flood-Control Management. The volume and timing and flood-control releases change in response to decreased levels of runoff. EBMUD modeling indicates that winter flood-control releases (November through March) would increase by 66% to 89%, depending on temperature. Spring flood-control releases would decrease by similar amounts.

Water Temperature. Increased air temperature would increase the temperature of Mokelumne River flow into Pardee Reservoir and consequently minimum, average, and maximum temperatures in the reservoir. Reservoir temperatures would increase by between 0.3°C and 2.5°C, depending on precipitation conditions in a given year.

7.3.3.1 Potential Impacts of Climate Change on Mokelumne River Fishery Resources

This document analyzes the anticipated impacts of EBMUD's Permit 10478 Time Extension Project on the native anadromous salmonids in the Mokelumne River based on historic hydrology and empirical observations, and proposes appropriate mitigation measures to address significant Project impacts. The analysis is based on the mass balance model, EBMUDSIM and the water quality model SSTEMP to quantitatively assess impacts from the proposed project. This subsection discusses the potential impacts of climate change on fishery resources. It is anticipated that the adaptive management approach utilized by the Lower Mokelumne Partnership will regularly evaluate climate impacts and adjust adaptive management actions or other measures to best manage the fishery resources.

Although global and regional climate models predict significant changes in hydrologic and meteorological parameters in the future, the development of higher resolution local watershed models remain an evolving science. Local models require numerous assumptions such as the exact timing of flows, specific variations in hydrology, air and water temperatures and other parameters that have significant influence on the model results. The range of climatic variability at local levels, such as the Mokelumne River watershed, requires long-term datasets and development of new tools to quantitatively assess impacts. These tools and datasets are not yet available. At this time, the assessment of impacts at the local level would therefore be speculative, but it does underscore the value of implementing adaptive water resources management. Adaptive resources management could provide the necessary means to address the range of climatic variability and the dynamic changes and complexity associated with climate change.

The impacts of climate change on California are potentially significant with major consequences expected on the state's hydrologic cycle. There is evidence that some changes, such as earlier spring snowmelt, increased winter runoff, and increased winter flooding frequency, have already occurred (Dracup et al. 2005). EBMUD has reviewed the available science regarding climate change impacts on fishery resources. Expected changes over the next 50 years in California include freshwater warming; altered timing, frequency, duration, and magnitude of peak flows; further increased

winter flood frequency (rain on snow events); altered timing of marine upwelling; decreased marine productivity; and increased marine predators (AFS 2010; Mote 2003). Peak stream flows shifted to earlier in spring, reduced summer flows resulting from an earlier snow melt, and higher air temperatures also reduce the availability of cold-water required by native California salmonids.

In addition to the changes in native salmonid fish habitat, climate-related changes are predicted to increase freshwater disease, parasitism, competition and predation by alien fishes; and to alter the distribution and timing of adult salmonid migration and smolt entry into the ocean. Although marine upwelling is predicted to increase with climate change, it may begin later and be less suitable for the predicted earlier ocean entry of salmonid smolts (ISAB 2007).

Moyle et al. (2012a) determined that all native California anadromous fishes were rated as highly vulnerable (i.e., species that are approaching extinction and are likely to be re-categorized as critically vulnerable if their populations or ranges are diminished further) or critically vulnerable (i.e., species that are at imminent risk of extinction), and Central Valley fall-run Chinook salmon are critically vulnerable to climate change effects. Suitable habitat for most native fish species in California is likely to shrink; especially cool water streams during extended periods of drought, a situation exacerbated by interactions with alien fishes (Leidy et al. 2011; Moyle et al. 2012b).

Null et al. (2010) relied upon a series of assumptions including increases in air temperature that is uniformly applied to a number of east-side watersheds including the Mokelumne under unimpaired conditions. The study indicates that the Mokelumne River basin may be less resilient to air temperature increases which could be manifested in a reduction in mean annual flow (MAF), a change in runoff centroid timing (CT), and an increase in low flow duration (LFD). Modeled air temperature increases of 2°C, 4°C and 6°C decreased MAF 3.4, 6.2, and 9.4 percent, respectively. CT, the date at which half of the annual runoff at the outlet of the watershed has passed, occurred nearly 2 weeks earlier for every 2°C rise in air temperature. LFD, the number of weeks with low flow conditions, increased about 1 additional week with each 2°C rise in air temperature. The modeling indicated that the Mokelumne River is among the most vulnerable to changes in MAF, CT, and LFD. The study relied on a relatively short dataset and did not include the effects of regulation by PG&E reservoirs on the Mokelumne, potential changes in evapotranspiration rates, water supply diversion and other model uncertainties that may affect the study predictions. Additional scientific research is necessary to further develop and evaluate impacts on a local level.

Some studies have found that the hydrology in the Mokelumne River basin is vulnerable to predicted climate changes (Null et al. 2010) and the native anadromous salmonids in the Mokelumne River are critically vulnerable to these climate change impacts (Moyle et al. 2012a). Although it is predicted that climate change will amplify the existing stresses on Mokelumne River salmonids, data are currently insufficient to determine if the weather extremes; seasonal, inter-annual, and multi-decadal climate variability; and long-term climate change will exacerbate insignificant Project-related impacts to the point that they will result in significant impacts to fish resources.

The scientific understanding of climate change at a more refined local level continues to evolve. Climate change related impacts at a local level are dependent on the complex interplay between numerous variables such as timing of flows, temperature and other meteorological factors, vegetative cover, evapotranspiration rates, location and size of existing infrastructure, water diversions, and operational scenarios.

EBMUD continues to monitor on-going developments in the climate change arena to gain a better understanding of changing conditions in order to manage and operate its Mokelumne River facilities

in an appropriate manner. It is anticipated that implementation of adaptive management measures and releases as prescribed in the Joint Settlement Agreement may provide the means to address the predicted range in climatic variations resulting from climate change.

7.3.4 East Bay Municipal Utility District's Response to Climate Change

EBMUD has developed a management strategy that incorporates climate change into internal decision-making, capital improvement planning, and budget planning. EBMUD has established and achieved a GHG reduction goal and continues to work with EPA's Climate Ready Water Utility Workgroup, EPA's Climate Change Risk Assessment and Awareness Tool Working Group, ARB, and other industry committees to develop best practices for water utilities for GHG reduction and climate adaptation planning. In addition to these efforts, EBMUD is doing the following to address the specific vulnerabilities identified and described in Section 7.3.3, *Assessment of Climate Change Impacts onto the Permit 10478 Time Extension Project*.

- Establish an Impacts, Vulnerability and Adaptation (IVA) Working Group with members from Water Distribution Planning, Water Supply Operations, Wastewater Planning, Legislative Affairs, Water Supply Improvements, Natural Resources and Water Treatment and Distribution.
- Identify key areas of vulnerability related to watershed management, operations, and wastewater.
- Commit to an approach of adjusting the water supply portfolio over time as climate change impacts manifest in the service area and the Mokelumne River watershed.
- Increase water conservation and use of recycled water within its service area to reduce demand.
- Pursue multiple, parallel supplemental supply projects, including desalination, water transfers, groundwater, and upcountry supply projects.
- Incorporate climate change considerations in all level one and level two master plans.
- Incorporate potential climate change impacts in watershed management plans.
- Implement the WSMP 2040 approach to adaptation.
- Implement measures at EBMUD's reservoirs to maintain water-based recreation services (e.g., extended boat ramps and shoreline access).
- Employ measures to reduce sediment/nutrient influx resulting from reservoir fluctuations and wildfires.
- Evaluate Corps flood-control guidelines in the Mokelumne River watershed to add flexibility to manage reservoirs based on an earlier runoff scenario, while still maintaining adequate flood control space.

7.4 Conclusions

The GHG emissions evaluated here are those associated with the increase from EBMUD's 2005 baseline diversion (214 MGD) to EBMUD's 2040 future diversion (230 MGD), a difference of 16 MGD. Electricity purchases are the primary source of GHG emissions for EBMUD operations and electricity consumption at the Walnut Creek Pumping Station would increase as a result of the Project. However, this analysis shows that EBMUD can still meet projected demand in non-drought conditions and decrease the system-wide GHG intensity factor and overall GHG emissions, assuming PG&E meets its RPS requirements pursuant to SB 1078 and SB 107. EBMUD's GHG emissions and emission intensity would decline during the years 2005 to 2040 due to PG&E's compliance with the state RPS (indirect emissions through the purchase of PG&E electricity) and EBMUD's continued conservation and increased use of its own renewable resources. The impact of the Project on GHG emissions is considered *less than significant*.

A significance determination of the impacts of climate change on the Project is not currently required under CEQA. A summary of climate change impacts in the service area and the Mokelumne River watershed, vulnerabilities on EBMUD's operations, and adaption measures taken by EBMUD are provided for informational purposes only. EBMUD's analysis of future changes in the watershed due to climate change is described in the WSMP 2040 (East Bay Municipal Utility District 2009). EBMUD's water supply could be affected by changes in temperature and precipitation patterns as substantial decreases in Sierra Nevada snowpack reduce the available water supply and higher temperatures may alter runoff timing. Climate change also could affect EBMUD's flood management and energy production, as well as water quality and fish resources in the Mokelumne River.

EBMUD has incorporated climate change considerations into its planning and decision-making in a manner that allows for flexibility as the science of the regional climate change impacts continues to evolve.

California Environmental Quality Act (CEQA) requires an Environmental Impact Report (EIR) to evaluate a project's effects in relationship to broader changes that are occurring or that potentially could occur in the surrounding environment. Accordingly, this chapter discusses areas of known controversy, the potential growth-inducing impacts of the Permit 10478 Time Extension Project (Project), and significant irreversible environmental changes.

8.1 Areas of Known Controversy

State CEQA Guidelines Section 15123(b) requires that an EIR include a description of areas of controversy known to the lead agency, including issues raised by agencies and the public and issues to be resolved, such as the choice among alternatives and whether or how to mitigate the significant impacts. Based on verbal input received during public scoping meetings and written input received during the comment period for the notice of preparation (NOP) (see Chapter 9, Agency Consultation and Public Outreach), the issues below reflect areas of known controversy.

8.1.1 Mokelumne River Water Supply Concerns

A key concern of San Joaquin County interests is the potential for reduced surface water supply for agricultural uses. Under the Project, the amount of Mokelumne River water available to junior water-rights holders may be reduced because EBMUD would continue to need to draw additional water from the Mokelumne River under the existing Permit 10478 to meet future water demands. Therefore, the Project could result in a reduction in the amount of water available to agricultural users with junior water rights on the Mokelumne River, whose water rights represent the unused portion of senior water rights holders.

An analysis of project-related impacts on agricultural resources is presented in Section 3.4, Agricultural Resources. Under baseline conditions, allocations to the North San Joaquin Water Conservation District (NSJWCD) (a junior water rights holder) would be available 49 years out of the 89 years modeled, with 1 of these years being less than the full 20,000 acre-feet delivery. Under project conditions, allocations to NSJWCD would be available 47 out of 89 years, with 2 of these years being less than the full 20,000 acre-feet delivery. The analysis concludes there would be no significant impacts on agricultural resources because of the slight reduction (less than 2%) in the number of years water would be available to NSJWCD.

8.1.2 Fisheries

During agency scoping meetings held for this EIR, fish agencies requested analysis of the Joint Settlement Agreement (JSA) and the federally listed Central Valley steelhead in the Mokelumne River. As described in Section 3.2, Fish Resources (Section 3.2.2.1), the JSA contains both flow and non-flow measures to benefit anadromous fish in the Mokelumne River, including steelhead and fall-run Chinook salmon. The California Department of Fish and Wildlife (CDFW) and U.S. Fish and Wildlife Service (USFWS) approved the JSA, agreeing that it provides reasonable protection and

enhancement for anadromous fish and wildlife resources of the lower Mokelumne River. Both agencies have agreed not to oppose the JSA flow and non-flow measures in any regulatory proceeding directed at EBMUD's obligation to protect fish resources of the Mokelumne River ecosystem.

USFWS also completed a biological opinion on the JSA under the federal Endangered Species Act (ESA) prior to its approval of the JSA. As noted in Section 3.2.2.1, the National Marine Fisheries Service (NMFS) also completed ESA Section 7 conferencing/consultation on the JSA in 1997–1998 on Central Valley steelhead.

In addition, CDFW, USFWS, and NMFS participate in ongoing efforts to benefit fish in the lower Mokelumne River. These efforts include the formation of and efforts carried out by the JSA Coordinating Committee, JSA Partnership Steering Committee, and the Mokelumne River Technical Advisory Committee.

The JSA Coordinating Committee is composed of biologists and related CDFW, USFWS, NMFS, and EBMUD staff. The 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 JSA Partnership Fund; and developing proposed adaptive management flow modifications to benefit fish.

Representatives from CDFW, USFWS, and EBMUD also form the JSA Partnership Steering Committee, whose work includes reviewing and approving use of the JSA Partnership Fund, approving adaptive management flow modifications, and working cooperatively on fish resource issues affecting the Mokelumne River, such as its recent efforts in requesting the state and federal water projects to implement a limited closure of the Delta Cross Channel during the first half of October to benefit in-migrating Mokelumne River anadromous fish.

Finally, the Mokelumne River Technical Advisory Committee meets two times a year to share technical information on the Mokelumne River hatchery. In total, these efforts encompass a broad scope of flow and non-flow measures intended to benefit the Mokelumne River fishery ecosystem, with its focus on anadromous (steelhead and fall-run Chinook salmon) fish.

Under the Project, EBMUD would continue to release water to the lower Mokelumne River as specified in the JSA. 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 198,100 acre-feet (in water year 2008) to about 1,216,000 acre-feet (in water year 2006 as published by the U.S. Geological Survey).

8.2 Growth-Inducing Impacts

State CEQA Guidelines Section 15126(d) requires that an EIR evaluate the potential growth-inducing impacts of a proposed project. Section 15126.2(d) of the State CEQA Guidelines provides the following guidance for the discussion of potential growth-inducing impacts: "... discuss the ways in which a project could foster economic or population growth, or the construction of additional housing either directly or indirectly, in a surrounding environment." Projects that remove obstacles to population growth also must be considered in this discussion. An example of a project that could

“remove obstacles to population growth” is resolving constraints on required public services or utilities. Direct or indirect growth inducement “may tax existing community service facilities, requiring construction of new facilities that could cause significant environmental effects” (State CEQA Guidelines Section 15126.2(d)). The guidelines conclude that “it must not be assumed that growth in any area is necessarily beneficial, detrimental, or of little significance to the environment.”

Local land use plans provide for land use development patterns and growth policies that allow the orderly expansion of urban development supported by adequate urban public services, such as water supply, roadway infrastructure, sewer service, and solid waste service. Typically, the growth-inducing potential of a project or program would be considered significant if it encourages growth or a concentration of population in excess of what is projected in the adopted general plan of the community in which the project is located, or significantly exceeds the population and employment projections made by regional planning agencies.

For decades, the availability of water under Permit 10478 has been assumed as part of the planning for the cities and counties in EBMUD’s service area. The Project would not provide a new water supply to land-use entities in the EBMUD service area. Once the Camanche Reservoir was completed in 1964, EBMUD could deliver and has delivered Permit 10478 water to the service area. Thus, the extension, if granted, would represent the continued availability of this long-existing water supply. Water supply assessments conducted by EBMUD to determine the availability of water for planned developments assume the availability of this long-existing water supply.

This section analyzes the nature and extent of growth-inducement potential for the Project by examining existing and projected water supply and demand, and conformance with the adopted general plans of the service area communities. The discussion also assesses the secondary effects of growth and addresses the mitigating policies and measures of the responsible agencies that are intended to reduce these secondary impacts.

8.2.1 EBMUD Service Area Growth Projections

As described in Chapter 1, Objective and Need for the Permit 10478 Time Extension Project, and other sections in this EIR, EBMUD recently (2009) completed an extensive and exhaustive study of factors to forecast future water demands to the year 2040 in EBMUD’s service area titled *2040 Demand Study* (East Bay Municipal Utility District 2009). The study effort included meeting with land-use planning agencies in the service area and reviewing general demand patterns, legislative directives, land-use trends, economic conditions, weather patterns, and general plan changes to forecast a water demand to the year 2040. It concluded that an emerging long-term pattern is the densification and infill of existing metropolitan areas such as Oakland, Emeryville, and Berkeley and development of urban corridors. Among other conclusions, the *2040 Demand Study* concluded that water demand in year 2040 for EBMUD would be 230 million gallons per day (MGD) after savings from conservation and non-potable uses are included.

8.2.2 Potential Growth-Inducing Impacts

As noted earlier, in accordance with California Government Code Section 65300, land-use agencies in EBMUD’s service area develop and adopt long-term planning documents such as the general plans for the physical development within their jurisdiction. These planning documents determine the nature and intensity of land uses to be served by EBMUD and undergo rigorous evaluation under CEQA at the time of their adoption. In adopting the applicable general and specific plans, the local

decision-making bodies adopt measures to mitigate adverse impacts associated with the growth that would occur under the plans and adopt statements of overriding considerations associated with impacts that cannot be reduced to an insignificant level.

The General Plan EIRs adopted by several of the service area land use approval agencies identify significant and unavoidable impacts associated with planned growth on aesthetics, agricultural resources, air quality, biological resources, geology and soils, hydrology and water quality, noise, and transportation and traffic associated with planned growth in several areas. Still other agencies have adopted feasible mitigation measures to reduce the significance of these impacts.

Changes to water demands resulting from unplanned growth would occur only after local approval of general plan amendments and the related CEQA review. This would include confirmation of the availability of water supply to meet demands beyond those currently planned by EBMUD pursuant to Water Code Section 10910. No such amendments are anticipated at this time.

Implementation of the Project would not support growth beyond planned levels or in areas not planned for development by the appropriate land use agencies, and would support additional growth in the communities served by EBMUD in accordance with the approved local land use plans of the cities and counties. The impacts of that growth have been disclosed in the EIRs for the applicable general plans, community plans, and specific plans. The Project would neither directly nor indirectly support unplanned economic expansion, population growth, or residential construction in the EBMUD service area. Therefore, any potential growth-inducing impacts from the Project would be considered less than significant.

8.3 Significant Irreversible Changes

The environmental effects associated with extending Permit 10478 are summarized in the introduction to Chapter 3, Impacts and Mitigation Measures, and are analyzed in detail in Sections 3.1 through 3.6 of this EIR. The analyses presented in the resource sections identified no significant impacts associated with implementing the Project with appropriate mitigation measures to reduce impacts to less-than-significant levels. Additionally, there would be no significant irreversible changes associated with the Project because there would be no commitment of non-renewable resources such as minerals and fossil fuels as a result of project implementation.

Chapter 9

Agency Consultation and Public Outreach

This chapter describes agency consultation, public outreach, and public participation activities associated with development of the Permit 10478 Time Extension Project¹ (Project) Environmental Impact Report (EIR).

9.1 Agency Consultation

9.1.1 Notice of Preparation

EBMUD issued the notice of preparation (NOP) for a Draft EIR on November 7, 2008, soliciting comments from agencies and the public on the content of the EIR for the Project. The NOP described Permit 10478, the purpose of and need for the Project, and announced the three public scoping meetings described below. The NOP invited submittal of comments during a 30-day period between November 7 and December 11, 2008.

In accordance with State California Environmental Quality Act (CEQA) Guidelines §15082(a)(3), the NOP was sent by certified mail to the responsible agencies and other parties on the project mailing list, and to the State Clearinghouse (SCH) on November 7, 2008. The SCH acknowledged receipt of the NOP on November 11, 2008, and assigned SCH 2008112043 to the EIR.

The NOP summarized the need to extend Permit 10478 through 2040 and presented EBMUD's determination that the Project may have a significant effect on the environment. The environmental analysis discussion described the resource categories that would be analyzed in the EIR, as well as climate change and growth-inducing effects. The NOP also described the public scoping process and the methods by which interested parties could submit comments.

In addition to certified mailing of the NOP, the NOP and its list of the public scoping meetings were published in newspapers of general circulation in EBMUD's service area and in newspapers serving the communities near Camanche and Pardee Reservoirs and the lower Mokelumne River. The NOP information was posted on EBMUD's website, and copies were available upon request.

9.1.2 Scoping Meeting with the Resource Agencies

On November 12, 2008, representatives from EBMUD and the consultant team (ICF International, formerly ICF Jones & Stokes) met with resource agencies, including California Department of Fish and Wildlife (CDFW), U.S. Fish and Wildlife Service (USFWS), and National Marine Fisheries Service (NMFS) for the purpose of understanding the agencies' interests and concerns to be addressed in the EIR. NMFS's concerns included addressing water quantity, temperature management, and restoration activities as they relate to steelhead. Steelhead was not listed under the federal Endangered Species Act (ESA) at the time the Joint Settlement Agreement (JSA) was adopted and, therefore, was not included in the JSA; however, NMFS completed its conferencing opinion of the JSA effects on Central Valley steelhead, and in April 1998 concluded the following.

¹ The Permit 10478 Time Extension Project is also known as the Camanche Permit Extension Project.

The conferencing previously done for 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 also conclude that this action is not likely to adversely affect the proposed-threatened CV fall-run Chinook ESU. This concludes Section 7 consultation for the threatened CV steelhead, and conferencing for the proposed-threatened CV 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 CV fall-run Chinook listing, provided that the project is implemented substantially as described in the November 1993 FEIS.

During the scoping meeting with the agencies, USFWS requested that the EIR consider the potential adverse effect of creating nursery areas for striped bass, which are predators of anadromous salmonids. The agencies also suggested that the cumulative impact analysis should consider overall San Joaquin River inflows, use recent data for climate change modeling, acknowledge the lack of understanding about changes in the ocean when modeling for aquatic resources, and consider the water plan for San Joaquin County that is being developed by Fresno State.

9.1.3 Agency Coordination

The State Water Board is the Responsible Agency for water rights permitting and licensing for this EIR. In response to the NOP, the State Water Board provided a comment letter dated November 19, 2008. In 2012 and 2013, EBMUD continued to consult with and obtained input from the State Water Board during the preparation and development of the Draft EIR. EBMUD also consulted with USFWS, NMFS, CDFW, and Woodbridge Irrigation District (WID) in the development of the Draft EIR.

9.2 Public Outreach

9.2.1 Scoping Meetings

Three public scoping meetings were held on the following dates to receive public input on the scoping process for the Project.

- **November 18, 2008—Lodi, California.** This public scoping meeting was held at the Lodi Public Library. Four people attended the meeting.
- **November 18, 2008—Sutter Creek, California.** This meeting was held at the Amador Water Agency, Board Hearing Room. Five people attended.
- **November 20, 2008—Oakland, California.** A third public scoping meeting was held at EBMUD's headquarters/administrative offices. There were no attendees.

9.2.2 Issues of Public Concern

Issues raised by the public during the public scoping meetings and in letters sent in response to the NOP raised a variety of issues. Brief summaries of these issues follow. A more detailed description of these issues is presented in the *Public Scoping Summary Report for the Camanche Water Rights Permit Extension Project* (ICF Jones & Stokes 2009).

9.2.2.1 San Joaquin County Interests

Commenters responding to the NOP asked that the EIR consider the potential future impacts of the Project on San Joaquin County interests, including concerns about impacts on the groundwater basin, biological resources, geology, soils, utilities, and the service systems of water purveyors. Concerns about the groundwater basin focus on the current overdraft situation, resulting seawater intrusion, and whether sufficient water would be available for recharge of the groundwater basin under the Project. This issue is addressed in Section 3.1, Water Resources; Section 3.3, Vegetation, Wetland, and Wildlife Resources; and Section 3.4, Agricultural Resources.

9.2.2.2 San Joaquin County Water Supply

Commenters asked that the EIR address the potential impact of the Project on the San Joaquin water supply. Specifically, they asked that the proposed MORE WATER Project be considered in the EIR and expressed concerns that the Project might affect the availability of water for the proposed MORE WATER Project. Others asked that the EIR consider inter-regional options, including the use of the proposed regulating reservoir on Duck Creek. Additionally, commenters asked that the developments since the issuance of the original permit in 1956 be considered. They stated that at the time Calaveras County Water District and the North San Joaquin Water Conservation District (NSJWCD) were denied applications based on the assumption that San Joaquin County could obtain water from the Feather River or American River projects. They also asked that the EIR consider the implications arising from the fact that San Joaquin County still has not obtained a supplemental water supply.

9.2.2.3 Water Supply

Some commenters expressed concern about the availability of water in the Mokelumne River and asked for a quantitative and qualitative evaluation of impacts associated with the Project. They noted that the water rights that exist on paper do not necessarily correlate with the amount of water that is actually in the river. Others asserted that the extension of Permit 10478 is akin to a new water right. Some asked that the EIR address the quantity of water that has not yet been put to beneficial use under Permit 10478. They argued that because Camanche Reservoir is not plumbed to EBMUD's service area, the water stored there cannot be considered to have been put to municipal use. Some further requested that the EIR address the impacts associated with consumptively using the full quantity of water under Permit 10478 because the water diverted and stored in Camanche is not being consumptively used at this time.

9.2.2.4 Other Water Source Alternatives

Many suggestions were made as to water source alternatives that should be explored in the EIR. Some suggest that one alternative should include allocation of the unused entitlement under Permit 10478 for public trust purposes, with EBMUD replacing that amount of water through additional conservation, desalination, or water recycling. Others recommend inclusion of an alternative that would allow EBMUD to obtain water during normal and wet years from the Freeport Regional Water Project (FRWP) to reduce reliance on Mokelumne River water. Still others suggest that the EIR consider an alternative where EBMUD obtains a normal and wet year supply from sources such as local water transfers and exchanges, the Walnut Creek-San Ramon Valley Improvement Project, the Bayside Groundwater Project, and development of desalinated water. Further, some suggested that looking to these water supply alternatives, including recycling and conservation, would reduce

hydrologic demands on the Mokelumne River, provide greater water supply reliability, lessen infrastructure concerns regarding seismic/flooding vulnerability in the Sacramento–San Joaquin River Delta (Delta), and may reduce the need for water supplies from the counties of origin. Others suggested that the EIR evaluate regional water supply options, including the Inter-Regional Conjunctive Use Project (IRCUP) being developed by the Mokelumne River Forum for the more efficient use of future Mokelumne River supplies. The feasibility of these alternatives is addressed in Chapter 2, Project Description, Baseline, and Alternatives; and Chapter 5, Alternatives Analysis.

9.2.2.5 Projected Water Demand

Commenters asked that the EIR address how projected water demands are to be calculated and how the full allocation of water provided by an extension of the permit would be put to beneficial use. Further, some asked that the EIR include a future water demand analysis, based on planned growth as adopted in the general plans of land-use agencies in EBMUD's service area. Others asked that the EIR discuss how the permit extension is justified in terms of the amount of water that would be available through the FRWP. This issue is addressed in the 2040 Demand Study (East Bay Municipal Utilities District 2009).

9.2.2.6 Construction of New Water Conveyance Facilities

Commenters stated that if a conveyance structure were constructed to direct water in the Camanche Reservoir to the EBMUD service area before the end of the 40-year permit, the impacts of construction should be evaluated in the EIR. Others suggested that any potential improvements to existing facilities be analyzed, and some asked for a map of the Mokelumne Aqueduct System and clarification as to what, if any, reconstruction or maintenance activities are anticipated. The conveyance facility is discussed in Chapter 6, Programmatic Evaluation of Use Beyond 2040.

9.2.2.7 Hydrology and Drainage

Commenters asked that the EIR evaluate Project effects on hydrology, that it include a map of the watersheds in the project area, and that it evaluate effects of the Project on the Mokelumne Watershed Master Plan. Additionally, inclusion of the Contra Costa County Flood Control and Water Conservation District is requested for review of all drainage facilities that have a region-wide benefit, that affect region-wide facilities, or that affect district-owned facilities.

9.2.2.8 Water Quality

In addition to requests that the EIR include mitigation for the Project's impact on water quality, commenters stated that water from public-supply, agriculture, and domestic wells in the western part of the subbasin adjacent to the Delta exceeds EPA's Secondary Maximum Contaminant Level for chloride of 250 milligrams per liter (mg/l).

9.2.2.9 Fish

Commenters suggested the previously unused volume of water identified for beneficial uses under Permit 10478 should be used to benefit protected Central Valley steelhead in the lower Mokelumne River by increasing instream flows and improving habitat. Others suggested that earlier water rights agreements, including the lower Mokelumne River JSA, were based on relatively old and potentially outdated or inaccurate information, and that new information identifies the need to improve flow

conditions for protected anadromous steelhead. Further, some suggested that the “extra and available” water should be used within an experimental flow design study to discover how fish populations respond to a more favorable flow regime. Some suggested that the extra water be used to enhance rearing habitat and survival for juvenile steelhead in the lower reach of the Mokelumne River during seasonal low-flow summer conditions. In addition, EBMUD and WID should focus on the impact of irrigation water diversions (including private direct diversion pumps in the river) on rearing habitat for steelhead juveniles between Woodbridge and the New Hope Road bridge crossing.

Additionally, respondents urged that the EIR rely on updated data rather than the data from the 1996 JSA because Delta conditions since have declined precipitously. In a related note, respondents asked that the EIR include a comprehensive habitat suitability study throughout the Upper Mokelumne River watershed. This study should acknowledge that the area inundated by Camanche Reservoir previously provided spawning habitat for Chinook salmon and that a prehistoric fish weir below Salt Springs has been reported.

Others asked that fish passage feasibility studies be conducted on both the Camanche and Pardee Reservoirs because there is an unknown amount of potentially suitable spawning and rearing habitat between the reservoirs and above Pardee Reservoir.

Some asked that reservoir management plans be completed for both reservoirs and should include the following items.

- A fisheries management program that considers the various factors affecting fish and fish management, including the physical, chemical, and biological conditions, as well as the impact of economic conditions and recreation activities on fish and fish management.
- An analysis of water quality and water quantity impacts from recreational activities on each reservoir.

Some asked for acknowledgment that the use of water in Camanche Reservoir for providing adequate flow and water quality for downstream flows and habitat for fish (as provided for in the lower Mokelumne River JSA) is an unacceptable use of the water in Camanche and Pardee Reservoirs. These issues are addressed in Section 3.1, Water Resources, and Section 3.2, Fish Resources.

9.2.2.10 Biological Resources

Respondents asked that the EIR provide adequate mitigation for the Project’s impact on fish and wildlife and their habitats, including special-status species; aquatic and terrestrial habitat along the Mokelumne River; habitat for sensitive species; habitat for Chinook salmon, steelhead, and delta smelt; and wetland and riparian habitat. Also, some asked that the EIR evaluate whether the Project would preclude or inhibit the full restoration of salmon populations above Pardee Dam. Others asked that the EIR evaluate alternatives that would reduce impacts on fish, wildlife, and vegetative resources, including adequate mitigation of the Project’s growth-inducing and cumulative impacts. These issues are addressed in Section 3.2, Fish Resources; Section 3.3, Vegetation, Wetland, and Wildlife Resources; and Chapter 4, Cumulative Impacts. The Project is not expected to adversely affect the existing conditions upstream of Pardee Dam or the conditions affecting passage to the area.

9.2.2.11 Growth Inducement and Climate Change

Commenters asked that the EIR analyze the growth-inducing impacts of extending the permit for an additional 40 years. Others asked that changes in watershed hydrology resulting from climate change be considered, including how these changes may relate to the overall availability of water demand patterns and the applicability of existing and planned infrastructure in the watershed. Additionally, some asked for an analysis of growth inducement and conversion of agricultural lands as a result of climate change. The issues related to climate change and growth inducement are addressed in Chapter 7, Climate Change, and Chapter 8, Other CEQA Analyses, respectively.

9.2.2.12 Cumulative Effects

Commenters stated that the cumulative effects on salmon, other aquatic life, and the Delta resulting from drawing more water from the lower Mokelumne River should be evaluated. Additionally, the EIR should analyze the cumulative effect of using the full allocation of water under Permit 10478 combined with reasonably foreseeable projects, including raising Pardee Dam, the Mokelumne/Amador/Calaveras (MAC) Integrated Regional Water Management Plan (IRWMP), the San Joaquin IRWMP, the proposed MORE WATER Project, and the proposal for the IRCUP. These issues are addressed in Chapter 4, Cumulative Impacts.

9.2.2.13 Socioeconomic Impacts and Environmental Justice

Respondents asked that the EIR include an analysis of the following issues.

- The burden on the San Joaquin County community from the diversion, storage, and conveyance of Mokelumne River water.
- The seismic integrity of the Pardee Dam.
- The impact of the Mokelumne Aqueduct easement in the City of Stockton on property values and crime, loitering, and illegal dumping.
- The increased costs of construction and mitigation for local projects in the vicinity of the Mokelumne Aqueduct.
- The disproportionate impact on San Joaquin County from the extension of Permit 10478 as it relates to
 - water supply impacts resulting from declines in groundwater levels;
 - economic impacts of potential dam failure and flooding and degraded groundwater quality resulting from saltwater intrusion;
 - health impacts from higher carbon, particulate, and other harmful emissions of increased energy usage to pump groundwater;
 - loss of recreation, subsistence fishing, habitat and fisheries as a result of water lost to the river and the Delta;
 - impacts on the taxpayers to mitigate the impacts of the Project; and
 - environmental justice impacts on San Joaquin County.

9.2.2.14 Permitting, Fees, and Agency Coordination

Commenters stated that the EIR should consider whether the Project would result in reasonably foreseeable potentially significant impacts that would be subject to regulation by CDFW under Section 1600 *et seq.* of the California Fish and Game Code. Additionally, if the Project would result in reasonably foreseeable substantial adverse effects on fish or wildlife, a Lake or Streambed Alteration Agreement would be required by CDFW. Therefore, the EIR also should include an analysis of whether potentially feasible mitigation measures would avoid or substantially reduce impacts requiring a Lake or Streambed Alteration Agreement. Respondents noted that the Project would result in impacts on fish and/or wildlife habitat and, therefore, an assessment of fees under Public Resources Code Section 21089 and defined by Fish and Game Code Section 711.4 would be needed.

Additionally, some asked that the EIR indicate that work within Contra Costa County Flood Control and Water Conservation District's right-of-way would require the issuance of an encroachment permit by the district.

Finally, commenters stated that if any adverse impact on traffic is anticipated, a Traffic Impact Analysis may be required, including coordination with Caltrans.

9.2.2.15 Other

Commenters asked that the Native American Heritage Commission be contacted regarding any cultural resources in the project area. Others asked that the EIR contain an evaluation of the Project's consistency with the applicable land use plans, while others asked that impacts on traffic and circulation and on air quality and recreation be evaluated.

Chapter 10

List of Contributors

10.1 East Bay Municipal Utility District

Contributor	Title
Richard Sykes	Director, Water and Natural Resources Department
Lena Tam	Manager, Water Resources Planning Division
Joe Miyamoto (retired)	Manager, Fish and Wildlife
James R. Smith	Supervising Fish and Wildlife Biologist
Ben Bray	Associate Water Resource Specialist
Ana Ulloa	Senior Civil Engineer
Uma Thomas	Associate Civil Engineer

10.2 ICF International

Contributor	Degree(s)	Years of Experience	Expertise
Project Management			
Harlan Glines, Sr. Vice President/Project Director	B.A.	30	Planning policy consistency assessment; land use planning and impact analysis; CEQA/NEPA/ESA compliance; project management
Colleen Lingappaiah, Project Manager	B.A.	22	Water resources project manager; NEPA; CEQA; ESA compliance; Clean Water Act Section 404 permitting
Jenna Wallis, Project Coordinator	B.S., M.E.M	5	NEPA, CEQA, and ESA compliance; marine planning and policy
Technical Support			
Terry Rivasplata, CEQA Advisor	B.S.	35	CEQA/NEPA
Susan Bushnell-Bergfalk, Botanist/Wetlands Ecologist	B.S.	23	Wetland resources; special-status species; NEPA/CEQA analysis; regulatory compliance for water projects
Anne Huber, Water Resources Analyst	B.A., M.S.	19	Hydrology; water quality
Bill Mitchell, Fisheries Biologist	B.S., M.S.	27	Anadromous salmonid ecology; fish population and habitat assessment monitoring; quantitative habitat assessment methods; ESA and NEPA/CEQA compliance documents
Kristen Lundstrom, Technical Editor	B.A.	9	Technical editing

Contributor	Degree(s)	Years of Experience	Expertise
Cory Matsui, Air Quality and Climate Change Specialist	A.A., B.A.	3	GHG emissions; climate change
Harry Oakes, Biologist	B.S.	21	Habitat restoration; biology
Corrine Ortega, Publications Specialist	A.A.	20	Word processing and document production
Senh Saelee, Graphic Artist	B.S.	9	Cartography; Illustrator, InDesign, Photoshop
Jennifer Stock, Landscape Architect	B.L.A.	15	Visual analysis; restoration design
Margaret Widdowson, Biologist/Botanist	B.S., PhD	16	Special-status plant surveys; floristic inventories; wetland delineation, vegetation mapping; CEQA/NEPA
Pablo Herrera, Wildlife Biologist	B.S.	17	Wildlife management; avian specialist

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11.2 Personal Communications

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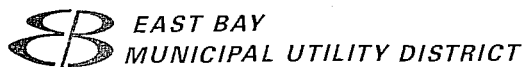
Jones, James. Wildlife Biologist. East Bay Municipal Utility District. April 3, 2009—phone conversation with Harry Oaks, ICF International, regarding special-status species that have been observed in the project area but have not been documented by the California Natural Diversity Database.

Leong, Rick. Watershed Planning Analyst. Natural Resources Department, East Bay Municipal Utility District. August 3, 2009—email correspondence regarding number of visitors at Pardee Recreation Area, Camanche Reservoir Recreation Areas, and the Lower Mokelumne River Day Use Area.

Mount, Jeffrey, Ph.D. Professor. Watershed Center and Department of Geology, University of California, Davis. March 10, 2004—email correspondence with James Smith, Supervising Fish and Wildlife Biologist, East Bay Municipal Utility District, regarding floodplain restoration in the lower Mokelumne and Cosumnes Rivers,

Appendix A

Permit 10478 Petition for Extension of Time



013156
File copy

HMS/JJ/ELD
cc: MLC

OFFICE OF GENERAL COUNSEL

ROBERT C. HELWICK
GENERAL COUNSEL

NANCIE RYAN
ASSISTANT GENERAL COUNSEL

CRAIG S. SPENCER
CHIEF TRIAL ATTORNEY

XANTHE M. BERRY
JYLANA COLLINS
FRED S. ETHERIDGE
VERONICA Y. FAUNTLEROY
JOEL FREID
PETER W. SLY

Via Messenger

November 27, 2000

Mr. Harry M. Schueller
Chief, Division of Water Rights
State Water Resources Control Board
1001 I Street, 14th Floor
Sacramento, California 95814

Re: Petition for Extension of Time -- Application 013156, Permit 10478

Dear Mr. Schueller:

Enclosed please find EBMUD's Petition for Extension of Time for Application 013156, Permit 10478, the district's Camanche M&I right, along with a check for \$50.00 to cover the applicable fee. EBMUD has met and continues to meet with North San Joaquin Water Conservation District to discuss coordination of our respective petitions for extension of time.

Very truly yours,

A handwritten signature in black ink, appearing to read 'R. Helwick', is written over the closing 'Very truly yours,'.

Robert C. Helwick
General Counsel
Enclosures

cc. Dennis M. Diemer, General Manager
Ed Steffani, NSJWCD

State of California
State Water Resources Control Board
DIVISION OF WATER RIGHTS
P.O. Box 2000, Sacramento, CA 95812-2000
Info: (916) 657-2170, FAX: (916) 657-1485, Web: <http://www.waterrights.ca.gov>

STATE WATER RESOURCES
CONTROL BOARD
DIV. OF WATER RIGHTS
SACRAMENTO
00 NOV 27 AM 11:30

PETITION FOR EXTENSION OF TIME

WATER USERS:

Application 013156 Permit 10478

Water Code section 1396 requires an applicant to exercise due diligence in developing a water supply for beneficial use. The State Water Resources Control Board (SWRCB), in considering requests for extension of time, will review the facts presented to determine whether there is good cause for granting an extension of time to complete the project. Where diligence in completing the project is not fully substantiated, the SWRCB may set the matter for hearing to determine the facts upon which to base formal action relating to the permit. Formal action may involve:

1. Revoking the permit for failure to proceed with due diligence in completing the project.
2. Issuing a license for the amount of water heretofore placed to beneficial use under the terms of the permit.
3. Granting a reasonable extension of time to complete construction work and/or full beneficial use of water.

The time previously allowed in your permit within which to complete construction work and/or use of water has either expired or will expire shortly.

Please check below the action you wish taken on this permit.

- ☐ The project has been abandoned and I request revocation of the permit.

Signature
- ☐ Full use of water has been made, both as to amount and season, and I request license be issued.

Signature
- ☒ The project is not yet complete. I request the SWRCB's consideration of the following petition for an extension of time.

PETITION FOR EXTENSION OF TIME
If START of construction has been delayed

Complete items 1, 2, and 3.

1. What has been done since permit was issued toward commencing construction?

2. Estimate date construction work will begin. _____

3. Reasons why construction work was not begun within the time allowed by the permit.

PETITION FOR EXTENSION OF TIME
If construction work is proceeding

If construction work and/or use of water is proceeding but is not complete, an extension of time may be petitioned by completing items 4 through 16. Statements must be restricted to construction or use of water only under this permit.

4. A forty - year extension of time is requested to complete construction work and/or beneficial use of water. (Indicate period of time. Must be consistent with time frame allowed in "Guidelines for considering Petitions for Extensions of Time.")
5. How much water has been used? See Attachment acre-feet/year _____ cfs
6. How many acres have been irrigated? N/A
7. How many houses or people have been served water? 1.3 Million people
8. Extent of past use of water for any other purpose. See Attachment
9. What construction work has been completed during the last extension? Not applicable. This is the first occasion for which EBMUD has requested an extension of time.
10. Approximate amount spent on project during last extension period. \$ Not applicable. See above
11. Estimate date construction work will be completed. See Attachment
12. Estimated year in which water will be fully used. See Attachment
13. Reasons why construction and/or use of water were not completed within time previously allowed. See Attachment

If the use of water is for municipal (including industrial) and irrigation supplies and is provided or regulated by public agencies and use of the water has commenced, but additional time is needed to reach full use contemplated, the following information must be provided.

14. What water conservation measures are in effect or feasible within the place of use?
See Attachment

15. How much water is being conserved or is it feasible to conserve using these conservation measures?
_____ acre-feet per annum. See Attachment
16. How much water per capita is used during the maximum 30-day period? _____ gpd. See Attachment

I (we) declare under penalty of perjury that the above is true and correct to the best of my (our) knowledge and belief.

Dated: NOVEMBER 27, 2000, at Oakland, California
Robert C. Helwick (510) 287-0168
Signature(s) Office of the General Counsel Telephone No.

NOTE: A \$50 FEE MADE PAYABLE TO THE State Water Resources Control Board must accompany a petition for an extension of time. An \$850 fee made payable to the Department of Fish and Game must accompany all but the first petition for an extension of time.

4. As a municipal water supplier, East Bay Municipal Utility District makes every effort to protect its Mokelumne River appropriative rights for existing and future uses in accordance with Water Code Section 106.5. The District has undertaken significant conservation measures to maximize efficient use of its supply and meet the demands within its service area. The extension of time requested, forty years, allows the District to satisfy the water needs resulting from population increases, while continuing its efforts to conserve water. Recognizing that the District cannot project with certainty what its service area population will be or what water use will be forty years from now, the District anticipates that it may have to seek further extensions of time as necessary to meet the municipal water supply needs of the East San Francisco Bay metropolitan area.
5. Operation of Camanche Reservoir, and the District's Pardee Reservoir, Mokelumne Aqueducts and local storage reservoirs is completely integrated, therefore water use under the District's various water rights is not segregated. Camanche Reservoir is critical to the District's municipal supply as it is operated to meet downstream Mokelumne River obligations that must be met prior to District diversions from the Mokelumne River. Maximum reservoir storage and maximum system diversions are provided below.

The maximum quantity of water directly diverted (December 1 through July 1) through the Mokelumne aqueducts was 472 cfs in June 1997.

The maximum quantity diverted to storage in Camanche reservoir over the storage season (December 1 through July 1) was 341,730 acre-feet in 1978.

8. Although the District's service area needs have not yet fully been developed, water diverted to and released from Camanche Reservoir has been consistently put to beneficial use by meeting the District's downstream Mokelumne River obligations. These obligations include flood control, recreation, fishery releases, and satisfying the prior rights of riparian landowners and senior appropriators. The District's use of Camanche Reservoir to meet the needs of downstream users and uses enables the District to meet its consumptive water supply needs from deliveries through the Mokelumne Aqueducts.

The District has also provided water for the following purposes through permanent and temporary changes in the permitted place of use.

City of Brentwood

A SWRCB Order, dated January 26, 1983 approved a change in the place of use to include delivery of a water supply to the City of Brentwood. The Order required that delivery be made only after development and continued implementation of a water conservation program or actions. Water was delivered to the City of Brentwood from July 1985 through September 1988. A total of 3,074 acre-feet was delivered to Brentwood to provide a temporary water supply because of high levels of nitrates in its well water supply.

Contra Costa Water District

A temporary change in place of use due to transfer of water was approved by the SWRCB on November 20, 1987. The transfer of up to 44 acre-feet of water for use in a prototype water treatment plant located within Contra Costa Water District was allowed. A total of 31 acre-feet was transferred to Contra Costa Water District in 1987.

A temporary change in place of use and the transfer of up to 5,000 acre-feet of water to Contra Costa Water District was issued by the SWRCB on October 22, 1985. A total of 2,474 acre-feet was transferred to Contra Costa Water District in November and December of 1985.

Conjunctive Use Pilot Test

A SWRCB Order authorizing temporary changes in place of use and purpose of use was granted on October 3, 1997. The District provided 379 acre-feet of Mokelumne River water to the East San Joaquin Parties Water Authority for a conjunctive use pilot project. The test period was from January 13, 1998 through September 23, 1998.

11. As a municipal supplier, the District continually upgrades and expands its water distribution system to meet the increasing water demands of the growing population within the District's service area. For example:
 - The District is implementing a \$189 million, 10-year, Seismic Improvement Program to strengthen the water distribution system and minimize damage to critical infrastructure from a major earthquake on the Hayward, Calaveras or Concord faults in the East Bay.
 - In July 2000, the District certified an EIR for the Walnut Creek-San Ramon Valley Improvement Project (WC-SRV Project) and approved the Project. The approximately \$184 million Project includes expansion of treatment and treated water storage capacity at the Walnut Creek Water Treatment Plant (WTP), construction of 4.4 miles of large-diameter transmission pipeline from Walnut Creek to Alamo, expansion of the Danville Pumping Plant in Alamo, and flow control improvements at the Lafayette WTP. The WC-SRV Project also includes a number of improvements within individual pressure zones in the service area.

In addition to improvements in the service area, the District continues to upgrade the Camanche Reservoir facilities and raw water delivery system to maximize the beneficial use of Mokelumne River water. For example:

- The District is carrying out a \$39.8 million Mokelumne Aqueduct Seismic Improvement Project to upgrade the District's aqueduct system and increase the reliability of the District's water supply following a major earthquake. The survival of the Mokelumne Aqueducts in an earthquake is essential to the District's ability to deliver water to its customers.

- The District is investing up to \$12.5 million to upgrade and expand the Mokelumne River Fish Hatchery. This investment demonstrates the District's continuing commitment to work with the California Department of Fish and Game to provide mitigation for the Mokelumne River fishery and to provide additional opportunities for enhancement of the fishery through a partnership agreement among EBMUD, U.S. Fish and Wildlife Service, and the California Department of Fish and Game.
 - The District installed and began operating in 1993, a state-of-the-art Hypolimnetic Oxygenation System (HOS) to add pure oxygen to the Camanche Reservoir hypolimnion. The HOS increases the dissolved oxygen concentration and prevents the formation of hydrogen sulfide in the Camanche Reservoir hypolimnion.
12. The year in which the water will be fully used cannot be forecasted with certainty at this time. Although growth in the District's service area is predicted, several changing and competing factors complicate the District's ability to precisely determine the time when the water will be fully utilized.

The factor most influencing water use is population. The State of California Department of Finance (DOF) has projected the population of California to increase 70% by the year 2040. The DOF also estimates the population of Contra Costa and Alameda counties, the two counties encompassing the District service area, will increase 41% and 36% respectively by the year 2040. Although these figures do not indicate the specific growth in the District service area, they do indicate the trend towards increasing population.

Land use is another significant factor in water use. The District does not have jurisdiction over the land use planning decisions of the local cities and counties within its service area, but those decisions do impact the amount of water the District may be obligated to supply.

Estimating future water use is further complicated by the effect of water conservation and reclamation programs. The District has taken a leadership role in promoting the state policy of encouraging water conservation and has implemented extensive programs and policies (see response to Question 14) to conserve its fresh water resources. With these programs and policies the District's water consumption has been significantly lower than it would have otherwise been.

The extent to which these programs will delay water use in the future is difficult to predict. As water efficiency measures are implemented there is a "hardening" of demand. In other words, as District customers install water efficient fixtures and change habits in response to District promotion of conservation, their ability to further reduce water use in the future, to levels below their already reduced levels, becomes constrained. This demand hardening makes it more difficult to achieve future water use reductions and leads to uncertainty in long-term demand projections.

Given the significant uncertainty of what may arise 40 years from now with respect to future water use, population growth in the service area, the impact of land use decisions, and the long-range effect of water conservation and reclamation measures, it is reasonable and prudent that the District's extension request be granted.

The water supply for municipal areas must keep a step ahead of the needs of its inhabitants. For this reason, municipal supplies must be secured in amounts that exceed present needs and allow for future growth. California has recognized the special circumstances of a municipality in meeting demand in Water Code §106.5 which states, "It is hereby declared to be the policy of this State that the right of a municipality to acquire and hold rights to the use of water should be protected to the fullest extent necessary for existing and future uses." The District is acting in accordance with the state policy set forth in Water Code §106.5 to protect its water rights for existing and future uses, and at the same time is ensuring that no waste of the valuable resource occurs.

13. While the District's water use has generally increased since the issuance of the permit, the growth of water use in the District has been slowed in part by the District's comprehensive water efficiency measures that maximize the beneficial use of the resource. These measures are listed below and are more fully described in the response to Question 14.

- An ongoing program to minimize distribution system losses including corrosion control, leak detection, and regular pipe replacement
- Water service regulations to encourage efficient water use and prohibit its waste
- Metering of water usage and use of an inclining rate structure to encourage efficient water use
- A Water Reclamation Master Plan and associated Program
- A Water Conservation Master Plan and associated Program

These water efficiency measures have been effective in reducing the District's historic and current water demand and will continue to limit demand in the long-term.

Over and above the long-term water savings from water efficiency measures, the District has further reduced water use by instituting a Drought Management Program (DMP) in years with forecasted water supply shortfall. The DMP includes measures to reduce water use up to 25%, one of the highest reduction goals among water agencies. Water demand is typically at peak levels during drought years, however, by implementing the DMP in 1977 and from 1987 to 1991, the District suppressed water use during those periods when demand would otherwise be highest. For example, in 1977 the DMP resulted in a 39% reduction in water use, and during 1987-1991, water use was reduced between 12 to 25%.

In summary, the District has made and continues to make strong and successful efforts in long-term water use efficiency and additional demand reduction during droughts. These efforts have slowed the growth of demand and suppressed peak demands. Yet despite the District's water saving policies and programs, the District's demand for water will increase as the population and economy within the service area continue to grow.

14. The District has conserved its water supply and encouraged conservation among its customers since the early 1970's. The District's conservation efforts are summarized below.

Water Distribution Improvements

To prevent distribution system water losses, the District has ongoing corrosion control, leak detection, and pipe and meter replacement programs. With these programs the District's unaccounted-for-water (i.e., leaks, fire-fighting water losses) is substantially less than the national average.

Tiered Water Rates

The District uses an inclining rate structure for single-family residential customers to fairly distribute cost and encourage conservation. Water use above a base allocation for residential accounts is billed at increasing rates at incremental steps.

Reclamation

The District recognizes the benefits of reclaiming wastewater as a means to conserve freshwater resources and has investigated and implemented reclamation projects. The District uses reclaimed water at its water and wastewater treatment plants and provides recycled water to seven large irrigation customers and one large industrial customer. The District is also actively pursuing an additional recycled water supply of 8 MGD (8960 acre-feet). A summary of the District's reclamation to date is provided in response to Question 15, Table 2.

Water Conservation Program

In 1994, the District developed a Water Conservation Master Plan (WCMP) to guide District efforts in meeting its long-range water conservation goals. The WCMP evaluated and outlined water conservation elements to be included in the District's Water Conservation Program. The Water Conservation Program continually adapts to new information to ensure resources are invested to achieve the greatest amount of conservation. The current Water Conservation Program elements are divided into five categories; audits, rebates and other incentives, regulatory measures, education, and support. These Program elements are outlined in Table 1 and described below.

Table 1
Water Conservation Program Elements

Audits	Rebates/Incentives	Regulatory Measures	Education	Support
Single-family Residential	Toilet Rebates	Water Waste Ordinance	Water Education Center	Reports
Multi-family Residential	Clothes Washer Rebates	Landscape Standards	Direct Mailings and Program Specific Marketing	Research
Large Landscape Irrigation	Large Landscape Irrigation Upgrade Rebates	Plan Review	Booths at Community Events and Trade Shows	Committees and Associations
Industrial	Industrial, Commercial and Institutional Rebates		Articles in Chamber Newsletters and Trade Magazines	Identification of Funding Sources
Commercial	Residential Landscape Rebates		Publications	Cooperative Efforts
Institutional			Brochure Distribution Stands	Program Evaluation
			Weather Stations & Evapotranspiration Hotline	
			Demonstration and School Gardens	
			Workshops and Conferences	

Audits

District staff offers and conducts water use audits (both indoor and outdoor) for all customer groups; single and multi-family residential customers, commercial, industrial, and institutional customers, and large landscape irrigation customers to determine water use practices, identify areas for increased efficiency and to describe District conservation education and incentive programs.

Rebates and Other Incentives

The District provides a number of financial incentives through rebates to encourage customers to switch to more efficient water use practices. Rebates are currently offered for installing ultra-low flow toilets, installing water efficient clothes washers, retrofitting landscapes and irrigation systems, and for improving efficiency in commercial, industrial and institutional uses.

Regulatory Measures

The District currently has three regulatory measures in effect, a water waste regulation, landscape standards for new development and plan review for new water service applicants. These measures are briefly described below.

The District's Water Waste Ordinance, Section 29, prohibits the wasteful use of water. District staff routinely investigates and responds to complaints of water waste by performing an inspection of the offending site and contacting the customer in person, by phone or by mail.

Landscape standards were developed as a condition of water service for developments in the Crow Canyon Corridor. Homeowners were notified of the landscape requirement and the compliance process as they moved in. Nearly 2,500 homes, including the common areas in 10 developments were subject to the landscape standards.

Plan reviews are conducted by District staff in determining required services to meet demand. District staff also offers landscape and irrigation design reviews upon request to promote conservation best management practices for applicants.

Education

Education is key to changing customer attitudes and behavior to achieve conservation water savings. The District's water conservation education activities include an interactive Water Education Center, program specific marketing and direct mailings, booths at community events and trade shows, articles in Chamber newsletters and trade magazines, publications, brochure distribution stands, weather stations and an evapotranspiration information hotline, demonstration gardens, school gardens, workshops and conferences. These activities increase public awareness about the value of water, encourage customers to take steps to increase water use efficiency, and provide the information customers need to implement conservation measures.

Support

The District supports activities that promote the implementation of the Water Conservation Program. These activities include; consumption monitoring, water use studies, new technology research, committee and association work, identification of conservation funding sources, areas of cooperative efforts, and preparation of internal and external reports.

15. Current estimates of water conserved and reclaimed are provided in Table 2. The District continues to refine its estimation of these quantities.

Table 2
Summary of Conserved Water

Year	Quantity of Water Conserved (AF)	Quantity of Water Reclaimed (AF)
1981	51,112	962
1982	56,888	752
1983	56,499	781
1984	39,849	642
1985	31,702	889
1986	31,416	4,453
1987	53,312	2,770
1988	80,037	2,859
1989	81,458	2,969
1990	46,941	4,568
1991	68,437	6,752
1992	60,183	8,726
1993	51,574	7,683
1994	50,500	7,582
1995	55,042	7,857
1996	53,101	7,567
1997	34,666	8,861
1998	55,958	6,747
1999	51,675	7,566

16. The District does not have per capita water use data. Table 3 provides the number of customer accounts and consumption for the District's thirteen customer categories.

Table 3
Water Use by Customer Category, Maximum Month – August 1987
Thousand Gallons

Customer Category	1987 Accounts¹	August 1987 Consumption¹
Agriculture, Construction	532	35,184
Food Processing	268	167,041
Wood, Paper, Chem	776	94,242
Petroleum	54	503,133
Metal, Plate, Clay	998	174,460
Transportation, Communication	1,853	100,073
Electric, Gas, Steam	164	13,289
Wholesale, Resale	14,104	422,783
Cemetery, Park Golf	3,975	1,733,985
Multi-Family Units	26,430	1,122,062
Laundry, Lab, Autos	2,163	167,623
Schools, Hospitals	4,317	392,062
Private Homes	289,507	3,613,217
Total Metered Water Use	345,141	8,539,154
Unaccounted for Water and District Use²		107,482
Total		8,646,636

(1) Water Consumption Information System 1987, all pressure zones

(2) Sum of Unaccounted for Water and District Water Use:

Water Supply Section Statistical Reports for Fiscal Year 1988

Appendix B

**East Bay Municipal Utility District's Water Supply
Planning and Supplemental Water Sources**

Appendix B

East Bay Municipal Utility District's Water Supply Planning and Supplemental Water Sources

B.1 Freeport Regional Water Project

The Freeport Regional Water Authority, a joint powers entity, was formed by the East Bay Municipal Utility District (EBMUD) and the Sacramento County Water Agency (SCWA) to undertake the Freeport Regional Water Project (FRWP). The FRWP intake facilities are sited along the Sacramento River near the unincorporated town of Freeport. The project enables EBMUD to take delivery of Central Valley Project (CVP) water to meet a portion of its drought year water demands. Conveyance facilities transport the water from the Sacramento River intake via pipeline to EBMUD's Mokelumne Aqueducts, where it then flows to the EBMUD service area for treatment and distribution during dry years.

Up to 100 million gallons per day (MGD) of water from the Sacramento River may be delivered to EBMUD customers through the FRWP in dry years. According to the terms of the CVP contract, the CVP water is a supplemental dry-year supply, and EBMUD is limited to a total delivery of 165 thousand acre-feet (TAF) over any consecutive 3-year period.

B.2 Water Supply Management Program 2040

In normal and above-normal water years, sufficient precipitation occurs in the Mokelumne River basin to provide EBMUD with an adequate supply of water to meet demands using its existing water rights (License 11109 and Permit 10478). In drier years, however, Mokelumne River basin precipitation and resulting river flow are inadequate to meet EBMUD's water needs, even after accounting for demand reductions from EBMUD's aggressive conservation and recycling programs. Therefore, EBMUD has engaged in efforts to assess its future demands and dry-year water supply needs to ensure that it can meet customer water needs in the future. Recently, EBMUD finalized the Water Supply Management Program (WSMP) 2040, and certified a Programmatic Environmental Impact Report (PEIR). The plan identifies options for meeting EBMUD's dry-year need in the future and includes both increased demand management measures and additional supplemental supplies. The future supplies identified in the program would supplement—but not replace—EBMUD's existing water rights and supply from the Mokelumne River in dry years and the WSMP 2040 assumes that the Mokelumne River supplies would continue to be available.

B.3 Water Supply and System Reliability

Many factors such as drought, high turbidity, and emergency and/or catastrophic events can affect the reliability of the EBMUD water supply and water supply system. To address these factors, EBMUD implements programs and projects that improve the reliability of the system. A discussion of the conditions that can adversely affect supply and supply system reliability follows.

B.3.1 Regulatory Obligations

The terms of the Joint Settlement Agreement (JSA) and other regulatory requirements dictate EBMUD's obligations to provide for fish, wildlife, and riparian habitat and further condition EBMUD's use of the permitted water. These obligations, and other requirements, such as flood-control requirements and senior downstream needs, as well as projected increases in diversion by senior water right holders, are discussed in detail in Chapter 1, Objective and Need for the Permit 10478 Time Extension Project, under the Factors Affecting East Bay Municipal Utility District's Full Entitlement of Mokelumne River Water section.

B.3.2 Water Supply Quality

Mokelumne River water requires only minimal treatment to meet health standards because it comes from the mostly undeveloped Mokelumne watershed and is conveyed to EBMUD's service area in large-diameter steel pipes—the Mokelumne Aqueducts. EBMUD further protects water quality at Pardee Reservoir through 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.

Water treatment plants that process the water supplied by local terminal reservoirs are designed to handle high-turbidity conditions encountered during severe local storm runoffs. Consequently, water quality variations do not limit the water supply available from terminal reservoirs.

B.3.3 Earthquake

Several active faults—including the San Andreas, Hayward, Calaveras, Concord, Greenville, Coast Range–Central Valley, and Hayward faults—may affect the geographic area served by EBMUD, and a seismic event would pose a significant threat to the delivery of water. EBMUD facilities located outside the EBMUD service area are also subject to damage from earthquakes. To address potential seismic events, EBMUD has implemented a \$200 million Seismic Improvement Program (SIP) to strengthen the water system to withstand earthquakes and improve post-earthquake firefighting capability. EBMUD has completed all of its planned SIP upgrades and is internationally recognized for its proactive approach to minimizing seismic risk. Furthermore, EBMUD developed an Aqueduct Emergency Response and Recovery Plan to be activated in the event of an aqueduct or levee failure, depending on the type and magnitude of the failure.

B.3.4 Delta Floods

The Mokelumne Aqueducts cross through the Lower Jones Tract and Upper Jones Tract, an area subject to Delta flooding during seismic events or levee breaches. Flood-related events in this area have threatened aqueduct infrastructure in the past (1980 and 2004).

B.4 Water Supply Shortage

EBMUD evaluates the adequacy of its water supply each year in accordance with its Water Supply Availability and Deficiency Policy. This policy establishes a drought demand-reduction limit of no

more than 15% of total customer demand district-wide only if supplemental supplies are obtained. Based on predicted runoff, EBMUD estimates its total system storage available through the end of the water year (September 30). If total system storage is projected to be less than 500,000 acre-feet by the end of September, the Board of Directors may establish voluntary or mandatory water use reduction goals for customers. EBMUD also may increase rates to encourage conservation and prohibit excessive or wasteful use through a variety of enforcement options.

B.5 Water Conservation

EBMUD has achieved a three-tiered level of water conservation savings over time. Tier One water conservation savings have been realized from implementing conservation measures initiated in the 1970s. Tier Two water conservation savings estimated at 23 MGD (through year 2008) resulted from the 1993 Water Supply Management Plan and 1994 Water Conservation Master Plan. Tier Three water conservation savings resulting from EBMUD's 2012 approval of the WSMP 2040 of an additional 39 MGD are projected to accrue through year 2040.

EBMUD's water conservation programs enhance water supply reliability through both supply-side and demand-side initiatives. Demand-side water conservation programs improve customer water use efficiency and include incentives for residential and nonresidential customers, education and outreach activities, support activities, and regulatory requirements. Supply-side water conservation programs improve water use efficiency before or after use by the customer and include distribution system leak detection, repair programs, and water recycling programs.

The Water Conservation Act of 2009, often referred to as "20 by 2020," creates a framework for future planning and actions by urban and agricultural water suppliers to reduce California's water use and requires urban water agencies to reduce statewide per capita water consumption 20% by the year 2020. Among other requirements, this bill establishes multiple pathways for urban water suppliers to achieve the statewide goal of a 20% reduction in urban water use. The act requires urban water suppliers to set an interim water use target, meet that target by December 31, 2015, and meet the overall target by December 31, 2020.

As reported in EBMUD's Urban Water Management Plan published in June 2011, EBMUD will pursue an interim target of 158 gallons per capita day for year 2015. Implementing the planning-level programs, EBMUD projects a lower demand level of 151 gallons per capita day for year 2015. In addition, EBMUD's Urban Water Management Plan 2010 planning level programs project an even more aggressive and lower 2020 demand level of 144 gallons per capita day.

B.6 Recycled Water

Recycled water, as defined in the California Water Code, is water that, as a result of treatment of wastewater, is suitable for a direct beneficial use or a controlled use that otherwise would not occur and is, therefore, a valuable resource. The intent of using recycled water is to supplement existing water sources to assist in meeting the future water demands of California.

Use of recycled water meets a portion of water-supply demand, increases the availability and reliability of the EBMUD potable water supply, and lessens the effect of extreme rationing induced by a prolonged, severe drought. Recycled water use delays or eliminates the need for more potable

water facilities, sustains the economy with increased water supply reliability, protects San Francisco Bay by reducing treated wastewater discharge, safeguards community and private investment in parks and landscaping with a drought-proof or drought-resistant supply, and contributes to a green and healthy environment.

EBMUD has a goal of 20 MGD of recycled water production by 2040. Recycled water is used in place of potable water for primarily irrigation and industrial processes. Recycled water use reduces demand for potable water and potentially reduces the need for rationing during droughts. Recipients of recycled water include an oil refinery, golf courses, parks, school grounds, office parks, and roadway landscaping. EBMUD's inventory of recycled water projects could produce about 9 MGD of recycled water. Under WSMP 2040, EBMUD will increase the amount of recycled water available for non-potable use by an additional 11 MGD by 2040, for a total recycled water program yield of 20 MGD by 2040.

Appendix C

**Summary of Auxiliary Change Petitions Submitted to
California State Water Resources Control Board**

Summary of Auxiliary Change Petitions Submitted to California State Water Resources Control Board

This appendix provides a summary of the auxiliary change petitions submitted by the East Bay Municipal Utility District (EBMUD) to the California State Water Resources Control Board (State Water Board). This appendix is for informational purposes only.

C.1 Pardee Municipal License 11109: Petition for Change in Place of Use and Purpose of Use

The existing authorized quantities in Pardee Municipal License 11109 and proposed changes are summarized in Table C-1.

Table C-1. Pardee Municipal License 11109 Authorized Quantities and Proposed Changes

License Term	License 11109
Direct Diversion–Rate	310 cubic feet per second (cfs)
Direct Diversion–Season	January 1–December 31
Diversion to Storage–Amount	209,950 acre-feet (AF)
Diversion to Storage–Season	October 1–July 15
Existing Place of Use	See Map No. 1563 ^a
Maximum Annual Beneficial Use	224,037 AF
Maximum Annual Diversion to Storage and Direct Diversion	316,250 AF
Existing Point of Diversion	Pardee Dam
Purpose of Use	Municipal and Recreational
Proposed Additional Place of Use	See Map 1935-R ^b
Proposed Additional Purpose of Use	Fish and Wildlife Preservation and Enhancement at Pardee Reservoir

Notes:

^a Map No. 1563 is on file at the office of the State Water Board.

^b Map No. 1935-R is included with the change petition.

The proposed change in place of use is a result of annexations of additional lands to EBMUD's current and ultimate service area boundaries by the Local Agency Formation Commissions (LAFCOs) of Alameda and Contra Costa Counties. For each of these annexations, LAFCO, as the lead agency, complied with the requirements of the California Environmental Quality Act (CEQA), approved environmental documents and added the areas to EBMUD's service area, thus, requiring that they be served by EBMUD. This proposed change in the place of use is to update the map on file with the State Water Board to conform the place of use to add areas LAFCO has already ordered to be served, for which CEQA documentation was completed, and which EBMUD is currently serving and in some cases has been serving for over 25 years. Formally adding these areas to the place of use would not result in any changes from existing baseline conditions or in any potentially

significant impacts that were not examined in prior CEQA documents. No additional CEQA assessment is required for the change in place of use.

The change in purpose of use would not create potentially significant environmental effects because waters stored in Pardee Reservoir have long supported fish and wildlife resources in and at the reservoir. Adding fish and wildlife preservation and enhancement at the reservoir as a purpose of use simply updates the water right to reflect that fact. No changes from existing baseline conditions would occur. The petition is exempt under CEQA Guideline §15061(b)(3) because it would have no significant effect on the environment, is an ongoing project approved prior to 1970 in accordance with §15261, and is an existing facility in accordance with §15301.

C.2 Camanche/Pardee Municipal Permit 10478: Petition for Change in Place of Use, Purpose of Use, and Clarifying Petition

The existing authorized quantities in Camanche/Pardee Municipal Permit 10478 and proposed changes are summarized in Table C-2.

Table C-2. Permit 10478 Authorized Quantities and Proposed Changes

Permit Term	Permit 10478
Direct Diversion–Rate	194 cubic feet per second (cfs) ^a
Direct Diversion–Season	December 1–July 1
Diversion to Storage–Amount	353,000 AF
Diversion to Storage–Season	December 1–July 1
Existing Place of Use	See Map No. 1821R ^b
Existing Point of Diversion	Pardee and Camanche Dams
Purpose of Use	Municipal
Proposed Additional Place of Use	See Map 1932-R ^c
Proposed Additional Purpose of Use	Recreation, Fish and Wildlife Preservation and Enhancement at Pardee and Camanche Reservoirs, and Industrial
Proposed New Permit Term	A new term to be added as follows: “For purposes of accounting for withdrawal from storage under Permit 10478, water diverted at Pardee Reservoir into the Aqueducts in excess of 310 cfs will be accounted for as withdrawal from storage under Permit 10478 when there is an equivalent corresponding net depletion in the combined storage of Pardee and Camanche Reservoirs.”

Notes:

^a Total amount to be diverted from the watershed by direct diversion or withdrawal from storage under Permit 10478 (and any subsequent license), as restricted by the 1959 Release of Priority, shall not exceed the equivalent of the average flow of 194 cfs (or 140,000 AFY).

^b Map No. 1821-R is on file at the office of the State Water Board.

^c Map No. 1932-R is included with the change petition.

The proposed change in place of use is a result of annexations of additional lands to EBMUD's current and ultimate service area boundaries by the LAFCO of Contra Costa County. For each of these annexations, LAFCO, as the lead agency, complied with the requirements of CEQA, approved environmental documents and added the areas to EBMUD's service area, thus requiring that they be served by EBMUD. This proposed change in the place of use is simply to update the map on file with the State Water Board to conform the place of use to add areas LAFCO has already ordered to be served, for which CEQA documentation was completed, and which EBMUD is currently serving and in some cases has been serving for over 25 years. Formally adding these areas to the place of use would not result in any changes from existing baseline conditions or in any potentially significant impacts that were not examined in prior CEQA documents. No additional CEQA assessment is required for the change in place of use.

The change in purpose of use would not create potentially significant environmental effects because waters stored in Pardee and Camanche Reservoirs support fish and wildlife and recreational resources at these reservoirs. Industrial use is already part of the authorized municipal use under Permit 10478. That permit was issued to EBMUD as a result of the State Water Board's Decision-858, which found that "municipal use includes all of those purposes for which water is customarily used by a municipality," including industrial use (D-858, pages 69-70). Thus, Permit 10478 already has industrial use as an authorized purpose of use. By its petition, EBMUD requests that industrial use be expressly added as a formal purpose of use in Permit 10478.

The addition of the new permit term would not create potentially significant environmental effects because no changes from existing baseline operations or conditions would occur. The new term is requested to more explicitly set forth the manner in which authorized diversions are occurring and to account for diversions consistent with existing water rights and limitations, particularly relative to withdrawals under Permit 10478. The proposed term would not affect the release and bypass requirements for the lower Mokelumne River or EBMUD's operations and the quantities of water that EBMUD is authorized to divert. The petition proposes to add a water right term and would not have the potential to impair the water supply of other legal users or impact instream beneficial uses. EBMUD is not seeking to make any changes in its diversion points relative to the diversion points of others, and the proposed term would not affect or impede EBMUD's obligation and ability to meet all water right and fish flow requirements. The petition is exempt under CEQA Guidelines §15061(b)(3) because it would have no significant effect on the environment, is an ongoing project approved prior to 1970 in accordance with §15261, and is an existing facility in accordance with §15301.

C.3 Pardee Hydropower Rights (L1388, L6062, P10479): Petitions for Change in Place of Use and Additional Point of Rediversion

The existing authorized quantities in Pardee Hydropower Rights, including License 1388, License 6062, and Permit 10479, and proposed changes are summarized in Table C-3.

Table C-3. Pardee Hydropower Rights Authorized Quantities and Proposed Changes

Permit Term	License 1388	License 6062	Permit 10479
Direct Diversion–Rate	375 cfs	375 cfs	350 cfs
Direct Diversion–Season	January 1– December 31	January 1– December 31	January 1– December 31
Diversion to Storage–Amount	198,965 AF	28,702 AF	50,000 AF
Diversion to Storage–Season	January 1–July 31	October 1– December 31	December 1–July 1
Existing Place of Use	Pardee Powerhouse	Pardee Powerhouse	Pardee Powerhouse
Existing Point of Diversion	Pardee Dam	Pardee Dam	Pardee Dam
Purpose of Use	Power Generation	Power Generation	Power Generation, Incidental and Domestic
Proposed Additional Place of Use	Camanche Powerhouse	Camanche Powerhouse	Camanche Powerhouse
Proposed Additional Point of Rediversion	Camanche Dam	Camanche Dam	Camanche Dam

The three hydropower change petitions are filed to make technical clarifications to conform License 1388, License 6062, and Permit 10479 to state and federally required terms and conditions and other downstream release obligations. These terms and conditions mandate EBMUD to meet certain requirements, including fish flows, temperature management, and flood control. In addition, EBMUD must meet its obligations to downstream water rights holders.

Under the proposed change petitions, EBMUD seeks to confirm Camanche Dam as a point of rediversion and confirm Camanche Powerhouse as an additional place of use to License 1388, License 6062, and Permit 10479. These change petitions would not result in any new construction, no changes to EBMUD's operations would occur, and the petitions would continue EBMUD's authorized use of these existing facilities. As a result, these three petitions would not create potentially significant environmental effects because no changes from existing conditions would occur (i.e., the petitions are to confirm existing authorized operations). The petitions are exempt under CEQA Guidelines §15061(b)(3) because they would have no significant effect on the environment; in accordance with §15261, they are an ongoing project approved prior to 1970; and in accordance with §15301, they are an existing facility.

Appendix D

**Lower Mokelumne River Project, Federal Energy
Regulatory Commission (FERC) Project No. 2916-004,
Joint Settlement Agreement and Ten-Year Review**

Appendix D.1

**Lower Mokelumne River Project, Federal Energy
Regulatory Commission (FERC) Project No. 2916-004,
Joint Settlement Agreement**

LOWER MOKELUMNE RIVER PROJECT

FERC Project No. 2916-004

JOINT SETTLEMENT AGREEMENT

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LOWER MOKELUMNE RIVER JOINT SETTLEMENT AGREEMENT

This Lower Mokelumne River Joint Settlement Agreement ("Agreement") for the Lower Mokelumne River Project, FERC No. 2916, regarding flow and non-flow measures appropriate for the lower Mokelumne River is entered into by and between East Bay Municipal Utility District ("EBMUD") and the U.S. Fish & Wildlife Service ("the Service"), and California Department of Fish & Game ("CDF&G"), collectively referred to as the "Resource Agencies." EBMUD, the Service and CDF&G are each referred to herein individually as "Party" and together as the "Parties."

WITNESSETH

WHEREAS, on March 10, 1981, the Federal Energy Regulatory Commission ("FERC") issued a license to EBMUD for the Lower Mokelumne River Project No. 2916.

WHEREAS, on July 1, 1991, the staff of the FERC initiated a license modification proceeding, Lower Mokelumne River Project No. 2916-004, to determine if modifications to the Lower Mokelumne River Project facilities or operations were appropriate for the conservation and development of fish and wildlife resources in the Mokelumne River.

WHEREAS, in 1992, the Service intervened in the FERC's license modification proceeding and proposed certain flow and non-flow measures to conserve and restore the anadromous fishery and improve other ecosystem values.

WHEREAS, on July 16, 1993, EBMUD made an Offer of Settlement in the FERC license modification proceeding, Lower Mokelumne River Project No. 2916-004.

WHEREAS, the Parties have engaged in extensive discussions in an effort to resolve issues in dispute in the license modification proceeding before the FERC and the differences between them regarding the flow and non-flow needs of the lower Mokelumne River, and to establish a more cooperative and mutually beneficial working relationship for the future.

WHEREAS, each of the Parties has separately concluded that greater protection and enhancement of the anadromous fishery resources of the lower Mokelumne River will result if EBMUD implements new instream flows and the Parties variously undertake certain non-flow measures.

WHEREAS, in February 1996, the Parties executed a Principles of Agreement setting forth elements of settlement, including flow and non-flow measures, to be reflected in a Joint Settlement Agreement.

WHEREAS, EBMUD has separately concluded that the flows and non-flow measures specified herein can be undertaken without unacceptably jeopardizing the Lower Mokelumne River Project as a reliable, high quality water supply.

WHEREAS, because EBMUD lacks authority to control diversions by other appropriators and riparians downstream of Camanche Dam, this Joint Settlement Agreement sets forth EBMUD's minimum water releases from Camanche Dam and non-flow related measures for the Mokelumne River Ecosystem (Pardee Reservoir to the Delta). The parties also recognize there are important resource management issues and opportunities downstream of Woodbridge Dam that will be considered by the Partnership Steering Committee for non-flow habitat measures.

WHEREAS, EBMUD has agreed to provide flows and the Parties have agreed to undertake certain non-flow measures as specified in this Joint Settlement Agreement.

WHEREAS, EBMUD acknowledges that it is subject to the terms of the Clean Water Act and the Porter-Cologne Act, including the water quality provisions of said acts.

WHEREAS, each of the Resource Agencies agrees to support this Joint Settlement Agreement including the flow and non-flow measures specified herein, believing they will provide reasonable protection and enhancement from current conditions with respect to EBMUD's contribution for the fish and wildlife resources of the lower Mokelumne River.

NOW, THEREFORE, EBMUD, the Service and CDF&G agree as follows:

A. Purpose and Scope.

The Parties intend this Agreement to resolve (1) the pending FERC Proceeding No. 2916-004; and (2) the pending Mokelumne River Water Rights Proceeding before the California State Water Resources Control Board (SWRCB). The Parties agree not to oppose the flows or non-flow measures set forth in this Agreement in any regulatory proceeding, or portion thereof, directed at EBMUD's obligation to protect the fish resources of the Mokelumne River Ecosystem. The Parties further agree that these resolutions are accomplished in a manner which:

- protects and maintains EBMUD's Lower Mokelumne River Project as a reliable, high quality water supply for EBMUD;
- contributes to EBMUD's ability to protect and maintain its water rights attendant to the Lower Mokelumne River Project;
- provides reasonable protection and enhancement from current conditions for the anadromous fishery and ecosystem of the lower Mokelumne River and constitutes

a reasonable contribution on the part of EBMUD toward state and federal fishery restoration goals for the River set forth in the California Salmon, Steelhead Trout, and Anadromous Fisheries Program Act and the CVPIA; and

- encourages cooperative action to achieve and to maintain these objectives over time.

B. Effective and Termination Dates.

This Agreement shall be effective on the date FERC issues a final order in License Modification Proceeding No. 2916-004, and shall remain in effect for the duration of the term of the FERC License No. 2916.

This Agreement shall terminate upon withdrawal from the Agreement of a Party pursuant to Section C below.

C. Action of the FERC.

Within 30 days after all Parties have initialed this Agreement, the Parties agree to submit jointly this Agreement as an Offer of Settlement to the FERC to resolve FERC License Modification Proceeding No. 2916-004 and jointly to request, as a fair and reasonable resolution of that proceeding, that following and subject to compliance with the Endangered Species Act (ESA) as described in Section J hereof, FERC amend EBMUD's existing license to include, in its entirety and without modification, Attachment 1 (pages 1-5) of this Agreement as the flow requirements for the Lower Mokelumne River Project No. 2916. Within 30 days of receiving notification of compliance with the ESA as described in Section J, each Party shall sign the Agreement and jointly submit it to FERC for final action.

In the event that the FERC does not by final, non-appealable Order implement without modification the flow requirements specified in Attachment 1 (pages 1-5) of this Agreement, then each Party shall have 30 days after the FERC Order becomes final and non-appealable to provide notice to the other Parties of its intent to withdraw from the Agreement or to accept the Agreement subject to the provisions reflected in the final, non-appealable Order of the FERC. A failure to provide such notice shall be deemed an acceptance of the Agreement.

D. Support of This Agreement.

The Parties agree that the provisions of this Agreement are in the public interest and represent EBMUD's reasonable obligation under FERC License No. 2916 and the Mokelumne River Water Rights Proceeding pending before the SWRCB to protect and enhance the fishery resources of the lower Mokelumne River and maintain the Lower Mokelumne River Project as a reliable, high quality water supply.

The Parties individually and collectively agree to support this Agreement and to work cooperatively to implement the terms of this Agreement. The Parties agree not to oppose the flows or non-flow measures set forth in this Agreement in any regulatory proceeding, or portion thereof, directed at EBMUD's obligation to protect the fish resources of the Mokelumne River Ecosystem. The Parties also agree that no Party shall take any action which has the purpose or effect of frustrating the accomplishment of the purposes and provisions of this Agreement.

The Parties agree that nothing in this Agreement is intended to nor shall be construed to abrogate, modify or waive any rights, duties or responsibilities of any Party under any federal or state law, order, license or permit, contract, or water rights determination.

E. Establishment of a Lower Mokelumne River Partnership.

EBMUD, the Service and CDF&G will establish a Lower Mokelumne River Partnership (the "Partnership") to develop joint action plans to protect the Mokelumne River Ecosystem (Pardee Reservoir to the Delta). The objectives of the Partnership shall include the:

- Protection and enhancement of the anadromous fishery;
- Protection and improvement of the Mokelumne River Ecosystem;
- Encouragement of stakeholder participation and cooperation; and
- Integration of Mokelumne River strategies with the Bay Delta Accord, CVPIA implementation, or similar measures.

1. Partnership Steering Committee.

One representative each from EBMUD, CDF&G, and the Service will serve as the Partnership Steering Committee responsible for guiding the Partnership, defining and developing annual action programs, schedules and cost estimates for projects and funding strategies to achieve them. EBMUD will chair the Steering Committee for the first year with the option for the Service, CDF&G and District to chair the Committee on an annual rotating basis in subsequent years. Actions of the Steering Committee are intended to be taken with full consideration of input from the Stakeholders Group (described below) and shall only be taken upon the unanimous approval of the Steering Committee. The Steering Committee will coordinate efforts to achieve the objectives of the Partnership through the flow requirements and anadromous fishery protection measures set forth in Section F below, the Ecosystem Protection measures set forth in Section G below, and the Technical Cooperation measures set forth in Section H below.

2. Establishment of a \$2 million Partnership Fund.

Within 45 days of the FERC Order implementing this Agreement becoming final and non-appealable, EBMUD will establish, manage and maintain a \$2 million fund (the "Partnership Fund") for the life of this Agreement, the annual income from which will provide operating support for the partnership programs. EBMUD will manage the Fund in a manner consistent with law and with an objective of maximizing its annual income. Annual interest earnings that remain unspent from year to year shall accrue in the fund and remain available for use of the Steering Committee during the term of the partnership agreement. The principal and any unspent earnings of the fund shall remain the property of EBMUD and will revert to EBMUD upon the expiration of this agreement or upon the withdrawal of any party to the agreement. EBMUD will report quarterly to the Steering Committee regarding the income earned and current balance of the Fund. Any expenses of administration of the Partnership Fund shall be paid separately by EBMUD and shall not be deducted from the Partnership Fund. The Resource Agencies will seek federal, state and other sources of funds ("Other Funds") to supplement the objectives of the Partnership. The Steering Committee will also solicit the financial participation and involvement of other public agencies, interest groups and private property owners along the lower Mokelumne River to advance the objectives of the Partnership.

EBMUD intends to provide this \$2 million Partnership Fund in addition to its current level of effort in funding fishery studies, water quality and biological monitoring, habitat protection, and other operating support for its ongoing operations and responsibilities on the lower Mokelumne River.

It is not EBMUD's intention to reduce its current level of effort. EBMUD, however, reserves the right, at its sole discretion, to reprioritize and reprogram its efforts that are undertaken outside the Partnership Fund based upon improving science, information collected and its operational needs.

3. Water Quality And Resource Management Program.

Within 30 days of the signature of this Agreement in accordance with Section C, the Partnership Steering Committee agrees to begin development of a Water Quality and Resource Management Program. Within six (6) months of the FERC Order implementing this Agreement becoming final and non-appealable, the Partnership Steering Committee will finalize the Water Quality and Resource Management Program. EBMUD agrees to provide \$200,000 to support the Partnership efforts in developing the final Water Quality and Resource Management Program. The Water Quality and Resource Management Program will define reasonable goals, measures, performance criteria, and responsive actions.

4. Additional Voluntary Participation.

The Resource Agencies recognize that aside from the upper one-half mile of the lower Mokelumne River corridor owned by EBMUD and included in its FERC project lands, the majority

of the riparian area and associated uplands are privately owned and not subject to the control of EBMUD. The Parties agree that the voluntary participation of these other property owners will be necessary to achieve certain long term objectives for protecting the lower Mokelumne River ecosystem. For actions involving access to the property of, and agreements with, other property owners along the lower Mokelumne River, the Resource Agencies will take the lead and EBMUD and other stakeholders will provide support.

5. Establishment of a Lower Mokelumne River Stakeholders Group.

A Stakeholders Group will be established consisting of EBMUD, the Service, CDF&G, and other stakeholders in the lower Mokelumne River invited to participate including but not limited to Amador, Calaveras and San Joaquin Counties, Woodbridge Irrigation District, the City of Lodi, North San Joaquin Water Conservation District, the Committee to Save the Mokelumne and other interested environmental groups, Native Americans, and private property owners along the river.

The role of the Stakeholders Group will be to:

- Encourage the voluntary participation and cooperation of other stakeholders along the river to contribute financial and in-kind resources, provide access to the river for enhancement work and participate in implementing the Partnership action plans and objectives;
- Recommend ecosystem protection and improvement priorities and measures to the Partnership Steering Committee for annual action plans in conjunction with additional resources available from other stakeholders; and
- Serve as a communications and coordination forum for stakeholders in discussing common concerns and developing joint action plans to address issues.

F. Flow Requirements and Anadromous Fishery Protection.

The Parties agree that water demands in the Mokelumne River basin during the planning horizon of 1996 to 2020 and until the expiration of the FERC license (year 2031) will increase. The Parties also agree that the frequency of critically dry year flows may increase. In order to ensure that protection of the fishery resource continues in the future to be reasonably balanced with other demands, the Parties agree that additional measures are needed and agree that the following additional actions will be implemented. Upon the FERC Order implementing this Agreement becoming final and non-appealable, EBMUD agrees to operate its Lower Mokelumne River Project in accordance with the flow requirements specified in Attachment 1 (pages 1-5) attached hereto and incorporated herein in its entirety by this reference.

1. Adaptive Management of River Operations.

The Parties agree that the flows specified in Attachment 1 and the other elements of the Agreement provide reasonable protection and enhancement from current conditions for the anadromous fishery and ecosystem of the lower Mokelumne River and meet EBMUD's obligation to protect the anadromous fishery and other resources in the lower Mokelumne River pursuant to FERC License No. 2916-004 and the pending SWRCB Water Rights Proceeding. To increase opportunity for optimizing fishery habitat and other ecosystem values consistent with this Agreement, the parties agree to implement an adaptive management approach with operations of the Lower Mokelumne River Project. This could require responsive actions based on changing river conditions. To accomplish this, the Parties agree that, with the prior written concurrence of CDF&G and the Service, EBMUD may reschedule or modify the flows specified in Attachment 1, provided the total quantity of water released in any given year will not be less than the quantity of water provided by the flow requirements specified on Attachment 1 for that type of water year.

2. Gainsharing Increases in Flows.

EBMUD agrees to increase instream flows beyond the flows specified in Attachment 1 by an amount equal to 20% of the actual yield of additional water supplies developed by EBMUD from new facilities until reaching a maximum quantity of 20 TAF¹ which will be available at the joint written request of CDF&G and the Service. Gainsharing water will be available in any year in which carryover storage in EBMUD's storage at the Lower Mokelumne River Project on November 5th is projected to be at the maximum allowable levels according to the US Corps of Engineers permit. But when carry-over storage on November 5th is less than the maximum allowable, such gainsharing water may be used only once during any drought sequence.² Such gainsharing water for flow augmentation will be provided upon the completion of construction and initial fill of EBMUD's

¹ EBMUD estimates its need for water to be 160 TAF by 2020 not counting gainsharing. The District anticipates that conservation and reclamation projects will be implemented sufficient to meet 75 TAF of that need for water in order to manage customer demand so it does not exceed 230 MGD through 2020. EBMUD would provide 20% of the yield from future water storage or conjunctive use projects needed to meet this remaining estimated 85 TAF need for water by 2020 up to a maximum of 20 TAF when such storage projects come on line and water from such projects is available to District customers. This gainsharing water could then be used annually if carry-over storage in the EBMUD Mokelumne storage on November 5th is at maximum allowable levels but may be used only once in each drought sequence.

² "Drought sequence" is defined as beginning whenever November 5th carry-over storage levels in Pardee and Camanche Reservoirs are projected to be less than maximum allowable levels under terms of the U.S. Army Corps of Engineers flood control manual, and ending when carry-over levels recover to maximum allowable storage levels.

share of any new reservoir on the Mokelumne River or the expansion of any existing EBMUD reservoir on the Mokelumne River or when EBMUD begins to take stored ground water into its system from any conjunctive use program. Water available to the Resource Agencies in any year under this gainsharing program may be added to carry over storage but shall not affect subsequent water year type determination. This additional gainsharing water will be available from any source other than conservation, reclamation projects, and the Amador Canal pipeline project, and shall be available only once during each drought sequence.

The Parties understand that EBMUD makes no guarantee regarding the timing for the development of new water storage facilities or projects eligible for gainsharing. The Parties, nevertheless, remain optimistic that such efforts will occur, at least partially, during EBMUD's water supply management program current planning period running through 2020 in order to meet the reasonable water supply needs of EBMUD. EBMUD understands that it is important to the Resource Agencies that the non-flow and the gainsharing measures outlined in this Agreement be planned and coordinated to meet agreed resource goals.

3. Surplus Water.

EBMUD agrees to notify the Resource Agencies of the availability for sale of surplus Mokelumne River water.

4. Ramping Rates.

The Parties agree that when flood control releases are not being made, river flow changes should be gradual but should not decrease by more than 50 cfs per day during the October 16 through March 31 spawning and incubation period and by not more than 100 cfs per day at other times except in the case of emergencies.

5. Managing Camanche Reservoir Hypolimnion.

The Parties agree 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. The Parties also agree that EBMUD will strive to maintain dissolved oxygen and to reduce hydrogen sulfide levels in the Camanche Reservoir hypolimnion during the period from May through October by using its Hypolimnetic Oxygenation System (HOS). This provision shall be incorporated into the Water Quality and Resource Management Program.

6. Expansion and Upgrade of the Mokelumne River Fish Hatchery.

The Parties agree that EBMUD will provide funding to expand and upgrade the Mokelumne River Fish Hatchery in accordance with the EBMUD Hatchery Master Plan (1996), up to a maximum of \$12.5 million. The Parties agree to support the expansion and upgrade of the fish

hatchery as an integral part of a strategy to supplement the natural production of and to meet the mitigation requirement for anadromous fish in the lower Mokelumne River. EBMUD will construct the fish hatchery in accordance with final design plans and final construction cost estimates approved by CDF&G. During construction, EBMUD and CDF&G will meet at the request of either party to discuss actual construction costs and jointly develop modifications as needed. EBMUD and CDF&G will jointly work to ensure that total project costs do not exceed \$12.5 million. EBMUD agrees that it will continue its existing financial support for operations and maintenance actions at the Mokelumne River Fish Hatchery. CDF&G agrees that it will continue to be responsible for the operation and maintenance of the fish hatchery as well as for hatchery production during construction of the hatchery expansion and upgrade.

7. Integration of Natural Production Strategies.

The Parties agree that CDF&G will, to the extent feasible, integrate natural production strategies when implementing its hatchery management operations. The parties agree that a trap and truck program, predator management practices and angling regulations, including provisions to prevent damage to redds from wading, could have some benefit to the fishery resource. However, the amount of such benefit is currently unknown. Trapping and trucking of anadromous salmonids shall take place during critical years with approval of the Partnership Steering Committee. Predator management activities shall only take place with the approval of the Partnership Steering Committee. The California Fish & Game Commission has the authority to adopt angling regulations in California. Upon approval of the Partnership Steering Committee, the Committee may request the Commission to adopt angling regulations for the lower Mokelumne River to prevent damage from redds from wading.

8. Satisfaction of EBMUD's Contribution Toward State and Federal Restoration Goals.

The Parties agree that implementation of the flow requirements and non-flow measures set forth in this Agreement constitutes a reasonable contribution by EBMUD to provide reasonable protection and enhancement from current conditions for the anadromous fishery and ecosystem of the lower Mokelumne River, and constitutes a reasonable contribution on the part of EBMUD toward state and federal fishery restoration goals for the River set forth in the California Salmon, Steelhead Trout, and Anadromous Fisheries Program Act and the CVPIA.

G. Ecosystem Protection.

The Parties agree to establish a Lower Mokelumne River Ecosystem Protection Program to encourage cooperative joint action to protect and to improve the natural production of anadromous fish and the natural resource habitat of the lower Mokelumne River ecosystem.

1. Ecosystem Action Priorities.

The Parties agree to work cooperatively through the Steering Committee using income from the Partnership Fund and Other Funds to develop and to implement measures, which will be consistent with the principles of this Agreement, to protect and enhance the natural production of anadromous fish and the habitat of the lower Mokelumne River corridor ecosystem. Such measures may include:

- **Identify riparian values and biological diversity** in the Mokelumne River Ecosystem. Support riparian management actions which improve the lower Mokelumne River Ecosystem, including: Planting trees and shrubs along the river corridor to provide shade cover for moderating instream temperatures, and selective removal of undesirable vegetation to improve habitat conditions. These efforts will be made in cooperation with the U.S. Natural Resources Conservation Service (formerly Soil Conservation Service) and property owners.
- **Improve spawning gravels** in the lower Mokelumne River above tidewater to correct compaction of existing gravels, adding new gravels and creating gravel berms, cleaning gravels, and measures to reduce sediments to improve instream spawning habitat.
- **Encourage fencing and barriers to prevent cattle and livestock from reaching the banks of the river** to enhance bank stability and to protect riparian corridor values. Upon approval of the Partnership Steering Committee, CDF&G would assume the lead in working in cooperation with private property owners along the river corridor, subject to available funding.
- **Identify, design and install screens on diversion facilities** to prevent unintended fish losses in cooperation with diverters. Upon approval of the Partnership Steering Committee, CDF&G would assume the lead for these activities, subject to available funding.
- **Encourage cooperative action and enforcement to reduce poaching** on the lower Mokelumne River.
- **Cooperative actions to improve fish passage at Woodbridge Dam.** The Parties will work cooperatively with Woodbridge Irrigation District and other parties to improve the coordination of efforts to ensure that the natural resources of the lower Mokelumne River below Camanche Dam are protected. While no commitments of funds for improvements to Woodbridge Dam have been made nor implied by any Party to this Agreement, each Party agrees to work cooperatively with Woodbridge Irrigation District to seek CVPIA Restoration Fund, Category III or other funds to implement agreed improvements.

- **Expand coded-wire tagging to include all fish released from the Mokelumne River Fish Hatchery**, if it is part of a statewide strategy to coded-wire tag all salmon released in California fish hatcheries in cooperation with commercial salmon trawlers, the Resource Agencies, and the California Fish and Game Commission.
- **Update and maintain database on biological diversity and habitat characteristics of aquatic resources at various instream flows.**
- **Other ecosystem improvement actions to be determined by the Steering Committee.**
- **Develop and implement a Water Quality and Resource Management Program.**

H. Mokelumne River Technical Cooperation

The Parties agree to coordinate their respective fishery and habitat studies, monitoring programs, and research efforts to advance the shared knowledge and science about the Mokelumne River. The following actions will be undertaken to support this objective:

1. Mokelumne River Technical Advisory Committee (MRTAC).

The Parties agree that for the interim, the MRTAC will remain the key forum for sharing technical information about the fishery, river operations and other data about the current conditions and planned actions affecting the river. EBMUD, the Service and CDF&G will continue actively to support the MRTAC as a technical information sharing forum.³

2. Mokelumne River Science Database.

The Parties agree to convert the technical notebook developed during the negotiation of this Agreement into a Mokelumne River Science Database to be available to the Parties (under the guidance of the Partnership Steering Committee). The database will be jointly maintained by the parties and will summarize existing science, data and research efforts and will be updated and maintained over time by adding new data, studies and research efforts undertaken by any Party using a standard agreed upon format and protocol. EBMUD agrees to provide a one time contribution of up to \$50,000 toward establishing this Mokelumne River Science Database.

³ The need for the MRTAC will be reviewed periodically by the Steering Committee with input from the Stakeholders Group.

3. Mokelumne River Symposium.

The Parties agree to sponsor periodic symposiums to provide opportunities for scientists, biologists and other professionals who have conducted studies or research on the Mokelumne River Ecosystem to present their papers and participate in peer group discussions about the river corridor and its ecosystem. These papers will be published and become part of the growing Mokelumne River Science Database. A growing professional partnership between EBMUD, the Resource Agencies and others interested in the Mokelumne River will be supported by each agency to build shared values, objectives and agreed upon strategies to protect and enhance the ecosystem of the Mokelumne River corridor. EBMUD will provide up to \$10,000 per year for ten years to support the establishment of this Symposium.

4. Adaptive Management Changes in Water Operations Plans.

EBMUD will inform and regularly consult with the Resource Agencies about anticipated changes in its real-time Lower Mokelumne River Project operations to discuss issues or points of concern. The parties intend for this communication to be informal, candid and focused on protecting the environmental resources while assuring water supply reliability.

5. Measuring Progress.

The Parties agree through the Partnership Steering Committee to engage in an ongoing process to measure the success of the flow requirements, non-flow measures and other actions contained in this Agreement. Measures of success shall be developed as a part of the Water Quality and Resource Management Program, and shall be based upon agreed criteria including counts of returning anadromous fish, redd surveys, fry/smolt condition factors, fry and smolt outmigration, and habitat quality taking into account different water year types or other criteria agreed to by the Parties.

The Parties agree that progress must be assessed annually and over time. Assessment of salmonids will be based on successive multi-year cycles to match the life cycle of the anadromous fishery. (E.g.: The first assessment is anticipated to take place in six years after two consecutive life cycles with subsequent future review to be determined by the Steering Committee.)

The Parties agree that in the event that the flow and non-flow measures employed during the first six year evaluation period fail to achieve the goals identified by the Partnership Steering Committee in the Water Quality and Resource Management Program, they will meet and attempt to reach consensus on new strategies for accomplishing the goals and objectives.

The Parties agree that after ten years following the effective date of this Agreement, they shall cooperate in the preparation of a report that describes the successes and failures with respect to agreed upon short and long-term goals and milestones reached. This report shall include findings that relate to protection of the anadromous fishery and ecosystem values of the Mokelumne River

based on the scientific data gathered during and prior to the ten year period. This report shall include the joint and or independent views of the Parties and recommendation for continued or new flow and non-flow measures. This ten year report shall be completed within six months following the ten year period end date.

6. EBMUDSIM.

EBMUD agrees, upon execution of appropriate non-disclosure agreements, to make EBMUDSIM computer runs available to the Parties for the purpose of facilitating a common understanding of river operations, hydrology, and the assessment of alternative approaches.

7. Inter-Agency Communication and Coordination.

The Parties agree to encourage a healthy interchange between their technical staff to build trust and professional respect, to share technical information and views, and to coordinate their efforts on issues related to the lower Mokelumne River to avoid surprises, misunderstandings and miscommunications in the future.

The Parties agree to develop a protocol to inform each other in a timely manner when they become aware of any situation that they believe constitutes an ecological or operational emergency. Such protocol shall be developed within three months of execution of this Agreement.

8. Permits.

The Resource Agencies and/or EBMUD, as appropriate, will seek and secure any permits or regulatory authorization needed to implement the programs or measures contained in this Agreement.

I. Settlement of Outstanding Issues.

The Parties agree that this Agreement resolves the outstanding issues between and among them regarding EBMUD's obligations to lower Mokelumne River flows and Mokelumne River Ecosystem non-flow measures needed to provide reasonable protection and enhancement beyond current conditions for the anadromous fishery and riparian habitat for purposes of:

- **FERC Proceeding 2916-004.** The Parties will jointly submit an initialed copy of this Agreement to the FERC and, in accordance with Section C hereof, recommend and support in writing acceptance of the flow and non-flow measures set forth in this Agreement as a just and reasonable resolution of the issues raised in the pending FERC matter *Lower Mokelumne River Project Proceeding # 2916-004*.
- **Submission to the SWRCB.** Following signature of this Agreement by all Parties as provided in Section C and following a FERC Order consistent with this

Agreement in Lower Mokelumne River Project Proceeding No. 2916-004 becoming final and non-appealable, EBMUD will submit this Agreement to the State Water Resources Control Board as satisfaction of EBMUD's lower Mokelumne River flow and non-flow obligations in the pending Mokelumne River Water Rights Proceeding. The Resource Agencies agree that they will not recommend to the State Water Resources Control Board flows or non-flow measures affecting EBMUD for the lower Mokelumne River in the Mokelumne River Water Rights Proceeding which are inconsistent with those set forth in this Agreement.

- **Fish Guidance Fence Improvement.** The Parties agree that the improvements made by EBMUD to the fish guidance fence in 1995 satisfied the FERC license requirements in 1995 based on available information, and may satisfy the FERC license requirements for permanent improvements, provided EBMUD demonstrates to FERC that the improvements now in place are reasonably effective in preventing fish movements past the fish guidance fence during the period in which the panels are in place.⁴ The Resource Agencies agree that the fish guidance fence panels will be installed on or before October 1 of each year and removed on or about January 1 of each year.

J. Section 7 Consultation

To ensure that ESA compliance is accomplished, the Parties will continue to engage in informal Section 7 consultation for those species over which the Service exercises program responsibilities in accordance with Section 3 of the ESA (16 U.S.C. 1532). Pursuant to Section C of this Agreement, upon initialing of the Settlement Agreement, the parties will submit the Agreement to the FERC and the FERC will be requested by the Parties to make its final determination of affect as required by the Interagency Cooperative Regulations (50 CFR 402.14) for those species over which the Service exercises program responsibilities, and to confer as appropriate with the National Marine Fisheries Service (NMFS) in accordance with 50 C.F.R. 402.10 for the steelhead trout which is currently proposed for listing by the NMFS. Throughout any Section 7 consultation and/or conference process, EBMUD will be involved as a "designated non-Federal representative" and as the "applicant" described in 50 CFR 402.08.

In the event any Section 7 consultation and/or conference referenced above results in recommended conditions or mitigations that are materially different from the terms and conditions of this Agreement, then any Party shall have 30 days after said consultation and/or conference is final and

⁴EBMUD is developing a monitoring plan (to be available on November 15, 1996) to be coordinated and concurred in by the Resource Agencies. The monitoring plan will address adequate monitoring implementation guidelines and provisions for remedial measures if the guidance fence is not effective. Planning for remedial measures may include a benefits analysis and related studies.

complete or 30 days after the FERC Order becomes final and non-appealable, to provide notice to the other Parties of its intent to withdraw from the Agreement.

K. Dispute Resolution.

In the event any Party to this Agreement believes there is an issue over the interpretation of, or compliance with, any provision of this Agreement, then, prior to that Party initiating a judicial or administrative proceeding, that Party shall provide written notice of said issue to the other Parties.

The Parties shall then meet and confer within (14) days of said written notice, or at a later date by mutual agreement, in an effort to resolve said issue.

If the matter cannot be resolved after 60 days from the date of the meeting, the Parties will enter into a non-binding mediation process. The mediator shall be approved by all Parties and the cost of the mediator borne equally amongst the parties. The non-binding mediation process shall not exceed 60 days without mutual agreement of all Parties.

If non-binding mediation does not resolve the issue, the complainant may file a protest of non-compliance with the FERC.

L. Choice of Law.

This Agreement shall be interpreted under the laws of the State of California and applicable federal law.

M. Authority.

The undersigned representative of each Party certifies that he or she is fully authorized by the Party whom he or she represents to enter into the terms and conditions of this Agreement and legally to bind such Party.

N. Execution in Counterparts.

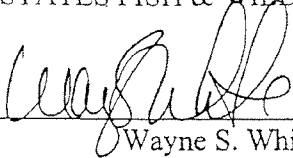
This Agreement may be executed in counterparts. A copy with all original executed signature pages affixed shall constitute the original Agreement, and shall be retained by EBMUD.

EBMUD shall distribute true copies of the Agreement with the executed signature pages to all Parties to this Agreement.

IN WITNESS WHEREOF, the Parties have caused this Lower Mokelumne River Joint Settlement Agreement to be executed in Oakland, California.

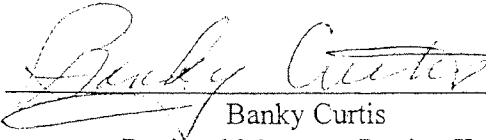
UNITED STATES FISH & WILDLIFE SERVICE

Date: 3/23/98

By: 
Wayne S. White
State Supervisor
United States Fish & Wildlife Service

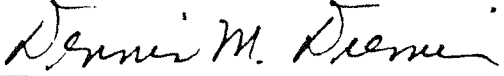
CALIFORNIA DEPARTMENT OF FISH & GAME

Date: 3/23/98

By: 
Banky Curtis
Regional Manager, Region II
California Department of Fish & Game

EAST BAY MUNICIPAL UTILITY DISTRICT

Date: 3/23/98

By: 
Dennis M. Diemer
General Manager
East Bay Municipal Utility District

Attachment 1

Normal and Above Year Flows Mokelumne River Minimum Flow Schedule (1)

Life Stage	Period	Days	Agreed Release		Expected Flow	
			From	Below	From	Below
Adult Immigration	10/1-10/15 (2)	15	Camanche Dam (cfs)	Woodbridge Dam (cfs)	100	100
Spawn/Incubation	10/16-10/31 (2)	16	325	100		
	11/1-11/30 (3)	30	325	100		
	12/1-12/31 (3)	31	325	100		
Incubation/Alevin	1/1-1/31 (3)	31	325	100		
	2/1-2/28 (3)	28	325	100		
Fry Rearing	3/1-3/31 (3)	31	325	100		
	4/1-4/15 (4),(5)	15	325	150		
	4/16-4/30 (4),(5)	15	325	150		
Fry Rearing/Juvenile Rearing/ Outmigration	5/1-5/31 (5)	31	325	300		
	6/1-6/30 (5)	30	325	300		
Oversummer	7/1-9/30	92	100	25		
	Total Days	365				

NOTES:

- (1) Due to changes in water conditions or to optimize fishery conditions, EBMUD may modify the above Flow Standards upon written concurrence of CDF&G and USFWS, provided the total quantity of water released for fishery purposes in Normal and Above year types is not less than the quantity provided by this flow schedule.
- (2) During October, EBMUD will maintain minimum flows of 325 cfs below Camanche Dam and 100 cfs below WID's dam in Normal and Above year types.
- (3) During the period when WID dam boards are pulled out and Lodi Lake is empty (approximately Nov. 1 through March 31), EBMUD shall make minimum releases of 325 cfs from Camanche Dam in Normal and Above year types. This release from Camanche dam is expected to provide at least 100 cfs below WID dam during this period. However, EBMUD shall not be obligated to increase releases above 325 cfs during this period in Normal and Above year types.
- (4) During April, EBMUD will maintain minimum flows of 325 cfs below Camanche Dam and 150 cfs below WID's dam in Normal and Above year types.
- (5) For the months of April, May, and June during Normal and Above year types, additional release of up to 200 cfs is required depending on combined Pardee and Camanche storage levels relative to the maximum allowable for the end of the prior month as follows:
 - Less than 10 TAF below maximum allowable storage (BMAS), additional release is 200 cfs for subsequent month.
 - 10 TAF <= BMAS < 20 TAF, additional release is 150 cfs for subsequent month.
 - 20 TAF <= BMAS < 30 TAF, additional release is 100 cfs for subsequent month.
 - 30 TAF <= BMAS < 40 TAF, additional release is 50 cfs for subsequent month.

Attachment 1

Below Normal Year Flows Mokelumne River Minimum Flow Schedule (1)

Life Stage	Period	Days	Agreed Release		Expected Flow	
			From	Camanche	Below	Woodbridge
Adult Immigration	10/1-10/15 (2)	15		Dam (cfs) 250	Dam (cfs) 100	
Spawn/Incubation	10/16-10/31 (2)	16		250	100	
	11/1-11/30 (3)	30		250	100	
	12/1-12/31 (3)	31		250	100	
Incubation/Alevin	1/1-1/31 (3)	31		250	100	
	2/1-2/28 (3)	28		250	100	
Fry Rearing	3/1-3/31 (3)	31		250	100	
	4/1-4/15 (4),(5)	15		250	150	
	4/16-4/30 (4),(5)	15		250	150	
Fry Rearing/Juvenile Rearing/ Outmigration	5/1-5/31 (5)	31		250	200	
	6/1-6/30 (5)	30		250	200	
Oversummer	7/1-9/30	92		100	20	
	Total Days	365				

- NOTES:
- (1) Due to changes in water conditions or to optimize fishery conditions, EBMUD may modify the above Flow Standards upon written concurrence of CDF&G and USFWS, provided the total quantity of water released for fishery purposes in Below Normal year types is not less than the quantity provided by this flow schedule.
 - (2) During October, EBMUD will maintain minimum flows of 250 cfs below Camanche Dam and 100 cfs below WID dam in Below Normal year types.
 - (3) During the period when WID dam boards are pulled out and Lodi Lake is empty (approximately Nov. 1 through March 31), EBMUD shall make a minimum release of 250 cfs from Camanche Dam in Below Normal year types. This release from Camanche dam is expected to provide at least 100 cfs below WID dam during this period. However, EBMUD shall not be obligated to increase releases above 250 cfs during this period in Below Normal year types.
 - (4) During April, EBMUD will maintain minimum flows of 250 cfs below Camanche Dam and 150 cfs below WID's dam in Below Normal year types.
 - (5) For the months of April, May, and June in Below Normal year types, additional release of up to 200 cfs is required depending on combined Pardee and Camanche storage levels relative to the maximum allowable for the end of the prior month as follows:
 - Less than 10 TAF below maximum allowable storage (BMAS), additional release is 200 cfs for subsequent month.
 - 10 TAF <= BMAS < 20 TAF, additional release is 150 cfs for subsequent month.
 - 20 TAF <= BMAS < 30 TAF, additional release is 100 cfs for subsequent month.
 - 30 TAF <= BMAS < 40 TAF, additional release is 50 cfs for subsequent month.

Attachment 1

Dry Year Flows
Mokelumne River Minimum Flow Schedule (1)

Life Stage	Period	Days	Agreed Release		Expected Flow	
			From	Below	From	Below
Adult Immigration	10/1-10/15 (2)	15	Camanche Dam (1)	Woodbridge Dam	(cfs)	(cfs)
			220		80	
Spawn/Incubation	10/16-10/31 (2)	16	220		80	
	11/1-11/30 (3)	30	220		80	
	12/1-12/31 (3)	31	220		80	
Incubation/Alevin	1/1-1/31 (3)	31	220		80	
	2/1-2/28 (3)	28	220		80	
Fry Rearing	3/1-3/31 (3)	31	220		80	
	4/1-4/15 (4)	15	220		150	
	4/16-4/30 (4)	15	220		150	
Fry Rearing/Juvenile Rearing/ Outmigration	5/1-5/31	31	220		150	
	6/1-6/30 (5)	30	100		20	
Oversummer	7/1-9/30	92	100		20	
	Total Days	365				

NOTES:

- (1) Due to changes in water conditions or to optimize fishery conditions, EBMUD may modify the above Flow Standards upon written concurrence of CDF&G and USFWS, provided the total quantity of water released for fishery purposes in Dry year types is not less than the quantity provided by this flow schedule.
- (2) During October, EBMUD will maintain minimum flows of 220 cfs below Camanche Dam and 100 cfs below WID dam in Dry year types.
- (3) During the period when WID dam boards are pulled out and Lodi Lake is empty (approximately Nov. 1 through March 31), EBMUD shall make minimum releases of 220 cfs from Camanche Dam in Dry year types. This release from Camanche dam is expected to provide at least 80 cfs below WID dam during this period. However, EBMUD shall not be obligated to increase releases above 220 cfs during this period in Dry year types.
- (4) During April, EBMUD will maintain minimum flows of 220 cfs below Camanche Dam and 150 cfs below WID's dam in Dry year types.
- (5) During June, outmigrating smolts will be trapped, tagged, and transported around the Delta in Dry year types.

Attachment 1

Critically Dry Year Flows
Mokelumne River Minimum Flow Schedule (1)

Life Stage	Period	Days	Agreed Release		Expected Flow	
			From	Below	From	Below
Adult Immigration	10/1-10/15 (2)	15	Camanche Dam (cfs)	Woodbridge Dam (cfs)	100	15
Spawn/Incubation	10/16-10/31 (2)	16	130	75		
	11/1-11/30 (3)	30	130	75		
	12/1-12/31 (3)	31	130	75		
Incubation/Alevin	1/1-1/31 (3)	31	130	75		
	2/1-2/28 (3)	28	130	75		
Fry Rearing	3/1-3/31 (3)	31	130	75		
	4/1-4/15 (4)	15	130	75		
	4/16-4/30 (4)	15	130	75		
Fry Rearing/Juvenile Rearing/ Outmigration	5/1-5/31 (5)	31	100	15		
	6/1-6/30 (5)	30	100	15		
Oversummer	7/1-9/30	92	100	15		
Total Days		365				

NOTES:

- (1) Due to changes in water conditions or to optimize fishery conditions, EBMUD may modify the above Flow Standards upon written concurrence of CDF&G and USFWS, provided the total quantity of water released for fishery purposes in Critically Dry year types is not less than the quantity provided by this flow schedule.
- (2) During October, EBMUD will maintain minimum flows of 130 cfs below Camanche Dam, and will maintain minimum flows of 15 cfs from Oct. 1 - 15 and 75 cfs from Oct. 16 - 31 below WID dam in Critically Dry year types.
- (3) During the period when WID dam boards are pulled out and Lodi Lake is empty (approximately Nov. 1 through March 31), EBMUD shall make minimum releases of 130 cfs from Camanche Dam in Critically Dry year types. This release from Camanche dam is expected to provide 75 cfs below WID dam during this period. However, EBMUD shall not be obligated to increase releases above 130 cfs during this period in Critically-Dry year types.
- (4) During April, EBMUD will maintain minimum flows of 130 cfs below Camanche Dam and 75 cfs below WID's dam in Critically Dry year types.
- (5) During May and June outmigrating smolts will be trapped, tagged, and transported around the Delta in Critically Dry year types.

Attachment 1

WATER YEAR TYPE DETERMINATION

Year Type	Normal/Above	Below Normal	Dry	Critically Dry
Oct. - Mar. (1) (Pardee/Camanche Storage)	Max Allowable (2)	Max Allowable to 400 TAF	399 TAF to 270 TAF	269 TAF or Less
Apr. - Sep. (3) (Unimpaired runoff)	890 TAF or More	889 TAF to 500 TAF	499 TAF to 300 TAF	299 TAF or Less (4)

- Notes:
- (1) October through March minimum flows are determined by total Pardee and Camanche storage on November 5th. Year type storage limits are based on the capacities of Pardee and Camanche Reservoirs in 1995.
 - (2) Maximum allowable storage on November 5th, shall be determined in accordance with the Army Corps of Engineer's Water Control Manual for Camanche Dam and Reservoir dated September, 1981.
 - (3) April through September minimum flows are determined by the water year unimpaired runoff into Pardee Reservoir as forecasted by DWR in the April 1st Bulletin 120 Report except when combined Pardee/Camanche Nov. 5 storage is projected to be less than 200 TAF.
 - (4) April through September minimum flows shall be critically dry whenever Nov. 5 combined Pardee/Camanche storage is projected to be 200 TAF or less based on the runoff forecast in DWR bulletin 120, beginning April 1st.

Appendix D.2

**Lower Mokelumne River Project Joint Settlement
Agreement Ten-Year Review**

LOWER MOKELUMNE RIVER PROJECT JOINT SETTLEMENT AGREEMENT TEN-YEAR REVIEW



PARTNERSHIP STEERING COMMITTEE

**East Bay Municipal Utility District
California Department of Fish and Game
U.S. Fish and Wildlife Service**

2008

LOWER MOKELUMNE RIVER JOINT SETTLEMENT AGREEMENT TEN-YEAR REVIEW

1.0 BACKGROUND

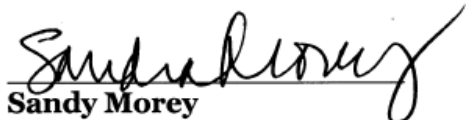
The Federal Energy Regulatory Commission's (FERC) November 27, 1998 Order "Approving Settlement Agreement and Amending License for the East Bay Municipal Utility District's Lower Mokelumne River Project No. 2916" approved the Joint Settlement Agreement (JSA) entered into by East Bay Municipal Utility District (EBMUD), U.S. Fish and Wildlife Service (USFWS) and California Department of Fish and Game (CDFG). The JSA included flow and non-flow measures, and required EBMUD, USFWS, and CDFG to develop a plan Water Quality and Resource Management Program (WQRMP) for FERC approval.

The Partnership Steering Committee, composed of one representative each from CDFG, USFWS and EBMUD, developed WQRMP to define reasonable goals, measures, performance criteria and responsive actions associated with the implementation of the JSA. It includes a comprehensive monitoring and applied research program integrated with a well-coordinated program to adaptively manage water and power supply operations, flood control, hatchery operations and ecosystem rehabilitation actions. It was approved by FERC in 2001.

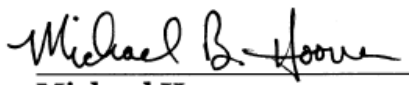
JSA Goals

- Provide, to the extent feasible, habitat quality and availability in the lower Mokelumne River to maintain fishery, wildlife and riparian resources in good condition
- Contribute towards the state and federal fishery restoration goals as defined in the California Salmon, Steelhead Trout and Anadromous Fisheries Program Act and the Central Valley Project Improvement Act
- Sustain 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 report summarizes the findings of the Partnership Steering Committee with respect to the progress and accomplishments resulting from the first ten years of JSA implementation as defined in the Water Quality and Resource Management Program and recommends strategies and measures for continued implementation.


Sandy Morey
California Department of Fish and Game

9-10-08
Date


Michael Hoover
U.S. Fish and Wildlife Service

9-10-08
Date


Alexander Coate
East Bay Municipal Utility District

9-10-08
Date

2.0 ACCOMPLISHMENTS

2.1 Flow Measures

The JSA specifies minimum flow releases from Camanche Dam and expected flow below the Woodbridge Irrigation District Dam (WIDD) based on time of year and water year types. Water year types are determined based on combined storage in Camanche and Pardee reservoirs (October through March) and the unimpaired runoff into Pardee Reservoir (April through September). Since 1998, there have been 6 Normal and Above, 2 Below Normal, and 2 Dry water year types from October through March; and, 2 Normal and Above, 4 Below Normal, and 4 Dry water year type from April through September. Although the minimum flow releases from Camanche Dam and the expected flows below WIDD are designed to protect the fish resources in the lower Mokelumne River, actual flows have always exceeded the required releases below Camanche Dam (Table 1) and the expected flows below WIDD (Table 2).

Table 1. Comparison of JSA required release and actual releases below Camanche Dam.

Year	Period	JSA Water Year Type	JSA Required Release (Acre-feet)	Actual Release (Acre-feet) ¹
1998/1999	Oct-Mar	Normal & Above	117,294	349,361
1999	Apr-Sep	Below Normal	63,357	320,530
1999/2000	Oct-Mar	Normal & Above	117,939	274,205
2000	Apr-Sep	Below Normal	63,357	200,664
2000/2001	Oct-Mar	Normal & Above	117,294	119,827
2001	Apr-Sep	Dry	50,804	113,937
2001/2002	Oct-Mar	Dry	79,399	87,062
2002	Apr-Sep	Below Normal	63,357	139,500
2002/2003	Oct-Mar	Below Normal	90,227	95,394
2003	Apr-Sep	Dry	50,804	231,018
2003/2004	Oct-Mar	Normal & Above	117,939	130,259
2004	Apr-Sep	Below Normal	84,476	170,839
2004/2005	Oct-Mar	Below Normal	90,227	190,733
2005	Apr-Sep	Normal & Above	107,033	546,981
2005/2006	Oct-Mar	Normal & Above	117,294	388,359
2006	Apr-Sep	Normal & Above	112,982	826,939
2006/2007	Oct-Mar	Normal & Above	117,294	132,694
2007	Apr-Sep	Dry	50,804	124,118
2007/2008	Oct-Mar	Dry	80,481	82,157 ²
2008	Apr-Sep	Dry	50,804	190,268 ²

¹ Actual Release from USGS published data for site 11323500

² Estimated

Table 2. Comparison of JSA expected flow and actual flow below Woodbridge Dam.

Year	Period	JSA Water Year Type	JSA Expected Flow (Acre-feet)	Actual Flow (Acre-feet) ¹
1998/1999	Oct-Mar	Normal & Above	36,091	313,161
1999	Apr-Sep	Below Normal	36,765	221,223
1999/2000	Oct-Mar	Normal & Above	36,289	249,674
2000	Apr-Sep	Below Normal	36,765	110,477
2000/2001	Oct-Mar	Normal & Above	36,091	97,219
2001	Apr-Sep	Dry	22,983	30,465
2001/2002	Oct-Mar	Dry	28,872	62,923
2002	Apr-Sep	Below Normal	36,765	44,927
2002/2003	Oct-Mar	Below Normal	36,091	71,503
2003	Apr-Sep	Dry	22,983	146,080
2003/2004	Oct-Mar	Normal & Above	36,289	94,034
2004	Apr-Sep	Below Normal	36,765	68,596
2004/2005	Oct-Mar	Below Normal	36,091	151,315
2005	Apr-Sep	Normal & Above	49,773	423,398
2005/2006	Oct-Mar	Normal & Above	36,091	360,198
2006	Apr-Sep	Normal & Above	49,773	726,760
2006/2007	Oct-Mar	Normal & Above	36,091	106,505
2007	Apr-Sep	Dry	22,983	34,054
2007/2008	Oct-Mar	Dry	29,031	66,074 ²
2008	Apr-Sep	Dry	22,983	94,236 ²

¹ Actual Release from USGS published data for site 11325500

² Estimated

2.2 Fall-run Chinook salmon

Since implementation of the JSA in 1998, the population of fall-run Chinook salmon as measured by total escapement to the lower Mokelumne River has increased (average 1964 through 1997 = 3,636; 1998 through 2007 = 8,455, Figure 1); and as measured by in-river escapement (average 1964 through 1997 = 2,503; 1998 through 2007 = 2,973, Figure 2). Total and in-river escapement, number of redds, and estimated number of outmigrating juvenile fall-run Chinook salmon through the period are shown in Table 3.

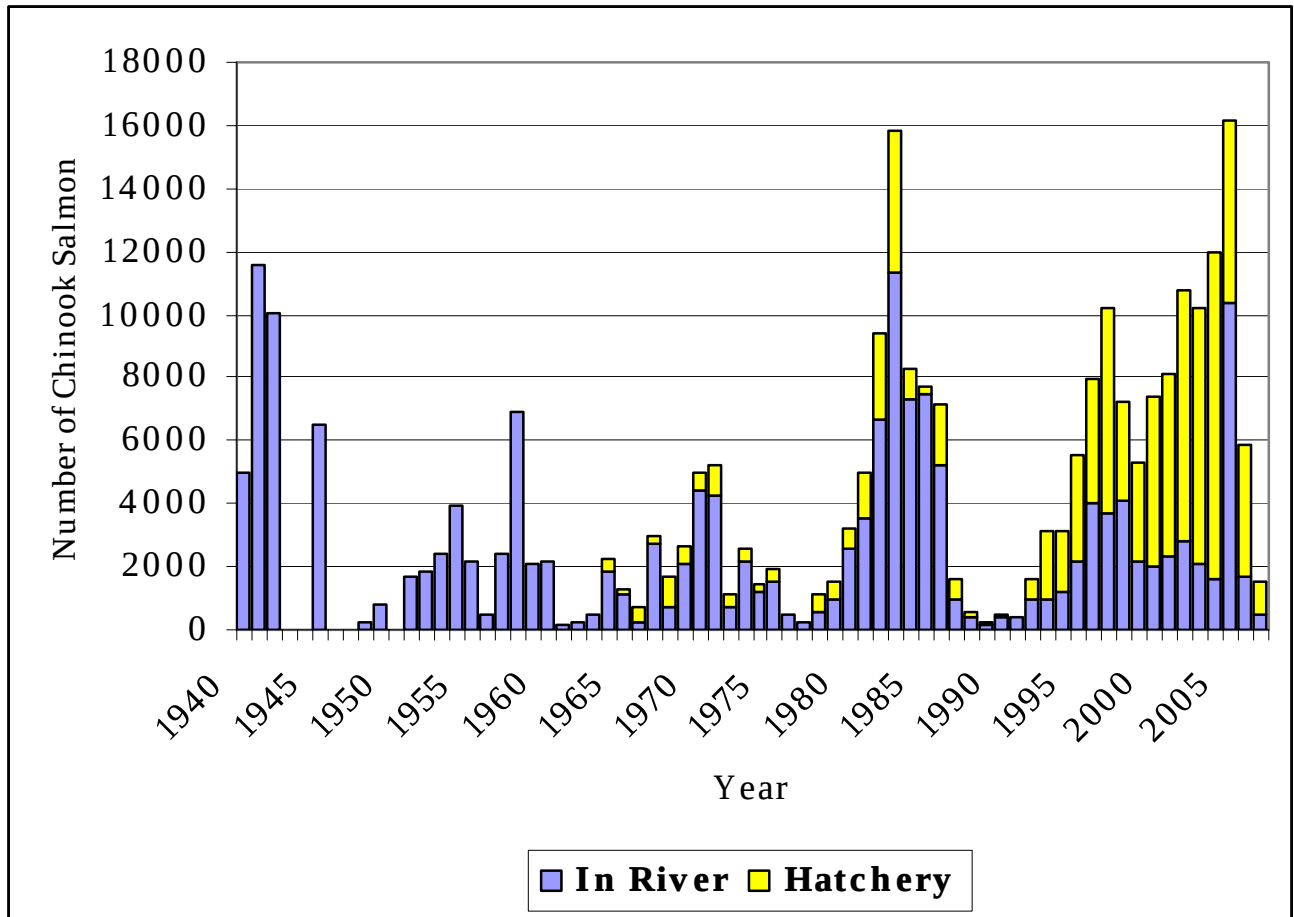


Figure 1. Mokelumne River Fall-run Chinook Salmon Escapement

Table 3. Fall-run Chinook salmon escapement, number of redds and outmigrants observed.

Year	Period	JSA Water Year Type	Preceding JSA Water Year Type	Total Escapement (In-river)	Number of Redds	Outmigrants
1998/1999	Oct-Mar	Normal & Above	Normal & Above	7,213 (4,122)	1,116	
1999	Apr-Sep	Below Normal	Normal & Above			1,535,439
1999/2000	Oct-Mar	Normal & Above	Below Normal	5,333 (2,183)	623	
2000	Apr-Sep	Below Normal	Normal & Above			168,525
2000/2001	Oct-Mar	Normal & Above	Below Normal	7,423 (1,973)	987	
2001	Apr-Sep	Dry	Normal & Above			119,334
2001/2002	Oct-Mar	Dry	Dry	8,116 (2,307)	843	
2002	Apr-Sep	Below Normal	Dry			77,923
2002/2003	Oct-Mar	Below Normal	Below Normal	10,759 (2,840)	848	
2003	Apr-Sep	Dry	Below Normal			140,471
2003/2004	Oct-Mar	Normal & Above	Dry	10,239 (2,122)	807	
2004	Apr-Sep	Below Normal	Normal & Above			87,654
2004/2005	Oct-Mar	Below Normal	Below Normal	11,944 (1,588)	835	
2005	Apr-Sep	Normal & Above	Below Normal			432,874
2005/2006	Oct-Mar	Normal & Above	Normal & Above	16,144 (10,406)	2,170	
2006	Apr-Sep	Normal & Above	Normal & Above			1,187,553
2006/2007	Oct-Mar	Normal & Above	Normal & Above	5,861 (1,723)	754	
2007	Apr-Sep	Dry	Normal & Above			39,627*
2007/2008	Oct-Mar	Dry	Dry	1,519 (470)	305	
2008	Apr-Sep	Dry	Dry			18,347*

* Sampling season abbreviated due to low flow conditions below WID dam

The lower Mokelumne River contributed about 2% (1.2-3.7%) to the total escapement of California Central Valley fall-run Chinook salmon and about 41% (16-77%) to total escapement of fall-run Chinook salmon in the San Joaquin River system. In-river escapement contributed about 1.1% (0.4-4.3%) to the total in-river escapement of California Central Valley fall-run Chinook salmon and about 22% (5-70%) to the total in-river escapement of fall-run Chinook salmon in the San Joaquin River system. Mokelumne River Fish Hatchery escapement contributed about 6.2% (3-9.3%) to the total hatchery escapement of California Central Valley fall-run Chinook salmon and about 83% (66-97%) to total hatchery escapement of fall-run Chinook salmon in the San Joaquin River system.

Table 4. California Central Valley fall-run Chinook salmon escapement.

YEAR	Sacramento River System		San Joaquin River System		Mokelumne River	
	Hatchery	In-river	Hatchery	In-river	Hatchery	In-river
1998/1999	75,028	151,732	3,890	19,711	3,091	4,122
1999/2000	49,657	341,693	4,787	17,893	3,150	2,183
2000/2001	50,965	385,593	7,396	39,474	5,450	1,973
2001/2002	61,702	528,472	7,391	27,303	5,809	2,307
2002/2003	96,471	739,537	9,753	26,666	7,919	2,840
2003/2004	118,144	451,208	8,666	12,717	8,117	2,122
2004/2005	115,929	246,508	13,626	8,637	10,356	1,588
2005/2006	186,833	226,888	6,159	14,835	5,738	10,406
2006/2007	78,326	203,568	4,266	7,245	4,138	1,723
2007/2008	21,638	70,494	1,128	1,450	1,049	470

2.3 Steelhead/Rainbow trout

Since implementation of the JSA, EBMUD has monitored *Oncorhynchus mykiss* populations in the lower Mokelumne River using video monitoring at the Woodbridge Irrigation District Dam fish ladder, rotary screw traps in the lower Mokelumne River below WIDD, and seasonal fish community surveys (electrofishing and seining) from Camanche Dam downstream to WIDD (Table 5).

Table 5. *O. mykiss* observed in the fisheries sampling conducted in the lower Mokelumne River from Camanche Dam downstream to Woodbridge Dam.

Year	Period	Community Surveys ¹		Rotary Screw Trap ²		WID Fish Ladder ³	
		Hatchery ⁴	Wild ⁵	Hatchery	Wild	Hatchery	Wild
1998/1999	Oct-Mar		347	620	22		555
1999	Apr-Sep		227	6	191		2
1999/2000	Oct-Mar		24	871	19		941
2000	Apr-Sep		205	31	148	8	3
2000/2001	Oct-Mar		274	487	77	3,067	89
2001	Apr-Sep		245	4	381	9	23
2001/2002	Oct-Mar		253	9	154	593	152
2002	Apr-Sep		213	1	50	357	400
2002/2003	Oct-Mar		196	82	78	1,017	117
2003	Apr-Sep		98	15	78	1,312	380
2003/2004	Oct-Mar		175	61	16	385	105
2004	Apr-Sep		131	9	43	749	439
2004/2005	Oct-Mar		410	28	7	265	70
2005	Apr-Sep		335	4	74	816	42
2005/2006	Oct-Mar		781	61	8	28	10
2006	Apr-Sep		189	6	51	108	22
2006/2007	Oct-Mar	2	324	75	15	337	16
2007	Apr-Sep	6	273	2	136	121	23
2007/2008	Oct-Mar		213	1	31	*	*

¹ Includes seasonal electrofishing and seining (Jan-Jun)

² Rotary screw trap(s) immediately below Woodbridge Irrigation District Dam (mid-Dec thru Jul)

³ Includes video monitoring and trapping in old ladder

⁴ Fish of hatchery origin (adipose fin clip)

⁵ Fish of natural origin

* Monitoring system inoperable due to construction of fish screens at WID canal

The number of *O. mykiss* observed in the fish community surveys has varied (Figure 2). In 2005 EBMUD developed a population estimate of *O. mykiss* in the lower Mokelumne River from Camanche Dam downstream to the Woodbridge Irrigation District Dam using a mark/recapture study with PIT (passive integrated transponder) tags. That estimate was $9,215 \pm 1,877$.

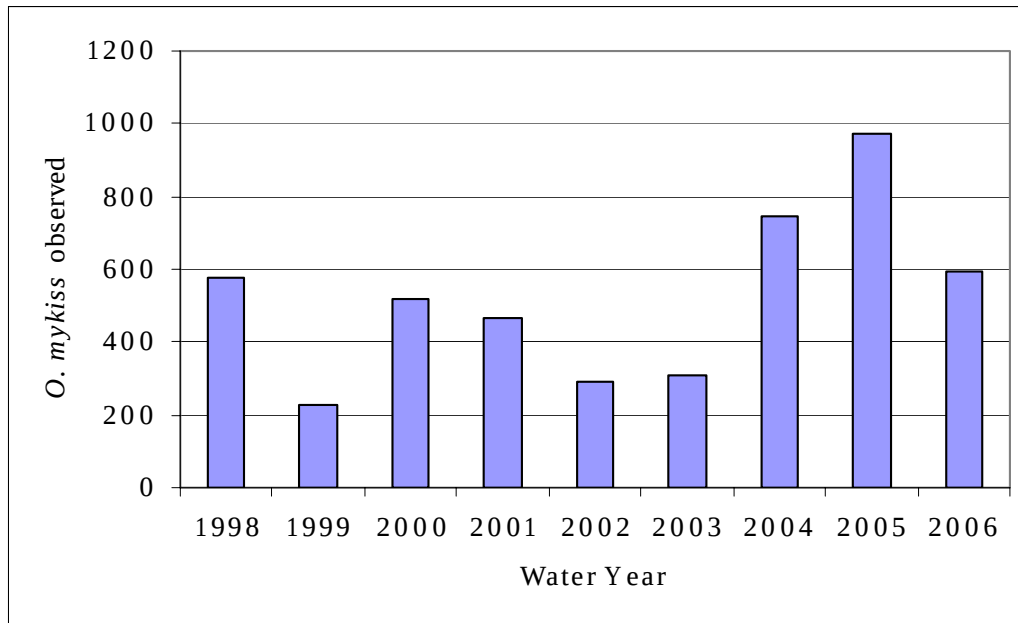


Figure 2. *O. mykiss* observed in the seasonal fish community surveys

Although the number of *O. mykiss* observed in the fish ladder videos and rotary screw traps (Figure 3) may give an impression of upstream (adults, Oct-Mar) and downstream (juveniles, Apr-Sep) movement of fish, it may not be an accurate representation of anadromy.

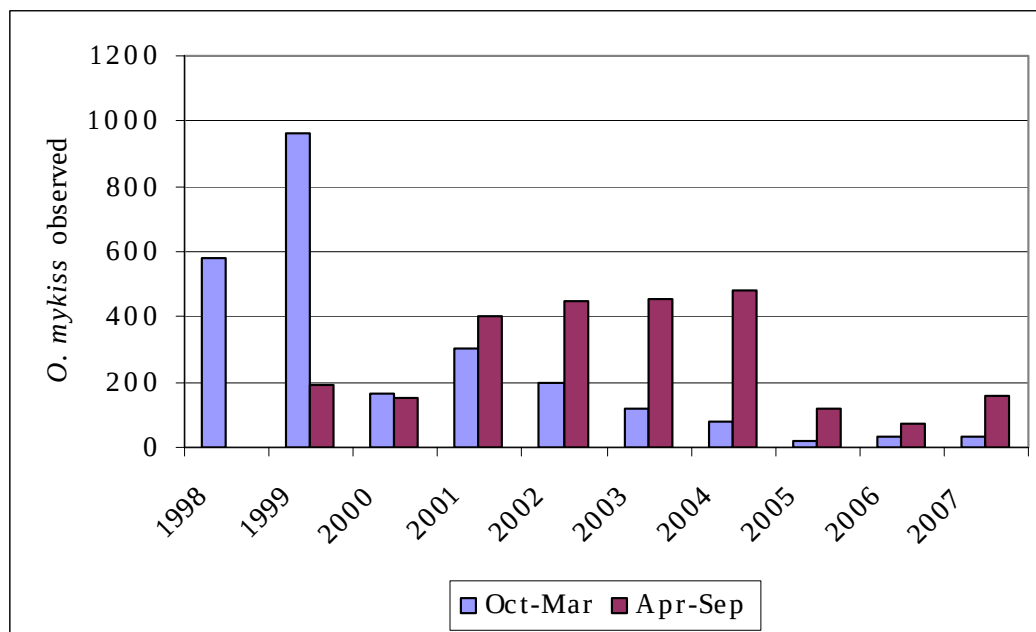


Figure 3. *O. mykiss* observations in the ladder videos and rotary screw traps.

Zimmerman et al. (2008) conducted an analysis of otolith strontium/calcium (Sr:Ca) ratios to determine maternal origin (anadromous v. non-anadromous) and migratory history (anadromous v. non-anadromous) of rainbow trout (*O. mykiss*) collected in tributaries of the Sacramento-San Joaquin River system in the Central Valley of California between 2001 and 2007. Of 964 otoliths examined, 224 were progeny of anadromous rainbow trout (i.e., steelhead) females and 740 were progeny of non-anadromous rainbow trout females. Of the 485 specimens examined from the Calaveras, Stanislaus, and Tuolumne rivers (similar to the Mokelumne river), less than 1% (4) exhibited anadromous migratory history, and less than 16% (77) were progeny of anadromous females (Table 6).

Table 6. Maternal origin and migratory history of *O. mykiss* from the Calaveras, Stanislaus and Tuolumne rivers.

	AGE					TOTAL
	0	1	2	3	4	
MATERNAL ORIGIN						
Anadromous	6	12	30	17	12	77
Resident	10	72	168	109	49	408
MIGRATORY HISTORY						
Anadromous	0	0	0	0	4	4
Resident	16	84	198	126	55	479
Unknown	0	0	0	0	2	2

The number of *O. mykiss* that have entered the fish ladder and trap in the Mokelumne River Fish Hatchery has steadily increased since implementation of the JSA (Table 7). The proportion of these fish that are hatchery origin has increased from 77% in 2005 to 96% in 2007 and 93% in 2008.

Table 6. *O. mykiss* trapped at the Mokelumne River Fish Hatchery.

Year	Females	Males	Juveniles (<40.6 cm)
1999	0	0	
2000	9	23	
2001	17	15	
2002	18	25	
2003	29	23	29
2004	29	30	23
2005	25	22	13
2006	61	79	49
2007	113	132	167
2008	99	135	110

2.4 Non-Flow Measures

As specified in the JSA, East Bay Municipal Utility District, U.S. Fish and Wildlife Service and California Department of Fish and Game established the Lower Mokelumne River Partnership (Partnership) in 1998 and each agency representative has participated in an annual meeting to measure the success of the JSA flow requirements, non-flow measures and other actions pursuant to implementation of the JSA. The Partnership also established the Partnership Coordinating Committee consisting of technical representatives of each agency that meets semiannually to ensure timely implementation of the measures identified in the JSA and the WQRMP.

In January 1999, EBMUD established the \$2 million Partnership fund, the interest from which is used to support Partnership programs to protect and enhance the lower Mokelumne River ecosystem. Since its inception, the Partnership fund has committed over \$740,000 to approved projects (Table 7). Restoration activities comprised 61% of the expenditures and approximately 17% was committed to research, 16% to outreach, and 6% to law enforcement. Over 92% of the funds were leveraged with additional funding sources or in-kind services.

The Partnership has worked collaboratively with the Lower Mokelumne River Watershed Stewardship Steering Committee to 1) encourage the voluntary participation and cooperation of other stakeholders along the river, 2) recommend ecosystem protection and improvement priorities, and, 3) serve as a communications and coordination forum for stakeholders.

Representatives of the Partnership along with other resource agency staff and technical experts convene the Mokelumne River Technical Advisory Committee semiannually. This meeting provides a forum for sharing technical information about the fisheries, river operations, hatchery operations, and other issues related to ecosystem actions in the lower Mokelumne River.

The Partnership sponsored periodic symposia to present research findings related to ecological studies in the lower Mokelumne River, including the “State of the Rivers” symposia in 1999 and 2001, and the Salmonid Restoration Conferences in 2004 and 2008. Projects associated with implementation of the JSA resulted in completion of one Ph.D. and 6 M.S. degrees, 14 peer-reviewed scientific journal articles, and 18 scientific conference presentations.

The JSA states that a trap and truck program could have some benefit to the fishery resource and recommends that trapping and trucking of anadromous salmonids take place during critical years upon approval of the Partnership Steering Committee. Appendix A presents the trapping and trucking program conducted during the past 10 years.

Table 7. Approved Partnership Fund Projects.

PROJECT	SPONSOR	DESCRIPTION	COMPLETED	FUNDING
Farm Edges Handbook	East Bay Municipal Utility District	Purchase and distribution of resource handbook	10/10/2001	\$760
2002 Enhanced Enforcement	California Department of Fish and Game	Increased warden surveillance & equipment	3/2/2002	\$15,000
2002 Spawning Gravel Enhancement	East Bay Municipal Utility District	Install supplemental spawning gravel	9/3/2002	\$24,685
Distribution, Abundance, and Habitat Association of Swainson's Hawks	San Joaquin County Resource Conservation District	Collect data for developing information to use raptors as ecosystem health indicator	12/9/2002	\$15,965
2003 Spawning Gravel Enhancement	East Bay Municipal Utility District	Install supplemental spawning gravel	10/10/2003	\$28,074
2004 Spawning Gravel Enhancement	East Bay Municipal Utility District	Install supplemental spawning gravel	9/17/2004	\$29,324
Mokelumne River Day Use Area Restoration	East Bay Municipal Utility District	Wildlife habitat restoration	10/29/2004	\$34,720
Riparian Area Restoration and Enhancement	San Joaquin County Resource Conservation District	Riparian restoration and invasive species removal	3/20/2005	\$33,181
2003-2005 Enhanced Enforcement	California Department of Fish and Game	Increased warden surveillance	4/29/2005	\$25,933
Salmonid Rearing Habitat Improvement	East Bay Municipal Utility District	Reestablishment of side channel habitat	9/29/2005	\$93,600
2006 Watershed Open House	San Joaquin County Resource Conservation District	Sponsor SJRCD watershed open house event	3/31/2006	\$500
2006 Spawning Gravel Enhancement	East Bay Municipal Utility District	Install supplemental spawning gravel	9/30/2006	\$84,813
2006 Spawning Gravel Enhancement	East Bay Municipal Utility District	Install supplemental spawning gravel	11/7/2006	\$28,797

Table 7. Approved Partnership Fund Projects (continued).

PROJECT	SPONSOR	DESCRIPTION	COMPLETED	FUNDING
Lower Mokelumne River Watershed Coordinator	San Joaquin County Resource Conservation District	Cash match for Dept of Conservation Watershed Coordinator Grant	7/15/2007	\$30,000
Cosumnes-Mokelumne River Floodplain Resource Management	Southeast Sacramento County Agricultural Water Authority	Feasibility study of ecosystem restoration/flood hazard reduction	12/31/2007	\$50,000
Large Woody Material	University of California, Davis	Develop large woody material budget for LMR	4/1/2008	\$25,663
Gil Creek Riparian Improvement	Gil Creek Landowners	Riparian improvement on private land along Gil Creek	Ongoing	\$11,191
Calvary Bible Church Riparian Restoration	Calvary Bible Church	Riparian restoration along LMR on church property	Ongoing	\$21,408
Hoffman Riparian Restoration	Center for Land Based Learning	Riparian restoration on the Hoffman Farm	Ongoing	\$14,988
2008-2010 Watershed Coordinator	San Joaquin County Resource Conservation District	Cash match for Dept of Conservation Watershed Coordinator Grant	Ongoing	\$30,000
Watershed Education and Riparian Restoration	San Joaquin County Resource Conservation District	Cash match for Dept of Water Resources CALFED grant	Ongoing	\$60,000
Invasive Species Removal - Murphy Creek	Murphy Creek Landowners	Removal of invasive species from Murphy Ck restoration site	Ongoing	\$47,212
Steelhead Acoustic Telemetry Study	East Bay Municipal Utility District	Purchase acoustic tags for steelhead acoustic telemetry study	Ongoing	\$35,000

The following table summarizes the accomplishments of JSA implementation as defined by the goals, measures, and performance criteria of the WQRMP. The measures and performance criteria were developed by the Partnership Steering Committee as a means to define specific methods to implement the goals of the JSA. The status of the performance criteria during the ten years since JSA implementation suggests that significant progress has been made towards the Partnership goals and that numerous successes and milestones have been achieved.

Goal: Provide, to the extent feasible, habitat quality and availability in the lower Mokelumne River to maintain fishery, wildlife and riparian resources in good condition

Measure	Performance Criterion	Status
Maintain water temperatures in the lower Mokelumne River to meet the life-history needs of aquatic organisms.	Use best efforts to maintain a minimum of 28,000 acre-feet of hypolimnetic volume (the volume of water colder than 16.4° C as determined by weekly hydro-lab at CAMD) in Camanche Reservoir through October whenever Pardee Reservoir total volume is in excess of 100,000 acre-feet.	Using best efforts, EBMUD managed the hypolimnetic volume in Camanche Reservoir so that at the end of October the volume has exceeded 28,000 acre-feet in every year except 2003 . The Mokelumne River watershed received uncharacteristically high precipitation in April and May 2003 and high flood control releases were required which diminished the cold-water pool during 2003 to 16,700 acre-feet. There was no significant difference in the number of juvenile outmigrating chinook salmon in spring 2004 (0.018/spawning adult) compared to the previous year (0.015/spawning adult) when the hypolimnetic volume was 63,500 acre-feet.
	Operate the upper and lower level outlets in Camanche Reservoir to maintain the best possible release temperatures to meet the life-history needs of aquatic organisms based on EBMUD's operation plan prepared annually in March	EBMUD opens the upper level outlet in Camanche Reservoir after lake turnover and closes the upper outlet when temperatures at Woodbridge Dam reach approximately 18°C to maintain the best possible release temperatures to meet the life-history needs of aquatic organisms
Maintain dissolved oxygen levels and reduce hydrogen sulfide levels in the Camanche Reservoir hypolimnion	Operate the Hypolimnetic Oxygenation System when dissolved oxygen levels in the Camanche Reservoir hypolimnion drop to 2 ppm (as measured at CAMC) during the period May through October	EBMUD operates the Hypolimnetic Oxygenation System (HOS) in Camanche Reservoir to maintain dissolved oxygen levels to prevent the formation of hydrogen sulfide. Since 1998 the system has operated typically from July/August through mid-November (108-143 days) and no hydrogen sulfide has developed.

Goal: Provide, to the extent feasible, habitat quality and availability in the lower Mokelumne River to maintain fishery, wildlife and riparian resources in good condition

Measure	Performance Criterion	Status
Increase summer and fall base flows in the lower Mokelumne River by developing new water supplies	Increase instream flows beyond the flows specified in Attachment 1 of the Agreement by an amount equal to 20% of the actual yield (up to 20,000 acre-feet) of additional water supplies developed by EBMUD from new facilities. Said gainsharing water shall be available in accord with Section F.2 of the Agreement	To date no additional water supplies have been developed by EBMUD. The Freeport Regional Water Project is a joint venture of the Sacramento County Water Agency and East Bay Municipal Utility District of Oakland to supply water from the Sacramento River to customers in Sacramento County and the East Bay. When operational in 2010, EBMUD will use up to 100 million gallons per day of water during dry years only as a supplemental water source to complement existing conservation programs.
Improve opportunities for the lower Mokelumne River from Camanche Dam downstream to the San Joaquin River to seasonally inundate the floodplain	Examine how revisions to the flood control requirements of the U.S. Army Corps of Engineers and the pattern of the flood flow releases could be modified to support restoration of ecological processes, and not create undue risk of flood damage	The existing agreement between the U.S. Army Corps of Engineers committed EBMUD to provide up to 200,000 acre-feet of flood space in Camanche and Pardee Reservoirs. Prior to the agreement, Mokelumne River flow records showed that True Natural Flow (TNF) had exceeded 100 Thousand Acre Feet (TAF) in every month from November through June, with TNF as high as 270 TAF in November. Since the agreement was signed, even greater runoff has occurred. To date, TNF has exceeded 220 TAF in every month from November through July. The Intergovernmental Panel on Climate Change projects a global temperature increase from 1990-2100. Precipitation is also expected to increase over the 21st century, particularly at northern mid-high latitudes. Based on this information, revisions to the flood control requirements of the U.S. Army Corps of Engineers at Camanche and Pardee reservoirs may change at some point to reflect changing climate conditions.

Goal: Provide, to the extent feasible, habitat quality and availability in the lower Mokelumne River to maintain fishery, wildlife and riparian resources in good condition

Measure	Performance Criterion	Status
Improve opportunities for the lower Mokelumne River from Camanche Dam downstream to the San Joaquin River to seasonally inundate the floodplain	Conduct a feasibility study to identify activities to minimize flood-related damage and improve flood plain habitats and processes. Activities considered for implementation will be those that respect private property rights, protect water rights and maintain economic viability of land owners and water users. The activities will be identified through a cooperative planning effort that will include landowners, local governments, land and water users, and interested public	Funded by the California Bay-Delta Authority (\$1,007,800), EBMUD Partnership Fund (\$50,000), Sacramento Area Flood Control Agency (\$50,000) and Sacramento County Water Agency (\$50,000) and with the Southeast Sacramento County Agricultural Water Authority as the lead agency, the feasibility study developed an Integrated Resource Management Plan (2007) to guide implementation of prioritized management actions to enhance floodplains and riparian habitat, flood management, and groundwater recharge. Additional study partners included The Nature Conservancy, University of California, Davis, San Joaquin County Resource Conservation District, and Reclamation District 800.

Goal: Provide, to the extent feasible, habitat quality and availability in the lower Mokelumne River to maintain fishery, wildlife and riparian resources in good condition

Measure	Performance Criterion	Status
Improve opportunities for the lower Mokelumne River from Camanche Dam downstream to the San Joaquin River to seasonally inundate the floodplain	Modify the minimum flow regime, in accord with Section F.1 of the Agreement, to optimize the conditions for ecosystem values provided the total quantity of water released in any given year will not be less than the quantity of water provided by the flow requirements specified in Attachment 1 of the Agreement	Minimum flow modification occurred in March 2004, when Woodbridge Irrigation District (WID) requested EBMUD delay planned April flow increases required by the JSA and release the deferred water in May to allow completion of the fish bypass pipeline component of their dam construction. The California Department of Fish and Game, U.S. Fish and Wildlife Service, NOAA Fisheries, and State Water Resources Control Board concurred and Camanche release was maintained at 330 cfs until mid-April, when WID completed the portion of the work that would be impacted by a higher release rate. The release increased to 515 cfs by the end of April as WID initiated their seasonal diversions. The deferred volume 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.
Maintain and enhance high quality habitat conditions for terrestrial riparian communities and shaded riverine aquatic habitat	Identify and map the aquatic and terrestrial components of the riparian system from Camanche Dam downstream to tidewater and cooperate with others to identify and map these components downstream to the San Joaquin River	Aquatic habitat in the lower Mokelumne River from Camanche Dam downstream to the San Joaquin River was mapped using aerial photographs and global positioning system equipment (Merz and Setka 2004a). Terrestrial vegetation communities adjacent to the lower Mokelumne River from Camanche Dam downstream to the confluence of the San Joaquin River were classified and mapped using aerial photographs (Reeves and Jones 2004a).

Goal: Provide, to the extent feasible, habitat quality and availability in the lower Mokelumne River to maintain fishery, wildlife and riparian resources in good condition

Measure	Performance Criterion	Status
Maintain and enhance high quality habitat conditions for terrestrial riparian communities and shaded riverine aquatic habitat	Continue monitoring invertebrates, fish, amphibian, reptile, mammal, raptor and neotropical bird communities in the lower Mokelumne River from Camanche Dam downstream to tidewater and cooperate with others to monitor these communities downstream to the San Joaquin River.	Surveys were conducted for invertebrates (Ochikubo-Chan 2003), fish (Merz and Saldate 2004), amphibians and reptiles (Workman and Smith 2004), mammals (Reeves and Jones 2004b), raptors (Reeves and Smith 2004), and neotropical birds (Smith 2004).
	Develop a cooperative program with local interests to improve land management and livestock grazing practices along riparian zones to reduce streambank erosion and fine sediment input	Over \$400,000 has been contributed by the Partnership Fund, AFRP, and California Bay-Delta Authority to fund 8 projects that incorporated fencing, streambank protection and riparian vegetation restoration along the lower Mokelumne River. Cooperative efforts on Murphy Creek resulted in the removal of a dam, restoration of riparian habitat and control of livestock grazing (fencing).
Reduce the adverse effects of invasive riparian plants on native species and ecosystem processes	Develop and implement a coordinated control program to reduce or eliminate invasive plant species from the riparian corridor along the lower Mokelumne River	Reeves and Jones (2004c) identified the extent of non-native invasive plant species in the lower Mokelumne River corridor, provided control measures and listed the ongoing management programs designed to reduce or eliminate invasive plant species in the area. The Lower Mokelumne River Watershed Stewardship Plan and the Lower Mokelumne River Conservation Handbook include recommendations to reduce invasive plant species along the lower Mokelumne River. In 2007, the Partnership sponsored removal of Himalayan blackberries in the Murphy Creek watershed.

Goal: Contribute towards the state and federal fishery restoration goals as defined in the California Salmon, Steelhead Trout and Anadromous Fisheries Program Act and the Central Valley Project Improvement Act

Measure	Performance Criterion	Status
Support the assessment of the overall effectiveness of actions implemented pursuant to the Central Valley Project Improvement Act in meeting Anadromous Fisheries Restoration Program production targets	Continue the daily enumeration of migrating adult chinook salmon and steelhead by video monitoring and trapping at Woodbridge Dam (or other appropriate methods). The enumeration begins in August and continues through March	EBMUD has monitored daily migration (escapement) of adult chinook salmon and steelhead at the fish ladders at Woodbridge Irrigation District Dam since 1990. Monitoring is currently conducted by video monitoring and carcass surveys. Data are stored in EBMUD's Oracle database and periodically submitted to the California Department of Water Resources Interagency Ecological Program (I.E.P.) database.
	Continue conducting weekly redd surveys in the lower Mokelumne River between Camanche Dam and the Elliott Road bridge from October through April	Systematic salmonid redd surveys have been conducted in the lower Mokelumne River since 1990. From September through December, surveys are conducted weekly, with bi-weekly surveys for the remainder of the season. The river is surveyed from the base of Camanche Dam to Elliott Road, with three individuals walking abreast down the river (water depths to 1.2 m) and searching for signs of redd construction (Setka 2004). Redd locations are recorded using a hand-held Global Positioning System (GPS) unit. Location of each redd is downloaded from the GPS unit into a Geographic Information System (GIS).

Goal: Contribute towards the state and federal fishery restoration goals as defined in the California Salmon, Steelhead Trout and Anadromous Fisheries Program Act and the Central Valley Project Improvement Act

Measure	Performance Criterion	Status
Support the assessment of the relative effectiveness of water management modifications, structural modifications, habitat restoration and fish screen installations to meet Anadromous Fisheries Restoration Program targets	Continue estimating the emigration of juvenile chinook salmon and steelhead by trapping at Woodbridge Dam and operation of the rotary screw traps below Woodbridge Dam (or other appropriate methods) and marking a portion of the natural outmigrants. The trapping begins in December and continues through July	EBMUD has monitored daily emigration of juvenile chinook salmon and steelhead at Woodbridge Irrigation District Dam since 1990. Monitoring is currently conducted by rotary screw trap(s) and trapping in the fish bypass system (when WID is diverting). Data are stored in EBMUD's Oracle database and periodically submitted to the California Department of Water Resources Interagency Ecological Program (I.E.P.) database. EBMUD has marked (coded-wire tag) over 230,000 juvenile fall-run Chinook salmon since 1994.
	Continue monitoring CAMC and CAMD in Camanche Reservoir to measure temperature, pH, dissolved oxygen, conductivity, oxidation-reduction potential, and turbidity. In addition, collect monthly water quality samples at CAMC and CAMD to analyze for volatile suspended solids (VSS), total suspended solids (TSS), nutrients (total and dissolved phosphorus and nitrogen), chlorophyll (corrected and uncorrected for phaeopigments), and phytoplankton and zooplankton abundance and taxonomic composition (to genus)	Monitoring of temperature, pH, dissolved oxygen, conductivity, oxidation-reduction potential, turbidity, volatile suspended solids (VSS), total suspended solids (TSS), nutrients (total and dissolved phosphorus and nitrogen), chlorophyll (corrected and uncorrected for phaeopigments), and phytoplankton and zooplankton abundance and taxonomic composition (to genus) at CAMC and CAMD was performed from December 1999 through May 2005. Based on the six-year review of the data collected, it was determined by the Partnership that this monitoring would be modified. Since May 2005 EBMUD has collected and analyzed monthly samples of temperature, pH, dissolved oxygen, conductivity and oxidation-reduction potential at CAMC and CAMD.

Goal: Contribute towards the state and federal fishery restoration goals as defined in the California Salmon, Steelhead Trout and Anadromous Fisheries Program Act and the Central Valley Project Improvement Act

Measure	Performance Criterion	Status
Support the assessment of the relative effectiveness of water management modifications, structural modifications, habitat restoration and fish screen installations to meet Anadromous Fisheries Restoration Program targets	Collect monthly water quality samples in the lower Mokelumne River at the Elliott Road Bridge to analyze for VSS, TSS, nutrients (total and dissolved phosphorus and nitrogen), chlorophyll (corrected and uncorrected for phaeopigments), and phytoplankton and zooplankton abundance and taxonomic composition (to genus). In addition, the samples are analyzed for hardness, Al, Cd, Cr, Cu, Fe, Ni, Pb, Zn, Hg, Ti, pH and turbidity	Monitoring of VSS, TSS, nutrients (total and dissolved phosphorus and nitrogen), chlorophyll (corrected and uncorrected for phaeopigments), and phytoplankton and zooplankton abundance and taxonomic composition (to genus), hardness, Al, Cd, Cr, Cu, Fe, Ni, Pb, Zn, Hg, Ti, pH and turbidity at the Elliott Road Bridge was performed from December 1999 through May 2005. Based on the six-year review of the data collected, it was determined by the Partnership that monitoring hardness, Cd, Cu, and Zn at the Elliott Road Bridge would continue and monitoring the other constituents would be discontinued.
	Collect monthly water quality samples at CAMA and PENN20 in Camanche Reservoir to analyze for TSS, hardness, Al, Cd, Cr, Cu, Fe, Ni, Pb, Zn, Hg, Ti, pH, and turbidity	Monitoring of TSS, hardness, Al, Cd, Cr, Cu, Fe, Ni, Pb, Zn, Hg, Ti, pH, and turbidity at CAMA and PENN20 was performed from December 1999 through May 2005. Based on the six-year review of the data collected, it was determined by the Partnership that monitoring hardness, Cd, Cu, and Zn would continue at PENN20 and monitoring the other constituents would be discontinued.
Maintain processes that provide for adequate sediment supply, channel meandering, and other fluvial geomorphologic attributes	When river flows allow it, provide average annual supplementation of approximately 1,200 cubic yards of suitably sized spawning gravel in the active stream channel to maintain and enhance spawning areas and to replace gravel that is transported downstream	Since fall 1998, EBMUD has placed 27,000 yds ³ of spawning gravel in the lower Mokelumne River. In addition, the Partnership restored two side channels to provide rearing habitat for salmonids adjacent to the spawning area below Camanche Dam.

Goal: Contribute towards the state and federal fishery restoration goals as defined in the California Salmon, Steelhead Trout and Anadromous Fisheries Program Act and the Central Valley Project Improvement Act

Measure	Performance Criterion	Status
Maintain processes that provide for adequate sediment supply, channel meandering, and other fluvial geomorphologic attributes	Continue monitoring spawning reach substrate characteristics, including channel configuration and gradient; substrate size; intergravel permeability, dissolved oxygen content, and temperature; and macroinvertebrate community structure (composition and abundance)	The extensive monitoring of salmonid substrate characteristics in the lower Mokelumne River that has been conducted (Merz 2004a, 2004b, Merz and Setka 2004c, Merz et al. 2004, Ochikubo-Chan 2003, Pasternak et al. 2004, Wheaton 2003, and Wheaton et al. 2004a, 2004b) demonstrated the substantial benefits of annual supplementation of spawning gravel in the active stream channel of the lower Mokelumne River.
Reduce entrainment of juvenile fish into water diversions to increase survival and contribute to restoration goals	Work cooperatively with the Woodbridge Irrigation District to install state-of-the-art fish screens and fish bypass system at Woodbridge Dam	EBMUD has worked cooperatively with the Woodbridge Irrigation District (WID) since 1998 to support WID's Lower Mokelumne River Restoration Program to improve fish passage at WID dam while maintaining WID's access to its water rights. In 2004-05, WID constructed a new bypass pipeline to transport fish migrating downstream from the existing fish screen to a location below the dam, and a smolt trap in the bypass pipeline. In addition, a new fish screen at the Woodbridge canal is currently under construction to meet Department of Fish and Game and NOAA Fisheries Service criteria. The new flat-plate "V"-shaped fish screen, head-gate structure, and enlarged bypass system will replace the existing diversion and will be complete in 2008.

Goal: Contribute towards the state and federal fishery restoration goals as defined in the California Salmon, Steelhead Trout and Anadromous Fisheries Program Act and the Central Valley Project Improvement Act

Measure	Performance Criterion	Status
Reduce entrainment of juvenile fish into water diversions to increase survival and contribute to restoration goals	Work cooperatively with riparian diverters to install state-of-the-art fish screens where appropriate in the lower Mokelumne River between Camanche Dam and the San Joaquin River	EBMUD completed a preliminary assessment of riparian diverters that indicates 62 riparian diverters from Camanche Dam downstream to river mile 10. Most of these diversions provide agricultural water diversion during the late spring, summer, and early fall and divert from 0.4 to 10.0 cfs. It is estimated that the intake velocities of these diversions range from 2.5 to 12 ft/sec when operating at full capacity. EBMUD provided a prioritized list of riparian diversions that could be screened to USFWS (AFRP) in 2007.
	Work cooperatively with the North San Joaquin Conservation District to evaluate the installation of permanent fish screens on their diversions	The North San Joaquin Conservation District diversions are currently under review by the State Water Resources Control Board.
Manage flow releases to prevent stranding of juvenile fish and exposure of redds	Except in case of emergencies or when flood control releases are being made, average daily flow releases from Camanche Dam will not decrease by more than 50 cfs per day during the period October 16 through March 31, and by not more than 100 cfs per day at other times of the year	Except in emergencies or when flood control releases were being made, daily flow releases from Camanche Dam have not decreased by more than 50 cfs per day during the period October 16 through March 31, and by not more than 100 cfs per day at other times of the year since 1999.

Goal: Contribute towards the state and federal fishery restoration goals as defined in the California Salmon, Steelhead Trout and Anadromous Fisheries Program Act and the Central Valley Project Improvement Act

Measure	Performance Criterion	Status
Improve anadromous fish passage at dams and diversions below Camanche Dam	Work cooperatively with the Woodbridge Irrigation District to improve fish passage at Woodbridge Dam	EBMUD has worked cooperatively with the Woodbridge Irrigation District (WID) since 1998 to support WID's Lower Mokelumne River Restoration Program to improve fish passage at WID dam while maintaining WID's access to its water rights. In 2004-05, WID replaced the existing Dam with a new adjustable weir dam immediately upstream. The new dam utilizes remotely operable Obermeyer gates, a downstream hydraulic control system to manage tailwater elevations at the entrances to the fish ladders, and a gated low-level outlet system. State-of-the-art fish passage facilities were also constructed at Woodbridge Dam, with improved design to attract fish to the ladder, fish ladders that operate when water levels in the lake are both high and low, and a fish-counting station and viewing area. Improvements to downstream fish-passage facilities included construction of a new bypass pipeline to transport fish migrating downstream from the existing fish screen to a location below the dam, and a smolt trap in the bypass pipeline.
	Work cooperatively with the Woodbridge Irrigation District and the City of Lodi to isolate the City of Lodi's Lake Lodi to improve salmon and steelhead passage and juvenile fish survival.	The predator isolation berm to isolate the City of Lodi's Lake Lodi was removed from the Woodbridge Irrigation District's Lower Mokelumne River Restoration Project due to a lack of data to justify its inclusion.

Goal: Contribute towards the state and federal fishery restoration goals as defined in the California Salmon, Steelhead Trout and Anadromous Fisheries Program Act and the Central Valley Project Improvement Act

Measure	Performance Criterion	Status
Reduce the loss of juvenile anadromous fish caused by hydraulic conditions created by man-made structures within or directly adjacent to the lower Mokelumne River	Modify and improve the fish bypass at the Woodbridge canal	In 2004-05, WID constructed improvements to downstream fish-passage facilities included construction of an 1,800 ft. long, 30-in diameter bypass pipeline to transport fish migrating downstream from the existing fish screen to a location below the dam, and a smolt trap in the bypass pipeline.
	Reduce the impact of predators on juvenile salmonids below Woodbridge Dam by modifying the stream channel below the dam and/or implementing a controlled recreational fishery	Woodbridge Irrigation District implemented predator-control measures below Woodbridge Dam to reduce predation on downstream-migrating smolts by regrading the riverbed below the dam to make the area less hospitable to predators and modifying the tailwater portion of the dam to help reduce the formation of a “hole” in the riverbed that would provide favorable habitat for predators.
	Construct a fish barrier separating recreational Lodi Lake from the river reach seasonally impounded behind Woodbridge Dam	The predator isolation berm to isolate the City of Lodi’s Lake Lodi was removed from the Woodbridge Irrigation District’s Lower Mokelumne River Restoration Project due to a lack of data to justify its inclusion.

Goal: Sustain the long-term viability of the salmon and steelhead fishery while protecting the genetic diversity of naturally producing populations in the lower Mokelumne River

Measure	Performance Criterion	Status
Continue operation of the Mokelumne River Fish Hatchery to meet the mitigation requirements to supplement natural production and sustain a viable commercial and recreational fishery	Reconstruct the hatchery in accordance with the 1996 Hatchery Master Plan and the final design in consultation with CDFG, USFWS and NMFS	The hatchery was reconstructed in accordance with the 1996 Hatchery Master Plan and the final design in consultation with CDFG, USFWS and NMFS. Reconstruction was completed in 2002.
	Operate the hatchery in accord with CDFG Best Management Practices	CDFG and EBMUD completed a new operation and maintenance agreement for the Mokelumne River Fish Hatchery in 2004. The new agreement clarifies and incorporates each party's roles and responsibilities into a single document (replacing several out-dated and obsolete agreements between the District and CDFG) and provides funding for operations and maintenance at the expanded hatchery. It will also ensure that operation of the hatchery meets EBMUD's Mokelumne River fishery mitigation requirements (for the Camanche Project) and provisions of the 1998 Mokelumne River Joint Settlement Agreement (JSA). Key elements of the new operations agreement include producing an annual report summarizing the adult salmon and steelhead returns, number of juvenile fish produced, the incidence of any diseases, water quality data, fish tagging and marking operations, and the number of visitors to the fish hatchery; and, developing an Annual Operations Plan that specifies the number of fish to be spawned, egg take goal, timing and release location of hatchery production, water quality monitoring, and operation of the fish ladder.

Goal: Sustain the long-term viability of the salmon and steelhead fishery while protecting the genetic diversity of naturally producing populations in the lower Mokelumne River

Measure	Performance Criterion	Status
Continue operation of the Mokelumne River Fish Hatchery to meet the mitigation requirements to supplement natural production and sustain a viable commercial and recreational fishery	Implement a protocol that will ensure notification of the parties of any abnormal losses and remedial actions taken	A protocol has been established to ensure notification of the parties of any abnormal losses and remedial actions taken at the Mokelumne River Fish Hatchery
	Monitor temperature, pH, dissolved oxygen, conductivity, oxidation-reduction potential, total and volatile suspended solids, total and dissolved phosphorous and nitrogen, and turbidity of the Mokelumne River Fish Hatchery water supply and effluent	Monitoring of temperature, pH, dissolved oxygen, conductivity, oxidation-reduction potential, total and volatile suspended solids, total and dissolved phosphorous and nitrogen, and turbidity at the Mokelumne River Fish Hatchery water supply and effluent was performed from December 1999 through May 2005. Based on the six-year review of the data collected, it was determined by the Partnership that monitoring temperature, pH, dissolved oxygen, conductivity, and oxidation-reduction potential of the Mokelumne River Fish Hatchery water supply and effluent would continue and monitoring the other constituents would be discontinued
	Operate the hatchery to provide the flexibility necessary to conduct focussed research to better integrate hatchery management practices with natural production	EBMUD has recommended that the Mokelumne River Fish Hatchery manager annually monitor the progress of the egg take and periodically during the run, determine the relationship between the projected egg take number, spawning guidelines established to ensure representation of the entire run, and the Goals and Constraints egg take target. If the projected number exceeds the target, the manager should, in order, (1) close the ladder on an interim basis, (2) return green fish to the river, or (3) truncate each egg lot by the percent exceeded

Goal: Sustain the long-term viability of the salmon and steelhead fishery while protecting the genetic diversity of naturally producing populations in the lower Mokelumne River

Measure	Performance Criterion	Status
Employ methods to limit straying of hatchery-produced fish and the possible reduction of the genetic integrity of naturally produced fish	Develop a cooperative program to evaluate the benefits of changing release locations in the Mokelumne River of salmon and steelhead produced at the Mokelumne River Fish Hatchery	EBMUD analyzed the efficacy of using coded-wire tags to evaluate various fall-run Chinook salmon hatchery release strategies such as changing release locations. Replicate groups of coded wire tagged (CWT) hatchery produced juvenile fall-run Chinook salmon were released in the lower Mokelumne River for nine years to evaluate relative survival and contribution to the ocean fishery from various release strategies. CWT recoveries for inland locations are incomplete to date. However, the recovery data associated with replicate experimental group recoveries in the ocean harvest suggests that CWT experiments lack the precision necessary to perform two-sample proportion comparison tests that would support hatchery management decisions such as changing release locations (Workman et al, 2005).
	Develop a plan to reduce the importation of eggs and fry from other hatcheries	The California Department of Fish and Game is working with NOAA Fisheries to develop a protocol for importation of eggs and fry from other hatcheries.

Goal: Sustain the long-term viability of the salmon and steelhead fishery while protecting the genetic diversity of naturally producing populations in the lower Mokelumne River

Measure	Performance Criterion	Status
Employ methods to limit straying of hatchery-produced fish and the possible reduction of the genetic integrity of naturally produced fish	Continue coded-wire tagging representative lots of chinook salmon released from the Mokelumne River Fish Hatchery and expand or modify the program if a statewide strategy is developed to constant fractional mark or coded-wire tag all salmon released from California fish hatcheries in cooperation with commercial salmon trawlers, the Resource Agencies and the California Fish and Game Commission	Over 5 million hatchery-produced fall-run Chinook salmon have been coded-wire tagged by EBMUD and released from the Mokelumne River Fish Hatchery since brood year 1992. In 2006, CALFED funded implementation of the Central Valley Constant Fractional Marking (CFM) program for marking/tagging production releases of fall-run Chinook salmon. The program is a cooperative effort of the California Department of Fish and Game, California Department of Water Resources, U.S. Fish and Wildlife Service, Pacific States Marine Fisheries Commission, U.S. Bureau of Reclamation and EBMUD. In spring 2007, 1,547,575 (24.98% of total production) fall-run Chinook salmon produced at the Mokelumne River Fish Hatchery were tagged and released.
	Develop a cooperative plan to reduce impacts of imported fish released in Camanche and Pardee reservoirs	Since 2005 EBMUD requires planting non-viable rainbow trout in Camanche Reservoir. CDFG continues to plant viable rainbow trout in Camanche Reservoir.
Develop harvest management strategies that allow naturally produced fish to increase their reproductive potential	Implement enforcement efforts to reduce or eliminate illegal salmon and steelhead harvest in the lower Mokelumne River	The Partnership funded \$15,000 in FY01, \$15,000 in FY03 and \$10,933 in FY04 for increased CDFG enforcement patrols in the lower Mokelumne River. CDFG policy precluded expenditures of overtime enforcement in FY05. EBMUD also funds (\$45K annually) enforcement efforts for watershed rules/regulations at the Mokelumne River Day Use Area

Goal: Sustain the long-term viability of the salmon and steelhead fishery while protecting the genetic diversity of naturally producing populations in the lower Mokelumne River

Measure	Performance Criterion	Status
Develop harvest management strategies that allow naturally produced fish to increase their reproductive potential	Mark and tag all hatchery-produced steelhead and establish a selective fishery in the lower Mokelumne River	Since 1998 CDFG is required to and does mark (adipose fin clip) all hatchery-produced steelhead.

3.0 RECOMMENDATIONS

Based on the review of the JSA flow and non-flow measures implemented since 1998 as described in the Water Quality and Resource Management Program (WQRMP), the Partnership Steering committee recommends implementing the following strategies and measures, designed to make significant progress towards meeting the JSA goals and measuring progress:

Strategy 1.0

Operate Camanche and Pardee reservoirs to maintain best available water temperatures in the lower Mokelumne River for salmonid spawning, incubation, rearing and over-summering based on temperature model simulations and water availability.

Measures

- 1.1 Develop an integrated reservoir/stream network temperature simulation model for the Mokelumne River to predict temporal water temperatures in the lower Mokelumne River.
- 1.2 Operate Camanche and Pardee reservoirs to maintain the best available water temperatures for all salmonid life stages in the lower Mokelumne River based on temperature model simulations and water availability.

Strategy 2.0

Provide flows in the lower Mokelumne River to enhance natural production of Chinook salmon and steelhead based on life history stage needs and water availability

Measures

- 2.1 Operate the Lower Mokelumne River Project in accordance with the flow requirements specified in Attachment 1 of the JSA.
- 2.2 Increase instream flows beyond the flows specified in Attachment 1 of the JSA by an amount equal to 20% of the actual yield (up to 20,000 acre-feet) of additional water supplies developed by EBMUD from new facilities. Said gainsharing water shall be available in accord with Section F.2 of the JSA.

Strategy 3.0

Replenish gravel suitable for salmonid spawning habitat.

Measure

- 3.1 Provide annual spawning gravel supplementation using the Spawning Habitat Integrated Rehabilitation Approach (SHIRA) developed by the University of California, Davis and EBMUD.

Strategy 4.0

Enhance and maintain the riparian corridor to improve streambank and channel rearing habitat for juvenile salmonids.

Measures

- 4.1 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.
- 4.2 Implement the Mokelumne River Day Use Area Recreation and Resource Management Plan as funding becomes available.

Strategy 5.0

Operate the Mokelumne River Fish Hatchery to maintain the genetic characteristics of the local, natural populations of fall-run Chinook salmon and California Central Valley steelhead and reduce the genetic risks that hatchery-origin fish may pose to naturally spawning populations.

Measures

- 5.1 Develop and implement a Hatchery and Genetics Management Plan for California Central Valley Steelhead and Fall-run Chinook salmon in cooperation with NOAA Fisheries.
- 5.2 Continue the Central Valley Constant Fractional Marking (CFM) program at the Mokelumne River Fish Hatchery.

Strategy 6.0

Evaluate the effects of the measures on Chinook salmon and steelhead in the lower Mokelumne River.

Measures

- 6.1 Continue the annual estimate of Chinook salmon and steelhead escapement by video monitoring at Woodbridge Dam, carcass surveys, or other appropriate methods.
- 6.2 Continue annual Chinook salmon and steelhead redd surveys in the lower Mokelumne River between Camanche Dam and the Elliott Road bridge.
- 6.3 Continue the annual estimate of juvenile Chinook salmon and steelhead outmigration by operation of the rotary screw traps or other appropriate methods.

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APPENDIX A

CHINOOK SALMON TRAP AND TRUCK PROGRAM: 1998-2007

Introduction

The Lower Mokelumne River Joint Settlement Agreement (JSA) parties agree that a trap and truck program could have some benefit to the fishery resource and recommends that trapping and trucking of anadromous salmonids take place during critical years upon approval of the Partnership Steering Committee. Outmigrating salmon smolts captured at the Woodbridge Irrigation District Dam were trapped and trucked in 2001, 2002 and 2007. Although 2003 was a dry water year type, instream temperatures did not warrant initiation of a trapping and trucking program.

2001 Operations

East Bay Municipal Utility District (EBMUD) operated under a dry water year type for the period of April through September of 2001. The JSA Partnership Coordinating Committee (PCC) developed operational criteria for the trap and truck program at its April, 2001 meeting (the first dry water year type since JSA implementation). A temperature trigger of $>18^{\circ}\text{C}$ daily mean water temperature at the Frandy gauging station (RKM 46) was agreed upon to initiate trapping and trucking. The temperature trigger of $>18^{\circ}\text{C}$ was met on April 24, 2001. Trapping and trucking of juvenile fall-run Chinook salmon began on April 26, 2001. A transport tank with two 75-gallon compartments equipped with mechanical aerators was used to haul fish. Tanks were filled from the high stage fish ladder at Woodbridge Irrigation District Dam using a submersible pump. Water was treated with Novaqua®, ice made from Mokelumne River water, supplemental O_2 , and salt to minimize stress to fish. A recommended concentration of salt for fish transport of a 0.1 to 0.3% salt solution was used in transport (Piper et al 1992). Oxygen levels in transport tanks were initially set at 9.00 ppm to accommodate high oxygen consumption associated with stress. Transport levels were kept at > 7.00 ppm. Each tank was supplied with a 1-gallon container of frozen Mokelumne River water to maintain constant temperatures during transport (Workman 2002a).

Fish were released at Wimpy's Marina, Lighthouse Marina, B&W Resort and Korth's Pirate's Lair. Release site determination was based on appropriate water temperatures, tides, predation activity and human activity at the site. All fish were acclimated to within 1.0°C of release water in the transport tanks by introducing release water into the tanks before release.

Trapping and trucking occurred from April 26, 2001 through July 24, 2001. During this period 56,229 fish were transported and released alive. A 1.2% mortality rate was attributed to handling and transport stress. Release location temperatures varied from within 0.1°C of trapping location to a high of 5.3°C . Average difference between release and trap temperatures was 3.0°C .

The average daily water temperatures at Frandy varied from 17.8 ° C (May 2nd) to 30.9 ° C (July 3rd). Water temperatures at capture (Woodbridge Irrigation District Dam) varied from 16.5 ° C (May 15th, 29th) to 22.8 ° C (July 3rd) and at the release sites from 17.7 ° C (May 3rd) to 25.7 ° C (June 21st). There was no correlation between ΔT (° C), release temperatures, capture temperatures, or number of captures and mortalities.

2002 Operations

Although the April through September time period was not designated as a dry water year type, the temperature criteria developed by the PCC was reached in June and trapping and trucking was conducted from July 1st through July 14th. The same transport protocols listed above for 2001 operations were again employed. Fish were released at Brannan Island State Park. Release site determination was based on appropriate water temperatures.

During the 2002 trap and truck operation, 577 smolt-sized fall-run Chinook salmon were trapped, and transported, with 575 released alive. The two mortalities were due to handling and transport stress. Release location temperatures were higher than trapping location temperatures by a range of 1.2° C - 3.3° C. Average difference in release and trap temperatures was 2.4° C. All fish were acclimated to within 1.0° C of release site water temperature in the transport tanks by introducing river water into the tanks.

2007 Operations

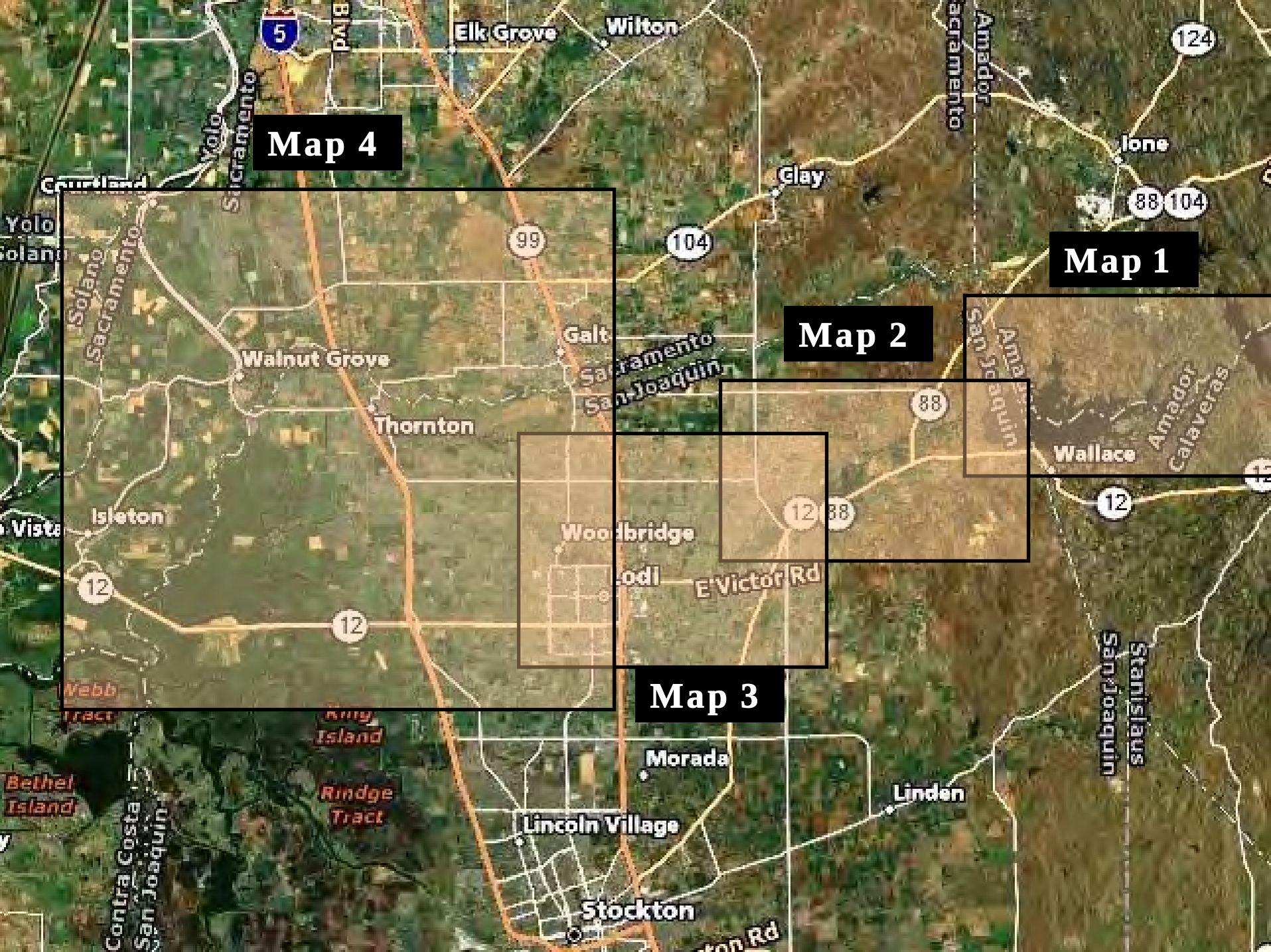
On April 6, 2007, the PCC agreed to the following revised criterion for trap and truck activities (mean average daily water temperature at Frandy gauge exceeds 24° C during April, May and June). The criterion change was based on recent published literature which indicates salmon growth and survival still occurs at 24° C (Marine and Cech 2004).

The trigger temperature of 24°C at Frandy was reached on June 4, 2007. Trap and truck operations were implemented on July 6, 2007 after approval from the Partnership Steering Committee, and amendment to scientific collector's permits were received on July 5, 2007. Trap and truck operations continued through July 11th at which time the agreed upon trigger to end the effort, < 50 fish per day for a 5 day period, was reached (Workman et al 2008).

During the 2007 operations, 295 fish were transported with 2 mortalities during transport (0.01% mortality rate). The two release locations were Lighthouse Marina and Korth's Pirate's Lair Marina on the Mokelumne River.

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Map 4

Map 1

Map 2

Map 3

Map 1



CAMC

HOS
System

CAMA

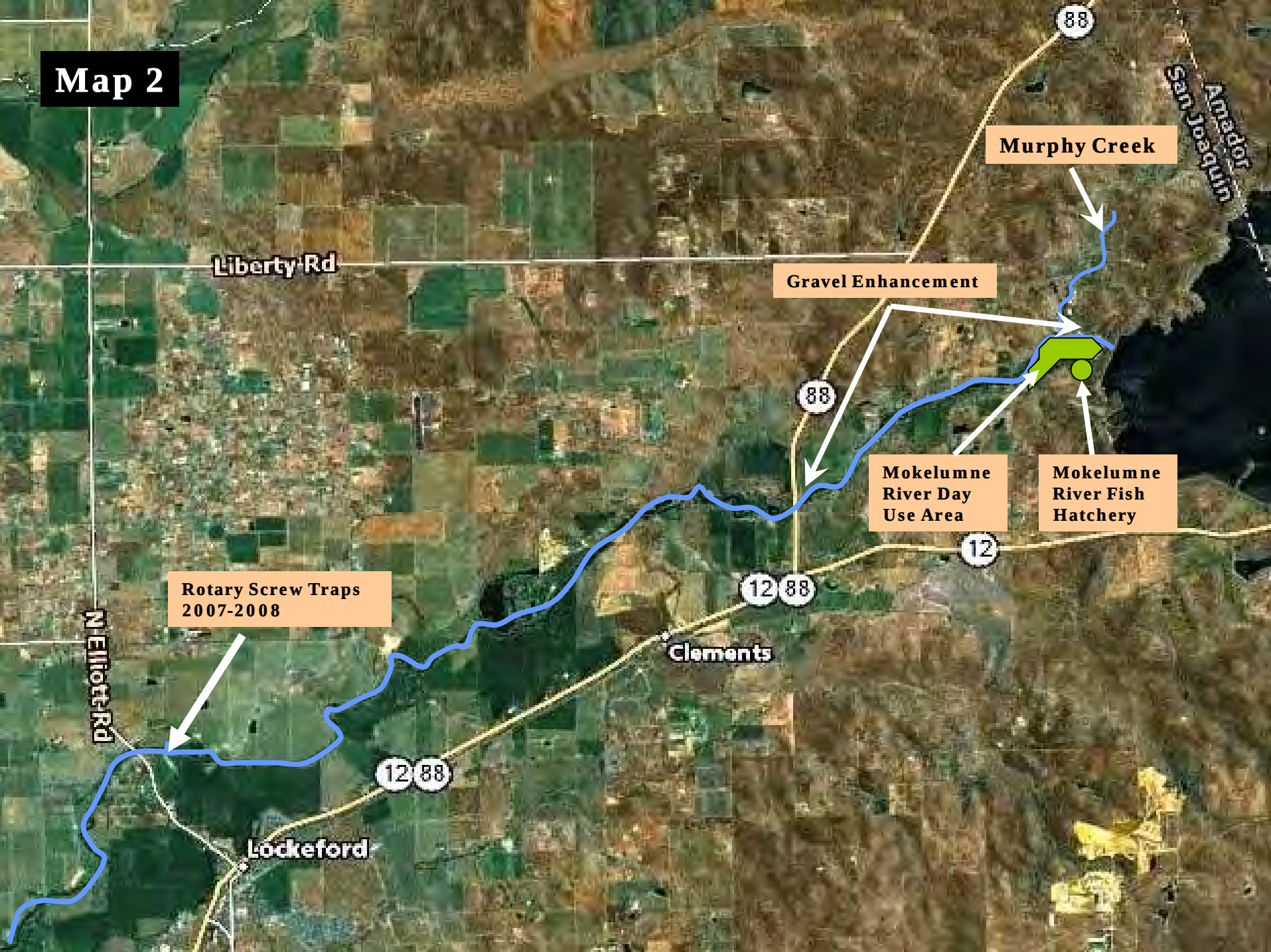
PENN20

Camanche Reservoir

CAMD

Pardee Reservoir

Map 2



Map 3



Map 4



Modeling Technical Appendix

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List of Abbreviations

Abbreviation	Definition
°C	degrees Celsius
°F	degrees Fahrenheit
AF	acre-feet
AN/N	Above Normal / Normal
Apr	April
ASR	Aquifer storage and Recovery
Aug	August
Ave	Average
AWA	Amador Water Agency via Amador canal diversion
BN	Below Normal
CAWP	Central Amador Water Project
CCWD	Contra Costa Water District
CD	Critically Dry
CDFG	California Department of Fish and Game
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CPUD	Calaveras Public Utility District
CY	calendar year
D	Dry
Dec	December
DPS	Drought Planning Sequence
DWR	Department of Water Resources
EBMUD	East Bay Municipal Utility District
<i>e.g.</i>	<i>exempli gratia</i> (Latin)
EIR	Environmental Impact Report
EOM	End-of-month
Feb	February
FERC	Federal Energy Regulatory Commission
FRWP	Freeport Regional Water Project
ft	feet

Abbreviation	Definition
FY	fiscal year
GUI	graphical user interface
hr	hour(s)
<i>i.e.</i>	<i>id est</i> (Latin)
I-O	input – output
Jan	January
JSA	Joint Settlement Agreement
Jul	July
Jun	June
JVID	Jackson Valley Irrigation District
LOD	level-of-development
M&I	municipal and industrial
Mar	March
MGD	million gallons per day
Mi	mile(s)
MM7DADM	monthly maximum of 7-day (moving) average of daily maximum
MRFH	Mokelumne River Fish Hatchery
msl	mean sea level
NSJWCD	North San Joaquin Water Conservation District
Nov	November
Oct	October
PG&E	Pacific Gas and Electric
POR	period-of-record
RMSE	root mean square error
RRG	rationing reduction goal
RUF	regulated undiminished flow
SCVWD	Santa Clara Valley Water District
Sep	September
SNTEMP	stream network temperature model
SSTEMP	stream segment temperature model
TAF	thousand acre-feet
TSS	total system storage

Abbreviation	Definition
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WID	Woodbridge Irrigation District
WSE	water surface elevation
WSMP	Water Supply Management Program
WY	water year

List of Symbols

Symbol	Description	Units
%	Percentage	[-]
$\beta_{0,m}$	Regression coefficient representing model intercept	<i>Varies</i>
$\beta_{1,m}$	Regression coefficient representing model slope	<i>Varies</i>
Γ_m	The index set of Julian days for m^{th} month	[-]
μ_m	Monthly average water temperature for m^{th} month	[°C]
ψ_m	Monthly maximum of 7-day average of daily maximum water temperature	[°C]
m	Month index	[-]
n_m	Number of days in m^{th} month	[-]
T_i	Monthly average release temperature from Camanche Dam	[°C]
T_m^*	Adjusted monthly average release temperature from Camanche Dam	[°C]
$T_j^{\max}$	Maximum daily temperature for j^{th} Julian day	[°C]
T_j^{mean}	Daily average temperature for j^{th} Julian day	[°C]
Q_m^{Elliott}	Monthly average discharge at station Elliott	[cfs]
Q_m^{Frandy}	Monthly average discharge at station Golf	[cfs]
Q_m^{Golf}	Monthly average discharge at station Frandy	[cfs]
Q_m^{McIntire}	Monthly average discharge at station Elliott	[cfs]
W_m	Monthly average temperature	[°C]
WSE_m	Simulated EOM Camanche water surface elevation	[ft msl]
X_m	Monthly maximum temperature	[°C]

Chapter 1

Introduction

This appendix documents the modeling methodology, computer modeling tools and computer simulations performed for the Permit 10478 Time Extension Project (Project) Environmental Impact Report (EIR). The modeling methodology employed and documented in this appendix was used to assess potential effects of the Project on key environmental parameters such as Mokelumne River flow and water quality. Specific details concerning the modeling methodology including modeling assumptions and model simulation results supporting the impact assessment in the body of the EIR are also included in this appendix.

The modeling tools employed in the assessment of impacts are representative of the most appropriate tools available at the time this work was performed. The models used for this CEQA analysis are planning models that provide generalized insight on project and environmental effects as compared to the baseline. Through providing quantitative insights, planning models differ from actual project operations in several ways. Due to the difficulty of incorporating complex operating criteria into long-term planning studies, planning models typically use monthly time steps, simplified system representations, and generalized monthly operational rules. As such, water balance and energy balance models in a planning context are not designed to predict system river, reservoir, or water quality conditions based on simulated operational decisions, but instead provide relative magnitudes and timing of project effects compared to baseline conditions. Unlike operations models, which would be infeasible to simulate long-term periods necessary for planning studies, planning models do not describe operations in absolute terms. Results from a single study, therefore, should not be presented as “stand alone” output; *i.e.* model output should always be presented in comparison with output from other modeling studies.

The planning models used in this analysis - EBMUDSIM and SSTEMP - use a monthly time step; whereas actual operational decisions may be formulated on weekly, daily, or hourly time scales. Inputs and results, therefore, represent monthly averages or end-of-month values. Interpretation of results from planning models must therefore consider this lower “resolution” and conclusions must remain generalized in nature. Proper interpretation of planning model results presented in this appendix therefore requires exercise of professional experience and judgment.

1.1 Appendix Organization

Chapter 1 of this appendix provides an overview of the modeling methodology used for the assessment of potential impacts. The modeling tools employed for the assessment of potential impacts are introduced in Chapter 1. General model descriptions, as well as a summary of model application, verification, and calibration to the Mokelumne system are provided as appropriate for each computer model utilized including various monitoring data sources relied upon for development, calibration, and verification.

Simulation results from the water-balance model EBMUDSIM are presented in Chapter 4 for the model cases described in Chapter 1. The results presented in Chapter 4 include water-balance variables such as reservoir storage, reservoir releases, and estimated flow at various monitoring

locations on the lower Mokelumne River and also regulated diversions from the Mokelumne by East Bay Municipal Utility District (EBMUD) and other Water Rights holders on the Mokelumne River.

Water quality modeling results, which focus on water temperatures, are presented in Chapter 5 for each modeling case documented in Chapter 1. Chapter 6 of this appendix provides a list of references.

Chapter 2

Modeling Methodology Overview

This chapter provides an overview of the modeling methodology employed for the environmental impact assessment for the Project. The modeling framework is presented as a set of modeling components, which form the quantitative basis for the impacts assessment. A listing of modeling tools employed for each modeling component is provided with a brief discussion of these tools and their interactions.

2.1 Approach to Applying Computer Simulation Models to Potential Impact Assessment

Computer modeling tools provide the means for a comparative quantitative assessment of potential environmental impacts associated with a given project. The basic modeling framework is presented before the modeling cases are presented and described.

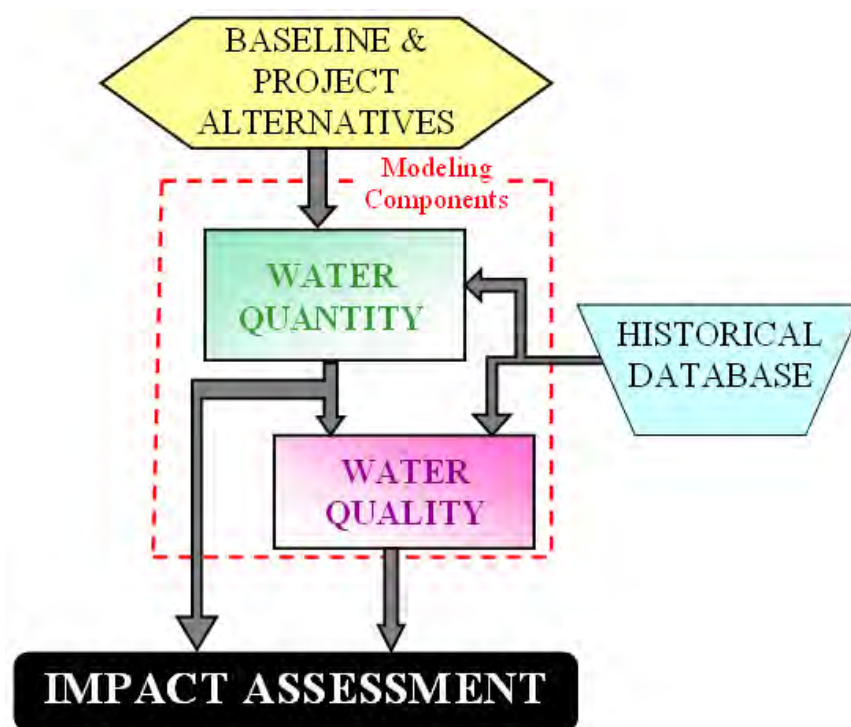


Figure 2.1-1. Modeling Components Schematic for Permit 10478 Time Extension Project EIR

The modeling for the Project EIR is broken up into a set of components shown in Figure 2.1-1. The two basic components are the water *quantity* and water *quality* components. The water quantity component consists of water mass-balance modeling of reservoir inflows, storage, and releases to the lower Mokelumne River. The water quality component of the modeling for the Project EIR is focused on modeling water temperatures for the lower Mokelumne River. EBMUD's database of

historical records are relied upon to calibrate statistical models used in these two modeling components in addition to providing the necessary inputs to the models used for this project.

The water quantity modeling output provides much of the information necessary to perform the impacts assessment. Comparative studies of modeling results facilitate the analysis of changes in reservoir levels and reservoir releases associated with each alternative.

However, water quantity modeling output alone is inadequate to perform a detailed impacts assessment of anadromous fisheries populations; hence the need for the water quality modeling component. As noted above, the water quality modeling for the Project Impact Assessment is focused on water temperatures. For the lower Mokelumne River, water temperature is considered to be the primary water quality indicator of resident fishery health as other water quality variables monitored (*e.g.* dissolved oxygen, pH, and turbidity) are generally within tolerable limits of target species as described in Section 3.2, Fish Resources, of the EIR.

2.2 Model Study Case Descriptions and Assumptions

Five different cases are modeled; (1) the baseline or base case, (2) the Project case, (3) the Project case without an aqueduct outage scenario included, (4) the programmatic use beyond year 2040 case, and (5) the cumulative effects case. A list of assumptions common to all of the model cases is presented below; the common assumptions are described in greater detail in Section 3.1.1. Each modeling case is then listed with a brief description and list of assumptions.

Common Assumptions

The following set of assumptions applies to all of the modeling cases presented.

- Hydrologic Period-of-Record (POR) 1921-2009
- Joint Settlement Agreement (JSA) Regulatory Requirements ACTIVE
- Drought Planning Sequence ACTIVE¹
- Maximum Customer Rationing 15%
- Freeport Regional Water Project (FRWP) CVP supplemental supply ACTIVE²
- Army Corps of Engineers Flood Control Regulatory Requirements ACTIVE

¹ In each simulation, historical inflow to Pardee for water year 1978 has been altered to simulate a 3 year drought planning sequence (DPS) beginning in 1976. Historically, the critically dry year of 1977 was followed by a very wet year (1978) that allowed the system to recover rapidly. The DPS is used to assess the District's water supply reliability if the dry conditions had continued for a third year. To simulate the DPS, the Pardee inflow for 1978 is not based on historical runoff; instead the 1978 monthly inflow to Pardee Reservoir is set equal to the average of the values for 1976 and 1977. For more information on the District's drought planning sequence, the reader is referred to §3.1.1.2.

² The delivery schedule for the FRWP supplemental supply is based on the methodology employed for the WSMP 2040 environmental analysis, which is the same methodology used in the 2003 Freeport EIR/EIS but updated to account for settlement agreements with Contra Costa Water District (CCWD) and Santa Clara Valley Water District (SCVWD). FRWP supply is not activated in drought recovery years 1925, 1935, 1962, 1979, 1993, and 2009.

Case 1: Baseline**Case Narrative:**

For Baseline, an average annual demand of 214 MGD³ is assumed with episodic diversions up to 325 MGD.

Case Assumptions:

- Annual EBMUD demand 214 MGD
- Upstream Senior Water Rights Level-of-Development (LOD) 2005 (24 MGD)
- Aqueduct outage scenario ACTIVE
- Bayside Phase I.....ACTIVE

Case 2: Project**Case Narrative:**

Extension of Permit 10478 is granted through year 2040. An average annual 2040 demand of 230 MGD is assumed with episodic diversions up to 325 MGD.

Case Assumptions:

- Annual EBMUD demand 230 MGD
- Upstream Senior Water Rights LOD 2005 (24 MGD)⁴
- Aqueduct outage scenario ACTIVE
- Bayside Phase I.....ACTIVE

Case 3: Project without Aqueduct Outage**Case Narrative:**

An average annual 2040 demand of 230 MGD is assumed with episodic diversions up to 325 MGD. This case is identical to Case 2 above with one exception; the aqueduct outage scenario is not simulated. The purpose of this case is simply to demonstrate the system effects without the aqueduct outage scenario included in the Project case.

Case Assumptions:

- Annual EBMUD demand 230 MGD
- Senior Water Rights LOD 2005 (24 MGD)
- Aqueduct outage scenario INACTIVE
- Bayside Phase I ACTIVE

³ The Baseline demand of 214 MGD is derived from the WSMP 2040 Demand Study where the actual fiscal year (FY) 2005 consumptive demand is normalized requiring an adjustment for various factors. For more information see Appendix B of the Water Supply Management Program WSMP 2040 (EBMUD, 2012).

⁴ Upstream senior water rights are held at the 2005 level of development to assess impacts of the project. The level of development under the cumulative analysis includes the full use of the upstream senior water rights

Case 4: Programmatic Evaluation of Use Beyond Year 2040

Case Narrative:

The average annual customer demand in EBMUD service area is increased to 275 MGD representing a condition beyond 2040. Rough estimates indicate that EBMUD demand would be expected to reach this level by the latter half of this century. The annual demand of 275 MGD would be met through a combination of surface supplies from the Mokelumne River, when available, and supplemental supply projects when the diversions from the Mokelumne River alone are insufficient. Supplemental supply projects include existing supplemental supplies (*e.g.* FRWP and Bayside Phase I), water transfers (via existing FRWP facilities), and groundwater from potential future conjunctive use projects.

Case Assumptions:

- Annual EBMUD demand 275 MGD
- Upstream Senior Water Rights LOD 2005 (24 MGD)
- Water Transfers ACTIVE (up to 50 MGD)
- Conjunctive-Use Project ACTIVE (up to 22 MGD)
 - Maximum Monthly Injection and/or Recharge Rate 122 cfs
 - Maximum Monthly Extraction Rate 70 cfs
 - Put:Take 2:1
 - Groundwater Basin Capacity..... UNCONSTRAINED
- Aqueduct outage scenario INACTIVE⁵
- Bayside Phase I..... INACTIVE⁶

Case 5: Cumulative

Case Narrative:

An average annual demand of 230 MGD is assumed and upstream senior water rights usage is set to 2040 LOD. By year 2040, some of the additional dry-year water supplies identified in EBMUD's 2040 Water Supply Management Plan (WSMP 2040) are expected to be in place to help reduce rationing to 15%.

Case Assumptions:

- Annual EBMUD demand 230 MGD
- Upstream Senior Water Rights LOD 2040 (42 MGD)
- WSMP 2040 Supplemental Water Supplies (up to 115TAF over 3 years) ACTIVE⁷

⁵ In this scenario the aqueduct outage is not active as the aqueducts are assumed to be less vulnerable to failure through infrastructure improvements.

⁶ Bayside Phase I is not explicitly modeled in the programmatic case, rather, Bayside Phase I project is assumed to be part or component of the larger conceptual conjunctive use project.

⁷ For modeling purposes, the supplemental supply is assumed to be a water transfer that is delivered via the FRWP facilities. This supplemental supply water is considered as lower or secondary priority to the CVP contract supply and is only triggered when end-of-September total system storage is projected to be below 500 TAF after CVP and Bayside Phase I water is activated. The quantity of the assumed water transfer is as follows, the minimum of 38.3

- Aqueduct outage scenario ACTIVE
- Bayside Phase I.....ACTIVE

TAF per year or the deficit in carryover storage needed to reach the total system storage trigger. Water transfers are assumed to be deactivated any month in which there is concurrent flood control releases. Deliveries of the supplemental supply over a calendar year may begin as early as January occurring in any month where there is available capacity through the FRWP facilities which is equal to 100 MGD in any given month.

Chapter 3

Surface Water and Reservoir Modeling

3.1 Modeling Methodology

Chapter 3 begins with an overview of the general model assumptions that apply to the modeling cases considered. The remainder of this chapter is comprised of introductions to each of the modeling tools used. Each introduction generally includes a description of the model, an overview of the model application to the Mokelumne system, and a review of the calibration and/or verification modeling studies as appropriate.

The Project CEQA analysis is comprised of two general components illustrated above in Figure 2.1-1: *water quantity* and *water quality*. The water quantity component consists of modeling changes in storage, diversions, and reservoir releases to the lower Mokelumne River for the modeling assumptions outlined in Section 2.2 above. The water quantity modeling component is exclusively addressed using the District's reservoir operations planning model EBMUDSIM.

Water quality modeling is dependent on the water quantity modeling with EBMUDSIM. The water quality modeling is focused on assessment of water temperatures associated with water released from Camanche Dam to the lower Mokelumne River and quantitatively propagating the release temperature downstream. The water temperature modeling involves a combination of deterministic and statistical models. The deterministic model is SSTEMP which is used to estimate mean monthly temperatures at three downstream locations on the lower Mokelumne River. The statistical model, a regression model, is used to adjust reservoir release temperatures when storage levels become critical in Camanche Reservoir. These two water quality models are introduced in Sections 3.3 and 3.4. Each model relies heavily on historical monitoring data for both model input formulation in addition to model calibration and verification. Both water quantity and water quality components are preconditioned on the general assumptions that establish the modeling setting. The general model assumptions are described in the next subsection below.

3.1.1 General Modeling Assumptions

Assumptions that are common among the model cases are described in this section. General assumptions include the minimum release requirements established by the Joint Settlement Agreement, the drought planning sequence, the District's Drought Management Program, and flood control requirements. One additional subsection is devoted to describing the aqueduct outage scenario used in three of five modeling cases presented in Section 2.2. Each of these general assumptions is described below. A concluding subsection is provided that describes input and output linkages among the various modeling tools employed.

3.1.1.1 Joint Settlement Agreement Minimum Release Requirements

Beginning in the 1990's, EBMUD, the U.S. Fish and Wildlife Service (USFWS), California Department of Fish and Game (CDFG)⁸ engaged in extensive, lengthy discussions in an effort to address issues

⁸ As of January 1, 2013 California's Department of Fish and Game is now called the Department of Fish and Wildlife.

raised during a Federal Energy Regulatory Commission (FERC) proceeding for the Lower Mokelumne River Project⁹. In February 1996, EBMUD, USFWS, and CDFG reached consensus on Principles of Agreement concerning the flow and non-flow measures appropriate to the lower Mokelumne River. The Principles of Agreement were the foundation for the 1998 Joint Settlement Agreement (JSA) that resolved outstanding issues between the parties. In November 1998 FERC issued an order amending EBMUD's License to include the flows specified in the JSA for EBMUD's Mokelumne River Project.

The JSA established a set of minimum flow criteria defined at two monitoring locations, "Agreed Release from Camanche Dam," and, "Expected Flow Below Woodbridge Dam." The water year type classifications that trigger the minimum flow requirements are broken up into two periods: the April through September period, and the October through March period. The April through September period is governed by the unimpaired runoff estimate for the Mokelumne Watershed. An exception to this trigger is allowed only when Pardee and Camanche combined storage is projected to be 200 thousand acre-feet (TAF) or less on November 5th thereby prescribing assignment of the critically dry year schedule for April through September. The October through March period is governed by the combined storage of Pardee and Camanche Reservoirs on November 5th.

Table 3.1-1 presents the year type trigger thresholds in both periods and Table 3.1-2 presents the minimum flow criteria for each year type at both monitoring locations. Note that release requirements in Above Normal/Normal (AN/N) and Below Normal (BN) year types in the months of April, May, and June, may be increased by up to 200 cfs depending on combined Pardee and Camanche storage levels relative to the maximum allowable under flood control requirements for the end of the prior month. Additional details are provided in the JSA documentation (see Appendix B.1).

Table 3.1-1. JSA Year Type Classification Triggers*

Year Type:	Normal/Above (AN/N)	Below Normal (BN)	Dry (D)	Critically Dry (CD)
October – March ⁽¹⁾ (Pardee + Camanche Storage)	AN/N ≥ Maximum Allowable ⁽²⁾	Maximum Allowable > BN ≥ 400	399 ≥ D ≥ 270	269 ≥ CD
April – September ⁽³⁾ (Unimpaired Runoff)	AN/N ≥ 890	889 ≥ BN ≥ 500	499 ≥ D ≥ 300	299 ≥ CD ⁽⁴⁾

* Note all numerical values reported are in units of TAF.

(1) October through March minimum flows are determined by total Pardee and Camanche storage on November 5th. Year type storage limits are based on the capacities of Pardee and Camanche Reservoirs in 1995.

(2) Maximum allowable storage on November 5th, shall be determined in accordance with the Army Corps of Engineer's Water Control Manual for Camanche Dam and Reservoir dated September, 1981.

(3) April through September minimum flows are determined by the water year unimpaired runoff into Pardee Reservoir as forecasted by the Department of Water Resources (DWR) in the April 1st Bulletin 120 Report except when combined Pardee/Camanche Nov. 5 storage is projected to be less than 200 TAF.

(4) April through September minimum flows shall be critically dry whenever Nov. 5 combined Pardee/Camanche storage is projected to be 200 TAF or less based on the runoff forecast in DWR Bulletin 120, beginning April 1st.

⁹ FERC Project No. 2916-004

Table 3.1-2. JSA Minimum Flow Requirements by Year Type and Compliance Point*

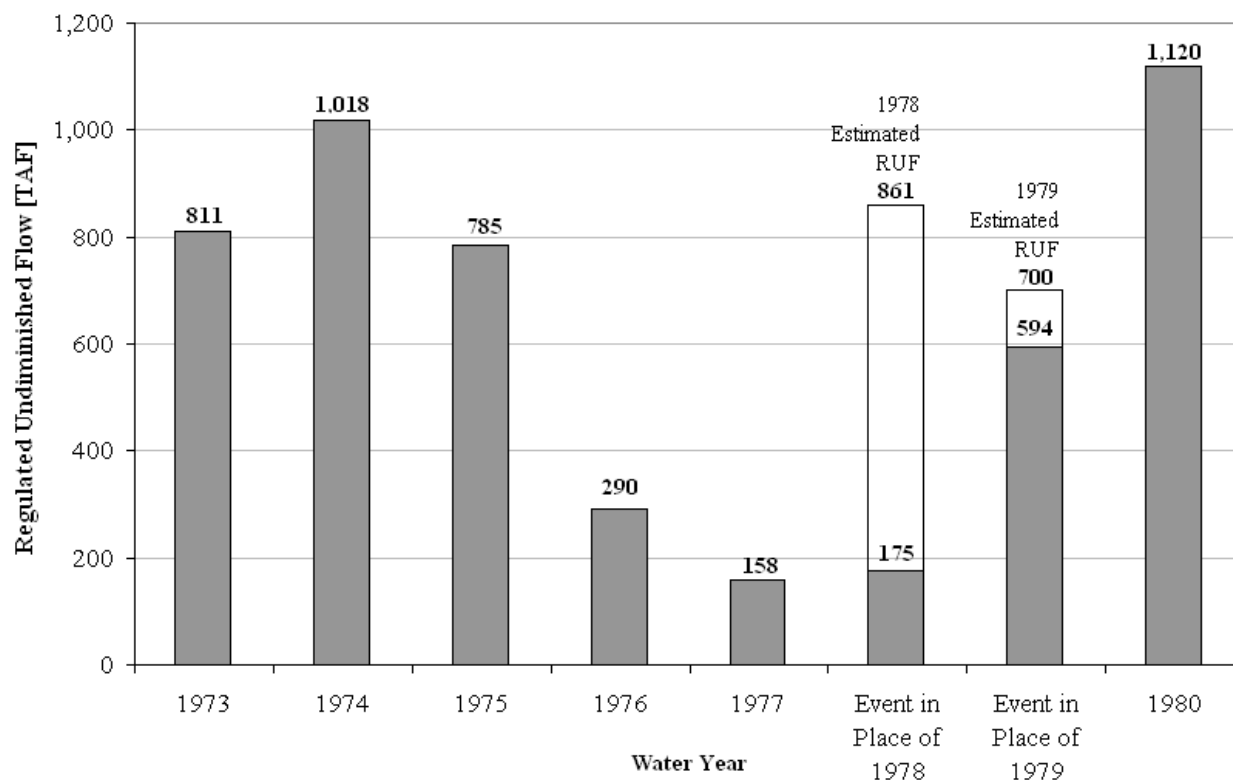
Year Type Class		Agreed Release from Camanche Dam [cfs]				Expected Flow Below Woodbridge [cfs]			
Period	Days	AN/N	BN	D	CD	AN/N	BN	D	CD
Oct. 1-15	15	325	250	220	100	100	100	80	15
Oct. 16-31	16	325	250	220	130	100	100	80	75
Nov. 1-30	30	325	250	220	130	100	100	80	75
Dec. 1-31	31	325	250	220	130	100	100	80	75
Jan. 1-31	31	325	250	220	130	100	100	80	75
Feb. 1-28	28	325	250	220	130	100	100	80	75
Mar. 1-31	31	325	250	220	130	100	100	80	75
Apr. 1-30	30	325	250	220	130	150	150	150	75
May 1-31	31	325	250	220	100	300	200	150	15
Jun. 1-30	30	325	250	100	100	300	200	20	15
Jul. 1-31	31	100	100	100	100	25	20	20	15
Aug. 1-31	31	100	100	100	100	25	20	20	15
Sep. 1-31	30	100	100	100	100	25	20	20	15

* Release requirement in Above Normal/Normal and Below Normal year types may be greater than that shown depending on combined Pardee and Camanche Storage and flood control reservation requirement. For specific details about the JSA see Appendix D of this EIR.

Under the gainsharing provision of the JSA, EBMUD committed to increasing in-stream flows beyond the flows established in the agreement by up to 20% of the yield of additional water supplies developed by EBMUD from new facilities or projects up to a maximum limit of 20 TAF during any continuous drought period. Water from conservation programs, recycled water projects, or the Amador Canal pipeline project are not subject to gainsharing.

3.1.1.2 Drought Planning Sequence

The District's drought planning sequence (DPS) is a key planning assumption applied to assess long-term water supply reliability. Under the drought planning sequence assumption, historical hydrology in 1978, a wet year, is replaced with a critically dry year. The effect is ultimately an extension of the severe 1976-1977 drought by one year. Hydrologic variables in 1978 (*e.g.* precipitation and unimpaired runoff), are replaced by monthly averages from corresponding months of Water Years (WYs) 1976 and 1977. Modifications to regulated inflow and PG&E storage are also necessary in 1979 to account for anticipated PG&E storage recovery following the critically dry conditions in the modified 1978. The DPS is displayed graphically in Figure 3.1-1 below. Additional details regarding the DPS are available in other District documents (*e.g.* Water Supply Management Program (WSMP) 2040 (EBMUD, 2012); Draft Environmental Impact Report/Environmental Impact Statement, Freeport Regional Water Project (EBMUD, 2003); and East Bay Municipal Utility District's Drought Planning Sequence by Skinner (2002)).



Note: RUF is an abbreviation for regulated undiminished flow.

Figure 3.1-1. EBMUD Drought Planning Sequence Hydrology

3.1.1.3 EBMUD Demand Management Program

Mokelumne Watershed runoff is quite variable ranging from a maximum unimpaired runoff estimate of 1,800 TAF in WY 1982 to 130 TAF in WY 1977. In drought periods where runoff is insufficient to meet consumptive needs, total system storage (TSS) is depleted to meet consumptive demands. As storage is depleted during a drought, EBMUD imposes rationing on customers based on the projected system storage at the end-of-September. Initiating rationing earlier in a drought period is intended to alleviate the severity of rationing required in subsequent years of the drought. Table 3.1-3 represents the demand management program relating customer rationing goals with end-of-September TSS. These criteria are used to achieve the system-wide annualized demand reduction target of a maximum of 15%.

Table 3.1-3. EBMUD Demand Management Program for a Maximum Rationing Policy of 15%

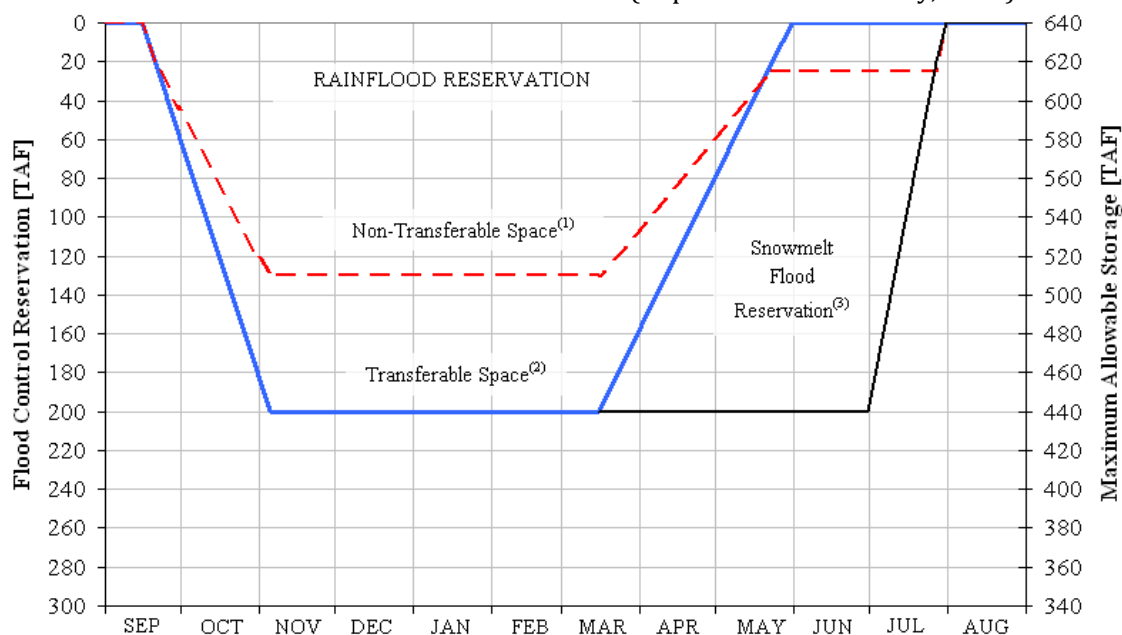
End-of-September Total System Storage (TSS)				Rationing Reduction Goal (RRG)			
500 TAF	≥	TSS	≥ 400 TAF	0%	≥	RRG	≥ 10%
400 TAF	≥	TSS	≥ 300 TAF	10%	≥	RRG	≥ 15%
300 TAF	≥	TSS				RRG	≥ 15%

Available water supply is determined in April of each year. On the basis of this determination, actions are initiated to ensure that any potential shortage is mitigated for in the following year. If water supply projections indicate a potential dry year where total system storage would be depleted to less than 500 TAF, Board adoption of voluntary customer demand reductions (consistent with the

Demand Management Program shown in Table 3.1-3) in the first year of a drought could occur as late as June or July, already half way through the calendar year. Thus, the EBMUDSIM model assumes that the rationing target is reduced by one-half in the first year of a drought. This assumption accounts for this potential lag in Drought Management Program implementation in the first year of a drought.

3.1.1.4 Flood Control Requirement

As one of its many purposes, Camanche Reservoir provides flood control protection for the lower Mokelumne River. In 1962, EBMUD executed an agreement with the US Army Corps of Engineers for flood control protection during certain months of the year. The agreement requires up to 200 TAF of flood storage capacity be maintained in Pardee and Camanche Reservoirs from November 5 through mid March and potentially extending up to the end of June depending on the quantity of estimated runoff to follow in the spring melt of the Mokelumne Watershed snow pack. Also, a portion of the requirement – up to 70 TAF – is transferrable to upstream PG&E reservoirs depending on their storage levels. The flood control storage requirement is represented below in Figure 3.1-2. More information regarding Mokelumne System flood control requirements is available in the Camanche Dam and Reservoir Water Control Manual (Department of the Army, 1981).



- (1) Non-Transferable Space is the absolute minimum flood control space that must be maintained in Pardee and Camanche Reservoirs.
- (2) Transferrable Space is the allowable reduction of flood control space requirement provided by upstream (PG&E) reservoirs.
- (3) Snowmelt Flood Reservation is dependant on estimated runoff-to-follow in TAF.

Figure 3.1-2. Flood Control Requirement for Combined Pardee and Camanche Storage

3.1.1.5 Aqueduct Outage Scenario

The aqueduct outage scenario is adopted to simulate a situation where a levee failure in the Sacramento-San Joaquin Delta occurs. This failure would severely damage the Mokelumne Aqueducts ability to convey water to the East Bay. The levee failure could be the result of an

extreme flood event or seismic activity in the area. EBMUD experienced a near-catastrophic event in 1980 when Lower Jones Tract flooded and the railroad embankment adjacent to the aqueducts subsequently failed, allowing floodwater to flow into Upper Jones Tract. This event nearly undermined the aqueduct supports in the area. The aqueduct outage scenario is used to simulate the raw water system response during a catastrophic failure of the Mokelumne Aqueducts. The assumptions that apply to the outage scenario are listed below.

- 100% catastrophic failure of all three aqueducts occurs on November 1, 1980.
- Aqueduct outage emergency demand management measures are implemented during and following the outage.
- All three aqueducts remain out of service for six months through April 30, 1981 and all consumptive demand must be met exclusively from local reservoir storage.
- Aqueduct #3 is restored to service and is available to supply the service area at an approximate rate of 172 MGD under pumped flow for 12 months from May 1, 1981 through April 30, 1982.
- Aqueducts #1 and #2 are restored to service on May 1, 1982 and pumped flow is initiated at approximately 325 MGD to meet service area demands and recover terminal storage to normal operating levels.

A timeline for the aqueduct outage scenario is presented in Figure 3.1-3.

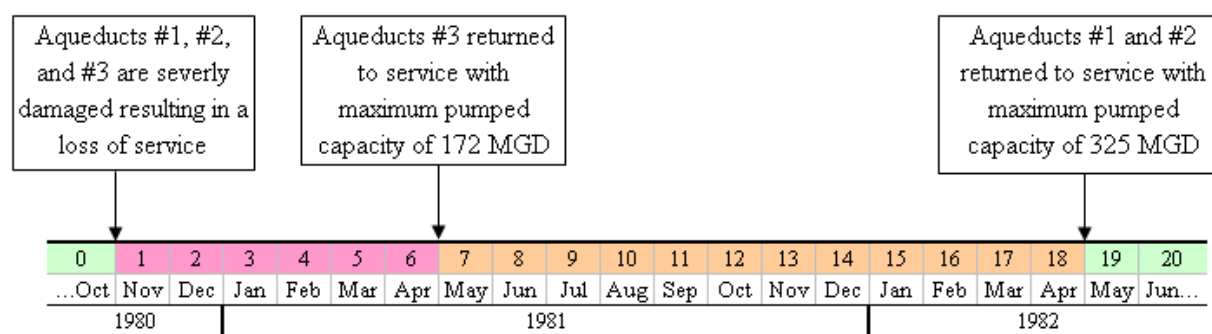


Figure 3.1-3. Aqueduct Outage Scenario Timeline

3.1.1.6 Bayside Phase I Project

The Bayside Phase I project is another element of the District's water supply portfolio. The Bayside Phase I project consists of a single aquifer storage and recovery (ASR) well within the EBMUD service area that provides an annual average supply of 1 MGD during drought periods where a maximum extraction or pumping rate of 2 MGD is assumed over a six month period as shown in Table 3.1-4. The Bayside Phase I project is activated any year in which the District's Freeport supplemental supply project is triggered (*i.e.* years in which projected October 1st total system storage is projected to be below 500 TAF).

Table 3.1-4. Bayside Phase I Assumed Monthly Supply Pattern for Typical Dry Year Operation

Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	
													Ave	Total
MGD	0	0	0	0	2.0	2.0	2.0	2.0	2.0	2.0	0	0	1.0	
AF	0	0	0	0	190.3	184.1	190.3	190.3	184.1	190.3	0.0	0.0		1,129

The Bayside Phase I project is a local supply available during emergencies such as during the aqueduct outage scenario described in Section 3.1.1.5. For the purposes of this study, the ASR well is assumed to be operated continuously during the outage period (November 1980 through April 1982) at one-half the maximum pumping capacity or 1 MGD. The assumed extraction sequence for the outage period is provided in Table 3.1-5.

Table 3.1-5. Bayside Phase I Monthly Pumping Pattern Over Aqueduct Outage Period

Year	Month	N Days	Delivery Pattern	
			MGD	AF
1980	Nov	30	1	92.1
1980	Dec	31	1	95.1
1981	Jan	31	1	95.1
1981	Feb	28	1	85.9
1981	Mar	31	1	95.1
1981	Apr	30	1	92.1
1981	May	31	1	95.1
1981	Jun	30	1	92.1
1981	Jul	31	1	95.1
1981	Aug	31	1	95.1
1981	Sep	30	1	92.1
1981	Oct	31	1	95.1
1981	Nov	30	1	92.1
1981	Dec	31	1	95.1
1982	Jan	31	1	95.1
1982	Feb	28	1	85.9
1982	Mar	31	1	95.1
1982	Apr	30	1	92.1
Average:			1	
Total:			546	1676

For more information on the Bayside Phase I project, please refer to the WSMP 2040 documentation (EBMUD, 2012) and the Bayside Phase I Final EIR (EBMUD, 2005).

3.1.2 Model Linkages

This section provides an overview of the domain of each model and also the input – output linkages among the various models used for this CEQA analysis. First, the water quantity component is exclusively modeled by EBMUDSIM. The domain of EBMUDSIM encompasses the entire raw water supply system (Pardee, Camanche, Terminal Reservoirs, and supplemental supply connections) and also the lower Mokelumne River below Camanche Dam downstream to the confluence with the Cosumnes River. The SSTEMP model is used to simulate the project effects (changes in flow and reservoir release temperature) for the lower Mokelumne River from station McIntire to station

Frandy (monitoring station locations are shown in Figure 3.3-2). SSTEMP input includes monthly average discharge output from EBMUDSIM combined with statistical relationships that relate station flows and reservoir release temperature as a function of Camanche storage levels to drive model simulations of monthly average temperature at downstream stations. Statistical regression models are implemented in a few cases where deterministic models are either not available or input data is insufficient for their use.

Figure 3.1-4 is a schematic representation of the input and output linkages among the various models and a historical database. EBMUDSIM model output provides the water balance components necessary for the water quality model inputs, *i.e.* total Camanche Release, flow below Woodbridge, and end-of-month (EOM) Camanche water surface elevation (WSE). For cases in which Camanche Reservoir WSE is less than the threshold of 190 ft msl¹⁰, appropriate adjustments to mean monthly water temperature below Camanche are conducted using the regression model presented in Section 3.4. Also, the discharge at stations Elliott and Frandy are estimated from simulated total Camanche release and flow below Woodbridge model outputs using regression models, respectively (see Sections 3.3.3.2 and 3.3.3.3 for additional details concerning calibration and validation of these respective regression models).

Meteorological data is also necessary input to the SSTEMP model. Meteorological input datasets are presented in Section 3.3 when the SSTEMP model is introduced. SSTEMP model output is simulated monthly average water temperature at stations Elliott, Golf, and Frandy. Another set of regression models are used to convert the simulated monthly average water temperature from SSTEMP to represent the monthly maximum of the seven day average daily maximum (MM7DADM) water temperature for each station required for the fisheries impacts assessment. Thermal assessment criterion for Mokelumne River fisheries are presented in Table 3.3-16 and the regression models relating monthly average water temperature to MM7DADM are presented in Section 3.3.5.

¹⁰ The background for this empirically derived threshold of 190 ft msl is provided in Section 3.4.2.

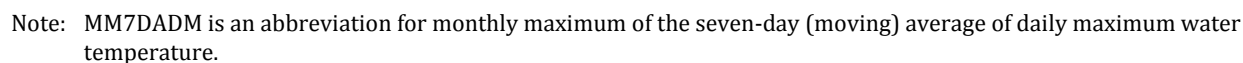


Figure 3.1-4. Input and Output Linkage between EBMUDSIM, Historical Database, SSTEMP, and Regression Models.

3.2 Mokelumne System Model: EBMUDSIM

The East Bay Municipal Utility District's hydrologic simulation model (EBMUDSIM) simulates the operation of the District's raw water supply system for present and future conditions with a fixed LOD mass-balance algorithm. EBMUDSIM is a computer simulation model used as a planning tool to analyze the effects of modified facilities and changed operational constraints in various planning alternatives. The primary purpose of the model is to assess the system's ability to meet customer demands with differing assumptions.

3.2.1 Model Description

EBMUDSIM simulates operation of the District's reservoir system for present and future conditions for planning studies. EBMUDSIM uses a monthly time step as the basis for its simulations. The output generated by EBMUDSIM represents average monthly or end-of-month values. By changing the input data the user can explore system effects of changes in such variables as projected customer demands, facilities development alternatives, operational or regulatory outcomes, and water supply availability. The model allows EBMUD to assess impacts of potential changed conditions for planning purposes. For short-term system operations, however, the District uses different tools that incorporate more detailed, real-time system components. Figure 3.2-1 shows a schematic representation of the EBMUDSIM model.

EBMUDSIM is a water balance model with layered regulatory constraints that simulates reservoir diversions, storage, and releases. Water allocations and reservoir releases must conform to principles of mass conservation with a complex set of regulatory and negotiated agreements overlaid. These complex set of rules and related equations of conservation of mass ultimately drives reservoir storage and release decisions over the simulation period.

EBMUDSIM accounts for inflows to EBMUD's Mokelumne River water supply system, balances reservoir operations, determines diversions from Pardee Reservoir into the Mokelumne Aqueducts, and calculates required downstream releases from Camanche Reservoir into the lower Mokelumne River to meet an array of downstream requirements. Inputs to EBMUDSIM include hydrologic variables necessary for the water balance, such as regulated undiminished flow (RUF) into Pardee Reservoir and net precipitation derived from historical records.

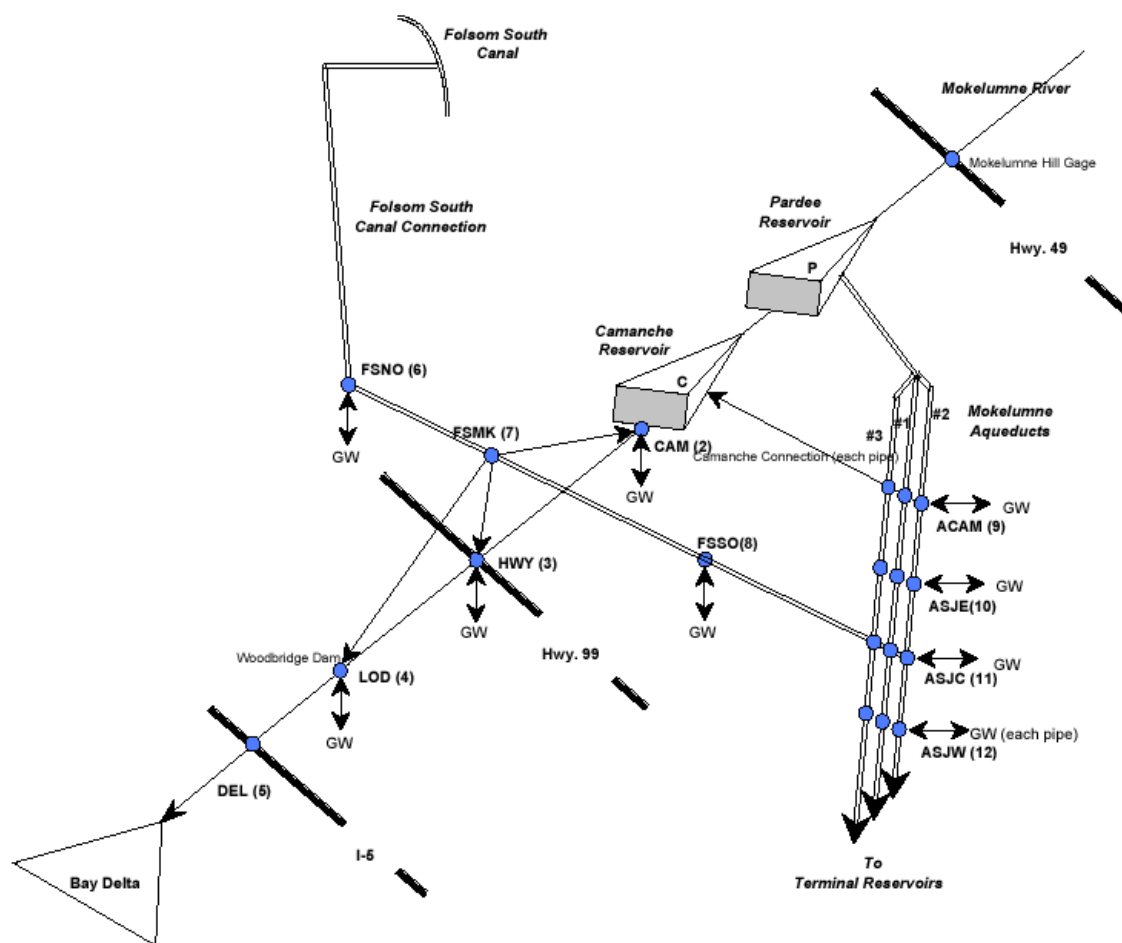


Figure 3.2-1. EBMUDSIM Model System Schematic

Hydrologic inputs are derived from an 89-year POR from January 1921 to December 2009. Annual customer consumptive demand is another key input that drives the model under the fixed LOD algorithm implemented. For simulations of future conditions RUF into Pardee Reservoir is adjusted to reflect anticipated changes in upstream diversions by water agencies in Calaveras and Amador Counties. Monthly draft to the Mokelumne Aqueducts is determined in response to the specified consumptive customer demand and required releases to the lower Mokelumne River. Releases from Camanche Reservoir to downstream users reflect the current water rights of, and agreements with, downstream water users, in addition to in-stream flow requirements established by the JSA (described above in Section 3.1.1.1). Channel losses are accounted for as a function of Camanche Reservoir releases to ensure that reservoir releases are adequate to meet downstream requirements. The model ensures that water is released from Pardee Reservoir to supply Camanche Reservoir with sufficient water to make the required releases to downstream users and meet all relevant regulatory requirements such as flood control or minimum cold water pool storage as required by the JSA.

EBMUDSIM has been an essential modeling tool utilized in many planning studies performed by the District including the effect of the FRWP on the District's water supply. In 2007, EBMUDSIM was integrated with the Water Evaluation and Planning Model in the District's WSMP 2040 Plan to evaluate various long-term water supply portfolios through 2040.

For additional background information regarding EBMUDSIM including details of the EBMUDSIM verification study, refer to Volume 3 of the Freeport Regional Water Project Draft Environmental Impact Report/Environmental Impact Statement (EBMUD, 2003) and EBMUD Exhibit 4 of the Bay-Delta Water Rights Hearings before the State Water Resources Control Board (EBMUD, 1998).

3.3 Temperature Model Application to Lower Mokelumne River with SSTEMP

Water temperature modeling is generally accomplished through one of three general modeling classifications: regression, stochastic, and deterministic (Caissie, 2006). The deterministic approach – sometimes referred to as a physically-based approach – models the energy balance for the stream or reservoir requiring extensive model inputs that describe physical characteristics of the system and meteorological forcing variables. Regression models –generally referred to as statistical models – and stochastic modeling methods rely more on cause and effect relationships relating water temperature to other variables such as air temperature or discharge. The reader is referred to the technical report by Deas and Lowney (2000) for a thorough review of water temperature modeling. For this modeling study, a combination of statistical and deterministic models is used.

This section introduces the deterministic Stream Segment Temperature Model (SSTEMP). SSTEMP is a public domain model developed and maintained by the US Geological Survey (USGS). SSTEMP is a one-dimensional, steady-state simulation model of the energy balance for a creek, river, or canal where water temperature at a downstream boundary is predicted as a function of discharge, upstream water temperature, channel characteristics, and meteorological variables. The next section presents additional details of the SSTEMP model followed by a discussion of model calibration to the lower Mokelumne River.

3.3.1 Model Description

SSTEMP is a scaled down version of the Stream Network Temperature Model (SNTEMP) with a graphical user interface (GUI) for model input and output display (Bartholow, 2002). The limitation of SSTEMP relative to SNTEMP is that model applications are limited to a single stream segment and single time step for each simulation set-up. If a river reach is to be modeled with multiple segments, the output from one segment can be entered (by the user) as the upstream temperature of another segment in a separate set-up. Figure 3.3-1 presents a screen capture of the SSTEMP model GUI.

SSTEMP Version 2.0.8

File View Help

Hydrology

Segment Inflow (cfs) 50.000

Inflow Temperature (°F) 70.000

Segment Outflow (cfs) 51.000

Accretion Temp. (°F) 55.000

Geometry

Latitude (degrees) 40.000

Dam at Head of Segment ☐

Segment Length (mi) 10.000

Upstream Elevation (ft) 100.000

Downstream Elevation (ft) 0.000

Width's A Term (s/ft²) 12.500

B Term where $W = A \cdot Q^{**B}$ 0.200

Manning's n 0.035

Meteorology

Air Temperature (°F) 90.000

☐ Maximum Air Temp (°F) 94.201

Relative Humidity (%) 60.000

Wind Speed (mph) 8.000

Ground Temperature (°F) 55.000

Thermal gradient (j/m²/s/C) 1.650

Possible Sun (%) 90.000

Dust Coefficient 5.000

Ground Reflectivity (%) 25.000

Solar Radiation (Langley's/d) 565.410

Shade

Total Shade (%) 42.035

Time of Year

Month/day (mm/dd) 08/16

Intermediate Values

Day Length (hrs) = 13.534

Slope (ft/100 ft) = 0.189

Width (ft) = 27.389

Depth (ft) = 1.005

Vegetation Shade (%) = 33.872

Topographic Shade (%) = 8.163

Mean Heat Fluxes at Inflow (j/m²/s)

Convect. = +98.39 Atmos. = +246.91

Conduct. = -13.75 Friction = +3.16

Evapor. = +67.78 Solar = +158.71

Back Rad. = -405.17 Vegetat. = +191.57

Net = +347.58

Optional Shading Variables

Segment Azimuth (degrees) -15.000

	West Side	East Side
Topographic Altitude (degrees)	25.000	15.000
Vegetation Height (ft)	25.000	35.000
Vegetation Crown (ft)	15.000	20.000
Vegetation Offset (ft)	5.000	15.000
Vegetation Density (%)	50.000	75.000

Model Results - Outflow Temperature

Predicted Mean (°F) = 79.05

Estimated Maximum (°F) = 83.24

Approximate Minimum (°F) = 74.87

Mean Equilibrium (°F) = 84.23

Maximum Equilibrium (°F) = 89.47

Minimum Equilibrium (°F) = 78.99

Double click to add title

4/16/2010 3:35 PM

Figure 3.3-1. Screen Capture of the SSTEMP Graphical User Interface

Model inputs fields are grouped into five categories, *hydrology*, *geometry*, *meteorology*, *optional shading variables*, and *time of year*. The *hydrology* category includes user defined upstream boundary discharge and associated temperature, downstream flow, and the temperature associated with accretion through hyporheic exchange¹¹. The *geometry* category includes parameters of latitude, segment length, upstream and downstream channel bottom elevation, the Manning's roughness coefficient for the channel, and two empirical parameters that define channel shape. The two empirical channel geometry parameters – labeled as the A term and the B term – are associated with the channel's wetted-width discharge relationship¹². The *meteorology* category includes input fields for air temperature, relative humidity, wind speed, and reflectivity with maximum air temperature as an optional input. The category *optional shading variables* contains a set of variables

¹¹ Hyporheic exchange would occur in a gaining stream segment where discharge at the downstream boundary is greater than the upstream boundary.

¹² The reader is referred to the model documentation Bartholow (2002) for more information on these two model parameters that are related to channel geometry.

characterizing riparian characteristics with user input fields for both east and west sides of the channel along with the segment azimuth. Optional shading variables include topographic altitude, vegetation height, vegetation crown, vegetation offset, and vegetation density. Last, the category *time of year* is where the user can input the simulation time period. The time input field is required to be of the form of mm/dd where mm is the month (from 01 to 12) and dd is the day (from 01 to 31).

Three model output categories are displayed on the right side of the SSTEMP GUI; these include *intermediate calculations*, *mean heat fluxes*, and *resultant outflow temperature*. The *resultant outflow temperature* category includes a predicted mean value, an estimated maximum, and approximate minimum in addition to mean, maximum, and minimum equilibrium temperatures. The reader is referred to the model documentation for additional information on SSTEMP. SSTEMP is a public domain model available online at: <http://www.fort.usgs.gov/Products/Software/SNTEMP/>.

3.3.2 Historical Datasets for Model Development and Calibration

Starting in 1994, water temperature and stage sensors were installed by the District. This section documents the monitoring records used in the calibration of the SSTEMP model presented in Section 3.3.4. Water temperature records for the Mokelumne River Fish Hatchery (MRFH) were also available for an extended POR. The hatchery records were adjusted using a two step regression method to extend the monthly average water temperature POR for station McIntire, the monitoring station immediately below Camanche Dam.

3.3.2.1 Lower Mokelumne River Water Quality Monitoring

Monitoring records from four stations – McIntire, Elliott, Golf, and Frandy – located along the lower Mokelumne River below Camanche Dam are used in this study. Stage and temperature are monitored at 15-minute intervals at all stations where stage is converted to discharge through rating relationships for all stations except Frandy due to tidal influence from the Sacramento-San Joaquin Delta downstream. Figure 3.3-2 shows the location of these monitoring stations along the lower Mokelumne River.

Located approximately one mile downstream of Camanche Dam, station McIntire is the furthest upstream monitoring station. While station McIntire is not immediately downstream from Camanche Dam, station McIntire is considered representative of river conditions directly downstream of the Dam as it is less than one mile downstream of Camanche Dam. Station Elliott is the next station downstream located approximately 10 miles downstream of Camanche Dam. The next monitoring station, station Golf, is 24.4 miles downstream of Camanche Dam and directly downstream of Lodi Lake. At station Golf, stage and water temperatures below Woodbridge Dam are monitored. The farthest downstream monitoring station is station Frandy. Station Frandy is approximately 33 miles downstream of Camanche Dam. As noted above, discharge at station Frandy is not calculated from stage measurements due to tidal influence from the Sacramento-San Joaquin Delta. The widest range of water temperatures is observed at station Frandy due to downstream effects which include the confluence of the Cosumnes and Mokelumne Rivers, Delta Cross Channel operations by the United States Bureau of Reclamation as part of the Central Valley Project and State Water Projects, and tidal effects traveling upstream from the Sacramento-San Joaquin Delta.

Monthly average discharge and water temperature for each monitoring station are derived from daily average records for each station maintained by the District. Monthly average discharge and water temperature for station McIntire from January 1994 through December 2011 are presented in Table 3.3-1 and Table 3.3-2, respectively.

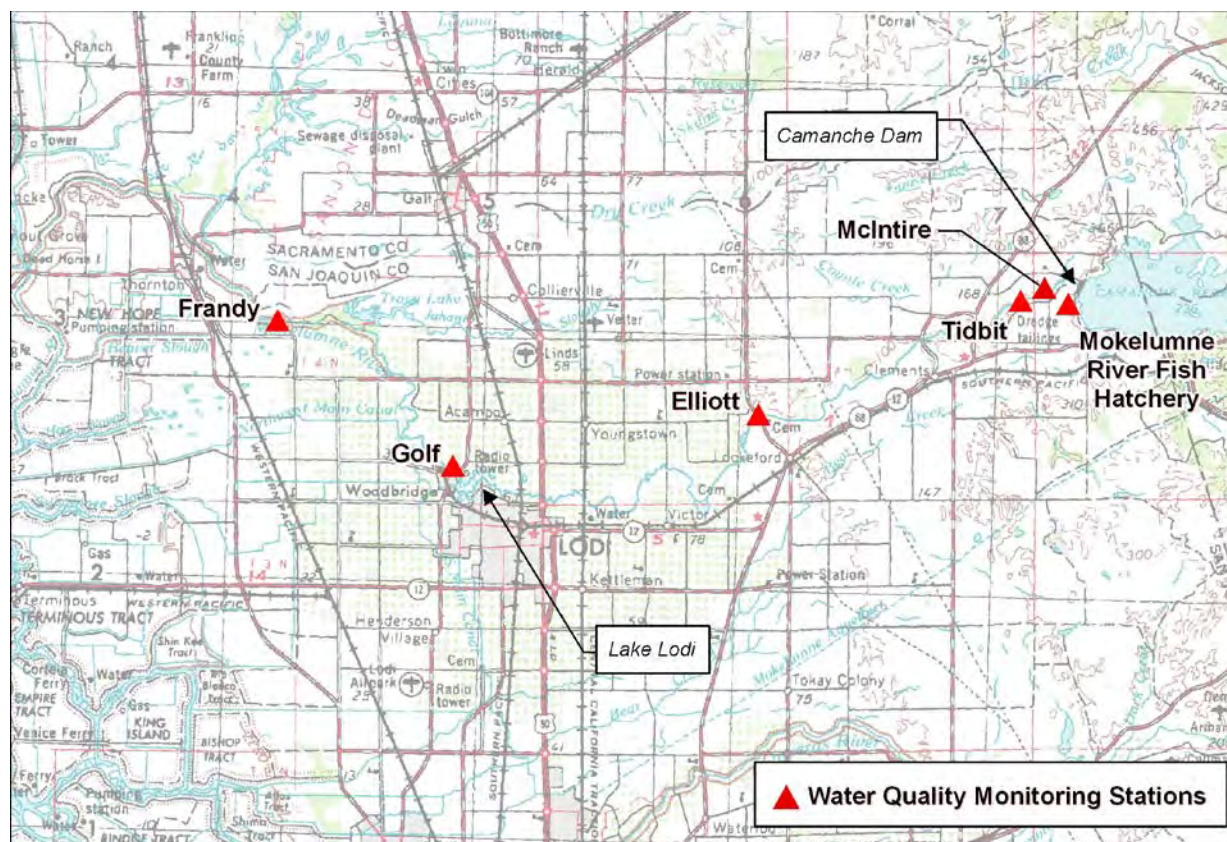


Figure 3.3-2. Lower Mokelumne River Water Quality Monitoring Stations

Monthly average discharge and water temperature for the same POR for station Elliott are presented in Table 3.3-3 and Table 3.3-4, respectively. From February through May 2007, temperature monitoring records are not available for station Elliott as indicated by "--" in Table 3.3-4.

Table 3.3-5 and Table 3.3-6, respectively present monthly average discharge and water temperature for station Golf from January 1994 through December 2011. Temperature monitoring records for station Golf from January 1994 through July 1994 are not available.

Monthly average temperature for station Frandy is presented in Table 3.3-7 for January 1994 through December 2011. Temperature monitoring records are not available for August 1994 at station Frandy.

Table 3.3-1. Historical Monthly Average Discharge [cfs], Station McIntire, January 1994 to December 2011

Month	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Jan	234	421	304	4,978	782	569	367	332	242	255	358	307	3,050	352	249	225	331	1,445
Feb	194	863	2,158	4,315	3,076	2,410	1,499	331	239	253	373	722	1,318	351	237	226	332	600
Mar	191	2,249	2,725	1,692	2,385	1,733	1,708	330	258	282	358	1,315	920	354	232	237	342	2,017
Apr	294	2,923	1,317	804	1,591	1,222	511	283	346	300	482	1,669	4,572	320	376	332	503	3,158
May	306	3,155	1,071	541	1,845	1,238	680	423	476	517	806	2,113	3,935	365	395	384	1,223	2,243
Jun	326	3,847	1,175	592	2,446	1,074	753	378	527	1,099	531	2,105	2,459	337	253	410	962	1,923
Jul	279	2,183	1,279	332	2,932	816	613	321	365	890	375	1,331	1,328	352	254	334	898	2,187
Aug	263	1,328	807	258	1,770	619	393	258	313	642	353	1,000	663	343	318	338	417	1,073
Sep	145	1,447	492	264	320	329	365	220	279	366	274	829	744	335	255	373	421	736
Oct	158	639	316	323	320	331	333	243	282	358	277	335	450	234	225	701	1,196	1,234
Nov	227	280	368	372	328	332	331	230	256	352	279	339	346	232	225	348	736	602
Dec	240	274	1,991	571	567	331	334	235	257	355	282	493	350	239	225	331	1,802	341

Table 3.3-2. Historical Monthly Average Temperature [°C], Station McIntire, January 1994 to December 2011

Month	1995	1994	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Jan	10.4	10.4	12.0	10.4	11.3	9.8	11.6	10.8	10.5	11.0	10.6	10.5	11.7	9.8	10.2	9.6	11.9	9.4
Feb	9.4	10.5	11.3	9.6	10.7	9.4	11.5	10.1	9.7	10.5	10.4	9.9	10.7	9.6	9.4	9.6	11.0	9.1
Mar	10.7	11.8	10.6	9.9	10.1	9.4	11.3	10.8	10.6	11.1	10.8	10.8	10.5	11.0	10.9	9.6	11.5	9.8
Apr	10.9	11.7	11.7	10.9	10.9	10.2	12.2	11.6	11.3	12.0	11.7	11.6	10.9	12.1	11.1	10.6	12.6	10.1
May	11.8	11.6	12.3	12.1	12.4	11.3	12.9	12.0	11.5	12.4	12.8	12.6	12.3	12.7	12.2	11.7	13.5	12.3
Jun	13.1	12.3	13.1	12.6	13.6	12.4	12.9	12.5	11.8	13.4	12.7	13.7	14.2	13.4	15.1	12.4	14.4	13.8
Jul	14.9	12.7	13.8	12.6	14.4	12.5	13.6	13.3	12.7	14.1	13.0	14.8	15.1	13.7	16.2	13.5	14.9	15.5
Aug	16.0	13.6	14.4	13.1	14.7	14.3	14.2	14.2	13.2	14.5	13.6	14.8	15.1	14.6	16.6	13.9	14.2	16.7
Sep	15.8	14.8	14.9	13.7	15.5	14.7	14.6	14.7	13.7	15.2	14.2	15.3	15.4	15.2	16.8	14.4	14.7	15.7
Oct	16.1	14.7	15.3	14.4	16.4	14.5	14.9	14.9	14.1	15.6	14.7	15.9	15.8	15.1	16.3	15.3	15.2	16.0
Nov	16.1	13.4	15.2	15.1	15.7	14.9	14.8	15.0	15.0	15.7	14.8	16.2	16.2	14.8	15.4	15.9	15.7	15.6
Dec	14.3	10.5	12.9	13.5	12.2	12.7	12.6	12.1	13.0	13.2	12.4	14.0	13.2	12.8	13.0	13.6	13.3	11.8

Table 3.3-3. Historical Monthly Average Discharge [cfs], Station Elliott, January 1994 to December 2011

Month	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Jan	234	421	304	4,978	782	569	367	332	230	253	332	289	3,045	346	235	223	311	1,450
Feb	194	863	2,158	4,315	3,076	2,410	1,499	331	222	252	339	652	1,323	348	228	229	317	566
Mar	191	2,249	2,725	1,692	2,385	1,733	1,708	330	242	276	333	1,260	905	336	224	231	323	1,900
Apr	294	2,923	1,317	804	1,591	1,222	511	283	328	290	431	1,640	4,601	295	340	310	474	3,016
May	306	3,155	1,071	541	1,845	1,238	680	423	434	533	751	2,090	3,919	328	357	360	1,259	2,241
Jun	326	3,847	1,175	592	2,446	1,074	753	378	480	1,098	484	2,010	2,445	293	238	387	944	1,859
Jul	279	2,183	1,279	332	2,932	816	613	321	315	884	320	1,243	1,295	303	231	307	873	2,194
Aug	263	1,328	807	258	1,770	619	393	258	271	621	311	965	636	301	280	299	373	1,058
Sep	145	1,447	492	264	320	329	365	220	243	351	245	815	730	300	234	337	367	683
Oct	158	639	316	323	320	331	333	243	268	327	261	322	449	217	214	736	1,196	1,200
Nov	227	280	368	372	328	332	331	230	253	326	254	330	352	217	220	356	730	708
Dec	240	274	1,991	571	567	331	334	235	261	330	260	494	352	225	225	313	1,804	321

Table 3.3-4. Historical Monthly Average Temperature [°C], Station Elliott, January 1994 to December 2011

Month	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Jan	9.8	10.8	12.2	10.8	10.9	9.5	11.2	10.1	9.8	11.0	10.2	9.6	11.2	9.4	9.3	9.1	10.7	9.6
Feb	10.3	10.0	12.0	10.3	10.5	9.4	11.5	10.0	9.9	10.6	10.5	9.6	10.6	--	9.6	10.2	10.9	9.3
Mar	13.0	11.3	11.5	10.9	10.2	9.8	11.5	11.6	11.3	12.1	11.9	10.6	10.1	--	11.4	11.1	11.9	10.0
Apr	15.4	11.6	12.9	12.7	11.4	10.8	13.1	12.7	12.3	13.0	12.7	11.4	10.3	--	12.4	12.7	12.6	10.3
May	14.3	12.8	13.7	14.6	13.0	12.6	13.8	13.7	13.0	14.0	13.7	12.3	11.9	--	13.9	13.7	13.3	--
Jun	15.0	14.1	14.7	15.0	14.4	14.1	14.0	14.6	13.7	14.8	14.3	13.5	13.7	15.2	17.3	14.0	14.6	--
Jul	16.1	16.0	15.3	16.0	15.1	14.1	14.8	15.7	15.3	15.6	15.3	14.8	15.0	15.9	18.0	15.2	15.0	15.8
Aug	16.3	17.1	16.1	15.9	15.6	15.1	15.6	16.6	15.6	16.3	15.6	15.0	15.4	16.8	17.6	15.4	15.7	17.5
Sep	17.3	16.7	16.5	15.6	17.2	15.8	15.5	16.4	15.4	16.3	15.6	15.3	15.4	16.5	17.1	15.3	15.7	15.4
Oct	15.4	16.7	16.1	14.8	16.2	15.0	14.8	15.2	14.5	15.8	14.9	15.4	15.3	15.5	15.3	14.9	15.5	15.1
Nov	12.8	16.1	15.5	14.9	14.7	14.7	13.8	14.4	14.5	14.9	13.7	14.8	15.1	14.0	14.2	14.6	15.1	14.2
Dec	10.3	14.3	13.4	12.6	11.4	12.3	11.9	11.4	12.4	12.5	11.2	12.6	12.2	11.3	11.1	11.7	12.7	10.3

Table 3.3-5. Historical Monthly Average Discharge [cfs], Station Golf, January 1994 to December 2011

Month	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Jan	184	349	237	4,746	693	518	312	287	194	210	285	240	2,930	302	199	179	270	1,504
Feb	152	816	1,978	4,285	2,840	2,172	1,433	297	183	215	304	568	1,302	307	188	185	278	588
Mar	113	2,129	2,633	1,594	2,262	1,667	1,708	258	181	191	287	1,156	831	246	179	149	235	1,854
Apr	136	2,840	1,209	645	1,490	1,062	384	174	173	174	275	1,438	4,179	190	179	167	371	3,150
May	152	2,937	870	321	1,660	934	462	166	216	303	516	1,703	3,869	179	160	177	1,044	2,151
Jun	99	3,505	843	311	2,085	765	455	39	217	850	231	1,723	2,231	53	34	162	729	1,652
Jul	34	1,976	903	58	2,561	482	291	41	51	613	47	907	1,003	47	29	37	636	2,021
Aug	39	993	501	35	1,462	313	89	40	46	369	34	665	371	47	32	31	176	822
Sep	36	1,172	253	91	123	105	149	44	42	104	30	572	389	48	34	50	177	478
Oct	110	465	126	180	148	138	199	96	125	118	132	248	299	198	90	523	1,031	1,064
Nov	171	237	318	320	306	298	300	195	224	282	219	276	306	168	209	296	660	580
Dec	177	217	1,861	514	502	274	279	199	225	282	209	406	311	181	175	264	1,701	262

Table 3.3-6. Historical Monthly Average Temperature [°C], Station Golf, January 1994 to December 2011

Month	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Jan	--	10.6	11.4	10.8	11.5	9.5	11.1	9.8	9.4	10.8	9.9	9.4	11.1	8.5	8.8	8.9	10.5	9.3
Feb	--	10.0	12.0	10.2	11.4	9.6	11.8	10.2	10.8	10.8	10.7	10.1	10.4	10.2	9.8	10.8	11.2	9.3
Mar	--	11.4	11.8	10.8	10.8	10.3	12.0	13.6	13.0	13.5	13.4	11.1	10.6	13.2	12.9	13.0	13.0	10.5
Apr	--	11.3	13.1	13.2	12.1	12.1	15.1	15.2	15.4	14.6	14.8	12.1	11.1	15.6	14.4	15.4	14.0	10.9
May	--	11.8	15.0	16.5	13.7	14.1	15.9	17.8	16.2	16.7	15.9	13.3	12.8	17.6	17.1	17.8	14.0	13.2
Jun	--	12.7	16.4	17.3	15.3	16.1	16.8	19.7	17.6	16.2	18.1	14.7	15.2	20.2	21.8	18.1	16.7	15.3
Jul	--	14.1	16.9	20.1	16.0	16.6	17.8	21.0	20.8	17.8	21.0	16.8	17.0	21.3	23.3	20.8	17.5	17.0
Aug	21.0	16.9	17.7	21.0	16.7	17.6	19.5	21.8	20.8	18.3	20.6	17.2	18.3	21.0	22.3	20.5	18.9	18.3
Sep	21.4	16.9	17.7	19.8	19.1	18.7	18.2	20.2	19.6	19.0	19.3	17.0	17.5	18.9	20.4	18.8	18.2	18.0
Oct	17.1	16.6	16.0	15.8	16.3	16.3	15.8	16.9	15.4	16.9	15.9	16.2	15.6	15.8	16.8	15.4	15.9	16.3
Nov	11.4	15.4	14.3	14.8	14.0	14.3	13.0	14.2	13.7	13.9	12.9	14.2	14.4	13.2	13.9	13.8	14.5	14.2
Dec	9.3	13.1	12.6	12.2	10.7	11.3	11.3	10.9	11.3	11.8	10.4	12.2	11.2	10.2	9.5	10.8	12.2	9.9

Table 3.3-7. Historical Monthly Average Temperature [°C], Station Frandy, January 1994 to December 2011

Month	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Jan	9.6	10.8	11.0	10.4	10.9	9.5	11.1	9.6	8.9	10.6	9.5	9.1	11.1	8.2	8.6	9.0	10.3	9.7
Feb	10.1	10.3	11.8	10.1	10.8	9.8	12.0	10.5	10.6	10.6	10.5	10.2	10.4	10.5	9.9	10.8	11.3	9.5
Mar	13.3	11.5	11.6	11.4	11.0	10.6	12.4	14.5	13.1	13.8	13.8	11.3	10.8	13.8	13.3	13.5	13.9	10.7
Apr	15.9	12.0	13.7	14.4	12.5	12.6	16.0	16.4	16.1	15.0	15.4	12.3	11.4	16.4	15.3	16.2	14.5	11.2
May	17.8	13.4	15.3	18.4	14.1	14.8	17.1	20.6	17.3	17.7	16.5	13.6	13.2	19.0	18.5	19.8	14.4	13.5
Jun	19.9	14.9	16.8	19.1	15.7	17.1	18.5	25.7	19.4	16.8	19.6	15.0	15.3	22.8	24.1	20.2	17.6	15.8
Jul	23.7	17.1	17.5	24.3	16.6	18.0	20.0	28.0	24.1	18.7	24.4	17.5	17.7	24.5	26.0	25.0	18.5	17.7
Aug	--	18.5	18.6	24.5	17.4	19.1	22.5	27.6	23.1	19.0	24.0	17.9	19.0	23.8	25.5	24.5	20.7	19.2
Sep	22.0	17.4	18.5	21.7	20.5	20.3	19.8	21.4	21.1	20.1	21.0	17.6	18.0	20.4	21.9	21.6	19.4	18.7
Oct	16.8	16.6	16.2	16.2	16.3	16.7	16.2	16.9	15.4	16.7	15.7	16.4	15.3	16.7	16.6	15.3	16.2	16.2
Nov	10.9	14.8	14.1	14.5	13.9	14.2	12.8	13.8	13.2	13.2	12.2	13.8	13.9	13.0	13.5	13.1	14.4	13.7
Dec	9.0	12.6	12.5	11.7	10.5	10.9	11.2	10.4	10.7	11.2	9.7	11.9	10.6	9.5	9.8	10.2	12.4	8.8

3.3.2.2 Extension of Water Temperature Period of Record for Station McIntire from Mokelumne River Fish Hatchery Records

As documented in the previous section, water temperature records are available for station McIntire from January 1994 through December 2011. While this period encompasses a few dry years (*i.e.* 2001, 2007, and 2008) the range in Camanche Storage and corresponding water level is relatively high¹³. Although 2007 and 2008 represented consecutive dry years triggering a drought declaration, Camanche Reservoir WSE was not drawn to as low a level as in previous drought periods. The POR for station McIntire, therefore, needed to be extended to a longer period that corresponds to a wider variation in Camanche storage. The extended POR for station McIntire would allow an investigation into the relationship between Camanche release temperature and Camanche storage over a broader range in storage, particularly lower storage levels where the hypolimnion volume is small or fully depleted. The goal of the investigation is to determine the threshold storage level that begins to affect Camanche release temperature.

Fortunately, for a longer POR the water temperature records from the MRFH, which is located immediately downstream of Camanche Dam, were available. MRFH annual reports were accumulated and converted to electronic records from fiscal year (FY) 1975 through FY 1994. These reports contained daily maximum temperature records for the MRFH which were then converted to monthly average values for FY 1975 through FY 1994. Unfortunately after FY 1994, the hatchery reports only reported temperatures from station McIntire and the MRFH. Only a limited six month overlapping POR is available for both the MRFH and station McIntire datasets in January through June of 1993, a period that is too short to perform an adequate correlation of the two monitoring records. To confirm that MRFH temperatures are typically cooler than temperatures at station McIntire, a comparison of multi-year monthly mean water temperature is assembled using all available datasets. The multi-year monthly mean water temperature for both locations are calculated and presented in Table 3.3-8.

Table 3.3-8. Multi-Year Monthly Mean Water Temperatures [°C] for MRFH (POR: October 1974 through December 1993) and McIntire (POR: January 1994 through December 2008)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
McIntire	10.8	10.2	10.7	11.4	12.2	13	13.7	14.3	14.8	15.2	15.2	12.8
MRFH	9.3	9.2	10	10.7	11.4	12.7	13.8	14.6	14.9	14.9	14.1	11.7
Difference	-1.44	-1.03	-0.63	-0.7	-0.8	-0.31	0.13	0.25	0.09	-0.27	-1.05	-1.16

The mean monthly temperatures for MRFH reported in Table 3.3-8 are calculated from the dataset of daily maximum water temperatures; whereas the mean monthly water temperature for McIntire is calculated from mean daily water temperature records. Since the diurnal fluctuations at MRFH are small, however, the maximum values are expected to be close in magnitude to the means; thus the two datasets are comparable although a bias is expected due to the spatial separation of the two locations. The MRFH receives water directly from outlet works of Camanche Dam while station

¹³ From January 1994 through December 2011, end-of-month Camanche storage range was 137,200-406,500 AF corresponding to a range in WSE of 187.73-234.07 ft msl. In comparison the range in Camanche storage from October 1976 to December 2011 was 9,200-422,800 AF which corresponds to a range in WSE of 125.38-236.25 ft msl.

McIntire is approximately one mile downstream of the dam. The MRFH water temperatures documented in hatchery annual reports are not considered representative of water temperatures at station McIntire in raw form because of the physical separation and physical characteristics of the two monitoring locations. Station McIntire monitoring records exhibit slightly higher temperatures and more pronounced diurnal fluctuations than records for the MRFH. The difference in the multi-year monthly means, calculated by subtracting station McIntire from MRFH records, is presented as the last row of the table above. The difference in temperature between the two stations reveals that MRFH is generally cooler than station McIntire except in the warmest months of July, August, and September. Warmer temperatures recorded at the MRFH in summer months is likely a result of a combination of ambient warming conducted through hatchery pluming and relatively low flow rates going to the hatchery.

The comparison of multi-year monthly mean temperatures in Table 3.3-8 confirms that MRFH temperatures are not representative of station McIntire. However, the limited six month period of overlap (January through June 1993) is also not adequate for developing a mathematical correlation needed to adjust the MRFH records to represent water temperatures at station McIntire. Fortunately, another source of water temperature monitoring data using temporary Tidbit data loggers was available that provided mean, minimum, and maximum daily water temperatures. The Tidbit monitoring station, located less than a mile downstream of station McIntire, provided a five year record that overlapped with both the MRFH dataset and the station McIntire datasets. The location of the MRFH and the Tidbit monitoring station are indicated in Figure 3.3-2. The POR available from the Tidbit monitoring station is 1991 through 1996. The mean daily water temperature record from 1991 through 1993 was used to develop a temperature correlation between the MRFH and Tidbit datasets. The subsequent period from 1994 through 1996 was used to develop a temperature correlation between station McIntire and the Tidbit datasets. The overlapping periods for the three monitoring locations are represented in Figure 3.3-3.

Jan-91	Feb-91	...	Nov-93	Dec-93	Jan-94	Feb-94	...	Nov-97	Dec-97
Tidbit Dataset (Mean Daily Water Temperature)									
MRFH Dataset (Max Daily Water Temperature)					McIntire Dataset (Mean Daily Water Temperature)				

Figure 3.3-3. Illustration of Overlapping Period-of-Record for Temperature Data from the Mokelumne River Fish Hatchery (MRFH), Station McIntire, and the Tidbit Monitoring Station

A simple linear regression model was adopted for each correlation using the daily time series for each dataset. Once the correlations were calibrated and validated, the entire MRFH POR is adjusted to represent the temperature at station McIntire using a two step procedure. The two step procedure is as follows; first the MRFH and Tidbit station correlation is applied to the MRFH dataset, and second the Tidbit station and station McIntire correlation is applied to the corrected MRFH dataset¹⁴. Once the daily maximum temperature records for the MRFH dataset were adjusted to be representative of daily average water temperature for station McIntire, the adjusted daily records for the MRFH are converted to monthly average water temperature from October 1974 through December 1993. Table 3.3-9 presents the adjusted monthly average water temperature dataset for MRFH.

¹⁴ R^2 statistic for the MRFH and Tidbit correlation daily datasets is 0.76 ($N=1050$), and R^2 statistic for the tidbit McIntire correlation daily datasets is 0.82 ($N=622$). Adjusted MRFH long-term monthly means are compared against long-term monthly mean water temperatures for McIntire for validation of the results which gave a range of 1.4°C with minimum error equal to -0.9°C corresponding to January and maximum error equal to +0.5°C in July where the average error from March through October is -0.3°C.

Table 3.3-10 presents the monthly average water temperature summary statistics for station McIntire based on historical data and reconstructed datasets from October of 1974 through December 2011 (by respectively combining Table 3.3-2 and Table 3.3-9).

Table 3.3-9. MRFH Adjusted Monthly Average Water Temperature [°C]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1974	--	--	--	--	--	--	--	--	--	14.6	15.1	12.8
1975	9.8	9.8	10.4	10.8	9.3	12.6	13.0	13.3	13.6	14.9	15.1	12.3
1976	10.3	10.4	11.7	12.7	13.7	14.4	15.4	15.5	15.9	16.1	15.9	12.9
1977	9.9	9.5	11.4	12.9	13.7	15.3	16.5	17.7	19.2	18.3	16.1	12.6
1978	11.5	10.6	10.9	11.2	12.4	13.4	14.0	14.6	14.6	14.9	14.7	11.9
1979	10.3	9.7	9.6	10.8	11.6	12.5	12.8	13.1	13.3	13.2	13.7	13.8
1980	11.4	10.6	10.6	11.5	12.6	13.0	14.2	14.9	15.7	16.2	15.7	14.7
1981	11.5	11.4	12.0	12.4	12.8	13.8	14.1	14.2	14.1	14.4	14.4	13.7
1982	10.4	10.1	10.1	11.4	12.4	14.0	14.9	16.3	16.9	16.9	14.9	11.0
1983	8.1	8.7	10.1	10.3	11.3	13.9	15.6	15.9	15.8	14.8	14.5	10.9
1984	9.0	8.4	8.7	9.8	10.7	11.8	13.4	14.6	14.7	14.1	12.7	11.2
1985	10.2	9.3	9.1	9.2	10.3	11.5	13.1	13.4	13.2	12.8	12.3	10.4
1986	9.4	10.5	10.8	11.5	12.4	12.7	13.4	13.4	12.9	13.9	14.6	13.3
1987	10.2	9.6	11.1	11.9	12.5	13.3	13.4	13.5	14.3	16.7	16.2	12.7
1988	9.5	9.7	10.8	12.6	13.6	16.5	18.7	21.3	22.6	19.6	15.2	10.0
1989	8.2	9.0	12.0	11.5	11.0	12.0	13.4	13.7	13.0	11.8	11.0	10.2
1990	10.1	9.9	9.6	9.8	10.6	11.3	12.2	14.1	14.2	14.4	14.2	11.5
1991	9.3	8.7	10.7	11.6	12.3	13.4	14.8	15.4	15.8	16.1	14.9	11.6
1992	9.6	10.2	11.2	11.2	11.7	11.7	13.9	15.1	15.7	15.8	15.4	11.6
1993	9.4	9.4	9.6	9.7	10.6	11.5	12.0	13.0	13.8	14.1	14.0	13.7

Table 3.3-10. Monthly Average Temperature Summary Statistics, Station McIntire, October 1974 through December 2011

Month	Maximum	Mean	Minimum	Standard Deviation
January	12.0	10.3	8.1	0.9
February	11.5	9.9	8.4	0.8
March	12.0	10.6	8.7	0.8
April	12.9	11.3	9.2	0.9
May	13.7	12.1	9.3	1.0
June	16.5	13.1	11.3	1.1
July	18.7	14.1	12.0	1.4
August	21.3	14.7	13.0	1.6
September	22.6	15.1	12.9	1.8
October	19.6	15.2	11.8	1.4
November	16.2	14.9	11.0	1.1
December	14.7	12.5	10.0	1.2

3.3.3 Model Application to the Lower Mokelumne River

The lower Mokelumne River was modeled using SSTEMP in three segments. The first segment runs the length of the river from station McIntire to station Elliott. The second segment runs the length of the river from station Elliott to station Golf. The third segment runs the length of the river from station Golf to station Frandy. The locations of the water quality monitoring stations along the lower Mokelumne Rivers are shown in Figure 3.3-2. The SSTEMP model application to the lower Mokelumne River is used to predict monthly¹⁵ average temperatures.

SSTEMP is used to simulate the effect of changes in flow and upstream temperature boundary conditions at Camanche Dam induced by the Project. The primary SSTEMP model inputs are monthly average discharge and temperature from Camanche Reservoir. Additional model inputs include meteorological variables and channel characteristics described in Section 3.3.1.

3.3.3.1 Meteorological Input

Meteorological datasets were not available in the immediate area for each year of the hydrologic period simulated: 1921-2009. Monthly average meteorological data from the Stockton California airport, however, is available online (Climate Data, 2010). The monthly average data from the Stockton Airport – derived from long-term records¹⁶ – provided the necessary meteorological input for the SSTEMP application. The datasets utilized for the SSTEMP application are summarized in Table 3.3-11. The monthly average meteorological data were used as input for each segment of the lower Mokelumne River simulated.

Monthly average discharge at station McIntire is assumed to be equivalent to simulated total Camanche Reservoir discharge from EBMUDSIM model output. EBMUDSIM standard output also

¹⁵ For monthly simulations, the middle of the month simulated is input in the *time of year* query box (e.g. 01/15 is entered to simulate monthly average temperatures for January of a given year, see Bartholow (2002) page 7).

¹⁶ The POR utilized to calculate the long-term means varies among the meteorological parameters listed ranging from 12 to 54 years. Furthermore, the long-term records are not available online, only the monthly average or “normal” values of the meteorological variables, which are the values reproduced in Table 3.3-11.

includes monthly average flow below Woodbridge Dam at station Golf. Discharge at stations Elliott and Frandy, however, are not model outputs. Hence regression models are used for predicting the discharge at stations Elliott and Frandy from available model outputs. These two regression models are presented in the next two sections.

Table 3.3-11. Summary of Monthly Average Meteorological Input from the Stockton California Airport. Source: <http://www.wrcc.dri.edu/cgi-bin/cliicl.pl?ca23237>

Month	Min. Air Temp. [°F]	Max. Air Temp. [°F]	Humidity [%]	Wind Speed [mi/hr]	Possible Sun ^a [%]
January	45.0	53.0	83.25	6.7	92.7
February	50.5	60.7	77.50	6.9	93.5
March	54.1	65.5	68.75	7.7	94.3
April	59.3	72.9	60.25	8.3	95.1
May	66.7	81.6	53.25	9.2	96.5
June	73.3	89.1	48.75	9.2	97.7
July	77.7	94.4	45.75	8.2	98.8
August	76.8	92.9	47.50	7.7	98.6
September	72.7	87.9	51.00	7.1	98.2
October	64.6	78.3	58.50	6.4	96.7
November	53.0	63.4	74.25	5.8	94.3
December	45.0	52.8	84.25	6.3	92.9

^a The percentage possible sun is the compliment of mean sky cover or cloud cover reported online where: Possible Sun + Mean Sky Cover = 100%.

3.3.3.2 Regression Model #1: Flow Correlation for Stations Elliott and McIntire

A simple linear regression model was applied to estimate the discharge at station Elliott as a function of the discharge at station McIntire. The regression model is shown in Equation 1.

Equation 1:
$$Q_m^{Elliott} = \beta_{0,m} + \beta_{1,m} Q_m^{McIntire}, m = 1, 2, \dots, 12$$

Where Q_m represents monthly average discharge and the superscripts indicate the monitoring station. The regression parameters $\beta_{0,m}$ and $\beta_{1,m}$ are respectively the unique intercept and slope estimated for each month of the year. Measured daily average discharge data for both stations were converted to monthly average discharge from 1993 through 2007. Therefore, for any given month, up to 15 observations of monthly average discharge at stations McIntire and Elliott are available. Any month in which observation records are only available for one of the two stations is discarded. The combined datasets for both stations McIntire and Elliott were then split into two subsets; one subset from 1993 to 2001 for calibration of the regression model; and the second subset initially included the period from 2002 to 2007 for verification of the calibrated regression model, which has been updated and extended through 2011. The regression parameters, $\beta_{0,m}$ and $\beta_{1,m}$, are estimated using data from 1993 to 2001, *i.e.* the calibration period, by standard minimization of the sum-of-square error.

Table 3.3-12 presents the calibrated monthly regression coefficients for the McIntire-Elliott discharge correlation. Station Elliott is approximately 10 miles downstream of station McIntire and there are no major diversions between these two stations; thus mean monthly discharge is generally

very similar in magnitude among the stations as reflected by the consistent slope (β_1) parameter on the order of unity. The intercept parameter (β_0) is indicative of monthly losses or gains between the stations. Winter months of January, February, and March contain positive intercepts indicating a typical gain in flow (due to local runoff) between the two stations. All other months contain a negative intercept indicating flow is generally lost due to seepage and evaporation between the two stations.

Table 3.3-12. Calibrated Monthly Regression Coefficients for McIntire-Elliott Correlation

Regression Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
β_0	9.00	17.85	9.05	-23.33	-11.77	-18.09	-11.35	-13.18	-15.71	-9.67	-2.81	-23.59
β_1	1.00	0.99	0.97	1.01	1.00	1.00	0.98	0.98	1.00	0.99	0.98	1.05

Figure 3.3-4 presents the correlation plot of measured and modeled discharge at station Elliott on log-log scale. Differing symbols are plotted for the calibration and verification subsets along with the 45° line of perfect agreement. The correlation is excellent in comparing the predicted flow at station Elliott (from Equation 1) with measured flow at station Elliott. The overall R^2 statistic calculated for the calibration dataset is 0.999 indicating nearly all of the observed variance is explained by the proposed model. The overall R^2 statistic for the verification dataset is 0.997 declining slightly but remaining high demonstrating excellent model performance.

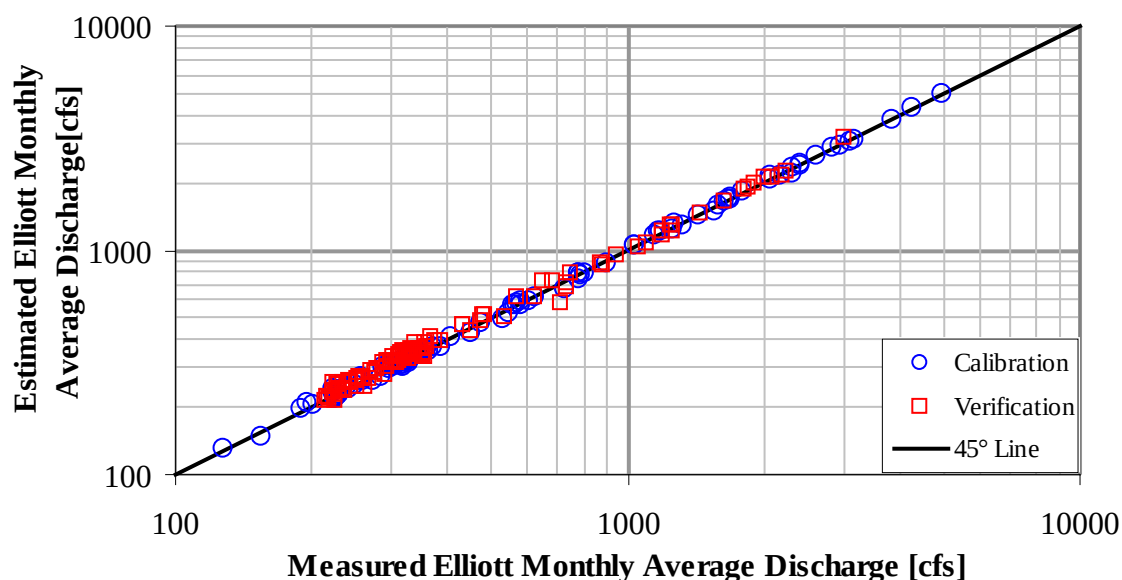


Figure 3.3-4. Station Elliott Measured and Estimated Monthly Average Discharge [cfs]. Different symbols are used to distinguish calibration (1993-2001) and verification (2002-2011) datasets

3.3.3.3 Regression Model #2: Flow Correlation for Stations Frandy and Golf

Discharge at station Frandy can not be estimated from observed stage records because of tidal influence. Upstream from station Frandy at station Golf, discharge data is available estimated from observed stage records. Simulated monthly average discharge at station Golf is also available from EBMUDSIM model output. However, it can not be assumed that the discharge at station Frandy is the same as the discharge at station Golf since a number of riparian diversions exist between the

stations. Without discharge records for station Frandy, a linear regression of flow at station Frandy to flow at upstream station Golf is not possible.

The convention selected for assigning flow at station Frandy based on the discharge at station Golf is the following. Channel losses between stations Golf and Frandy are estimated to be about 15 cfs on average. During the irrigation season (March through September), diversions between stations Golf and Frandy can account for a maximum additional reduction in flow of approximately 15 cfs assuming the irrigation pumps are operating at full capacity. A maximum possible reduction in flow during irrigation season, therefore, is assumed to be 30 cfs. Based on the information available, the following conservative assumption is applied to estimate the flow at station Frandy based on the flow at station Golf. Note that this assumption represents a worst-case reduction in flow that could occur at station Frandy based on the information available. Worst-case reductions in flow will produce the highest simulated temperatures due to inverse correlation between these two variables. If, for example, riparian diversions are less than 15 cfs, the flow reduction from station Golf to station Frandy would be *less than* that assumed and, therefore, water temperature at station Frandy would be *less than* that predicted by SSTEMP. Based on the discussion above concerning channel losses and riparian diversions from the lower Mokelumne River, the following model is applied to estimate the flow at station Frandy as a function of the flow at station Golf.

$$\text{Equation 2: } Q_m^{\text{Frandy}} = \begin{cases} 1 \leq m \leq 2 & \max \{Q_m^{\text{Golf}} - 15\text{cfs}, 1\} \\ 3 \leq m \leq 9 & \max \{Q_m^{\text{Golf}} - 30\text{cfs}, 1\} \\ 10 \leq m \leq 12 & \max \{Q_m^{\text{Golf}} - 15\text{cfs}, 1\} \end{cases}$$

In Equation 2, m is an index representing the calendar month. The variable Q_m^{Golf} represents the monthly average flow at station Golf corresponding to the m^{th} month and the variable Q_m^{Frandy} represents the monthly average flow at station Frandy in the m^{th} month. In months where the reduction in flow from station Golf results in a negative flow assignment for Frandy, a minimum value of 1 cfs is assumed.

3.3.4 SSTEMP Model Calibration

A set of SSTEMP input parameters were calibrated to provide a least-squares best fit to water temperature monitoring data at three stations, Elliott, Golf, and Frandy. Water temperature monitoring was initiated in 1994 for monitoring stations on the lower Mokelumne River. Mean daily water temperature records for each month were converted to mean monthly water temperature for stations McIntire, Elliott, Golf, and Frandy with Equation 3 below. Maximum monthly temperatures were also calculated from maximum daily temperature records (see Equation 4).

$$\text{Equation 3: } W_m = \frac{1}{n_m} \sum_{j \in \Gamma_m} T_j^{\text{mean}}, \quad m = 1, \dots, 12$$

$$\text{Equation 4: } X_m = \frac{1}{n_m} \sum_{j \in \Gamma_m} T_j^{\text{max}}, \quad m = 1, \dots, 12$$

In Equations 3 and 4 above, j and m are index variables for Julian days and months, respectively. The variable W_m is the monthly average of daily average water temperature or T^{mean} and X_m is the monthly average of maximum daily water temperature or T^{max} . Also, n_m is the number of days for month m , and I_m is the index set of Julian days for month m .

The available POR for each station was split into two subsets, one for calibration and one for verification. The period from 1994 through 2002 was used for calibration and the period from 2003 through 2008 was used for verification. The dependent variable selected for calibration was the mean monthly water temperature for stations Elliott, Golf, and Frandy. Manual adjustments to input fields under general categories of *geometry* and *optional shading variables* were conducted to provide a best-fit match to the calculated monthly mean temperatures derived from the monitoring records. Predicted monthly maximum water temperatures from SSTEMP were also compared against historical monthly maximum temperatures from daily average water temperature records for each station during the model calibration; however calibration adjustments to model parameters were based only on achieving the best performance for monthly mean water temperatures as these temperature outputs were converted to monthly maximum seven-day (moving) average of daily maximum water temperatures required for the biological impact assessment through another correlation described in the next section (see Section 3.3.5 below). Initial estimates for the set of *optional shading variables* were established based on general field characteristics of each reach. Upstream reaches have relatively taller and denser riparian vegetation closer to the active channel relative to downstream reaches.

Table 3.3-13 presents the calibrated model parameters. In general, increasing the *optional shading parameters* characterizing the riparian vegetation (*i.e.* vegetation height, vegetation crown, vegetation offset, and vegetation density) tended to decrease temperatures in the warmest months of June through September. Decreases to the A Term and B Term model parameters lead to small decreases in monthly average temperatures in late spring to early fall and a significant decrease in monthly maximum temperatures in all months.

The correlation plots of measured and modeled mean and maximum monthly temperatures for stations Elliott, Golf, and Frandy are shown in Figure 3.3-5 to Figure 3.3-10. Peak temperatures generally occur in the months of June, July, and August for stations Golf and Frandy.

Table 3.3-13. Calibrated SSTEMP Input Model Parameters

Parameter	Segment 1: McIntire to Elliott	Segment 2: Elliott to Golf	Segment 3: Golf to Frandy
Accretion temperature [°F]	55.0	55.0	55.0
Latitude [degrees]	38.14	38.14	38.14
Segment Length [miles]	9.9	14.3	9.0
Upstream Elevation [ft msl]	100	71	29
Downstream Elevation [ft msl]	71	29	0
A term ^a [sec/ft ²]	12.5	12.5b	12.5
B term ^a	0.200	0.200c	0.15
Manning's n	0.035	0.035	0.035
Segment Azimuth [degrees]	90	90	90
Topographic Altitude ^d [degrees]	45/45	15/15	15/15
Vegetation Height ^d [ft]	50/50	50/50	40/40
Vegetation Crown ^d [ft]	30/30	30/30	20/20
Vegetation Offset ^d [ft]	5/5	5/5	10/10
Vegetation Density ^d [%]	60/60	50/50	15/15
Ground Reflectivity [%]	40	40	40

^a For definition of terms A and B, see Bartholow (2002) page 6.

^b For Elliott to Frandy mean monthly temperature, a value of 16.5 is assigned for months April through October.

^c For Elliott to Frandy mean monthly temperature, a value of 0.275 is assigned for months April through October.

^d Note that the parameter on the left of the "/" represents left bank and the parameter on the right represents right bank. Symmetry is assumed for right and left bank, thus the parameters are the same.

The R^2 statistic for the calibration and verification datasets of mean monthly water temperature and maximum monthly water temperature for each station is presented in Table 3.3-14. The range in R^2 over all datasets and dependant variables is 0.87 to 0.99 indicating that a high degree of the total variance of each dependent variable is explained by the model. Furthermore, the R^2 statistic calculated for each verification dataset is higher than the R^2 statistic calculated for the corresponding calibration dataset reflecting a high predictive skill of the calibrated SSTEMP model. Also, the calculated R^2 statistic is higher for downstream stations relative to upstream stations in each dataset.

Table 3.3-14. Mean Monthly and Maximum Monthly Water Temperature Calibration and Verification R^2 Statistics for Station Elliott, Golf, and Frandy

Station	Mean Monthly		Maximum Monthly	
	Calibration 1994-2002	Verification 2003-2008	Calibration 1994-2002	Verification 2003-2008
Elliott	0.867	0.946	0.882	0.951
Golf	0.954	0.978	0.951	0.971
Frandy	0.966	0.992	0.952	0.973

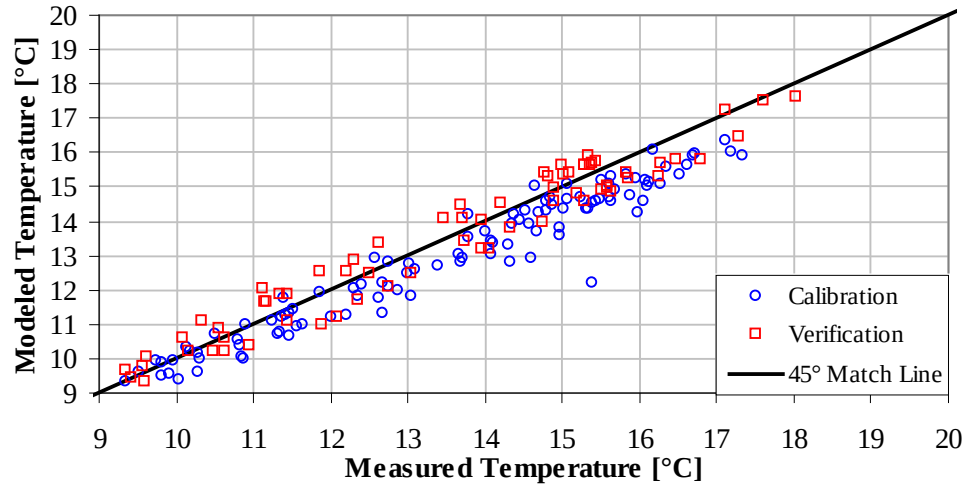


Figure 3.3-5. Modeled and Measured Monthly Average Temperature, Station Elliott

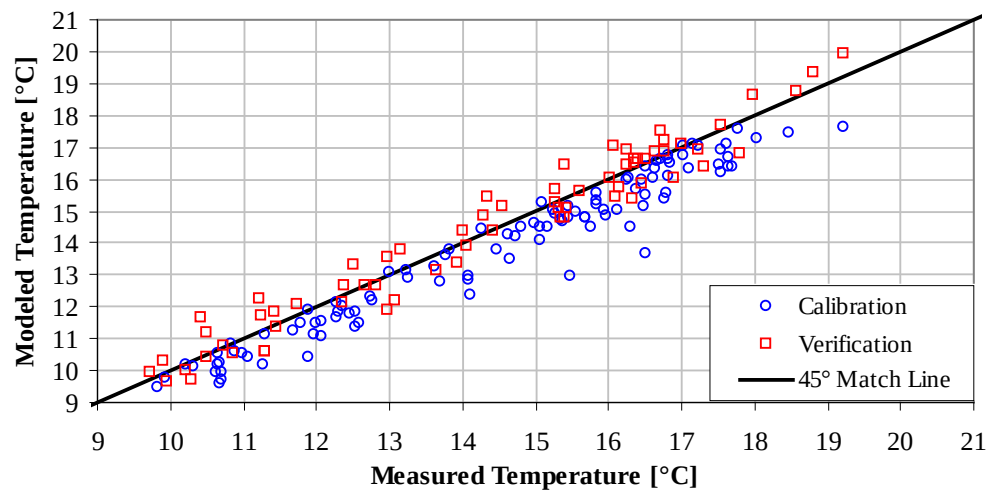


Figure 3.3-6. Modeled and Measured Monthly Maximum Temperature, Station Elliott

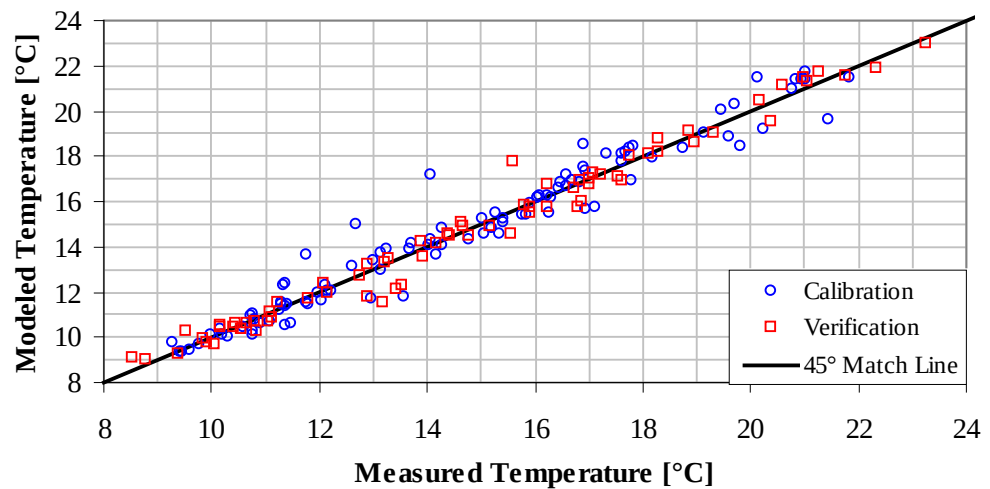


Figure 3.3-7. Modeled and Measured Monthly Average Temperature, Station Golf

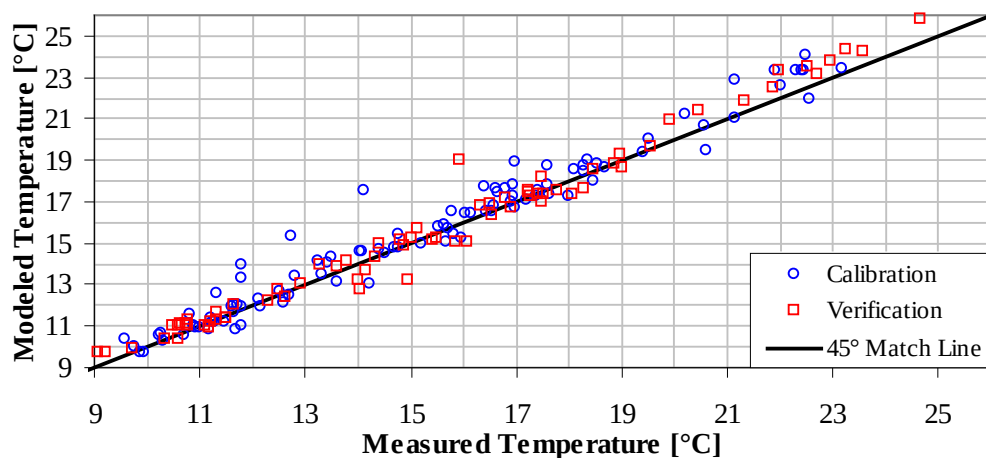


Figure 3.3-8. Modeled and Measured Monthly Maximum Temperature, Station Golf

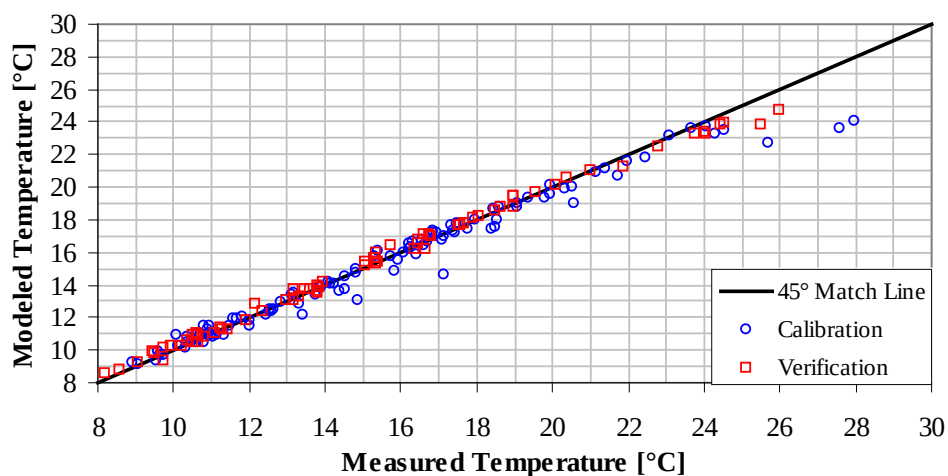


Figure 3.3-9. Modeled and Measured Monthly Average Temperature, Station Frandy

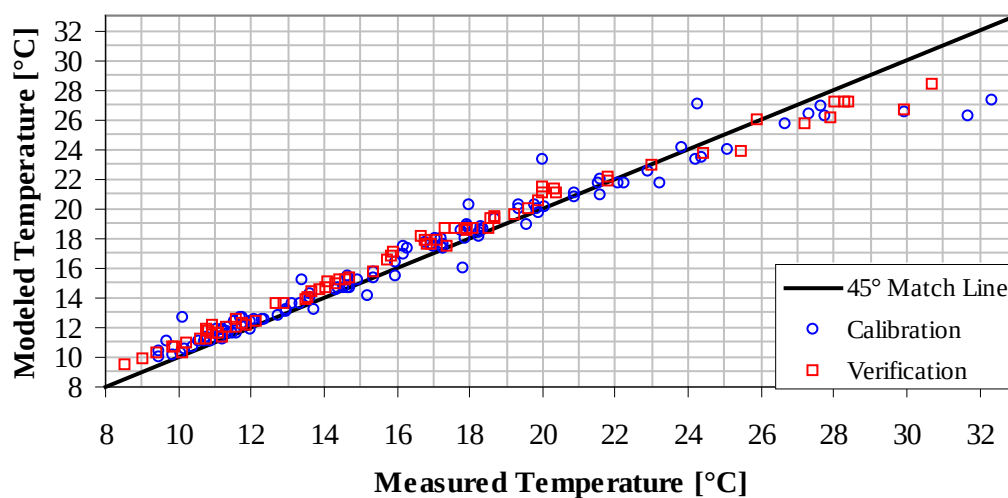


Figure 3.3-10. Modeled and Measured Monthly Maximum Temperature, Station Frandy

Table 3.3-15 presents the root-mean-square-error (RMSE) statistics by month for each station and the average RMSE aggregating all years and months. The average RMSE is similar for stations Elliott and Golf at about 0.7°C and increases to about 0.9°C for station Frandy. Station Frandy is expected to exhibit the highest lack-of-fit statistics because of tidal influence that is not captured in the model.

Table 3.3-15. RMSE Summary Statistics of Mean Monthly Water Temperature [°C] for 1994-2008 POR

Month	Station		
	Elliott	Golf	Frandy
January	0.43	0.55	0.59
February	0.38	0.46	0.37
March	0.66	1.28	1.33
April	1.07	0.58	0.80
May	0.85	0.67	1.12
June	0.79	0.59	1.02
July	0.86	0.76	1.18
August	0.79	0.39	1.28
September	0.79	0.95	0.96
October	0.56	0.84	0.62
November	0.45	0.58	0.71
December	0.51	0.58	0.59
Overall	0.71	0.72	0.93

3.3.5 Correlation between Monthly Average Water Temperature and Monthly Maximum of 7-Day Moving Average of Maximum Daily Water Temperature

The EPA's thermal temperature criteria for Pacific Northwest fish are adopted for the environmental impact assessment (USEPA, 2003). The thermal criteria for Chinook salmon and steelhead trout adapted for the lower Mokelumne River is presented below in Table 3.3-16. These criteria are specific to the monthly maximum of the seven-day (moving) average of daily maximum (MM7DADM) water temperature. The SSTEMP model output, however, is mean monthly water temperature. Thus, a correlation between the MM7DADM and mean monthly water temperatures is necessary using historical monitoring records. This section presents the correlations for monitoring stations Elliott, Golf, and Frandy¹⁷. The simple linear regression equation relating monthly mean water temperature (μ_m) to the MM7DADM (ψ_m) is shown below in Equation 5. Equation 5 is applied for each month and for each station Elliott, Golf, and Frandy as required for evaluation of the EPA criteria in Table 3.3-16. The remainder of this section presents the calibration and verification results for each station. The datasets for each station spans 1994 through 2009. The period of 1994 to 2001 is used for calibrating each regression equation; the period of 2002 to 2007 is used for verification, which has been updated to include recent monitoring data through 2011.

Equation 5:
$$\psi_m = \beta_{0,m} + \mu_m \beta_{1,m}, \quad m = 1, \dots, 12$$

¹⁷ A correlation for station McIntire is not necessary as this station is not one of the designated stations for the thermal assessment listed in Table 3.3-16.

The parameters $\beta_{0,m}$ and $\beta_{1,m}$ are the m^{th} monthly intercept and slope regression coefficients.

Table 3.3-16. EPA Thermal Temperature Criteria for Chinook Salmon and Steelhead Trout Adapted for the Lower Mokelumne River. Temperature criteria are defined using seven-day moving average of maximum daily water temperature and represent an upper bound

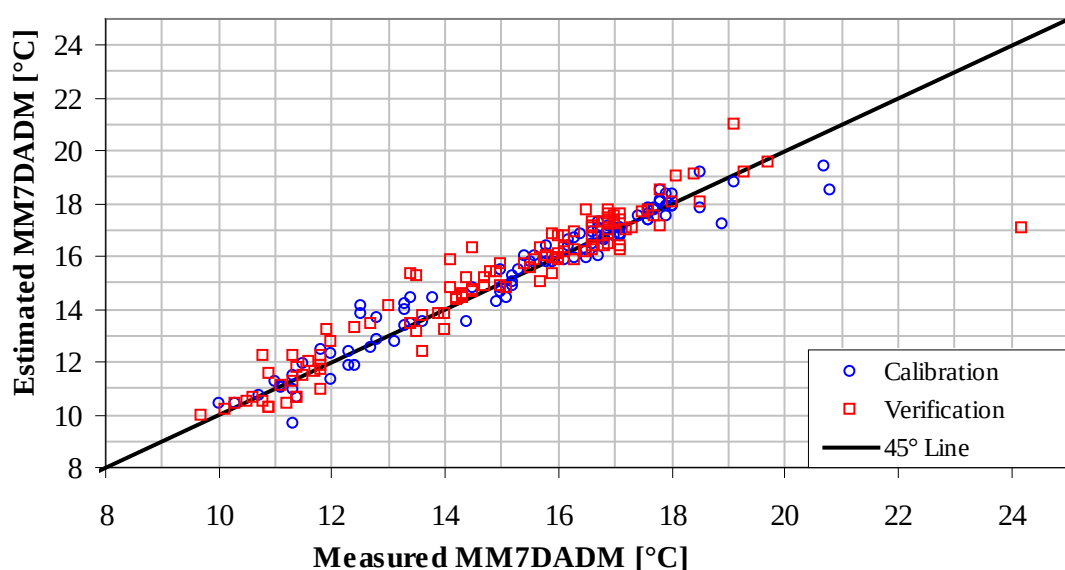
Species/Life Stage	Period of Interest	Applies to Station	Temperature Criteria
Chinook Salmon Adult Migration	Sep-Dec	Frandy	18°C
Chinook Salmon Spawning/Incubation	Oct-Mar	Elliott	13°C
Chinook Salmon Juvenile Rearing	Jan-Jun	Golf	16°C
Chinook Salmon Smoltification	Apr-Jun	Golf	15°C
Chinook Salmon Emigration	Jan-Jun	Frandy	18°C
Steelhead Adult Migration	Sep-Feb	Frandy	18°C
Steelhead Spawning/Incubation	Dec-May	Elliott	13°C
Steelhead Juvenile Rearing	Jan-Dec	Golf	16°C
Steelhead Smoltification	Feb-Jun	Golf	14°C
Steelhead Emigration	Feb-Jun	Frandy	18°C

3.3.5.1 Regression Model #3: Monthly Maximum of Seven-Day Average Maximum Daily Water Temperature Correlation to Mean Monthly Water Temperature, Station Elliott

Monthly average water temperature for station Elliott (presented in Table 3.3-4) was correlated to MM7DADM for station Elliott using Equation 5. Historical MM7DADM is presented in Table 3.3-17. Figure 3.3-11 shows the correlation plot for calibration and verification datasets for station Elliott.

Table 3.3-17. Historical Monthly Maximum of Seven-Day (Moving) Average of Daily Maximum Water Temperatures, Station Elliott. Data are unavailable from February to May, 2007

Month	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Jan	10.7	12.3	13.4	12.4	11.5	10.3	12.0	11.1	11.4	11.6	11.1	10.5	11.8	10.9	10.1	9.7	11.4	10.8
Feb	12.0	11.1	12.8	11.0	11.3	10.0	12.3	11.3	11.8	11.7	11.5	10.6	10.9	--	11.4	11.3	11.8	10.3
Mar	20.8	12.5	12.5	12.7	11.4	11.3	13.3	13.4	13.9	14.1	13.4	11.8	11.2	--	13.0	11.9	13.5	10.9
Apr	17.6	12.8	15.2	15.0	13.3	13.1	15.2	15.1	14.2	14.4	15.0	12.7	10.8	--	14.3	14.7	14.5	11.3
May	16.8	13.8	15.9	16.9	14.5	14.9	16.3	15.8	15.1	16.1	16.0	13.6	13.5	--	16.1	15.6	14.7	12.0
Jun	17.6	15.6	16.6	17.6	15.8	16.7	16.1	16.7	15.9	17.3	16.8	15.7	14.9	16.5	19.1	16.3	15.9	14.5
Jul	18.0	18.5	16.7	17.6	16.7	16.5	17.1	17.6	17.0	17.7	17.0	16.9	16.9	16.9	19.7	17.0	16.6	17.5
Aug	17.8	19.1	18.0	17.7	17.9	17.0	17.4	18.0	17.0	18.5	16.9	17.2	17.1	17.8	19.3	16.8	17.1	18.1
Sep	20.7	17.8	17.8	17.0	18.5	17.1	16.8	17.9	16.9	17.6	16.6	17.1	17.1	18.0	18.4	16.5	16.9	16.6
Oct	18.9	17.9	17.7	16.2	18.0	16.4	16.3	17.1	15.7	16.9	16.1	16.6	24.2	16.8	17.8	16.0	16.6	16.3
Nov	15.2	17.1	16.6	15.8	16.5	15.4	15.3	15.5	15.9	16.0	14.8	15.8	16.3	15.5	15.0	16.0	16.6	15.4
Dec	11.8	16.2	15.0	15.0	14.4	15.1	13.3	13.6	14.3	14.3	12.4	14.5	14.2	13.4	14.0	14.0	14.1	13.6

**Figure 3.3-11 Correlation for Measured and Estimated Monthly Maximum of Seven-Day Average of Daily Maximum, Station Elliott**

The calibrated monthly regression coefficients for station Elliott is presented in Table 3.3-18. The pooled R^2 statistics for the calibration and verification datasets were 0.947 and 0.939, respectively.

Table 3.3-18. Calibrated Monthly Regression Coefficients for Equation 5, Station Elliott

Regression Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
β_0	-0.201	1.91	-17.2	0.971	-4.21	-5.97	4.56	4.15	-7.69	3.20	7.34	2.37
β_1	1.11	0.911	2.73	1.09	1.46	1.56	0.831	0.855	1.56	0.909	0.589	0.978

3.3.5.2 Regression Model #4: Monthly Maximum of Seven-Day Average Maximum Daily Water Temperature Correlation to Mean Monthly Water Temperature, Station Golf

This section presents the results of the correlation of MM7DADM to monthly average water temperature for station Golf using Equation 5. Monthly average water temperature is presented in Table 3.3-6 and historical MM7DADM is presented in Table 3.3-19. Calibration and verification datasets of estimated MM7DADM with measured MM7DADM are shown in Figure 3.3-12.

The calibrated monthly regression parameters for station Golf is presented in Table 3.3-20. The pooled R^2 statistics for the calibration and verification datasets were 0.973 and 0.965, respectively.

Table 3.3-19. Historical Monthly Maximum of Seven-Day (Moving) Average of Daily Maximum Water Temperatures, Station Golf. Data are unavailable from January to July, 1994

Month	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Jan	--	12.6	12.4	12.2	12.3	11.0	12.2	10.9	11.7	12.0	11.2	10.2	11.9	10.2	9.9	10.4	11.5	10.4
Feb	--	11.0	12.5	10.6	12.1	10.0	12.4	11.7	13.1	12.1	12.2	10.7	11.4	11.5	12.1	12.8	12.5	10.6
Mar	--	12.4	12.0	11.5	11.4	11.2	13.6	16.0	16.3	15.7	16.1	11.9	12.1	15.0	15.1	15.2	14.8	11.4
Apr	--	11.4	14.7	15.0	13.5	13.7	17.0	18.7	17.5	15.8	16.9	12.9	11.8	18.1	16.6	18.9	15.8	11.9
May	--	12.1	17.0	17.9	14.6	15.7	18.1	19.4	18.3	18.8	17.4	14.0	13.8	19.0	19.4	19.4	15.4	14.1
Jun	--	13.1	18.4	18.3	16.1	18.3	18.2	22.2	18.8	17.3	19.0	16.4	16.4	23.0	24.9	19.7	18.5	16.3
Jul	--	14.9	17.8	23.7	16.8	18.4	19.6	23.0	23.3	19.5	23.3	18.0	18.3	23.6	25.7	23.2	19.0	18.4
Aug	22.5	17.7	19.1	23.1	18.0	18.5	21.5	23.6	22.7	20.3	22.5	19.6	19.9	23.7	24.6	22.4	20.7	19.8
Sep	23.4	17.0	19.0	22.9	20.7	20.0	19.4	23.4	22.5	20.3	21.9	19.7	19.7	23.6	22.6	21.5	19.9	19.6
Oct	22.4	16.9	19.0	19.5	17.9	18.7	18.2	20.1	18.3	19.0	19.4	18.1	16.6	18.5	20.9	18.6	18.2	17.6
Nov	14.9	16.3	15.5	16.4	15.9	15.7	14.9	16.0	15.4	15.9	14.6	16.2	16.0	16.3	16.2	15.8	16.2	16.0
Dec	10.6	15.0	13.8	14.8	13.8	14.3	12.8	12.3	12.9	14.0	12.5	13.7	13.3	12.4	13.6	13.0	13.2	13.3

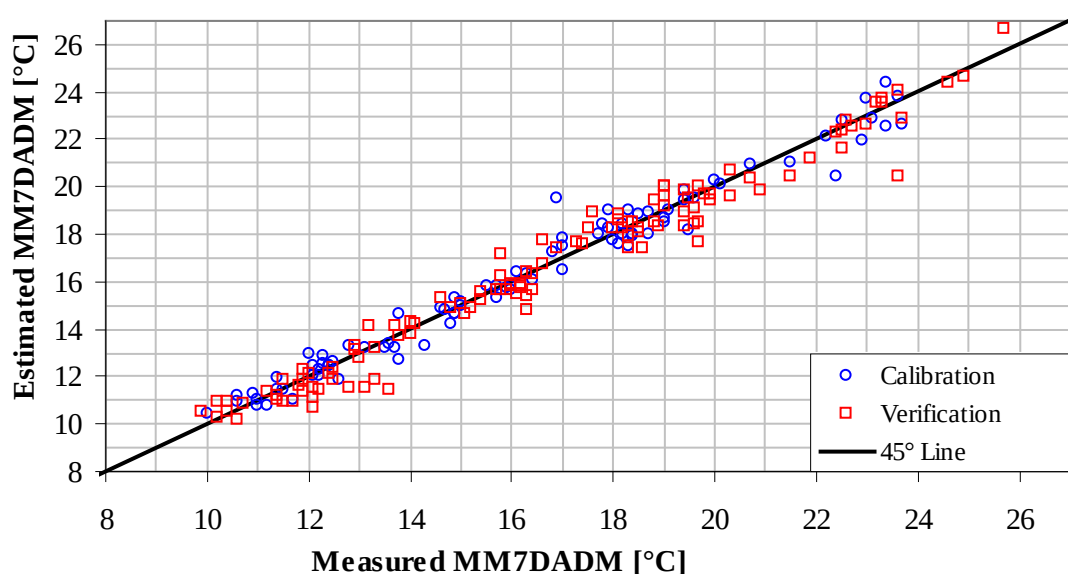


Figure 3.3-12. Correlation for Measured and Estimated Monthly Maximum of 7-Day Average of Daily Maximum, Station Golf

Table 3.3-20. Calibrated Monthly Regression Coefficients for Equation 5, Station Golf

Regression Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
β_0	3.64	1.72	-4.78	-5.84	-1.84	-2.90	-3.78	-1.84	-8.36	-9.93	10.1	1.77
β_1	0.780	0.909	1.51	1.57	1.22	1.27	1.31	1.17	1.53	1.77	0.403	1.02

3.3.5.3 Regression Model #5: Monthly Maximum of Seven-Day Average Maximum Daily Water Temperature Correlation to Mean Monthly Water Temperature, Station Frandy

This section presents the results of the correlation of MM7DADM to monthly average water temperature for station Frandy using Equation 5. Monthly average water temperature is presented above in Section 3.3.2 (see Table 3.3-7). Historical MM7DADM is presented below in Table 3.3-21 for station Frandy. Calibration and verification datasets of estimated MM7DADM with measured MM7DADM are plotted in Figure 3.3-13.

The calibrated monthly regression parameters for station Frandy is presented in Table 3.3-22. The pooled R^2 statistics for the calibration and verification datasets were 0.977 and 0.954, respectively.

Table 3.3-21. Historical Monthly Maximum of 7-Day Average of Daily Maximum Water Temperatures, Station Golf. Data are unavailable August, 1994

Month	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Jan	10.1	12.9	12.2	11.9	11.7	11.2	12.4	10.9	11.5	12.3	10.9	10.1	11.8	9.6	9.9	10.4	11.1	10.7
Feb	10.6	11.3	12.5	10.6	11.5	10.2	12.6	12.1	14.1	12.6	12.0	11.0	11.4	11.6	12.4	13.5	12.7	10.5
Mar	14.2	12.5	12.1	13.3	11.9	12.0	14.1	18.7	18.1	17.4	15.9	12.2	11.8	15.6	15.9	16.9	16.4	11.6
Apr	18.8	12.9	16.2	17.2	14.4	15.0	18.6	22.0	19.0	17.6	19.2	13.5	12.9	19.3	18.6	21.1	17.2	12.0
May	18.9	14.6	17.3	21.3	15.6	17.1	20.4	24.7	21.2	21.8	19.2	14.6	14.1	20.8	22.7	23.1	16.3	14.6
Jun	21.9	16.2	19.0	22.1	17.0	20.5	21.0	33.0	22.0	19.2	22.1	17.7	17.2	31.5	30.9	23.9	19.7	17.6
Jul	25.2	19.8	19.0	28.7	17.6	20.7	24.4	34.0	29.0	22.1	30.3	19.4	19.1	28.9	31.9	32.3	20.4	20.0
Aug	--	20.1	20.7	30.0	19.9	21.7	27.6	33.1	27.9	22.9	29.5	22.0	21.3	29.1	31.3	31.5	24.3	20.6
Sep	24.7	18.5	20.9	27.4	23.6	23.1	22.5	29.4	26.8	23.0	27.7	22.0	21.3	28.5	28.9	29.5	22.9	21.2
Oct	23.0	18.0	20.8	21.1	18.8	21.0	20.6	22.5	19.8	20.7	21.9	19.3	16.8	20.8	24.6	20.6	20.2	17.7
Nov	15.2	16.7	15.5	16.7	16.0	16.3	15.4	16.1	15.0	15.8	14.3	15.6	15.7	16.8	16.4	15.7	16.6	15.7
Dec	10.6	14.8	13.9	14.2	13.7	14.0	12.8	11.7	12.3	13.5	12.3	13.3	12.7	11.9	13.2	12.1	13.5	12.7

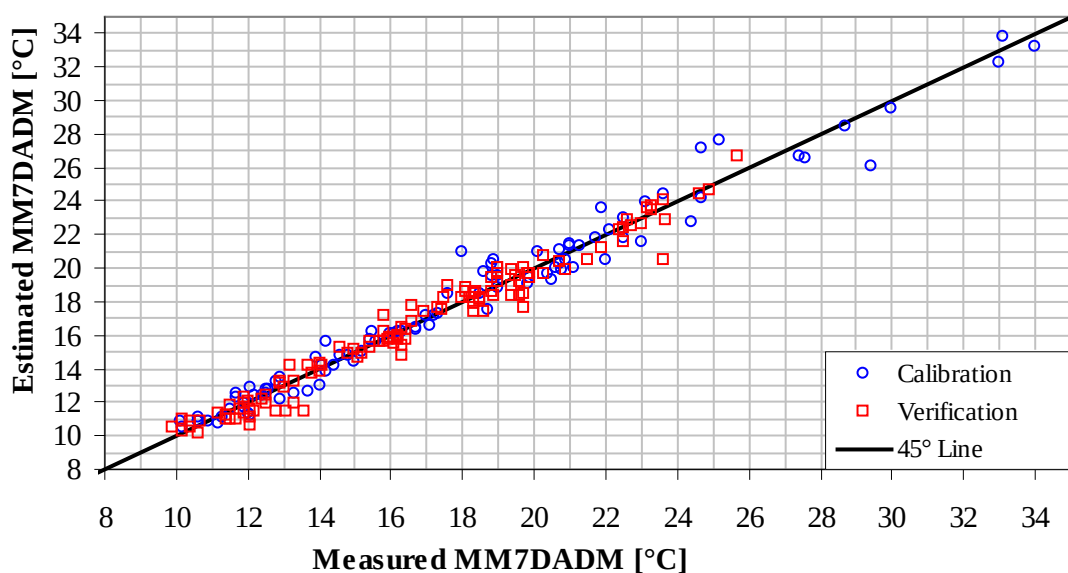
**Figure 3.3-13 Correlation for Measured and Estimated Monthly Maximum of 7-Day Average of Daily Maximum, Station Frandy**

Table 3.3-22. Calibrated Monthly Regression Parameters for Equation 5, Station Frandy

Regression Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
β_0	-0.009	0.816	-5.51	-5.94	-2.93	-6.79	-3.06	-5.27	-14.1	-22.8	10.9	1.90
β_1	1.13	0.994	1.59	1.61	1.32	1.52	1.30	1.42	1.87	2.64	0.375	1.02

3.4 Camanche Reservoir Release Temperature Regression Model

An important component of the environmental impacts assessment is the evaluation of potential project impacts on water temperature. Central to this evaluation is modeling the relationship of reservoir release temperature to changes in reservoir storage. This section presents the background information and regression model used to analyze how changes in Camanche Reservoir storage, as a result of the Project, could affect temperatures downstream of Camanche Dam. This section begins with an overview of the annual temperature cycle for Camanche Reservoir thus establishing the intra-annual temperature management period for the lower Mokelumne River. Then the concept of a critical Camanche Reservoir storage threshold is introduced. The regression model relating reservoir release temperature with end-of-month Camanche Reservoir WSE is presented next. The final section presents the methodology for the use of the regression model in the impacts assessment.

3.4.1 Identifying the Intra-annual Temperature Management Period

The next section, Section 3.4.2, introduces the concept of a critical reservoir storage threshold affecting reservoir release temperature for Camanche Reservoir. However, the concept is only relevant during periods where the reservoir is stratified. This section lays out the background information necessary to establish the intra-annual temperature cycle for Camanche Reservoir.

Camanche Reservoir is located in the foothills immediately below the Sierra Nevada mountain range in California. Like many such reservoirs, Camanche Reservoir exhibits a typical pattern of stratification for most of the year as a natural response to predictable meteorological forcing following seasonal patterns driven by the solar cycle (Deas and Lowney, 2000). In winter months, the difference in surface and bottom water temperatures in Camanche Reservoir is typically less than $\frac{1}{2}^{\circ}\text{C}$ and the reservoir is characterized as weakly stratified or de-stratified. Spring brings warmer temperatures and longer days, warming the surface waters of the Reservoir. The reservoir begins to stratify forming three distinct layers; the warm surface layer called the epilimnion, a transitional layer referred to as the metalimnion where temperature rapidly decreases with depth, and lastly the deepest, coldest layer called the hypolimnion. Peak surface water temperatures occur in summer before cooling is initiated in fall as stratification begins to weaken before the cycle restarts again in winter.

An illustration of the Camanche Reservoir annual temperature cycle is provided in Figure 3.4-1 based on data collected in 2002. The upper left corner shows an aerial view of Camanche Reservoir with a red dot indicating Station CAMD located immediately behind Camanche Dam where profiles

are collected. The contour plot on the right side represents the evolution of reservoir temperatures with depth for calendar year 2002 based on temperature profiles collected at Station CAMD. The isotherms are nearly vertical in winter months at the beginning and end of the calendar year representing an unstratified state. From March into May, reservoir stratification develops as three distinct layers become established. June through September marks a period of well-defined stratification as epilimnion temperatures are highest at this time of the year. The vertical profile in the lower left illustrates a single temperature profile collected August 14, 2002 at CAMD where a thick black line and caption is used to show the position of this profile on the contour plot to the right. The dashed lines on the figure delineate the approximate boundaries of the three stratified layers; epilimnion, metalimnion and, hypolimnion.

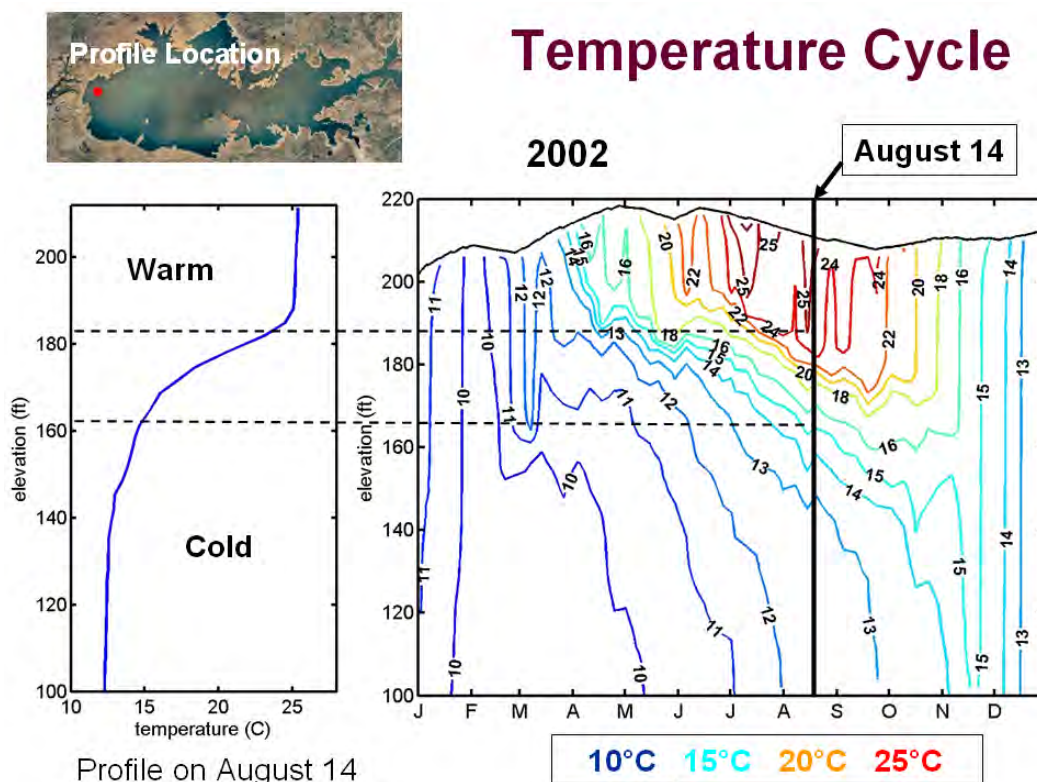


Figure 3.4-1. Camanche Reservoir Temperature Cycle Illustrated with Data Collected in 2002

Figure 3.4-2 shows the difference in surface and bottom water temperature, termed “stratification temperature” recorded immediately behind Camanche Dam at Station CAMD. The data plotted in Figure 3.4-2 is derived from vertical temperature profile data collected from 1988 through 2011. These data show that the difference in surface and bottom water temperature is typically 3°C or less from November through February. Reservoir stratification, therefore, typically begins in March and persists through October.

Monitoring data for Camanche Reservoir shows that the patterns of vertical stratification are generally consistent each year in terms of the relative depth of the stratified layers and both relative and absolute temperature range from top to bottom of the reservoir (Figure 3.4-2)¹⁸. Significant

¹⁸ Relative depth means relative to the water surface; since the water surface is constantly changing in elevation, depth is relative to a axis of 0 depth that constantly changes in reference to a fixed datum used to determine

variations in stratification (*i.e.* temperature and extent) of both the epilimnion and metalimnion, however, can occur in the short-term – on the order of days or weeks – and are explained by short-term meteorological variation that govern the reservoir energy balance.

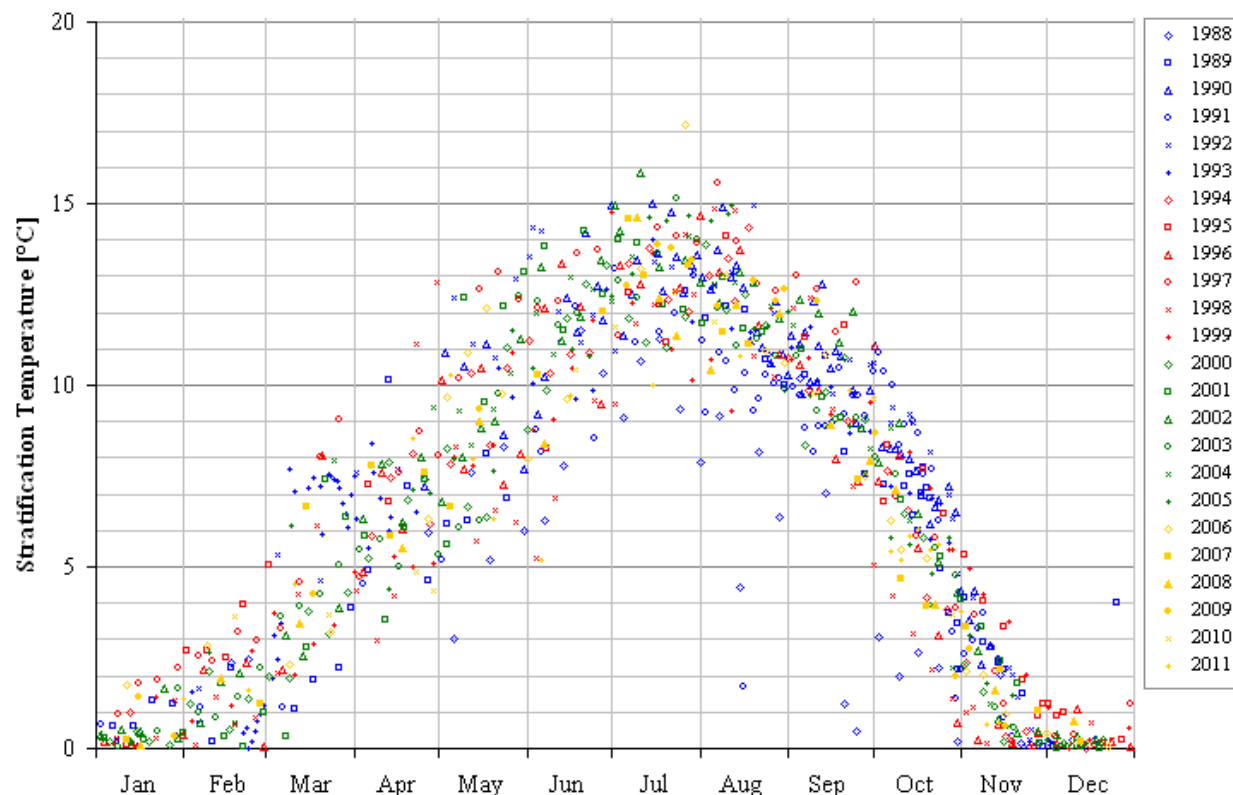


Figure 3.4-2. Annual Reservoir Stratification Temperature Measured at Camanche Dam from 1988 through 2011. Stratification temperature is defined as the bottom water temperature measurement subtracted from the surface water temperature

Camanche Dam has three reservoir outlets, a high level outlet that is 48 inches in diameter with center line elevation at 203 ft msl and a pair of 84 inch diameter low level outlets co-located at the bottom of the dam with center line elevations at 105 ft msl (see Figure 3.4-3). Releases downstream of Camanche Dam are dominated by the releases through the low level outlets, generally containing 96% or more of the total release¹⁹. Historically, the high level outlet is typically opened in winter months thus drawing upper level waters of Camanche Reservoir into the lower Mokelumne River and typically remains open through late spring or summer where its closure is adaptively triggered by thermal conditions monitored downstream of Camanche Dam. The magnitude of the flow through the high level outlet is a complex function of many factors that include the reservoir WSE, the outlet gate setting, and the magnitude of flow through the low level outlets. The flow through

elevation. In the context of relative and absolute temperatures, relative temperature of surface waters is in reference to the bottom temperature in the context of “stratification temperature” as plotted in Figure 3.4-2. Absolute temperature means simply the temperature measured on the Celsius scale relative to 0°C.

¹⁹ Estimate is based on daily average Camanche release records from January 2000 through December 2009. The high level outlet was opened for about 1,100 days over the ten year period (30%). When the high level outlet is closed, 100% of the release from Camanche flows through the low level outlets. During periods when the high level outlet is opened, 84% to 99% of the total release from Camanche Dam flows through the low level outlets.

the high level outlet can range from a few cfs to a maximum around 400 cfs. Figure 3.4-3 is a schematic diagram of Camanche Dam and Reservoir illustrating the high and low outlets in cross-section.

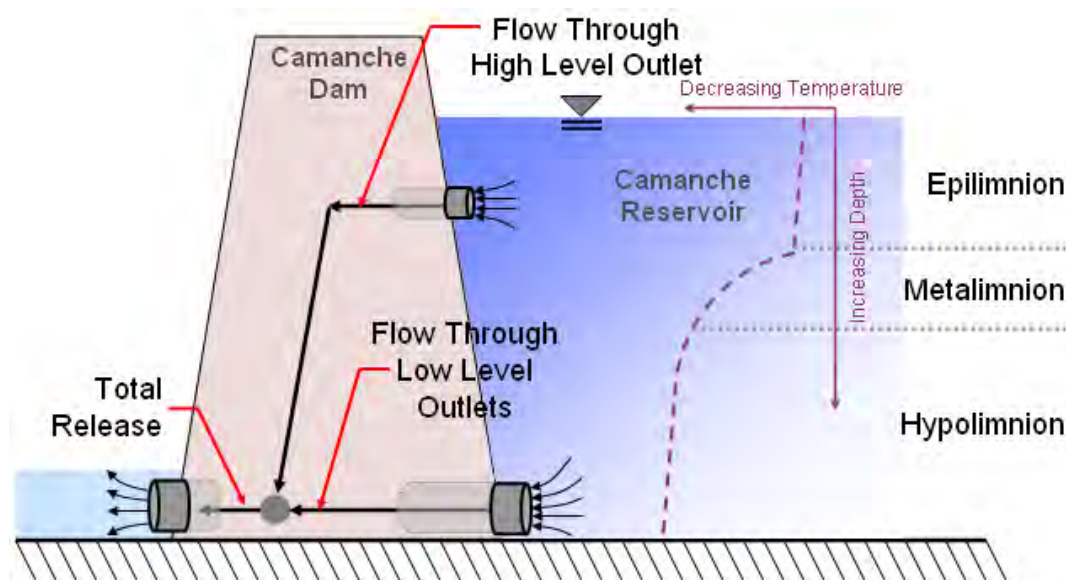


Figure 3.4-3. Camanche Dam and Reservoir Schematic Illustrating Dam Outlets and Reservoir Temperature Stratification (Note figure is not to scale)

The dashed line in Figure 3.4-3 illustrates the typical changes in water temperature with depth or elevation when the reservoir is thermally stratified. The different stratified layers are labeled on the right side of the figure. As reservoir storage decreases, the reservoir WSE can drop below the high level outlet. Once Camanche WSE is below the high level outlet, all reservoir releases must flow through the low level outlets. Low Camanche Reservoir storage could occur, for example, during a prolonged drought where carryover storage is depleted in successive dry or critically dry years.

The hypolimnion generally exhibits a small vertical temperature gradient from top to bottom and is insulated from short-term temperature variations by the metalimnion and epilimnion. Thus the average temperature of the hypolimnion displays a gradual rise in temperature over the year from a minimum in winter to a maximum in fall. As a result Camanche release temperature is reflective of this stable, gradual rise in hypolimnion temperature. Aside from short-term, sharp declines in temperature that typically occur when the high level outlet is closed in spring or summer, the consistent yearly rise in Camanche release temperature is because downstream releases are dominated by flow through the low level outlets, which withdraw water directly from the deepest point in the hypolimnion (see Figure 3.4-3). For example, Figure 3.4-4 shows the mean daily water temperature for station McIntire downstream of Camanche Dam for 2006 and 2007, an Above Normal/Normal JSA year type followed by a Dry year type. The closure date for the high level outlet in both years is indicated on the graph. Since the hypolimnion temperature variation with depth is generally small and releases through the low level outlet are essentially withdrawals from the bottom of the hypolimnion, release temperature is relatively invariant to reservoir storage given there is a sufficiently large amount of water in storage and, therefore, a deep hypolimnion. However, when Camanche storage drops below a critical level and the hypolimnion is depleted the release temperature is no longer insensitive to Camanche WSE.

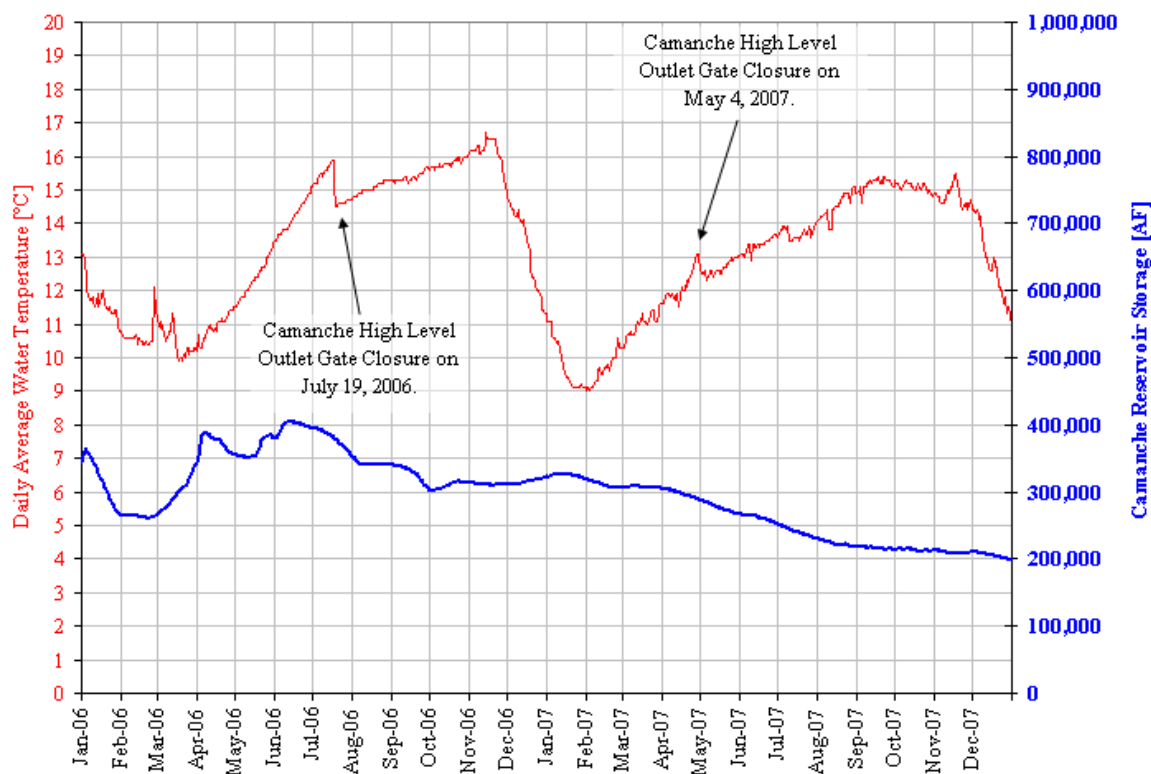


Figure 3.4-4. Mean Daily Water Temperature at McIntire Station Below Camanche, January 2006 through December 2007. Note short periods of missing data are linearly interpolated

During winter months when the reservoir is not stratified or well-mixed, reservoir release temperatures are not correlated with reservoir storage levels. In early winter, temperatures recorded along the lower Mokelumne River are generally highest immediately below the dam and decrease rapidly downstream. Thus, changes in flow or reservoir storage as a result of the Project will not significantly affect water temperatures downstream in winter months. The intra-annual temperature management period is, therefore, the period when the reservoir is typically stratified from March through October.

In the next section a threshold WSE is derived based on historical temperature data. Then the regression model relating reservoir WSE and downstream release temperature is introduced in Section 3.4.3 and the model calibration is presented in Section 3.4.4.

3.4.2 Critical Camanche Storage Threshold Concept

As Camanche Reservoir WSE drops, reservoir release temperature will only gradually warm at first, reflecting the small vertical variation in temperature exhibited by the hypolimnion. As reservoir levels continue falling and the hypolimnion volume is depleted, the much warmer metalimnion is drawn down into the low level outlets' zone of influence and Camanche release temperature begins to increase more rapidly. Thus, at some threshold WSE, the hypolimnion will reach a critical minimum volume and the release temperature will begin to increase at a faster rate. Assuming the Pardee hypolimnion is not depleted, cold water releases from Pardee Reservoir can be used to maintain the Camanche Reservoir hypolimnion; however, once the critical storage threshold is reached for Camanche, cold water releases from Pardee become less effective in maintaining

Camanche Reservoir hypolimnion and ultimately reducing the Camanche release temperature because of the thermal inertia accumulated in Camanche.

Temperature profiles recorded in September or October behind Camanche Dam from 2000 through 2011 are plotted together in Figure 3.4-5²⁰. The months of September and October are selected because Camanche storage tends to be lowest during these months of the intra-annual temperature management period, thus the hypolimnion volume tends to be lowest. Hence, focusing on these months is conservative in that the hypolimnion volume earlier in the intra-annual management period tends to be larger as reservoir storage tends to be higher. To the right of the figure, the stratified reservoir layers are labeled with grey shaded lines indicating the transition zone between each of the three stratified layers.

Over the 11 year period plotted in Figure 3.4-5, a consistent stratification pattern is clearly evident. A relatively narrow range of temperatures is seen in the hypolimnion of 12 to 16°C. A similarly narrow range is observed in the metalimnion. As the hypolimnion warms from September to October, the lowest temperatures are associated with September profiles and the highest with October profiles. The range in temperatures shown for the epilimnion is about twice that of the lower layers, ranging from 17 to 25°C. The highest temperatures for the epilimnion are generally associated with measurements in September as the surface layer generally cools from September to October.

²⁰ Range in Camanche Reservoir WSE over the period of interest was 188.7-224.7 ft msl. Minimum Camanche WSE during the period of interest – September and October from 2000 through 2011 – occurred on September 24, 2008 when Camanche WSE dropped to 188.74 ft msl, the lowest level since February 9th, 1993 when Camanche refilled following the 1987-92 drought period.

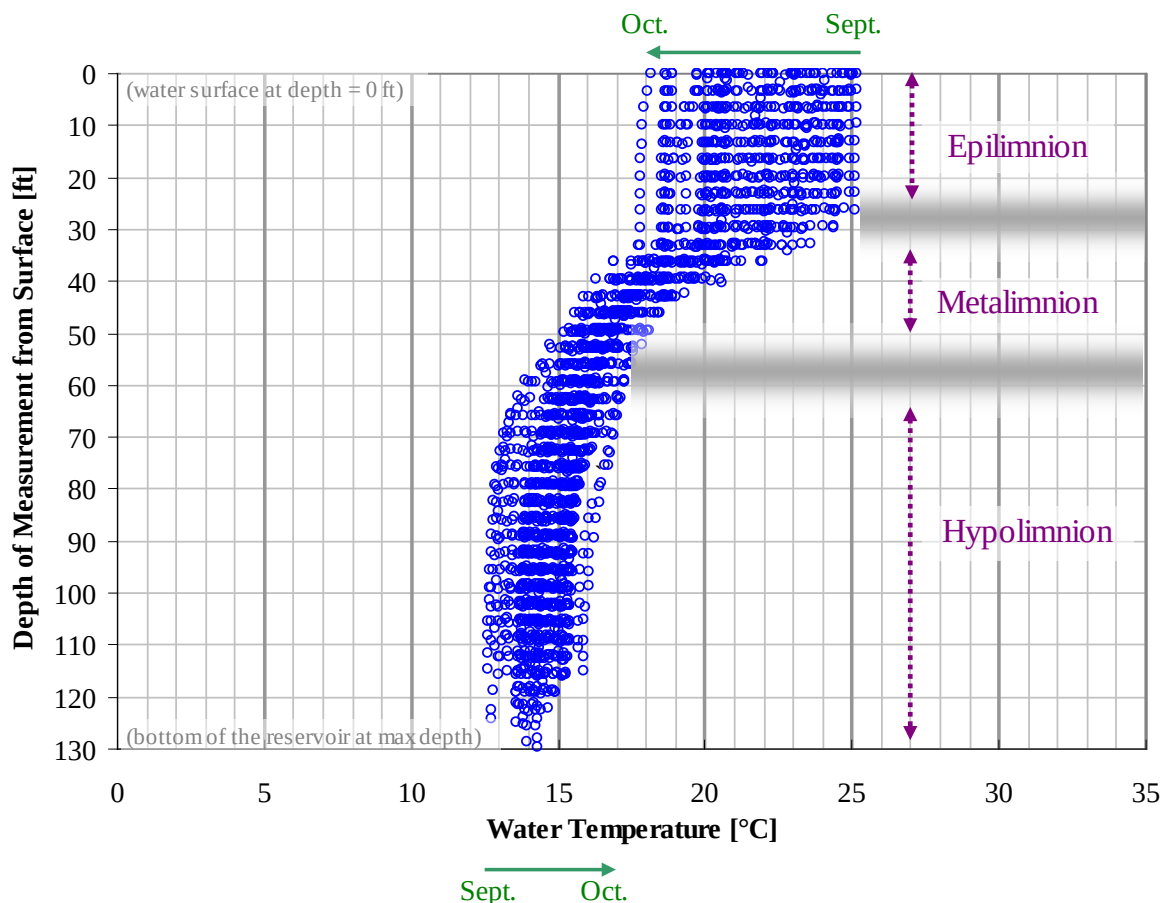


Figure 3.4-5. Water Temperature Profiles Collected Behind Camanche Dam in September and October from 2000 through 2011. Grey bars indicate transitional boundary between stratified layers

The zone of influence²¹ for Camanche Dam's low level outlets is roughly 30 to 40 ft from the bottom of the reservoir for releases on the order of about 250 to 500 cfs. Of course the maximum depth is associated with the bottom of the reservoir. Thus the bottom of the reservoir up to the maximum depth less 40ft defines the vertical extent of the zone of influence. For example if the water surface elevation is 200 ft msl and the maximum depth is 100ft, then the zone of influence would extend from 100 ft msl up to 140 ft msl or from a depth of 60 ft to a depth of 100 ft. Note the maximum extent of the zone of influence equal to 40 ft is adopted as a worst case as this then leads to a *minimum* storage threshold.

As water surface elevation drops, the maximum depth decreases, and the hypolimnion volume thereby decreases. The vertical extent of epilimnion and metalimnion are driven by environmental factors and are therefore assumed to be fixed; decreasing water surface elevation therefore reduces the extent of the remaining layer, the hypolimnion. Assuming the maximum extent of the zone of influence is 40 ft following the discussion above and from Figure 3.4-5 the bottom of the metalimnion is at an approximate depth of 50 ft; the bottom of the metalimnion is expected to begin

²¹ The zone of influence is defined as the volume of water in proximity to a reservoir outlet that is drawn into the outlet. The flow through the outlet therefore is influenced by this larger volume of water that is mixed turbulently as water flows through the reservoir outlet works. For more information, see Davis *et al.* (1987).

to drawn into the low level outlets if the maximum depth is, therefore, reduced to 90 ft²². The bottom elevation of Camanche is roughly 100 ft msl²³. Therefore, the *maximum* water surface elevation expected to result in elevated temperatures blending the metalimnion waters with the hypolimnion through the low level outlets is about 100 ft msl + 90 ft = 190 ft msl. Once Camanche WSE drops below elevation 190 ft msl and continues to decline, the release temperature, therefore, is expected to begin increasing at a much faster rate as a greater proportion of the metalimnion – and eventually the epilimnion – is drawn through the low level outlets. Therefore, the water surface threshold equal to elevation 190 ft msl is designated as the critical threshold where modeled Camanche Reservoir WSE would begin to affect reservoir release temperature. At elevation 190 ft msl, Camanche Reservoir storage is estimated to be 146,700 AF.

3.4.3 Regression Model #6 Description

Adjustments to mean monthly release temperature, used as input to SSTEMP (see Table 3.3-10), are necessary in cases where Camanche storage drops below critical levels thereby affecting release temperature. This section presents a regression model used to account for warmer mean monthly release temperatures due to low storage levels in Camanche Reservoir. The regression model is used to estimate the expected increase in monthly mean release temperature due to critical storage levels in Camanche Reservoir. The regression model is shown below in Equation 6.

Equation 6:
$$T_i = \beta_0 + \beta_1 WSE_i, \quad i = 1, \dots, N$$

In Equation 6, i is an index, T_i is the monthly average release temperature from Camanche Dam in degrees Celsius, WSE_i is the end-of-month Camanche water surface elevation in feet for the corresponding i^{th} month, and β_0 and β_1 are simple linear regression model intercept and slope parameters, respectively. The parameter N is the maximum number of observations which is equal to the intra-annual temperature management period (March through October) multiplied by the number of years available for calibration. The regression model parameter calibration is presented next followed by a description of the use of the regression model in the broader context of the water quality modeling component of this CEQA analysis.

3.4.4 Regression Model #6 Calibration

The first step was to compile monthly average water temperatures for the McIntire monitoring station from gauging records and reconstructed records derived from Mokelumne River Fish Hatchery datasets (presented above in Table 3.3-2 and Table 3.3-9, respectively). Next, corresponding end-of-month Camanche WSE records are assembled that correspond to each monthly average water temperature record for station McIntire.

As discussed above in Section 3.4.2, Camanche Reservoir is typically de-stratified during winter months; thus months of November, December, January, and February are screened out of the dataset compiled. Figure 3.4-6 presents the Camanche WSE dataset and corresponding monthly average water temperature at station McIntire following the procedure outlined above. The POR plotted in

²² Where a maximum depth of 90 ft less the maximum extent of the zone of influence is 40 ft would mean that the upper bound of the water column drawn into the low level outlets is 90 ft – 40 ft = 50 ft which is roughly the bottom of the metalimnion.

²³ Center line elevation of the low level outlets is 105.13 ft and the diameter of the outlet pipe is 7 ft.

Figure 3.4-6 is October 1974 through October 2011²⁴. A red vertical dashed line is shown to distinguish the two subsets of the data above and below Camanche WSE equal to 190 ft msl. Figure 3.4-6 reveals that release temperature is not correlated to WSE for high storage levels in Camanche. However, when Camanche Reservoir WSE drops to an elevation of about 190 ft msl, the release temperature generally begins rising with decreasing WSE. For WSE equal to 170 ft msl and lower, release temperature is clearly a function of Camanche WSE. Based on the assessment described above, the dataset was split into two parts, the first containing all measurement data where Camanche WSE is less than 190 ft msl and the second for all remaining data in which Camanche WSE is greater than 190 ft msl.

The calibrated regression model is plotted as a solid black line in the figure and the calibrated regression equation is presented above the plot legend. At the bottom of the plot the number of observations available in each subset is listed with the R^2 statistic and corresponding p value.

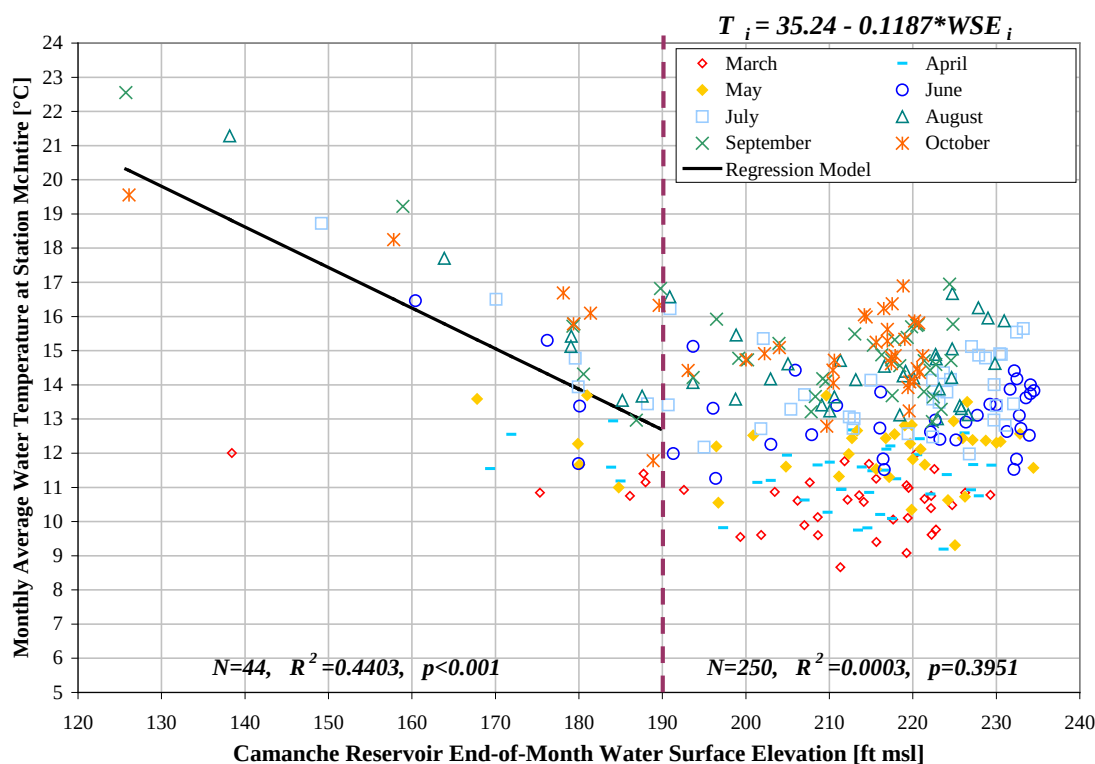


Figure 3.4-6. Regression Model Relating Camanche Reservoir Water Surface Elevation with In-Stream Temperature at Station McIntire. Dataset POR is October 1974 through October 2011 excluding winter months November through February. Monthly average temperature for station McIntire is not available in October 1975, October 1976, and August 1978

Historical data is insufficient to develop unique simple linear regression models to apply for each month of the stratification period (*i.e.* from March through October). Thus historical data for all relevant months are pooled as shown in Figure 3.4-6 and a single simple linear regression model is calibrated for only those data where Camanche WSE is less than 190 ft msl. The limitations on the available data necessarily limit the calibration to a single regression model. However, the

²⁴ Monthly average temperature data are not available for three months: October 1975, October 1976, and August 1978. Hence the total number of observations for the period-of-record is: $N = (2011 - 1975 + 1) * 8 + 1 - 3 = 294$.

application of the model is considered to capture worst-case conditions as the Camanche release temperature will likely be over estimated in earlier months of the stratification period (*i.e.* months associated with spring) when surface waters tend to be cooler. The model is expected to be more accurate when applied to the later part of the stratification period (*i.e.* months associated with summer and fall). Since the objective of this study is to assess and disclose potential environmental effects of the Project, this model limitation was deemed acceptable conditional upon consistent application of the simple linear regression model among the various modeling cases simulated.

3.4.5 Water Quality Modeling Screening Methodology

The technical discussion in the preceding two sections establishes the foundation for the following statement that is fundamental to the water quality modeling procedure for this modeling study.

If simulated end-of-month Camanche Reservoir water surface elevation is reduced to less than 190 ft msl then monthly average Camanche release temperature will be greater than the mean of the monthly average temperature when the reservoir is stratified (from March through October); and – in these instances – mean monthly average water temperature is necessarily adjusted to account for anticipated warming of reservoir releases.

The statement written above is the key to establishing months in which a potential impact to water quality could occur due to project conditions affecting Camanche Reservoir storage levels. Furthermore once these months are identified, the potential impact is then explored further using water quality modeling tools available. The next section describes how the calibrated regression model is implemented.

3.4.6 Regression Model Implementation

The regression model is used to correct for temperature effects of low storage levels which are anticipated to increase Camanche Reservoir release temperature above the mean monthly average in a given month when the reservoir is stratified. Equation 6 however is not unique to a given month of interest and the monitoring dataset is not large enough to justify developing separate regression models for each month from March through October. The effect is that the regression equation using WSE = 190 ft msl results in a singular mean monthly average value equal to 12.7°C. Monthly average Camanche release temperature, however, varies by month (see Table 3.3-10). Thus, implementing the regression model to adjust the reservoir release temperature – a necessary input to the SSTEMP model – requires a modification in order that the equation yields the mean monthly water temperature that is consistent with the month of interest at WSE = 190ft msl. Therefore, the following adjustment is made to Equation 6 such that it results in a unique monthly adjustment where the calibrated slope is retained to adjust the mean monthly average temperature as a function of end-of-month Camanche WSE²⁵.

First, Equation 6 is solved for the intercept, β_0 .

Equation 7:
$$\beta_0 = T_i - \beta_1 WSE_i$$

²⁵ The underlying assumption of this approach is that the intercept parameter *is unique* to each month over the intra-annual temperature management period whereas the calibrated slope *is not unique* over the period. Again, this approach is likely to overestimate the warming effect in spring months when a shallow slope would be expected, yet is expected to be more accurate when applied months associated with summer and fall.

Then WSE_i is set to 190 ft msl with the multi-year mean monthly average water temperature for the month m under consideration, μ_m . The parameters μ_m for each month of the stratification period is listed in Table 3.3-10. The resulting equation shown below is now unique to each month m over the stratification period (March through October).

Equation 8:
$$\beta_0^* = \mu_m - \beta_1(190 \text{ ft msl}), \quad m = 3, 4, \dots, 10$$

Now substitute the form of the intercept shown above in Equation 8 back into Equation 6 and rearrange to yield an equation that is unique to each month m of the stratification period shown below.

Equation 9:
$$T_m^* = \mu_m + \beta_1(WSE_m - 190 \text{ ft msl}), \quad m = 3, 4, \dots, 10$$

Equation 9 is used to estimate the adjusted release temperature, T_m^* , as a function of end-of-month Camanche WSE when end-of-month Camanche Reservoir WSE drops to 190 ft msl or lower. When Camanche WSE is greater than 190 ft msl or in winter months (November, December, January, and February), the mean monthly average water temperature μ_m is assigned as the release temperature. Camanche release temperature is then input to the SSTEMP model along with the appropriate modeled monthly average discharge outputs from the water balance model, EBMUDSIM, to simulate model temperature effects downstream.

Chapter 4

Reservoir Water Quantity Model Results

This chapter presents simulation results from surface water mass-balance reservoir operations modeling for the cases presented in Chapter 2. The baseline case is presented first followed by results for the Project, Programmatic Use, and the Cumulative Cases. Results are also presented for the Project Case without the aqueduct outage scenario activated for 1980 through 1984 that is used to investigate potential impacts without this assumption (See Attachment to Appendix E – Permit 10478 Time Extension Project Without Mokelumne Aqueduct Outage). Simulation results presented are water balance model outputs that include total system storage, reservoir releases and flows at specific locations on the lower Mokelumne River, and Mokelumne River diversions by EBMUD and other agencies. The water supply deliveries and quantities of water saved from customer cutbacks during droughts consistent with District’s Demand Management Program (presented in Section 3.1.1.3) are also presented for each modeling case.

4.1 Case 1: Baseline

Baseline Case assumptions were formulated into the appropriate model input to EBMUDSIM. Selected model output necessary for the impacts assessment is compiled in this section.

Table 4.1-1 presents the simulated end-of-month (EOM) Total System Storage (TSS). Peak TSS typically occurs in June in wet years but may occur in May or July depending on the timing and quantity of runoff. Simulated EOM Camanche Reservoir WSE is presented in Table 4.1-2.

Total Camanche Reservoir releases are shown in Table 4.1-3. The simulated monthly average total Camanche release is used to estimate the monthly average discharge at Elliott with Equation 1 and parameters in Table 3.3-12. The estimated monthly average discharge at Elliott is presented in Table 4.1-4. Because of the high degree of correlation to total Camanche Reservoir releases (in Table 4.1-3), the range and distribution of flows estimated for station Elliott are similar in magnitude and pattern.

Simulated monthly average flows below Woodbridge Irrigation Dam– at station Golf – are presented in Table 4.1-5. Most downstream diversions by riparian and senior appropriators including Woodbridge Irrigation District (WID) and diversions by a junior water rights appropriator, North San Joaquin Water Conservation District (NSJWCD), occur in the reach between Camanche Dam and station Golf. As a result of these diversions and channel carriage losses, the discharge at station Golf is typically much lower relative to the total Camanche releases (in Table 4.1-3) particularly from April to September during irrigation season.

Discharge at Frandy is estimated based on the simulated monthly average flows below WID (in Table 4.1-5) using Equation 2. The resulting estimated monthly average flow at Frandy is presented in Table 4.1-6. The monthly average discharge estimates for station Frandy do not account for downstream effects such as tidal influence from the Sacramento-San Joaquin Delta, Delta Cross Channel operations where up to 10,500 cfs has been diverted into the lower reaches of the North and South forks of the Mokelumne River, and potential influence by the Cosumnes downstream of the monitoring station. The estimates presented are consistent with conservative assumptions

Table 4.1-1. Simulated End-of-Month Total EBMUD System Storage [AF], Baseline Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	611,016	611,715	628,147	639,307	715,845	744,894	687,991	635,397	596,980	585,867	579,873	584,054
1922	591,580	617,916	639,614	650,673	652,937	744,894	691,779	631,525	583,831	574,879	575,713	599,823
1923	613,008	620,711	626,170	655,697	695,265	711,078	667,969	620,707	588,189	578,864	573,266	571,427
1924	569,382	552,109	537,548	534,606	523,628	501,447	479,211	459,721	449,000	436,510	424,223	417,665
1925	420,100	482,756	515,472	556,536	661,093	705,336	661,162	619,583	593,513	582,909	577,576	575,591
1926	576,162	578,931	572,169	577,656	584,973	575,133	558,918	546,057	544,143	547,920	560,673	568,946
1927	587,129	620,711	648,333	672,449	703,392	744,894	688,824	631,560	587,918	577,898	569,137	571,358
1928	573,548	571,259	595,244	626,529	733,752	697,839	666,498	639,026	625,156	612,853	603,126	586,934
1929	569,960	557,857	553,981	555,677	551,101	543,639	535,324	529,261	524,265	517,557	514,758	512,261
1930	513,499	509,063	527,755	534,591	534,895	570,067	555,186	544,028	543,985	547,729	557,439	560,519
1931	552,643	540,245	530,356	513,414	496,551	467,122	441,638	412,704	390,990	377,997	370,525	376,603
1932	387,654	428,156	461,526	486,724	528,097	650,352	635,600	612,970	601,849	589,912	584,039	582,221
1933	572,263	550,182	547,572	565,539	579,261	588,732	579,241	570,167	570,733	569,031	568,738	586,280
1934	598,347	598,933	615,891	601,029	580,148	573,846	558,811	536,122	523,158	514,046	515,068	516,585
1935	520,177	534,576	546,149	621,265	649,479	714,356	669,527	626,991	598,439	588,885	584,802	583,599
1936	607,085	620,711	649,157	672,449	727,799	744,894	688,514	633,253	591,330	581,882	577,334	579,942
1937	573,590	611,948	649,157	682,591	721,133	731,582	681,740	635,123	600,815	590,878	588,210	542,952
1938	554,336	577,786	606,232	552,611	653,903	744,894	697,940	633,114	580,738	572,887	572,104	573,811
1939	577,128	563,186	563,099	562,283	548,732	545,350	535,795	529,115	530,420	534,779	534,827	528,748
1940	558,948	619,685	619,212	656,689	749,804	733,169	683,490	639,440	607,752	598,847	596,453	607,852
1941	613,008	620,711	649,157	684,261	712,178	744,894	689,445	631,176	585,736	576,871	574,663	574,889
1942	569,057	573,742	596,342	639,777	667,910	744,894	698,636	635,700	585,662	575,906	572,155	576,881
1943	567,065	569,757	595,244	672,449	732,809	730,532	679,062	629,711	591,962	584,901	581,619	583,201
1944	580,930	574,828	582,616	575,558	578,847	576,845	554,549	534,318	523,266	517,270	531,839	544,463
1945	555,067	609,723	642,523	656,476	686,665	734,988	680,545	628,094	588,226	579,890	570,163	560,883
1946	570,084	585,393	613,063	634,383	737,368	721,929	676,543	634,351	605,778	596,855	600,528	604,453
1947	605,701	607,743	602,499	610,672	594,712	577,871	553,057	530,760	519,880	518,220	508,633	493,886
1948	499,440	486,026	479,679	501,351	523,049	630,218	608,129	589,131	580,116	573,604	573,688	579,483
1949	582,042	570,322	579,548	609,658	646,932	656,781	635,461	613,755	603,138	591,334	588,094	584,091
1950	596,379	620,711	649,157	687,221	701,373	737,565	678,033	621,596	580,018	573,913	533,216	537,942

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1951	543,097	550,800	595,244	663,722	726,437	692,258	657,691	625,912	605,793	594,862	596,673	607,852
1952	613,008	620,711	641,187	561,606	624,925	736,895	703,839	629,129	565,761	559,907	560,994	572,368
1953	610,140	566,376	583,579	623,729	623,580	665,902	638,836	600,206	575,622	573,913	574,788	574,793
1954	576,881	582,394	603,138	637,595	669,133	647,748	620,087	598,558	589,890	583,310	586,234	588,064
1955	592,780	587,547	584,919	576,997	572,562	572,799	547,666	526,951	516,500	511,131	512,733	550,922
1956	543,097	566,799	622,170	666,714	696,828	744,894	686,304	620,740	568,331	563,891	567,297	574,621
1957	574,966	583,521	600,863	604,014	630,666	683,270	643,304	606,765	585,289	579,890	584,371	590,909
1958	606,885	620,711	649,157	675,407	681,856	744,894	691,113	627,823	571,375	565,884	564,835	560,097
1959	564,756	584,521	595,210	589,150	572,802	560,468	544,211	531,550	530,180	530,162	534,922	542,532
1960	541,341	553,671	562,496	563,732	578,144	588,368	570,435	555,787	543,506	533,781	531,104	528,980
1961	520,676	507,292	491,980	476,902	458,210	441,512	421,432	404,041	396,502	388,116	376,033	363,953
1962	353,921	392,570	414,277	462,415	476,128	544,926	525,769	508,163	499,426	503,595	508,739	516,399
1963	533,087	552,792	570,034	637,568	725,806	744,894	685,037	628,534	583,756	578,864	563,160	568,053
1964	582,664	584,286	588,564	589,646	579,951	571,031	558,404	548,118	548,895	555,423	573,810	546,937
1965	556,621	576,941	618,509	682,997	694,656	726,376	671,489	612,368	578,880	590,576	594,976	607,671
1966	613,008	605,647	608,046	619,735	612,849	587,308	561,721	539,892	531,439	525,003	533,025	576,795
1967	612,827	620,530	648,070	676,192	607,357	714,607	716,490	637,464	571,972	567,635	571,363	576,044
1968	583,946	598,494	608,788	606,319	583,587	568,843	541,116	517,935	507,507	501,020	510,710	526,695
1969	605,763	620,530	648,070	635,683	670,868	744,894	694,334	629,248	577,220	582,184	583,884	597,831
1970	542,856	550,559	602,006	616,965	654,372	688,819	657,013	620,888	597,722	588,946	590,629	607,671
1971	612,827	620,530	648,070	669,351	648,998	689,442	662,608	636,166	611,456	611,102	602,945	607,671
1972	607,811	604,002	621,102	624,884	608,051	616,234	595,296	573,893	565,432	561,881	569,793	583,822
1973	612,827	620,530	648,070	673,499	723,320	724,358	683,181	636,711	604,866	600,899	558,511	569,999
1974	564,650	595,354	641,248	692,734	715,006	731,841	688,903	645,819	606,146	598,303	590,331	585,226
1975	576,017	587,665	633,945	659,492	659,180	724,449	680,419	631,259	593,775	596,673	596,063	596,047
1976	586,463	566,591	553,369	545,106	531,040	509,127	485,682	466,572	455,027	438,888	419,113	396,200
1977	378,159	358,061	344,788	335,325	326,426	309,330	292,128	277,378	271,383	265,811	260,138	243,681
1978	229,938	218,570	220,912	205,619	189,758	168,145	145,423	118,894	104,749	88,586	70,048	55,381
1979	70,165	94,201	155,329	212,902	279,730	327,927	325,474	313,554	309,202	313,908	328,949	354,705
1980	504,974	568,067	630,743	664,644	680,545	723,829	693,172	627,152	574,114	565,099	559,712	561,977
1981	572,697	574,233	585,046	597,676	588,125	572,146	558,232	542,202	538,622	542,543	566,309	537,682
1982	557,526	550,541	591,139	608,455	692,541	730,672	676,282	604,167	537,402	549,764	538,528	549,654
1983	582,098	600,486	639,437	652,768	565,941	683,284	721,728	631,941	548,005	565,582	532,956	537,682

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984	542,838	559,433	612,269	638,637	691,414	700,700	669,845	638,310	605,183	601,865	599,202	606,765
1985	594,750	596,675	610,032	629,384	610,645	589,262	561,796	541,657	533,165	528,562	535,105	542,111
1986	566,049	555,509	594,762	668,855	726,289	736,192	681,485	625,473	583,284	573,974	571,534	565,789
1987	554,658	542,268	543,009	538,403	522,831	505,369	494,082	486,008	483,989	471,394	462,384	456,411
1988	452,038	439,975	434,617	431,454	425,055	415,683	409,465	401,353	396,939	383,730	367,812	352,227
1989	336,890	325,256	358,906	399,372	453,268	460,617	440,066	420,346	413,474	401,687	406,897	410,550
1990	414,746	412,768	425,733	423,034	420,948	420,255	414,094	407,661	409,746	407,132	384,680	366,293
1991	342,345	325,524	339,213	339,055	334,807	345,006	341,769	338,020	342,310	357,587	376,636	386,443
1992	386,823	402,729	427,781	418,741	395,643	370,743	354,634	341,751	328,089	319,726	310,674	313,277
1993	381,149	435,158	528,379	585,791	661,652	727,927	672,456	637,621	598,639	593,051	585,786	581,612
1994	567,586	554,256	543,769	538,551	530,256	520,553	501,788	490,142	492,723	497,662	490,339	503,141
1995	611,172	620,530	636,841	613,828	555,376	693,185	728,685	641,145	568,841	577,234	572,599	575,655
1996	589,144	565,772	606,836	669,813	737,035	735,691	691,605	651,845	616,762	591,964	591,535	575,976
1997	576,956	550,541	594,762	633,907	699,739	694,652	659,509	632,536	613,606	607,540	602,945	593,575
1998	612,827	620,530	648,070	643,471	596,973	721,742	720,308	650,529	587,029	585,263	588,730	596,644
1999	612,827	620,288	643,844	676,388	692,809	735,626	695,217	644,061	602,581	591,663	591,847	585,459
2000	603,610	620,530	648,070	659,352	703,114	698,721	668,930	637,230	612,528	601,926	596,969	591,163
2001	574,751	562,670	571,926	593,407	592,428	579,941	564,595	550,872	544,826	539,917	535,819	549,464
2002	568,787	574,836	608,519	625,724	621,084	615,764	587,756	562,194	547,353	536,829	537,092	548,112
2003	567,999	584,552	595,371	614,792	647,437	687,739	649,722	615,624	595,865	583,693	575,410	587,116
2004	600,712	620,530	648,070	652,777	626,588	617,731	590,372	568,369	554,643	533,900	531,859	543,601
2005	599,773	620,530	648,070	694,424	712,102	744,894	707,391	654,299	608,814	595,768	591,861	584,368
2006	555,534	552,068	610,217	643,652	707,514	744,894	709,111	664,978	614,775	603,677	601,089	607,671
2007	600,592	605,906	619,859	617,785	608,350	591,774	573,643	558,638	553,835	545,050	547,960	548,688
2008	559,624	566,462	583,639	579,131	575,299	569,093	550,967	539,324	519,810	510,802	510,813	507,493
2009	518,620	530,974	576,149	602,625	694,039	677,022	645,120	615,686	590,637	577,415	575,160	607,671
Min.	70,165	94,201	155,329	205,619	189,758	168,145	145,423	118,894	104,749	88,586	70,048	55,381
Max.	613,008	620,711	649,157	694,424	749,804	744,894	728,685	664,978	625,156	612,853	603,126	607,852
Mean	544,804	552,126	573,380	591,371	610,851	632,273	602,785	567,707	542,496	536,708	533,920	536,107
Median	572,263	574,233	596,342	617,785	626,588	683,284	649,722	613,755	574,114	572,887	569,137	571,358

Table 4.1-2. Simulated End-of-Month Camanche Reservoir Water Surface Elevation [ft msl], Baseline Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	222.06	220.99	222.21	222.77	230.88	235.50	228.49	222.16	217.37	220.23	218.79	218.71
1922	219.08	221.94	223.93	224.46	221.76	235.50	229.02	221.58	215.27	218.52	218.15	221.14
1923	222.36	222.36	221.92	225.20	227.98	230.90	225.60	219.92	215.97	219.14	217.76	216.72
1924	215.57	212.50	209.04	206.40	203.19	199.13	194.89	190.94	189.35	193.23	190.15	187.31
1925	186.28	198.40	203.37	209.48	222.98	230.10	224.60	219.75	216.82	219.77	218.44	217.38
1926	216.65	215.87	213.39	213.06	211.88	210.05	208.22	207.60	208.58	214.21	215.76	216.32
1927	218.39	222.36	225.21	227.63	229.13	235.50	228.60	221.58	215.93	218.99	217.11	216.71
1928	216.24	214.62	216.94	220.84	233.34	229.06	225.38	222.71	221.73	224.29	222.36	219.40
1929	216.47	213.68	210.39	209.33	205.94	204.39	203.92	204.54	204.99	209.07	208.01	206.71
1930	206.01	203.75	205.66	205.55	202.91	209.16	207.56	207.24	208.55	214.18	215.23	214.96
1931	212.82	210.56	207.84	205.18	202.00	197.90	193.58	189.56	186.53	184.26	182.17	181.03
1932	179.08	186.36	192.28	196.16	201.61	222.11	220.77	218.72	218.14	220.85	219.44	218.42
1933	216.03	213.07	209.69	211.03	210.91	212.36	211.74	211.79	213.12	217.61	217.04	219.06
1934	220.13	219.02	220.35	217.26	213.22	209.82	208.20	205.81	204.78	208.46	208.07	207.49
1935	207.21	208.40	208.96	217.39	221.23	231.35	225.83	220.88	217.60	220.69	219.56	218.64
1936	221.46	216.64	221.89	225.58	232.53	235.50	228.56	221.84	216.47	219.61	218.40	218.07
1937	216.24	221.03	225.33	229.07	231.61	233.71	227.59	222.12	217.98	220.99	220.09	212.07
1938	213.10	213.90	213.89	204.65	221.91	235.50	229.89	221.82	214.76	218.21	217.58	217.10
1939	216.81	213.98	211.88	210.47	206.15	204.71	204.01	204.51	206.12	212.03	211.49	209.64
1940	213.87	221.49	217.38	222.50	235.50	233.93	227.85	222.77	219.06	222.20	221.35	222.36
1941	222.36	222.36	225.33	229.31	230.37	235.50	228.69	221.52	215.58	218.83	217.98	217.27
1942	215.33	215.02	217.30	222.84	224.00	235.50	229.99	222.21	215.56	218.68	217.59	217.59
1943	213.89	214.38	212.07	224.30	233.21	233.57	227.21	221.30	216.57	220.08	219.07	218.58
1944	217.41	215.20	215.10	212.72	210.84	210.34	207.44	205.48	204.80	209.02	210.98	212.32
1945	213.22	219.35	224.36	225.31	226.74	234.17	227.42	221.05	215.98	219.30	217.27	215.02
1946	215.68	216.89	219.91	222.03	233.83	232.41	226.84	222.01	218.75	221.90	221.97	221.85
1947	221.25	220.39	218.27	218.39	214.01	210.51	207.17	204.82	204.17	209.19	206.91	204.03
1948	203.39	200.71	197.87	199.17	200.62	219.02	216.48	214.93	214.66	218.33	217.83	218.00
1949	217.59	215.50	214.60	218.23	221.75	223.09	220.74	218.84	218.34	221.06	220.07	218.72
1950	219.83	222.36	225.33	229.73	228.85	234.52	227.06	220.06	214.65	218.37	204.65	204.65
1951	204.65	204.65	212.07	223.00	232.34	228.27	224.09	220.72	218.76	221.60	221.38	222.36

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1952	220.41	218.67	219.47	206.31	217.42	234.43	230.70	221.21	212.29	216.16	215.81	216.87
1953	221.93	213.82	215.25	220.41	217.21	224.43	221.26	216.71	213.93	218.37	218.00	217.25
1954	216.77	216.42	218.37	222.51	225.06	221.73	218.37	216.45	216.25	219.84	219.78	219.33
1955	219.27	217.24	215.47	212.96	209.76	209.64	206.20	204.11	203.54	207.95	207.65	207.02
1956	204.65	207.57	216.48	223.44	228.20	235.50	228.25	219.93	212.72	216.79	216.81	217.23
1957	216.46	216.60	218.02	217.34	218.33	226.96	221.94	217.75	215.50	219.30	219.49	219.78
1958	221.43	221.87	223.82	224.73	226.05	235.50	228.93	221.01	213.23	217.11	216.42	214.89
1959	214.81	216.76	217.12	214.95	210.40	207.46	205.57	204.96	206.08	211.25	211.50	212.00
1960	210.91	211.70	211.77	210.72	210.72	212.30	210.23	209.32	208.46	211.86	210.85	209.68
1961	207.30	204.82	201.95	199.14	195.70	191.18	185.85	180.88	177.17	181.30	177.37	172.94
1962	167.96	176.46	180.43	190.79	190.62	204.61	202.10	200.50	200.24	206.59	206.93	207.46
1963	209.49	211.27	213.03	220.16	232.26	235.50	228.07	221.12	215.25	219.14	216.16	216.18
1964	217.69	216.72	216.06	215.03	211.02	209.33	208.13	207.97	209.41	215.43	217.85	206.31
1965	207.12	209.35	217.99	225.84	227.90	233.00	226.12	218.63	214.46	220.95	221.12	222.33
1966	222.36	220.07	219.13	219.80	216.45	212.40	208.71	206.49	206.30	210.37	211.18	217.57
1967	222.33	222.33	224.07	224.85	214.60	231.39	232.45	222.47	213.33	217.38	217.46	217.45
1968	217.89	218.96	219.25	217.70	213.31	209.11	205.00	202.40	201.82	206.12	207.28	209.28
1969	215.48	216.61	220.53	218.71	224.44	235.50	229.38	221.23	214.19	219.66	219.42	220.84
1970	204.60	204.60	213.19	218.55	221.98	227.76	223.99	219.95	217.49	220.70	220.46	222.33
1971	222.33	222.33	225.17	227.18	221.16	227.85	224.81	222.28	219.64	224.04	222.33	222.33
1972	221.57	219.81	221.14	220.59	215.81	216.84	214.40	212.41	212.24	216.47	217.21	218.67
1973	222.33	221.81	225.17	227.78	231.92	232.73	227.80	222.36	218.61	222.51	215.40	216.49
1974	213.94	218.47	220.10	227.25	230.76	233.75	228.61	223.72	218.81	222.12	220.41	218.89
1975	216.63	217.26	223.08	225.76	222.70	232.74	227.40	221.54	216.86	221.88	221.29	220.56
1976	218.28	215.32	211.95	209.47	206.39	202.49	198.44	194.77	191.99	193.75	190.64	187.26
1977	183.79	180.44	176.35	171.55	169.35	165.49	161.51	158.41	157.63	158.49	154.11	149.07
1978	143.33	137.26	128.85	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60
1979	118.60	118.60	118.60	118.60	138.88	157.03	159.90	163.95	170.56	177.48	175.10	172.75
1980	197.17	207.79	217.84	223.13	225.86	232.66	229.22	220.91	213.68	216.98	215.60	215.20
1981	216.10	215.10	215.49	216.33	212.41	209.52	208.10	206.91	207.60	213.32	216.66	211.17
1982	208.33	204.60	211.37	214.37	227.59	233.59	226.81	217.34	207.38	214.51	212.00	206.79
1983	211.57	213.35	219.19	221.35	207.54	226.96	233.16	223.86	215.98	223.23	211.17	204.60
1984	204.60	206.24	214.88	220.05	227.43	229.45	225.88	222.60	218.66	222.66	221.77	222.20

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	219.57	218.67	219.44	221.27	217.10	213.13	208.73	206.81	206.61	210.97	211.54	211.92
1986	215.02	205.52	211.99	223.76	232.32	234.33	227.56	220.65	215.18	218.38	217.49	215.82
1987	213.15	210.43	208.41	206.25	203.01	198.90	195.70	195.98	197.10	200.51	198.05	195.82
1988	193.76	190.91	187.48	184.08	184.35	183.59	183.27	183.61	185.06	185.80	182.46	178.74
1989	174.61	170.46	165.82	173.51	184.88	186.68	186.88	187.89	190.79	193.84	190.73	187.30
1990	184.91	182.35	183.57	180.80	180.99	182.11	182.65	184.02	186.76	188.85	185.40	181.75
1991	177.87	174.20	171.48	164.29	167.33	171.59	174.78	178.67	183.60	189.14	187.19	185.27
1992	183.26	182.28	184.12	179.58	177.62	176.82	175.48	175.22	176.70	179.22	176.78	174.65
1993	175.27	188.09	201.03	210.57	223.07	233.21	226.25	222.50	217.64	221.32	219.72	218.33
1994	215.34	212.76	209.25	206.89	203.94	199.95	197.31	196.84	198.89	205.51	203.54	205.04
1995	216.35	218.57	218.79	215.24	205.63	228.38	234.11	223.02	212.80	218.89	217.66	217.39
1996	218.70	207.99	213.99	223.91	233.79	234.27	229.00	224.61	220.45	221.16	220.60	211.40
1997	210.69	204.60	211.99	218.44	228.62	228.61	224.36	221.73	219.97	223.51	222.33	220.19
1998	222.33	216.61	220.53	219.93	212.89	232.37	232.97	224.42	215.79	220.14	220.17	220.66
1999	222.33	216.57	219.88	224.87	227.63	234.26	229.51	223.46	218.26	221.11	220.65	218.93
2000	220.93	221.61	224.79	225.74	229.09	229.18	225.74	222.44	219.80	222.67	221.43	219.82
2001	216.82	214.24	213.35	215.64	213.12	210.87	209.22	208.46	208.69	212.89	211.66	213.15
2002	215.47	215.20	219.21	220.71	217.76	216.77	213.16	210.43	209.14	212.37	211.87	212.92
2003	215.34	216.76	217.14	219.03	220.92	227.61	222.90	219.13	217.19	219.90	218.10	219.19
2004	220.49	222.33	225.17	224.77	220.52	217.08	213.59	211.48	210.40	211.88	210.98	212.17
2005	220.35	222.33	220.67	227.49	230.36	235.50	231.21	224.97	219.23	221.74	220.65	216.98
2006	207.62	206.37	214.54	219.95	229.72	235.50	231.45	226.53	220.15	222.93	222.05	222.33
2007	220.47	220.11	220.95	219.49	215.73	212.86	210.78	209.82	210.27	213.74	213.68	213.02
2008	213.98	213.84	215.26	213.31	210.23	208.99	206.80	206.39	204.16	207.89	207.30	205.85
2009	206.93	207.77	214.05	217.12	227.81	226.08	222.21	219.14	216.36	218.92	218.06	220.16
Min.	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60
Max.	222.36	222.36	222.33	229.73	235.50	235.50	234.11	226.53	221.73	224.29	222.36	222.36
Mean	209.66	209.42	211.09	212.71	214.49	218.08	214.59	210.81	208.18	211.89	210.64	209.66
Median	215.57	215.02	215.49	218.55	218.33	226.96	222.90	218.84	213.93	218.33	217.11	216.49

Table 4.1-3. Simulated Total Camanche Release [cfs], Baseline Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	2,498	799	731	512	1,239	1,974	928	835	700	325	325	325
1922	325	325	325	525	2,547	2,595	1,075	977	843	325	325	474
1923	537	485	325	400	905	1,010	836	753	619	325	325	325
1924	325	325	325	227	242	304	276	238	175	220	220	220
1925	220	220	220	300	743	848	724	641	508	325	325	325
1926	325	325	325	300	400	363	398	348	236	250	250	250
1927	250	754	250	596	1,427	1,859	1,020	922	790	325	450	325
1928	325	325	936	500	523	777	506	420	287	325	441	325
1929	325	325	325	302	369	304	314	262	189	250	250	250
1930	250	250	250	300	400	363	398	348	236	250	250	250
1931	250	250	250	227	242	304	276	238	175	126	130	130
1932	130	130	130	300	486	583	455	384	258	325	325	325
1933	325	325	325	300	400	363	398	348	236	250	250	250
1934	250	250	250	302	369	304	314	262	189	220	220	220
1935	220	220	220	300	770	875	750	668	534	325	325	325
1936	325	2,410	554	666	1,740	1,577	1,021	922	788	325	325	325
1937	325	325	679	500	1,031	1,186	871	779	645	325	325	1,335
1938	325	1,239	1,805	2,476	3,056	2,332	1,225	1,123	983	325	325	325
1939	325	325	325	302	369	304	314	262	189	250	250	250
1940	250	407	1,596	525	1,570	1,236	831	733	601	325	325	372
1941	604	939	701	500	1,291	1,627	1,072	979	846	325	325	561
1942	1,425	1,097	325	425	2,178	2,118	1,178	1,078	942	325	603	491
1943	1,587	1,070	1,903	798	1,776	1,369	965	865	730	325	325	325
1944	325	325	325	300	400	363	398	348	236	250	250	250
1945	250	535	250	500	1,074	1,128	954	872	738	325	561	1,139
1946	669	325	325	450	831	1,085	771	679	545	325	325	325
1947	325	325	325	300	400	363	398	348	236	250	250	250
1948	250	250	250	300	450	533	398	348	236	250	250	250
1949	250	250	250	300	459	542	407	357	245	325	325	325
1950	325	543	359	549	1,238	1,345	1,032	936	795	325	3,424	4,195
1951	1,369	1,154	463	525	950	1,005	640	552	419	325	325	763

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1952	1,459	1,351	1,166	3,147	3,251	1,997	1,473	1,369	1,227	325	325	325
1953	325	1,279	325	300	780	884	760	678	544	325	325	325
1954	325	325	325	300	460	542	408	358	246	325	325	325
1955	325	325	325	300	400	363	398	348	236	220	220	2,053
1956	3,105	1,064	332	534	2,193	1,958	1,205	1,104	967	325	325	325
1957	325	325	325	300	648	753	628	546	412	325	325	325
1958	325	1,179	1,061	1,965	2,711	2,016	1,296	1,195	1,058	325	325	325
1959	325	325	325	300	400	363	398	348	236	250	250	250
1960	250	250	250	300	400	363	398	348	236	250	250	250
1961	250	250	250	227	242	304	314	262	184	220	220	220
1962	220	220	220	300	450	533	398	348	236	220	220	220
1963	220	991	220	400	1,602	1,484	1,079	987	853	325	689	325
1964	325	325	325	300	400	363	398	348	236	250	250	3,820
1965	2,335	923	250	475	1,539	1,645	1,240	1,141	1,006	325	624	343
1966	352	325	325	300	400	363	398	348	236	250	250	250
1967	556	584	960	1,256	3,302	1,883	1,479	1,378	1,241	325	325	325
1968	325	325	325	300	400	363	398	348	236	220	220	220
1969	1,401	1,701	878	2,447	3,553	1,920	1,404	1,300	1,159	325	325	437
1970	3,495	1,134	568	525	801	906	686	603	469	325	666	830
1971	749	680	587	500	948	953	829	746	613	325	383	418
1972	325	325	325	400	450	533	398	348	236	250	250	250
1973	762	1,318	668	502	956	1,160	846	754	620	325	1,385	937
1974	1,422	325	960	761	1,444	1,548	1,144	1,045	912	325	325	325
1975	325	325	325	450	1,302	1,357	1,232	1,150	1,016	325	379	325
1976	325	325	325	227	242	304	276	238	175	220	220	220
1977	220	220	220	227	242	304	276	238	175	126	130	130
1978	130	130	130	227	242	304	276	238	175	126	130	130
1979	130	130	130	225	273	363	398	348	231	163	130	130
1980	130	1,568	586	525	1,485	1,640	1,235	1,137	1,004	325	325	325
1981	325	325	325	300	400	363	398	348	236	250	250	1,670
1982	1,524	3,054	1,861	3,745	3,126	1,961	1,558	1,453	1,307	325	1,423	1,775
1983	1,462	2,390	3,538	1,946	4,560	3,683	2,206	2,100	1,954	325	2,348	2,761
1984	1,570	1,056	435	525	1,031	1,135	914	832	700	325	583	325

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	325	325	325	300	400	363	398	348	236	250	250	250
1986	250	5,226	2,780	555	1,863	1,484	1,080	978	838	325	325	325
1987	325	325	325	227	242	304	314	262	184	220	220	220
1988	220	220	220	227	242	304	276	238	175	220	220	220
1989	220	220	220	300	450	533	398	348	236	220	220	220
1990	220	220	220	302	369	304	314	262	189	220	220	220
1991	220	220	220	302	369	304	314	262	189	126	130	130
1992	130	130	130	302	369	304	314	262	189	126	130	130
1993	130	130	130	325	1,088	1,242	971	889	757	325	325	325
1994	325	325	325	227	242	304	314	262	184	220	220	220
1995	220	833	2,944	2,700	4,628	2,333	1,838	1,733	1,587	325	325	325
1996	325	2,286	1,162	534	2,041	1,345	941	840	703	325	605	2,402
1997	5,598	2,310	509	533	823	880	660	575	438	325	472	325
1998	665	2,254	1,395	1,836	2,935	2,044	1,641	1,538	1,396	325	325	325
1999	614	1,978	770	501	1,217	1,272	1,051	965	831	325	325	325
2000	325	1,167	733	500	848	853	679	596	463	325	325	325
2001	325	325	325	300	400	363	398	348	236	250	250	250
2002	250	250	250	350	450	533	398	348	236	250	250	250
2003	250	250	250	300	627	732	608	525	391	325	325	325
2004	325	371	508	300	400	363	398	348	236	250	250	250
2005	250	721	1,318	830	2,130	1,662	1,154	1,054	918	325	325	1,490
2006	2,049	1,244	1,363	4,094	3,178	1,904	1,099	995	852	325	325	341
2007	325	325	325	300	400	363	398	348	236	250	250	250
2008	250	250	250	302	369	304	314	262	189	220	220	220
2009	220	220	220	300	589	693	569	487	353	325	325	887
Min.	130	130	130	225	242	304	276	238	175	126	130	130
Max.	5,598	5,226	3,538	4,094	4,626	3,683	2,206	2,100	1,954	325	3,424	4,195
Mean	623	723	584	630	1,092	973	727	654	537	281	391	534
Median	325	325	325	302	648	777	628	546	412	325	325	325

Table 4.1-4. Estimated Flow at Elliott [cfs], Baseline Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	2,495	809	721	495	1,226	1,959	901	804	686	312	315	318
1922	332	340	325	508	2,532	2,581	1,046	942	829	312	315	474
1923	543	498	325	381	892	993	811	723	605	312	315	318
1924	332	340	325	206	230	286	260	220	160	208	213	207
1925	228	236	223	280	730	831	701	614	493	312	315	318
1926	332	340	325	280	388	345	380	327	221	238	242	239
1927	258	765	252	580	1,414	1,844	992	889	776	312	438	318
1928	332	340	920	482	511	760	486	398	272	312	429	318
1929	332	340	325	282	357	286	297	243	174	238	242	239
1930	258	265	252	280	388	345	380	327	221	238	242	239
1931	258	265	252	206	230	286	260	220	160	115	124	113
1932	138	147	136	280	474	566	436	362	243	312	315	318
1933	332	340	325	280	388	345	380	327	221	238	242	239
1934	258	265	252	282	357	286	297	243	174	208	213	207
1935	228	236	223	280	757	858	726	640	519	312	315	318
1936	332	2,404	548	650	1,726	1,561	993	889	774	312	315	318
1937	332	340	670	482	1,018	1,170	845	749	631	312	315	1,378
1938	332	1,245	1,766	2,481	3,041	2,318	1,193	1,085	970	312	315	318
1939	332	340	325	282	357	286	297	243	174	238	242	239
1940	258	421	1,563	508	1,557	1,220	806	704	587	312	315	367
1941	610	948	691	482	1,278	1,611	1,043	944	832	312	315	565
1942	1,427	1,104	325	407	2,164	2,103	1,147	1,041	928	312	588	492
1943	1,588	1,077	1,862	784	1,762	1,353	938	833	716	312	315	318
1944	332	340	325	280	388	345	380	327	221	238	242	239
1945	258	548	252	482	1,061	1,112	927	840	724	312	546	1,172
1946	675	340	325	432	818	1,069	747	651	531	312	315	318
1947	332	340	325	280	388	345	380	327	221	238	242	239
1948	258	265	252	280	438	516	380	327	221	238	242	239
1949	258	265	252	280	447	525	389	336	230	312	315	318
1950	332	556	359	532	1,225	1,329	1,004	902	781	312	3,349	4,381
1951	1,371	1,161	460	508	937	988	618	527	404	312	315	778

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1952	1,461	1,356	1,144	3,160	3,236	1,982	1,437	1,326	1,214	312	315	318
1953	332	1,284	325	280	767	867	736	650	530	312	315	318
1954	332	340	325	280	448	525	390	337	231	312	315	318
1955	332	340	325	280	388	345	380	327	221	208	213	2,132
1956	3,099	1,072	332	517	2,179	1,943	1,174	1,067	953	312	315	318
1957	332	340	325	280	636	736	606	521	397	312	315	318
1958	332	1,185	1,042	1,964	2,696	2,001	1,263	1,156	1,045	312	315	318
1959	332	340	325	280	388	345	380	327	221	238	242	239
1960	258	265	252	280	388	345	380	327	221	238	242	239
1961	258	265	252	206	230	286	297	243	169	208	213	207
1962	228	236	223	280	438	516	380	327	221	208	213	207
1963	228	999	223	381	1,588	1,468	1,050	952	839	312	672	318
1964	332	340	325	280	388	345	380	327	221	238	242	3,987
1965	2,333	932	252	457	1,526	1,629	1,208	1,103	993	312	608	337
1966	359	340	325	280	388	345	380	327	221	238	242	239
1967	562	596	944	1,247	3,287	1,868	1,443	1,335	1,228	312	315	318
1968	332	340	325	280	388	345	380	327	221	208	213	207
1969	1,403	1,702	864	2,452	3,537	1,905	1,369	1,258	1,146	312	315	435
1970	3,487	1,141	562	508	788	889	663	577	454	312	649	848
1971	754	691	580	482	935	936	804	717	599	312	372	415
1972	332	340	325	381	438	516	380	327	221	238	242	239
1973	767	1,323	659	484	943	1,144	821	724	606	312	1,353	960
1974	1,424	340	944	746	1,431	1,532	1,114	1,009	898	312	315	318
1975	332	340	325	432	1,289	1,341	1,200	1,112	1,003	312	368	318
1976	332	340	325	206	230	286	260	220	160	208	213	207
1977	228	236	223	206	230	286	260	220	160	115	124	113
1978	138	147	136	206	230	286	260	220	160	115	124	113
1979	138	147	136	204	261	345	380	327	216	152	124	113
1980	138	1,571	579	508	1,472	1,624	1,203	1,099	991	312	315	318
1981	332	340	325	280	388	345	380	327	221	238	242	1,730
1982	1,526	3,042	1,821	3,765	3,111	1,946	1,521	1,408	1,294	312	1,390	1,840
1983	1,464	2,385	3,453	1,945	4,543	3,671	2,158	2,041	1,943	312	2,296	2,876
1984	1,571	1,064	432	508	1,018	1,119	888	801	686	312	568	318

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	332	340	325	280	388	345	380	327	221	238	242	239
1986	258	5,193	2,715	538	1,849	1,468	1,051	943	824	312	315	318
1987	332	340	325	206	230	286	297	243	169	208	213	207
1988	228	236	223	206	230	286	260	220	160	208	213	207
1989	228	236	223	280	438	516	380	327	221	208	213	207
1990	228	236	223	282	357	286	297	243	174	208	213	207
1991	228	236	223	282	357	286	297	243	174	115	124	113
1992	138	147	136	282	357	286	297	243	174	115	124	113
1993	138	147	136	305	1,075	1,226	944	856	743	312	315	318
1994	332	340	325	206	230	286	297	243	169	208	213	207
1995	228	843	2,875	2,708	4,611	2,319	1,796	1,682	1,575	312	315	318
1996	332	2,282	1,140	517	2,027	1,329	914	808	689	312	589	2,499
1997	5,580	2,305	505	516	810	863	638	549	423	312	459	318
1998	671	2,250	1,367	1,834	2,920	2,029	1,603	1,491	1,383	312	315	318
1999	620	1,977	759	483	1,204	1,256	1,022	931	817	312	315	318
2000	332	1,174	723	482	835	836	656	570	448	312	315	318
2001	332	340	325	280	388	345	380	327	221	238	242	239
2002	258	265	252	331	438	516	380	327	221	238	242	239
2003	258	265	252	280	615	715	587	500	376	312	315	318
2004	332	385	504	280	388	345	380	327	221	238	242	239
2005	258	732	1,292	816	2,116	1,647	1,124	1,018	904	312	315	1,541
2006	2,048	1,250	1,336	4,118	3,163	1,889	1,070	960	838	312	315	334
2007	332	340	325	280	388	345	380	327	221	238	242	239
2008	258	265	252	282	357	286	297	243	174	208	213	207
2009	228	236	223	280	577	676	548	463	338	312	315	908
Min.	138	147	136	204	230	286	260	220	160	115	124	113
Max.	5,580	5,193	3,453	4,118	4,611	3,671	2,158	2,041	1,943	312	3,349	4,381
Mean	629	734	578	614	1,079	957	704	627	522	268	380	538
Median	332	340	325	282	636	760	606	521	397	312	315	318

Table 4.1-5. Simulated Flow Below Woodbridge Irrigation Dam [cfs], Baseline Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	2,420	731	635	350	921	1,550	458	440	439	180	259	243
1922	252	260	234	368	2,234	2,177	611	587	587	183	263	396
1923	470	425	240	250	600	600	379	372	370	188	268	254
1924	258	268	241	75	23	31	18	15	15	139	163	149
1925	153	161	135	150	438	438	267	260	258	188	268	254
1926	258	266	240	150	150	31	29	22	20	132	193	179
1927	183	695	165	446	1,122	1,449	564	540	540	188	393	254
1928	258	268	851	350	217	367	50	39	37	188	384	254
1929	258	266	241	150	150	31	29	22	20	169	193	179
1930	183	191	165	150	150	31	29	22	20	132	193	179
1931	183	191	166	75	23	31	18	15	15	45	73	59
1932	63	73	45	150	200	200	29	22	20	195	268	254
1933	258	266	240	150	150	31	29	22	20	132	193	179
1934	183	191	166	150	150	31	29	22	20	139	163	149
1935	153	161	135	150	465	465	294	286	285	188	268	254
1936	250	2,346	461	507	1,425	1,157	554	530	530	182	261	246
1937	258	266	595	350	726	776	415	397	396	188	268	1,264
1938	212	1,138	1,671	2,273	2,694	1,863	708	684	684	152	230	208
1939	258	266	241	150	150	31	29	22	20	169	193	179
1940	183	350	1,512	375	1,265	826	375	351	351	188	268	301
1941	538	879	616	350	985	1,217	615	598	596	188	268	490
1942	1,340	1,021	220	254	1,850	1,684	697	673	673	174	530	401
1943	1,503	995	1,799	629	1,449	937	486	462	462	174	254	236
1944	258	268	240	150	150	31	29	22	20	132	193	179
1945	183	476	165	350	768	718	498	490	488	188	504	1,068
1946	602	266	240	300	525	675	314	297	295	188	268	254
1947	258	266	240	150	150	31	29	22	20	132	193	179
1948	183	193	165	150	200	200	29	22	20	132	193	179
1949	183	191	165	150	209	209	39	31	29	207	268	254
1950	216	446	228	350	880	880	519	502	500	155	3,332	4,081
1951	1,302	1,095	378	375	645	595	184	170	170	188	268	692

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1952	1,330	1,240	1,014	2,925	2,869	1,507	935	911	911	140	216	192
1953	258	1,220	240	150	474	474	304	296	294	188	268	254
1954	258	266	240	150	210	210	39	31	30	207	268	254
1955	258	266	240	150	150	31	29	22	20	102	163	1,982
1956	3,008	982	216	350	1,852	1,510	710	686	686	165	244	224
1957	258	266	240	150	343	343	172	164	163	188	268	254
1958	227	1,092	942	1,779	2,367	1,566	799	775	775	163	242	222
1959	258	266	240	150	150	31	29	22	20	132	193	179
1960	183	193	165	150	150	31	29	22	20	132	193	179
1961	183	191	166	75	23	31	29	22	15	139	163	149
1962	153	161	135	150	200	200	29	22	20	102	163	149
1963	153	932	135	250	1,297	1,074	623	605	604	188	633	254
1964	258	268	240	150	150	31	29	22	20	132	193	3,749
1965	2,253	850	148	307	1,215	1,215	763	740	740	176	554	256
1966	285	266	240	150	150	31	29	22	20	132	193	179
1967	458	497	842	1,070	2,958	1,434	983	959	959	164	242	223
1968	258	268	240	150	150	31	29	22	20	102	163	149
1969	1,278	1,591	731	2,231	3,178	1,437	873	849	849	144	221	309
1970	3,419	1,067	474	365	485	485	218	210	210	181	602	750
1971	682	621	503	350	643	543	372	365	363	188	326	347
1972	258	268	240	250	200	200	29	22	20	132	193	179
1973	693	1,257	581	350	648	748	387	370	368	186	1,326	864
1974	1,350	261	870	606	1,132	1,132	680	657	657	184	264	248
1975	258	266	240	300	997	947	776	768	767	188	322	254
1976	258	268	241	75	23	31	18	15	15	139	163	149
1977	153	161	136	75	23	31	18	15	15	45	73	59
1978	63	71	46	75	23	31	18	15	15	45	73	59
1979	63	71	45	75	23	31	29	22	15	45	73	59
1980	61	1,508	499	372	1,177	1,227	775	752	752	186	266	251
1981	258	266	240	150	150	31	29	22	20	132	193	1,598
1982	1,375	2,921	1,687	3,499	2,720	1,445	994	970	970	124	1,298	1,621
1983	1,313	2,257	3,364	1,701	4,154	3,167	1,641	1,617	1,617	124	2,222	2,608
1984	1,503	999	351	375	725	725	458	450	450	188	526	254

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	258	266	240	150	150	31	29	22	20	132	193	179
1986	136	5,124	2,644	350	1,499	1,012	561	537	537	151	228	206
1987	258	266	241	75	23	31	29	22	15	139	163	149
1988	153	163	136	75	23	31	18	15	15	139	163	149
1989	153	161	135	150	200	200	29	22	20	102	163	149
1990	153	161	136	150	150	31	29	22	20	139	163	149
1991	153	161	136	150	150	31	29	22	20	45	73	59
1992	63	73	46	150	150	31	29	22	20	45	73	59
1993	63	71	45	175	782	832	515	507	507	188	268	254
1994	258	266	241	75	23	31	29	22	15	139	163	149
1995	71	700	2,770	2,455	4,222	1,817	1,274	1,250	1,250	124	200	172
1996	229	2,204	1,045	350	1,700	897	446	422	422	165	524	2,302
1997	5,502	2,225	394	350	483	433	166	158	158	166	391	225
1998	543	2,146	1,250	1,622	2,562	1,563	1,112	1,088	1,088	145	222	199
1999	546	1,918	684	350	910	860	593	582	580	187	267	253
2000	258	1,107	648	350	543	443	222	215	213	188	268	254
2001	258	266	240	150	150	31	29	22	20	132	193	179
2002	183	191	165	200	200	200	29	22	20	132	193	179
2003	183	191	165	150	322	322	151	143	142	188	268	254
2004	258	314	424	150	150	31	29	22	20	132	193	179
2005	164	645	1,213	659	1,801	1,228	673	649	649	173	252	1,400
2006	1,917	1,127	1,208	3,869	2,793	1,410	558	534	534	138	214	205
2007	258	266	240	150	150	31	29	22	20	132	193	179
2008	183	193	166	150	150	31	29	22	20	139	163	149
2009	153	161	135	150	284	284	113	105	104	188	268	816
Min.	138	147	136	204	230	286	260	220	160	115	124	113
Max.	5,580	5,193	3,453	4,118	4,611	3,671	2,158	2,041	1,943	312	3,349	4,381
Mean	629	734	578	614	1,079	957	704	627	522	268	380	538
Median	332	340	325	282	636	760	606	521	397	312	315	318

necessary to develop an estimate of flows at station Frandy; a prerequisite for the water quality modeling presented in Chapter 5 of this appendix.

Table 4.1-7 presents the annual customer rationing and the contribution of the Mokelumne and Freeport to meeting the total consumptive demand on a calendar year (CY) basis. The 5th column of the table reports the supplemental supply needed to reduce rationing to 15% as specified in the addendum to the WSMP 2040 adopted by the EBMUD Board of Directors in April, 2012.

Table 4.1-8 presents the simulated CY total annual diversions from the Mokelumne. Upstream diversions are the collective sum of diversions by the Amador Water Agency via Amador canal diversion (AWA), the Amador Water Agency from the Central Amador Water Project (CAWP), Calaveras County Water District, and the Calaveras Public Utility District (CPUD). Annual total diversions to Jackson Valley Irrigation District (JVID) are typically 3.3 to 3.4 TAF where diversions occur in 78 of 86 years (91%). Simulated diversions by NSJWCD are typically 20 TAF and occur in 48 of 86 years (56%). WID diversions are typically 60 TAF in wet years (71 of 86 years or 83%) and 39 TAF in dry years (15 of 86 years or 17%) where wet year and dry years are distinguished by the total runoff to Pardee respectively above or below 375 TAF²⁶. Finally diversions by EBMUD range from 306 TAF following the simulated aqueduct outage in 1982 to a minimum of 96.8 TAF in 1977, the driest year of record.

²⁶ See page 3 paragraph 3 of 2nd supplementary agreement between Woodbridge Irrigation District and East Bay Municipal Agreement (1983).

Table 4.1-6. Estimated Flow at Frandy [cfs], Baseline Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	2,405	716	605	320	891	1,520	428	410	409	165	244	228
1922	237	245	204	338	2,204	2,147	581	557	557	168	248	381
1923	455	410	210	220	570	570	349	342	340	173	253	239
1924	243	253	211	45	1	1	1	1	1	124	148	134
1925	138	146	105	120	408	408	237	230	228	173	253	239
1926	243	251	210	120	120	1	1	1	1	117	178	164
1927	168	680	135	416	1,092	1,419	534	510	510	173	378	239
1928	243	253	821	320	187	337	20	9	7	173	369	239
1929	243	251	211	120	120	1	1	1	1	154	178	164
1930	168	176	135	120	120	1	1	1	1	117	178	164
1931	168	176	136	45	1	1	1	1	1	30	58	44
1932	48	58	15	120	170	170	1	1	1	180	253	239
1933	243	251	210	120	120	1	1	1	1	117	178	164
1934	168	176	136	120	120	1	1	1	1	124	148	134
1935	138	146	105	120	435	435	264	256	255	173	253	239
1936	235	2,331	431	477	1,395	1,127	524	500	500	167	246	231
1937	243	251	565	320	696	746	385	367	366	173	253	1,249
1938	197	1,123	1,641	2,243	2,664	1,833	678	654	654	137	215	193
1939	243	251	211	120	120	1	1	1	1	154	178	164
1940	168	335	1,482	345	1,235	796	345	321	321	173	253	286
1941	523	864	586	320	955	1,187	585	568	566	173	253	475
1942	1,325	1,006	190	224	1,820	1,654	667	643	643	159	515	386
1943	1,488	980	1,769	599	1,419	907	456	432	432	159	239	221
1944	243	253	210	120	120	1	1	1	1	117	178	164
1945	168	461	135	320	738	688	468	460	458	173	489	1,053
1946	587	251	210	270	495	645	284	267	265	173	253	239
1947	243	251	210	120	120	1	1	1	1	117	178	164
1948	168	178	135	120	170	170	1	1	1	117	178	164
1949	168	176	135	120	179	179	9	1	1	192	253	239
1950	201	431	198	320	850	850	489	472	470	140	3,317	4,066

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1951	1,287	1,080	348	345	615	565	154	140	140	173	253	677
1952	1,315	1,225	984	2,895	2,839	1,477	905	881	881	125	201	177
1953	243	1,205	210	120	444	444	274	266	264	173	253	239
1954	243	251	210	120	180	180	9	1	1	192	253	239
1955	243	251	210	120	120	1	1	1	1	87	148	1,967
1956	2,993	967	186	320	1,822	1,480	680	656	656	150	229	209
1957	243	251	210	120	313	313	142	134	133	173	253	239
1958	212	1,077	912	1,749	2,337	1,536	769	745	745	148	227	207
1959	243	251	210	120	120	1	1	1	1	117	178	164
1960	168	178	135	120	120	1	1	1	1	117	178	164
1961	168	176	136	45	1	1	1	1	1	124	148	134
1962	138	146	105	120	170	170	1	1	1	87	148	134
1963	138	917	105	220	1,267	1,044	593	575	574	173	618	239
1964	243	253	210	120	120	1	1	1	1	117	178	3,734
1965	2,238	835	118	277	1,185	1,185	733	710	710	161	539	241
1966	270	251	210	120	120	1	1	1	1	117	178	164
1967	443	482	812	1,040	2,928	1,404	953	929	929	149	227	208
1968	243	253	210	120	120	1	1	1	1	87	148	134
1969	1,263	1,576	701	2,201	3,148	1,407	843	819	819	129	206	294
1970	3,404	1,052	444	335	455	455	188	180	180	166	587	735
1971	667	606	473	320	613	513	342	335	333	173	311	332
1972	243	253	210	220	170	170	1	1	1	117	178	164
1973	678	1,242	551	320	618	718	357	340	338	171	1,311	849
1974	1,335	246	840	576	1,102	1,102	650	627	627	169	249	233
1975	243	251	210	270	967	917	746	738	737	173	307	239
1976	243	253	211	45	1	1	1	1	1	124	148	134
1977	138	146	106	45	1	1	1	1	1	30	58	44
1978	48	56	16	45	1	1	1	1	1	30	58	44
1979	48	56	15	45	1	1	1	1	1	30	58	44
1980	46	1,493	469	342	1,147	1,197	745	722	722	171	251	236
1981	243	251	210	120	120	1	1	1	1	117	178	1,583
1982	1,360	2,906	1,657	3,469	2,690	1,415	964	940	940	109	1,283	1,606
1983	1,298	2,242	3,334	1,671	4,124	3,137	1,611	1,587	1,587	109	2,207	2,593

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984	1,488	984	321	345	695	695	428	420	420	173	511	239
1985	243	251	210	120	120	1	1	1	1	117	178	164
1986	121	5,109	2,614	320	1,469	982	531	507	507	136	213	191
1987	243	251	211	45	1	1	1	1	1	124	148	134
1988	138	148	106	45	1	1	1	1	1	124	148	134
1989	138	146	105	120	170	170	1	1	1	87	148	134
1990	138	146	106	120	120	1	1	1	1	124	148	134
1991	138	146	106	120	120	1	1	1	1	30	58	44
1992	48	58	16	120	120	1	1	1	1	30	58	44
1993	48	56	15	145	752	802	485	477	477	173	253	239
1994	243	251	211	45	1	1	1	1	1	124	148	134
1995	56	685	2,740	2,425	4,192	1,787	1,244	1,220	1,220	109	185	157
1996	214	2,189	1,015	320	1,670	867	416	392	392	150	509	2,287
1997	5,487	2,210	364	320	453	403	136	128	128	151	376	210
1998	528	2,131	1,220	1,592	2,532	1,533	1,082	1,058	1,058	130	207	184
1999	531	1,903	654	320	880	830	563	552	550	172	252	238
2000	243	1,092	618	320	513	413	192	185	183	173	253	239
2001	243	251	210	120	120	1	1	1	1	117	178	164
2002	168	176	135	170	170	170	1	1	1	117	178	164
2003	168	176	135	120	292	292	121	113	112	173	253	239
2004	243	299	394	120	120	1	1	1	1	117	178	164
2005	149	630	1,183	629	1,771	1,198	643	619	619	158	237	1,385
2006	1,902	1,112	1,178	3,839	2,763	1,380	528	504	504	123	199	190
2007	243	251	210	120	120	1	1	1	1	117	178	164
2008	168	178	136	120	120	1	1	1	1	124	148	134
2009	138	146	105	120	254	254	83	75	74	173	253	801
Min.	46	56	15	45	1	1	1	1	1	30	58	44
Max.	5,487	5,109	3,334	3,839	4,192	3,137	1,611	1,587	1,587	192	3,317	4,066
Mean	531	640	459	438	776	567	286	277	276	136	311	438
Median	243	251	210	120	313	337	136	128	128	137	215	210

Table 4.1-7. Calendar Year Water Supply Deliveries, Customer Cutbacks, and Undelivered Supply, Baseline Case^a

Year	Customer Cutback	Additional Deficiency ^b	Total Deficiency	WSMP 2040 Supplemental Supply Requirement ^c [MGD]	Freeport Supplemental Supply [MGD]	Bayside Phase I Supplemental Supply [MGD]	Mokelumne Supply [MGD]	Total Supply Delivered [MGD]
1921	0.0%	0.0%	0.0%	0	0	0	214	214
1922	0.0%	0.0%	0.0%	0	0	0	214	214
1923	0.0%	0.0%	0.0%	0	0	0	214	214
1924	2.3%	0.0%	2.3%	0	59	1	149	209
1925	0.0%	0.0%	0.0%	0	0	0	214	214
1926	0.0%	0.0%	0.0%	0	67	1	146	214
1927	0.0%	0.0%	0.0%	0	0	0	214	214
1928	0.0%	0.0%	0.0%	0	0	0	214	214
1929	0.0%	0.0%	0.0%	0	54	1	159	214
1930	0.0%	0.0%	0.0%	0	84	1	129	214
1931	5.0%	0.0%	5.0%	0	10	1	193	203
1932	0.0%	0.0%	0.0%	0	0	0	214	214
1933	0.0%	0.0%	0.0%	0	60	1	153	214
1934	0.0%	0.0%	0.0%	0	84	1	129	214
1935	0.0%	0.0%	0.0%	0	3	0	212	214
1936	0.0%	0.0%	0.0%	0	0	0	214	214
1937	0.0%	0.0%	0.0%	0	0	0	214	214
1938	0.0%	0.0%	0.0%	0	0	0	214	214
1939	0.0%	0.0%	0.0%	0	83	1	130	214
1940	0.0%	0.0%	0.0%	0	0	0	214	214
1941	0.0%	0.0%	0.0%	0	0	0	214	214
1942	0.0%	0.0%	0.0%	0	0	0	214	214
1943	0.0%	0.0%	0.0%	0	0	0	214	214
1944	0.0%	0.0%	0.0%	0	0	0	214	214
1945	0.0%	0.0%	0.0%	0	0	0	214	214
1946	0.0%	0.0%	0.0%	0	0	0	214	214
1947	0.0%	0.0%	0.0%	0	0	0	214	214
1948	0.0%	0.0%	0.0%	0	0	0	214	214

Year	Customer Cutback	Additional Deficiency ^b	Total Deficiency	WSMP 2040 Supplemental Supply Requirement ^c [MGD]	Freeport Supplemental Supply [MGD]	Bayside Phase I Supplemental Supply [MGD]	Mokelumne Supply [MGD]	Total Supply Delivered [MGD]
1949	0.0%	0.0%	0.0%	0	0	0	214	214
1950	0.0%	0.0%	0.0%	0	0	0	214	214
1951	0.0%	0.0%	0.0%	0	0	0	214	214
1952	0.0%	0.0%	0.0%	0	0	0	214	214
1953	0.0%	0.0%	0.0%	0	0	0	214	214
1954	0.0%	0.0%	0.0%	0	0	0	214	214
1955	0.0%	0.0%	0.0%	0	0	0	214	214
1956	0.0%	0.0%	0.0%	0	0	0	214	214
1957	0.0%	0.0%	0.0%	0	0	0	214	214
1958	0.0%	0.0%	0.0%	0	0	0	214	214
1959	0.0%	0.0%	0.0%	0	84	1	129	214
1960	0.0%	0.0%	0.0%	0	63	1	150	214
1961	4.7%	0.0%	4.7%	0	0	0	204	204
1962	0.1%	0.0%	0.1%	0	0	0	214	214
1963	0.0%	0.0%	0.0%	0	0	0	214	214
1964	0.0%	0.0%	0.0%	0	75	1	138	214
1965	0.0%	0.0%	0.0%	0	0	0	214	214
1966	0.0%	0.0%	0.0%	0	0	0	214	214
1967	0.0%	0.0%	0.0%	0	0	0	214	214
1968	0.0%	0.0%	0.0%	0	0	0	214	214
1969	0.0%	0.0%	0.0%	0	0	0	214	214
1970	0.0%	0.0%	0.0%	0	0	0	214	214
1971	0.0%	0.0%	0.0%	0	0	0	214	214
1972	0.0%	0.0%	0.0%	0	0	0	214	214
1973	0.0%	0.0%	0.0%	0	0	0	214	214
1974	0.0%	0.0%	0.0%	0	0	0	214	214
1975	0.0%	0.0%	0.0%	0	0	0	214	214
1976	2.0%	0.0%	2.0%	0	66	1	143	210
1977	15.0%	0.0%	15.0%	0	72	1	109	182
1978	15.0%	0.0%	15.0%	0	9	1	80	182

Year	Customer Cutback	Additional Deficiency ^b	Total Deficiency	WSMP 2040 Supplemental Supply Requirement ^c [MGD]	Freeport Supplemental Supply [MGD]	Bayside Phase I Supplemental Supply [MGD]	Mokelumne Supply [MGD]	Total Supply Delivered [MGD]
1979	14.5%	0.0%	14.5%	0	0	0	183	183
1980	0.0%	0.0%	0.0%	0	0	0	214	214
1981	0.5%	20.7%	21.2%	0	75	1	138	214
1982	1.2%	0.0%	1.2%	0	0	0	214	214
1983	0.0%	0.0%	0.0%	0	0	0	214	214
1984	0.0%	0.0%	0.0%	0	0	0	214	214
1985	0.0%	0.0%	0.0%	0	0	0	214	214
1986	0.0%	0.0%	0.0%	0	0	0	214	214
1987	0.7%	0.0%	0.7%	0	82	1	129	212
1988	10.0%	0.0%	10.0%	0	65	1	126	192
1989	6.1%	0.0%	6.1%	0	0	0	201	201
1990	7.7%	0.0%	7.7%	0	59	1	137	198
1991	12.2%	0.0%	12.2%	0	77	1	110	188
1992	12.9%	0.0%	12.9%	0	11	1	175	186
1993	0.0%	0.0%	0.0%	0	0	0	214	214
1994	0.3%	0.0%	0.3%	0	84	1	128	213
1995	0.0%	0.0%	0.0%	0	8	0	206	214
1996	0.0%	0.0%	0.0%	0	0	0	214	214
1997	0.0%	0.0%	0.0%	0	0	0	214	214
1998	0.0%	0.0%	0.0%	0	0	0	214	214
1999	0.0%	0.0%	0.0%	0	0	0	214	214
2000	0.0%	0.0%	0.0%	0	0	0	214	214
2001	0.0%	0.0%	0.0%	0	83	1	130	214
2002	0.0%	0.0%	0.0%	0	0	0	214	214
2003	0.0%	0.0%	0.0%	0	0	0	214	214
2004	0.0%	0.0%	0.0%	0	0	0	214	214
2005	0.0%	0.0%	0.0%	0	0	0	214	214
2006	0.0%	0.0%	0.0%	0	0	0	214	214
2007	0.0%	0.0%	0.0%	0	84	1	129	214
2008	0.0%	0.0%	0.0%	0	63	1	150	214

Year	Customer Cutback	Additional Deficiency ^b	Total Deficiency	WSMP 2040 Supplemental Supply Requirement ^c [MGD]	Freeport Supplemental Supply [MGD]	Bayside Phase I Supplemental Supply [MGD]	Mokelumne Supply [MGD]	Total Supply Delivered [MGD]
2009	0.0%	0.0%	0.0%	0	0	0	214	214
^a The sum of supplemental supplies and the Mokelumne supply do not necessarily equate to the total supply delivered due to Terminal Reservoir storage regulation.								
^b Additional deficiency of 20.7% in 1981 is due to a limitation on the Mokelumne water supply resulting from the simulated aqueduct outage scenario as described in Section 3.1.1.3.								
^c WSMP 2040 supplemental supply requirement to reduce District wide rationing to 15%.								

Table 4.1-8. Calendar Year Total Annual Diversions, [TAF], Baseline Case

Year	Upstream	JVID	NSJWCD	WID	EBMUD [‡]	Year	Upstream	JVID	NSJWCD	WID	EBMUD ^a
1921	24	3.4	20	60	240	1966	24	3.4	0	60	240
1922	24	3.4	20	60	240	1967	24	3.4	20	60	240
1923	24	3.4	20	60	240	1968	24	3.4	0	60	240
1924	24	0.0	0	39	167	1969	24	3.4	20	60	240
1925	24	3.4	20	60	240	1970	24	3.4	20	60	240
1926	24	3.4	0	60	163	1971	24	3.4	20	60	240
1927	24	3.4	20	60	240	1972	24	3.4	0	60	240
1928	24	3.4	20	60	240	1973	24	3.4	20	60	240
1929	24	3.3	0	39	179	1974	24	3.4	20	60	240
1930	24	3.4	0	60	145	1975	24	3.4	20	60	240
1931	24	0.0	0	39	216	1976	24	0.0	0	39	160
1932	24	3.4	13	60	240	1977	24	0.0	0	39	122
1933	24	3.4	0	60	172	1978	24	0.0	0	39	89
1934	24	0.4	0	39	145	1979	24	2.1	0	60	308
1935	24	3.4	20	60	237	1980	24	3.4	20	60	240
1936	24	3.4	20	60	240	1981	24	3.4	0	60	154
1937	24	3.4	20	60	240	1982	24	3.4	20	60	240
1938	24	3.4	20	60	240	1983	24	3.4	20	60	240
1939	24	3.4	0	39	146	1984	24	3.4	20	60	240
1940	24	3.4	20	60	240	1985	24	3.4	0	60	240
1941	24	3.4	20	60	240	1986	24	3.4	20	60	240
1942	24	3.4	20	60	240	1987	24	0.0	0	39	145
1943	24	3.4	20	60	240	1988	24	0.0	0	39	142
1944	24	3.4	0	60	240	1989	24	1.7	0	60	225
1945	24	3.4	20	60	240	1990	24	0.4	0	39	154
1946	24	3.4	20	60	240	1991	24	0.0	0	39	123
1947	24	3.4	0	60	240	1992	24	0.4	0	39	196
1948	24	3.3	0	60	240	1993	24	3.4	20	60	240
1949	24	3.4	0	60	240	1994	24	3.3	0	39	144
1950	24	3.4	20	60	240	1995	24	3.4	20	60	230
1951	24	3.4	20	60	240	1996	24	3.4	20	60	240
1952	24	3.4	20	60	240	1997	24	3.3	20	60	240
1953	24	3.4	20	60	240	1998	24	3.4	20	60	240
1954	24	3.4	0	60	240	1999	24	3.4	20	60	240
1955	24	3.4	0	60	240	2000	24	3.4	20	60	240
1956	24	3.4	20	60	240	2001	24	3.4	0	60	145
1957	24	3.4	20	60	240	2002	24	3.4	0	60	240
1958	24	3.4	20	60	240	2003	24	3.3	20	60	240
1959	24	3.3	0	60	145	2004	24	3.3	0	60	240
1960	24	3.4	0	60	168	2005	24	3.4	20	60	240
1961	24	3.1	0	39	229	2006	24	3.4	20	60	240

Year	Upstream	JVID	NSJWCD	WID	EBMUD [‡]	Year	Upstream	JVID	NSJWCD	WID	EBMUD ^a
1962	24	3.4	0	60	240	2007	24	3.3	0	60	145
1963	24	3.4	20	60	240	2008	24	3.4	0	39	168
1964	24	3.4	0	60	155	2009	24	3.4	20	60	240
1965	24	3.4	20	60	240						

a EBMUD Diversions reflect only the quantity diverted from the Mokelumne to meet customer demand and/or to refill terminal reservoir storage and do not include supplemental supply deliveries from sources external to the Mokelumne System.

Recall that there are two six month periods in which JSA year type classifications are defined; October to March which is based on combined Pardee and Camanche storage on November 5th, and the April to September period which is generally based on unimpaired runoff estimates (year type thresholds are presented in Table 3.1-1). Table 4.1-9 summarizes the frequency of each year type designation over the 89 year POR simulated for the two six month periods. Overall, there were 126 of 178 periods (71%) that were Above Normal/Normal or Below Normal year types and 52 of 178 (29%) Dry and Critically Dry year types.

Table 4.1-9. JSA Year Type Classifications Summary, Baseline Case

Class	April-September	October-March	Total
Above Normal/Normal	28	51	79
Below Normal	28	19	47
Dry	23	13	36
Critically Dry	10	6	16
Total	89	89	178

4.2 Case 2: Project

Assumptions for the Project case were formulated into the appropriate model input to EBMUDSIM. This section presents the modeling results for the Project case.

Simulated EOM TSS is presented in Table 4.2-1. EOM TSS range and pattern is similar to that in Table 4.1-1 for the baseline case.

Simulated EOM Camanche Reservoir WSE is presented in Table 4.2-2. The months in which Camanche Reservoir WSE was below 190 ft msl for the simulated Project case but above 190 ft msl in the baseline case is listed in Table 4.2-3. Four of 11 months (36%) occur during the intra-annual temperature management period defined in Section 3.4.1. Months where Camanche Reservoir is typically de-stratified or weakly stratified and, therefore, are not expected to induce any increases in water temperature are shaded grey in Table 4.2-3. Water quality modeling results are presented and discussed in Chapter 5.

Table 4.2-4 presents monthly average total Camanche releases for the Project case. Discharge at station Elliott is estimated with Equation 1 and parameters in Table 3.3-12 based on simulated total releases from Camanche Reservoir (in Table 4.2-4). Discharge at station Elliott for the Project case is reported in Table 4.2-5. Discharge for station Elliott is similar in magnitude and pattern to the total releases from Camanche due to the high degree of correlation among the two monitoring locations.

Table 4.2-1. Simulated End-of-Month Total System Storage [AF], Project Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	611,016	611,715	628,147	638,098	715,845	744,894	688,418	636,272	598,436	585,867	578,630	581,589
1922	587,925	613,169	633,578	646,269	652,937	744,894	692,211	632,406	585,287	574,879	574,468	599,823
1923	613,008	620,711	624,887	653,055	696,073	712,045	669,019	621,877	589,644	578,864	572,023	568,968
1924	565,844	547,561	531,837	527,678	515,283	491,575	467,719	446,646	434,546	420,786	407,408	399,704
1925	400,966	462,374	493,798	533,512	643,226	692,248	652,927	616,204	594,968	582,909	576,333	573,132
1926	572,513	574,194	566,159	570,293	575,972	564,376	546,308	531,646	528,143	530,522	541,975	549,052
1927	566,005	620,711	647,049	672,449	703,849	744,894	689,236	632,417	589,373	577,898	569,137	570,140
1928	571,142	567,739	595,244	625,172	732,986	697,913	667,589	640,450	626,610	612,853	603,126	585,716
1929	567,553	554,374	549,211	549,559	543,342	534,102	523,927	516,057	509,468	503,224	501,016	499,140
1930	500,985	497,121	516,372	521,883	520,583	554,043	537,361	524,452	522,856	525,244	533,743	535,662
1931	526,700	513,345	502,365	484,334	466,292	435,639	408,934	378,831	356,076	342,028	333,504	338,246
1932	348,066	387,203	419,379	443,386	485,528	609,245	596,340	574,292	563,009	554,388	551,813	553,392
1933	546,779	527,796	528,514	545,196	557,336	565,146	553,924	543,167	542,226	539,157	537,714	553,898
1934	564,851	564,326	580,153	564,140	538,581	530,895	514,487	490,498	476,328	466,054	465,881	466,223
1935	471,815	485,162	495,378	569,011	608,372	683,792	649,746	617,956	599,898	588,885	583,559	581,139
1936	603,425	620,711	649,157	672,449	727,799	744,894	688,943	634,131	592,785	581,882	576,092	577,479
1937	569,931	607,195	649,157	681,235	720,512	731,473	682,079	635,945	602,270	590,878	586,966	542,952
1938	553,147	577,786	606,232	552,611	653,903	744,894	698,367	633,989	582,192	572,887	570,862	571,352
1939	573,479	558,459	557,084	554,933	539,731	534,595	523,192	514,717	514,422	517,398	516,258	508,985
1940	537,843	606,425	619,212	655,330	749,804	733,527	684,139	640,413	609,207	598,847	595,210	607,852
1941	613,008	620,711	649,157	682,904	711,556	744,894	689,857	632,034	587,191	576,871	573,420	574,889
1942	569,057	573,742	595,059	637,136	667,910	744,894	699,065	636,578	586,962	575,906	572,155	576,881
1943	567,065	569,757	595,244	672,449	732,809	730,899	679,731	630,706	593,417	584,901	580,377	580,741
1944	577,279	570,052	576,559	568,152	569,799	566,042	541,894	519,866	507,226	501,677	516,740	529,986
1945	541,265	609,723	643,084	655,679	686,490	735,214	681,106	629,023	589,680	579,890	570,163	560,883
1946	570,084	584,320	610,704	630,676	737,326	722,256	677,170	635,314	607,233	596,855	599,283	601,993
1947	602,054	603,024	596,492	603,327	585,722	567,119	540,452	516,358	503,894	502,654	493,633	479,529
1948	485,751	472,936	467,110	487,404	507,474	612,932	589,023	568,263	557,693	549,815	548,717	553,265
1949	554,635	541,810	549,667	578,530	614,821	623,575	601,110	578,308	566,761	558,260	558,285	557,701
1950	573,321	612,861	646,741	683,875	701,621	738,135	678,864	622,688	581,471	573,913	533,216	537,942
1951	543,097	550,800	595,244	662,366	728,269	693,995	659,251	627,331	607,247	594,862	595,429	607,852

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1952	613,008	620,711	641,187	561,606	624,925	736,895	704,265	630,004	567,083	559,907	559,751	569,903
1953	606,482	566,376	582,295	621,090	621,938	665,025	638,668	600,780	577,077	573,913	573,545	572,334
1954	573,231	577,670	597,121	630,231	660,720	638,135	609,189	586,422	576,715	573,341	579,491	584,704
1955	592,838	590,699	591,388	582,108	575,964	574,355	547,250	524,618	512,492	505,694	506,062	550,922
1956	543,097	566,799	622,170	665,505	696,828	744,894	686,731	621,615	569,786	563,891	566,055	572,163
1957	571,318	578,795	594,842	596,647	625,251	679,554	641,262	606,421	586,746	579,890	583,128	588,447
1958	603,229	620,711	649,157	675,407	681,856	744,894	691,543	628,702	572,831	565,884	563,593	557,640
1959	561,102	579,783	589,194	581,795	563,807	549,713	531,606	517,150	514,161	512,777	516,356	522,777
1960	520,356	531,522	539,043	538,971	551,857	560,449	540,829	524,543	510,794	501,617	499,470	498,026
1961	490,536	477,900	463,332	447,160	427,509	409,775	388,591	370,072	361,474	360,985	353,219	345,632
1962	340,105	382,776	408,902	455,900	468,531	536,142	515,720	496,895	487,101	490,209	494,322	500,919
1963	516,429	552,792	568,749	634,924	725,806	744,894	685,449	629,390	585,210	578,864	563,160	566,837
1964	580,256	580,770	583,767	583,507	572,158	561,465	546,974	534,875	534,052	539,156	556,324	546,937
1965	556,621	576,941	617,225	680,356	693,013	725,508	671,345	612,966	580,335	590,576	594,976	607,571
1966	613,008	604,573	605,691	616,031	607,481	580,151	552,669	529,007	518,941	512,960	521,509	565,879
1967	612,827	620,530	648,070	676,192	607,357	714,981	717,175	638,473	573,427	567,635	570,119	573,582
1968	580,288	593,720	612,260	617,635	602,872	595,566	575,303	559,565	556,514	556,260	572,223	594,620
1969	605,763	620,530	648,070	635,683	670,868	744,894	694,698	630,047	578,675	582,184	582,641	597,831
1970	542,856	550,559	602,006	615,609	653,750	688,720	657,376	621,734	599,177	588,946	590,629	607,671
1971	612,827	620,530	648,070	667,995	648,377	689,332	662,947	636,987	612,911	611,102	602,945	607,671
1972	606,623	601,702	617,523	622,928	604,422	610,802	587,952	564,692	554,587	549,633	556,283	569,089
1973	612,827	620,530	648,070	672,275	721,528	727,768	686,121	638,815	606,199	600,899	558,511	569,999
1974	564,650	594,281	641,248	692,734	715,465	732,553	689,800	646,924	607,601	598,303	589,088	582,766
1975	572,371	582,933	627,914	655,085	656,131	722,512	679,551	631,489	595,229	596,673	596,063	594,831
1976	584,160	563,271	548,877	539,379	523,868	500,397	475,298	454,565	441,594	424,192	403,323	379,346
1977	360,271	339,234	324,858	314,335	304,236	285,936	267,506	251,570	244,490	237,801	231,139	213,712
1978	201,243	190,959	194,671	180,864	168,510	150,668	131,999	109,449	98,806	84,156	66,913	53,513
1979	67,316	90,467	150,535	206,988	272,576	319,429	315,533	302,218	296,652	300,185	314,193	338,930
1980	487,907	568,067	630,743	663,288	679,924	723,732	693,538	628,001	575,404	565,099	550,021	551,148
1981	551,248	539,285	543,571	549,862	536,673	517,838	501,184	482,326	475,501	472,848	472,616	436,368
1982	451,047	436,454	473,362	488,617	583,682	635,074	594,368	535,912	482,379	494,284	491,954	512,303
1983	553,414	576,601	625,531	649,951	565,941	683,284	722,137	632,794	549,456	565,582	532,956	537,682
1984	542,838	559,433	612,269	637,281	690,791	700,590	670,184	639,130	606,637	601,865	599,202	605,548

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	592,346	593,197	605,262	623,274	602,883	579,718	550,369	528,411	518,313	514,157	521,221	528,851
1986	553,427	555,509	594,762	667,772	726,289	736,566	682,170	626,483	584,659	573,974	570,291	563,331
1987	551,105	537,719	537,267	531,438	514,432	495,425	482,525	472,896	469,504	455,639	445,520	438,412
1988	433,085	420,189	413,893	409,702	402,370	391,994	384,716	375,532	370,126	361,647	350,113	339,117
1989	328,259	320,690	358,881	398,081	450,836	456,937	435,052	414,022	405,994	393,144	397,280	399,887
1990	403,187	400,404	412,439	408,791	405,782	404,138	396,947	389,469	390,599	386,952	363,597	344,319
1991	319,491	301,867	314,533	313,375	308,141	317,338	313,193	308,621	312,198	326,506	344,783	353,720
1992	353,295	368,154	392,303	387,020	371,215	345,708	329,093	315,732	301,884	292,744	283,027	284,533
1993	350,778	403,371	495,215	551,375	634,105	709,790	660,885	632,607	600,095	593,051	584,542	579,150
1994	564,027	549,697	538,035	531,573	521,816	510,543	490,142	476,933	478,128	481,800	473,321	484,974
1995	591,640	620,530	636,841	613,828	555,376	693,185	729,130	642,043	570,297	577,234	571,356	573,191
1996	585,482	565,772	606,836	668,650	737,035	736,061	692,280	652,845	618,216	591,964	591,535	575,976
1997	575,954	550,541	594,762	632,710	699,245	694,648	659,934	633,410	614,916	607,540	602,945	592,358
1998	612,827	620,530	648,070	643,471	596,973	722,109	720,978	651,525	588,484	585,263	587,486	594,183
1999	612,827	620,288	643,844	675,106	692,246	735,566	695,596	644,908	604,036	591,663	590,603	583,001
2000	599,952	620,530	648,070	657,995	701,892	700,403	670,452	638,630	613,981	601,926	595,726	588,706
2001	571,101	557,938	565,914	586,049	583,432	569,186	551,987	536,462	528,821	522,529	517,199	529,547
2002	547,676	552,631	585,003	603,888	597,651	590,655	560,915	533,682	517,356	507,375	508,228	519,774
2003	540,348	557,497	568,898	586,929	625,687	671,776	639,689	611,401	597,320	583,693	574,167	584,649
2004	597,056	618,377	648,070	651,422	623,556	612,892	583,618	559,755	544,392	522,206	518,936	529,429
2005	584,358	620,530	648,070	694,424	712,102	744,894	707,834	655,194	610,269	595,768	590,618	584,368
2006	555,534	552,068	610,217	643,652	707,514	744,894	709,539	665,855	616,230	603,677	599,846	606,201
2007	597,935	602,165	614,840	611,417	600,332	581,987	561,991	545,176	538,775	528,598	530,305	529,787
2008	539,516	545,289	561,306	555,603	550,366	542,678	523,023	509,898	489,062	478,831	477,722	473,254
2009	483,149	494,310	538,178	563,407	661,813	652,685	629,499	606,764	587,028	576,970	577,931	607,671
Min.	67,316	90,467	150,535	180,864	168,510	150,668	131,999	109,449	98,806	84,156	66,913	53,513
Max.	613,008	620,711	649,157	694,424	749,804	744,894	729,130	665,855	626,610	612,853	603,126	607,852
Mean	533,551	542,197	563,497	580,809	600,893	622,615	593,356	558,486	533,564	527,002	523,564	525,751
Median	565,844	567,739	595,059	613,828	614,821	671,776	639,689	606,764	570,297	565,582	559,751	563,331

Table 4.2-2. Simulated End-of-Month Camanche Reservoir Water Surface Elevation [ft msl], Project Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	222.06	220.99	222.21	222.59	230.88	235.50	228.55	222.29	217.60	220.23	218.60	218.33
1922	218.51	221.21	223.03	223.81	221.76	235.50	229.08	221.71	215.50	218.52	217.95	221.14
1923	222.36	222.36	221.72	224.81	228.10	231.03	225.76	220.10	216.21	219.14	217.56	216.33
1924	214.99	211.91	208.42	205.76	202.52	198.43	194.15	190.16	187.15	189.63	186.36	183.29
1925	181.22	194.33	199.14	205.35	220.28	228.25	223.38	219.22	217.05	219.77	218.24	216.99
1926	216.07	215.10	212.39	211.84	210.35	208.16	205.96	204.98	205.70	211.31	212.69	213.08
1927	215.02	222.36	225.02	227.63	229.20	235.50	228.66	221.71	216.16	218.99	217.11	216.51
1928	215.85	214.05	217.12	220.63	233.24	229.07	225.55	222.92	221.96	224.29	222.36	219.40
1929	216.47	213.68	210.39	208.25	204.51	202.59	201.75	202.04	202.20	206.52	205.53	204.30
1930	203.68	201.57	203.54	203.18	200.14	206.31	204.30	203.64	204.72	210.41	211.30	210.82
1931	208.37	205.97	203.06	200.25	196.83	192.42	187.75	183.34	179.97	177.36	174.89	173.45
1932	171.05	174.73	181.86	186.21	192.76	215.71	214.57	212.48	211.83	215.26	214.32	213.80
1933	211.84	209.45	206.73	207.48	207.06	208.30	207.33	207.08	208.24	212.76	211.98	213.89
1934	214.83	213.48	214.70	211.43	207.11	203.26	199.89	196.91	195.49	199.45	198.76	197.87
1935	197.96	199.10	199.46	208.94	214.77	227.04	222.91	219.50	217.84	220.69	219.37	218.26
1936	220.90	216.64	222.08	225.97	232.53	235.50	228.62	221.97	216.71	219.61	218.21	217.68
1937	215.65	220.30	225.33	228.88	231.53	233.70	227.64	222.25	218.21	220.99	219.90	212.07
1938	212.90	214.08	213.89	204.65	221.91	235.50	229.95	221.95	215.00	218.21	217.38	216.71
1939	216.23	213.37	210.85	209.20	204.81	202.68	201.60	201.78	203.14	209.04	208.27	206.12
1940	210.32	219.63	217.76	222.86	235.50	233.99	227.94	222.91	219.29	222.20	221.16	222.36
1941	222.36	222.36	225.33	229.12	230.28	235.50	228.75	221.65	215.81	218.83	217.79	217.27
1942	215.51	215.02	217.09	222.45	224.00	235.50	230.05	222.34	215.78	218.68	217.59	217.59
1943	214.09	214.38	212.07	224.30	233.21	233.62	227.30	221.45	216.81	220.08	218.87	218.19
1944	216.83	214.54	214.11	211.47	209.27	208.45	205.14	202.77	201.76	206.24	208.36	209.85
1945	210.90	219.52	224.44	225.20	226.72	234.20	227.50	221.19	216.21	219.30	217.27	215.02
1946	215.68	216.72	219.55	221.47	233.83	232.46	226.93	222.15	218.98	221.90	221.78	221.47
1947	220.69	219.66	217.32	217.23	212.79	208.64	204.87	202.10	201.11	206.42	204.16	201.52
1948	200.75	198.31	195.74	196.30	197.48	216.30	213.37	211.46	210.92	214.52	213.81	213.78
1949	213.15	210.94	209.57	213.21	216.76	218.01	215.35	213.15	212.46	215.89	215.37	214.51
1950	216.20	221.17	224.98	229.25	228.88	234.60	227.18	220.23	214.88	218.37	204.65	204.65
1951	204.65	204.65	212.07	222.79	232.59	228.51	224.32	220.94	218.98	221.60	221.19	222.36

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1952	220.59	219.03	219.49	206.31	217.42	234.43	230.77	221.34	212.51	216.16	215.61	216.48
1953	221.37	213.82	215.05	220.01	216.95	224.30	221.23	216.80	214.17	218.37	217.81	216.86
1954	216.19	215.66	217.42	221.40	223.82	220.27	216.64	214.49	214.11	218.28	218.74	218.81
1955	219.27	217.74	216.51	213.80	210.34	209.91	206.13	203.67	202.77	206.97	206.45	207.02
1956	204.65	207.57	216.48	223.26	228.20	235.50	228.31	220.06	212.96	216.79	216.62	216.84
1957	215.88	215.84	217.06	216.17	217.48	226.43	221.63	217.70	215.74	219.30	219.30	219.39
1958	220.87	222.04	224.18	224.73	226.05	235.50	228.99	221.15	213.47	217.11	216.23	214.50
1959	214.22	216.00	216.16	213.75	209.13	205.51	203.21	202.25	203.09	208.23	208.29	208.59
1960	207.24	207.86	207.71	206.35	206.08	207.46	204.94	203.66	202.45	206.23	205.24	204.10
1961	201.68	199.33	196.59	193.55	191.42	188.32	184.56	181.45	179.86	179.32	176.89	174.30
1962	171.55	173.25	178.87	189.26	188.84	202.95	200.14	198.24	197.75	204.13	204.29	204.63
1963	206.53	211.45	212.82	219.96	232.26	235.50	228.13	221.25	215.49	219.14	216.16	215.99
1964	217.30	216.16	215.29	214.04	209.69	207.64	206.08	205.58	206.77	212.76	215.05	206.31
1965	207.12	209.35	217.99	225.46	227.66	232.89	226.09	218.72	214.70	220.95	221.12	222.32
1966	222.36	219.90	218.77	219.22	215.59	211.50	207.10	204.49	204.00	208.27	209.19	215.83
1967	222.33	222.33	224.26	224.85	214.60	231.44	232.54	222.62	213.57	217.38	217.26	217.06
1968	217.31	218.21	219.79	219.47	215.15	213.49	211.06	209.98	210.72	215.57	217.60	220.35
1969	215.48	216.61	220.53	218.71	224.44	235.50	229.43	221.35	214.43	219.66	219.23	220.84
1970	204.60	204.60	213.19	218.55	221.88	227.75	224.05	220.08	217.72	220.70	220.46	222.33
1971	222.33	222.33	225.17	226.99	221.06	227.84	224.86	222.40	219.86	224.04	222.33	222.33
1972	221.39	219.46	220.60	220.29	215.49	215.98	213.19	210.86	210.39	214.49	215.04	216.35
1973	222.33	221.98	225.17	227.60	231.67	233.19	228.22	222.67	218.82	222.51	215.40	216.49
1974	214.14	218.30	220.30	227.25	230.83	233.85	228.74	223.89	219.04	222.12	220.22	218.51
1975	216.05	216.50	222.18	225.11	222.24	232.48	227.28	221.57	217.09	221.88	221.29	220.38
1976	217.92	214.95	211.56	209.06	205.98	202.06	197.98	194.30	191.48	190.43	187.14	183.53
1977	179.77	176.07	171.45	165.94	162.19	156.14	149.68	143.86	140.87	140.25	132.84	123.04
1978	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60
1979	118.60	118.60	118.60	118.60	138.07	157.02	159.18	162.67	169.01	175.77	173.27	170.79
1980	193.52	207.79	217.84	222.93	225.77	232.64	229.27	221.04	213.90	216.98	217.41	220.30
1981	222.33	222.33	224.22	226.18	222.20	218.18	215.95	213.84	213.53	217.77	217.49	210.68
1982	207.28	204.60	211.37	214.37	227.59	233.97	227.67	218.72	209.46	214.51	212.12	207.85
1983	211.57	213.35	219.19	221.35	207.54	226.96	233.22	223.77	215.70	222.47	211.17	204.60
1984	204.60	206.24	214.88	220.05	227.34	229.43	225.93	222.72	218.89	222.66	221.77	222.01

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	219.20	218.13	218.70	220.34	216.13	212.13	207.20	204.38	203.88	208.48	209.14	209.65
1986	212.95	205.52	211.99	223.60	232.32	234.39	227.66	220.81	215.40	218.38	217.29	215.42
1987	212.56	209.81	207.39	204.97	201.68	197.50	193.18	193.13	194.02	197.32	194.49	191.87
1988	189.43	186.37	182.62	178.82	180.22	180.44	181.15	182.50	184.91	187.96	186.14	184.21
1989	182.14	180.21	178.47	173.06	184.43	185.76	186.25	187.55	190.72	194.03	190.92	187.51
1990	184.27	181.28	179.91	176.58	177.94	180.24	181.86	184.21	187.85	190.74	187.40	183.91
1991	180.22	176.77	174.30	167.72	167.90	169.66	170.70	172.87	176.56	181.16	178.89	176.56
1992	174.09	172.75	173.63	169.04	169.28	168.05	166.13	165.59	167.43	170.38	167.30	164.36
1993	164.06	179.71	194.48	204.42	218.86	230.72	224.56	221.74	217.87	221.32	219.52	217.95
1994	214.94	212.35	208.82	206.45	203.48	199.45	194.85	194.03	195.88	202.53	200.25	201.61
1995	213.16	218.73	218.79	215.24	205.63	228.38	234.17	223.16	213.05	218.89	217.46	217.00
1996	218.13	208.19	213.99	223.73	233.79	234.32	229.09	224.76	220.68	221.16	220.60	211.40
1997	210.52	204.60	211.99	218.25	228.55	228.61	224.42	221.86	220.17	223.51	222.33	220.00
1998	222.33	216.61	220.53	219.93	212.89	232.42	233.06	224.57	216.02	220.14	219.98	220.28
1999	222.33	216.57	219.90	224.89	227.55	234.25	229.56	223.59	218.48	221.11	220.46	218.55
2000	220.37	221.78	225.14	225.54	228.92	229.42	225.97	222.65	220.03	222.67	221.24	219.43
2001	216.43	213.83	212.35	214.45	211.62	209.00	206.98	205.87	205.83	209.94	208.44	209.78
2002	211.99	211.53	215.49	217.32	213.99	212.68	208.57	205.36	203.70	207.27	206.84	208.06
2003	210.74	212.35	212.84	214.59	218.48	225.29	221.39	218.48	217.43	219.90	217.91	218.80
2004	219.93	222.01	225.17	224.57	220.32	216.31	212.47	210.01	208.62	209.89	208.74	209.75
2005	217.95	222.33	220.86	227.49	230.36	235.50	231.27	225.10	219.45	221.74	220.46	217.17
2006	208.05	206.99	214.54	219.95	229.72	235.50	231.51	226.66	220.37	222.93	221.86	222.11
2007	220.07	219.53	220.19	218.50	214.43	211.21	208.76	207.44	207.62	210.98	210.72	209.82
2008	210.60	210.27	211.57	209.31	205.80	204.21	201.57	200.84	198.15	201.96	201.11	199.29
2009	200.24	200.92	207.55	210.66	223.09	222.48	219.83	217.75	215.79	218.85	218.49	220.35
Min.	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60
Max.	222.36	222.36	225.33	229.25	235.50	235.50	234.17	226.66	221.96	224.29	222.36	222.36
Mean	207.99	208.07	209.90	211.41	213.29	216.93	213.36	209.54	206.93	210.44	209.08	208.11
Median	214.83	213.83	215.05	218.50	217.42	226.43	221.63	218.48	213.53	217.38	216.23	215.42

Table 4.2-3. Additional Months Simulated Camanche WSE $\leq$ 190 ft msl for Project Case Relative to the Baseline Case

Year	Month	Baseline Case [ft msl]	Project Case [ft msl]	Decline in WSE [ft]
1924	October	193.2	189.6	3.6
1924	November	190.2	186.4	3.8
1931	July	193.6	187.8	5.8
1932	March	192.3	181.9	10.4
1932	April	196.2	186.2	9.9
1961	June	191.2	188.3	2.9
1962	April	190.8	189.3	1.5
1962	May	190.6	188.8	1.8
1976	November	190.6	187.1	3.5
1988	January	193.8	189.4	4.3
1988	February	190.9	186.4	4.5

Table 4.2-6 presents the simulated monthly average discharge at station Golf immediately below the Woodbridge Irrigation Dam. The discharge at station Frandy is estimated from simulated flow at Golf using Equation 2. Estimated monthly average discharge at Frandy is reported in Table 4.2-7.

Annual customer rationing, raw water supplies from Freeport and the Mokelumne, total supply delivered to meet consumptive demand, the WSMP 2040 supplemental supply need to achieve a District wide rationing goal of 15%, and quantity of water undelivered by demand management actions are listed in Table 4.2-8 on a CY basis for each year simulated. Additional demand deficiency imposed during the aqueduct outage period was 27% in 1981 and 3.8% in 1982. The maximum total deficiency over the POR equal to 31.8% occurs in 1978, the last year of the drought planning sequence.

Simulated CY total annual diversions from the Mokelumne for the Project case are presented in Table 4.2-9.

Table 4.2-4. Simulated Total Camanche Release [cfs], Project Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	2,478	780	710	509	1,192	1,943	889	796	661	325	325	325
1922	325	325	325	475	2,449	2,564	1,036	938	805	325	325	434
1923	518	465	325	400	822	976	802	720	586	325	325	325
1924	325	325	325	227	242	304	276	238	175	220	220	220
1925	220	220	220	300	634	738	614	532	398	325	325	325
1926	325	325	325	300	400	363	398	348	236	250	250	250
1927	250	354	250	551	1,393	1,835	982	883	751	325	429	325
1928	325	325	857	500	486	732	457	383	258	325	420	325
1929	325	325	325	302	369	304	314	262	189	220	220	220
1930	220	220	220	300	400	363	398	348	236	250	250	250
1931	250	250	250	227	242	304	276	238	175	126	130	130
1932	130	130	130	300	450	533	398	348	236	250	250	250
1933	250	250	250	300	400	363	398	348	236	250	250	250
1934	250	250	250	302	369	304	314	262	189	220	220	220
1935	220	220	220	300	565	670	546	463	330	325	325	325
1936	325	2,327	533	644	1,713	1,546	982	883	750	325	325	325
1937	325	325	581	500	992	1,146	832	740	606	325	325	1,295
1938	325	1,198	1,784	2,453	3,029	2,301	1,186	1,084	944	325	325	325
1939	325	325	325	302	369	304	314	262	189	250	250	250
1940	250	250	1,360	525	1,521	1,199	795	696	564	325	325	332
1941	585	919	680	500	1,252	1,586	1,033	941	807	325	325	521
1942	1,406	1,077	325	425	2,108	2,087	1,139	1,039	904	325	582	471
1943	1,568	1,050	1,882	776	1,749	1,333	928	828	694	325	325	325
1944	325	325	325	300	400	363	398	348	236	220	220	220
1945	220	267	220	500	1,036	1,091	916	834	700	325	540	1,119
1946	649	325	325	450	744	1,048	734	642	508	325	325	325
1947	325	325	325	300	400	363	398	348	236	220	220	220
1948	220	220	220	300	450	533	398	348	236	250	250	250
1949	250	250	250	300	450	533	398	348	236	250	250	250
1950	250	250	250	542	1,152	1,309	995	900	760	325	3,404	4,175

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1951	1,349	1,135	442	525	871	976	611	522	390	325	325	723
1952	1,440	1,332	1,145	3,124	3,224	1,966	1,434	1,330	1,188	325	325	325
1953	325	1,194	325	300	736	841	717	634	500	325	325	325
1954	325	325	325	300	450	533	398	348	236	250	250	250
1955	250	250	250	300	400	363	398	348	236	220	220	1,924
1956	3,085	1,045	312	531	2,146	1,928	1,166	1,065	928	325	325	325
1957	325	325	325	300	589	694	570	487	353	325	325	325
1958	325	1,094	1,040	1,942	2,683	1,986	1,257	1,156	1,019	325	325	325
1959	325	325	325	300	400	363	398	348	236	250	250	250
1960	250	250	250	300	400	363	398	348	236	220	220	220
1961	220	220	220	227	242	304	314	262	184	126	130	130
1962	130	130	130	300	450	533	398	348	236	220	220	220
1963	220	672	220	400	1,532	1,453	1,041	948	815	325	668	325
1964	325	325	325	300	400	363	398	348	236	250	250	3,515
1965	2,316	904	250	475	1,496	1,601	1,197	1,097	963	325	603	325
1966	331	325	325	300	400	363	398	348	236	220	220	220
1967	359	565	939	1,233	3,274	1,846	1,442	1,341	1,205	325	325	325
1968	325	325	325	300	400	363	398	348	236	250	250	250
1969	2,490	1,682	857	2,424	3,526	1,889	1,366	1,262	1,119	325	325	397
1970	3,476	1,115	547	525	762	867	646	563	430	325	646	810
1971	729	660	566	500	909	914	789	707	573	325	362	399
1972	325	325	325	350	450	533	398	348	236	250	250	250
1973	503	1,299	647	500	938	1,042	821	736	602	325	1,364	917
1974	1,403	325	922	739	1,409	1,513	1,109	1,010	877	325	325	325
1975	325	325	325	400	1,253	1,307	1,183	1,101	967	325	358	325
1976	325	325	325	227	242	304	276	238	175	220	220	220
1977	220	220	220	227	242	304	276	238	175	126	130	130
1978	130	130	130	227	242	304	276	238	175	126	130	130
1979	130	130	130	225	273	363	398	348	231	163	130	130
1980	130	1,251	566	525	1,446	1,600	1,196	1,097	965	325	468	325
1981	543	611	325	300	400	363	398	348	236	250	548	1,838
1982	1,603	3,186	1,916	3,774	2,949	1,739	1,336	1,231	1,084	325	1,267	1,619
1983	1,302	2,285	3,354	1,737	4,487	3,653	2,167	2,061	1,915	325	2,327	2,741

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984	1,551	1,037	414	525	992	1,096	875	793	661	325	562	325
1985	325	325	325	300	400	363	398	348	236	220	220	220
1986	220	4,979	2,759	551	1,818	1,447	1,043	941	801	325	325	325
1987	325	325	325	227	242	304	314	262	184	220	220	220
1988	220	220	220	227	242	304	276	238	175	126	130	130
1989	130	130	130	300	450	533	398	348	236	220	220	220
1990	220	220	220	302	369	304	314	262	189	220	220	220
1991	220	220	220	302	369	304	314	262	189	126	130	130
1992	130	130	130	227	242	304	314	262	184	126	130	130
1993	130	130	130	325	951	1,055	834	752	620	325	325	325
1994	325	325	325	227	242	304	314	262	184	220	220	220
1995	220	462	2,923	2,678	4,600	2,302	1,799	1,694	1,549	325	325	325
1996	325	2,203	1,141	531	1,995	1,308	904	803	667	325	584	2,383
1997	5,595	2,272	489	530	785	841	621	536	399	325	451	325
1998	626	2,235	1,374	1,813	2,907	2,008	1,604	1,501	1,360	325	325	325
1999	554	1,959	749	500	1,178	1,233	1,012	926	792	325	325	325
2000	325	1,081	712	500	819	773	649	567	433	325	325	325
2001	325	325	325	300	400	363	398	348	236	250	250	250
2002	250	250	250	300	450	533	398	348	236	220	220	220
2003	220	220	220	300	502	605	481	400	268	325	325	325
2004	325	325	452	300	400	363	398	348	236	250	250	250
2005	250	424	1,297	807	2,102	1,632	1,114	1,015	880	325	325	1,450
2006	2,029	1,225	1,342	4,071	3,150	1,873	1,060	956	814	325	325	325
2007	325	325	325	300	400	363	398	348	236	250	250	250
2008	250	250	250	302	369	304	314	262	189	220	220	220
2009	220	220	220	300	450	533	398	348	236	250	250	912
Min.	130	130	130	225	242	304	276	238	175	126	130	130
Max.	5,595	4,979	3,354	4,071	4,600	3,653	2,167	2,061	1,915	325	3,404	4,175
Mean	621	681	565	621	1,059	943	697	625	508	273	383	518
Median	325	325	325	302	565	694	546	463	330	325	325	325

Table 4.2-5. Estimated Flow at Elliott [cfs], Project Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	2,475	790	700	492	1,179	1,928	863	765	647	312	315	318
1922	332	340	325	457	2,435	2,550	1,008	904	791	312	315	432
1923	524	478	325	381	809	959	777	691	572	312	315	318
1924	332	340	325	206	230	286	260	220	160	208	213	207
1925	228	236	223	280	622	721	593	507	383	312	315	318
1926	332	340	325	280	388	345	380	327	221	238	242	239
1927	258	368	252	534	1,380	1,820	954	851	737	312	417	318
1928	332	340	843	482	474	715	438	361	243	312	408	318
1929	332	340	325	282	357	286	297	243	174	208	213	207
1930	228	236	223	280	388	345	380	327	221	238	242	239
1931	258	265	252	206	230	286	260	220	160	115	124	113
1932	138	147	136	280	438	516	380	327	221	238	242	239
1933	258	265	252	280	388	345	380	327	221	238	242	239
1934	258	265	252	282	357	286	297	243	174	208	213	207
1935	228	236	223	280	553	653	526	440	315	312	315	318
1936	332	2,322	528	628	1,699	1,530	954	851	736	312	315	318
1937	332	340	575	482	979	1,130	807	711	592	312	315	1,336
1938	332	1,204	1,746	2,458	3,014	2,287	1,155	1,047	930	312	315	318
1939	332	340	325	282	357	286	297	243	174	238	242	239
1940	258	265	1,333	508	1,508	1,183	771	668	550	312	315	325
1941	591	928	671	482	1,239	1,570	1,005	907	793	312	315	523
1942	1,408	1,084	325	407	2,094	2,072	1,109	1,003	890	312	567	471
1943	1,569	1,058	1,841	762	1,735	1,317	901	797	680	312	315	318
1944	332	340	325	280	388	345	380	327	221	208	213	207
1945	228	282	223	482	1,023	1,075	890	803	686	312	526	1,151
1946	655	340	325	432	731	1,032	711	615	493	312	315	318
1947	332	340	325	280	388	345	380	327	221	208	213	207
1948	228	236	223	280	438	516	380	327	221	238	242	239
1949	258	265	252	280	438	516	380	327	221	238	242	239
1950	258	265	252	525	1,139	1,293	967	867	746	312	3,330	4,360
1951	1,351	1,142	439	508	858	959	590	497	375	312	315	736

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1952	1,442	1,337	1,124	3,137	3,209	1,951	1,399	1,288	1,175	312	315	318
1953	332	1,200	325	280	723	824	694	607	485	312	315	318
1954	332	340	325	280	438	516	380	327	221	238	242	239
1955	258	265	252	280	388	345	380	327	221	208	213	1,997
1956	3,079	1,053	313	514	2,132	1,913	1,135	1,029	914	312	315	318
1957	332	340	325	280	577	677	549	463	338	312	315	318
1958	332	1,101	1,021	1,941	2,668	1,971	1,225	1,118	1,006	312	315	318
1959	332	340	325	280	388	345	380	327	221	238	242	239
1960	258	265	252	280	388	345	380	327	221	208	213	207
1961	228	236	223	206	230	286	297	243	169	115	124	113
1962	138	147	136	280	438	516	380	327	221	208	213	207
1963	228	683	223	381	1,519	1,437	1,012	914	801	312	651	318
1964	332	340	325	280	388	345	380	327	221	238	242	3,667
1965	2,314	913	252	457	1,483	1,585	1,166	1,060	949	312	588	318
1966	338	340	325	280	388	345	380	327	221	208	213	207
1967	366	577	923	1,224	3,259	1,831	1,407	1,299	1,192	312	315	318
1968	332	340	325	280	388	345	380	327	221	238	242	239
1969	2,487	1,683	843	2,429	3,510	1,874	1,332	1,221	1,106	312	315	393
1970	3,468	1,122	542	508	749	850	624	538	415	312	630	827
1971	734	671	560	482	896	897	765	678	559	312	352	395
1972	332	340	325	331	438	516	380	327	221	238	242	239
1973	510	1,304	639	482	925	1,026	796	707	588	312	1,333	939
1974	1,405	340	907	724	1,396	1,497	1,079	975	863	312	315	318
1975	332	340	325	381	1,240	1,291	1,152	1,064	953	312	348	318
1976	332	340	325	206	230	286	260	220	160	208	213	207
1977	228	236	223	206	230	286	260	220	160	115	124	113
1978	138	147	136	206	230	286	260	220	160	115	124	113
1979	138	147	136	204	261	345	380	327	216	152	124	113
1980	138	1,257	560	508	1,433	1,584	1,165	1,060	951	312	455	318
1981	549	623	325	280	388	345	380	327	221	238	534	1,906
1982	1,604	3,173	1,874	3,794	2,934	1,724	1,303	1,191	1,071	312	1,238	1,676
1983	1,305	2,281	3,274	1,734	4,470	3,641	2,120	2,003	1,904	312	2,275	2,855
1984	1,553	1,045	412	508	979	1,080	849	762	647	312	547	318

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	332	340	325	280	388	345	380	327	221	208	213	207
1986	228	4,948	2,695	534	1,804	1,431	1,014	907	787	312	315	318
1987	332	340	325	206	230	286	297	243	169	208	213	207
1988	228	236	223	206	230	286	260	220	160	115	124	113
1989	138	147	136	280	438	516	380	327	221	208	213	207
1990	228	236	223	282	357	286	297	243	174	208	213	207
1991	228	236	223	282	357	286	297	243	174	115	124	113
1992	138	147	136	206	230	286	297	243	169	115	124	113
1993	138	147	136	305	938	1,039	809	722	606	312	315	318
1994	332	340	325	206	230	286	297	243	169	208	213	207
1995	228	475	2,854	2,686	4,583	2,288	1,758	1,644	1,537	312	315	318
1996	332	2,199	1,120	514	1,981	1,292	878	772	653	312	569	2,479
1997	5,577	2,268	485	513	772	824	599	511	384	312	439	318
1998	632	2,231	1,347	1,811	2,892	1,993	1,566	1,455	1,347	312	315	318
1999	560	1,958	738	482	1,165	1,217	984	893	778	312	315	318
2000	332	1,088	702	482	806	756	627	541	418	312	315	318
2001	332	340	325	280	388	345	380	327	221	238	242	239
2002	258	265	252	280	438	516	380	327	221	208	213	207
2003	228	236	223	280	490	588	462	378	253	312	315	318
2004	332	340	449	280	388	345	380	327	221	238	242	239
2005	258	438	1,272	793	2,088	1,616	1,084	980	866	312	315	1,499
2006	2,028	1,231	1,315	4,095	3,135	1,858	1,031	922	800	312	315	318
2007	332	340	325	280	388	345	380	327	221	238	242	239
2008	258	265	252	282	357	286	297	243	174	208	213	207
2009	228	236	223	280	438	516	380	327	221	238	242	934
Min.	138	147	136	204	230	286	260	220	160	115	124	113
Max.	5,577	4,948	3,274	4,095	4,583	3,641	2,120	2,003	1,904	312	3,330	4,360
Mean	627	692	559	605	1,046	926	674	598	494	261	372	520
Median	332	340	325	282	553	677	526	440	315	312	315	318

Table 4.2-6. Simulated Flow Below Woodbridge Irrigation Dam [cfs], Project Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	2,403	713	616	350	877	1,522	422	404	403	181	261	245
1922	255	263	237	322	2,139	2,150	576	552	552	185	265	359
1923	451	406	240	250	517	567	346	338	337	188	268	254
1924	258	268	241	75	23	31	18	15	15	139	163	149
1925	153	161	135	150	328	328	158	150	148	188	268	254
1926	258	266	240	150	150	31	29	22	20	132	193	179
1927	183	295	165	402	1,087	1,426	525	502	502	188	372	254
1928	258	268	773	350	200	350	33	22	20	195	363	254
1929	258	266	241	150	150	31	29	22	20	139	163	149
1930	153	161	135	150	150	31	29	22	20	132	193	179
1931	183	191	166	75	23	31	18	15	15	45	73	59
1932	63	73	45	150	200	200	29	22	20	132	193	179
1933	183	191	165	150	150	31	29	22	20	132	193	179
1934	183	191	166	150	150	31	29	22	20	139	163	149
1935	153	161	135	150	260	260	89	82	80	188	268	254
1936	253	2,265	442	487	1,401	1,129	518	494	494	183	263	248
1937	258	266	496	350	687	737	376	358	357	188	268	1,224
1938	214	1,099	1,652	2,253	2,670	1,835	672	648	648	154	231	210
1939	258	266	241	150	150	31	29	22	20	169	193	179
1940	183	193	1,275	375	1,215	790	338	315	315	188	268	261
1941	518	860	596	350	946	1,176	577	559	558	188	268	449
1942	1,323	1,004	223	257	1,783	1,657	661	638	638	175	512	384
1943	1,486	977	1,781	608	1,425	903	451	428	428	176	255	238
1944	258	268	240	150	150	31	29	22	20	102	163	149
1945	153	207	135	350	731	681	460	452	451	188	483	1,048
1946	583	266	240	300	438	638	277	260	258	188	268	254
1947	258	266	240	150	150	31	29	22	20	102	163	149
1948	153	163	135	150	200	200	29	22	20	132	193	179
1949	183	191	165	150	200	200	29	22	20	132	193	179
1950	147	158	126	350	802	852	491	474	472	160	3,316	4,068
1951	1,283	1,076	357	375	566	566	155	141	141	188	268	652

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1952	1,313	1,223	995	2,905	2,845	1,479	899	875	875	142	218	194
1953	258	1,135	240	150	431	431	260	252	251	188	268	254
1954	258	266	240	150	200	200	29	22	20	132	193	179
1955	183	191	165	150	150	31	29	22	20	102	163	1,853
1956	2,991	965	197	350	1,807	1,482	674	650	650	167	245	227
1957	258	266	240	150	284	284	113	105	104	188	268	254
1958	229	1,008	924	1,759	2,342	1,538	763	739	739	165	244	225
1959	258	266	240	150	150	31	29	22	20	132	193	179
1960	183	193	165	150	150	31	29	22	20	102	163	149
1961	153	161	136	75	23	31	29	22	15	45	73	59
1962	63	71	45	150	200	200	29	22	20	102	163	149
1963	153	612	135	250	1,226	1,044	584	567	565	188	612	254
1964	258	268	240	150	150	31	29	22	20	132	193	3,444
1965	2,236	833	151	310	1,174	1,174	723	699	699	177	535	240
1966	264	266	240	150	150	31	29	22	20	102	163	149
1967	265	481	825	1,052	2,936	1,401	950	926	926	167	245	227
1968	258	268	240	150	150	31	29	22	20	132	193	179
1969	2,360	1,566	703	2,201	3,142	1,397	826	802	802	139	215	262
1970	3,403	1,050	456	368	449	449	181	174	174	183	583	732
1971	662	601	482	350	604	504	333	325	324	188	305	327
1972	258	268	240	200	200	200	29	22	20	132	193	179
1973	436	1,239	563	350	632	632	365	354	352	188	1,307	846
1974	1,333	263	834	585	1,099	1,099	648	624	624	185	265	251
1975	258	266	240	250	948	898	727	719	718	188	301	254
1976	258	268	241	75	23	31	18	15	15	139	163	149
1977	153	161	136	75	23	31	18	15	15	45	73	59
1978	63	71	46	75	23	31	18	15	15	45	73	59
1979	63	71	45	75	23	31	29	22	15	45	73	59
1980	63	1,194	481	375	1,141	1,191	739	716	716	188	411	254
1981	476	552	240	150	150	31	29	22	20	132	491	1,767
1982	1,454	3,053	1,741	3,528	2,542	1,223	772	748	748	124	1,141	1,465
1983	1,153	2,152	3,180	1,492	4,081	3,136	1,602	1,579	1,579	124	2,202	2,588
1984	1,484	980	330	375	686	686	419	411	411	188	505	254

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	258	266	240	150	150	31	29	22	20	102	163	149
1986	109	4,880	2,627	350	1,459	981	529	506	506	154	232	210
1987	258	266	241	75	23	31	29	22	15	139	163	149
1988	153	163	136	75	23	31	18	15	15	45	73	59
1989	63	71	45	150	200	200	29	22	20	102	163	149
1990	153	161	136	150	150	31	29	22	20	139	163	149
1991	153	161	136	150	150	31	29	22	20	45	73	59
1992	63	73	46	75	23	31	29	22	15	45	73	59
1993	63	71	45	175	645	645	378	370	370	188	268	254
1994	258	266	241	75	23	31	29	22	15	139	163	149
1995	76	333	2,755	2,438	4,200	1,792	1,241	1,217	1,217	128	203	176
1996	232	2,123	1,027	350	1,657	864	412	389	389	167	505	2,285
1997	5,501	2,189	375	350	447	397	130	122	122	167	372	228
1998	506	2,128	1,232	1,602	2,537	1,529	1,078	1,054	1,054	147	224	201
1999	487	1,900	664	350	873	823	555	544	543	188	268	254
2000	258	1,022	628	350	514	364	193	185	184	188	268	254
2001	258	266	240	150	150	31	29	22	20	132	193	179
2002	183	191	165	150	200	200	29	22	20	102	163	149
2003	153	161	135	150	200	200	29	22	20	189	268	254
2004	258	268	368	150	150	31	29	22	20	132	193	179
2005	169	352	1,197	641	1,779	1,203	639	615	615	177	256	1,364
2006	1,900	1,109	1,190	3,849	2,768	1,382	522	498	498	140	216	192
2007	258	266	240	150	150	31	29	22	20	132	193	179
2008	183	193	166	150	150	31	29	22	20	139	163	149
2009	153	161	135	150	200	200	29	22	20	132	193	841
Min.	63	71	45	75	23	31	18	15	15	45	73	59
Max.	5,501	4,880	3,180	3,849	4,200	3,136	1,602	1,579	1,579	195	3,316	4,068
Mean	545	614	470	460	774	569	287	275	274	145	319	438
Median	258	266	240	150	260	284	89	82	80	139	218	225

Table 4.2-7. Estimated Flow at Frandy [cfs], Project Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	2,388	698	586	320	847	1,492	392	374	373	166	246	230
1922	240	248	207	292	2,109	2,120	546	522	522	170	250	344
1923	436	391	210	220	487	537	316	308	307	173	253	239
1924	243	253	211	45	1	1	1	1	1	124	148	134
1925	138	146	105	120	298	298	128	120	118	173	253	239
1926	243	251	210	120	120	1	1	1	1	117	178	164
1927	168	280	135	372	1,057	1,396	495	472	472	173	357	239
1928	243	253	743	320	170	320	3	1	1	180	348	239
1929	243	251	211	120	120	1	1	1	1	124	148	134
1930	138	146	105	120	120	1	1	1	1	117	178	164
1931	168	176	136	45	1	1	1	1	1	30	58	44
1932	48	58	15	120	170	170	1	1	1	117	178	164
1933	168	176	135	120	120	1	1	1	1	117	178	164
1934	168	176	136	120	120	1	1	1	1	124	148	134
1935	138	146	105	120	230	230	59	52	50	173	253	239
1936	238	2,250	412	457	1,371	1,099	488	464	464	168	248	233
1937	243	251	466	320	657	707	346	328	327	173	253	1,209
1938	199	1,084	1,622	2,223	2,640	1,805	642	618	618	139	216	195
1939	243	251	211	120	120	1	1	1	1	154	178	164
1940	168	178	1,245	345	1,185	760	308	285	285	173	253	246
1941	503	845	566	320	916	1,146	547	529	528	173	253	434
1942	1,308	989	193	227	1,753	1,627	631	608	608	160	497	369
1943	1,471	962	1,751	578	1,395	873	421	398	398	161	240	223
1944	243	253	210	120	120	1	1	1	1	87	148	134
1945	138	192	105	320	701	651	430	422	421	173	468	1,033
1946	568	251	210	270	408	608	247	230	228	173	253	239
1947	243	251	210	120	120	1	1	1	1	87	148	134
1948	138	148	105	120	170	170	1	1	1	117	178	164
1949	168	176	135	120	170	170	1	1	1	117	178	164
1950	132	143	96	320	772	822	461	444	442	145	3,301	4,053
1951	1,268	1,061	327	345	536	536	125	111	111	173	253	637

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1952	1,298	1,208	965	2,875	2,815	1,449	869	845	845	127	203	179
1953	243	1,120	210	120	401	401	230	222	221	173	253	239
1954	243	251	210	120	170	170	1	1	1	117	178	164
1955	168	176	135	120	120	1	1	1	1	87	148	1,838
1956	2,976	950	167	320	1,777	1,452	644	620	620	152	230	212
1957	243	251	210	120	254	254	83	75	74	173	253	239
1958	214	993	894	1,729	2,312	1,508	733	709	709	150	229	210
1959	243	251	210	120	120	1	1	1	1	117	178	164
1960	168	178	135	120	120	1	1	1	1	87	148	134
1961	138	146	106	45	1	1	1	1	1	30	58	44
1962	48	56	15	120	170	170	1	1	1	87	148	134
1963	138	597	105	220	1,196	1,014	554	537	535	173	597	239
1964	243	253	210	120	120	1	1	1	1	117	178	3,429
1965	2,221	818	121	280	1,144	1,144	693	669	669	162	520	225
1966	249	251	210	120	120	1	1	1	1	87	148	134
1967	250	466	795	1,022	2,906	1,371	920	896	896	152	230	212
1968	243	253	210	120	120	1	1	1	1	117	178	164
1969	2,345	1,551	673	2,171	3,112	1,367	796	772	772	124	200	247
1970	3,388	1,035	426	338	419	419	151	144	144	168	568	717
1971	647	586	452	320	574	474	303	295	294	173	290	312
1972	243	253	210	170	170	170	1	1	1	117	178	164
1973	421	1,224	533	320	602	602	335	324	322	173	1,292	831
1974	1,318	248	804	555	1,069	1,069	618	594	594	170	250	236
1975	243	251	210	220	918	868	697	689	688	173	286	239
1976	243	253	211	45	1	1	1	1	1	124	148	134
1977	138	146	106	45	1	1	1	1	1	30	58	44
1978	48	56	16	45	1	1	1	1	1	30	58	44
1979	48	56	15	45	1	1	1	1	1	30	58	44
1980	48	1,179	451	345	1,111	1,161	709	686	686	173	396	239
1981	461	537	210	120	120	1	1	1	1	117	476	1,752
1982	1,439	3,038	1,711	3,498	2,512	1,193	742	718	718	109	1,126	1,450
1983	1,138	2,137	3,150	1,462	4,051	3,106	1,572	1,549	1,549	109	2,187	2,573
1984	1,469	965	300	345	656	656	389	381	381	173	490	239

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	243	251	210	120	120	1	1	1	1	87	148	134
1986	94	4,865	2,597	320	1,429	951	499	476	476	139	217	195
1987	243	251	211	45	1	1	1	1	1	124	148	134
1988	138	148	106	45	1	1	1	1	1	30	58	44
1989	48	56	15	120	170	170	1	1	1	87	148	134
1990	138	146	106	120	120	1	1	1	1	124	148	134
1991	138	146	106	120	120	1	1	1	1	30	58	44
1992	48	58	16	45	1	1	1	1	1	30	58	44
1993	48	56	15	145	615	615	348	340	340	173	253	239
1994	243	251	211	45	1	1	1	1	1	124	148	134
1995	61	318	2,725	2,408	4,170	1,762	1,211	1,187	1,187	113	188	161
1996	217	2,108	997	320	1,627	834	382	359	359	152	490	2,270
1997	5,486	2,174	345	320	417	367	100	92	92	152	357	213
1998	491	2,113	1,202	1,572	2,507	1,499	1,048	1,024	1,024	132	209	186
1999	472	1,885	634	320	843	793	525	514	513	173	253	239
2000	243	1,007	598	320	484	334	163	155	154	173	253	239
2001	243	251	210	120	120	1	1	1	1	117	178	164
2002	168	176	135	120	170	170	1	1	1	87	148	134
2003	138	146	105	120	170	170	1	1	1	174	253	239
2004	243	253	338	120	120	1	1	1	1	117	178	164
2005	154	337	1,167	611	1,749	1,173	609	585	585	162	241	1,349
2006	1,885	1,094	1,160	3,819	2,738	1,352	492	468	468	125	201	177
2007	243	251	210	120	120	1	1	1	1	117	178	164
2008	168	178	136	120	120	1	1	1	1	124	148	134
2009	138	146	105	120	170	170	1	1	1	117	178	826
Min.	48	56	15	45	1	1	1	1	1	30	58	44
Max.	5,486	4,865	3,150	3,819	4,170	3,106	1,572	1,549	1,549	180	3,301	4,053
Mean	530	599	440	430	745	539	259	250	250	130	304	423
Median	243	251	210	120	230	254	59	52	50	124	203	210

Table 4.2-8. Calendar Year Water Supply Deliveries, Customer Cutbacks, and Undelivered Supply, Project Case^a

Year	Customer Cutback	Additional Deficiency ^b	Total Deficiency	WSMP 2040 Supplemental Supply Requirement ^c [MGD]	Freeport Supplemental Supply [MGD]	Bayside Phase I Supplemental Supply [MGD]	Mokelumne Supply [MGD]	Total Supply Delivered [MGD]
1921	0.0%	0.0%	0.0%	0	0	0	230	230
1922	0.0%	0.0%	0.0%	0	0	0	230	230
1923	0.0%	0.0%	0.0%	0	0	0	230	230
1924	3.0%	0.0%	3.0%	0	59	1	163	223
1925	0.0%	0.0%	0.0%	0	0	0	230	230
1926	0.0%	0.0%	0.0%	0	67	1	162	230
1927	0.0%	0.0%	0.0%	0	0	0	230	230
1928	0.0%	0.0%	0.0%	0	0	0	230	230
1929	0.0%	0.0%	0.0%	0	54	1	175	230
1930	0.0%	0.0%	0.0%	0	84	1	145	230
1931	5.8%	0.0%	5.8%	0	10	1	206	217
1932	0.0%	0.0%	0.0%	0	0	0	230	230
1933	0.0%	0.0%	0.0%	0	60	1	169	230
1934	0.5%	0.0%	0.5%	0	81	1	147	229
1935	0.0%	0.0%	0.0%	0	5	0	225	230
1936	0.0%	0.0%	0.0%	0	0	0	230	230
1937	0.0%	0.0%	0.0%	0	0	0	230	230
1938	0.0%	0.0%	0.0%	0	0	0	230	230
1939	0.0%	0.0%	0.0%	0	83	1	146	230
1940	0.0%	0.0%	0.0%	0	0	0	230	230
1941	0.0%	0.0%	0.0%	0	0	0	230	230
1942	0.0%	0.0%	0.0%	0	0	0	230	230
1943	0.0%	0.0%	0.0%	0	0	0	230	230
1944	0.0%	0.0%	0.0%	0	0	0	230	230
1945	0.0%	0.0%	0.0%	0	0	0	230	230
1946	0.0%	0.0%	0.0%	0	0	0	230	230
1947	0.0%	0.0%	0.0%	0	0	0	230	230
1948	0.0%	0.0%	0.0%	0	0	0	230	230

Year	Customer Cutback	Additional Deficiency ^b	Total Deficiency	WSMP 2040 Supplemental Supply Requirement ^c [MGD]	Freeport Supplemental Supply [MGD]	Bayside Phase I Supplemental Supply [MGD]	Mokelumne Supply [MGD]	Total Supply Delivered [MGD]
1949	0.0%	0.0%	0.0%	0	0	0	230	230
1950	0.0%	0.0%	0.0%	0	0	0	230	230
1951	0.0%	0.0%	0.0%	0	0	0	230	230
1952	0.0%	0.0%	0.0%	0	0	0	230	230
1953	0.0%	0.0%	0.0%	0	0	0	230	230
1954	0.0%	0.0%	0.0%	0	0	0	230	230
1955	0.0%	0.0%	0.0%	0	0	0	230	230
1956	0.0%	0.0%	0.0%	0	0	0	230	230
1957	0.0%	0.0%	0.0%	0	0	0	230	230
1958	0.0%	0.0%	0.0%	0	0	0	230	230
1959	0.0%	0.0%	0.0%	0	84	1	145	230
1960	0.0%	0.0%	0.0%	0	63	1	166	230
1961	5.6%	0.0%	5.6%	0	0	1	216	217
1962	1.3%	0.0%	1.3%	0	0	1	226	227
1963	0.0%	0.0%	0.0%	0	0	0	230	230
1964	0.0%	0.0%	0.0%	0	75	1	154	230
1965	0.0%	0.0%	0.0%	0	0	0	230	230
1966	0.0%	0.0%	0.0%	0	0	0	230	230
1967	0.0%	0.0%	0.0%	0	0	0	230	230
1968	0.0%	0.0%	0.0%	0	84	1	145	230
1969	0.0%	0.0%	0.0%	0	0	0	230	230
1970	0.0%	0.0%	0.0%	0	0	0	230	230
1971	0.0%	0.0%	0.0%	0	0	0	230	230
1972	0.0%	0.0%	0.0%	0	0	0	230	230
1973	0.0%	0.0%	0.0%	0	0	0	230	230
1974	0.0%	0.0%	0.0%	0	0	0	230	230
1975	0.0%	0.0%	0.0%	0	0	0	230	230
1976	2.6%	0.0%	2.6%	0	66	1	157	224
1977	15.0%	0.0%	15.0%	0	72	1	122	196
1978	15.0%	16.8%	31.8%	39	9	1	53	157

Year	Customer Cutback	Additional Deficiency ^b	Total Deficiency	WSMP 2040 Supplemental Supply Requirement ^c [MGD]	Freeport Supplemental Supply [MGD]	Bayside Phase I Supplemental Supply [MGD]	Mokelumne Supply [MGD]	Total Supply Delivered [MGD]
1979	15.0%	0.0%	15.0%	0	0	0	196	196
1980	0.0%	0.0%	0.0%	0	0	0.2	191	230
1981	0.5%	27.0%	27.5%	0	0	1.0	114	167
1982	2.1%	3.8%	5.9%	0	0	0.3	216	216
1983	0.0%	0.0%	0.0%	0	0	0	230	230
1984	0.0%	0.0%	0.0%	0	0	0	230	230
1985	0.0%	0.0%	0.0%	0	0	0	230	230
1986	0.0%	0.0%	0.0%	0	0	0	230	230
1987	1.4%	0.0%	1.4%	0	82	1	144	227
1988	11.3%	0.0%	11.3%	0	65	1	138	204
1989	6.8%	0.0%	6.8%	0	0	1	213	214
1990	9.5%	0.0%	9.5%	0	59	1	148	208
1991	13.6%	0.0%	13.6%	0	77	1	121	199
1992	14.8%	0.0%	14.8%	0	11	1	184	196
1993	0.0%	0.0%	0.0%	0	0	0	230	230
1994	1.0%	0.0%	1.0%	0	84	1	143	228
1995	0.0%	0.0%	0.0%	0	8	0	222	230
1996	0.0%	0.0%	0.0%	0	0	0	230	230
1997	0.0%	0.0%	0.0%	0	0	0	230	230
1998	0.0%	0.0%	0.0%	0	0	0	230	230
1999	0.0%	0.0%	0.0%	0	0	0	230	230
2000	0.0%	0.0%	0.0%	0	0	0	230	230
2001	0.0%	0.0%	0.0%	0	83	1	146	230
2002	0.0%	0.0%	0.0%	0	0	0	230	230
2003	0.0%	0.0%	0.0%	0	0	0	230	230
2004	0.0%	0.0%	0.0%	0	0	0	230	230
2005	0.0%	0.0%	0.0%	0	0	0	230	230
2006	0.0%	0.0%	0.0%	0	0	0	230	230
2007	0.0%	0.0%	0.0%	0	84	1	145	230
2008	0.5%	0.0%	0.5%	0	63	1	164	229

Year	Customer Cutback	Additional Deficiency ^b	Total Deficiency	WSMP 2040 Supplemental Supply Requirement ^c [MGD]	Freeport Supplemental Supply [MGD]	Bayside Phase I Supplemental Supply [MGD]	Mokelumne Supply [MGD]	Total Supply Delivered [MGD]
2009	0.0%	0.0%	0.0%	0	0	0	230	230
a	The sum of supplemental supplies and the Mokelumne supply do not necessarily equate to the total supply delivered due to Terminal Reservoir storage regulation.							
b	Additional deficiency of 27% in 1981 and 3.8% in 1982 is due to a limitation on the Mokelumne water supply resulting from the simulated aqueduct outage scenario as described in Section 3.1.1.3.							
c	WSMP 2040 supplemental supply requirement external to the Mokelumne River to reduce District wide rationing to 15%.							

Table 4.2-9. Calendar Year Total Annual Diversions, [TAF], Project Case

Year	Upstream	JVID	NSJWCD	WID	EBMUD ^a	Year	Upstream	JVID	NSJWCD	WID	EBMUD ^a
1921	24	3.4	20	60	258	1966	24	3.40	0	60	258
1922	24	3.4	20	60	258	1967	24	3.40	20	60	258
1923	24	3.4	20	60	258	1968	24	3.40	0	60	163
1924	24	0.0	0	39	183	1969	24	3.40	20	60	258
1925	24	3.4	20	60	258	1970	24	3.40	20	60	258
1926	24	3.4	0	60	181	1971	24	3.40	20	60	258
1927	24	3.4	20	60	258	1972	24	3.40	0	60	258
1928	24	3.4	13	60	258	1973	24	3.40	20	60	258
1929	24	3.3	0	39	197	1974	24	3.40	20	60	258
1930	24	3.4	0	60	163	1975	24	3.40	20	60	258
1931	24	0.0	0	39	231	1976	24	0.00	0	39	176
1932	24	3.4	0	60	258	1977	24	0.00	0	39	137
1933	24	3.4	0	60	189	1978	24	0.00	0	39	60
1934	24	0.4	0	39	165	1979	24	2.10	0	60	324
1935	24	3.4	20	60	252	1980	24	3.40	20	60	215
1936	24	3.4	20	60	258	1981	24	3.40	0	60	128
1937	24	3.4	20	60	258	1982	24	3.40	20	60	306
1938	24	3.4	20	60	258	1983	24	3.40	20	60	295
1939	24	3.4	0	39	164	1984	24	3.40	20	60	258
1940	24	3.4	20	60	258	1985	24	3.40	0	60	258
1941	24	3.4	20	60	258	1986	24	3.40	20	60	258
1942	24	3.4	20	60	258	1987	24	0.00	0	39	161
1943	24	3.4	20	60	258	1988	24	0.00	0	39	155
1944	24	3.4	0	60	258	1989	24	1.70	0	60	239
1945	24	3.4	20	60	258	1990	24	0.40	0	39	166
1946	24	3.4	20	60	258	1991	24	0.00	0	39	135
1947	24	3.4	0	60	258	1992	24	0.40	0	39	207
1948	24	3.3	0	60	258	1993	24	3.40	20	60	258
1949	24	3.4	0	60	258	1994	24	3.30	0	39	160
1950	24	3.4	20	60	258	1995	24	3.40	20	60	248
1951	24	3.4	20	60	258	1996	24	3.40	20	60	258
1952	24	3.3	20	60	258	1997	24	3.40	20	60	258
1953	24	3.4	20	60	258	1998	24	3.40	20	60	258
1954	24	3.4	0	60	258	1999	24	3.40	20	60	258
1955	24	3.4	0	60	258	2000	24	3.40	20	60	258
1956	24	3.4	20	60	258	2001	24	3.40	0	60	163
1957	24	3.4	20	60	258	2002	24	3.40	0	60	258
1958	24	3.4	20	60	258	2003	24	3.30	19	60	258
1959	24	3.3	0	60	163	2004	24	3.30	0	60	258
1960	24	3.4	0	60	186	2005	24	3.40	20	60	258
1961	24	0.0	0	39	242	2006	24	3.40	20	60	258
1962	24	3.4	0	60	253	2007	24	3.30	0	60	163

Year	Upstream	JVID	NSJWCD	WID	EBMUD ^a	Year	Upstream	JVID	NSJWCD	WID	EBMUD ^a
1963	24	3.4	20	60	258	2008	24	3.40	0	39	185
1964	24	3.4	0	60	173	2009	24	3.40	0	60	258
1965	24	3.4	20	60	258						

a EBMUD Diversions reflect only the quantity diverted from the Mokelumne to meet customer demand and/or to refill terminal reservoir storage and do not include supplemental supply deliveries from sources external to the Mokelumne System.

Table 4.2-10 presents the JSA year type summary for the two classification periods, October through March and April through September. For the Project case, there were a total of 120 of 178 periods (67%) that were Above Normal/Normal or Below Normal year types. Furthermore, there were 58 of 178 periods (33%) that were classified as Dry or Critically Dry. An increase of three Critically Dry year type classifications occurred for the project case relative to the baseline case (*i.e.* 1961, 1988, and 1992).

Table 4.2-10. JSA Year Type Classifications Summary, Project Case

Class	April-September	October-March	Total
Above Normal/Normal	28	47	75
Below Normal	28	17	45
Dry	22	17	39
Critically Dry	11	8	19
Total	89	89	178

4.3 Case 3: Project without Aqueduct Outage

Recall that this modeling case (Case 3) differs from the Project case (Case 2) by only one assumption, the aqueduct outage scenario. The results presented in this section, therefore, are limited to only the period that differs among the two cases beginning in 1980 before the outage is initiated through 1985 after the refill operations necessary following the outage have subsided. The modeling results presented, therefore illustrate the state of the Mokelumne system had the aqueduct outage not been simulated which are compared against the baseline case to assess any potential environmental impacts.

Simulated EOM TSS is presented in Table 4.3-1 and simulated end-of-month Camanche Reservoir WSE is presented in Table 4.3-3. Simulated total Camanche release, estimated flow at Elliott, below Woodbridge, and Frandy are respectively presented in Table 4.3-3, Table 4.3-4, Table 4.3-5, Table 4.3-6. Table 4.3-7 presents the simulated customer rationing, supply deficiencies, and water supply components that meet an annual customer demand equal to 230MGD. Note that the Freeport supplemental supply is triggered in the dry year of 1981 whereas the project is not accessible and therefore unavailable during the aqueduct outage simulated for the Project case. WY 1985 was also designated as Dry year for the Mokelumne but did not trigger supplemental supplies. The Bayside Phase I supplemental supply project is operated normally in 1981 where the typical pumping pattern for the project is shown in Table 3.1-4.

Table 4.3-1. Simulated End-of-Month Total System Storage [AF], Project Case without Aqueduct Outage

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980	487,907	568,067	630,743	663,288	679,924	723,732	693,538	628,001	575,404	565,099	558,469	559,518
1981	569,039	569,503	579,014	590,302	579,112	561,377	545,610	527,780	522,610	525,121	547,582	537,682
1982	557,526	550,541	591,139	608,455	692,541	731,029	676,928	605,137	538,855	549,764	538,528	549,654
1983	582,098	600,486	639,437	652,768	565,941	683,284	722,138	632,795	549,457	565,582	532,956	537,682
1984	542,838	559,433	612,269	637,281	690,791	700,590	670,184	639,130	606,637	601,865	599,202	605,548
1985	592,346	593,197	605,262	623,274	602,883	579,718	550,369	528,411	518,313	514,157	521,221	528,851
Min	487,907	550,541	579,014	590,302	565,941	561,377	545,610	527,780	518,313	514,157	521,221	528,851
Max	592,346	600,486	639,437	663,288	692,541	731,029	722,138	639,130	606,637	601,865	599,202	605,548
Mean	555,292	573,538	609,644	629,228	635,199	663,288	643,128	593,542	551,879	553,598	549,660	553,156
Median	563,283	568,785	608,766	630,278	641,404	691,937	673,556	616,569	544,156	557,432	543,055	543,668

Table 4.3-2. Simulated End-of-Month Camanche Reservoir Water Surface Elevation [ft msl], Project Case without Aqueduct Outage

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980	193.52	207.79	217.84	222.93	225.77	232.64	229.27	221.04	213.90	216.98	215.40	214.80
1981	215.51	214.33	214.51	215.14	210.88	207.63	205.83	204.27	204.68	210.39	213.62	211.17
1982	208.54	204.60	211.37	214.37	227.59	233.64	226.90	217.49	207.64	214.51	212.12	206.79
1983	211.57	213.35	219.19	221.35	207.54	226.96	233.22	223.83	215.82	222.63	211.17	204.60
1984	204.60	206.24	214.88	220.05	227.34	229.43	225.93	222.72	218.89	222.66	221.77	222.01
1985	219.20	218.13	218.70	220.34	216.13	212.13	207.20	204.38	203.88	208.48	209.14	209.65
Min	193.52	204.60	211.37	214.37	207.54	207.63	205.83	204.27	203.88	208.48	209.14	204.60
Max	219.20	218.13	219.19	222.93	227.59	233.64	233.22	223.83	218.89	222.66	221.77	222.01
Mean	208.82	210.74	216.08	219.03	219.21	223.74	221.39	215.62	210.80	215.94	213.87	211.50
Median	210.06	210.57	216.36	220.20	220.95	228.20	226.42	219.27	210.77	215.75	212.87	210.41

Table 4.3-3. Simulated Total Camanche Release [cfs], Project Case without Aqueduct Outage

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980	130	1,251	566	525	1,446	1,600	1,196	1,097	965	325	325	325
1981	325	325	325	300	400	363	398	348	236	250	250	1,345
1982	1,505	3,035	1,840	3,722	3,099	1,925	1,521	1,416	1,270	325	1,402	1,755
1983	1,443	2,371	3,517	1,923	4,533	3,653	2,167	2,061	1,915	325	2,327	2,741
1984	1,551	1,037	414	525	992	1,096	875	793	661	325	562	325
1985	325	325	325	300	400	363	398	348	236	220	220	220
Min	130	325	325	300	400	363	398	348	236	220	220	220
Max	1,551	3,035	3,517	3,722	4,533	3,653	2,167	2,061	1,915	325	2,327	2,741
Mean	880	1,391	1,165	1,216	1,812	1,500	1,093	1,011	881	295	848	1,119
Median	884	1,144	490	525	1,219	1,348	1,036	945	813	325	444	835

Table 4.3-4. Estimated Flow at Elliott [cfs], Project Case without Aqueduct Outage

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980	138	1,257	560	508	1,433	1,584	1,165	1,060	951	312	315	318
1981	332	340	325	280	388	345	380	327	221	238	242	1,389
1982	1,507	3,023	1,800	3,742	3,084	1,910	1,485	1,372	1,257	312	1,370	1,819
1983	1,445	2,366	3,433	1,922	4,516	3,641	2,120	2,003	1,904	312	2,275	2,855
1984	1,553	1,045	412	508	979	1,080	849	762	647	312	547	318
1985	332	340	325	280	388	345	380	327	221	208	213	207
Min	138	340	325	280	388	345	380	327	221	208	213	207
Max	1,553	3,023	3,433	3,742	4,516	3,641	2,120	2,003	1,904	312	2,275	2,855
Mean	885	1,395	1,143	1,207	1,798	1,484	1,063	975	867	282	827	1,151
Median	889	1,151	486	508	1,206	1,332	1,007	911	799	312	431	854

Table 4.3-5. Simulated Flow Below Woodbridge Irrigation Dam [cfs], Project Case without Aqueduct Outage

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980	63	1,194	481	375	1,141	1,191	739	716	716	188	268	254
1981	258	266	240	150	150	31	29	22	20	132	193	1,274
1982	1,356	2,902	1,666	3,477	2,693	1,408	957	933	933	124	1,277	1,602
1983	1,294	2,238	3,343	1,678	4,126	3,136	1,602	1,579	1,579	124	2,202	2,588
1984	1,484	980	330	375	686	686	419	411	411	188	505	254
1985	258	266	240	150	150	31	29	22	20	102	163	149
Min	63	266	240	150	150	31	29	22	20	102	163	149
Max	1,484	2,902	3,343	3,477	4,126	3,136	1,602	1,579	1,579	188	2,202	2,588
Mean	786	1,308	1,050	1,034	1,491	1,081	629	614	613	143	768	1,020
Median	776	1,087	406	375	914	939	579	564	564	128	387	764

Table 4.3-6. Estimated Flow at Frandy [cfs], Project Case without Aqueduct Outage

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980	48	1,179	451	345	1,111	1,161	709	686	686	173	253	239
1981	243	251	210	120	120	1	1	1	1	117	178	1,259
1982	1,341	2,887	1,636	3,447	2,663	1,378	927	903	903	109	1,262	1,587
1983	1,279	2,223	3,313	1,648	4,096	3,106	1,572	1,549	1,549	109	2,187	2,573
1984	1,469	965	300	345	656	656	389	381	381	173	490	239
1985	243	251	210	120	120	1	1	1	1	87	148	134
Min	48	251	210	120	120	1	1	1	1	87	148	134
Max	1,469	2,887	3,313	3,447	4,096	3,106	1,572	1,549	1,549	173	2,187	2,573
Mean	771	1,293	1,020	1,004	1,461	1,051	600	587	587	128	753	1,005
Median	761	1,072	376	345	884	909	549	534	534	113	372	749

Table 4.3-7. Calendar Year Water Supply Deliveries, Customer Cutbacks, and Undelivered Supply, Project Case without Aqueduct Outage

Year	Customer Cutback	Additional Deficiency	Total Deficiency	WSMP 2040 Supplemental Supply Requirement ^a [MGD]	Freeport Supplemental Supply [MGD]	Bayside Phase I Supplemental Supply [MGD]	Mokelumne Supply [MGD]	Total Supply Delivered [MGD]
1980	0.0%	0.0%	0.0%	0	0	0	230	230
1981	0.0%	0.0%	0.0%	0	75	1	154	230
1982	0.0%	0.0%	0.0%	0	0	0	230	230
1983	0.0%	0.0%	0.0%	0	0	0	230	230
1984	0.0%	0.0%	0.0%	0	0	0	230	230
1985	0.0%	0.0%	0.0%	0	0	0	230	230

^a WSMP 2040 supplemental supply requirement external to the Mokelumne River to reduce District wide rationing to 15%.

Calendar year total diversions for the Mokelumne system are presented below in Table 4.3-8 where 1980 and 1984 are leap years and the dry year in 1981 resulted in a reduction in EBMUD diversions due to activation of the Freeport project (see Table 4.3-7 above). Upstream diversions and JVID account for roughly 27 TAF and Woodbridge Irrigation District diversions are 60 TAF each year of the period of interest. NSJWCD diversions were 20 TAF in wet years (*i.e.* 1980, 1982, 1983, and 1984) and were 0 TAF in dry years 1981 and 1985.

Table 4.3-8. Calendar Year Total Annual Diversions, [TAF], Project Case without Aqueduct Outage

Year	Upstream	JVID	NSJWCD	WID	EBMUD ^a
1980	24	3.4	20	60	258
1981	24	3.4	0	60	172
1982	24	3.4	20	60	258
1983	24	3.4	20	60	258
1984	24	3.4	20	60	258
1985	24	3.4	0	60	258

^a EBMUD Diversions reflect only the quantity diverted from the Mokelumne to meet customer demand and/or to refill terminal reservoir storage and do not include supplemental supply deliveries from sources external to the Mokelumne System.

JSA year types are not affected by the simulated aqueduct outage; the frequency of JSA year types for the Project variant is the same as shown in Table 4.2-10.

4.4 Case 4: Programmatic Evaluation of Use Beyond Year 2040

For the programmatic evaluation, customer demand is set to 275 MGD. Supplemental supply options available when Mokelumne Project supplies are insufficient during droughts are (1) surface water deliveries from EBMUD's USBR contract, (2) surface water transfers up to 50 MGD per year, and (3) conjunctive-use project withdrawals. Supplemental supply deliveries from EBMUD's USBR contract in this model case are consistent with the other cases documented where contract limitations and settlement agreements constrain the quantities supplied from this source. Explicit simulation of Bayside Phase I is not performed, rather the Bayside project is assumed to be part of the conceptual conjunctive use project element.

Surface water transfers and conjunctive-use supplemental supply deliveries are both triggered by projected reservoir storage where two storage conditions must be met; first that end-of-September Total System Storage is less than 500 TAF and second that combined end-of-October Pardee and Camanche Storage is less than 400 TAF. Assuming both conditions are met, the quantity of surface water transfers is determined based on end-of-October Camanche Reservoir storage as follows. If projected end-of-October Camanche Reservoir storage is above 147 TAF²⁷ then surface water transfers up to 25 MGD is permitted; however if projected end-of-October Camanche Reservoir storage is less than 147 TAF, then up to 50 MGD of surface water transfers are assumed available for supplemental supply. The quantity of the surface water transfer delivered in any calendar year triggered is ultimately constrained by the available annual capacity of the FRWP facilities²⁸.

Conjunctive use supplemental supply withdrawals are assumed to be delivered through Mokelumne Aqueducts by direct connection to project infrastructure. Conjunctive-use withdrawals are assumed to be 22 MGD in any active (calendar) year. Conjunctive-use Basin recharge ranges annually up to a maximum of 44 MGD. Conjunctive-use basin recharge is conditioned upon concurrent Mokelumne River flood control releases and is further constrained by water rights limitations with respect to direct diversion and diversion from storage²⁹.

Monthly supplemental supply deliveries were developed based on the conceptual operating rules described above. Supplemental supply schedules and modeling case assumptions were formulated into the appropriate set of input to EBMUDSIM. The remainder of this section presents the model output from the EBMUDSIM model for the programmatic use case.

Simulated EOM TSS is presented in Table 4.4-1. For consistency with results presented from other modeling cases, total system storage presented in Table 4.4-1 does not include available storage from the conceptual groundwater basin.

Table 4.4-2 presents simulated EOM Camanche Reservoir WSE for the programmatic use case. Due to the higher demand associated with this case, Camanche WSE is drawn below elevation 190 ft msl

²⁷ Camanche Reservoir storage of 147 TAF is roughly equivalent to Camanche WSE equal to 190 ft.

²⁸ The maximum annual capacity of FRWP is assumed to be 100 MGD in any given calendar year less 3.2 TAF per annum as required by EBMUD's settlement agreement with CCWD.

²⁹ Additionally, conjunctive-use diversions from the Mokelumne are eliminated in years with sufficiently low volumes of flood control release, *i.e.* 1923, 1928, 1946, 1953, 1971, 1981, and 1993.

in several months relative to the Base Case. Table 4.4-3 lists all the months, 35 in total, where Camanche WSE is less than 190 ft msl in the programmatic use case but above 190 ft msl in the Base Case. Twelve of 35 months (34%) occur in winter months where Camanche Reservoir is expected to be de-stratified (these rows are shaded grey in Table 4.4-3). The remaining 23 of 31 months (66%) that occur in the temperature management period of March through October correspond to drought periods over the hydrologic POR.

Table 4.4-4 presents monthly average total Camanche releases for the programmatic use case. Discharge at station Elliott is estimated with Equation 1 using parameters in Table 3.3-12 from total Camanche releases. Estimated discharge at station Elliott is presented in Table 4.4-5.

Simulated flow below Woodbridge Dam corresponding to station Golf is presented in Table 4.4-6. Discharge at station Frandy is estimated from the simulated flow below Woodbridge with Equation 2. Estimated monthly average flow at station Frandy is presented in Table 4.4-7.

Table 4.4-8 presents annual customer rationing with the corresponding quantity of water saved or undelivered, the total supplemental supply deliveries, the quantity of water diverted from the Mokelumne to meet customer demand, total supply delivered, and the WSMP 2040 supplemental supply need to achieve a District wide rationing goal of 15% for each CY simulated.

Simulated CY total annual diversion from the Mokelumne (which includes the annual quantity diverted from the Mokelumne for storage in the conceptual conjunctive use basin(s)) for the programmatic use case are presented in Table 4.4-9.

Table 4.4-1. Simulated End-of-Month Total System Storage [AF], Programmatic Use Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	610,249	610,265	626,006	632,724	715,745	744,820	692,140	643,269	608,628	585,373	574,642	574,162
1922	577,150	599,318	616,101	630,970	652,837	744,820	693,832	635,243	589,380	574,879	570,968	599,563
1923	613,008	620,711	621,279	645,626	691,446	709,570	668,542	623,485	593,738	578,864	568,529	562,053
1924	555,791	534,571	515,463	511,928	499,303	475,011	450,274	428,417	416,084	407,243	399,835	398,260
1925	405,711	469,524	497,340	533,235	644,297	694,062	655,285	619,203	599,063	582,909	572,836	566,215
1926	562,286	560,939	549,366	549,735	550,697	534,068	510,705	490,906	482,860	483,013	492,622	498,222
1927	513,551	572,472	597,064	632,186	680,784	744,820	691,227	635,416	593,463	577,898	566,598	564,177
1928	561,836	555,296	595,244	621,357	726,639	692,386	660,044	629,723	612,457	599,278	596,142	579,917
1929	563,050	551,041	546,909	543,468	532,406	517,961	502,326	489,173	483,695	482,866	486,479	484,657
1930	483,149	476,279	491,969	497,955	496,174	528,796	509,012	490,929	484,761	484,967	491,869	492,369
1931	483,014	469,349	464,396	453,279	442,615	418,859	399,181	376,065	353,501	336,638	325,871	328,453
1932	334,928	370,910	409,027	438,475	485,426	613,212	604,259	586,231	579,301	567,237	561,136	559,291
1933	549,349	527,345	524,865	537,328	544,589	547,188	530,451	514,331	508,656	509,755	506,703	521,142
1934	531,015	529,389	543,986	524,778	498,689	486,937	466,314	438,259	420,459	406,706	399,792	387,732
1935	383,535	393,913	400,327	469,832	512,202	591,271	561,501	532,107	515,418	507,073	504,656	505,274
1936	524,959	619,704	648,034	667,299	726,297	743,419	689,656	636,536	596,785	581,882	572,598	570,551
1937	559,640	593,828	647,887	676,153	716,255	731,377	683,925	638,874	606,363	590,878	583,468	542,242
1938	549,090	577,186	605,416	551,807	653,116	744,133	699,585	636,665	586,284	572,887	567,367	564,437
1939	563,261	545,252	540,302	538,607	522,826	516,769	504,138	494,547	493,695	494,388	491,658	483,766
1940	520,487	593,278	618,799	651,095	749,734	735,956	689,466	648,169	619,427	598,383	591,251	600,897
1941	612,241	619,260	647,016	676,945	707,285	744,820	691,455	634,842	591,285	576,871	569,924	574,179
1942	567,580	571,580	589,287	627,546	667,809	744,820	700,740	639,479	590,448	575,906	572,155	576,171
1943	565,588	567,596	592,810	670,027	730,404	730,100	680,929	633,375	596,948	584,901	576,881	573,824
1944	567,011	556,615	569,050	566,053	572,490	572,780	552,547	534,498	526,182	524,161	543,236	559,928
1945	565,984	609,146	637,047	648,815	684,581	732,539	680,853	630,923	593,770	579,890	569,480	559,490
1946	570,084	581,300	604,071	623,220	731,997	721,400	678,026	637,576	611,325	596,855	595,784	595,072
1947	591,797	589,750	589,132	601,385	588,575	574,028	551,274	531,157	523,011	525,335	520,212	510,174
1948	517,517	499,881	498,220	523,970	545,461	650,368	625,040	604,856	595,561	578,864	569,741	566,274
1949	559,690	539,683	539,300	564,390	596,017	599,763	571,993	544,047	527,981	515,592	512,193	508,231
1950	520,283	555,006	585,243	631,798	665,467	720,795	669,570	620,248	585,560	573,913	533,031	537,807

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1951	542,957	550,650	592,258	655,562	723,542	693,689	660,207	629,642	611,338	594,862	591,928	607,142
1952	611,591	618,761	638,805	559,125	622,461	734,457	704,382	632,147	571,144	559,907	556,255	562,968
1953	596,194	566,376	578,686	613,667	617,319	662,557	638,197	602,392	581,169	573,913	570,048	565,416
1954	562,965	564,383	580,194	609,519	635,368	607,790	573,586	545,730	531,544	524,305	527,001	528,648
1955	533,269	528,111	534,868	531,036	530,017	532,870	510,221	492,107	484,719	483,523	489,522	550,196
1956	542,366	566,058	617,055	656,955	696,828	744,894	688,451	624,537	573,879	563,891	562,561	565,250
1957	561,057	565,502	577,908	575,926	608,397	667,225	634,028	602,359	584,916	578,592	582,795	589,303
1958	605,357	620,027	647,782	673,865	680,330	743,395	692,272	630,723	576,215	565,884	560,098	550,730
1959	550,872	566,543	572,414	565,461	546,925	531,909	512,570	496,996	493,425	489,783	491,783	496,714
1960	492,893	502,734	508,629	509,145	521,808	529,828	509,369	492,353	478,394	465,311	459,812	455,179
1961	445,356	430,633	423,096	417,786	409,353	402,285	391,804	383,312	376,016	372,376	362,135	352,154
1962	343,408	383,404	406,069	453,582	465,771	532,559	510,976	491,102	480,852	479,847	480,634	483,928
1963	496,108	552,164	564,505	629,832	725,774	744,888	687,090	632,218	589,300	578,864	562,477	562,734
1964	572,860	570,315	569,774	565,815	549,751	534,025	514,266	497,052	491,699	494,531	510,122	546,495
1965	556,172	576,488	615,003	674,316	691,126	725,091	672,785	615,749	584,429	590,576	594,976	604,146
1966	606,620	595,162	602,208	617,956	614,176	590,876	567,284	547,565	541,795	539,290	551,810	600,350
1967	612,060	619,134	645,985	673,817	604,953	713,430	719,791	641,813	577,521	567,635	566,620	566,660
1968	569,998	580,293	595,211	596,824	577,243	564,798	539,137	518,137	510,445	507,931	522,115	542,848
1969	605,511	620,280	647,790	635,411	670,613	744,666	696,327	632,966	582,766	582,184	579,143	595,344
1970	542,604	550,297	601,691	611,476	651,750	688,250	658,271	624,050	603,273	588,946	590,629	606,961
1971	612,827	620,530	648,070	664,182	649,083	690,871	665,122	639,896	617,005	611,102	601,643	607,471
1972	603,082	595,032	607,258	611,838	588,655	590,003	561,834	533,416	518,727	511,701	516,573	527,778
1973	580,002	619,079	645,929	666,324	717,853	723,717	685,089	640,331	610,286	600,899	557,829	568,606
1974	562,490	589,102	639,729	691,167	714,685	732,941	691,726	649,908	611,693	598,303	585,592	575,849
1975	562,115	569,625	610,949	637,301	645,490	713,222	675,059	631,310	599,318	596,673	594,505	589,855
1976	576,036	552,192	534,398	525,486	509,688	485,571	459,515	437,910	424,642	404,647	389,755	371,966
1977	359,498	341,202	323,680	314,076	304,191	285,777	266,952	250,685	243,735	233,286	227,020	215,947
1978	207,783	198,170	196,232	189,430	181,851	167,725	152,372	133,327	127,071	105,983	83,269	64,516
1979	75,377	95,870	152,758	205,553	260,598	297,452	293,380	279,922	274,364	274,309	285,237	306,956
1980	452,522	549,491	612,141	640,873	663,940	711,385	685,264	623,321	574,304	559,892	549,774	547,406
1981	553,636	551,182	557,123	564,773	549,031	526,448	505,605	482,859	473,327	473,670	494,333	537,682
1982	557,089	550,048	590,620	607,947	692,051	731,617	678,958	608,147	542,941	549,764	537,846	548,710
1983	581,129	599,521	638,444	651,787	564,978	682,348	725,250	636,545	553,536	565,582	532,052	536,640

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984	541,790	558,372	606,694	627,897	683,780	696,273	668,976	640,562	610,726	601,865	599,202	602,126
1985	585,584	583,414	601,385	624,805	609,191	590,074	564,633	546,631	540,847	540,200	551,241	562,975
1986	591,926	555,290	594,515	663,958	726,289	737,539	684,482	629,654	588,528	573,974	566,796	556,417
1987	541,011	524,735	520,820	515,593	498,300	478,655	464,832	454,394	450,736	432,898	419,509	411,116
1988	412,379	402,506	393,153	389,854	382,948	372,707	365,324	356,083	351,040	341,198	335,862	331,242
1989	326,833	321,847	356,656	396,522	449,075	454,613	431,839	410,005	401,725	384,908	385,810	385,262
1990	385,645	380,237	389,576	386,849	384,174	382,618	375,240	367,625	369,059	376,359	364,555	357,199
1991	344,183	334,050	349,354	348,489	342,410	350,385	344,448	338,256	340,961	351,058	365,858	379,041
1992	384,608	402,106	422,459	419,240	403,593	385,246	375,364	368,751	361,891	350,193	336,431	334,807
1993	398,473	448,570	536,924	589,138	666,066	732,617	677,125	642,408	604,188	593,051	581,044	572,227
1994	553,916	536,686	521,611	515,699	505,597	493,628	472,217	458,142	459,048	458,745	446,922	455,266
1995	558,283	602,973	636,758	613,757	555,323	693,158	732,809	645,942	574,392	577,234	567,862	566,259
1996	575,183	565,719	606,722	665,056	737,035	737,070	694,676	655,433	621,636	591,964	591,535	575,780
1997	568,441	550,341	594,519	628,956	699,998	696,256	662,211	636,410	618,746	607,540	602,945	588,935
1998	612,060	619,544	647,057	642,470	595,989	721,653	724,356	655,263	592,577	585,263	583,987	587,262
1999	612,827	620,059	643,540	670,977	689,416	734,396	696,469	647,360	608,129	591,663	587,104	576,087
2000	589,664	619,846	646,696	652,808	701,499	701,114	672,078	641,267	618,070	601,926	592,231	581,794
2001	560,837	544,630	549,004	569,518	566,255	550,976	532,423	515,660	507,374	498,748	491,723	502,379
2002	519,002	522,572	562,674	591,181	593,951	595,199	573,558	554,451	546,554	536,453	531,977	538,331
2003	553,701	566,164	572,104	586,319	623,547	668,843	636,337	605,855	588,923	575,855	567,301	578,950
2004	592,625	615,120	648,070	656,820	633,714	627,066	601,658	581,722	570,651	553,885	556,297	572,175
2005	612,827	620,530	647,658	693,981	711,675	744,494	709,257	657,947	614,363	595,768	587,123	583,692
2006	554,351	550,470	608,394	641,841	705,720	743,127	710,099	668,216	620,332	603,677	596,349	599,276
2007	587,676	588,847	597,932	594,884	583,136	563,757	542,405	524,347	517,302	504,785	504,838	502,699
2008	510,901	515,342	529,776	524,659	519,071	510,701	490,109	476,856	464,905	460,161	464,229	456,439
2009	462,964	471,025	511,266	536,925	634,881	624,924	600,602	576,851	556,691	542,642	540,194	607,188
Min.	75,377	95,870	152,758	189,430	181,851	167,725	152,372	133,327	127,071	105,983	83,269	64,516
Max.	613,008	620,711	648,070	693,981	749,734	744,894	732,809	668,216	621,636	611,102	602,945	607,471
Mean	526,453	535,278	555,995	572,899	594,611	617,107	588,707	554,328	530,127	521,072	516,567	519,573
Median	558,283	558,372	589,287	607,947	614,176	667,225	636,337	604,856	573,879	563,891	556,255	559,490

Table 4.4-2. Simulated End-of-Month Camanche Reservoir Water Surface Elevation [ft msl], Programmatic Use Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	222.06	220.99	222.21	221.78	230.88	235.50	229.09	223.36	219.22	220.23	217.98	217.15
1922	216.81	219.08	220.38	221.51	221.76	235.50	229.33	222.16	216.19	218.52	217.40	221.10
1923	222.36	222.36	221.17	223.72	227.43	230.69	225.68	220.35	216.86	219.14	217.01	215.21
1924	213.34	210.20	206.63	203.91	200.59	196.39	191.99	187.87	184.75	186.35	183.60	181.90
1925	182.52	195.37	199.86	205.30	220.44	228.51	223.73	219.69	217.70	219.77	217.69	215.89
1926	214.41	212.92	209.52	208.28	205.87	202.58	199.13	197.00	196.87	202.76	203.97	204.13
1927	206.02	214.82	217.41	221.70	225.91	235.50	228.96	222.18	216.84	218.99	216.81	215.56
1928	214.34	211.98	217.12	220.05	232.37	228.29	224.44	221.30	219.79	222.27	221.30	219.03
1929	216.82	214.73	212.27	209.03	204.49	200.64	197.42	196.64	197.04	202.73	202.80	201.54
1930	200.24	198.01	198.77	198.48	195.10	201.56	198.79	197.00	197.26	203.13	203.83	203.02
1931	200.60	198.24	195.37	192.21	190.16	187.15	184.09	181.51	180.23	179.90	177.58	176.27
1932	174.06	173.29	178.90	184.96	192.74	216.34	215.86	214.45	214.53	217.32	215.83	214.76
1933	212.60	210.24	207.54	206.06	204.74	205.05	202.99	201.71	202.04	207.70	206.56	208.30
1934	209.13	207.76	208.58	205.05	200.36	196.17	191.22	186.70	183.34	186.21	183.59	179.91
1935	176.33	176.87	176.25	189.79	198.09	212.76	208.67	205.07	203.33	207.21	206.19	205.44
1936	208.20	216.64	223.56	227.09	232.53	235.50	228.93	222.56	217.59	219.61	217.66	216.58
1937	213.98	218.23	225.14	228.16	230.95	233.69	227.92	222.70	218.87	220.99	219.35	212.07
1938	212.23	214.76	213.89	204.65	221.91	235.50	230.23	222.47	215.80	218.21	216.82	215.60
1939	214.57	211.67	208.33	206.29	201.73	199.18	197.80	197.76	199.09	204.90	203.79	201.37
1940	207.26	217.17	218.86	223.91	235.50	234.32	228.70	224.09	220.88	222.20	220.55	221.30
1941	222.36	222.36	225.33	228.27	229.70	235.50	228.99	222.10	216.49	218.83	217.23	217.27
1942	215.51	215.02	216.18	220.99	224.00	235.50	230.30	222.79	216.36	218.68	217.59	217.59
1943	215.19	214.38	212.07	224.30	233.21	233.83	227.82	222.22	217.76	220.08	218.33	217.10
1944	215.18	212.84	212.87	211.11	209.75	209.63	207.08	205.51	205.34	210.22	212.90	214.87
1945	215.01	220.17	223.54	224.19	226.46	233.85	227.48	221.50	216.88	219.30	217.27	215.02
1946	215.68	216.24	218.52	220.33	233.10	232.34	227.06	222.49	219.62	221.90	221.25	220.42
1947	219.11	217.59	216.15	216.92	212.48	209.85	206.85	204.89	204.75	210.42	208.97	206.34
1948	206.73	204.18	201.49	203.58	204.90	222.11	219.14	217.45	217.15	219.14	217.20	215.90
1949	213.99	211.10	208.42	210.83	213.72	214.19	210.50	207.24	205.67	208.73	207.55	205.99
1950	207.23	212.04	215.53	221.64	223.65	232.25	225.85	219.87	215.57	218.37	204.65	204.65
1951	204.65	205.51	213.89	221.77	231.95	228.47	224.46	221.29	219.62	221.60	220.66	222.36
1952	221.81	220.99	222.89	206.31	217.42	234.43	231.13	222.05	213.60	216.16	215.04	215.36
1953	219.80	213.82	214.46	218.85	216.22	223.94	221.16	217.06	214.83	218.37	217.25	215.76

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1954	214.52	213.49	214.71	218.21	219.99	215.49	210.77	207.54	206.32	210.25	210.15	209.62
1955	209.52	207.25	206.95	204.90	201.98	202.35	199.03	197.25	197.25	202.86	203.38	207.02
1956	204.65	207.57	216.53	221.98	228.20	235.50	228.55	220.52	213.65	216.79	216.06	215.73
1957	214.21	213.68	214.33	212.78	215.74	224.62	220.53	217.05	215.44	219.10	219.25	219.53
1958	221.20	222.36	225.33	224.73	226.05	235.50	229.31	221.69	214.28	217.11	215.66	213.36
1959	212.53	213.85	213.43	211.01	206.24	202.17	199.51	198.26	199.03	204.05	203.81	203.85
1960	202.14	202.55	202.07	200.72	200.38	201.77	198.86	197.30	195.93	199.30	197.52	195.55
1961	192.66	189.93	186.70	183.09	183.62	183.14	182.17	182.09	183.56	185.94	183.84	181.64
1962	179.37	179.21	178.03	188.71	188.18	202.27	199.19	197.04	196.45	202.16	201.68	201.40
1963	202.75	211.55	212.11	219.76	232.26	235.50	228.36	221.69	216.16	219.14	216.16	215.32
1964	216.13	214.47	212.99	211.07	206.41	202.57	199.85	198.27	198.68	204.93	207.18	206.31
1965	207.12	209.88	218.74	224.57	227.39	232.83	226.31	219.16	215.38	220.95	221.12	221.80
1966	221.39	218.84	218.23	219.52	216.66	212.71	209.69	207.87	208.16	212.78	214.32	221.22
1967	222.33	222.33	225.17	226.57	214.60	231.56	232.90	223.13	214.25	217.38	216.71	215.96
1968	215.67	216.08	217.12	216.19	211.73	208.24	204.63	202.44	202.38	207.37	209.30	212.05
1969	215.48	216.61	220.75	218.71	224.44	235.50	229.70	221.84	215.14	219.66	218.68	220.46
1970	204.60	205.47	213.72	218.51	221.58	227.68	224.18	220.44	218.36	220.70	220.46	222.33
1971	222.33	222.33	225.17	226.44	221.17	228.06	225.18	222.84	220.49	224.04	222.14	222.30
1972	220.85	218.42	219.01	218.57	213.69	212.57	208.73	205.31	203.96	208.05	208.33	209.47
1973	217.38	222.33	225.17	226.75	231.17	232.65	228.09	222.92	219.48	222.51	215.40	216.49
1974	214.80	217.65	221.76	227.25	230.93	234.10	229.23	224.56	219.92	222.12	219.68	217.42
1975	214.39	214.35	219.59	222.47	220.64	231.21	226.64	221.56	217.77	221.88	221.05	219.61
1976	216.63	213.62	210.17	207.64	204.49	200.50	196.34	192.57	189.69	186.05	182.47	178.47
1977	174.19	169.87	164.28	157.39	154.01	148.07	141.69	136.38	134.88	136.21	127.67	118.60
1978	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60
1979	118.60	118.60	118.60	118.60	130.58	149.52	154.03	159.60	167.66	175.66	173.15	170.66
1980	189.81	207.79	217.84	222.89	225.09	232.51	229.71	222.06	215.58	216.98	214.08	212.81
1981	212.98	211.28	210.86	210.90	206.24	201.26	198.10	195.30	194.84	200.95	204.29	211.17
1982	209.98	204.60	211.37	214.37	227.59	233.78	227.26	218.05	208.46	214.51	212.12	207.85
1983	211.57	213.35	219.19	221.35	207.54	226.96	233.64	223.75	215.10	219.97	210.19	204.60
1984	204.60	206.51	214.80	219.97	226.33	228.82	225.76	222.95	219.54	222.66	221.77	221.49
1985	218.44	216.58	218.10	220.57	216.37	212.58	209.22	207.71	208.00	212.93	214.22	215.36
1986	219.13	205.52	211.99	223.03	232.32	234.52	227.99	221.30	216.04	218.38	216.73	214.30
1987	211.02	208.21	204.99	202.10	198.68	194.32	189.12	188.87	189.76	192.42	189.28	185.97

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1988	184.30	180.88	176.64	172.21	174.36	175.12	176.44	178.42	181.47	185.10	183.16	181.09
1989	178.88	176.78	174.86	172.53	183.98	185.17	185.88	187.38	190.76	194.23	191.14	187.74
1990	184.51	181.55	177.81	171.97	174.29	177.53	179.95	183.03	187.32	192.10	190.10	188.13
1991	186.17	184.49	184.08	178.99	178.70	179.62	179.97	181.25	183.92	187.57	185.57	183.58
1992	181.49	180.46	182.70	179.72	179.30	180.04	180.24	181.38	183.97	187.35	185.29	183.62
1993	183.66	191.25	203.62	211.26	223.73	233.85	226.93	223.21	218.51	221.32	218.98	216.85
1994	213.81	211.17	207.59	205.18	202.17	198.07	193.32	189.76	191.68	197.97	195.26	195.57
1995	207.89	216.00	218.79	215.24	205.63	228.38	234.66	223.74	213.74	218.89	216.90	215.90
1996	216.50	209.05	213.99	223.20	233.79	234.45	229.43	225.15	221.21	221.16	220.60	211.40
1997	209.25	204.60	212.87	218.03	228.65	228.83	224.76	222.32	220.76	223.51	222.33	219.47
1998	222.33	216.61	220.53	219.93	212.89	232.49	233.52	225.12	216.68	220.14	219.44	219.21
1999	222.33	216.74	221.58	226.49	227.15	234.10	229.69	223.96	219.13	221.11	219.92	217.46
2000	218.78	222.33	225.17	224.78	228.87	229.52	226.20	223.04	220.65	222.67	220.70	218.36
2001	215.31	212.68	209.46	211.70	208.65	205.75	203.37	201.97	201.79	205.71	203.80	204.90
2002	207.00	206.25	211.80	215.28	213.38	213.43	210.77	209.08	209.00	212.31	211.00	211.28
2003	213.00	213.79	213.38	214.49	218.15	224.86	220.88	217.61	216.09	218.68	216.81	217.91
2004	219.24	221.51	225.17	225.36	221.14	218.55	215.44	213.72	213.11	215.18	215.05	216.84
2005	222.33	222.33	222.32	227.49	230.36	235.50	231.53	225.57	220.16	221.74	219.92	218.43
2006	210.87	210.61	214.54	219.95	229.72	235.50	231.83	227.26	221.28	222.93	221.33	221.06
2007	218.47	217.44	217.55	215.88	211.57	208.05	205.23	203.62	203.69	206.80	206.23	204.96
2008	205.53	204.92	206.04	203.71	199.83	197.96	194.84	194.01	193.00	198.26	198.42	195.82
2009	196.11	196.19	202.57	205.99	218.99	218.22	215.26	212.91	210.75	213.34	212.39	220.80
Min.	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60
Max.	222.36	222.36	225.33	228.27	235.50	235.50	234.66	227.26	221.28	224.04	222.33	222.36
Mean	206.74	206.79	208.48	209.78	211.76	215.52	212.09	208.36	205.96	209.24	207.72	206.89
Median	213.00	212.68	213.89	216.19	216.37	224.62	220.88	217.45	213.74	216.98	215.04	214.76

Table 4.4-3. Additional Months Simulated Camanche WSE $\leq$ 190 ft msl for Programmatic Use Case Relative to the Baseline Case

Year	Month	Baseline Case [ft msl]	Programmatic Case [ft msl]	Decline in WSE [ft]
1924	August	190.94	187.87	3.07
1924	October	193.23	186.35	6.88
1924	November	190.15	183.60	6.55
1931	June	197.90	187.15	10.75
1931	July	193.58	184.09	9.49
1932	March	192.28	178.90	13.38
1932	April	196.16	184.96	11.20
1934	August	205.81	186.70	19.11
1934	September	204.78	183.34	21.44
1934	October	208.46	186.21	22.25
1934	November	208.07	183.59	24.48
1934	December	207.49	179.91	27.58
1935	January	207.21	176.33	30.88
1935	February	208.40	176.87	31.53
1935	March	208.96	176.25	32.71
1935	April	217.39	189.79	27.60
1961	February	204.82	189.93	14.89
1961	March	201.95	186.70	15.25
1961	April	199.14	183.09	16.05
1961	May	195.70	183.62	12.08
1961	June	191.18	183.14	8.04
1962	April	190.79	188.71	2.08
1962	May	190.62	188.18	2.44
1976	September	191.99	189.69	2.30
1976	October	193.75	186.05	7.70
1976	November	190.64	182.47	8.17
1980	January	197.17	189.81	7.36
1987	July	195.70	189.12	6.58
1987	August	195.98	188.87	7.11
1987	September	197.10	189.76	7.34
1987	November	198.05	189.28	8.77
1987	December	195.82	185.97	9.85
1988	January	193.76	184.30	9.46
1988	February	190.91	180.88	10.03
1994	August	196.84	189.76	7.08

Table 4.4-4. Simulated Total Camanche Release [cfs], Programmatic Use Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	2,349	706	558	500	957	1,799	689	597	463	325	325	325
1922	325	325	325	375	2,052	2,420	871	773	640	325	325	325
1923	459	411	325	400	700	854	680	598	464	325	325	325
1924	325	325	325	227	242	304	276	238	175	220	220	220
1925	220	220	220	300	535	639	515	432	299	325	325	325
1926	325	325	325	300	400	363	398	348	236	220	220	220
1927	220	220	220	325	965	1,307	810	722	589	325	325	325
1928	325	325	596	500	450	633	401	348	236	250	250	250
1929	250	250	250	302	369	304	314	262	189	220	220	220
1930	220	220	220	300	400	363	398	348	236	220	220	220
1931	220	220	220	227	242	304	276	238	175	126	130	130
1932	130	130	130	300	450	533	398	348	236	250	250	250
1933	250	250	250	300	400	363	398	348	236	220	220	220
1934	220	220	220	302	369	304	314	262	189	220	220	220
1935	220	220	220	300	450	533	398	348	236	220	220	220
1936	220	881	372	525	1,503	1,402	808	710	577	325	325	325
1937	325	325	325	500	829	933	662	577	443	325	325	1,109
1938	325	1,049	1,625	2,267	2,879	2,158	1,016	915	777	325	325	325
1939	325	325	325	302	369	304	314	262	189	220	220	220
1940	220	220	989	525	1,303	1,014	609	511	379	325	325	325
1941	343	845	529	500	1,074	1,372	868	776	642	325	325	335
1942	1,277	1,003	325	425	1,803	1,943	972	873	740	325	523	342
1943	1,439	976	1,724	589	1,599	1,162	757	659	526	325	325	325
1944	325	325	325	300	400	363	398	348	236	250	250	250
1945	250	638	250	450	806	960	739	654	520	325	405	990
1946	572	325	325	400	632	887	616	530	397	325	325	325
1947	325	325	325	300	400	363	398	348	236	250	250	250
1948	250	250	250	300	503	606	481	401	268	325	325	325
1949	325	325	325	300	450	533	398	348	236	250	250	250
1950	250	250	250	321	746	852	728	644	507	325	3,260	4,034

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1951	1,208	1,049	325	525	761	815	501	412	280	325	325	537
1952	1,310	1,249	989	2,940	3,073	1,822	1,254	1,152	1,012	325	325	325
1953	325	955	325	300	614	719	594	512	378	325	325	325
1954	325	325	325	300	450	533	398	348	236	250	250	250
1955	250	250	250	300	400	363	398	348	236	220	220	1,516
1956	2,944	954	220	525	1,857	1,784	1,000	900	765	325	325	325
1957	325	325	325	300	450	533	398	348	236	250	250	250
1958	250	1,058	889	1,759	2,533	1,842	1,083	983	848	325	325	325
1959	325	325	325	300	400	363	398	348	236	220	220	220
1960	220	220	220	300	400	363	398	348	236	220	220	220
1961	220	220	220	227	242	304	314	262	184	126	130	130
1962	130	130	130	300	450	533	398	348	236	220	220	220
1963	220	231	220	350	1,299	1,310	876	784	650	325	533	325
1964	325	325	325	300	400	363	398	348	236	220	220	2,623
1965	2,175	818	220	475	1,279	1,433	1,028	930	797	325	545	325
1966	325	325	325	300	400	363	398	348	236	250	250	250
1967	792	491	788	1,052	3,124	1,689	1,284	1,184	1,048	325	325	325
1968	325	325	325	300	400	363	398	348	236	220	220	220
1969	1,509	1,596	695	2,238	3,376	1,746	1,198	1,095	956	325	325	325
1970	3,298	1,029	386	525	650	755	534	452	320	325	587	681
1971	663	606	508	500	759	813	689	606	473	325	325	325
1972	325	325	325	300	450	533	398	348	236	220	220	220
1973	220	646	496	500	751	905	634	549	415	325	1,229	788
1974	1,274	325	700	553	1,246	1,350	945	847	715	325	325	325
1975	325	325	325	350	988	1,142	968	886	752	325	325	325
1976	325	325	325	227	242	304	276	238	175	220	220	220
1977	220	220	220	227	242	304	276	238	175	126	130	130
1978	130	130	130	227	242	304	276	238	175	126	130	130
1979	130	130	130	300	450	533	398	348	236	163	130	130
1980	130	876	403	525	1,192	1,396	991	893	761	325	325	325
1981	325	325	325	300	400	363	398	348	236	220	220	424
1982	1,370	2,949	1,677	3,535	2,949	1,763	1,360	1,254	1,108	325	1,267	1,619
1983	1,302	2,285	3,354	1,737	4,382	3,509	2,011	1,905	1,759	325	2,202	2,603

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984	1,409	946	325	525	803	908	687	605	472	325	503	325
1985	325	325	325	300	400	363	398	348	236	250	250	250
1986	250	5,592	2,597	546	1,606	1,287	883	781	642	325	325	325
1987	325	325	325	227	242	304	314	262	184	220	220	220
1988	220	220	220	227	242	304	276	238	175	126	130	130
1989	130	130	130	300	450	533	398	348	236	220	220	220
1990	220	220	220	302	369	304	314	262	189	126	130	130
1991	130	130	130	302	369	304	314	262	189	126	130	130
1992	130	130	130	302	369	304	314	262	189	126	130	130
1993	130	130	130	325	966	1,120	849	767	635	325	325	325
1994	325	325	325	227	242	304	314	262	184	220	220	220
1995	220	220	2,476	2,491	4,450	2,158	1,648	1,545	1,402	325	325	325
1996	325	1,938	979	525	1,786	1,148	743	644	509	325	525	2,245
1997	5,572	2,054	326	525	634	740	519	436	301	325	392	325
1998	441	2,152	1,212	1,627	2,757	1,855	1,451	1,349	1,210	325	325	325
1999	387	1,877	587	500	1,007	1,061	840	755	621	325	325	325
2000	325	821	561	500	664	668	544	462	328	325	325	325
2001	325	325	325	300	400	363	398	348	236	220	220	220
2002	220	220	220	300	450	533	398	348	236	250	250	250
2003	250	250	250	300	450	533	398	348	236	250	250	250
2004	250	250	341	300	400	363	398	348	236	250	250	250
2005	430	883	1,141	622	1,952	1,488	947	848	714	325	325	1,263
2006	1,896	1,146	1,183	3,885	3,000	1,729	884	782	641	325	325	325
2007	325	325	325	300	400	363	398	348	236	220	220	220
2008	220	220	220	302	369	304	314	262	189	220	220	220
2009	220	220	220	300	450	533	398	348	236	250	250	250
Min.	130	130	130	227	242	304	276	238	175	126	130	130
Max.	5,572	5,592	3,354	3,885	4,450	3,509	2,011	1,905	1,759	325	3,260	4,034
Mean	577	623	502	587	970	865	619	549	433	267	358	453
Median	325	325	325	302	450	606	401	348	236	250	250	325

Table 4.4-5. Estimated Flow at Elliott [cfs], Programmatic Use Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	2,347	717	552	482	944	1,784	666	571	448	312	315	318
1922	332	340	325	356	2,038	2,406	845	743	626	312	315	318
1923	466	425	325	381	687	837	657	572	449	312	315	318
1924	332	340	325	206	230	286	260	220	160	208	213	207
1925	228	236	223	280	523	622	495	409	284	312	315	318
1926	332	340	325	280	388	345	380	327	221	208	213	207
1927	228	236	223	305	952	1,291	785	693	575	312	315	318
1928	332	340	589	482	438	616	383	327	221	238	242	239
1929	258	265	252	282	357	286	297	243	174	208	213	207
1930	228	236	223	280	388	345	380	327	221	208	213	207
1931	228	236	223	206	230	286	260	220	160	115	124	113
1932	138	147	136	280	438	516	380	327	221	238	242	239
1933	258	265	252	280	388	345	380	327	221	208	213	207
1934	228	236	223	282	357	286	297	243	174	208	213	207
1935	228	236	223	280	438	516	380	327	221	208	213	207
1936	228	890	371	508	1,490	1,386	783	681	563	312	315	318
1937	332	340	325	482	816	916	640	551	428	312	315	1,141
1938	332	1,057	1,591	2,270	2,864	2,143	988	882	763	312	315	318
1939	332	340	325	282	357	286	297	243	174	208	213	207
1940	228	236	972	508	1,290	997	588	487	364	312	315	318
1941	350	855	524	482	1,061	1,356	842	746	628	312	315	328
1942	1,280	1,011	325	407	1,789	1,928	945	841	726	312	509	336
1943	1,441	984	1,687	572	1,585	1,146	733	631	511	312	315	318
1944	332	340	325	280	388	345	380	327	221	238	242	239
1945	258	650	252	432	793	943	715	627	505	312	394	1,016
1946	578	340	325	381	620	870	594	505	382	312	315	318
1947	332	340	325	280	388	345	380	327	221	238	242	239
1948	258	265	252	280	491	589	462	379	253	312	315	318
1949	332	340	325	280	438	516	380	327	221	238	242	239
1950	258	265	252	301	733	835	705	617	492	312	3,189	4,212
1951	1,211	1,057	325	508	748	798	481	390	265	312	315	540

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1952	1,313	1,255	972	2,951	3,058	1,807	1,222	1,114	999	312	315	318
1953	332	964	325	280	602	702	573	488	363	312	315	318
1954	332	340	325	280	438	516	380	327	221	238	242	239
1955	258	265	252	280	388	345	380	327	221	208	213	1,568
1956	2,939	963	223	508	1,843	1,769	972	867	751	312	315	318
1957	332	340	325	280	438	516	380	327	221	238	242	239
1958	258	1,066	874	1,756	2,518	1,827	1,054	948	834	312	315	318
1959	332	340	325	280	388	345	380	327	221	208	213	207
1960	228	236	223	280	388	345	380	327	221	208	213	207
1961	228	236	223	206	230	286	297	243	169	115	124	113
1962	138	147	136	280	438	516	380	327	221	208	213	207
1963	228	247	223	331	1,286	1,294	850	754	636	312	519	318
1964	332	340	325	280	388	345	380	327	221	208	213	2,731
1965	2,173	828	223	457	1,266	1,417	1,000	896	783	312	531	318
1966	332	340	325	280	388	345	380	327	221	238	242	239
1967	797	504	776	1,041	3,109	1,674	1,251	1,145	1,035	312	315	318
1968	332	340	325	280	388	345	380	327	221	208	213	207
1969	1,511	1,598	686	2,240	3,361	1,731	1,167	1,058	942	312	315	318
1970	3,291	1,037	385	508	638	738	514	429	305	312	572	691
1971	669	618	504	482	746	796	666	580	458	312	315	318
1972	332	340	325	280	438	516	380	327	221	208	213	207
1973	228	658	492	482	738	888	612	524	400	312	1,200	804
1974	1,277	340	690	536	1,233	1,334	918	815	701	312	315	318
1975	332	340	325	331	975	1,126	941	853	738	312	315	318
1976	332	340	325	206	230	286	260	220	160	208	213	207
1977	228	236	223	206	230	286	260	220	160	115	124	113
1978	138	147	136	206	230	286	260	220	160	115	124	113
1979	138	147	136	280	438	516	380	327	221	152	124	113
1980	138	885	401	508	1,179	1,380	963	860	747	312	315	318
1981	332	340	325	280	388	345	380	327	221	208	213	422
1982	1,372	2,938	1,642	3,552	2,934	1,748	1,326	1,213	1,095	312	1,238	1,676
1983	1,305	2,281	3,274	1,734	4,365	3,496	1,966	1,850	1,747	312	2,153	2,710
1984	1,411	955	325	508	790	891	664	579	457	312	490	318

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	332	340	325	280	388	345	380	327	221	238	242	239
1986	258	5,555	2,537	529	1,592	1,271	857	751	628	312	315	318
1987	332	340	325	206	230	286	297	243	169	208	213	207
1988	228	236	223	206	230	286	260	220	160	115	124	113
1989	138	147	136	280	438	516	380	327	221	208	213	207
1990	228	236	223	282	357	286	297	243	174	115	124	113
1991	138	147	136	282	357	286	297	243	174	115	124	113
1992	138	147	136	282	357	286	297	243	174	115	124	113
1993	138	147	136	305	953	1,104	824	737	621	312	315	318
1994	332	340	325	206	230	286	297	243	169	208	213	207
1995	228	236	2,419	2,496	4,433	2,143	1,609	1,498	1,389	312	315	318
1996	332	1,937	962	508	1,772	1,132	719	617	494	312	511	2,334
1997	5,554	2,052	326	508	622	723	499	413	286	312	381	318
1998	448	2,149	1,189	1,622	2,742	1,840	1,416	1,306	1,197	312	315	318
1999	394	1,877	580	482	994	1,045	815	725	607	312	315	318
2000	332	831	555	482	652	651	524	439	313	312	315	318
2001	332	340	325	280	388	345	380	327	221	208	213	207
2002	228	236	223	280	438	516	380	327	221	238	242	239
2003	258	265	252	280	438	516	380	327	221	238	242	239
2004	258	265	341	280	388	345	380	327	221	238	242	239
2005	437	892	1,120	606	1,938	1,472	920	816	700	312	315	1,303
2006	1,896	1,153	1,161	3,906	2,985	1,714	858	752	627	312	315	318
2007	332	340	325	280	388	345	380	327	221	208	213	207
2008	228	236	223	282	357	286	297	243	174	208	213	207
2009	228	236	223	280	438	516	380	327	221	238	242	239
Min.	138	147	136	206	230	286	260	220	160	115	124	113
Max.	5,554	5,555	3,274	3,906	4,433	3,496	1,966	1,850	1,747	312	3,189	4,212
Mean	583	635	497	570	958	848	597	523	418	255	348	452
Median	332	340	325	282	438	589	383	327	221	238	242	318

Table 4.4-6. Simulated Flow Below Woodbridge Irrigation Dam [cfs], Programmatic UseCase

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	2,283	647	474	350	651	1,389	233	215	214	188	268	254
1922	258	266	240	225	1,746	2,011	415	391	391	188	268	254
1923	392	352	240	250	394	444	224	216	214	188	268	254
1924	258	268	241	75	23	31	18	15	15	139	163	149
1925	153	161	135	150	229	229	59	51	49	188	268	254
1926	258	266	240	150	150	31	29	22	20	102	163	149
1927	153	161	135	175	660	897	354	340	340	188	268	254
1928	258	268	511	350	200	300	33	22	20	132	193	179
1929	183	191	166	150	150	31	29	22	20	139	163	149
1930	153	161	135	150	150	31	29	22	20	102	163	149
1931	153	161	136	75	23	31	18	15	15	45	73	59
1932	63	73	45	150	200	200	29	22	20	132	193	179
1933	183	191	165	150	150	31	29	22	20	102	163	149
1934	153	161	136	150	150	31	29	22	20	139	163	149
1935	153	161	135	150	200	200	29	22	20	102	163	149
1936	153	824	287	375	1,198	993	352	328	328	188	268	254
1937	258	266	240	350	523	523	206	195	193	188	268	1,037
1938	225	960	1,504	2,079	2,532	1,705	516	492	492	162	240	221
1939	258	266	241	150	150	31	29	22	20	139	163	149
1940	153	163	905	375	998	604	153	129	129	188	268	254
1941	276	786	444	350	769	962	411	394	392	188	268	263
1942	1,205	940	235	270	1,492	1,527	509	486	486	184	462	266
1943	1,368	914	1,635	435	1,288	747	296	272	272	185	265	250
1944	258	268	240	150	150	31	29	22	20	132	193	179
1945	183	578	165	300	500	550	283	272	270	188	348	919
1946	506	266	240	250	327	477	160	149	147	188	268	254
1947	258	266	240	150	150	31	29	22	20	132	193	179
1948	183	193	165	150	200	200	29	22	20	189	268	254
1949	258	266	240	150	200	200	29	22	20	132	193	179
1950	164	174	145	150	418	418	247	239	238	173	3,187	3,944
1951	1,141	989	240	375	455	405	44	30	30	188	268	466

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1952	1,195	1,151	852	2,734	2,708	1,350	734	711	711	150	228	205
1953	258	896	240	150	309	309	138	130	129	188	268	254
1954	258	266	240	150	200	200	29	22	20	132	193	179
1955	183	191	165	150	150	31	29	22	20	102	163	1,445
1956	2,860	882	117	356	1,531	1,353	521	498	498	175	254	237
1957	258	266	240	150	200	200	29	22	20	132	193	179
1958	165	982	784	1,588	2,205	1,408	602	579	579	173	253	235
1959	258	266	240	150	150	31	29	22	20	102	163	149
1960	153	163	135	150	150	31	29	22	20	102	163	149
1961	153	161	136	75	23	31	29	22	15	45	73	59
1962	63	71	45	150	200	200	29	22	20	102	163	149
1963	153	172	135	200	994	900	419	402	400	188	476	254
1964	258	268	240	150	150	31	29	22	20	102	163	2,552
1965	2,105	755	132	321	969	1,019	568	544	544	185	485	250
1966	258	266	240	150	150	31	29	22	20	132	193	179
1967	704	413	680	878	2,793	1,252	800	777	777	172	251	233
1968	258	268	240	150	150	31	29	22	20	102	163	149
1969	1,397	1,496	561	2,036	3,015	1,278	683	659	659	153	231	209
1970	3,231	969	301	375	345	345	78	70	70	188	530	610
1971	597	547	423	350	453	403	233	225	223	188	268	254
1972	258	268	240	150	200	200	29	22	20	102	163	149
1973	153	587	411	350	446	496	178	167	166	188	1,172	717
1974	1,207	266	615	404	940	940	489	465	465	188	268	254
1975	258	266	240	200	682	732	512	504	502	188	268	254
1976	258	268	241	75	23	31	18	15	15	139	163	149
1977	153	161	136	75	23	31	18	15	15	45	73	59
1978	63	71	46	75	23	31	18	15	15	45	73	59
1979	63	71	45	150	200	200	29	22	20	45	73	59
1980	63	819	319	375	886	986	535	511	511	188	268	254
1981	258	266	240	150	150	31	29	22	20	102	163	353
1982	1,221	2,816	1,503	3,290	2,542	1,247	795	772	772	124	1,141	1,465
1983	1,153	2,152	3,180	1,492	3,976	2,992	1,446	1,423	1,423	124	2,077	2,450
1984	1,343	889	240	375	498	498	231	223	223	188	446	254

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	258	266	240	150	150	31	29	22	20	132	193	179
1986	143	5,497	2,469	350	1,251	825	374	350	350	157	234	214
1987	258	266	241	75	23	31	29	22	15	139	163	149
1988	153	163	136	75	23	31	18	15	15	45	73	59
1989	63	71	45	150	200	200	29	22	20	102	163	149
1990	153	161	136	150	150	31	29	22	20	45	73	59
1991	63	71	46	150	150	31	29	22	20	45	73	59
1992	63	73	46	150	150	31	29	22	20	45	73	59
1993	63	71	45	175	660	710	393	385	385	188	268	254
1994	258	266	241	75	23	31	29	22	15	139	163	149
1995	89	103	2,321	2,267	4,066	1,666	1,108	1,084	1,084	138	215	190
1996	244	1,869	879	359	1,463	719	268	244	244	177	456	2,159
1997	5,487	1,979	222	355	307	307	40	32	32	174	320	236
1998	333	2,056	1,082	1,429	2,401	1,392	941	917	917	156	234	213
1999	320	1,817	503	350	702	652	384	373	372	188	268	254
2000	258	762	476	350	359	259	88	80	79	188	268	254
2001	258	266	240	150	150	31	29	22	20	102	163	149
2002	153	161	135	150	200	200	29	22	20	132	193	179
2003	183	191	165	150	200	200	29	22	20	132	193	179
2004	183	193	256	150	150	31	29	22	20	132	193	179
2005	355	816	1,047	462	1,636	1,067	479	456	456	181	261	1,183
2006	1,779	1,041	1,044	3,676	2,632	1,253	361	337	337	149	226	203
2007	258	266	240	150	150	31	29	22	20	102	163	149
2008	153	163	136	150	150	31	29	22	20	139	163	149
2009	153	161	135	150	200	200	29	22	20	132	193	179
Min.	63	71	45	75	23	31	18	15	15	45	73	59
Max.	5,487	5,497	3,180	3,676	4,066	2,992	1,446	1,423	1,423	189	3,187	3,944
Mean	503	558	409	428	690	496	215	203	202	141	295	375
Median	258	266	240	150	200	200	29	22	20	139	193	205

Table 4.4-7. Estimated Flow at Frandy [cfs], Programmatic Use Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	2,268	632	444	320	621	1,359	203	185	184	173	253	239
1922	243	251	210	195	1,716	1,981	385	361	361	173	253	239
1923	377	337	210	220	364	414	194	186	184	173	253	239
1924	243	253	211	45	1	1	1	1	1	124	148	134
1925	138	146	105	120	199	199	29	21	19	173	253	239
1926	243	251	210	120	120	1	1	1	1	87	148	134
1927	138	146	105	145	630	867	324	310	310	173	253	239
1928	243	253	481	320	170	270	3	1	1	117	178	164
1929	168	176	136	120	120	1	1	1	1	124	148	134
1930	138	146	105	120	120	1	1	1	1	87	148	134
1931	138	146	106	45	1	1	1	1	1	30	58	44
1932	48	58	15	120	170	170	1	1	1	117	178	164
1933	168	176	135	120	120	1	1	1	1	87	148	134
1934	138	146	106	120	120	1	1	1	1	124	148	134
1935	138	146	105	120	170	170	1	1	1	87	148	134
1936	138	809	257	345	1,168	963	322	298	298	173	253	239
1937	243	251	210	320	493	493	176	165	163	173	253	1,022
1938	210	945	1,474	2,049	2,502	1,675	486	462	462	147	225	206
1939	243	251	211	120	120	1	1	1	1	124	148	134
1940	138	148	875	345	968	574	123	99	99	173	253	239
1941	261	771	414	320	739	932	381	364	362	173	253	248
1942	1,190	925	205	240	1,462	1,497	479	456	456	169	447	251
1943	1,353	899	1,605	405	1,258	717	266	242	242	170	250	235
1944	243	253	210	120	120	1	1	1	1	117	178	164
1945	168	563	135	270	470	520	253	242	240	173	333	904
1946	491	251	210	220	297	447	130	119	117	173	253	239
1947	243	251	210	120	120	1	1	1	1	117	178	164
1948	168	178	135	120	170	170	1	1	1	174	253	239
1949	243	251	210	120	170	170	1	1	1	117	178	164
1950	149	159	115	120	388	388	217	209	208	158	3,172	3,929
1951	1,126	974	210	345	425	375	14	1	1	173	253	451

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1952	1,180	1,136	822	2,704	2,678	1,320	704	681	681	135	213	190
1953	243	881	210	120	279	279	108	100	99	173	253	239
1954	243	251	210	120	170	170	1	1	1	117	178	164
1955	168	176	135	120	120	1	1	1	1	87	148	1,430
1956	2,845	867	87	326	1,501	1,323	491	468	468	160	239	222
1957	243	251	210	120	170	170	1	1	1	117	178	164
1958	150	967	754	1,558	2,175	1,378	572	549	549	158	238	220
1959	243	251	210	120	120	1	1	1	1	87	148	134
1960	138	148	105	120	120	1	1	1	1	87	148	134
1961	138	146	106	45	1	1	1	1	1	30	58	44
1962	48	56	15	120	170	170	1	1	1	87	148	134
1963	138	157	105	170	964	870	389	372	370	173	461	239
1964	243	253	210	120	120	1	1	1	1	87	148	2,537
1965	2,090	740	102	291	939	989	538	514	514	170	470	235
1966	243	251	210	120	120	1	1	1	1	117	178	164
1967	689	398	650	848	2,763	1,222	770	747	747	157	236	218
1968	243	253	210	120	120	1	1	1	1	87	148	134
1969	1,382	1,481	531	2,006	2,985	1,248	653	629	629	138	216	194
1970	3,216	954	271	345	315	315	48	40	40	173	515	595
1971	582	532	393	320	423	373	203	195	193	173	253	239
1972	243	253	210	120	170	170	1	1	1	87	148	134
1973	138	572	381	320	416	466	148	137	136	173	1,157	702
1974	1,192	251	585	374	910	910	459	435	435	173	253	239
1975	243	251	210	170	652	702	482	474	472	173	253	239
1976	243	253	211	45	1	1	1	1	1	124	148	134
1977	138	146	106	45	1	1	1	1	1	30	58	44
1978	48	56	16	45	1	1	1	1	1	30	58	44
1979	48	56	15	120	170	170	1	1	1	30	58	44
1980	48	804	289	345	856	956	505	481	481	173	253	239
1981	243	251	210	120	120	1	1	1	1	87	148	338
1982	1,206	2,801	1,473	3,260	2,512	1,217	765	742	742	109	1,126	1,450
1983	1,138	2,137	3,150	1,462	3,946	2,962	1,416	1,393	1,393	109	2,062	2,435
1984	1,328	874	210	345	468	468	201	193	193	173	431	239

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	243	251	210	120	120	1	1	1	1	117	178	164
1986	128	5,482	2,439	320	1,221	795	344	320	320	142	219	199
1987	243	251	211	45	1	1	1	1	1	124	148	134
1988	138	148	106	45	1	1	1	1	1	30	58	44
1989	48	56	15	120	170	170	1	1	1	87	148	134
1990	138	146	106	120	120	1	1	1	1	30	58	44
1991	48	56	16	120	120	1	1	1	1	30	58	44
1992	48	58	16	120	120	1	1	1	1	30	58	44
1993	48	56	15	145	630	680	363	355	355	173	253	239
1994	243	251	211	45	1	1	1	1	1	124	148	134
1995	74	88	2,291	2,237	4,036	1,636	1,078	1,054	1,054	123	200	175
1996	229	1,854	849	329	1,433	689	238	214	214	162	441	2,144
1997	5,472	1,964	192	325	277	277	10	2	2	159	305	221
1998	318	2,041	1,052	1,399	2,371	1,362	911	887	887	141	219	198
1999	305	1,802	473	320	672	622	354	343	342	173	253	239
2000	243	747	446	320	329	229	58	50	49	173	253	239
2001	243	251	210	120	120	1	1	1	1	87	148	134
2002	138	146	105	120	170	170	1	1	1	117	178	164
2003	168	176	135	120	170	170	1	1	1	117	178	164
2004	168	178	226	120	120	1	1	1	1	117	178	164
2005	340	801	1,017	432	1,606	1,037	449	426	426	166	246	1,168
2006	1,764	1,026	1,014	3,646	2,602	1,223	331	307	307	134	211	188
2007	243	251	210	120	120	1	1	1	1	87	148	134
2008	138	148	106	120	120	1	1	1	1	124	148	134
2009	138	146	105	120	170	170	1	1	1	117	178	164
Min.	48	56	15	45	1	1	1	1	1	30	58	44
Max.	5,472	5,482	3,150	3,646	4,036	2,962	1,416	1,393	1,393	174	3,172	3,929
Mean	488	543	379	398	661	466	187	178	178	126	280	360
Median	243	251	210	120	170	170	1	1	1	124	178	190

Table 4.4-8. Calendar Year Water Supply Deliveries, Customer Cutbacks, and Undelivered Supply, Programmatic Use Case^a

Year	Customer Cutback	Additional Deficiency	Total Deficiency	WSMP 2040 Supplemental Supply Requirement ^b [MGD]	Total Supplemental Supply ^c [MGD]	Mokelumne Supply ^d [MGD]	Total Supply Delivered [MGD]
1921	0.0%	0.0%	0.0%	0	0	275	275
1922	0.0%	0.0%	0.0%	0	0	275	275
1923	0.0%	0.0%	0.0%	0	0	275	275
1924	3.7%	0.0%	3.7%	0	106	159	265
1925	0.0%	0.0%	0.0%	0	13	262	275
1926	0.2%	0.0%	0.2%	0	67	207	274
1927	0.0%	0.0%	0.0%	0	0	275	275
1928	0.0%	0.0%	0.0%	0	0	275	275
1929	0.2%	0.0%	0.2%	0	79	196	275
1930	0.3%	0.0%	0.3%	0	97	177	274
1931	12.3%	0.0%	12.3%	0	60	181	241
1932	0.0%	0.0%	0.0%	0	59	216	275
1933	0.0%	0.0%	0.0%	0	66	209	275
1934	3.0%	0.0%	3.0%	0	72	195	267
1935	0.0%	0.0%	0.0%	0	0	275	275
1936	0.0%	0.0%	0.0%	0	0	275	275
1937	0.0%	0.0%	0.0%	0	0	274	275
1938	0.0%	0.0%	0.0%	0	0	275	275
1939	0.3%	0.0%	0.3%	0	106	168	274
1940	0.0%	0.0%	0.0%	0	14	261	275
1941	0.0%	0.0%	0.0%	0	0	274	275
1942	0.0%	0.0%	0.0%	0	0	275	275
1943	0.0%	0.0%	0.0%	0	0	275	275
1944	0.0%	0.0%	0.0%	0	83	192	275
1945	0.0%	0.0%	0.0%	0	0	274	275
1946	0.0%	0.0%	0.0%	0	0	275	275
1947	0.0%	0.0%	0.0%	0	84	191	275
1948	0.0%	0.0%	0.0%	0	63	212	275

Year	Customer Cutback	Additional Deficiency	Total Deficiency	WSMP 2040 Supplemental Supply Requirement ^b [MGD]	Total Supplemental Supply ^c [MGD]	Mokelumne Supply ^d [MGD]	Total Supply Delivered [MGD]
1949	0.0%	0.0%	0.0%	0	0	275	275
1950	0.0%	0.0%	0.0%	0	0	275	275
1951	0.0%	0.0%	0.0%	0	0	275	275
1952	0.0%	0.0%	0.0%	0	0	275	275
1953	0.0%	0.0%	0.0%	0	0	275	275
1954	0.0%	0.0%	0.0%	0	0	275	275
1955	0.1%	0.0%	0.1%	0	75	199	275
1956	0.0%	0.0%	0.0%	0	0	275	275
1957	0.0%	0.0%	0.0%	0	0	275	275
1958	0.0%	0.0%	0.0%	0	0	275	275
1959	0.3%	0.0%	0.3%	0	106	168	274
1960	0.9%	0.0%	0.9%	0	86	187	272
1961	11.1%	0.0%	11.1%	0	72	172	245
1962	1.9%	0.0%	1.9%	0	22	247	270
1963	0.0%	0.0%	0.0%	0	0	275	275
1964	0.4%	0.0%	0.4%	0	75	198	274
1965	0.0%	0.0%	0.0%	0	0	275	275
1966	0.0%	0.0%	0.0%	0	84	191	275
1967	0.0%	0.0%	0.0%	0	0	275	275
1968	0.0%	0.0%	0.0%	0	84	191	275
1969	0.0%	0.0%	0.0%	0	0	275	275
1970	0.0%	0.0%	0.0%	0	0	274	275
1971	0.0%	0.0%	0.0%	0	0	275	275
1972	0.0%	0.0%	0.0%	0	0	275	275
1973	0.0%	0.0%	0.0%	0	0	274	275
1974	0.0%	0.0%	0.0%	0	0	275	275
1975	0.0%	0.0%	0.0%	0	0	275	275
1976	3.3%	0.0%	3.3%	0	106	160	266
1977	15.0%	0.0%	15.0%	0	119	114	234
1978	15.0%	0.0%	15.0%	0	95	55	234

Year	Customer Cutback	Additional Deficiency	Total Deficiency	WSMP 2040 Supplemental Supply Requirement ^b [MGD]	Total Supplemental Supply ^c [MGD]	Mokelumne Supply ^d [MGD]	Total Supply Delivered [MGD]
1979	15.0%	0.0%	15.0%	0	22	211	234
1980	0.0%	0.0%	0.0%	0	0	275	275
1981	0.6%	0.0%	0.6%	0	75	198	273
1982	0.0%	0.0%	0.0%	0	0	274	275
1983	0.0%	0.0%	0.0%	0	0	275	275
1984	0.0%	0.0%	0.0%	0	0	275	275
1985	0.0%	0.0%	0.0%	0	84	191	275
1986	0.0%	0.0%	0.0%	0	8	267	275
1987	2.2%	0.0%	2.2%	0	106	163	269
1988	12.3%	0.0%	12.3%	0	119	122	241
1989	7.3%	0.0%	7.3%	0	36	219	255
1990	10.8%	0.0%	10.8%	0	106	139	245
1991	12.2%	0.0%	12.2%	0	119	122	242
1992	11.1%	0.0%	11.1%	0	97	148	244
1993	0.0%	0.0%	0.0%	0	0	275	275
1994	1.8%	0.0%	1.8%	0	106	164	270
1995	0.0%	0.0%	0.0%	0	13	262	275
1996	0.0%	0.0%	0.0%	0	0	275	275
1997	0.0%	0.0%	0.0%	0	0	275	275
1998	0.0%	0.0%	0.0%	0	0	275	275
1999	0.0%	0.0%	0.0%	0	0	275	275
2000	0.0%	0.0%	0.0%	0	0	275	275
2001	0.0%	0.0%	0.0%	0	106	169	275
2002	0.0%	0.0%	0.0%	0	86	189	275
2003	0.0%	0.0%	0.0%	0	0	275	275
2004	0.0%	0.0%	0.0%	0	75	200	275
2005	0.0%	0.0%	0.0%	0	0	274	275
2006	0.0%	0.0%	0.0%	0	0	275	275
2007	0.0%	0.0%	0.0%	0	106	169	275
2008	1.0%	0.0%	1.0%	0	111	162	272

Year	Customer Cutback	Additional Deficiency	Total Deficiency	WSMP 2040 Supplemental Supply Requirement ^b [MGD]	Total Supplemental Supply ^c [MGD]	Mokelumne Supply ^d [MGD]	Total Supply Delivered [MGD]
2009	0.0%	0.0%	0.0%	0	22	253	275
^a The sum of supplemental supplies and the Mokelumne supply do not necessarily equate to the total supply delivered due to Terminal Reservoir storage regulation. ^b WSMP 2040 supplemental supply requirement external to the Mokelumne River to reduce District wide rationing to 15%. ^c Total supplemental supply includes delivery from USBR Contract, surface water transfers, and conjunctive-use basin withdrawals. ^d Mokelumne supply reports the quantity of water diverted from the Mokelumne to meet customer demands and does not include diversions to conjunctive use groundwater basin(s).							

Table 4.4-9. Calendar Year Total Annual Diversions, [TAF], Programmatic Use Case

Year	Upstream	JVID	NSJWCD	WID	EBMUD ^a	Year	Upstream	JVID	NSJWCD	WID	EBMUD ^a
1921	24	3.4	20	60	346	1966	24	3.4	0	60	214
1922	24	3.4	20	60	326	1967	24	3.4	20	60	344
1923	24	3.4	20	60	308	1968	24	3.4	0	60	215
1924	24	0.0	0	39	178	1969	24	3.4	20	60	347
1925	24	3.4	20	60	293	1970	24	3.4	20	60	326
1926	24	3.4	0	60	232	1971	24	3.4	20	60	309
1927	24	3.4	20	60	331	1972	24	3.4	0	60	309
1928	24	3.4	0	60	309	1973	24	3.4	20	60	349
1929	24	3.3	0	39	220	1974	24	3.4	20	60	347
1930	24	3.4	0	60	199	1975	24	3.4	20	60	326
1931	24	0.0	0	39	203	1976	24	0.0	0	39	180
1932	24	3.4	0	60	242	1977	24	0.0	0	39	128
1933	24	3.4	0	60	235	1978	24	0.0	0	39	62
1934	24	0.4	0	39	218	1979	24	2.1	0	60	307
1935	24	3.4	0	60	308	1980	24	3.4	20	60	359
1936	24	3.4	20	60	348	1981	24	3.4	0	60	222
1937	24	3.4	20	60	331	1982	24	3.4	20	60	357
1938	24	3.4	20	60	342	1983	24	3.4	20	60	354
1939	24	3.4	0	39	188	1984	24	3.4	20	60	342
1940	24	3.4	20	60	325	1985	24	3.4	0	60	214
1941	24	3.4	20	60	344	1986	24	3.3	20	60	325
1942	24	3.4	20	60	339	1987	24	0.0	0	39	182
1943	24	3.4	20	60	348	1988	24	0.0	0	39	137
1944	24	3.4	0	60	216	1989	24	1.7	0	60	246
1945	24	3.4	20	60	337	1990	24	0.0	0	39	156
1946	24	3.4	20	60	310	1991	24	0.0	0	39	137
1947	24	3.4	0	60	214	1992	24	0.4	0	39	166
1948	24	3.3	19	60	238	1993	24	3.4	20	60	308
1949	24	3.4	0	60	308	1994	24	3.3	0	39	184
1950	24	3.4	20	60	338	1995	24	3.4	20	60	322
1951	24	3.4	20	60	326	1996	24	3.4	20	60	340
1952	24	3.4	20	60	349	1997	24	3.4	20	60	322
1953	24	3.4	20	60	308	1998	24	3.4	20	60	344
1954	24	3.4	0	60	308	1999	24	3.4	20	60	334
1955	24	3.4	0	60	228	2000	24	3.4	20	60	316
1956	24	3.4	20	60	341	2001	24	3.4	0	60	190
1957	24	3.4	0	60	308	2002	24	3.4	0	60	211
1958	24	3.4	20	60	342	2003	24	3.3	0	60	308
1959	24	3.3	0	60	188	2004	24	3.3	0	60	225
1960	24	3.4	0	60	210	2005	24	3.4	20	60	344

Year	Upstream	JVID	NSJWCD	WID	EBMUD ^a	Year	Upstream	JVID	NSJWCD	WID	EBMUD ^a
1961	24	0.0	0	39	193	2006	24	3.4	20	60	348
1962	24	3.4	0	60	277	2007	24	3.3	0	60	189
1963	24	3.4	20	60	333	2008	24	3.4	0	39	182
1964	24	3.4	0	60	228	2009	24	3.4	0	60	283
1965	24	3.4	20	60	334						

^a EBMUD diversions reflect the quantity diverted from the Mokelumne to meet customer demand and/or to refill terminal reservoir storage in addition to water diverted to groundwater conjunctive use basin(s) and does not include supplemental supply deliveries from sources external to the Mokelumne System

The JSA year type summary for the programmatic use case is shown in Table 4.4-10.

Table 4.4-10. JSA Year Type Classifications Summary, Programmatic Use Case

Class	April-September	October-March	Total
Above Normal/Normal	28	44	72
Below Normal	29	13	42
Dry	23	23	46
Critically Dry	9	9	18
Total	89	89	178

4.5 Case 5: Cumulative Effects

The cumulative effects case differs from the Project case by one major model assumption. In the cumulative case senior water rights are advanced to 2040 LOD (47 TAF) which reflects full-use by senior water rights appropriators upstream of Pardee Reservoir. In contrast for the project case, the upstream senior water rights are set at the 2005 LOD (27 TAF). The increase in senior use and customer demand by 2040 result in a need for supplemental supplies equal to about 115 TAF over the three-year drought planning sequence. Supplemental supplies are modeled as a water transfer, however, the 115 TAF need for supplemental supplies is likely to be some mix of the projects identified in the preferred portfolio described in the WSMP 2040 Plan. Since the projects that will be selected and sequenced over the next 30 years is uncertain yet likely to come from a source outside of the Mokelumne Basin, the supplemental supply is modeled as a water transfer not to exceed 38 TAF in any single year and 115 TAF over any consecutive three year period where the supplemental supply trigger is the same as that used for the Freeport and Bayside Phase I projects; 500 TAF end-of-September total system storage. Results for the cumulative effects case are presented below.

Simulated EOM TSS is presented in Table 4.5-1. Simulated EOM Camanche Reservoir WSE is presented in Table 4.5-2. Cumulative effects case resulted in 12 additional months where Camanche WSE fell below 190 ft msl relative to the baseline case as (Table 4.5-3). Five of 12 cases (42%) occurred during winter months when Camanche Reservoir is expected to be de-stratified while the remaining 7 cases (58%) occurred between March through October.

Monthly average total Camanche Release for the cumulative effects case are presented in Table 4.5-4. Discharge at station Elliott is estimated with Equation 1 and parameters in Table 3.3-12 based on simulated total releases from Camanche Reservoir (in Table 4.5-4). The resultant estimate of the flow at station Elliott for the Project case is reported in Table 4.5-5.

Table 4.5-1. Simulated End-of-Month Total System Storage [AF], Cumulative Effects Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	611,016	611,715	628,147	636,561	715,845	744,894	688,259	636,023	598,483	585,867	577,086	578,408
1922	583,094	607,009	626,389	640,646	652,937	744,894	692,477	632,583	585,751	574,879	572,922	599,823
1923	613,008	620,711	623,865	650,333	694,879	709,065	666,744	620,579	589,692	578,864	570,480	565,795
1924	570,581	559,938	542,800	536,533	521,492	494,925	468,218	444,388	430,034	423,485	417,800	410,361
1925	409,968	470,151	500,555	538,568	647,586	695,644	654,996	617,034	595,016	582,909	574,788	569,958
1926	567,689	568,048	558,589	561,328	566,741	555,870	540,159	528,051	525,084	527,978	537,874	543,327
1927	558,617	617,769	643,084	668,636	701,154	744,894	689,061	632,148	589,420	577,898	569,137	568,509
1928	567,863	563,153	595,244	623,475	730,770	695,332	665,147	636,945	621,659	608,288	602,647	583,605
1929	563,817	549,355	542,775	541,881	533,522	521,518	508,668	498,227	495,957	493,124	489,436	485,949
1930	495,641	496,300	514,527	518,347	514,827	545,872	526,402	510,809	507,016	511,270	520,029	522,359
1931	513,532	500,497	496,352	485,413	474,185	449,796	423,986	391,005	365,896	350,085	339,990	343,033
1932	351,204	389,027	420,177	442,485	482,389	603,668	588,351	563,581	550,074	541,051	536,968	536,917
1933	528,598	508,317	508,012	523,077	533,084	538,616	524,787	511,522	508,791	513,718	517,830	532,276
1934	551,221	558,065	573,000	555,026	530,393	520,134	501,233	474,865	458,757	446,993	445,376	444,359
1935	451,630	469,069	478,233	550,120	593,404	673,222	643,817	615,324	599,941	588,885	582,015	577,964
1936	598,586	620,711	649,157	672,449	727,799	744,894	688,788	633,885	592,832	581,882	574,549	574,300
1937	565,094	601,029	649,157	679,538	718,221	734,257	684,007	636,706	602,318	590,878	585,421	542,952
1938	551,497	577,786	606,232	552,611	653,903	744,894	698,625	634,156	582,656	572,887	569,318	568,179
1939	568,660	558,615	556,222	551,969	534,128	526,167	511,995	500,858	499,199	504,450	503,595	496,683
1940	525,641	594,591	619,212	653,902	749,804	733,642	684,040	640,182	609,254	598,847	593,666	605,114
1941	613,008	620,711	649,157	681,205	710,543	744,894	690,099	632,182	587,815	576,871	571,876	574,889
1942	569,057	573,742	594,035	634,686	667,910	744,894	699,327	636,750	587,651	575,906	572,155	576,881
1943	567,065	569,757	595,244	672,449	732,809	731,024	679,655	630,497	593,465	584,901	578,833	577,567
1944	572,453	563,904	578,920	578,030	587,076	590,108	572,532	557,094	551,267	553,385	574,496	593,137
1945	600,848	609,723	640,214	651,119	685,648	734,694	680,589	628,586	589,728	579,890	570,163	560,883
1946	570,084	583,016	608,376	629,630	736,829	721,996	676,824	634,961	607,280	596,855	597,738	598,817
1947	597,234	596,901	598,875	613,218	602,605	590,397	570,309	552,811	547,154	554,495	551,278	543,169
1948	552,177	536,403	527,478	546,574	562,170	662,072	631,717	605,809	591,557	578,864	571,692	570,020
1949	565,131	546,847	549,076	576,247	610,302	616,622	591,340	565,828	552,068	543,587	542,091	539,892
1950	553,787	591,999	624,845	666,624	689,398	733,465	675,902	621,080	581,519	573,913	533,216	537,942

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1951	543,097	550,800	595,244	660,940	726,873	695,306	659,945	627,492	607,878	594,862	593,883	607,852
1952	613,008	620,711	641,187	561,606	624,925	736,895	704,525	630,174	568,340	559,907	558,207	566,721
1953	601,647	566,376	581,272	618,370	620,111	663,768	638,081	600,523	578,374	573,913	572,001	569,159
1954	568,406	571,541	589,956	621,381	649,663	624,485	592,770	567,348	556,898	552,321	556,944	560,470
1955	566,881	563,430	572,671	570,801	572,289	577,619	557,286	541,441	536,265	537,163	543,367	550,922
1956	543,097	566,799	622,170	663,967	696,828	744,894	686,990	621,782	570,250	563,891	564,512	568,991
1957	566,495	572,663	587,674	587,793	618,525	674,605	637,817	604,551	586,794	579,890	581,584	585,271
1958	598,396	620,711	649,157	675,407	681,856	744,894	691,804	628,873	573,296	565,884	562,049	554,469
1959	556,272	573,634	582,030	572,423	553,755	540,387	524,646	512,754	510,297	511,968	515,790	522,593
1960	520,368	531,958	540,301	538,413	550,984	560,653	543,304	529,575	516,296	507,046	503,355	500,274
1961	500,610	495,226	488,689	479,516	458,374	437,506	413,229	391,808	380,907	378,644	369,264	359,986
1962	352,872	394,397	419,576	464,896	475,142	540,180	516,796	495,116	482,975	485,913	488,552	493,568
1963	507,435	552,792	567,724	632,199	725,806	744,894	685,276	629,125	586,506	578,864	563,160	565,207
1964	576,974	576,190	578,167	576,229	562,251	548,743	531,508	516,770	514,059	519,706	535,510	546,937
1965	556,621	576,941	616,201	677,906	691,402	724,425	670,891	613,203	581,632	590,576	594,976	605,939
1966	610,109	600,369	600,470	609,128	598,366	568,217	537,968	511,652	501,076	493,897	500,878	543,561
1967	597,277	620,530	648,070	676,192	607,357	715,121	717,549	638,715	574,724	567,635	568,574	570,406
1968	575,452	587,576	605,088	608,788	591,406	581,296	558,297	539,919	534,711	535,316	549,707	570,605
1969	605,763	620,530	648,070	635,683	670,868	744,894	694,984	630,664	579,971	582,184	581,096	597,831
1970	542,856	550,559	602,006	614,183	652,951	688,245	656,907	621,334	599,224	588,946	590,629	607,671
1971	612,827	620,530	648,070	666,299	647,365	688,689	662,766	637,345	614,208	611,102	602,945	607,671
1972	604,976	598,751	613,555	617,269	596,545	600,508	574,876	548,944	536,629	531,707	536,783	547,947
1973	605,490	620,530	648,070	670,579	720,516	727,122	685,937	638,754	607,000	600,899	558,511	569,999
1974	564,650	592,978	641,248	692,734	715,804	732,935	690,313	647,633	608,897	598,303	587,544	579,592
1975	567,550	576,795	620,731	646,215	651,861	719,418	677,751	631,052	596,524	596,673	596,063	593,201
1976	590,430	577,173	561,349	549,738	531,557	505,202	477,220	453,700	438,450	420,726	407,562	391,381
1977	380,193	363,246	347,431	334,772	321,981	300,742	279,351	260,533	251,093	242,628	237,855	228,300
1978	222,222	214,191	214,241	204,743	194,824	178,518	158,204	127,820	110,464	91,560	70,635	53,513
1979	65,666	87,499	146,125	200,471	264,674	309,143	302,951	287,046	279,396	281,285	293,738	316,818
1980	463,952	568,067	630,743	661,862	679,126	723,248	693,461	627,993	576,096	565,099	550,021	549,517
1981	551,250	539,290	542,553	547,151	531,316	509,632	490,169	468,616	459,589	457,757	472,618	436,359
1982	451,029	436,440	473,355	488,617	583,696	635,220	594,733	536,574	483,748	494,366	492,043	512,379
1983	553,483	576,671	625,600	650,021	565,941	683,284	722,660	633,916	551,165	565,582	532,956	537,682

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1984	542,838	559,433	612,269	635,855	690,592	698,313	668,923	638,958	607,932	601,865	599,202	603,918
1985	589,069	588,616	609,187	634,700	621,297	604,543	581,793	566,432	563,168	567,496	580,523	594,223
1986	612,827	563,909	594,762	665,611	726,289	736,653	682,007	626,186	584,787	573,974	568,748	560,158
1987	555,845	549,807	547,973	540,025	520,363	498,486	482,722	470,357	464,755	449,241	437,622	431,064
1988	433,687	425,249	417,588	411,367	401,522	388,441	378,494	366,733	359,227	351,366	347,584	344,563
1989	341,101	337,185	382,984	429,454	488,125	499,480	479,229	453,886	442,434	427,270	429,337	429,766
1990	440,774	445,120	455,781	449,565	443,085	437,673	426,760	415,787	414,079	417,205	401,199	382,199
1991	365,032	354,540	365,793	362,235	353,781	359,445	351,545	343,272	343,761	355,957	372,325	387,121
1992	384,665	398,137	420,877	415,002	397,106	376,696	365,173	356,931	345,654	333,997	322,077	321,939
1993	387,124	438,827	529,747	584,373	661,320	728,154	673,262	639,118	601,392	593,051	582,997	575,973
1994	559,316	543,777	530,813	522,380	510,244	496,421	473,528	457,967	459,096	462,794	452,882	463,153
1995	567,955	614,365	636,841	613,828	555,376	693,185	729,407	642,649	571,594	577,234	569,813	570,010
1996	580,642	565,772	606,836	667,172	737,035	736,189	692,213	652,645	618,264	591,964	591,535	575,976
1997	574,563	550,541	594,762	631,188	700,824	695,964	660,649	633,595	615,957	607,540	602,945	590,727
1998	612,827	620,530	648,070	643,471	596,973	722,238	721,325	652,154	589,781	585,263	585,941	591,007
1999	612,827	620,288	643,844	673,408	691,231	734,919	695,412	644,848	605,333	591,663	589,058	579,828
2000	595,117	620,530	648,070	656,298	700,877	699,757	670,268	638,984	614,860	601,926	594,183	585,534
2001	566,277	551,799	558,755	577,091	574,208	560,685	545,841	532,870	525,763	517,778	510,906	523,826
2002	540,306	543,949	584,822	611,222	612,411	612,238	589,108	568,497	558,995	553,182	550,631	558,842
2003	575,884	590,060	598,568	614,936	648,347	688,900	650,730	616,595	598,151	583,693	572,622	581,466
2004	592,224	612,222	648,070	649,726	619,397	606,887	574,977	548,592	531,188	509,339	507,986	518,667
2005	573,751	619,949	648,070	694,424	712,102	744,894	708,107	655,796	611,566	595,768	589,074	584,368
2006	555,534	552,068	610,217	643,652	707,514	744,894	709,798	666,439	617,110	603,677	598,301	603,023
2007	593,113	596,022	607,683	602,043	590,271	572,653	555,021	540,766	534,904	523,036	526,118	524,129
2008	532,190	536,663	551,688	543,925	536,949	526,511	504,182	489,192	475,439	475,163	481,741	480,804
2009	489,061	498,936	541,783	565,306	661,458	649,868	623,828	598,341	576,354	566,278	565,721	607,671
Min.	65,666	87,499	146,125	200,471	194,824	178,518	158,204	127,820	110,464	91,560	70,635	53,513
Max.	613,008	620,711	649,157	694,424	749,804	744,894	729,407	666,439	621,659	611,102	602,945	607,852
Mean	535,053	544,034	565,647	582,553	602,876	624,462	594,869	559,492	534,636	528,279	524,819	526,582
Median	565,131	566,799	594,762	613,218	618,525	673,222	638,081	605,809	571,594	565,884	562,049	560,883

Table 4.5-2. Simulated End-of-Month Camanche Reservoir Water Surface Elevation [ft msl], Cumulative Effects Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	222.06	220.99	222.21	222.36	230.88	235.50	228.52	222.26	217.61	220.23	218.36	217.83
1922	217.75	220.28	221.95	222.97	221.76	235.50	229.12	221.74	215.58	218.52	217.71	221.14
1923	222.36	222.36	221.56	224.41	227.93	230.62	225.42	219.90	216.21	219.14	217.32	215.82
1924	215.76	212.75	209.30	206.62	203.35	199.24	194.94	190.93	187.93	190.27	188.15	185.19
1925	183.67	196.01	200.49	206.28	220.94	228.73	223.69	219.35	217.06	219.77	218.00	216.49
1926	215.29	214.10	211.11	210.31	208.74	206.64	204.82	204.32	205.14	210.87	212.01	212.13
1927	213.81	221.92	224.44	227.08	228.82	235.50	228.64	221.67	216.17	218.99	217.11	216.26
1928	215.32	213.29	217.12	220.37	232.93	228.70	225.19	222.39	221.20	223.62	222.29	219.33
1929	216.39	213.60	210.31	206.94	202.65	200.14	198.72	198.51	199.54	204.67	203.37	201.80
1930	202.67	201.31	203.19	202.51	198.98	204.80	202.22	201.02	201.72	207.97	208.94	208.52
1931	206.28	204.12	201.50	198.56	195.06	190.51	185.70	181.11	177.61	174.95	172.32	170.73
1932	168.14	175.33	182.08	185.99	192.06	214.80	213.26	210.67	209.61	213.08	211.85	211.04
1933	208.75	206.26	203.42	203.41	202.57	203.44	201.91	201.16	202.07	208.40	208.55	210.25
1934	212.58	212.44	213.53	210.17	205.72	201.74	197.19	193.57	191.61	195.51	194.46	193.20
1935	193.67	195.77	195.94	205.81	212.30	225.50	222.02	219.09	217.84	220.69	219.13	217.76
1936	220.17	216.64	222.23	226.32	232.53	235.50	228.60	221.94	216.71	219.61	217.97	217.18
1937	214.87	219.35	225.33	228.64	231.21	234.08	227.92	222.36	218.22	220.99	219.66	212.07
1938	212.63	214.29	213.89	204.65	221.91	235.50	229.99	221.98	215.08	218.21	217.13	216.20
1939	215.45	212.57	210.70	208.68	204.20	201.05	199.39	199.04	200.19	206.74	206.00	203.85
1940	208.19	217.99	218.13	223.21	235.50	234.01	227.92	222.88	219.29	222.20	220.92	221.95
1941	222.36	222.36	225.33	228.87	230.14	235.50	228.78	221.68	215.91	218.83	217.54	217.27
1942	215.51	215.02	216.93	222.08	224.00	235.50	230.09	222.37	215.89	218.68	217.59	217.59
1943	214.36	214.38	212.07	224.30	233.21	233.64	227.29	221.42	216.81	220.08	218.63	217.69
1944	216.06	213.75	214.50	213.13	212.23	212.58	210.59	209.55	209.82	215.10	217.96	220.12
1945	220.51	219.72	224.02	224.53	226.60	234.13	227.43	221.13	216.22	219.30	217.27	215.02
1946	215.68	216.52	219.19	221.31	233.76	232.42	226.88	222.10	218.99	221.90	221.54	220.99
1947	219.96	218.71	217.70	218.78	214.80	212.63	210.21	208.80	209.10	215.28	214.23	212.10
1948	212.74	210.40	207.95	207.72	207.94	223.86	220.17	217.60	216.51	219.14	217.51	216.50
1949	214.88	212.02	209.47	212.83	216.05	216.90	213.75	211.05	209.96	213.50	212.71	211.55
1950	213.01	217.94	221.71	226.79	227.14	233.97	226.75	219.98	214.89	218.37	204.65	204.65
1951	204.65	204.87	212.29	222.58	232.40	228.70	224.42	220.96	219.08	221.60	220.96	222.36

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1952	220.85	219.49	220.11	206.31	217.42	234.43	230.81	221.37	212.72	216.16	215.36	215.97
1953	220.63	213.82	214.88	219.58	216.66	224.12	221.14	216.76	214.38	218.37	217.56	216.36
1954	215.41	214.67	216.28	220.05	222.16	218.15	213.99	211.31	210.79	214.93	215.15	214.96
1955	215.16	213.33	213.47	211.92	209.71	210.47	207.93	206.77	207.17	212.43	212.92	207.02
1956	204.65	207.57	216.48	223.03	228.20	235.50	228.34	220.09	213.04	216.79	216.37	216.33
1957	215.10	214.85	215.92	214.73	217.23	225.71	221.10	217.40	215.75	219.30	219.06	218.90
1958	220.14	222.23	224.52	224.73	226.05	235.50	229.02	221.17	213.55	217.11	215.98	213.98
1959	213.42	215.00	215.00	212.19	207.77	203.88	201.89	201.40	202.35	208.09	208.19	208.56
1960	207.24	207.94	207.93	206.25	205.92	207.50	205.40	204.60	203.50	207.21	205.96	204.51
1961	203.61	201.32	198.66	195.67	191.97	187.10	181.27	175.71	171.46	178.57	176.10	173.44
1962	170.62	177.02	181.92	191.36	190.40	203.72	200.35	197.88	196.89	203.31	203.20	203.25
1963	204.88	211.55	212.65	219.76	232.26	235.50	228.10	221.21	215.70	219.14	216.16	215.72
1964	216.78	215.42	214.38	212.83	208.21	205.33	203.20	202.18	203.07	209.45	211.60	206.31
1965	207.12	209.35	217.99	225.10	227.43	232.74	226.03	218.76	214.91	220.95	221.12	222.07
1966	221.92	219.38	217.95	218.15	214.11	209.90	204.77	201.18	200.56	204.81	205.50	212.17
1967	219.97	222.33	224.41	224.85	214.60	231.46	232.59	222.66	213.78	217.38	217.02	216.56
1968	216.54	217.24	218.67	218.09	213.66	211.10	208.11	206.50	206.89	212.12	213.97	216.59
1969	215.48	216.61	220.53	218.71	224.44	235.50	229.47	221.44	214.64	219.66	218.99	220.84
1970	204.60	204.83	213.19	218.55	221.76	227.68	223.98	220.02	217.73	220.70	220.46	222.33
1971	222.33	222.33	225.17	226.74	220.91	227.74	224.84	222.45	220.06	224.04	222.33	222.33
1972	221.14	219.00	219.99	219.41	214.52	214.31	210.99	208.12	207.24	211.51	211.82	212.90
1973	221.22	222.17	225.17	227.36	231.53	233.11	228.19	222.67	218.94	222.51	215.40	216.49
1974	214.40	218.10	220.45	227.25	230.87	233.90	228.81	223.99	219.24	222.12	219.99	218.02
1975	215.27	215.52	221.09	223.80	221.60	232.06	227.02	221.50	217.30	221.88	221.29	220.13
1976	218.90	215.97	212.61	210.11	206.99	203.06	198.97	195.27	192.47	189.62	186.29	182.61
1977	178.75	174.96	170.20	164.33	161.07	155.62	149.96	145.17	143.47	144.15	137.55	129.15
1978	118.73	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60
1979	118.60	118.60	118.60	118.60	135.04	151.61	152.73	155.54	162.19	169.51	166.49	163.42
1980	187.99	207.79	217.84	222.89	225.65	232.58	229.26	221.04	214.01	216.98	217.41	220.05
1981	222.33	222.33	224.07	225.78	221.74	217.50	214.16	211.55	210.85	215.35	217.49	210.96
1982	207.53	204.60	211.37	214.37	227.59	233.99	227.72	218.81	209.68	214.51	212.12	208.13
1983	211.57	213.35	219.19	221.35	207.54	226.96	233.29	223.73	215.53	221.78	211.08	204.60
1984	204.60	206.24	214.88	220.05	227.31	229.11	225.74	222.70	219.09	222.66	221.77	221.77

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	218.72	217.41	219.31	222.08	217.88	214.96	212.17	211.15	211.86	217.36	218.90	220.29
1986	222.33	207.05	211.99	223.28	232.32	234.40	227.63	220.76	215.42	218.38	217.04	214.90
1987	213.35	211.04	209.28	206.54	203.25	199.09	194.18	192.56	192.96	195.99	193.02	190.18
1988	189.58	186.52	182.78	178.92	180.21	180.33	180.95	182.22	184.59	187.64	185.81	183.87
1989	181.79	179.84	178.08	182.58	192.02	195.61	192.45	188.75	187.77	191.14	190.87	189.87
1990	191.22	190.45	190.97	187.74	182.37	180.60	179.13	178.66	180.32	188.78	185.33	181.67
1991	177.78	174.11	171.38	164.05	166.99	171.20	174.35	178.21	183.16	188.75	186.79	184.85
1992	182.83	181.84	182.27	178.47	177.39	177.52	177.11	177.75	180.02	183.21	180.97	179.09
1993	179.07	188.97	201.75	210.33	223.02	233.25	226.37	222.72	218.07	221.32	219.28	217.44
1994	214.42	211.81	208.26	205.82	202.76	198.63	193.87	189.72	191.69	198.79	196.13	197.23
1995	209.29	217.27	218.79	215.24	205.63	228.38	234.20	223.25	213.26	218.89	217.21	216.49
1996	217.36	208.41	213.99	223.51	233.79	234.33	229.08	224.73	220.68	221.16	220.60	211.40
1997	210.28	204.60	211.99	218.01	228.77	228.79	224.53	221.89	220.33	223.51	222.33	219.75
1998	222.33	216.61	220.53	219.93	212.89	232.44	233.11	224.66	216.23	220.14	219.74	219.79
1999	222.33	216.57	220.06	225.00	227.40	234.16	229.54	223.58	218.68	221.11	220.22	218.05
2000	219.63	221.98	225.17	225.29	228.78	229.33	225.94	222.70	220.16	222.67	221.00	218.94
2001	215.92	213.30	211.14	212.97	210.05	207.50	205.87	205.21	205.26	209.11	207.32	208.77
2002	210.74	210.04	215.46	218.47	216.38	216.21	213.38	211.50	211.15	215.07	214.13	214.69
2003	216.61	217.64	217.65	219.05	221.12	227.77	223.05	219.28	217.56	219.90	217.66	218.31
2004	219.18	221.07	225.17	224.32	220.01	215.84	211.01	208.06	206.26	207.62	206.79	207.87
2005	216.27	222.24	221.02	227.49	230.36	235.50	231.31	225.19	219.65	221.74	220.22	217.43
2006	208.63	207.82	214.54	219.95	229.72	235.50	231.54	226.74	220.51	222.93	221.63	221.63
2007	219.32	218.57	219.08	217.02	212.76	209.61	207.53	206.65	206.93	210.03	210.00	208.83
2008	209.33	208.77	209.93	207.25	203.30	201.12	197.81	196.64	195.30	201.25	201.90	200.79
2009	201.40	201.82	208.19	210.99	223.04	222.06	218.95	216.41	214.05	217.17	216.56	220.60
Min.	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60	118.60
Max.	222.36	222.36	225.33	228.87	235.50	235.50	234.20	226.74	221.20	224.04	222.33	222.36
Mean	208.12	208.27	210.14	211.63	213.39	216.98	213.31	209.34	206.73	210.47	209.14	208.12
Median	214.87	213.60	214.88	218.47	217.42	225.71	222.02	218.76	213.55	217.17	216.37	215.02

Table 4.5-3. Additional Months Simulated Camanche WSE $\leq$ 190 ft msl for Cumulative Effects Case Relative to the Baseline Case

Year	Month	Baseline Case [ft msl]	Cumulative Case [ft msl]	Decline in WSE [ft]
1924	November	190.15	188.15	2.00
1931	July	193.58	185.70	7.88
1932	March	192.28	182.08	10.20
1932	April	196.16	185.99	10.17
1961	June	191.18	187.10	4.08
1976	October	193.75	189.62	4.13
1976	November	190.64	186.29	4.35
1980	January	197.17	187.99	9.18
1988	January	193.76	189.58	4.18
1988	February	190.91	186.52	4.39
1989	September	190.79	187.77	3.02
1994	August	196.84	189.72	7.12

Table 4.5-4. Simulated Total Camanche Release [cfs], Cumulative Effects Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	2,451	757	693	511	1,136	1,907	850	757	620	325	325	325
1922	325	325	325	425	2,326	2,528	997	899	764	325	325	382
1923	491	442	325	404	766	971	749	663	527	325	325	325
1924	325	325	325	231	247	309	281	243	177	220	220	220
1925	220	220	220	304	613	718	593	511	375	325	325	325
1926	325	325	325	306	374	309	319	266	191	250	250	250
1927	250	250	250	525	1,343	1,754	943	844	710	325	403	325
1928	325	325	766	504	463	696	413	360	246	325	325	325
1929	325	325	325	306	374	309	319	266	191	220	220	220
1930	220	220	220	304	405	369	403	353	239	220	220	220
1931	220	220	220	231	247	309	281	243	177	126	130	130
1932	130	130	130	304	455	538	403	353	239	250	250	250
1933	250	250	250	304	405	369	403	353	239	250	250	250
1934	250	250	250	306	374	309	319	266	191	220	220	220
1935	220	220	220	304	472	561	429	370	249	325	325	325
1936	325	2,219	516	620	1,681	1,510	942	844	709	325	325	325
1937	325	325	464	504	971	1,025	804	718	582	325	325	1,243
1938	325	1,145	1,768	2,429	2,998	2,265	1,147	1,045	903	325	325	325
1939	325	325	325	306	374	309	319	266	191	220	220	220
1940	220	220	1,150	525	1,466	1,162	756	658	523	325	325	325
1941	514	896	663	504	1,209	1,533	994	902	766	325	325	469
1942	1,379	1,054	325	425	2,037	2,051	1,099	1,000	863	325	556	445
1943	1,541	1,027	1,866	752	1,718	1,294	889	790	653	325	325	325
1944	325	325	325	304	405	369	403	353	239	250	250	250
1945	250	1,318	250	504	945	1,049	875	792	656	325	514	1,093
1946	623	325	325	404	704	1,008	693	601	465	325	325	325
1947	325	325	325	304	405	369	403	353	239	250	250	250
1948	250	250	250	304	488	584	455	386	259	325	325	325
1949	325	325	325	304	455	538	403	353	239	250	250	250
1950	250	250	250	441	1,040	1,147	926	838	696	325	3,378	4,149
1951	1,322	1,111	425	525	839	894	579	490	356	325	325	672

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1952	1,413	1,309	1,128	3,100	3,192	1,930	1,395	1,291	1,147	325	325	325
1953	325	1,084	325	304	691	795	671	588	452	325	325	325
1954	325	325	325	304	455	538	403	353	239	250	250	250
1955	250	250	250	304	405	369	403	353	239	250	250	2,507
1956	3,058	1,022	295	533	2,090	1,892	1,126	1,026	887	325	325	325
1957	325	325	325	304	524	628	504	421	285	325	325	325
1958	325	983	1,024	1,918	2,652	1,950	1,218	1,117	978	325	325	325
1959	325	325	325	306	374	309	319	266	191	220	220	220
1960	220	220	220	306	374	309	319	266	191	220	220	220
1961	220	220	220	231	247	309	319	266	186	126	130	130
1962	130	130	130	304	455	538	403	353	239	220	220	220
1963	220	486	220	404	1,456	1,417	1,001	909	773	325	642	325
1964	325	325	325	304	405	369	403	353	239	250	250	3,149
1965	2,289	880	250	475	1,451	1,556	1,151	1,052	916	325	577	325
1966	325	325	325	304	405	369	403	353	239	220	220	220
1967	220	262	923	1,209	3,243	1,808	1,403	1,303	1,165	325	325	325
1968	325	325	325	304	405	369	403	353	239	250	250	250
1969	2,072	1,659	840	2,400	3,495	1,853	1,326	1,223	1,078	325	325	346
1970	3,449	1,091	531	525	721	826	604	522	387	325	620	783
1971	702	637	550	504	867	871	747	664	528	325	336	372
1972	325	325	325	354	455	538	403	353	239	250	250	250
1973	250	1,143	631	504	895	1,000	779	693	557	325	1,338	890
1974	1,376	325	884	715	1,372	1,477	1,071	973	838	325	325	325
1975	325	325	325	404	1,147	1,252	1,127	1,045	909	325	332	325
1976	325	325	325	231	247	309	281	243	177	220	220	220
1977	220	220	220	231	247	309	281	243	177	126	130	130
1978	130	130	130	231	247	309	281	243	177	126	130	130
1979	130	130	130	229	278	369	403	353	234	163	130	130
1980	130	811	549	525	1,404	1,559	1,154	1,055	921	325	442	325
1981	489	587	325	304	405	369	403	353	239	250	268	1,811
1982	1,577	3,163	1,899	3,750	2,917	1,701	1,298	1,192	1,044	325	1,241	1,592
1983	1,275	2,261	3,338	1,713	4,457	3,617	2,123	2,018	1,869	325	2,315	2,715
1984	1,524	1,014	398	525	940	1,095	823	741	607	325	536	325

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	325	325	325	304	405	369	403	353	239	250	250	250
1986	292	5,878	2,880	563	1,752	1,410	1,005	902	760	325	325	325
1987	325	325	325	231	247	309	319	266	186	220	220	220
1988	220	220	220	231	247	309	281	243	177	126	130	130
1989	130	130	130	304	455	538	403	353	239	220	220	220
1990	220	220	220	306	374	309	319	266	191	220	220	220
1991	220	220	220	306	374	309	319	266	191	126	130	130
1992	130	130	130	306	374	309	319	266	191	126	130	130
1993	130	130	130	325	1011	1166	895	812	678	325	325	325
1994	325	325	325	231	247	309	319	266	186	220	220	220
1995	220	220	2,806	2,654	4,569	2,266	1,759	1,654	1,508	325	325	325
1996	325	2,096	1,124	532	1,939	1,270	865	765	626	325	558	2,356
1997	5,590	2,224	472	532	703	809	588	504	366	325	425	325
1998	572	2,211	1,357	1,789	2,876	1,969	1,565	1,462	1,319	325	325	325
1999	476	1,935	732	504	1,136	1,190	969	883	747	325	325	325
2000	325	970	695	504	777	731	607	524	388	325	325	325
2001	325	325	325	306	374	309	319	266	191	250	250	250
2002	250	250	250	304	455	538	403	353	239	250	250	250
2003	250	250	250	304	556	661	536	454	318	325	325	325
2004	325	325	336	304	405	369	403	353	239	220	220	220
2005	220	220	1,271	783	2,071	1,595	1,075	975	839	325	325	1,398
2006	2,003	1,201	1,326	4,047	3,119	1,837	1,021	917	773	325	325	325
2007	325	325	325	306	374	309	319	266	191	250	250	250
2008	250	250	250	306	374	309	319	266	191	220	220	220
2009	220	220	220	304	455	538	403	353	239	250	250	687
Min.	130	130	130	229	247	309	281	243	177	126	130	130
Max.	5,590	5,878	3,338	4,047	4,569	3,617	2,123	2,018	1,869	325	3,378	4,149
Mean	605	673	555	619	1,037	921	675	603	486	274	376	512
Median	325	325	325	306	524	661	504	421	285	325	325	325

Table 4.5-5. Estimated Flow at Elliott [cfs], Cumulative Effects Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	2,448	767	684	494	1,123	1,892	825	727	606	312	315	318
1922	332	340	325	407	2,312	2,514	969	866	750	312	315	378
1923	498	456	325	385	753	954	725	635	512	312	315	318
1924	332	340	325	210	235	291	265	225	162	208	213	207
1925	228	236	223	284	601	701	572	487	360	312	315	318
1926	332	340	325	286	362	291	302	247	176	238	242	239
1927	258	265	252	508	1,330	1,739	916	812	696	312	392	318
1928	332	340	755	486	451	679	395	339	231	312	315	318
1929	332	340	325	286	362	291	302	247	176	208	213	207
1930	228	236	223	284	393	351	385	332	224	208	213	207
1931	228	236	223	210	235	291	265	225	162	115	124	113
1932	138	147	136	284	443	521	385	332	224	238	242	239
1933	258	265	252	284	393	351	385	332	224	238	242	239
1934	258	265	252	286	362	291	302	247	176	208	213	207
1935	228	236	223	284	460	544	411	349	234	312	315	318
1936	332	2,215	511	604	1,667	1,494	915	812	695	312	315	318
1937	332	340	461	486	958	1,009	779	689	568	312	315	1,282
1938	332	1,152	1,730	2,434	2,983	2,250	1,117	1,009	889	312	315	318
1939	332	340	325	286	362	291	302	247	176	208	213	207
1940	228	236	1,129	508	1,453	1,146	732	630	508	312	315	318
1941	521	905	654	486	1,196	1,517	966	869	752	312	315	469
1942	1,381	1,062	325	407	2,023	2,036	1,070	965	849	312	542	444
1943	1,543	1,035	1,825	737	1,704	1,278	863	760	639	312	315	318
1944	332	340	325	284	393	351	385	332	224	238	242	239
1945	258	1,323	252	486	932	1,033	849	762	642	312	500	1,124
1946	629	340	325	385	691	991	670	575	450	312	315	318
1947	332	340	325	284	393	351	385	332	224	238	242	239
1948	258	265	252	284	476	567	436	364	244	312	315	318
1949	332	340	325	284	443	521	385	332	224	238	242	239
1950	258	265	252	423	1,027	1,131	899	806	682	312	3,304	4,333
1951	1,325	1,118	423	508	826	877	558	466	341	312	315	682

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1952	1,415	1,314	1,107	3,112	3,177	1,915	1,361	1,250	1,134	312	315	318
1953	332	1,091	325	284	678	778	649	562	437	312	315	318
1954	332	340	325	284	443	521	385	332	224	238	242	239
1955	258	265	252	284	393	351	385	332	224	238	242	2,609
1956	3,052	1,030	296	516	2,076	1,877	1,096	990	873	312	315	318
1957	332	340	325	284	512	611	484	399	270	312	315	318
1958	332	991	1,006	1,917	2,637	1,935	1,187	1,079	965	312	315	318
1959	332	340	325	286	362	291	302	247	176	208	213	207
1960	228	236	223	286	362	291	302	247	176	208	213	207
1961	228	236	223	210	235	291	302	247	171	115	124	113
1962	138	147	136	284	443	521	385	332	224	208	213	207
1963	228	499	223	385	1,443	1,401	973	876	759	312	626	318
1964	332	340	325	284	393	351	385	332	224	238	242	3,283
1965	2,287	889	252	457	1,438	1,540	1,121	1,016	902	312	562	318
1966	332	340	325	284	393	351	385	332	224	208	213	207
1967	228	277	908	1,200	3,228	1,793	1,369	1,261	1,152	312	315	318
1968	332	340	325	284	393	351	385	332	224	238	242	239
1969	2,071	1,661	827	2,404	3,479	1,838	1,293	1,183	1,065	312	315	340
1970	3,441	1,098	526	508	708	809	583	497	372	312	604	799
1971	708	649	544	486	854	854	723	636	513	312	326	367
1972	332	340	325	335	443	521	385	332	224	238	242	239
1973	258	1,150	623	486	882	983	755	665	543	312	1,307	911
1974	1,378	340	870	700	1,359	1,461	1,042	939	824	312	315	318
1975	332	340	325	385	1,134	1,236	1,097	1,009	895	312	322	318
1976	332	340	325	210	235	291	265	225	162	208	213	207
1977	228	236	223	210	235	291	265	225	162	115	124	113
1978	138	147	136	210	235	291	265	225	162	115	124	113
1979	138	147	136	208	266	351	385	332	219	152	124	113
1980	138	821	543	508	1,391	1,543	1,124	1,019	907	312	430	318
1981	496	599	325	284	393	351	385	332	224	238	260	1,878
1982	1,578	3,150	1,858	3,770	2,902	1,686	1,265	1,153	1,031	312	1,212	1,648
1983	1,278	2,257	3,258	1,709	4,440	3,605	2,077	1,961	1,858	312	2,264	2,827
1984	1,526	1,022	396	508	927	1,079	798	712	593	312	522	318

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	332	340	325	284	393	351	385	332	224	238	242	239
1986	300	5,839	2,813	546	1,738	1,394	977	869	746	312	315	318
1987	332	340	325	210	235	291	302	247	171	208	213	207
1988	228	236	223	210	235	291	265	225	162	115	124	113
1989	138	147	136	284	443	521	385	332	224	208	213	207
1990	228	236	223	286	362	291	302	247	176	208	213	207
1991	228	236	223	286	362	291	302	247	176	115	124	113
1992	138	147	136	286	362	291	302	247	176	115	124	113
1993	138	147	136	305	998	1,150	869	781	664	312	315	318
1994	332	340	325	210	235	291	302	247	171	208	213	207
1995	228	236	2,741	2,661	4,552	2,251	1,719	1,605	1,496	312	315	318
1996	332	2,093	1,103	515	1,925	1,254	839	735	612	312	543	2,450
1997	5,572	2,220	469	515	690	792	567	480	351	312	413	318
1998	578	2,207	1,330	1,786	2,861	1,954	1,528	1,417	1,306	312	315	318
1999	483	1,934	722	486	1,123	1,174	942	851	733	312	315	318
2000	332	978	686	486	764	714	586	499	373	312	315	318
2001	332	340	325	286	362	291	302	247	176	238	242	239
2002	258	265	252	284	443	521	385	332	224	238	242	239
2003	258	265	252	284	544	644	516	431	303	312	315	318
2004	332	340	336	284	393	351	385	332	224	208	213	207
2005	228	236	1,246	769	2,057	1,579	1,046	941	825	312	315	1,444
2006	2,002	1,207	1,300	4,070	3,104	1,822	993	884	759	312	315	318
2007	332	340	325	286	362	291	302	247	176	238	242	239
2008	258	265	252	286	362	291	302	247	176	208	213	207
2009	228	236	223	284	443	521	385	332	224	238	242	698
Min.	138	147	136	208	235	291	265	225	162	115	124	113
Max.	5,572	5,839	3,258	4,070	4,552	3,605	2,077	1,961	1,858	312	3,304	4,333
Mean	611	684	549	603	1,024	905	652	577	472	262	365	514
Median	332	340	325	286	512	644	484	399	270	312	315	318

Table 4.5-6. Simulated Flow Below Woodbridge Irrigation Dam [cfs], Cumulative Effects Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	2,379	692	601	350	818	1,484	381	363	361	182	263	248
1922	258	266	239	271	2,015	2,113	536	512	512	187	268	311
1923	424	383	239	250	455	555	288	277	275	187	268	254
1924	258	268	240	75	23	31	18	15	15	139	163	149
1925	153	161	134	150	303	303	132	124	123	187	268	254
1926	258	266	240	150	150	31	29	22	20	169	193	179
1927	183	191	164	371	1,033	1,339	481	458	458	187	346	254
1928	258	268	680	350	208	358	40	29	28	207	268	254
1929	258	266	240	150	150	31	29	22	20	139	163	149
1930	153	161	134	150	150	31	29	22	20	102	163	149
1931	153	161	135	75	23	31	18	15	15	45	73	59
1932	63	73	44	150	200	200	29	22	20	132	193	179
1933	183	191	164	150	150	31	29	22	20	132	193	179
1934	183	191	165	150	150	31	29	22	20	139	163	149
1935	153	161	134	150	200	200	29	22	20	201	268	254
1936	255	2,160	427	462	1,367	1,091	477	453	453	185	266	251
1937	258	266	378	350	660	610	342	331	330	187	268	1,172
1938	217	1,048	1,637	2,227	2,636	1,796	631	607	607	155	233	212
1939	258	266	240	150	150	31	29	22	20	139	163	149
1940	153	163	1,065	371	1,156	746	295	271	271	187	268	254
1941	447	837	578	350	899	1,118	532	515	513	187	268	398
1942	1,299	983	225	255	1,710	1,619	620	597	597	177	488	360
1943	1,461	956	1,766	582	1,391	862	411	387	387	177	257	241
1944	258	268	239	150	150	31	29	22	20	132	193	179
1945	183	1,258	164	350	634	634	413	405	404	187	457	1,021
1946	556	266	239	250	393	593	232	214	213	187	268	254
1947	258	266	239	150	150	31	29	22	20	132	193	179
1948	183	193	164	150	200	200	29	22	20	195	268	254
1949	258	266	239	150	200	200	29	22	20	132	193	179
1950	152	163	130	250	691	691	424	412	411	163	3,294	4,046
1951	1,256	1,052	339	371	529	479	118	104	104	187	268	600

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1952	1,288	1,202	980	2,879	2,811	1,440	858	834	834	143	220	196
1953	258	1,025	239	150	380	380	209	202	200	187	268	254
1954	258	266	239	150	200	200	29	22	20	132	193	179
1955	183	191	164	150	150	31	29	22	20	132	193	2,435
1956	2,967	944	182	350	1,748	1,444	632	609	609	168	247	229
1957	258	266	239	150	213	213	42	35	33	187	268	254
1958	232	900	909	1,733	2,309	1,500	722	698	698	167	246	228
1959	258	266	240	150	150	31	29	22	20	139	163	149
1960	153	163	135	150	150	31	29	22	20	139	163	149
1961	153	161	135	75	23	31	29	22	15	45	73	59
1962	63	71	44	150	200	200	29	22	20	102	163	149
1963	153	427	134	250	1,145	1,002	540	523	521	187	586	254
1964	258	268	239	150	150	31	29	22	20	132	193	3,078
1965	2,212	811	152	308	1,127	1,127	676	652	652	179	511	243
1966	258	266	239	150	150	31	29	22	20	102	163	149
1967	131	183	813	1,030	2,906	1,365	913	890	890	170	250	232
1968	258	268	239	150	150	31	29	22	20	132	193	179
1969	1,947	1,548	692	2,179	3,113	1,363	789	765	765	143	220	217
1970	3,379	1,029	441	367	405	405	138	130	130	184	560	708
1971	636	578	464	350	556	456	285	278	276	187	279	301
1972	258	268	239	200	200	200	29	22	20	132	193	179
1973	183	1,084	545	350	585	585	317	306	305	187	1,281	819
1974	1,308	265	797	559	1,060	1,060	609	585	585	186	267	253
1975	258	266	239	250	837	837	666	658	657	187	275	254
1976	258	268	240	75	23	31	18	15	15	139	163	149
1977	153	161	135	75	23	31	18	15	15	45	73	59
1978	63	71	45	75	23	31	18	15	15	45	73	59
1979	63	71	44	75	23	31	29	22	15	45	73	59
1980	63	754	463	371	1,094	1,144	693	669	669	187	385	254
1981	423	528	239	150	150	31	29	22	20	132	211	1,740
1982	1,428	3,030	1,724	3,500	2,506	1,179	728	704	704	124	1,115	1,439
1983	1,126	2,128	3,163	1,463	4,045	3,095	1,554	1,530	1,530	124	2,190	2,562
1984	1,457	957	312	371	630	680	362	355	355	187	479	254

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	258	266	239	150	150	31	29	22	20	132	193	179
1986	174	5,774	2,739	350	1,379	929	478	454	454	148	226	203
1987	258	266	240	75	23	31	29	22	15	139	163	149
1988	153	163	135	75	23	31	18	15	15	45	73	59
1989	63	71	44	150	200	200	29	22	20	102	163	149
1990	153	161	135	150	150	31	29	22	20	139	163	149
1991	153	161	135	150	150	31	29	22	20	45	73	59
1992	63	73	45	150	150	31	29	22	20	45	73	59
1993	63	71	44	171	701	751	433	426	426	187	268	254
1994	258	266	240	75	23	31	29	22	15	139	163	149
1995	80	95	2,641	2,415	4,169	1,757	1,202	1,178	1,178	131	207	181
1996	235	2,019	1,013	350	1,600	824	373	349	349	169	482	2,261
1997	5,500	2,143	360	350	363	363	96	88	88	169	348	230
1998	455	2,107	1,217	1,576	2,504	1,489	1,038	1,014	1,014	148	226	204
1999	409	1,876	647	350	825	775	508	497	495	187	268	254
2000	258	911	610	350	466	316	145	137	136	187	268	254
2001	258	266	240	150	150	31	29	22	20	169	193	179
2002	183	191	164	150	200	200	29	22	20	132	193	179
2003	183	191	164	150	245	245	75	67	65	187	268	254
2004	258	268	250	150	150	31	29	22	20	102	163	149
2005	143	152	1,174	618	1,748	1,167	600	576	576	179	260	1,317
2006	1,876	1,088	1,175	3,823	2,735	1,344	481	457	457	141	218	194
2007	258	266	240	150	150	31	29	22	20	169	193	179
2008	183	193	165	150	150	31	29	22	20	139	163	149
2009	153	161	134	150	200	200	29	22	20	132	193	616
Min.	63	71	44	75	23	31	18	15	15	45	73	59
Max.	5,500	5,774	3,163	3,823	4,169	3,095	1,554	1,530	1,530	207	3,294	4,046
Mean	530	607	460	454	750	547	266	254	253	148	312	433
Median	258	266	239	150	213	245	42	35	33	148	220	228

Table 4.5-7. Estimated Flow at Frandy [cfs], Cumulative Effects Case

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	2,364	677	571	320	788	1,454	351	333	331	167	248	233
1922	243	251	209	241	1,985	2,083	506	482	482	172	253	296
1923	409	368	209	220	425	525	258	247	245	172	253	239
1924	243	253	210	45	1	1	1	1	1	124	148	134
1925	138	146	104	120	273	273	102	94	93	172	253	239
1926	243	251	210	120	120	1	1	1	1	154	178	164
1927	168	176	134	341	1,003	1,309	451	428	428	172	331	239
1928	243	253	650	320	178	328	10	1	1	192	253	239
1929	243	251	210	120	120	1	1	1	1	124	148	134
1930	138	146	104	120	120	1	1	1	1	87	148	134
1931	138	146	105	45	1	1	1	1	1	30	58	44
1932	48	58	14	120	170	170	1	1	1	117	178	164
1933	168	176	134	120	120	1	1	1	1	117	178	164
1934	168	176	135	120	120	1	1	1	1	124	148	134
1935	138	146	104	120	170	170	1	1	1	186	253	239
1936	240	2,145	397	432	1,337	1,061	447	423	423	170	251	236
1937	243	251	348	320	630	580	312	301	300	172	253	1,157
1938	202	1,033	1,607	2,197	2,606	1,766	601	577	577	140	218	197
1939	243	251	210	120	120	1	1	1	1	124	148	134
1940	138	148	1,035	341	1,126	716	265	241	241	172	253	239
1941	432	822	548	320	869	1,088	502	485	483	172	253	383
1942	1,284	968	195	225	1,680	1,589	590	567	567	162	473	345
1943	1,446	941	1,736	552	1,361	832	381	357	357	162	242	226
1944	243	253	209	120	120	1	1	1	1	117	178	164
1945	168	1,243	134	320	604	604	383	375	374	172	442	1,006
1946	541	251	209	220	363	563	202	184	183	172	253	239
1947	243	251	209	120	120	1	1	1	1	117	178	164
1948	168	178	134	120	170	170	1	1	1	180	253	239
1949	243	251	209	120	170	170	1	1	1	117	178	164
1950	137	148	100	220	661	661	394	382	381	148	3,279	4,031
1951	1,241	1,037	309	341	499	449	88	74	74	172	253	585

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1952	1,273	1,187	950	2,849	2,781	1,410	828	804	804	128	205	181
1953	243	1,010	209	120	350	350	179	172	170	172	253	239
1954	243	251	209	120	170	170	1	1	1	117	178	164
1955	168	176	134	120	120	1	1	1	1	117	178	2,420
1956	2,952	929	152	320	1,718	1,414	602	579	579	153	232	214
1957	243	251	209	120	183	183	12	5	3	172	253	239
1958	217	885	879	1,703	2,279	1,470	692	668	668	152	231	213
1959	243	251	210	120	120	1	1	1	1	124	148	134
1960	138	148	105	120	120	1	1	1	1	124	148	134
1961	138	146	105	45	1	1	1	1	1	30	58	44
1962	48	56	14	120	170	170	1	1	1	87	148	134
1963	138	412	104	220	1,115	972	510	493	491	172	571	239
1964	243	253	209	120	120	1	1	1	1	117	178	3,063
1965	2,197	796	122	278	1,097	1,097	646	622	622	164	496	228
1966	243	251	209	120	120	1	1	1	1	87	148	134
1967	116	168	783	1,000	2,876	1,335	883	860	860	155	235	217
1968	243	253	209	120	120	1	1	1	1	117	178	164
1969	1,932	1,533	662	2,149	3,083	1,333	759	735	735	128	205	202
1970	3,364	1,014	411	337	375	375	108	100	100	169	545	693
1971	621	563	434	320	526	426	255	248	246	172	264	286
1972	243	253	209	170	170	170	1	1	1	117	178	164
1973	168	1,069	515	320	555	555	287	276	275	172	1,266	804
1974	1,293	250	767	529	1,030	1,030	579	555	555	171	252	238
1975	243	251	209	220	807	807	636	628	627	172	260	239
1976	243	253	210	45	1	1	1	1	1	124	148	134
1977	138	146	105	45	1	1	1	1	1	30	58	44
1978	48	56	15	45	1	1	1	1	1	30	58	44
1979	48	56	14	45	1	1	1	1	1	30	58	44
1980	48	739	433	341	1,064	1,114	663	639	639	172	370	239
1981	408	513	209	120	120	1	1	1	1	117	196	1,725
1982	1,413	3,015	1,694	3,470	2,476	1,149	698	674	674	109	1,100	1,424
1983	1,111	2,113	3,133	1,433	4,015	3,065	1,524	1,500	1,500	109	2,175	2,547
1984	1,442	942	282	341	600	650	332	325	325	172	464	239

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	243	251	209	120	120	1	1	1	1	117	178	164
1986	159	5,759	2,709	320	1,349	899	448	424	424	133	211	188
1987	243	251	210	45	1	1	1	1	1	124	148	134
1988	138	148	105	45	1	1	1	1	1	30	58	44
1989	48	56	14	120	170	170	1	1	1	87	148	134
1990	138	146	105	120	120	1	1	1	1	124	148	134
1991	138	146	105	120	120	1	1	1	1	30	58	44
1992	48	58	15	120	120	1	1	1	1	30	58	44
1993	48	56	14	141	671	721	403	396	396	172	253	239
1994	243	251	210	45	1	1	1	1	1	124	148	134
1995	65	80	2,611	2,385	4,139	1,727	1,172	1,148	1,148	116	192	166
1996	220	2,004	983	320	1,570	794	343	319	319	154	467	2,246
1997	5,485	2,128	330	320	333	333	66	58	58	154	333	215
1998	440	2,092	1,187	1,546	2,474	1,459	1,008	984	984	133	211	189
1999	394	1,861	617	320	795	745	478	467	465	172	253	239
2000	243	896	580	320	436	286	115	107	106	172	253	239
2001	243	251	210	120	120	1	1	1	1	154	178	164
2002	168	176	134	120	170	170	1	1	1	117	178	164
2003	168	176	134	120	215	215	45	37	35	172	253	239
2004	243	253	220	120	120	1	1	1	1	87	148	134
2005	128	137	1,144	588	1,718	1,137	570	546	546	164	245	1,302
2006	1,861	1,073	1,145	3,793	2,705	1,314	451	427	427	126	203	179
2007	243	251	210	120	120	1	1	1	1	154	178	164
2008	168	178	135	120	120	1	1	1	1	124	148	134
2009	138	146	104	120	170	170	1	1	1	117	178	601
Min.	48	56	14	45	1	1	1	1	1	30	58	44
Max.	5,485	5,759	3,133	3,793	4,139	3,065	1,524	1,500	1,500	192	3,279	4,031
Mean	515	592	430	424	721	517	238	229	229	133	297	418
Median	243	251	209	120	183	215	12	5	3	133	205	213

Table 4.5-6 presents the flow below Woodbridge at station Golf for the cumulative effects case. The flow at station Frandy is estimated from the simulated flow below Woodbridge at station Golf (see Table 4.5-6) using Equation 2 and is reported in Table 4.5-7.

Table 4.5-8 presents the total water delivered by the Mokelumne system and Freeport supplemental supplies, the percentage of demand rationed, WSMP 2040 supplemental supply to reduce rationing to 15%, and total supply delivered along with corresponding savings in water in any year rationing is required.

Simulated CY total annual diversions from the Mokelumne for the cumulative effects case are presented in Table 4.5-9. JVID diversions totaling 3.4 TAF is accounted for under the upstream diversions where the supply to JVID is assumed to be delivered via the Amador Canal in 2040; thus diversions under the JVID column of Table 4.5-9 are zero indicating that there are no direct diversions to JVID from Pardee assumed in 2040. Simulated diversions to NSJWCD of 20 TAF occur in 47 of 89 years (53%). In two of those years (1935 and 1948), less than the full 20 TAF entitlement is allocated to NSJWCD due to a small volume of surplus available because of the use of the Freeport supplemental supply triggered in the cumulative effects case that is not triggered in the baseline case. WID Diversions are determined by the quantity of regulated inflow to Pardee.

The JSA year type summary for the two classification periods, October through March and April through September, are presented in Table 4.5-10 for the cumulative effects case. A total of 121 of 178 periods (68%) were Above Normal/Normal or Below Normal year types, a reduction of 5 periods total relative to the baseline case. In the April to September period, 10 Critically Dry years are simulated in the cumulative effects case. In the October to March period, 8 Critically Dry years are simulated, an increase of 2 periods (1961-62, 1988-89).

Table 4.5-8. Calendar Year Water Supply Deliveries, Customer Cutbacks, and Undelivered Supply, Cumulative Effects Case^a

Year	Customer Cutback	Additional Deficiency ^b	Total Deficiency	WSMP 2040 Supplemental Supply ^c [MGD]	Freeport Supplemental Supply [MGD]	Bayside Phase I Supplemental Supply [MGD]	Mokelumne Supply [MGD]	Total Supply Delivered [MGD]
1921	0.0%	0.0%	0.0%	0	0	0	230	230
1922	0.0%	0.0%	0.0%	0	0	0	230	230
1923	0.0%	0.0%	0.0%	0	0	0	230	230
1924	3.9%	0.0%	3.9%	34	59	1	161	221
1925	0.0%	0.0%	0.0%	0	0	0	230	230
1926	0.0%	0.0%	0.0%	0	67	1	162	230
1927	0.0%	0.0%	0.0%	0	0	0	230	230
1928	0.0%	0.0%	0.0%	0	0	0	230	230
1929	0.4%	0.0%	0.4%	8	54	1	174	229
1930	0.3%	0.0%	0.3%	14	84	1	144	229
1931	13.7%	0.0%	13.7%	34	10	1	188	198
1932	0.0%	0.0%	0.0%	0	0	0	230	230
1933	0.1%	0.0%	0.1%	14	60	1	169	230
1934	6.5%	0.0%	6.5%	26	84	1	133	215
1935	0.0%	0.0%	0.0%	0	3	0	225	230
1936	0.0%	0.0%	0.0%	0	0	0	230	230
1937	0.0%	0.0%	0.0%	0	0	0	230	230
1938	0.0%	0.0%	0.0%	0	0	0	230	230
1939	0.3%	0.0%	0.3%	6	83	1	145	229
1940	0.0%	0.0%	0.0%	0	0	0	230	230
1941	0.0%	0.0%	0.0%	0	0	0	230	230
1942	0.0%	0.0%	0.0%	0	0	0	230	230
1943	0.0%	0.0%	0.0%	0	0	0	230	230
1944	0.0%	0.0%	0.0%	0	83	1	146	230
1945	0.0%	0.0%	0.0%	0	0	0	230	230
1946	0.0%	0.0%	0.0%	0	0	0	230	230
1947	0.0%	0.0%	0.0%	0	84	1	145	230
1948	0.0%	0.0%	0.0%	0	6	0	224	230
1949	0.0%	0.0%	0.0%	0	0	0	230	230

Year	Customer Cutback	Additional Deficiency ^b	Total Deficiency	WSMP 2040 Supplemental Supply ^c [MGD]	Freeport Supplemental Supply [MGD]	Bayside Phase I Supplemental Supply [MGD]	Mokelumne Supply [MGD]	Total Supply Delivered [MGD]
1950	0.0%	0.0%	0.0%	0	0	0	230	230
1951	0.0%	0.0%	0.0%	0	0	0	230	230
1952	0.0%	0.0%	0.0%	0	0	0	230	230
1953	0.0%	0.0%	0.0%	0	0	0	230	230
1954	0.0%	0.0%	0.0%	0	0	0	230	230
1955	0.0%	0.0%	0.0%	0	75	1	154	230
1956	0.0%	0.0%	0.0%	0	0	0	230	230
1957	0.0%	0.0%	0.0%	0	0	0	230	230
1958	0.0%	0.0%	0.0%	0	0	0	230	230
1959	0.0%	0.0%	0.0%	0	84	1	145	230
1960	0.0%	0.0%	0.0%	0	63	1	166	230
1961	6.0%	0.0%	6.0%	34	0	1	215	216
1962	2.5%	0.0%	2.5%	0	0	0	224	224
1963	0.0%	0.0%	0.0%	0	0	0	230	230
1964	0.0%	0.0%	0.0%	0	75	1	154	230
1965	0.0%	0.0%	0.0%	0	0	0	230	230
1966	0.0%	0.0%	0.0%	0	0	0	230	230
1967	0.0%	0.0%	0.0%	0	0	0	230	230
1968	0.0%	0.0%	0.0%	0	84	1	145	230
1969	0.0%	0.0%	0.0%	0	0	0	230	230
1970	0.0%	0.0%	0.0%	0	0	0	230	230
1971	0.0%	0.0%	0.0%	0	0	0	230	230
1972	0.0%	0.0%	0.0%	0	0	0	230	230
1973	0.0%	0.0%	0.0%	0	0	0	230	230
1974	0.0%	0.0%	0.0%	0	0	0	230	230
1975	0.0%	0.0%	0.0%	0	0	0	230	230
1976	3.5%	0.0%	3.5%	34	66	1	155	222
1977	15.0%	0.0%	15.0%	34	63	1	122	196
1978	15.0%	36.6%	51.6%	34	18	1	8	111
1979	15.0%	0.0%	15.0%	0	0	0	196	196
1980	0.0%	0.0%	0.0%	0	0	0.2	191	230

Year	Customer Cutback	Additional Deficiency ^b	Total Deficiency	WSMP 2040 Supplemental Supply ^c [MGD]	Freeport Supplemental Supply [MGD]	Bayside Phase I Supplemental Supply [MGD]	Mokelumne Supply [MGD]	Total Supply Delivered [MGD]
1981	1.2%	26.3%	27.5%	0	0	1	114	167
1982	2.0%	4.0%	6.0%	0	0	0.3	216	216
1983	0.0%	0.0%	0.0%	0	0	0	230	230
1984	0.0%	0.0%	0.0%	0	0	0	230	230
1985	0.0%	0.0%	0.0%	0	84	1	145	230
1986	0.0%	0.0%	0.0%	0	0	0	230	230
1987	2.3%	0.0%	2.3%	34	66	1	142	225
1988	13.3%	0.0%	13.3%	34	63	1	133	199
1989	10.9%	0.0%	10.9%	34	18	1	204	205
1990	11.5%	0.0%	11.5%	34	59	1	143	204
1991	14.9%	0.0%	14.9%	34	66	1	118	196
1992	15.0%	0.0%	15.0%	34	22	1	184	195
1993	0.0%	0.0%	0.0%	0	0	0	230	230
1994	1.8%	0.0%	1.8%	0	84	1	141	226
1995	0.0%	0.0%	0.0%	0	13	0	217	230
1996	0.0%	0.0%	0.0%	0	0	0	230	230
1997	0.0%	0.0%	0.0%	0	0	0	230	230
1998	0.0%	0.0%	0.0%	0	0	0	230	230
1999	0.0%	0.0%	0.0%	0	0	0	230	230
2000	0.0%	0.0%	0.0%	0	0	0	230	230
2001	0.0%	0.0%	0.0%	0	83	1	146	230
2002	0.0%	0.0%	0.0%	0	64	1	165	230
2003	0.0%	0.0%	0.0%	0	0	0	230	230
2004	0.0%	0.0%	0.0%	0	0	1	229	230
2005	0.0%	0.0%	0.0%	0	0	0	230	230
2006	0.0%	0.0%	0.0%	0	0	0	230	230
2007	0.0%	0.0%	0.0%	0	84	1	145	230
2008	1.0%	0.0%	1.0%	30	63	1	163	228
2009	0.0%	0.0%	0.0%	0	0	0	230	230

^a The sum of supplemental supplies and the Mokelumne supply do not necessarily equate to the total supply delivered due to Terminal Reservoir storage regulation.

^b Additional deficiency of 26.3% in 1981 and 4.0% in 1982 is due to a limitation on the Mokelumne water supply resulting from the simulated aqueduct outage scenario as described in Section 3.1.1.3.

Year	Customer Cutback	Additional Deficiency ^b	Total Deficiency	WSMP 2040 Supplemental Supply ^c [MGD]	Freeport Supplemental Supply [MGD]	Bayside Phase I Supplemental Supply [MGD]	Mokelumne Supply [MGD]	Total Supply Delivered [MGD]
^c	WSMP 2040 supplemental supply that is external to the Mokelumne River intended to limit District wide rationing to 15%.							

Table 4.5-9. Calendar Year Total Annual Diversions, [TAF], Cumulative Effects Case

Year	Upstream	JVID ^a	NSJWCD	WID	EBMUD ^b	Year	Upstream	JVID ^a	NSJWCD	WID	EBMUD ^b
1921	47	0	20	60	258	1966	47	0	0	60	258
1922	47	0	20	60	258	1967	47	0	20	60	258
1923	47	0	20	60	258	1968	47	0	0	60	163
1924	47	0	0	39	144	1969	47	0	20	60	258
1925	47	0	20	60	258	1970	47	0	20	60	258
1926	47	0	0	39	181	1971	47	0	20	60	258
1927	47	0	20	60	258	1972	47	0	0	60	258
1928	47	0	0	60	258	1973	47	0	20	60	258
1929	47	0	0	39	187	1974	47	0	20	60	258
1930	47	0	0	60	147	1975	47	0	20	60	258
1931	47	0	0	39	193	1976	47	0	0	39	138
1932	47	0	0	60	258	1977	47	0	0	39	109
1933	47	0	0	60	174	1978	46	0	0	39	155
1934	47	0	0	39	141	1979	47	0	0	60	219
1935	47	0	6	60	243	1980	47	0	20	60	258
1936	47	0	20	60	258	1981	47	0	0	60	185
1937	47	0	20	60	258	1982	47	0	20	60	242
1938	47	0	20	60	258	1983	47	0	20	60	258
1939	47	0	0	39	157	1984	47	0	20	60	258
1940	47	0	20	60	258	1985	47	0	0	60	163
1941	47	0	20	60	258	1986	47	0	20	60	258
1942	47	0	20	60	258	1987	47	0	0	39	140
1943	47	0	20	60	258	1988	47	0	0	39	117
1944	47	0	0	60	164	1989	47	0	0	60	190
1945	47	0	20	60	258	1990	47	0	0	39	133
1946	47	0	20	60	258	1991	47	0	0	39	113
1947	47	0	0	60	163	1992	47	0	0	39	163
1948	47	0	12	60	252	1993	47	0	20	60	258
1949	47	0	0	60	258	1994	47	0	0	39	158
1950	47	0	20	60	258	1995	47	0	20	60	243
1951	47	0	20	60	258	1996	47	0	20	60	258
1952	47	0	20	60	258	1997	47	0	20	60	258
1953	47	0	20	60	258	1998	47	0	20	60	258
1954	47	0	0	60	258	1999	47	0	20	60	258
1955	47	0	0	60	172	2000	47	0	20	60	258
1956	47	0	20	60	258	2001	47	0	0	39	163
1957	47	0	20	60	258	2002	47	0	0	60	185
1958	47	0	20	60	258	2003	47	0	20	60	258
1959	47	0	0	39	163	2004	47	0	0	60	257
1960	47	0	0	39	186	2005	47	0	20	60	258
1961	47	0	0	39	205	2006	47	0	20	60	258
1962	47	0	0	60	253	2007	47	0	0	39	163
1963	47	0	20	60	258	2008	47	0	0	39	151
1964	47	0	0	60	173	2009	47	0	0	60	258

Year	Upstream JVID ^a	NSJWCD	WID	EBMUD ^b	Year	Upstream JVID ^a	NSJWCD	WID	EBMUD ^b
1965	47	0	20	60	258				

^a From 2020 through 2040, annual diversions for JVID of 3.85 TAF are assumed to be provided via the Amador Canal. Therefore, JVID diversions are included in the 47 TAF listed under the “Upstream” column.

^b EBMUD Diversions reflect only the quantity diverted from the Mokelumne to meet customer demand and/or to refill terminal reservoir storage and do not include supplemental supply deliveries from sources external to the Mokelumne System.

Table 4.5-10. JSA Year Type Classifications Summary, Cumulative Effects Case

Class	April-September	October-March	Total
Above Normal/Normal	28	48	76
Below Normal	28	17	45
Dry	23	16	39
Critically Dry	10	8	22
Total	89	89	178

Chapter 5

Reservoir Water Quality Model Results

This chapter presents the water quality results, specifically the water temperature modeling results. The calibrated SSTEMP model application of the lower Mokelumne River (presented in Section 3.3) in concert with the Camanche Reservoir release temperature regression model in Section 3.4 were used to generate the water quality modeling results presented herein. The water quantity modeling presented in Chapter 4 provide the requisite input data for the water quality modeling evaluation. The following subsections include model results for each of the modeling cases listed in Section 2.2.

5.1 Case 1: Baseline

Water quantity modeling results from the District's reservoir operations planning model EBMUDSIM presented in Section 4.1 for the Baseline condition provided the necessary inputs for the water quality modeling assessment.

Camanche Reservoir release temperature is assigned as the monthly mean from the summary statistics from Table 3.3-10. For each month from March to October of each year simulated that Camanche WSE is below 190 ft msl, the mean is adjusted following the technical procedure documented in Section 3.4.5 as illustrated in the flow chart in Figure 3.1-4. Camanche Release temperature, flow at Stations McIntire, Elliott, Golf, and Frandy for each month over the 89 year hydrologic period (1921-2009) is input to SSTEMP to generate a set of monthly average water temperature results for each downstream station of the lower Mokelumne River (*i.e.* Elliott, Golf, and Frandy). Monthly average water temperature at each station is run through the set of regression models presented in Section 3.3.5 to estimate the MM7DADM for each station. Table 5.1-1 presents simulated monthly mean and corresponding MM7DADM water temperatures for each month of the POR for stations McIntire, Elliott, Golf, and Frandy for the baseline case.

Table 5.1-1. Simulated Monthly Average and Estimated Monthly Maximum of 7-Day Average of Daily Maximum (7DADM) Water Temperature [°C], Baseline Case

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1921	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.5
1921	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1921	Mar	10.6	10.7	12.0	10.9	12.3	11.2	12.3
1921	Apr	11.3	11.7	13.4	13.6	15.2	14.1	16.6
1921	May	12.1	12.5	14.2	14.2	16.0	14.6	16.3
1921	Jun	13.1	13.6	15.5	15.1	17.2	15.4	16.8
1921	Jul	14.1	14.8	16.8	17.6	19.4	18.4	20.8
1921	Aug	14.7	15.4	17.2	17.8	19.7	18.5	21.4
1921	Sep	15.1	15.5	16.8	17.1	19.1	17.5	19.9
1921	Oct	15.2	15.0	17.2	15.5	17.9	15.9	19.7
1921	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1921	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1922	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1922	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1922	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1922	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1922	May	12.1	12.3	13.9	12.9	15.2	13.1	14.3
1922	Jun	13.1	13.5	15.5	14.2	16.8	14.4	15.3
1922	Jul	14.1	14.7	16.7	16.2	18.2	16.9	18.8
1922	Aug	14.7	15.3	17.1	16.6	18.6	17.2	19.6
1922	Sep	15.1	15.4	16.7	16.2	18.2	16.6	18.5
1922	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
1922	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1922	Dec	12.5	12.0	14.0	11.4	13.4	11.2	13.3
1923	Jan	10.3	10.0	11.1	9.8	11.4	9.7	11.1
1923	Feb	9.9	9.9	11.0	10.1	11.1	10.2	11.4
1923	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1923	Apr	11.3	11.8	13.5	13.1	14.9	13.8	16.2
1923	May	12.1	12.6	14.3	13.9	15.8	14.4	16.1
1923	Jun	13.1	13.8	15.8	15.3	17.4	16.0	17.8
1923	Jul	14.1	14.8	16.8	16.8	18.6	17.7	19.9
1923	Aug	14.7	15.4	17.2	17.0	19.0	17.9	20.5
1923	Sep	15.1	15.5	16.8	16.5	18.4	17.0	19.2
1923	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1923	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1923	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1924	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1924	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1924	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1924	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1924	May	12.1	13.4	15.4	17.6	18.1	21.1	25.1

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1924	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1924	Jul	14.1	15.8	17.5	21.2	22.8	24.9	29.7
1924	Aug	14.7	16.2	17.9	20.8	22.4	24.0	29.0
1924	Sep	15.2	16.1	17.6	18.7	20.8	21.6	26.9
1924	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1924	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1924	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1925	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1925	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1925	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1925	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1925	May	12.1	12.7	14.4	14.2	16.0	14.9	16.8
1925	Jun	13.1	13.9	15.9	15.7	17.6	16.5	18.6
1925	Jul	14.1	14.9	16.9	17.2	19.0	18.4	20.9
1925	Aug	14.7	15.5	17.3	17.4	19.3	18.5	21.4
1925	Sep	15.1	15.5	16.9	16.7	18.7	17.4	19.8
1925	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1925	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1925	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1926	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1926	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1926	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1926	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1926	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1926	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1926	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1926	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1926	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1926	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1926	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1926	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1927	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1927	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1927	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1927	Apr	11.3	11.7	13.4	12.7	14.7	13.1	15.2
1927	May	12.1	12.5	14.1	13.3	15.5	13.7	15.1
1927	Jun	13.1	13.6	15.6	14.5	16.9	14.9	16.0
1927	Jul	14.1	14.7	16.8	16.3	18.2	17.1	19.0
1927	Aug	14.7	15.3	17.2	16.7	18.7	17.3	19.8
1927	Sep	15.1	15.4	16.8	16.3	18.2	16.7	18.6
1927	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1927	Nov	14.9	14.4	15.8	14.0	15.8	13.9	16.0
1927	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1928	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1928	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1928	Mar	10.6	10.7	12.0	10.9	12.2	11.1	12.2
1928	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1928	May	12.1	12.9	14.7	14.9	16.5	16.1	18.3
1928	Jun	13.1	14.0	16.0	15.9	17.7	16.8	19.0
1928	Jul	14.1	15.2	17.1	19.1	20.8	22.9	26.9
1928	Aug	14.7	15.7	17.5	19.3	21.0	23.0	27.6
1928	Sep	15.1	15.8	17.2	17.9	19.9	20.7	25.5
1928	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1928	Nov	14.9	14.4	15.7	14.0	15.8	13.8	16.0
1928	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1929	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1929	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1929	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1929	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1929	May	12.1	13.1	15.0	15.6	16.9	17.0	19.5
1929	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1929	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1929	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
1929	Sep	15.1	16.0	17.5	18.5	20.6	21.5	26.9
1929	Oct	15.2	15.0	17.1	15.4	17.6	15.7	19.4
1929	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1929	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1930	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1930	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1930	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1930	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1930	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1930	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1930	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1930	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1930	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1930	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1930	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1930	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1931	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1931	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1931	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1931	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1931	May	12.1	13.4	15.4	17.6	18.1	21.1	25.1
1931	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1931	Jul	14.1	15.8	17.5	21.2	22.8	24.9	29.7

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1931	Aug	14.8	16.2	17.9	20.8	22.4	24.0	29.0
1931	Sep	15.5	16.4	18.0	18.8	20.9	21.6	26.9
1931	Oct	15.9	15.3	17.4	15.8	18.2	16.6	20.9
1931	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1931	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1932	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1932	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1932	Mar	10.6	11.0	12.8	11.9	13.4	13.6	16.3
1932	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1932	May	12.1	12.9	14.7	15.1	16.6	16.3	18.6
1932	Jun	13.1	14.1	16.2	16.6	18.1	18.0	21.0
1932	Jul	14.1	15.3	17.2	19.8	21.5	24.8	29.6
1932	Aug	14.7	15.8	17.6	19.9	21.5	24.0	29.0
1932	Sep	15.1	15.8	17.3	18.2	20.3	21.5	26.9
1932	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1932	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1932	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1933	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1933	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1933	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1933	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1933	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1933	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1933	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1933	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1933	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1933	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1933	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1933	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1934	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1934	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1934	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1934	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1934	May	12.1	13.1	15.0	15.6	16.9	17.0	19.5
1934	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1934	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1934	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
1934	Sep	15.1	16.0	17.5	18.5	20.6	21.5	26.9
1934	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1934	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1934	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1935	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1935	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1935	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1935	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1935	May	12.1	12.7	14.4	14.1	16.0	14.8	16.6
1935	Jun	13.1	13.9	15.9	15.6	17.5	16.4	18.4
1935	Jul	14.1	14.9	16.9	17.1	18.9	18.2	20.6
1935	Aug	14.7	15.5	17.3	17.3	19.2	18.3	21.1
1935	Sep	15.1	15.5	16.9	16.7	18.6	17.3	19.6
1935	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1935	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1935	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1936	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1936	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1936	Mar	10.6	10.7	12.1	11.0	12.4	11.3	12.5
1936	Apr	11.3	11.7	13.3	12.6	14.6	13.0	15.0
1936	May	12.1	12.4	14.0	13.2	15.3	13.5	14.8
1936	Jun	13.1	13.6	15.6	14.7	17.0	15.1	16.3
1936	Jul	14.1	14.7	16.8	16.3	18.2	17.1	19.0
1936	Aug	14.7	15.3	17.2	16.7	18.7	17.4	19.8
1936	Sep	15.1	15.4	16.8	16.3	18.2	16.7	18.6
1936	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
1936	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1936	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1937	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1937	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1937	Mar	10.6	10.7	12.0	10.9	12.3	11.2	12.3
1937	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1937	May	12.1	12.6	14.3	13.7	15.7	14.2	15.8
1937	Jun	13.1	13.7	15.7	15.0	17.2	15.6	17.1
1937	Jul	14.1	14.8	16.8	16.7	18.6	17.6	19.7
1937	Aug	14.7	15.4	17.2	17.0	18.9	17.8	20.4
1937	Sep	15.1	15.5	16.8	16.5	18.4	17.0	19.0
1937	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1937	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1937	Dec	12.5	12.3	14.3	12.1	14.0	12.0	14.0
1938	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1938	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1938	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9
1938	Apr	11.3	11.5	13.1	11.8	14.2	12.0	13.4
1938	May	12.1	12.3	13.9	12.8	15.1	13.0	14.1
1938	Jun	13.1	13.5	15.5	14.3	16.8	14.6	15.5
1938	Jul	14.1	14.7	16.7	16.1	18.0	16.7	18.5
1938	Aug	14.7	15.2	17.1	16.4	18.4	17.0	19.3
1938	Sep	15.1	15.4	16.7	16.1	18.0	16.5	18.2

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1938	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1938	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1938	Dec	12.5	11.8	13.8	11.0	13.0	10.7	12.8
1939	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1939	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1939	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1939	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1939	May	12.1	13.1	15.0	15.6	16.9	17.0	19.5
1939	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1939	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1939	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
1939	Sep	15.1	16.0	17.5	18.5	20.6	21.5	26.9
1939	Oct	15.2	15.0	17.1	15.4	17.6	15.7	19.4
1939	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1939	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1940	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1940	Feb	9.9	9.9	11.0	10.1	11.1	10.3	11.4
1940	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9
1940	Apr	11.3	11.7	13.4	12.8	14.8	13.3	15.4
1940	May	12.1	12.4	14.1	13.3	15.4	13.6	15.0
1940	Jun	13.1	13.7	15.7	15.0	17.2	15.5	17.1
1940	Jul	14.1	14.8	16.8	16.8	18.7	17.7	20.0
1940	Aug	14.7	15.4	17.2	17.1	19.0	18.0	20.6
1940	Sep	15.1	15.5	16.8	16.5	18.5	17.1	19.2
1940	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1940	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1940	Dec	12.5	11.9	13.9	11.2	13.2	11.0	13.1
1941	Jan	10.3	10.0	11.1	9.8	11.4	9.8	11.2
1941	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1941	Mar	10.6	10.7	12.0	10.9	12.3	11.2	12.3
1941	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1941	May	12.1	12.5	14.2	13.5	15.5	13.8	15.3
1941	Jun	13.1	13.6	15.6	14.6	17.0	15.0	16.2
1941	Jul	14.1	14.7	16.7	16.2	18.2	16.9	18.8
1941	Aug	14.7	15.3	17.1	16.6	18.6	17.2	19.6
1941	Sep	15.1	15.4	16.7	16.2	18.1	16.6	18.5
1941	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1941	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1941	Dec	12.5	12.1	14.0	11.6	13.5	11.4	13.4
1942	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1942	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1942	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1942	Apr	11.3	11.8	13.5	13.1	14.9	13.8	16.1

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1942	May	12.1	12.4	14.0	13.0	15.3	13.3	14.6
1942	Jun	13.1	13.6	15.5	14.4	16.9	14.7	15.8
1942	Jul	14.1	14.7	16.7	16.1	18.0	16.7	18.5
1942	Aug	14.7	15.2	17.1	16.4	18.4	17.0	19.3
1942	Sep	15.1	15.4	16.7	16.1	18.0	16.5	18.2
1942	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1942	Nov	14.9	14.5	15.8	14.1	15.9	14.1	16.1
1942	Dec	12.5	12.0	14.0	11.5	13.4	11.2	13.3
1943	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1943	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1943	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.8
1943	Apr	11.3	11.6	13.3	12.4	14.5	12.8	14.7
1943	May	12.1	12.4	14.0	13.1	15.3	13.5	14.8
1943	Jun	13.1	13.7	15.7	14.8	17.1	15.3	16.7
1943	Jul	14.1	14.8	16.8	16.5	18.4	17.3	19.4
1943	Aug	14.7	15.3	17.2	16.8	18.8	17.5	20.0
1943	Sep	15.1	15.5	16.8	16.3	18.3	16.8	18.8
1943	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1943	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1943	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1944	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1944	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1944	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1944	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1944	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1944	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1944	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1944	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1944	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1944	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1944	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1944	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1945	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1945	Feb	9.9	9.9	11.0	10.1	11.1	10.2	11.3
1945	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1945	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1945	May	12.1	12.6	14.2	13.7	15.7	14.1	15.7
1945	Jun	13.1	13.8	15.8	15.1	17.3	15.7	17.3
1945	Jul	14.1	14.8	16.8	16.5	18.4	17.3	19.3
1945	Aug	14.7	15.3	17.2	16.8	18.7	17.5	19.9
1945	Sep	15.1	15.5	16.8	16.3	18.2	16.8	18.7
1945	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1945	Nov	14.9	14.5	15.8	14.1	15.8	14.0	16.0

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1945	Dec	12.5	12.3	14.3	12.0	13.9	11.9	13.9
1946	Jan	10.3	10.1	11.1	9.8	11.4	9.8	11.2
1946	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1946	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1946	Apr	11.3	11.8	13.5	13.0	14.9	13.6	15.9
1946	May	12.1	12.7	14.4	14.0	15.9	14.6	16.4
1946	Jun	13.1	13.8	15.8	15.2	17.3	15.8	17.4
1946	Jul	14.1	14.9	16.9	17.0	18.9	18.1	20.4
1946	Aug	14.7	15.4	17.3	17.3	19.2	18.2	21.0
1946	Sep	15.1	15.5	16.9	16.6	18.6	17.2	19.5
1946	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1946	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1946	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1947	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1947	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1947	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1947	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1947	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1947	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1947	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1947	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1947	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1947	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1947	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1947	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1948	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1948	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1948	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1948	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1948	May	12.1	13.0	14.8	15.1	16.6	16.3	18.7
1948	Jun	13.1	14.2	16.3	16.8	18.2	18.2	21.2
1948	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1948	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1948	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1948	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1948	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1948	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1949	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1949	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1949	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1949	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1949	May	12.1	13.0	14.8	15.1	16.6	16.2	18.5
1949	Jun	13.1	14.2	16.2	16.7	18.2	18.1	21.0

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1949	Jul	14.1	15.4	17.2	19.8	21.4	23.9	28.3
1949	Aug	14.7	15.8	17.6	19.7	21.4	23.9	28.9
1949	Sep	15.1	15.9	17.3	18.1	20.2	21.4	26.7
1949	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.3
1949	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1949	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1950	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1950	Feb	9.9	9.9	11.0	10.1	11.1	10.2	11.3
1950	Mar	10.6	10.7	12.2	11.2	12.6	11.7	13.1
1950	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1950	May	12.1	12.5	14.2	13.5	15.6	13.9	15.4
1950	Jun	13.1	13.7	15.7	14.9	17.2	15.4	16.8
1950	Jul	14.1	14.7	16.8	16.4	18.3	17.1	19.1
1950	Aug	14.7	15.3	17.2	16.7	18.7	17.3	19.8
1950	Sep	15.1	15.4	16.8	16.3	18.2	16.7	18.6
1950	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1950	Nov	14.9	14.8	16.0	14.8	16.1	14.8	16.4
1950	Dec	12.5	12.4	14.4	12.4	14.2	12.4	14.3
1951	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1951	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1951	Mar	10.6	10.7	12.1	11.1	12.4	11.4	12.7
1951	Apr	11.3	11.7	13.4	12.8	14.8	13.3	15.4
1951	May	12.1	12.6	14.3	13.8	15.8	14.4	16.0
1951	Jun	13.1	13.8	15.8	15.3	17.4	16.0	17.8
1951	Jul	14.1	15.0	17.0	17.6	19.4	19.2	21.9
1951	Aug	14.7	15.6	17.4	17.9	19.7	19.2	22.4
1951	Sep	15.1	15.6	17.0	17.0	19.0	17.9	20.6
1951	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1951	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1951	Dec	12.5	12.2	14.2	11.8	13.7	11.6	13.7
1952	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1952	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1952	Mar	10.6	10.6	11.9	10.9	12.2	11.0	12.0
1952	Apr	11.3	11.4	13.1	11.8	14.2	11.9	13.3
1952	May	12.1	12.3	13.9	12.8	15.1	13.0	14.1
1952	Jun	13.1	13.6	15.5	14.4	16.9	14.8	15.9
1952	Jul	14.1	14.6	16.6	15.7	17.7	16.2	17.9
1952	Aug	14.7	15.2	17.0	16.2	18.2	16.6	18.7
1952	Sep	15.1	15.4	16.7	16.0	17.9	16.3	17.9
1952	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.6
1952	Nov	14.9	14.3	15.7	13.7	15.6	13.5	15.8
1952	Dec	12.5	11.8	13.8	11.0	13.0	10.7	12.8
1953	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1953	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1953	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1953	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1953	May	12.1	12.7	14.4	14.1	15.9	14.8	16.6
1953	Jun	13.1	13.9	15.9	15.6	17.5	16.3	18.3
1953	Jul	14.1	14.9	16.9	17.0	18.9	18.2	20.5
1953	Aug	14.7	15.4	17.3	17.3	19.2	18.2	21.0
1953	Sep	15.1	15.5	16.9	16.6	18.6	17.2	19.5
1953	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1953	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1953	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1954	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1954	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1954	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1954	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1954	May	12.1	12.9	14.8	15.1	16.6	16.2	18.5
1954	Jun	13.1	14.2	16.2	16.7	18.1	18.1	21.0
1954	Jul	14.1	15.4	17.2	19.8	21.4	23.9	28.3
1954	Aug	14.7	15.8	17.6	19.7	21.4	23.9	28.9
1954	Sep	15.1	15.8	17.3	18.1	20.2	21.4	26.7
1954	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.3
1954	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1954	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1955	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1955	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1955	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1955	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1955	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1955	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1955	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1955	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1955	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1955	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1955	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1955	Dec	12.5	12.4	14.4	12.2	14.1	12.2	14.1
1956	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.5
1956	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1956	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1956	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1956	May	12.1	12.4	14.0	13.0	15.2	13.3	14.5
1956	Jun	13.1	13.6	15.5	14.4	16.9	14.8	15.9
1956	Jul	14.1	14.7	16.7	16.1	18.0	16.7	18.5
1956	Aug	14.7	15.2	17.1	16.4	18.4	17.0	19.3

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1956	Sep	15.1	15.4	16.7	16.1	18.0	16.5	18.2
1956	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1956	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1956	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1957	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1957	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1957	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1957	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1957	May	12.1	12.8	14.5	14.5	16.2	15.3	17.2
1957	Jun	13.1	14.0	16.0	16.0	17.7	16.9	19.2
1957	Jul	14.1	15.0	17.0	17.7	19.5	19.4	22.2
1957	Aug	14.7	15.6	17.4	17.9	19.7	19.3	22.5
1957	Sep	15.1	15.6	17.0	17.0	19.0	17.9	20.7
1957	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1957	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1957	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1958	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1958	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1958	Mar	10.6	10.6	12.0	10.9	12.2	11.1	12.1
1958	Apr	11.3	11.5	13.1	11.9	14.3	12.1	13.6
1958	May	12.1	12.3	13.9	12.9	15.2	13.1	14.3
1958	Jun	13.1	13.6	15.5	14.4	16.9	14.7	15.8
1958	Jul	14.1	14.6	16.7	15.9	17.9	16.5	18.3
1958	Aug	14.7	15.2	17.1	16.3	18.3	16.8	19.0
1958	Sep	15.1	15.4	16.7	16.1	18.0	16.4	18.1
1958	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1958	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1958	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1959	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1959	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1959	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1959	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1959	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1959	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1959	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1959	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1959	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1959	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1959	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1959	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1960	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1960	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1960	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1960	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1960	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1960	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1960	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1960	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1960	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1960	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1960	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1960	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1961	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1961	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1961	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1961	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1961	May	12.1	13.4	15.4	17.6	18.1	21.1	25.1
1961	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1961	Jul	14.5	16.0	17.7	20.7	22.3	24.9	29.6
1961	Aug	15.8	17.0	18.5	20.7	22.3	24.0	29.0
1961	Sep	16.6	17.2	19.1	19.0	21.2	21.6	26.9
1961	Oct	16.3	15.8	17.9	15.9	18.4	16.3	20.3
1961	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1961	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1962	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1962	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1962	Mar	11.7	11.8	14.6	12.1	13.6	12.7	14.8
1962	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1962	May	12.1	13.0	14.8	15.1	16.6	16.3	18.7
1962	Jun	13.1	14.2	16.3	16.8	18.2	18.2	21.2
1962	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1962	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1962	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1962	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1962	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1962	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1963	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1963	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1963	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1963	Apr	11.3	11.8	13.5	13.1	14.9	13.8	16.2
1963	May	12.1	12.4	14.1	13.3	15.4	13.6	15.0
1963	Jun	13.1	13.7	15.6	14.7	17.1	15.2	16.5
1963	Jul	14.1	14.7	16.7	16.2	18.1	16.9	18.8
1963	Aug	14.7	15.3	17.1	16.6	18.6	17.1	19.5
1963	Sep	15.1	15.4	16.7	16.2	18.1	16.6	18.4
1963	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1963	Nov	14.9	14.6	15.8	14.2	15.9	14.1	16.1
1963	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1964	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1964	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1964	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1964	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1964	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1964	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1964	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1964	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1964	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1964	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1964	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1964	Dec	12.5	12.4	14.4	12.4	14.2	12.3	14.3
1965	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.5
1965	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1965	Mar	10.6	10.8	12.3	11.4	12.8	12.1	13.8
1965	Apr	11.3	11.8	13.5	13.0	14.8	13.6	15.8
1965	May	12.1	12.4	14.1	13.3	15.4	13.6	15.0
1965	Jun	13.1	13.6	15.6	14.6	17.0	15.0	16.2
1965	Jul	14.1	14.6	16.7	16.0	17.9	16.6	18.4
1965	Aug	14.7	15.2	17.1	16.4	18.4	16.9	19.1
1965	Sep	15.1	15.4	16.7	16.1	18.0	16.4	18.2
1965	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
1965	Nov	14.9	14.5	15.8	14.2	15.9	14.1	16.1
1965	Dec	12.5	11.9	13.8	11.1	13.1	10.8	12.9
1966	Jan	10.3	9.9	11.0	9.6	11.4	9.5	11.0
1966	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1966	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1966	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1966	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1966	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1966	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1966	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1966	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1966	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1966	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1966	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1967	Jan	10.3	10.0	11.1	9.8	11.4	9.7	11.1
1967	Feb	9.9	9.9	11.0	10.1	11.1	10.2	11.3
1967	Mar	10.6	10.7	12.0	10.9	12.2	11.1	12.2
1967	Apr	11.3	11.5	13.2	12.2	14.4	12.4	14.1
1967	May	12.1	12.3	13.9	12.8	15.1	13.0	14.1

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1967	Jun	13.1	13.6	15.6	14.5	16.9	14.9	16.0
1967	Jul	14.1	14.6	16.6	15.7	17.7	16.2	17.9
1967	Aug	14.7	15.2	17.0	16.2	18.2	16.6	18.7
1967	Sep	15.1	15.4	16.7	16.0	17.9	16.3	17.9
1967	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1967	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1967	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1968	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1968	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1968	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1968	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1968	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1968	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1968	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1968	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1968	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1968	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1968	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1968	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1969	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1969	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1969	Mar	10.6	10.7	12.0	10.9	12.2	11.1	12.2
1969	Apr	11.3	11.5	13.1	11.8	14.2	12.0	13.4
1969	May	12.1	12.3	13.8	12.7	15.1	12.9	14.0
1969	Jun	13.1	13.6	15.6	14.4	16.9	14.8	15.9
1969	Jul	14.1	14.6	16.7	15.8	17.8	16.4	18.1
1969	Aug	14.7	15.2	17.1	16.2	18.2	16.7	18.9
1969	Sep	15.1	15.4	16.7	16.0	17.9	16.4	18.0
1969	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.6
1969	Nov	14.9	14.3	15.7	13.7	15.6	13.5	15.8
1969	Dec	12.5	12.0	13.9	11.3	13.3	11.1	13.2
1970	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.5
1970	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1970	Mar	10.6	10.7	12.1	11.0	12.4	11.3	12.5
1970	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1970	May	12.1	12.7	14.4	14.1	15.9	14.7	16.5
1970	Jun	13.1	13.9	15.9	15.6	17.5	16.3	18.3
1970	Jul	14.1	15.0	16.9	17.4	19.2	18.8	21.4
1970	Aug	14.7	15.5	17.3	17.6	19.5	18.8	21.8
1970	Sep	15.1	15.6	16.9	16.8	18.8	17.6	20.2
1970	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
1970	Nov	14.9	14.5	15.8	14.2	15.9	14.1	16.1
1970	Dec	12.5	12.2	14.2	11.9	13.8	11.8	13.8

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1971	Jan	10.3	10.1	11.1	9.9	11.5	9.8	11.2
1971	Feb	9.9	9.9	11.0	10.1	11.1	10.2	11.3
1971	Mar	10.6	10.7	12.1	11.0	12.3	11.2	12.4
1971	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1971	May	12.1	12.6	14.3	13.8	15.8	14.4	16.0
1971	Jun	13.1	13.8	15.9	15.4	17.4	16.1	18.0
1971	Jul	14.1	14.8	16.8	16.8	18.7	17.8	20.0
1971	Aug	14.7	15.4	17.2	17.1	19.0	17.9	20.5
1971	Sep	15.1	15.5	16.8	16.5	18.4	17.0	19.2
1971	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1971	Nov	14.9	14.4	15.7	13.8	15.7	13.7	15.9
1971	Dec	12.5	11.9	13.9	11.3	13.3	11.1	13.2
1972	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1972	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1972	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1972	Apr	11.3	11.8	13.5	13.1	14.9	13.8	16.2
1972	May	12.1	13.0	14.8	15.1	16.6	16.3	18.7
1972	Jun	13.1	14.2	16.3	16.8	18.2	18.2	21.2
1972	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1972	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1972	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1972	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1972	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1972	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1973	Jan	10.3	10.1	11.1	9.9	11.5	9.8	11.2
1973	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1973	Mar	10.6	10.7	12.0	10.9	12.3	11.2	12.3
1973	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1973	May	12.1	12.6	14.3	13.8	15.8	14.4	16.0
1973	Jun	13.1	13.8	15.8	15.1	17.3	15.7	17.3
1973	Jul	14.1	14.8	16.8	16.7	18.6	17.7	19.9
1973	Aug	14.7	15.4	17.2	17.0	19.0	17.9	20.5
1973	Sep	15.1	15.5	16.8	16.5	18.4	17.0	19.2
1973	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1973	Nov	14.9	14.7	15.9	14.5	16.0	14.5	16.2
1973	Dec	12.5	12.2	14.2	11.9	13.8	11.8	13.8
1974	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1974	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1974	Mar	10.6	10.7	12.0	10.9	12.2	11.1	12.2
1974	Apr	11.3	11.6	13.3	12.5	14.6	12.8	14.7
1974	May	12.1	12.5	14.1	13.3	15.5	13.7	15.1
1974	Jun	13.1	13.6	15.6	14.7	17.0	15.1	16.4
1974	Jul	14.1	14.7	16.7	16.1	18.0	16.7	18.6

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1974	Aug	14.7	15.3	17.1	16.5	18.5	17.0	19.4
1974	Sep	15.1	15.4	16.7	16.1	18.1	16.5	18.3
1974	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
1974	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1974	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1975	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1975	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1975	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1975	Apr	11.3	11.8	13.5	13.0	14.9	13.6	15.9
1975	May	12.1	12.5	14.1	13.4	15.5	13.8	15.3
1975	Jun	13.1	13.7	15.7	14.9	17.1	15.4	16.8
1975	Jul	14.1	14.6	16.7	16.0	17.9	16.6	18.4
1975	Aug	14.7	15.2	17.1	16.4	18.4	16.9	19.1
1975	Sep	15.1	15.4	16.7	16.1	18.0	16.4	18.1
1975	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1975	Nov	14.9	14.3	15.7	13.8	15.7	13.7	15.9
1975	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1976	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1976	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1976	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1976	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1976	May	12.1	13.4	15.4	17.6	18.1	21.1	25.1
1976	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1976	Jul	14.1	15.8	17.5	21.2	22.8	24.9	29.7
1976	Aug	14.7	16.2	17.9	20.8	22.4	24.0	29.0
1976	Sep	15.1	16.1	17.6	18.7	20.8	21.6	26.9
1976	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1976	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1976	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1977	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1977	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1977	Mar	12.2	12.2	15.6	12.4	14.0	12.9	15.2
1977	Apr	13.5	13.8	16.0	15.0	16.0	16.2	19.8
1977	May	14.5	15.4	18.2	18.3	18.6	21.1	25.1
1977	Jun	16.0	17.1	19.5	20.4	20.2	23.5	29.6
1977	Jul	17.4	18.6	19.6	22.2	23.7	24.9	29.7
1977	Aug	18.5	19.2	20.3	21.7	23.2	24.0	29.0
1977	Sep	18.9	19.0	21.4	19.5	21.7	21.6	27.0
1977	Oct	19.0	17.5	19.4	16.7	19.4	17.1	21.6
1977	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1977	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1978	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1978	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1978	Mar	17.8	16.2	24.8	14.6	16.6	14.8	18.3
1978	Apr	19.7	18.8	22.2	17.6	17.4	17.8	22.1
1978	May	20.5	20.2	24.9	20.0	19.7	21.2	25.2
1978	Jun	21.6	21.6	24.6	22.2	21.2	23.6	29.7
1978	Jul	22.5	22.7	22.7	23.5	24.9	24.9	29.7
1978	Aug	23.2	22.9	23.4	22.8	24.2	24.0	29.0
1978	Sep	23.6	22.4	25.9	20.4	22.7	21.6	27.0
1978	Oct	23.7	20.8	22.3	17.9	21.1	17.7	22.6
1978	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1978	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1979	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1979	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1979	Mar	19.1	17.0	26.8	15.0	17.0	14.9	18.6
1979	Apr	19.7	18.8	22.2	17.6	17.4	17.8	22.1
1979	May	18.1	18.3	22.2	19.4	19.3	21.1	25.2
1979	Jun	17.1	17.8	20.4	20.6	20.3	23.5	29.6
1979	Jul	17.6	18.5	19.6	21.5	23.1	24.9	29.6
1979	Aug	17.8	18.5	19.8	21.2	22.7	24.0	29.0
1979	Sep	17.4	17.7	19.8	19.1	21.2	21.6	27.0
1979	Oct	16.7	16.1	18.1	16.1	18.6	16.8	21.1
1979	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1979	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1980	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1980	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1980	Mar	10.6	10.7	12.1	11.0	12.3	11.2	12.4
1980	Apr	11.3	11.7	13.4	12.8	14.8	13.3	15.4
1980	May	12.1	12.5	14.1	13.3	15.4	13.6	15.0
1980	Jun	13.1	13.6	15.6	14.6	17.0	15.0	16.2
1980	Jul	14.1	14.6	16.7	16.0	17.9	16.6	18.4
1980	Aug	14.7	15.2	17.1	16.4	18.4	16.9	19.1
1980	Sep	15.1	15.4	16.7	16.1	18.0	16.4	18.2
1980	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1980	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1980	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1981	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1981	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1981	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1981	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1981	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1981	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1981	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1981	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1981	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1981	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1981	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1981	Dec	12.5	12.3	14.3	12.1	14.0	12.0	14.0
1982	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1982	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1982	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9
1982	Apr	11.3	11.4	13.0	11.7	14.2	11.8	13.2
1982	May	12.1	12.3	13.9	12.8	15.1	13.0	14.1
1982	Jun	13.1	13.6	15.5	14.4	16.9	14.8	15.9
1982	Jul	14.1	14.6	16.6	15.7	17.6	16.2	17.9
1982	Aug	14.7	15.2	17.0	16.1	18.2	16.6	18.7
1982	Sep	15.1	15.4	16.6	15.9	17.8	16.2	17.8
1982	Oct	15.2	15.0	17.2	15.4	17.7	15.9	19.6
1982	Nov	14.9	14.7	15.9	14.5	16.0	14.5	16.2
1982	Dec	12.5	12.4	14.3	12.1	14.0	12.1	14.1
1983	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1983	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1983	Mar	10.6	10.6	11.9	10.7	12.0	10.8	11.7
1983	Apr	11.3	11.5	13.1	11.9	14.3	12.1	13.6
1983	May	12.1	12.2	13.8	12.6	15.0	12.8	13.9
1983	Jun	13.1	13.4	15.4	14.0	16.6	14.2	15.0
1983	Jul	14.1	14.4	16.5	15.3	17.3	15.6	17.1
1983	Aug	14.7	15.1	17.0	15.8	17.8	16.1	18.0
1983	Sep	15.1	15.3	16.6	15.7	17.6	15.9	17.3
1983	Oct	15.2	15.0	17.2	15.4	17.7	15.9	19.6
1983	Nov	14.9	14.8	16.0	14.7	16.1	14.6	16.3
1983	Dec	12.5	12.4	14.4	12.3	14.1	12.2	14.2
1984	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1984	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1984	Mar	10.6	10.7	12.1	11.1	12.5	11.4	12.7
1984	Apr	11.3	11.7	13.4	12.8	14.8	13.3	15.4
1984	May	12.1	12.6	14.3	13.7	15.7	14.2	15.8
1984	Jun	13.1	13.8	15.8	15.1	17.3	15.7	17.3
1984	Jul	14.1	14.8	16.8	16.5	18.4	17.4	19.5
1984	Aug	14.7	15.4	17.2	16.8	18.8	17.6	20.1
1984	Sep	15.1	15.5	16.8	16.4	18.3	16.8	18.8
1984	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1984	Nov	14.9	14.5	15.8	14.1	15.9	14.1	16.1
1984	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1985	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1985	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1985	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1985	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1985	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1985	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1985	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1985	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1985	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1985	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1985	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1985	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1986	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1986	Feb	9.9	9.9	11.0	10.0	11.0	10.0	11.2
1986	Mar	10.6	10.6	11.9	10.7	12.1	10.8	11.7
1986	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1986	May	12.1	12.4	14.0	13.1	15.3	13.4	14.7
1986	Jun	13.1	13.7	15.6	14.8	17.1	15.2	16.6
1986	Jul	14.1	14.7	16.7	16.3	18.2	17.0	19.0
1986	Aug	14.7	15.3	17.1	16.6	18.6	17.2	19.6
1986	Sep	15.1	15.4	16.7	16.3	18.2	16.7	18.6
1986	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1986	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1986	Dec	12.5	11.8	13.8	11.0	13.0	10.7	12.8
1987	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1987	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1987	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1987	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1987	May	12.1	13.4	15.4	17.6	18.1	21.1	25.1
1987	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1987	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1987	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
1987	Sep	15.1	16.0	17.5	18.6	20.8	21.6	26.9
1987	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1987	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1987	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1988	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1988	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1988	Mar	10.9	11.1	13.0	11.6	13.1	12.3	14.2
1988	Apr	12.0	12.5	14.4	14.3	15.6	15.8	19.1
1988	May	12.7	14.0	16.2	17.8	18.3	21.1	25.1
1988	Jun	13.9	15.3	17.5	19.6	19.8	23.5	29.6
1988	Jul	14.9	16.4	18.0	21.4	23.0	24.9	29.7
1988	Aug	15.5	16.8	18.4	21.0	22.6	24.0	29.0
1988	Sep	15.7	16.5	18.1	18.8	21.0	21.6	26.9
1988	Oct	15.7	15.4	17.5	15.6	18.0	16.0	19.9
1988	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1988	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1989	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1989	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1989	Mar	13.4	13.2	17.9	13.1	14.8	13.5	16.2
1989	Apr	13.2	13.6	15.7	14.6	15.8	15.4	18.5
1989	May	12.7	13.5	15.6	15.5	16.9	16.6	19.1
1989	Jun	13.5	14.5	16.6	17.0	18.3	18.4	21.5
1989	Jul	14.4	15.7	17.5	20.3	21.9	24.9	29.6
1989	Aug	15.0	16.1	17.8	20.1	21.8	24.0	29.0
1989	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1989	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1989	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1989	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1990	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1990	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1990	Mar	11.3	11.5	13.9	11.9	13.4	12.5	14.5
1990	Apr	12.4	12.8	14.8	14.1	15.5	15.0	17.9
1990	May	13.1	14.0	16.3	16.2	17.3	17.5	20.2
1990	Jun	14.1	15.4	17.7	19.7	19.8	23.5	29.6
1990	Jul	14.9	16.4	18.0	20.9	22.4	24.9	29.6
1990	Aug	15.4	16.7	18.3	20.6	22.2	24.0	29.0
1990	Sep	15.5	16.3	17.9	18.6	20.7	21.5	26.9
1990	Oct	15.4	15.1	17.2	15.5	17.8	15.9	19.7
1990	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1990	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1991	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1991	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1991	Mar	12.8	12.7	16.7	12.7	14.4	13.2	15.6
1991	Apr	14.3	14.5	16.9	15.2	16.1	15.9	19.3
1991	May	14.7	15.4	18.2	17.1	17.8	18.1	21.1
1991	Jun	15.3	16.5	18.9	20.1	20.1	23.5	29.6
1991	Jul	15.9	17.2	18.6	21.2	22.8	24.9	29.6
1991	Aug	16.1	17.2	18.7	20.8	22.4	24.0	29.0
1991	Sep	15.9	16.6	18.2	18.7	20.8	21.5	26.9
1991	Oct	15.3	14.9	17.1	15.6	18.0	16.5	20.7
1991	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1991	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1992	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1992	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1992	Mar	11.3	11.5	14.0	12.1	13.7	13.6	16.4
1992	Apr	12.5	12.9	14.9	14.2	15.5	15.1	18.1
1992	May	13.5	14.3	16.7	16.4	17.4	17.6	20.4
1992	Jun	14.7	16.0	18.3	19.9	19.9	23.5	29.6

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1992	Jul	15.8	17.1	18.5	21.2	22.7	24.9	29.6
1992	Aug	16.5	17.5	19.0	21.0	22.5	24.0	29.0
1992	Sep	16.7	17.2	19.1	18.9	21.1	21.5	26.9
1992	Oct	16.5	15.8	17.8	15.9	18.4	16.7	21.0
1992	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1992	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1993	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1993	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1993	Mar	10.6	11.0	12.8	11.9	13.4	13.6	16.3
1993	Apr	11.3	11.9	13.6	13.4	15.1	14.3	16.9
1993	May	12.1	12.6	14.2	13.6	15.7	14.1	15.7
1993	Jun	13.1	13.7	15.7	15.0	17.2	15.5	17.0
1993	Jul	14.1	14.8	16.8	16.4	18.3	17.2	19.2
1993	Aug	14.7	15.3	17.2	16.8	18.7	17.4	19.9
1993	Sep	15.1	15.4	16.8	16.3	18.2	16.7	18.6
1993	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1993	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1993	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1994	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1994	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1994	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1994	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1994	May	12.1	13.4	15.4	17.6	18.1	21.1	25.1
1994	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1994	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1994	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
1994	Sep	15.1	16.0	17.5	18.6	20.8	21.6	26.9
1994	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1994	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1994	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1995	Jan	10.3	9.8	10.9	9.2	11.2	9.0	10.5
1995	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1995	Mar	10.6	10.6	11.9	10.7	12.1	10.8	11.7
1995	Apr	11.3	11.4	13.1	11.8	14.2	11.9	13.3
1995	May	12.1	12.2	13.8	12.6	15.0	12.8	13.9
1995	Jun	13.1	13.5	15.5	14.3	16.8	14.6	15.6
1995	Jul	14.1	14.5	16.6	15.5	17.5	15.9	17.5
1995	Aug	14.7	15.1	17.0	16.0	18.0	16.3	18.3
1995	Sep	15.1	15.3	16.6	15.8	17.7	16.1	17.5
1995	Oct	15.2	15.0	17.2	15.4	17.7	15.9	19.6
1995	Nov	14.9	14.3	15.7	13.7	15.6	13.5	15.8
1995	Dec	12.5	11.8	13.8	11.0	13.0	10.6	12.7
1996	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1996	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1996	Mar	10.6	10.6	11.9	10.8	12.2	11.0	12.0
1996	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1996	May	12.1	12.4	14.0	13.1	15.3	13.3	14.6
1996	Jun	13.1	13.7	15.7	14.9	17.2	15.4	16.8
1996	Jul	14.1	14.8	16.8	16.5	18.4	17.4	19.5
1996	Aug	14.7	15.3	17.2	16.9	18.8	17.6	20.2
1996	Sep	15.1	15.5	16.8	16.4	18.3	16.9	18.9
1996	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1996	Nov	14.9	14.5	15.8	14.1	15.9	14.1	16.1
1996	Dec	12.5	12.4	14.4	12.2	14.1	12.2	14.1
1997	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.6
1997	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1997	Mar	10.6	10.7	12.1	11.0	12.4	11.4	12.7
1997	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1997	May	12.1	12.7	14.4	14.1	15.9	14.7	16.5
1997	Jun	13.1	13.9	15.9	15.6	17.6	16.5	18.5
1997	Jul	14.1	15.0	16.9	17.7	19.5	19.4	22.2
1997	Aug	14.7	15.5	17.3	17.9	19.7	19.4	22.6
1997	Sep	15.1	15.6	17.0	17.0	19.0	18.0	20.8
1997	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1997	Nov	14.9	14.4	15.8	14.0	15.8	13.9	16.0
1997	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1998	Jan	10.3	10.1	11.1	9.8	11.4	9.8	11.2
1998	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1998	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9
1998	Apr	11.3	11.5	13.1	12.0	14.3	12.1	13.7
1998	May	12.1	12.3	13.9	12.8	15.1	13.0	14.2
1998	Jun	13.1	13.6	15.5	14.4	16.9	14.7	15.8
1998	Jul	14.1	14.5	16.6	15.6	17.6	16.1	17.7
1998	Aug	14.7	15.1	17.0	16.0	18.1	16.4	18.5
1998	Sep	15.1	15.3	16.6	15.9	17.8	16.1	17.7
1998	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.6
1998	Nov	14.9	14.3	15.7	13.7	15.6	13.5	15.8
1998	Dec	12.5	11.8	13.8	11.0	13.0	10.7	12.8
1999	Jan	10.3	10.1	11.1	9.8	11.4	9.8	11.2
1999	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1999	Mar	10.6	10.7	12.0	10.9	12.3	11.1	12.2
1999	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1999	May	12.1	12.5	14.2	13.5	15.6	13.9	15.4
1999	Jun	13.1	13.7	15.7	14.9	17.2	15.5	16.9
1999	Jul	14.1	14.7	16.8	16.3	18.2	17.0	18.9
1999	Aug	14.7	15.3	17.1	16.6	18.6	17.2	19.6

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
1999	Sep	15.1	15.4	16.7	16.2	18.2	16.6	18.5
1999	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1999	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1999	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
2000	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
2000	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
2000	Mar	10.6	10.7	12.0	10.9	12.3	11.1	12.2
2000	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
2000	May	12.1	12.6	14.4	14.0	15.9	14.6	16.3
2000	Jun	13.1	13.9	15.9	15.6	17.6	16.5	18.6
2000	Jul	14.1	15.0	16.9	17.4	19.2	18.8	21.4
2000	Aug	14.7	15.5	17.3	17.6	19.5	18.8	21.8
2000	Sep	15.1	15.6	16.9	16.8	18.8	17.6	20.2
2000	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
2000	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
2000	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
2001	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
2001	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
2001	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
2001	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
2001	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
2001	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
2001	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
2001	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
2001	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
2001	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
2001	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
2001	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
2002	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
2002	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
2002	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
2002	Apr	11.3	11.8	13.6	13.3	15.0	14.1	16.6
2002	May	12.1	13.0	14.8	15.1	16.6	16.3	18.7
2002	Jun	13.1	14.2	16.3	16.8	18.2	18.2	21.2
2002	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
2002	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
2002	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
2002	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
2002	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
2002	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
2003	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
2003	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
2003	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
2003	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
2003	May	12.1	12.8	14.5	14.5	16.2	15.4	17.4
2003	Jun	13.1	14.0	16.0	16.0	17.8	17.1	19.5
2003	Jul	14.1	15.0	17.0	17.9	19.7	19.7	22.6
2003	Aug	14.7	15.6	17.4	18.1	19.9	19.6	22.9
2003	Sep	15.1	15.6	17.0	17.1	19.1	18.2	21.1
2003	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
2003	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
2003	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
2004	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
2004	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.4
2004	Mar	10.6	10.7	12.1	11.0	12.4	11.4	12.6
2004	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
2004	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
2004	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
2004	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
2004	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
2004	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
2004	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
2004	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
2004	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
2005	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
2005	Feb	9.9	9.9	11.0	10.1	11.1	10.2	11.3
2005	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9
2005	Apr	11.3	11.6	13.3	12.4	14.5	12.8	14.6
2005	May	12.1	12.4	14.0	13.0	15.3	13.3	14.6
2005	Jun	13.1	13.6	15.6	14.6	17.0	15.0	16.2
2005	Jul	14.1	14.7	16.7	16.1	18.0	16.8	18.6
2005	Aug	14.7	15.3	17.1	16.5	18.5	17.1	19.4
2005	Sep	15.1	15.4	16.7	16.1	18.1	16.5	18.3
2005	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
2005	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
2005	Dec	12.5	12.3	14.3	12.1	14.0	12.0	14.0
2006	Jan	10.3	10.2	11.2	10.1	11.5	10.1	11.5
2006	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
2006	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9
2006	Apr	11.3	11.4	13.0	11.7	14.1	11.8	13.1
2006	May	12.1	12.3	13.9	12.8	15.1	13.0	14.1
2006	Jun	13.1	13.6	15.6	14.5	16.9	14.8	15.9
2006	Jul	14.1	14.7	16.7	16.3	18.2	17.0	19.0
2006	Aug	14.7	15.3	17.1	16.6	18.6	17.3	19.6
2006	Sep	15.1	15.4	16.7	16.3	18.2	16.7	18.6
2006	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.6

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
		Mean	Mean	Max 7DADM	Mean	Max 7DADM	Mean	Max 7DADM
2006	Nov	14.9	14.3	15.7	13.7	15.6	13.5	15.8
2006	Dec	12.5	11.8	13.8	11.0	13.1	10.7	12.8
2007	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
2007	Feb	9.9	9.9	11.0	10.1	11.2	10.4	11.5
2007	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
2007	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.3
2007	May	12.1	13.0	14.9	15.5	16.8	16.9	19.5
2007	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.6
2007	Jul	14.1	15.4	17.2	20.1	21.7	24.7	29.4
2007	Aug	14.7	15.9	17.6	20.0	21.7	23.6	28.5
2007	Sep	15.1	15.9	17.3	18.3	20.4	21.1	26.1
2007	Oct	15.2	15.0	17.1	15.4	17.7	15.7	19.4
2007	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
2007	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
2008	Jan	10.3	9.8	10.9	9.4	11.3	9.4	10.8
2008	Feb	9.9	9.9	11.0	10.1	11.2	10.6	11.7
2008	Mar	10.6	10.8	12.3	11.4	12.8	12.1	13.9
2008	Apr	11.3	11.9	13.6	13.5	15.1	14.7	17.5
2008	May	12.1	13.1	15.0	15.6	16.9	17.1	19.7
2008	Jun	13.1	14.7	16.8	19.4	19.6	23.4	29.5
2008	Jul	14.1	15.6	17.4	20.5	22.1	24.4	28.9
2008	Aug	14.7	16.1	17.8	20.4	22.0	23.1	27.8
2008	Sep	15.1	16.0	17.5	18.5	20.6	20.4	25.0
2008	Oct	15.2	15.0	17.1	15.4	17.7	15.6	19.2
2008	Nov	14.9	14.1	15.5	13.4	15.5	13.1	15.6
2008	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
2009	Jan	10.3	9.8	10.9	9.3	11.3	9.4	10.9
2009	Feb	9.9	9.9	11.0	10.2	11.2	10.8	11.9
2009	Mar	10.6	10.8	12.4	11.4	12.8	12.5	14.6
2009	Apr	11.3	11.9	13.6	13.5	15.1	14.8	17.6
2009	May	12.1	12.8	14.6	14.7	16.3	15.7	17.8
2009	Jun	13.1	14.0	16.1	16.2	17.8	17.3	19.8
2009	Jul	14.1	15.1	17.0	18.2	20.0	20.1	23.1
2009	Aug	14.7	15.6	17.4	18.3	20.1	19.7	23.0
2009	Sep	15.1	15.7	17.1	17.3	19.3	18.0	20.9
2009	Oct	15.2	15.0	17.2	15.4	17.6	15.4	18.9
2009	Nov	14.9	14.3	15.7	13.7	15.7	13.5	15.8
2009	Dec	12.5	12.2	14.2	11.9	13.8	11.8	13.8

5.2 Case 2: Project

Water quantity modeling results from the District's reservoir operations planning model EBMUDSIM presented in Section 4.2 for the Project case provided the necessary inputs for the water quality modeling assessment.

In months where simulated EOM Camanche WSE is greater than 190 ft msl, mean monthly release temperature from Table 3.3-10 is assigned as the Camanche release temperature. In months where simulated Camanche WSE is less than 190 ft msl in the March to October period, mean monthly release temperature from Table 3.3-10 is adjusted following the procedure in Section 3.4.6. The remaining required model inputs to SSTEMP were available from the water balance modeling results (presented in Section 4.2). SSTEMP model output was mean monthly water temperature at each downstream station: Elliott, Golf, and Frandy. For each station, simulated mean monthly water temperature is then converted to MM7DADM using the regression models presented in Section 3.3.5. Simulated monthly mean water temperature and corresponding MM7DADM water temperature for the Project case is presented in Table 5.2-1.

Table 5.2-1. Simulated Monthly Average and Estimated Monthly Maximum of 7-Day Average of Daily Maximum (7DADM) Water Temperature [°C], Project Case

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM
1921	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.5
1921	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1921	Mar	10.6	10.7	12.0	10.9	12.3	11.2	12.3
1921	Apr	11.3	11.7	13.4	13.6	15.2	14.1	16.6
1921	May	12.1	12.5	14.2	14.3	16.0	14.7	16.4
1921	Jun	13.1	13.6	15.6	15.1	17.3	15.4	16.9
1921	Jul	14.1	14.8	16.8	17.8	19.6	18.6	21.1
1921	Aug	14.7	15.4	17.2	18.0	19.8	18.6	21.6
1921	Sep	15.1	15.5	16.8	17.2	19.2	17.6	20.2
1921	Oct	15.2	15.0	17.2	15.5	17.9	15.9	19.7
1921	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1921	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1922	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1922	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1922	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1922	Apr	11.3	11.8	13.5	12.9	14.8	13.5	15.8
1922	May	12.1	12.3	13.9	12.9	15.2	13.2	14.4
1922	Jun	13.1	13.5	15.5	14.2	16.8	14.5	15.4
1922	Jul	14.1	14.7	16.8	16.3	18.2	17.0	18.9
1922	Aug	14.7	15.3	17.2	16.6	18.6	17.3	19.7
1922	Sep	15.1	15.4	16.7	16.3	18.2	16.7	18.6
1922	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
1922	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1922	Dec	12.5	12.0	13.9	11.3	13.3	11.1	13.2

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1923	Jan	10.3	10.0	11.1	9.7	11.4	9.7	11.1
1923	Feb	9.9	9.9	11.0	10.1	11.1	10.2	11.4
1923	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1923	Apr	11.3	11.8	13.5	13.1	14.9	13.8	16.2
1923	May	12.1	12.7	14.4	14.0	15.9	14.7	16.4
1923	Jun	13.1	13.8	15.8	15.4	17.4	16.1	17.9
1923	Jul	14.1	14.9	16.9	16.9	18.8	17.9	20.2
1923	Aug	14.7	15.4	17.3	17.2	19.1	18.0	20.7
1923	Sep	15.1	15.5	16.8	16.5	18.5	17.1	19.3
1923	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1923	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1923	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1924	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1924	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1924	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1924	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1924	May	12.1	13.4	15.4	17.6	18.1	21.1	25.1
1924	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1924	Jul	14.1	15.8	17.5	21.2	22.8	24.9	29.7
1924	Aug	14.7	16.2	17.9	20.8	22.4	24.0	29.0
1924	Sep	15.4	16.3	17.9	18.8	20.9	21.6	26.9
1924	Oct	15.3	15.0	17.1	15.4	17.7	15.8	19.6
1924	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1924	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1925	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1925	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1925	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1925	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1925	May	12.1	12.8	14.5	14.5	16.2	15.3	17.4
1925	Jun	13.1	14.0	16.0	16.0	17.8	17.0	19.4
1925	Jul	14.1	15.0	17.0	17.8	19.6	19.6	22.4
1925	Aug	14.7	15.6	17.4	18.0	19.8	19.5	22.7
1925	Sep	15.1	15.6	17.0	17.0	19.0	18.1	21.0
1925	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1925	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1925	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1926	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1926	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1926	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1926	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1926	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1926	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1926	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1926	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1926	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1926	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1926	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1926	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1927	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1927	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1927	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1927	Apr	11.3	11.7	13.4	12.8	14.7	13.3	15.4
1927	May	12.1	12.5	14.1	13.4	15.5	13.8	15.2
1927	Jun	13.1	13.6	15.6	14.5	16.9	14.9	16.0
1927	Jul	14.1	14.8	16.8	16.4	18.3	17.2	19.2
1927	Aug	14.7	15.3	17.2	16.8	18.7	17.4	19.9
1927	Sep	15.1	15.4	16.8	16.3	18.2	16.8	18.7
1927	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1927	Nov	14.9	14.4	15.7	13.9	15.8	13.8	16.0
1927	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1928	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1928	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1928	Mar	10.6	10.7	12.0	10.9	12.2	11.1	12.2
1928	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1928	May	12.1	12.9	14.7	15.1	16.6	16.3	18.6
1928	Jun	13.1	14.0	16.0	16.0	17.7	17.0	19.3
1928	Jul	14.1	15.3	17.2	19.7	21.4	24.5	29.2
1928	Aug	14.7	15.8	17.6	19.9	21.5	24.0	29.0
1928	Sep	15.1	15.8	17.3	18.2	20.3	21.5	26.9
1928	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1928	Nov	14.9	14.4	15.7	13.9	15.8	13.8	15.9
1928	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1929	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1929	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1929	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1929	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1929	May	12.1	13.1	15.0	15.6	16.9	17.0	19.5
1929	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1929	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1929	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
1929	Sep	15.1	16.0	17.5	18.5	20.6	21.5	26.9
1929	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1929	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1929	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1930	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1930	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1930	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1930	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1930	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1930	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1930	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1930	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1930	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1930	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1930	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1930	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1931	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1931	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1931	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1931	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1931	May	12.1	13.4	15.4	17.6	18.1	21.1	25.1
1931	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1931	Jul	14.3	16.0	17.7	21.3	22.8	24.9	29.7
1931	Aug	15.5	16.8	18.4	21.0	22.6	24.0	29.0
1931	Sep	16.3	17.0	18.8	18.9	21.1	21.6	26.9
1931	Oct	16.7	15.9	18.0	16.0	18.5	16.7	21.0
1931	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1931	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1932	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1932	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1932	Mar	11.5	11.7	14.5	12.2	13.8	13.7	16.5
1932	Apr	11.7	12.3	14.1	13.8	15.3	14.7	17.5
1932	May	12.1	13.0	14.8	15.1	16.6	16.3	18.7
1932	Jun	13.1	14.2	16.3	16.8	18.2	18.2	21.2
1932	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1932	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1932	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1932	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1932	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1932	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1933	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1933	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1933	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1933	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1933	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1933	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1933	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1933	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1933	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1933	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1933	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1933	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1934	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1934	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1934	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1934	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1934	May	12.1	13.1	15.0	15.6	16.9	17.0	19.5
1934	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1934	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1934	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
1934	Sep	15.1	16.0	17.5	18.5	20.6	21.5	26.9
1934	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1934	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1934	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1935	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1935	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1935	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1935	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1935	May	12.1	12.8	14.6	14.7	16.3	15.7	17.8
1935	Jun	13.1	14.0	16.1	16.3	17.9	17.5	20.1
1935	Jul	14.1	15.1	17.0	18.5	20.2	21.1	24.4
1935	Aug	14.7	15.7	17.5	18.6	20.4	20.9	24.7
1935	Sep	15.1	15.7	17.1	17.4	19.5	19.0	22.6
1935	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1935	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1935	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1936	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1936	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1936	Mar	10.6	10.7	12.1	11.0	12.4	11.4	12.6
1936	Apr	11.3	11.7	13.4	12.6	14.6	13.1	15.0
1936	May	12.1	12.4	14.0	13.2	15.4	13.5	14.9
1936	Jun	13.1	13.6	15.6	14.7	17.0	15.1	16.4
1936	Jul	14.1	14.8	16.8	16.4	18.3	17.2	19.2
1936	Aug	14.7	15.3	17.2	16.8	18.7	17.4	19.9
1936	Sep	15.1	15.4	16.8	16.3	18.2	16.8	18.7
1936	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
1936	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1936	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1937	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1937	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1937	Mar	10.6	10.7	12.1	11.0	12.3	11.2	12.4
1937	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1937	May	12.1	12.6	14.3	13.8	15.7	14.3	15.9
1937	Jun	13.1	13.8	15.8	15.1	17.3	15.7	17.3
1937	Jul	14.1	14.8	16.8	16.8	18.7	17.7	20.0
1937	Aug	14.7	15.4	17.2	17.1	19.0	17.9	20.5
1937	Sep	15.1	15.5	16.8	16.5	18.5	17.1	19.2
1937	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1937	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1937	Dec	12.5	12.3	14.3	12.0	13.9	12.0	14.0
1938	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1938	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1938	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9
1938	Apr	11.3	11.5	13.1	11.8	14.2	12.0	13.4
1938	May	12.1	12.3	13.9	12.8	15.1	13.0	14.2
1938	Jun	13.1	13.5	15.5	14.3	16.8	14.6	15.6
1938	Jul	14.1	14.7	16.7	16.1	18.0	16.8	18.6
1938	Aug	14.7	15.2	17.1	16.5	18.4	17.0	19.3
1938	Sep	15.1	15.4	16.7	16.1	18.0	16.5	18.2
1938	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1938	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1938	Dec	12.5	11.8	13.8	11.0	13.0	10.7	12.8
1939	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1939	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1939	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1939	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1939	May	12.1	13.1	15.0	15.6	16.9	17.0	19.5
1939	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1939	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1939	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
1939	Sep	15.1	16.0	17.5	18.5	20.6	21.5	26.9
1939	Oct	15.2	15.0	17.1	15.4	17.6	15.7	19.4
1939	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1939	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1940	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1940	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1940	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9
1940	Apr	11.3	11.7	13.4	12.8	14.8	13.3	15.4
1940	May	12.1	12.4	14.1	13.3	15.4	13.6	15.0
1940	Jun	13.1	13.7	15.7	15.0	17.2	15.6	17.1
1940	Jul	14.1	14.9	16.9	16.9	18.8	18.0	20.3
1940	Aug	14.7	15.4	17.3	17.2	19.1	18.1	20.9
1940	Sep	15.1	15.5	16.9	16.6	18.5	17.2	19.4
1940	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1940	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1940	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1941	Jan	10.3	10.0	11.1	9.8	11.4	9.8	11.2
1941	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1941	Mar	10.6	10.7	12.0	10.9	12.3	11.2	12.3
1941	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1941	May	12.1	12.5	14.2	13.5	15.6	13.9	15.4
1941	Jun	13.1	13.6	15.6	14.7	17.0	15.1	16.3
1941	Jul	14.1	14.7	16.8	16.3	18.2	17.0	18.9
1941	Aug	14.7	15.3	17.2	16.6	18.6	17.2	19.6
1941	Sep	15.1	15.4	16.7	16.3	18.2	16.7	18.6
1941	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1941	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1941	Dec	12.5	12.0	14.0	11.5	13.5	11.4	13.4
1942	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1942	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1942	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1942	Apr	11.3	11.8	13.5	13.1	14.9	13.8	16.1
1942	May	12.1	12.4	14.0	13.0	15.3	13.3	14.6
1942	Jun	13.1	13.6	15.5	14.4	16.9	14.7	15.8
1942	Jul	14.1	14.7	16.7	16.1	18.0	16.8	18.6
1942	Aug	14.7	15.3	17.1	16.5	18.5	17.1	19.5
1942	Sep	15.1	15.4	16.7	16.1	18.1	16.5	18.3
1942	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1942	Nov	14.9	14.5	15.8	14.1	15.9	14.0	16.0
1942	Dec	12.5	12.0	14.0	11.4	13.4	11.2	13.3
1943	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1943	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1943	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.8
1943	Apr	11.3	11.6	13.3	12.4	14.6	12.8	14.7
1943	May	12.1	12.4	14.0	13.2	15.3	13.5	14.8
1943	Jun	13.1	13.7	15.7	14.9	17.2	15.4	16.8
1943	Jul	14.1	14.8	16.8	16.5	18.4	17.4	19.5
1943	Aug	14.7	15.4	17.2	16.9	18.8	17.6	20.2
1943	Sep	15.1	15.5	16.8	16.4	18.3	16.9	18.9
1943	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
1943	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1943	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1944	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1944	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1944	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1944	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1944	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1944	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1944	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1944	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1944	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1944	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1944	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1944	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1945	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1945	Feb	9.9	9.9	11.0	10.1	11.2	10.4	11.6
1945	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1945	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1945	May	12.1	12.6	14.3	13.7	15.7	14.2	15.7
1945	Jun	13.1	13.8	15.8	15.2	17.3	15.8	17.4
1945	Jul	14.1	14.8	16.8	16.5	18.4	17.4	19.5
1945	Aug	14.7	15.4	17.2	16.8	18.8	17.5	20.1
1945	Sep	15.1	15.5	16.8	16.4	18.3	16.8	18.8
1945	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1945	Nov	14.9	14.5	15.8	14.1	15.8	14.0	16.0
1945	Dec	12.5	12.3	14.3	12.0	13.9	11.9	13.9
1946	Jan	10.3	10.1	11.1	9.8	11.4	9.8	11.2
1946	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1946	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1946	Apr	11.3	11.8	13.5	13.0	14.9	13.6	15.9
1946	May	12.1	12.7	14.4	14.2	16.0	14.9	16.8
1946	Jun	13.1	13.8	15.8	15.2	17.3	15.9	17.6
1946	Jul	14.1	14.9	16.9	17.1	19.0	18.3	20.7
1946	Aug	14.7	15.5	17.3	17.4	19.3	18.5	21.4
1946	Sep	15.1	15.5	16.9	16.7	18.7	17.4	19.8
1946	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1946	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1946	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1947	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1947	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1947	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1947	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1947	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1947	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1947	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1947	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1947	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1947	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1947	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1947	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1948	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1948	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1948	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1948	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1948	May	12.1	13.0	14.8	15.1	16.6	16.3	18.7
1948	Jun	13.1	14.2	16.3	16.8	18.2	18.2	21.2
1948	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1948	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1948	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1948	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1948	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1948	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1949	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1949	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1949	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1949	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1949	May	12.1	13.0	14.8	15.1	16.6	16.3	18.7
1949	Jun	13.1	14.2	16.3	16.8	18.2	18.2	21.2
1949	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1949	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1949	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1949	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1949	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1949	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1950	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1950	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1950	Mar	10.6	10.8	12.3	11.4	12.8	12.2	14.0
1950	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1950	May	12.1	12.5	14.2	13.6	15.6	14.1	15.6
1950	Jun	13.1	13.7	15.7	14.9	17.2	15.5	16.9
1950	Jul	14.1	14.7	16.8	16.4	18.3	17.2	19.2
1950	Aug	14.7	15.3	17.2	16.8	18.7	17.5	20.0
1950	Sep	15.1	15.4	16.8	16.3	18.2	16.8	18.8
1950	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1950	Nov	14.9	14.8	16.0	14.8	16.1	14.8	16.4
1950	Dec	12.5	12.4	14.4	12.4	14.2	12.4	14.3
1951	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1951	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1951	Mar	10.6	10.7	12.1	11.1	12.5	11.4	12.7
1951	Apr	11.3	11.7	13.4	12.8	14.8	13.3	15.4
1951	May	12.1	12.6	14.3	13.9	15.8	14.5	16.2
1951	Jun	13.1	13.8	15.8	15.4	17.4	16.1	17.9
1951	Jul	14.1	15.0	17.0	17.9	19.6	19.6	22.5
1951	Aug	14.7	15.6	17.4	18.1	19.9	19.6	23.0

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1951	Sep	15.1	15.6	17.0	17.1	19.1	18.2	21.1
1951	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1951	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1951	Dec	12.5	12.2	14.1	11.8	13.7	11.6	13.7
1952	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1952	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1952	Mar	10.6	10.6	11.9	10.9	12.2	11.0	12.0
1952	Apr	11.3	11.4	13.1	11.8	14.2	11.9	13.3
1952	May	12.1	12.3	13.9	12.8	15.1	13.0	14.1
1952	Jun	13.1	13.6	15.5	14.4	16.9	14.8	15.9
1952	Jul	14.1	14.6	16.7	15.8	17.8	16.4	18.1
1952	Aug	14.7	15.2	17.1	16.2	18.2	16.7	18.8
1952	Sep	15.1	15.4	16.7	16.0	17.9	16.3	17.9
1952	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.6
1952	Nov	14.9	14.3	15.7	13.7	15.6	13.5	15.8
1952	Dec	12.5	11.8	13.8	11.0	13.0	10.7	12.8
1953	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1953	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1953	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1953	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1953	May	12.1	12.7	14.4	14.2	16.0	14.9	16.8
1953	Jun	13.1	13.9	15.9	15.7	17.6	16.5	18.6
1953	Jul	14.1	14.9	16.9	17.2	19.1	18.5	20.9
1953	Aug	14.7	15.5	17.3	17.5	19.4	18.5	21.4
1953	Sep	15.1	15.6	16.9	16.7	18.7	17.4	19.8
1953	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1953	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1953	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1954	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1954	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1954	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1954	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1954	May	12.1	13.0	14.8	15.1	16.6	16.3	18.7
1954	Jun	13.1	14.2	16.3	16.8	18.2	18.2	21.2
1954	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1954	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1954	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1954	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1954	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1954	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1955	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1955	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1955	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1955	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1955	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1955	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1955	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1955	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1955	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1955	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1955	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1955	Dec	12.5	12.4	14.3	12.2	14.1	12.2	14.1
1956	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.5
1956	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1956	Mar	10.6	10.8	12.2	11.2	12.7	11.8	13.3
1956	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1956	May	12.1	12.4	14.0	13.0	15.3	13.3	14.6
1956	Jun	13.1	13.6	15.6	14.4	16.9	14.8	15.9
1956	Jul	14.1	14.7	16.7	16.1	18.0	16.8	18.6
1956	Aug	14.7	15.3	17.1	16.5	18.5	17.1	19.4
1956	Sep	15.1	15.4	16.7	16.1	18.0	16.5	18.3
1956	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1956	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1956	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1957	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1957	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1957	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1957	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1957	May	12.1	12.8	14.6	14.7	16.3	15.6	17.7
1957	Jun	13.1	14.0	16.1	16.2	17.8	17.3	19.8
1957	Jul	14.1	15.1	17.0	18.2	20.0	20.4	23.6
1957	Aug	14.7	15.6	17.4	18.3	20.1	20.3	23.8
1957	Sep	15.1	15.7	17.1	17.3	19.3	18.6	21.8
1957	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1957	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1957	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1958	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1958	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1958	Mar	10.6	10.7	12.0	10.9	12.2	11.1	12.1
1958	Apr	11.3	11.5	13.1	11.9	14.3	12.1	13.6
1958	May	12.1	12.3	13.9	12.9	15.2	13.1	14.3
1958	Jun	13.1	13.6	15.5	14.4	16.9	14.8	15.9
1958	Jul	14.1	14.6	16.7	16.0	17.9	16.6	18.4
1958	Aug	14.7	15.2	17.1	16.4	18.4	16.9	19.1
1958	Sep	15.1	15.4	16.7	16.1	18.0	16.4	18.2
1958	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1958	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1958	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1959	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1959	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1959	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1959	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1959	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1959	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1959	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1959	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1959	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1959	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1959	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1959	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1960	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1960	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1960	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1960	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1960	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1960	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1960	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1960	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1960	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1960	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1960	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1960	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1961	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1961	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1961	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1961	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1961	May	12.1	13.4	15.4	17.6	18.1	21.1	25.1
1961	Jun	13.3	14.8	17.0	19.4	19.7	23.5	29.6
1961	Jul	14.7	16.2	17.9	20.8	22.4	24.9	29.6
1961	Aug	15.7	16.9	18.5	20.7	22.3	24.0	29.0
1961	Sep	16.3	16.9	18.7	18.9	21.1	21.6	26.9
1961	Oct	16.5	15.8	17.8	15.9	18.4	16.7	21.0
1961	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1961	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1962	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1962	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1962	Mar	11.9	12.0	15.0	12.4	14.0	13.8	16.7
1962	Apr	11.4	11.9	13.7	13.5	15.2	14.5	17.3
1962	May	12.2	13.1	14.9	15.2	16.7	16.4	18.7

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM
1962	Jun	13.1	14.2	16.3	16.8	18.2	18.2	21.2
1962	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1962	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1962	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1962	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1962	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1962	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1963	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1963	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1963	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1963	Apr	11.3	11.8	13.5	13.1	14.9	13.8	16.2
1963	May	12.1	12.4	14.1	13.3	15.4	13.6	15.0
1963	Jun	13.1	13.7	15.7	14.8	17.1	15.2	16.6
1963	Jul	14.1	14.7	16.8	16.3	18.2	17.0	18.9
1963	Aug	14.7	15.3	17.2	16.6	18.6	17.2	19.6
1963	Sep	15.1	15.4	16.7	16.3	18.2	16.7	18.6
1963	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1963	Nov	14.9	14.5	15.8	14.2	15.9	14.1	16.1
1963	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1964	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1964	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1964	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1964	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1964	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1964	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1964	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1964	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1964	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1964	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1964	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1964	Dec	12.5	12.4	14.4	12.3	14.2	12.3	14.3
1965	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.5
1965	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1965	Mar	10.6	10.8	12.3	11.4	12.8	12.1	13.8
1965	Apr	11.3	11.8	13.5	12.9	14.8	13.6	15.8
1965	May	12.1	12.5	14.1	13.3	15.4	13.6	15.0
1965	Jun	13.1	13.6	15.6	14.6	17.0	15.0	16.3
1965	Jul	14.1	14.7	16.7	16.1	18.0	16.7	18.5
1965	Aug	14.7	15.2	17.1	16.4	18.4	17.0	19.3
1965	Sep	15.1	15.4	16.7	16.1	18.0	16.5	18.2
1965	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
1965	Nov	14.9	14.5	15.8	14.1	15.9	14.1	16.1
1965	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1966	Jan	10.3	9.9	11.0	9.6	11.4	9.5	10.9
1966	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1966	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1966	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1966	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1966	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1966	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1966	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1966	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1966	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1966	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1966	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1967	Jan	10.3	9.9	11.0	9.6	11.4	9.5	11.0
1967	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1967	Mar	10.6	10.7	12.0	10.9	12.2	11.1	12.2
1967	Apr	11.3	11.5	13.2	12.2	14.4	12.4	14.1
1967	May	12.1	12.3	13.9	12.8	15.1	13.0	14.1
1967	Jun	13.1	13.6	15.6	14.5	16.9	14.9	16.0
1967	Jul	14.1	14.6	16.6	15.8	17.7	16.3	18.0
1967	Aug	14.7	15.2	17.1	16.2	18.2	16.6	18.7
1967	Sep	15.1	15.4	16.7	16.0	17.9	16.3	17.9
1967	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1967	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1967	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1968	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1968	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1968	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1968	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1968	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1968	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1968	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1968	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1968	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1968	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1968	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1968	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1969	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.5
1969	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1969	Mar	10.6	10.7	12.0	10.9	12.3	11.1	12.2
1969	Apr	11.3	11.5	13.1	11.8	14.2	12.0	13.4
1969	May	12.1	12.3	13.8	12.7	15.1	12.9	14.0
1969	Jun	13.1	13.6	15.6	14.5	16.9	14.9	16.0
1969	Jul	14.1	14.6	16.7	15.9	17.8	16.4	18.2

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM
1969	Aug	14.7	15.2	17.1	16.3	18.3	16.8	19.0
1969	Sep	15.1	15.4	16.7	16.0	18.0	16.4	18.0
1969	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.6
1969	Nov	14.9	14.3	15.7	13.7	15.6	13.5	15.8
1969	Dec	12.5	11.9	13.9	11.3	13.2	11.0	13.1
1970	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.5
1970	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1970	Mar	10.6	10.7	12.1	11.0	12.4	11.3	12.5
1970	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1970	May	12.1	12.7	14.4	14.1	16.0	14.9	16.7
1970	Jun	13.1	13.9	15.9	15.6	17.5	16.4	18.5
1970	Jul	14.1	15.0	17.0	17.6	19.4	19.2	21.9
1970	Aug	14.7	15.5	17.4	17.8	19.7	19.2	22.4
1970	Sep	15.1	15.6	17.0	17.0	18.9	17.9	20.6
1970	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
1970	Nov	14.9	14.5	15.8	14.2	15.9	14.1	16.1
1970	Dec	12.5	12.2	14.2	11.9	13.8	11.7	13.7
1971	Jan	10.3	10.1	11.1	9.9	11.5	9.8	11.2
1971	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1971	Mar	10.6	10.7	12.1	11.0	12.4	11.3	12.5
1971	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1971	May	12.1	12.6	14.3	13.9	15.8	14.4	16.1
1971	Jun	13.1	13.9	15.9	15.5	17.5	16.3	18.2
1971	Jul	14.1	14.9	16.9	16.9	18.8	18.0	20.3
1971	Aug	14.7	15.4	17.3	17.2	19.1	18.1	20.8
1971	Sep	15.1	15.5	16.8	16.6	18.5	17.1	19.4
1971	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1971	Nov	14.9	14.3	15.7	13.8	15.7	13.7	15.9
1971	Dec	12.5	11.9	13.9	11.3	13.3	11.1	13.2
1972	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1972	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1972	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1972	Apr	11.3	11.8	13.6	13.3	15.0	14.1	16.6
1972	May	12.1	13.0	14.8	15.1	16.6	16.3	18.7
1972	Jun	13.1	14.2	16.3	16.8	18.2	18.2	21.2
1972	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1972	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1972	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1972	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1972	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1972	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1973	Jan	10.3	10.0	11.1	9.7	11.4	9.7	11.1
1973	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1973	Mar	10.6	10.7	12.0	10.9	12.3	11.2	12.4
1973	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1973	May	12.1	12.6	14.3	13.8	15.8	14.4	16.0
1973	Jun	13.1	13.8	15.8	15.3	17.4	15.9	17.7
1973	Jul	14.1	14.8	16.8	16.8	18.7	17.8	20.1
1973	Aug	14.7	15.4	17.2	17.1	19.0	17.9	20.6
1973	Sep	15.1	15.5	16.8	16.5	18.5	17.1	19.2
1973	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1973	Nov	14.9	14.7	15.9	14.5	16.0	14.5	16.2
1973	Dec	12.5	12.2	14.2	11.9	13.8	11.8	13.8
1974	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1974	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1974	Mar	10.6	10.7	12.0	10.9	12.2	11.1	12.2
1974	Apr	11.3	11.6	13.3	12.5	14.6	12.9	14.8
1974	May	12.1	12.5	14.1	13.3	15.5	13.7	15.1
1974	Jun	13.1	13.7	15.6	14.7	17.1	15.2	16.5
1974	Jul	14.1	14.7	16.7	16.2	18.1	16.9	18.8
1974	Aug	14.7	15.3	17.1	16.6	18.5	17.1	19.5
1974	Sep	15.1	15.4	16.7	16.2	18.1	16.6	18.4
1974	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
1974	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1974	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1975	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1975	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1975	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1975	Apr	11.3	11.8	13.5	13.1	14.9	13.8	16.2
1975	May	12.1	12.5	14.2	13.5	15.6	13.9	15.4
1975	Jun	13.1	13.7	15.7	14.9	17.2	15.4	16.9
1975	Jul	14.1	14.7	16.7	16.1	18.0	16.7	18.5
1975	Aug	14.7	15.2	17.1	16.4	18.4	16.9	19.2
1975	Sep	15.1	15.4	16.7	16.1	18.0	16.5	18.2
1975	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1975	Nov	14.9	14.3	15.7	13.8	15.7	13.7	15.9
1975	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1976	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1976	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1976	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1976	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1976	May	12.1	13.4	15.4	17.6	18.1	21.1	25.1
1976	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1976	Jul	14.1	15.8	17.5	21.2	22.8	24.9	29.7
1976	Aug	14.7	16.2	17.9	20.8	22.4	24.0	29.0
1976	Sep	15.1	16.1	17.6	18.7	20.8	21.6	26.9

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1976	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1976	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1976	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1977	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1977	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1977	Mar	12.8	12.7	16.7	12.7	14.4	13.2	15.6
1977	Apr	14.1	14.3	16.6	15.3	16.1	16.4	20.0
1977	May	15.4	16.1	19.1	18.6	18.8	21.1	25.1
1977	Jun	17.2	18.0	20.6	20.8	20.4	23.5	29.6
1977	Jul	18.8	19.7	20.5	22.5	24.0	24.9	29.7
1977	Aug	20.2	20.5	21.4	22.1	23.6	24.0	29.0
1977	Sep	20.9	20.5	23.4	19.9	22.2	21.6	27.0
1977	Oct	21.1	19.1	20.7	17.2	20.2	17.4	22.1
1977	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1977	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1978	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1978	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1978	Mar	19.1	17.0	26.8	15.0	17.0	15.0	18.6
1978	Apr	19.7	18.8	22.2	17.6	17.4	17.8	22.1
1978	May	20.5	20.2	24.9	20.0	19.7	21.2	25.2
1978	Jun	21.6	21.6	24.6	22.2	21.2	23.6	29.7
1978	Jul	22.5	22.7	22.7	23.5	24.9	24.9	29.7
1978	Aug	23.2	22.9	23.4	22.8	24.2	24.0	29.0
1978	Sep	23.6	22.4	25.9	20.4	22.7	21.6	27.0
1978	Oct	23.7	20.8	22.3	17.9	21.1	17.7	22.6
1978	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1978	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1979	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1979	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1979	Mar	19.1	17.0	26.8	15.0	17.0	14.9	18.6
1979	Apr	19.7	18.8	22.2	17.6	17.4	17.8	22.1
1979	May	18.2	18.4	22.3	19.4	19.3	21.1	25.2
1979	Jun	17.1	17.8	20.4	20.6	20.3	23.5	29.6
1979	Jul	17.7	18.6	19.6	21.6	23.1	24.9	29.6
1979	Aug	18.0	18.6	19.9	21.2	22.7	24.0	29.0
1979	Sep	17.6	17.9	20.0	19.2	21.3	21.6	27.0
1979	Oct	16.9	16.2	18.2	16.1	18.7	16.8	21.1
1979	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1979	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1980	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1980	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1980	Mar	10.6	10.7	12.1	11.0	12.4	11.3	12.5
1980	Apr	11.3	11.7	13.4	12.8	14.8	13.3	15.4

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1980	May	12.1	12.5	14.1	13.3	15.5	13.7	15.1
1980	Jun	13.1	13.6	15.6	14.6	17.0	15.0	16.2
1980	Jul	14.1	14.7	16.7	16.0	18.0	16.7	18.5
1980	Aug	14.7	15.2	17.1	16.4	18.4	16.9	19.2
1980	Sep	15.1	15.4	16.7	16.1	18.0	16.5	18.2
1980	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1980	Nov	14.9	14.4	15.8	14.0	15.8	13.9	16.0
1980	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1981	Jan	10.3	10.0	11.1	9.8	11.4	9.7	11.1
1981	Feb	9.9	9.9	11.0	10.1	11.1	10.2	11.3
1981	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1981	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1981	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1981	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1981	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1981	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1981	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1981	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1981	Nov	14.9	14.5	15.8	14.1	15.8	14.0	16.0
1981	Dec	12.5	12.4	14.3	12.2	14.1	12.2	14.1
1982	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1982	Feb	9.9	9.9	11.0	10.0	11.1	10.0	11.2
1982	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9
1982	Apr	11.3	11.4	13.0	11.7	14.2	11.8	13.2
1982	May	12.1	12.3	13.9	12.8	15.1	13.0	14.2
1982	Jun	13.1	13.6	15.6	14.6	17.0	15.0	16.2
1982	Jul	14.1	14.6	16.7	15.9	17.9	16.5	18.3
1982	Aug	14.7	15.2	17.1	16.3	18.3	16.8	19.1
1982	Sep	15.1	15.4	16.7	16.1	18.0	16.4	18.1
1982	Oct	15.2	15.0	17.2	15.4	17.7	15.9	19.6
1982	Nov	14.9	14.7	15.9	14.5	16.0	14.4	16.2
1982	Dec	12.5	12.3	14.3	12.1	14.0	12.0	14.0
1983	Jan	10.3	10.2	11.2	10.0	11.5	10.0	11.4
1983	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1983	Mar	10.6	10.6	11.9	10.7	12.0	10.8	11.7
1983	Apr	11.3	11.5	13.1	12.0	14.3	12.2	13.8
1983	May	12.1	12.2	13.8	12.6	15.0	12.8	13.9
1983	Jun	13.1	13.4	15.4	14.0	16.6	14.2	15.0
1983	Jul	14.1	14.5	16.5	15.3	17.3	15.6	17.1
1983	Aug	14.7	15.1	17.0	15.8	17.8	16.1	18.0
1983	Sep	15.1	15.3	16.6	15.8	17.7	16.0	17.4
1983	Oct	15.2	15.0	17.2	15.4	17.7	15.9	19.6
1983	Nov	14.9	14.8	16.0	14.7	16.1	14.6	16.3

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM
1983	Dec	12.5	12.4	14.4	12.3	14.1	12.2	14.2
1984	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1984	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1984	Mar	10.6	10.7	12.1	11.1	12.5	11.5	12.8
1984	Apr	11.3	11.7	13.4	12.8	14.8	13.3	15.4
1984	May	12.1	12.6	14.3	13.8	15.7	14.3	15.9
1984	Jun	13.1	13.8	15.8	15.2	17.3	15.8	17.4
1984	Jul	14.1	14.8	16.8	16.7	18.6	17.6	19.7
1984	Aug	14.7	15.4	17.2	17.0	18.9	17.7	20.3
1984	Sep	15.1	15.5	16.8	16.4	18.4	16.9	19.0
1984	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1984	Nov	14.9	14.5	15.8	14.1	15.8	14.0	16.0
1984	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1985	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1985	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1985	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1985	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1985	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1985	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1985	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1985	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1985	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1985	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1985	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1985	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1986	Jan	10.3	9.8	10.9	9.3	11.2	9.1	10.6
1986	Feb	9.9	9.9	11.0	10.0	11.0	10.0	11.2
1986	Mar	10.6	10.6	11.9	10.7	12.1	10.8	11.7
1986	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1986	May	12.1	12.4	14.0	13.1	15.3	13.4	14.7
1986	Jun	13.1	13.7	15.7	14.8	17.1	15.2	16.6
1986	Jul	14.1	14.7	16.8	16.3	18.2	17.1	19.1
1986	Aug	14.7	15.3	17.2	16.7	18.6	17.3	19.8
1986	Sep	15.1	15.4	16.7	16.3	18.2	16.7	18.6
1986	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1986	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1986	Dec	12.5	11.8	13.8	11.0	13.0	10.7	12.8
1987	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1987	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1987	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1987	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1987	May	12.1	13.4	15.4	17.6	18.1	21.1	25.1
1987	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1987	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1987	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
1987	Sep	15.1	16.0	17.5	18.6	20.8	21.6	26.9
1987	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1987	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1987	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1988	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1988	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1988	Mar	11.5	11.6	14.1	11.9	13.5	12.6	14.6
1988	Apr	12.6	13.1	15.1	14.6	15.8	16.0	19.4
1988	May	13.2	14.4	16.8	17.9	18.4	21.1	25.1
1988	Jun	14.3	15.6	17.9	19.8	19.8	23.5	29.6
1988	Jul	15.1	16.6	18.2	21.5	23.0	24.9	29.7
1988	Aug	15.6	16.9	18.5	21.0	22.6	24.0	29.0
1988	Sep	15.7	16.5	18.2	18.8	21.0	21.6	26.9
1988	Oct	15.5	15.0	17.1	15.6	18.0	16.5	20.7
1988	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1988	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1989	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1989	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1989	Mar	11.9	12.0	15.1	12.4	14.0	13.8	16.7
1989	Apr	13.3	13.6	15.7	14.6	15.8	15.4	18.6
1989	May	12.7	13.6	15.6	15.6	16.9	16.6	19.1
1989	Jun	13.6	14.6	16.8	17.1	18.4	18.4	21.6
1989	Jul	14.5	15.8	17.5	20.3	21.9	24.9	29.6
1989	Aug	15.0	16.1	17.8	20.1	21.8	24.0	29.0
1989	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1989	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1989	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1989	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1990	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1990	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1990	Mar	11.8	11.8	14.7	12.1	13.7	12.7	14.8
1990	Apr	12.9	13.3	15.3	14.4	15.7	15.2	18.3
1990	May	13.5	14.3	16.7	16.4	17.4	17.6	20.4
1990	Jun	14.3	15.6	17.9	19.8	19.8	23.5	29.6
1990	Jul	15.0	16.4	18.0	20.9	22.5	24.9	29.6
1990	Aug	15.4	16.6	18.3	20.6	22.2	24.0	29.0
1990	Sep	15.4	16.2	17.7	18.6	20.7	21.5	26.9
1990	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1990	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1990	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1991	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1991	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1991	Mar	12.4	12.4	16.0	12.5	14.1	13.1	15.4
1991	Apr	13.9	14.1	16.4	15.0	16.0	15.7	19.0
1991	May	14.7	15.4	18.1	17.1	17.8	18.1	21.1
1991	Jun	15.6	16.7	19.1	20.2	20.1	23.5	29.6
1991	Jul	16.3	17.5	18.9	21.4	22.9	24.9	29.6
1991	Aug	16.7	17.7	19.1	21.0	22.6	24.0	29.0
1991	Sep	16.7	17.2	19.1	18.9	21.1	21.5	26.9
1991	Oct	16.3	15.6	17.7	15.9	18.3	16.7	20.9
1991	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1991	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1992	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1992	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1992	Mar	12.5	12.4	16.1	12.6	14.2	13.9	16.8
1992	Apr	13.8	14.0	16.3	15.1	16.1	16.3	19.9
1992	May	14.5	15.4	18.2	18.3	18.6	21.1	25.1
1992	Jun	15.7	16.8	19.2	20.3	20.1	23.5	29.6
1992	Jul	16.9	18.0	19.2	21.6	23.1	24.9	29.6
1992	Aug	17.6	18.5	19.7	21.3	22.8	24.0	29.0
1992	Sep	17.8	18.1	20.3	19.3	21.5	21.6	27.0
1992	Oct	17.6	16.5	18.5	16.3	18.8	16.9	21.3
1992	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1992	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1993	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1993	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1993	Mar	10.6	11.0	12.8	11.9	13.4	13.6	16.3
1993	Apr	11.3	11.9	13.6	13.4	15.1	14.3	16.9
1993	May	12.1	12.6	14.3	13.8	15.8	14.4	16.0
1993	Jun	13.1	13.8	15.8	15.2	17.3	15.9	17.6
1993	Jul	14.1	14.8	16.8	16.8	18.6	17.7	19.9
1993	Aug	14.7	15.4	17.2	17.0	19.0	17.9	20.5
1993	Sep	15.1	15.5	16.8	16.5	18.4	17.0	19.2
1993	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1993	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1993	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1994	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1994	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1994	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1994	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1994	May	12.1	13.4	15.4	17.6	18.1	21.1	25.1
1994	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1994	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1994	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1994	Sep	15.1	16.0	17.5	18.6	20.8	21.6	26.9
1994	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1994	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1994	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1995	Jan	10.3	9.8	10.9	9.2	11.2	9.0	10.5
1995	Feb	9.9	9.9	11.0	10.1	11.1	10.3	11.4
1995	Mar	10.6	10.6	11.9	10.7	12.1	10.8	11.7
1995	Apr	11.3	11.4	13.1	11.8	14.2	11.9	13.3
1995	May	12.1	12.2	13.8	12.6	15.0	12.8	13.9
1995	Jun	13.1	13.5	15.5	14.3	16.8	14.6	15.6
1995	Jul	14.1	14.5	16.6	15.5	17.5	15.9	17.5
1995	Aug	14.7	15.1	17.0	16.0	18.0	16.3	18.3
1995	Sep	15.1	15.3	16.6	15.9	17.7	16.1	17.5
1995	Oct	15.2	15.0	17.2	15.4	17.7	15.9	19.6
1995	Nov	14.9	14.3	15.7	13.7	15.6	13.5	15.8
1995	Dec	12.5	11.8	13.8	11.0	13.0	10.6	12.7
1996	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1996	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1996	Mar	10.6	10.6	11.9	10.9	12.2	11.0	12.0
1996	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1996	May	12.1	12.4	14.0	13.1	15.3	13.3	14.6
1996	Jun	13.1	13.7	15.7	14.9	17.2	15.5	16.9
1996	Jul	14.1	14.8	16.8	16.6	18.5	17.5	19.7
1996	Aug	14.7	15.4	17.2	17.0	18.9	17.8	20.4
1996	Sep	15.1	15.5	16.8	16.5	18.4	17.0	19.1
1996	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1996	Nov	14.9	14.5	15.8	14.1	15.9	14.0	16.0
1996	Dec	12.5	12.4	14.4	12.2	14.1	12.2	14.1
1997	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.6
1997	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1997	Mar	10.6	10.7	12.1	11.1	12.4	11.4	12.7
1997	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1997	May	12.1	12.7	14.4	14.1	16.0	14.8	16.6
1997	Jun	13.1	13.9	15.9	15.7	17.6	16.6	18.8
1997	Jul	14.1	15.0	17.0	17.9	19.7	20.0	23.0
1997	Aug	14.7	15.6	17.4	18.1	19.9	19.9	23.3
1997	Sep	15.1	15.6	17.0	17.1	19.1	18.3	21.3
1997	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1997	Nov	14.9	14.4	15.8	14.0	15.8	13.9	16.0
1997	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1998	Jan	10.3	10.1	11.1	9.8	11.4	9.8	11.2
1998	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1998	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1998	Apr	11.3	11.5	13.1	12.0	14.3	12.1	13.7
1998	May	12.1	12.3	13.9	12.9	15.2	13.0	14.2
1998	Jun	13.1	13.6	15.5	14.4	16.9	14.7	15.8
1998	Jul	14.1	14.5	16.6	15.7	17.6	16.1	17.8
1998	Aug	14.7	15.1	17.0	16.1	18.1	16.5	18.6
1998	Sep	15.1	15.4	16.6	15.9	17.8	16.2	17.7
1998	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.6
1998	Nov	14.9	14.3	15.7	13.7	15.6	13.6	15.8
1998	Dec	12.5	11.8	13.8	11.0	13.0	10.7	12.8
1999	Jan	10.3	10.0	11.1	9.8	11.4	9.8	11.2
1999	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1999	Mar	10.6	10.7	12.0	10.9	12.3	11.1	12.2
1999	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1999	May	12.1	12.5	14.2	13.5	15.6	14.0	15.5
1999	Jun	13.1	13.7	15.7	15.0	17.2	15.5	17.1
1999	Jul	14.1	14.7	16.8	16.3	18.2	17.1	19.0
1999	Aug	14.7	15.3	17.2	16.7	18.7	17.3	19.8
1999	Sep	15.1	15.4	16.8	16.3	18.2	16.7	18.6
1999	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1999	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1999	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
2000	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
2000	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
2000	Mar	10.6	10.7	12.0	10.9	12.3	11.2	12.3
2000	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
2000	May	12.1	12.7	14.4	14.0	15.9	14.7	16.4
2000	Jun	13.1	14.0	16.0	15.9	17.7	16.8	19.1
2000	Jul	14.1	15.0	17.0	17.6	19.4	19.1	21.8
2000	Aug	14.7	15.5	17.4	17.8	19.6	19.1	22.2
2000	Sep	15.1	15.6	17.0	16.9	18.9	17.8	20.5
2000	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
2000	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
2000	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
2001	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
2001	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
2001	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
2001	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
2001	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
2001	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
2001	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
2001	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
2001	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
2001	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
2001	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
2001	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
2002	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
2002	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
2002	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
2002	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
2002	May	12.1	13.0	14.8	15.1	16.6	16.3	18.7
2002	Jun	13.1	14.2	16.3	16.8	18.2	18.2	21.2
2002	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
2002	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
2002	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
2002	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
2002	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
2002	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
2003	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
2003	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
2003	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
2003	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
2003	May	12.1	12.9	14.7	15.0	16.5	16.2	18.5
2003	Jun	13.1	14.1	16.2	16.6	18.1	18.0	21.0
2003	Jul	14.1	15.2	17.1	19.7	21.4	24.8	29.6
2003	Aug	14.7	15.8	17.5	19.8	21.5	24.0	29.0
2003	Sep	15.1	15.8	17.2	18.2	20.3	21.5	26.9
2003	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
2003	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
2003	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
2004	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
2004	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
2004	Mar	10.6	10.7	12.1	11.1	12.4	11.4	12.7
2004	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
2004	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
2004	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
2004	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
2004	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
2004	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
2004	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
2004	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
2004	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
2005	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
2005	Feb	9.9	9.9	11.0	10.1	11.1	10.3	11.4
2005	Mar	10.6	10.6	11.9	10.8	12.2	11.0	12.0
2005	Apr	11.3	11.6	13.3	12.4	14.5	12.8	14.7
2005	May	12.1	12.4	14.0	13.0	15.3	13.3	14.6

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
2005	Jun	13.1	13.6	15.6	14.6	17.0	15.0	16.2
2005	Jul	14.1	14.7	16.7	16.2	18.1	16.8	18.7
2005	Aug	14.7	15.3	17.1	16.6	18.5	17.1	19.5
2005	Sep	15.1	15.4	16.7	16.2	18.1	16.6	18.4
2005	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
2005	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
2005	Dec	12.5	12.3	14.3	12.1	14.0	12.0	14.0
2006	Jan	10.3	10.2	11.2	10.1	11.5	10.1	11.5
2006	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
2006	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9
2006	Apr	11.3	11.4	13.0	11.7	14.1	11.8	13.1
2006	May	12.1	12.3	13.9	12.8	15.1	13.0	14.1
2006	Jun	13.1	13.6	15.6	14.5	16.9	14.9	16.0
2006	Jul	14.1	14.7	16.7	16.3	18.2	17.1	19.1
2006	Aug	14.7	15.3	17.2	16.7	18.6	17.3	19.8
2006	Sep	15.1	15.4	16.7	16.3	18.2	16.7	18.6
2006	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.6
2006	Nov	14.9	14.3	15.7	13.7	15.6	13.5	15.8
2006	Dec	12.5	11.8	13.8	11.0	13.0	10.7	12.8
2007	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
2007	Feb	9.9	9.9	11.0	10.1	11.2	10.4	11.5
2007	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
2007	Apr	11.3	11.9	13.6	13.6	15.2	14.6	17.4
2007	May	12.1	13.0	14.9	15.6	16.9	17.0	19.5
2007	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.6
2007	Jul	14.1	15.4	17.2	20.0	21.6	24.7	29.4
2007	Aug	14.7	15.9	17.6	19.7	21.4	23.6	28.5
2007	Sep	15.1	15.9	17.3	18.1	20.2	21.1	26.1
2007	Oct	15.2	15.0	17.1	15.3	17.5	15.6	19.3
2007	Nov	14.9	14.1	15.6	13.5	15.5	13.2	15.7
2007	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
2008	Jan	10.3	9.8	10.9	9.5	11.3	9.4	10.9
2008	Feb	9.9	9.9	11.0	10.3	11.3	10.7	11.8
2008	Mar	10.6	10.8	12.3	11.5	13.0	12.3	14.1
2008	Apr	11.3	11.9	13.6	13.9	15.4	15.0	18.0
2008	May	12.1	13.1	15.0	15.8	17.0	17.2	19.8
2008	Jun	13.1	14.7	16.8	19.3	19.6	23.4	29.5
2008	Jul	14.1	15.6	17.4	20.2	21.8	24.4	28.9
2008	Aug	14.7	16.1	17.8	19.6	21.3	23.1	27.8
2008	Sep	15.1	16.0	17.5	18.0	20.1	20.4	25.0
2008	Oct	15.2	15.0	17.1	15.1	17.3	15.4	18.8
2008	Nov	14.9	14.1	15.5	13.2	15.4	13.0	15.6
2008	Dec	12.5	11.6	13.5	10.6	12.7	10.3	12.4

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
2009	Jan	10.3	9.8	10.9	9.5	11.3	9.6	11.0
2009	Feb	9.9	9.9	11.0	10.4	11.5	11.0	12.2
2009	Mar	10.6	10.8	12.4	11.8	13.3	12.8	15.1
2009	Apr	11.3	11.9	13.6	14.1	15.5	15.2	18.3
2009	May	12.1	13.0	14.8	15.3	16.7	16.6	19.0
2009	Jun	13.1	14.2	16.3	16.7	18.2	18.1	21.0
2009	Jul	14.1	15.4	17.2	19.5	21.2	23.9	28.3
2009	Aug	14.7	15.9	17.6	18.7	20.5	22.5	26.9
2009	Sep	15.1	15.9	17.3	17.6	19.6	19.8	23.8
2009	Oct	15.2	15.0	17.1	15.0	17.2	15.2	18.5
2009	Nov	14.9	14.1	15.6	13.4	15.5	13.1	15.6
2009	Dec	12.5	12.2	14.2	11.9	13.8	11.9	13.8

5.3 Case 3: Project without Aqueduct Outage

The purpose of this case is to present modeling results for the Project without the aqueduct outage. The water balance results for the Project case without aqueduct outage produced from EBMUDSIM are the main model inputs used to drive the modeling simulations with the SSTEMP model. Both the baseline case and the Project case without aqueduct outage modeling results show Camanche Reservoir is maintained above 190 ft msl from January of 1980 through December of 1985. Thus the incremental change in temperature from the baseline case to the Project case without aqueduct outage are purely due to potential changes in downstream releases that result from the higher assumed customer demand of 230 MGD input in the later case. Table 5.3-1 presents the monthly mean water temperatures from the SSTEMP model and the corresponding MM7DADM by application of the regression models presented in Section 3.3.5.

Table 5.3-1. Simulated Monthly Average and Estimated Monthly Maximum of 7-Day Average of Daily Maximum (7DADM) Water Temperature [°C], Project Case without Aqueduct Outage

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM
1980	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1980	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1980	Mar	10.6	10.7	12.1	11.0	12.4	11.3	12.5
1980	Apr	11.3	11.7	13.4	12.8	14.8	13.3	15.4
1980	May	12.1	12.5	14.1	13.3	15.5	13.7	15.1
1980	Jun	13.1	13.6	15.6	14.6	17.0	15.0	16.2
1980	Jul	14.1	14.7	16.7	16.0	18.0	16.7	18.5
1980	Aug	14.7	15.2	17.1	16.4	18.4	16.9	19.2
1980	Sep	15.1	15.4	16.7	16.1	18.0	16.5	18.2
1980	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1980	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1980	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1981	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1981	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1981	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1981	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1981	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1981	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1981	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1981	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1981	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1981	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1981	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1981	Dec	12.5	12.3	14.3	12.1	14.0	12.0	14.0
1982	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1982	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1982	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9
1982	Apr	11.3	11.4	13.0	11.7	14.2	11.8	13.2
1982	May	12.1	12.3	13.9	12.8	15.1	13.0	14.1
1982	Jun	13.1	13.6	15.6	14.5	16.9	14.8	15.9
1982	Jul	14.1	14.6	16.6	15.7	17.7	16.2	17.9
1982	Aug	14.7	15.2	17.0	16.2	18.2	16.6	18.7
1982	Sep	15.1	15.4	16.6	15.9	17.8	16.2	17.8
1982	Oct	15.2	15.0	17.2	15.4	17.7	15.9	19.6
1982	Nov	14.9	14.7	15.9	14.5	16.0	14.5	16.2
1982	Dec	12.5	12.4	14.3	12.1	14.0	12.1	14.1
1983	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1983	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1983	Mar	10.6	10.6	11.9	10.7	12.0	10.8	11.7
1983	Apr	11.3	11.5	13.1	11.9	14.3	12.1	13.6
1983	May	12.1	12.2	13.8	12.6	15.0	12.8	13.9

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly Max	Monthly Mean	Monthly Max	Monthly Mean	Monthly Max
				7DADM		7DADM		7DADM
1983	Jun	13.1	13.4	15.4	14.0	16.6	14.2	15.0
1983	Jul	14.1	14.5	16.5	15.3	17.3	15.6	17.1
1983	Aug	14.7	15.1	17.0	15.8	17.8	16.1	18.0
1983	Sep	15.1	15.3	16.6	15.8	17.7	16.0	17.4
1983	Oct	15.2	15.0	17.2	15.4	17.7	15.9	19.6
1983	Nov	14.9	14.8	16.0	14.7	16.1	14.6	16.3
1983	Dec	12.5	12.4	14.4	12.3	14.1	12.2	14.2
1984	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1984	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1984	Mar	10.6	10.7	12.1	11.1	12.5	11.5	12.8
1984	Apr	11.3	11.7	13.4	12.8	14.8	13.3	15.4
1984	May	12.1	12.6	14.3	13.8	15.7	14.3	15.9
1984	Jun	13.1	13.8	15.8	15.2	17.3	15.8	17.4
1984	Jul	14.1	14.8	16.8	16.7	18.6	17.6	19.7
1984	Aug	14.7	15.4	17.2	17.0	18.9	17.7	20.3
1984	Sep	15.1	15.5	16.8	16.4	18.4	16.9	19.0
1984	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1984	Nov	14.9	14.5	15.8	14.1	15.8	14.0	16.0
1984	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1985	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1985	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1985	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1985	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1985	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1985	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1985	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1985	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1985	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1985	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1985	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1985	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4

5.4 Case 4: Programmatic Use Beyond Year 2040

Water balance model results for the programmatic use case from EBMUDSIM presented in 4.3 provides the flow boundary conditions for each upstream and downstream station modeled. Following the procedure illustrated in Figure 3.1-4, mean monthly water temperature for station McIntire from Table 3.3-10 is assigned as the Camanche release temperature for all months in which simulated EOM Camanche WSE is above 190 ft msl. In those months where simulated EOM Camanche WSE is below 190 ft msl, the mean monthly temperature from Table 3.3-10 is adjusted as described in Section 3.4.6. Additional SSTEMP model parameters from Table 3.3-13 are input to the SSTEMP model.

SSTEMP model output is mean monthly water temperature downstream of Camanche Dam at stations Elliott, Golf, and Frandy. For each station, simulated mean monthly water temperature is then converted to MM7DADM using the regression models presented in Section 3.3.5. Simulated monthly mean water temperature and corresponding MM7DADM water temperature for the programmatic use case is presented in Table 5.4-1.

Table 5.4-1. Simulated Monthly Average and Estimated Monthly Maximum of 7-Day Average of Daily Maximum (7DADM) Water Temperature [°C], Programmatic Use Case

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM
1921	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.5
1921	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1921	Mar	10.6	10.7	12.0	10.9	12.3	11.2	12.3
1921	Apr	11.3	11.7	13.4	13.6	15.2	14.1	16.6
1921	May	12.1	12.5	14.2	14.2	16.0	14.6	16.4
1921	Jun	13.1	13.6	15.5	15.1	17.2	15.4	16.9
1921	Jul	14.1	14.8	16.8	17.7	19.5	18.5	21.0
1921	Aug	14.7	15.4	17.2	17.9	19.8	18.6	21.5
1921	Sep	15.1	15.5	16.8	17.1	19.1	17.5	20.1
1921	Oct	15.2	15.0	17.2	15.5	17.9	15.9	19.7
1921	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1921	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1922	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1922	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1922	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1922	Apr	11.3	11.8	13.5	12.9	14.8	13.5	15.8
1922	May	12.1	12.3	13.9	12.9	15.2	13.1	14.3
1922	Jun	13.1	13.5	15.5	14.2	16.8	14.5	15.4
1922	Jul	14.1	14.7	16.8	16.3	18.2	17.0	18.9
1922	Aug	14.7	15.3	17.2	16.6	18.6	17.2	19.6
1922	Sep	15.1	15.4	16.7	16.3	18.2	16.7	18.6
1922	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
1922	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1922	Dec	12.5	12.0	14.0	11.4	13.4	11.2	13.2
1923	Jan	10.3	10.0	11.1	9.7	11.4	9.7	11.1
1923	Feb	9.9	9.9	11.0	10.1	11.1	10.2	11.4
1923	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1923	Apr	11.3	11.8	13.5	13.1	14.9	13.8	16.2
1923	May	12.1	12.6	14.4	14.0	15.9	14.6	16.4
1923	Jun	13.1	13.8	15.8	15.4	17.4	16.0	17.8
1923	Jul	14.1	14.9	16.8	16.8	18.7	17.8	20.1
1923	Aug	14.7	15.4	17.2	17.1	19.0	17.9	20.6
1923	Sep	15.1	15.5	16.8	16.5	18.5	17.1	19.2
1923	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1923	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM
1923	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1924	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1924	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1924	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1924	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1924	May	12.1	13.4	15.4	17.6	18.1	21.1	25.1
1924	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1924	Jul	14.1	15.8	17.5	21.2	22.8	24.9	29.7
1924	Aug	14.7	16.2	17.9	20.8	22.4	24.0	29.0
1924	Sep	15.4	16.3	17.8	18.8	20.9	21.6	26.9
1924	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1924	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1924	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1925	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1925	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1925	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1925	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1925	May	12.1	12.7	14.5	14.3	16.1	15.1	17.0
1925	Jun	13.1	14.0	16.0	15.9	17.7	16.8	19.0
1925	Jul	14.1	15.0	17.0	17.5	19.4	19.0	21.7
1925	Aug	14.7	15.5	17.3	17.7	19.6	19.0	22.1
1925	Sep	15.1	15.6	17.0	16.9	18.9	17.7	20.4
1925	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1925	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1925	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1926	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1926	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1926	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1926	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1926	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1926	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1926	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1926	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1926	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1926	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1926	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1926	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1927	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1927	Feb	9.9	9.9	11.0	10.1	11.1	10.2	11.3
1927	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1927	Apr	11.3	11.7	13.4	12.7	14.7	13.2	15.3
1927	May	12.1	12.5	14.1	13.3	15.5	13.7	15.1
1927	Jun	13.1	13.6	15.6	14.5	16.9	14.9	16.0

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM
1927	Jul	14.1	14.7	16.8	16.4	18.3	17.1	19.1
1927	Aug	14.7	15.3	17.2	16.7	18.7	17.4	19.8
1927	Sep	15.1	15.4	16.8	16.3	18.2	16.7	18.6
1927	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1927	Nov	14.9	14.4	15.7	13.9	15.8	13.8	16.0
1927	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1928	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1928	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1928	Mar	10.6	10.7	12.0	10.9	12.2	11.1	12.2
1928	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1928	May	12.1	12.9	14.7	15.0	16.5	16.2	18.5
1928	Jun	13.1	14.0	16.0	16.0	17.7	16.9	19.2
1928	Jul	14.1	15.2	17.1	19.6	21.3	24.5	29.1
1928	Aug	14.7	15.8	17.5	19.8	21.5	24.0	29.0
1928	Sep	15.1	15.8	17.2	18.2	20.3	21.5	26.9
1928	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1928	Nov	14.9	14.4	15.7	13.9	15.8	13.8	16.0
1928	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1929	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1929	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1929	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1929	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1929	May	12.1	13.1	15.0	15.6	16.9	17.0	19.5
1929	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1929	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1929	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
1929	Sep	15.1	16.0	17.5	18.5	20.6	21.5	26.9
1929	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1929	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1929	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1930	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1930	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1930	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1930	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1930	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1930	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1930	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1930	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1930	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1930	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1930	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1930	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1931	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM
1931	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1931	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1931	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1931	May	12.1	13.4	15.4	17.6	18.1	21.1	25.1
1931	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1931	Jul	14.1	15.8	17.5	21.2	22.8	24.9	29.7
1931	Aug	15.1	16.5	18.1	20.9	22.5	24.0	29.0
1931	Sep	15.9	16.7	18.4	18.9	21.0	21.6	26.9
1931	Oct	16.3	15.6	17.7	15.9	18.3	16.7	20.9
1931	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1931	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1932	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1932	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1932	Mar	10.9	11.3	13.4	12.0	13.5	13.6	16.4
1932	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1932	May	12.1	13.0	14.8	15.1	16.6	16.3	18.7
1932	Jun	13.1	14.2	16.3	16.8	18.2	18.2	21.2
1932	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1932	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1932	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1932	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1932	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1932	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1933	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1933	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1933	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1933	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1933	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1933	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1933	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1933	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1933	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1933	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1933	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1933	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1934	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1934	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1934	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1934	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1934	May	12.1	13.1	15.0	15.6	16.9	17.0	19.5
1934	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1934	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1934	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM
1934	Sep	15.1	16.0	17.5	18.5	20.6	21.5	26.9
1934	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1934	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1934	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1935	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1935	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1935	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1935	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1935	May	12.1	12.7	14.5	14.3	16.1	15.1	17.0
1935	Jun	13.1	13.9	16.0	15.8	17.7	16.7	18.9
1935	Jul	14.1	15.0	16.9	17.4	19.2	18.8	21.4
1935	Aug	14.7	15.5	17.3	17.6	19.5	18.8	21.8
1935	Sep	15.1	15.6	16.9	16.8	18.8	17.6	20.2
1935	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1935	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1935	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1936	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1936	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1936	Mar	10.6	10.7	12.1	11.0	12.4	11.3	12.5
1936	Apr	11.3	11.7	13.4	12.6	14.6	13.1	15.0
1936	May	12.1	12.4	14.0	13.2	15.4	13.5	14.8
1936	Jun	13.1	13.6	15.6	14.7	17.0	15.1	16.4
1936	Jul	14.1	14.7	16.8	16.4	18.3	17.1	19.1
1936	Aug	14.7	15.3	17.2	16.7	18.7	17.4	19.8
1936	Sep	15.1	15.4	16.8	16.3	18.2	16.7	18.6
1936	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
1936	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1936	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1937	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1937	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1937	Mar	10.6	10.7	12.0	10.9	12.3	11.2	12.4
1937	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1937	May	12.1	12.6	14.3	13.7	15.7	14.2	15.8
1937	Jun	13.1	13.8	15.8	15.1	17.3	15.7	17.3
1937	Jul	14.1	14.8	16.8	16.7	18.6	17.7	19.8
1937	Aug	14.7	15.4	17.2	17.0	19.0	17.9	20.5
1937	Sep	15.1	15.5	16.8	16.5	18.4	17.0	19.2
1937	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1937	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1937	Dec	12.5	12.3	14.3	12.1	14.0	12.0	14.0
1938	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1938	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1938	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM
1938	Apr	11.3	11.5	13.1	11.8	14.2	12.0	13.4
1938	May	12.1	12.3	13.9	12.8	15.1	13.0	14.1
1938	Jun	13.1	13.5	15.5	14.3	16.8	14.6	15.6
1938	Jul	14.1	14.7	16.7	16.1	18.0	16.7	18.5
1938	Aug	14.7	15.2	17.1	16.4	18.4	17.0	19.3
1938	Sep	15.1	15.4	16.7	16.1	18.0	16.5	18.2
1938	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1938	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1938	Dec	12.5	11.8	13.8	11.0	13.0	10.7	12.8
1939	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1939	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1939	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1939	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1939	May	12.1	13.1	15.0	15.6	16.9	17.0	19.5
1939	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1939	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1939	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
1939	Sep	15.1	16.0	17.5	18.5	20.6	21.5	26.9
1939	Oct	15.2	15.0	17.1	15.4	17.6	15.7	19.4
1939	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1939	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1940	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1940	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1940	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9
1940	Apr	11.3	11.7	13.4	12.8	14.8	13.3	15.4
1940	May	12.1	12.4	14.1	13.3	15.4	13.6	15.0
1940	Jun	13.1	13.7	15.7	15.0	17.2	15.5	17.1
1940	Jul	14.1	14.9	16.9	16.8	18.7	17.8	20.1
1940	Aug	14.7	15.4	17.3	17.2	19.1	18.1	20.8
1940	Sep	15.1	15.5	16.8	16.6	18.5	17.1	19.4
1940	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1940	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1940	Dec	12.5	11.9	13.8	11.1	13.1	10.9	12.9
1941	Jan	10.3	10.0	11.1	9.8	11.4	9.8	11.2
1941	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1941	Mar	10.6	10.7	12.0	10.9	12.3	11.2	12.3
1941	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1941	May	12.1	12.5	14.2	13.5	15.5	13.8	15.3
1941	Jun	13.1	13.6	15.6	14.6	17.0	15.0	16.2
1941	Jul	14.1	14.7	16.8	16.3	18.2	17.0	18.9
1941	Aug	14.7	15.3	17.2	16.6	18.6	17.2	19.6
1941	Sep	15.1	15.4	16.7	16.2	18.2	16.6	18.5
1941	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM
1941	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1941	Dec	12.5	12.1	14.0	11.5	13.5	11.4	13.4
1942	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1942	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1942	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1942	Apr	11.3	11.8	13.5	13.1	14.9	13.8	16.1
1942	May	12.1	12.4	14.0	13.0	15.3	13.3	14.6
1942	Jun	13.1	13.6	15.5	14.4	16.9	14.7	15.8
1942	Jul	14.1	14.7	16.7	16.1	18.0	16.8	18.6
1942	Aug	14.7	15.3	17.1	16.5	18.5	17.1	19.4
1942	Sep	15.1	15.4	16.7	16.1	18.1	16.5	18.3
1942	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1942	Nov	14.9	14.5	15.8	14.1	15.9	14.1	16.1
1942	Dec	12.5	12.0	14.0	11.4	13.4	11.2	13.3
1943	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1943	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1943	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.8
1943	Apr	11.3	11.6	13.3	12.4	14.6	12.8	14.7
1943	May	12.1	12.4	14.0	13.1	15.3	13.5	14.8
1943	Jun	13.1	13.7	15.7	14.9	17.1	15.4	16.8
1943	Jul	14.1	14.8	16.8	16.5	18.4	17.3	19.4
1943	Aug	14.7	15.3	17.2	16.8	18.8	17.6	20.1
1943	Sep	15.1	15.5	16.8	16.4	18.3	16.8	18.8
1943	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1943	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1943	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1944	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1944	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1944	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1944	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1944	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1944	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1944	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1944	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1944	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1944	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1944	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1944	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1945	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1945	Feb	9.9	9.9	11.0	10.1	11.1	10.3	11.4
1945	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1945	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1945	May	12.1	12.6	14.2	13.7	15.7	14.1	15.7

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM
1945	Jun	13.1	13.8	15.8	15.2	17.3	15.8	17.4
1945	Jul	14.1	14.8	16.8	16.5	18.4	17.3	19.4
1945	Aug	14.7	15.3	17.2	16.8	18.8	17.5	20.0
1945	Sep	15.1	15.5	16.8	16.3	18.3	16.8	18.8
1945	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1945	Nov	14.9	14.5	15.8	14.1	15.8	14.0	16.0
1945	Dec	12.5	12.3	14.3	12.0	13.9	11.9	13.9
1946	Jan	10.3	10.1	11.1	9.8	11.4	9.8	11.2
1946	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1946	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1946	Apr	11.3	11.8	13.5	13.0	14.9	13.6	15.9
1946	May	12.1	12.7	14.4	14.1	16.0	14.8	16.6
1946	Jun	13.1	13.8	15.8	15.2	17.3	15.8	17.5
1946	Jul	14.1	14.9	16.9	17.1	18.9	18.2	20.6
1946	Aug	14.7	15.5	17.3	17.3	19.2	18.3	21.2
1946	Sep	15.1	15.5	16.9	16.7	18.6	17.3	19.7
1946	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1946	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1946	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1947	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1947	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1947	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1947	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1947	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1947	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1947	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1947	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1947	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1947	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1947	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1947	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1948	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1948	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1948	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1948	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1948	May	12.1	13.0	14.8	15.1	16.6	16.3	18.7
1948	Jun	13.1	14.2	16.3	16.8	18.2	18.2	21.2
1948	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1948	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1948	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1948	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1948	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1948	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM
1949	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1949	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1949	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1949	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1949	May	12.1	13.0	14.8	15.1	16.6	16.3	18.7
1949	Jun	13.1	14.2	16.3	16.8	18.2	18.2	21.2
1949	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1949	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1949	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1949	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1949	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1949	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1950	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1950	Feb	9.9	9.9	11.0	10.1	11.1	10.2	11.4
1950	Mar	10.6	10.7	12.2	11.2	12.6	11.7	13.2
1950	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1950	May	12.1	12.5	14.2	13.5	15.6	13.9	15.5
1950	Jun	13.1	13.7	15.7	14.9	17.2	15.5	16.9
1950	Jul	14.1	14.7	16.8	16.4	18.3	17.2	19.2
1950	Aug	14.7	15.3	17.2	16.8	18.7	17.5	19.9
1950	Sep	15.1	15.4	16.8	16.3	18.2	16.8	18.8
1950	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1950	Nov	14.9	14.8	16.0	14.8	16.1	14.8	16.4
1950	Dec	12.5	12.4	14.4	12.4	14.2	12.4	14.3
1951	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1951	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1951	Mar	10.6	10.7	12.1	11.1	12.4	11.4	12.7
1951	Apr	11.3	11.7	13.4	12.8	14.8	13.3	15.4
1951	May	12.1	12.6	14.3	13.9	15.8	14.4	16.0
1951	Jun	13.1	13.8	15.8	15.4	17.4	16.1	17.9
1951	Jul	14.1	15.0	17.0	17.8	19.6	19.6	22.4
1951	Aug	14.7	15.6	17.4	18.0	19.9	19.6	22.9
1951	Sep	15.1	15.6	17.0	17.1	19.0	18.1	21.0
1951	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1951	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1951	Dec	12.5	12.2	14.1	11.8	13.7	11.6	13.7
1952	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1952	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1952	Mar	10.6	10.6	11.9	10.9	12.2	11.0	12.0
1952	Apr	11.3	11.4	13.1	11.8	14.2	11.9	13.3
1952	May	12.1	12.3	13.9	12.8	15.1	13.0	14.1
1952	Jun	13.1	13.6	15.5	14.4	16.9	14.8	15.9
1952	Jul	14.1	14.6	16.6	15.8	17.8	16.3	18.1

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM
1952	Aug	14.7	15.2	17.1	16.2	18.2	16.7	18.8
1952	Sep	15.1	15.4	16.7	16.0	17.9	16.3	17.9
1952	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.6
1952	Nov	14.9	14.3	15.7	13.7	15.6	13.5	15.8
1952	Dec	12.5	11.8	13.8	11.0	13.0	10.7	12.8
1953	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1953	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1953	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1953	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1953	May	12.1	12.7	14.4	14.2	16.0	14.9	16.7
1953	Jun	13.1	13.9	15.9	15.6	17.6	16.4	18.5
1953	Jul	14.1	14.9	16.9	17.1	19.0	18.3	20.7
1953	Aug	14.7	15.5	17.3	17.4	19.3	18.4	21.2
1953	Sep	15.1	15.5	16.9	16.7	18.7	17.4	19.8
1953	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1953	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1953	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1954	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1954	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1954	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1954	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1954	May	12.1	13.0	14.8	15.1	16.6	16.3	18.7
1954	Jun	13.1	14.2	16.3	16.8	18.2	18.2	21.2
1954	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1954	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1954	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1954	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1954	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1954	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1955	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1955	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1955	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1955	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1955	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1955	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1955	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1955	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1955	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1955	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1955	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1955	Dec	12.5	12.4	14.4	12.2	14.1	12.2	14.1
1956	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.5
1956	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM
1956	Mar	10.6	10.8	12.2	11.2	12.6	11.8	13.3
1956	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1956	May	12.1	12.4	14.0	13.0	15.3	13.3	14.6
1956	Jun	13.1	13.6	15.6	14.4	16.9	14.8	15.9
1956	Jul	14.1	14.7	16.7	16.1	18.0	16.7	18.6
1956	Aug	14.7	15.2	17.1	16.4	18.4	17.0	19.3
1956	Sep	15.1	15.4	16.7	16.1	18.0	16.5	18.2
1956	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1956	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1956	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1957	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1957	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1957	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1957	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1957	May	12.1	12.8	14.6	14.6	16.2	15.4	17.5
1957	Jun	13.1	14.0	16.0	16.1	17.8	17.1	19.6
1957	Jul	14.1	15.1	17.0	18.0	19.8	19.9	22.9
1957	Aug	14.7	15.6	17.4	18.2	20.0	19.9	23.3
1957	Sep	15.1	15.7	17.0	17.2	19.2	18.3	21.4
1957	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1957	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1957	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1958	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1958	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1958	Mar	10.6	10.7	12.0	10.9	12.2	11.1	12.1
1958	Apr	11.3	11.5	13.1	11.9	14.3	12.1	13.6
1958	May	12.1	12.3	13.9	12.9	15.2	13.1	14.3
1958	Jun	13.1	13.6	15.5	14.4	16.9	14.7	15.8
1958	Jul	14.1	14.6	16.7	15.9	17.9	16.5	18.3
1958	Aug	14.7	15.2	17.1	16.4	18.4	16.9	19.1
1958	Sep	15.1	15.4	16.7	16.1	18.0	16.4	18.1
1958	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1958	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1958	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1959	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1959	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1959	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1959	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1959	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1959	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1959	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1959	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1959	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM
1959	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1959	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1959	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1960	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1960	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1960	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1960	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1960	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1960	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1960	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1960	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1960	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1960	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1960	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1960	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1961	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1961	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1961	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1961	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1961	May	12.1	13.4	15.4	17.6	18.1	21.1	25.1
1961	Jun	13.3	14.8	17.0	19.4	19.7	23.5	29.6
1961	Jul	14.9	16.4	18.0	20.9	22.4	24.9	29.6
1961	Aug	16.2	17.3	18.8	20.9	22.5	24.0	29.0
1961	Sep	17.1	17.5	19.5	19.1	21.3	21.6	27.0
1961	Oct	16.7	15.9	17.9	16.0	18.5	16.7	21.0
1961	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1961	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1962	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1962	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1962	Mar	11.3	11.6	14.1	12.2	13.7	13.7	16.5
1962	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1962	May	12.1	13.0	14.8	15.1	16.6	16.3	18.7
1962	Jun	13.1	14.2	16.3	16.8	18.2	18.2	21.2
1962	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1962	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1962	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1962	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1962	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1962	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1963	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1963	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1963	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1963	Apr	11.3	11.8	13.5	13.1	14.9	13.8	16.2

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM
1963	May	12.1	12.4	14.1	13.3	15.4	13.6	15.0
1963	Jun	13.1	13.7	15.7	14.8	17.1	15.2	16.6
1963	Jul	14.1	14.7	16.7	16.3	18.2	17.0	18.9
1963	Aug	14.7	15.3	17.1	16.6	18.6	17.2	19.6
1963	Sep	15.1	15.4	16.7	16.2	18.2	16.6	18.5
1963	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1963	Nov	14.9	14.5	15.8	14.2	15.9	14.1	16.1
1963	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1964	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1964	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1964	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1964	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1964	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1964	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1964	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1964	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1964	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1964	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1964	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1964	Dec	12.5	12.4	14.4	12.4	14.2	12.3	14.3
1965	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.5
1965	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1965	Mar	10.6	10.8	12.3	11.4	12.8	12.1	13.8
1965	Apr	11.3	11.8	13.5	12.9	14.8	13.6	15.8
1965	May	12.1	12.4	14.1	13.3	15.4	13.6	15.0
1965	Jun	13.1	13.6	15.6	14.6	17.0	15.0	16.3
1965	Jul	14.1	14.7	16.7	16.0	18.0	16.7	18.5
1965	Aug	14.7	15.2	17.1	16.4	18.4	16.9	19.2
1965	Sep	15.1	15.4	16.7	16.1	18.0	16.5	18.2
1965	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
1965	Nov	14.9	14.5	15.8	14.2	15.9	14.1	16.1
1965	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1966	Jan	10.3	9.9	11.0	9.6	11.4	9.5	10.9
1966	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1966	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1966	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1966	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1966	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1966	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1966	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1966	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1966	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1966	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM
1966	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1967	Jan	10.3	10.0	11.0	9.6	11.4	9.5	11.0
1967	Feb	9.9	9.9	11.0	10.1	11.1	10.2	11.3
1967	Mar	10.6	10.7	12.0	10.9	12.2	11.1	12.2
1967	Apr	11.3	11.5	13.2	12.2	14.4	12.4	14.1
1967	May	12.1	12.3	13.9	12.8	15.1	13.0	14.1
1967	Jun	13.1	13.6	15.6	14.5	16.9	14.9	16.0
1967	Jul	14.1	14.6	16.6	15.7	17.7	16.2	17.9
1967	Aug	14.7	15.2	17.0	16.2	18.2	16.6	18.7
1967	Sep	15.1	15.4	16.7	16.0	17.9	16.3	17.9
1967	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1967	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1967	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1968	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1968	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1968	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1968	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1968	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1968	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1968	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1968	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1968	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1968	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1968	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1968	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1969	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.5
1969	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1969	Mar	10.6	10.7	12.0	10.9	12.2	11.1	12.2
1969	Apr	11.3	11.5	13.1	11.8	14.2	12.0	13.4
1969	May	12.1	12.3	13.8	12.7	15.1	12.9	14.0
1969	Jun	13.1	13.6	15.6	14.5	16.9	14.8	15.9
1969	Jul	14.1	14.6	16.7	15.9	17.8	16.4	18.2
1969	Aug	14.7	15.2	17.1	16.2	18.3	16.7	18.9
1969	Sep	15.1	15.4	16.7	16.0	17.9	16.4	18.0
1969	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.6
1969	Nov	14.9	14.3	15.7	13.7	15.6	13.5	15.8
1969	Dec	12.5	11.9	13.9	11.3	13.3	11.0	13.1
1970	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.5
1970	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1970	Mar	10.6	10.7	12.1	11.0	12.4	11.3	12.5
1970	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1970	May	12.1	12.7	14.4	14.1	16.0	14.8	16.6
1970	Jun	13.1	13.9	15.9	15.6	17.5	16.4	18.4

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM
1970	Jul	14.1	15.0	16.9	17.6	19.4	19.1	21.8
1970	Aug	14.7	15.5	17.3	17.8	19.6	19.1	22.2
1970	Sep	15.1	15.6	17.0	16.9	18.9	17.8	20.4
1970	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
1970	Nov	14.9	14.5	15.8	14.2	15.9	14.1	16.1
1970	Dec	12.5	12.2	14.2	11.9	13.8	11.7	13.7
1971	Jan	10.3	10.1	11.1	9.9	11.5	9.8	11.2
1971	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1971	Mar	10.6	10.7	12.1	11.0	12.3	11.2	12.4
1971	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1971	May	12.1	12.6	14.3	13.9	15.8	14.4	16.1
1971	Jun	13.1	13.9	15.9	15.5	17.5	16.2	18.2
1971	Jul	14.1	14.9	16.9	16.9	18.8	17.9	20.2
1971	Aug	14.7	15.4	17.3	17.2	19.1	18.0	20.7
1971	Sep	15.1	15.5	16.8	16.5	18.5	17.1	19.3
1971	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1971	Nov	14.9	14.3	15.7	13.8	15.7	13.7	15.9
1971	Dec	12.5	11.9	13.9	11.3	13.3	11.1	13.2
1972	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1972	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1972	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1972	Apr	11.3	11.8	13.5	13.1	14.9	13.8	16.2
1972	May	12.1	13.0	14.8	15.1	16.6	16.3	18.7
1972	Jun	13.1	14.2	16.3	16.8	18.2	18.2	21.2
1972	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1972	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1972	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1972	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1972	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1972	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1973	Jan	10.3	10.0	11.1	9.8	11.4	9.8	11.2
1973	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1973	Mar	10.6	10.7	12.0	10.9	12.3	11.2	12.4
1973	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1973	May	12.1	12.6	14.3	13.8	15.8	14.4	16.0
1973	Jun	13.1	13.8	15.8	15.2	17.3	15.9	17.6
1973	Jul	14.1	14.8	16.8	16.8	18.6	17.7	19.9
1973	Aug	14.7	15.4	17.2	17.1	19.0	17.9	20.5
1973	Sep	15.1	15.5	16.8	16.5	18.4	17.0	19.2
1973	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1973	Nov	14.9	14.7	15.9	14.5	16.0	14.5	16.2
1973	Dec	12.5	12.2	14.2	11.9	13.8	11.8	13.8
1974	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM
1974	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1974	Mar	10.6	10.7	12.0	10.9	12.2	11.1	12.2
1974	Apr	11.3	11.6	13.3	12.5	14.6	12.9	14.8
1974	May	12.1	12.5	14.1	13.3	15.5	13.7	15.1
1974	Jun	13.1	13.7	15.6	14.7	17.0	15.2	16.5
1974	Jul	14.1	14.7	16.7	16.1	18.1	16.8	18.6
1974	Aug	14.7	15.3	17.1	16.5	18.5	17.1	19.5
1974	Sep	15.1	15.4	16.7	16.2	18.1	16.6	18.4
1974	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
1974	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1974	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1975	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1975	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1975	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1975	Apr	11.3	11.8	13.5	13.0	14.9	13.6	15.9
1975	May	12.1	12.5	14.2	13.5	15.5	13.8	15.3
1975	Jun	13.1	13.7	15.7	14.9	17.2	15.4	16.8
1975	Jul	14.1	14.7	16.7	16.0	18.0	16.7	18.5
1975	Aug	14.7	15.2	17.1	16.4	18.4	16.9	19.2
1975	Sep	15.1	15.4	16.7	16.1	18.0	16.4	18.2
1975	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1975	Nov	14.9	14.3	15.7	13.8	15.7	13.7	15.9
1975	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1976	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1976	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1976	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1976	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1976	May	12.1	13.4	15.4	17.6	18.1	21.1	25.1
1976	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1976	Jul	14.1	15.8	17.5	21.2	22.8	24.9	29.7
1976	Aug	14.7	16.2	17.9	20.8	22.4	24.0	29.0
1976	Sep	15.1	16.1	17.6	18.7	20.8	21.6	26.9
1976	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1976	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1976	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1977	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1977	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1977	Mar	12.6	12.5	16.2	12.6	14.2	13.1	15.5
1977	Apr	13.9	14.1	16.4	15.2	16.1	16.3	19.9
1977	May	15.0	15.8	18.8	18.5	18.7	21.1	25.1
1977	Jun	16.7	17.7	20.2	20.6	20.3	23.5	29.6
1977	Jul	18.3	19.2	20.2	22.4	23.9	24.9	29.7
1977	Aug	19.5	20.0	21.0	22.0	23.5	24.0	29.0

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM
1977	Sep	20.1	19.8	22.5	19.7	22.0	21.6	27.0
1977	Oct	20.2	18.4	20.1	17.0	19.8	17.3	21.9
1977	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1977	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1978	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1978	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1978	Mar	19.1	17.0	26.8	15.0	17.0	15.0	18.6
1978	Apr	19.7	18.8	22.2	17.6	17.4	17.8	22.1
1978	May	20.5	20.2	24.9	20.0	19.7	21.2	25.2
1978	Jun	21.6	21.6	24.6	22.2	21.2	23.6	29.7
1978	Jul	22.5	22.7	22.7	23.5	24.9	24.9	29.7
1978	Aug	23.2	22.9	23.4	22.8	24.2	24.0	29.0
1978	Sep	23.6	22.4	25.9	20.4	22.7	21.6	27.0
1978	Oct	23.7	20.8	22.3	17.9	21.1	17.7	22.6
1978	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1978	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1979	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1979	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1979	Mar	19.1	17.0	26.8	15.0	17.0	14.9	18.6
1979	Apr	19.7	18.8	22.2	17.6	17.4	17.8	22.1
1979	May	18.2	18.4	22.3	19.4	19.3	21.1	25.2
1979	Jun	17.1	17.8	20.4	20.6	20.3	23.5	29.6
1979	Jul	17.7	18.6	19.6	21.6	23.1	24.9	29.6
1979	Aug	18.0	18.6	19.9	21.2	22.7	24.0	29.0
1979	Sep	17.6	17.9	20.0	19.2	21.3	21.6	27.0
1979	Oct	16.9	16.2	18.2	16.1	18.7	16.8	21.1
1979	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1979	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1980	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1980	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1980	Mar	10.6	10.7	12.1	11.0	12.3	11.2	12.4
1980	Apr	11.3	11.7	13.4	12.8	14.8	13.3	15.4
1980	May	12.1	12.5	14.1	13.3	15.4	13.7	15.1
1980	Jun	13.1	13.6	15.6	14.6	17.0	15.0	16.2
1980	Jul	14.1	14.7	16.7	16.0	18.0	16.6	18.5
1980	Aug	14.7	15.2	17.1	16.4	18.4	16.9	19.2
1980	Sep	15.1	15.4	16.7	16.1	18.0	16.4	18.2
1980	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1980	Nov	14.9	14.4	15.8	14.0	15.8	13.9	16.0
1980	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1981	Jan	10.3	10.0	11.1	9.8	11.4	9.7	11.1
1981	Feb	9.9	9.9	11.0	10.1	11.1	10.2	11.3
1981	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM
1981	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1981	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1981	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1981	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1981	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1981	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1981	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1981	Nov	14.9	14.5	15.8	14.1	15.8	14.0	16.0
1981	Dec	12.5	12.4	14.3	12.2	14.1	12.2	14.1
1982	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1982	Feb	9.9	9.9	11.0	10.0	11.1	10.0	11.2
1982	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9
1982	Apr	11.3	11.4	13.0	11.7	14.2	11.8	13.2
1982	May	12.1	12.3	13.9	12.8	15.1	13.0	14.2
1982	Jun	13.1	13.6	15.6	14.6	17.0	15.0	16.2
1982	Jul	14.1	14.6	16.7	15.9	17.9	16.5	18.3
1982	Aug	14.7	15.2	17.1	16.3	18.3	16.8	19.1
1982	Sep	15.1	15.4	16.7	16.1	18.0	16.4	18.1
1982	Oct	15.2	15.0	17.2	15.4	17.7	15.9	19.6
1982	Nov	14.9	14.7	15.9	14.5	16.0	14.4	16.2
1982	Dec	12.5	12.3	14.3	12.1	14.0	12.0	14.0
1983	Jan	10.3	10.2	11.2	10.0	11.5	10.0	11.4
1983	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1983	Mar	10.6	10.6	11.9	10.7	12.0	10.8	11.7
1983	Apr	11.3	11.5	13.1	12.0	14.3	12.2	13.8
1983	May	12.1	12.2	13.8	12.6	15.0	12.8	13.9
1983	Jun	13.1	13.4	15.4	14.0	16.6	14.2	15.0
1983	Jul	14.1	14.5	16.5	15.3	17.3	15.6	17.1
1983	Aug	14.7	15.1	17.0	15.8	17.8	16.1	18.0
1983	Sep	15.1	15.3	16.6	15.7	17.6	15.9	17.3
1983	Oct	15.2	15.0	17.2	15.4	17.7	15.9	19.6
1983	Nov	14.9	14.8	16.0	14.7	16.1	14.6	16.3
1983	Dec	12.5	12.4	14.4	12.3	14.1	12.2	14.2
1984	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1984	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1984	Mar	10.6	10.7	12.1	11.1	12.5	11.5	12.8
1984	Apr	11.3	11.7	13.4	12.8	14.8	13.3	15.4
1984	May	12.1	12.6	14.3	13.7	15.7	14.2	15.8
1984	Jun	13.1	13.8	15.8	15.2	17.3	15.8	17.4
1984	Jul	14.1	14.8	16.8	16.6	18.5	17.5	19.6
1984	Aug	14.7	15.4	17.2	16.9	18.9	17.7	20.2
1984	Sep	15.1	15.5	16.8	16.4	18.3	16.9	18.9
1984	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM
1984	Nov	14.9	14.5	15.8	14.1	15.9	14.0	16.0
1984	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1985	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1985	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1985	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1985	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1985	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1985	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1985	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1985	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
1985	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1985	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1985	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1985	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1986	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1986	Feb	9.9	9.9	11.0	10.0	11.0	10.0	11.2
1986	Mar	10.6	10.6	11.9	10.7	12.1	10.8	11.7
1986	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1986	May	12.1	12.4	14.0	13.1	15.3	13.4	14.7
1986	Jun	13.1	13.7	15.7	14.8	17.1	15.2	16.6
1986	Jul	14.1	14.7	16.7	16.3	18.2	17.1	19.1
1986	Aug	14.7	15.3	17.2	16.7	18.6	17.3	19.7
1986	Sep	15.1	15.4	16.7	16.3	18.2	16.7	18.6
1986	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1986	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1986	Dec	12.5	11.8	13.8	11.0	13.0	10.7	12.8
1987	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1987	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1987	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1987	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1987	May	12.1	13.4	15.4	17.6	18.1	21.1	25.1
1987	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1987	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1987	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
1987	Sep	15.1	16.0	17.5	18.6	20.8	21.6	26.9
1987	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1987	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1987	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1988	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1988	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1988	Mar	11.2	11.4	13.7	11.8	13.3	12.5	14.5
1988	Apr	12.4	12.9	14.8	14.5	15.7	15.8	19.2
1988	May	13.0	14.2	16.6	17.9	18.3	21.1	25.1

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM
1988	Jun	14.2	15.5	17.8	19.7	19.8	23.5	29.6
1988	Jul	15.1	16.6	18.2	21.5	23.0	24.9	29.7
1988	Aug	15.6	16.9	18.5	21.0	22.6	24.0	29.0
1988	Sep	15.8	16.6	18.2	18.8	21.0	21.6	26.9
1988	Oct	15.6	15.1	17.2	15.7	18.1	16.6	20.8
1988	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1988	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1989	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1989	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1989	Mar	12.1	12.1	15.4	12.5	14.1	13.8	16.7
1989	Apr	12.8	13.2	15.3	14.4	15.6	15.2	18.3
1989	May	12.3	13.2	15.1	15.3	16.7	16.5	18.9
1989	Jun	13.3	14.3	16.4	16.8	18.2	18.2	21.3
1989	Jul	14.3	15.6	17.4	20.2	21.8	24.9	29.6
1989	Aug	14.9	16.1	17.8	20.1	21.8	24.0	29.0
1989	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1989	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1989	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1989	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1990	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1990	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1990	Mar	11.4	11.5	13.9	11.9	13.4	12.5	14.5
1990	Apr	12.4	12.8	14.8	14.1	15.5	15.0	17.9
1990	May	13.2	14.1	16.3	16.2	17.3	17.5	20.2
1990	Jun	14.1	15.5	17.7	19.7	19.8	23.5	29.6
1990	Jul	14.9	16.4	18.0	20.9	22.4	24.9	29.6
1990	Aug	15.4	16.7	18.3	20.6	22.2	24.0	29.0
1990	Sep	15.5	16.3	17.8	18.6	20.7	21.5	26.9
1990	Oct	15.3	15.1	17.2	15.4	17.7	15.9	19.7
1990	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1990	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1991	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1991	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1991	Mar	12.7	12.6	16.6	12.7	14.3	13.1	15.6
1991	Apr	14.3	14.4	16.8	15.2	16.1	15.9	19.3
1991	May	14.8	15.5	18.3	17.2	17.9	18.2	21.2
1991	Jun	15.5	16.7	19.0	20.2	20.1	23.5	29.6
1991	Jul	16.1	17.4	18.7	21.3	22.8	24.9	29.6
1991	Aug	16.4	17.5	18.9	20.9	22.5	24.0	29.0
1991	Sep	16.2	16.9	18.6	18.8	21.0	21.5	26.9
1991	Oct	15.7	15.2	17.3	15.7	18.1	16.6	20.8
1991	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1991	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM
1992	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1992	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1992	Mar	11.8	11.9	14.9	12.4	14.0	13.8	16.6
1992	Apr	13.0	13.4	15.5	14.8	15.9	16.1	19.5
1992	May	13.7	14.8	17.3	18.1	18.5	21.1	25.1
1992	Jun	14.9	16.2	18.5	20.0	20.0	23.5	29.6
1992	Jul	16.0	17.3	18.7	21.3	22.8	24.9	29.6
1992	Aug	16.8	17.8	19.2	21.1	22.6	24.0	29.0
1992	Sep	17.0	17.5	19.4	19.1	21.2	21.6	27.0
1992	Oct	16.8	16.0	18.0	16.0	18.5	16.8	21.1
1992	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1992	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1993	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1993	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1993	Mar	10.6	11.0	12.8	11.9	13.4	13.6	16.3
1993	Apr	11.3	11.9	13.6	13.4	15.1	14.3	16.9
1993	May	12.1	12.6	14.3	13.7	15.7	14.2	15.7
1993	Jun	13.1	13.8	15.8	15.1	17.3	15.7	17.3
1993	Jul	14.1	14.8	16.8	16.5	18.4	17.4	19.5
1993	Aug	14.7	15.4	17.2	16.8	18.8	17.5	20.1
1993	Sep	15.1	15.5	16.8	16.4	18.3	16.8	18.8
1993	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1993	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1993	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1994	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1994	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1994	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1994	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1994	May	12.1	13.4	15.4	17.6	18.1	21.1	25.1
1994	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
1994	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1994	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
1994	Sep	15.1	16.0	17.5	18.6	20.8	21.6	26.9
1994	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1994	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1994	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1995	Jan	10.3	9.8	10.9	9.2	11.2	9.0	10.5
1995	Feb	9.9	9.9	11.0	10.1	11.1	10.2	11.3
1995	Mar	10.6	10.6	11.9	10.7	12.1	10.8	11.7
1995	Apr	11.3	11.4	13.1	11.8	14.2	11.9	13.3
1995	May	12.1	12.2	13.8	12.6	15.0	12.8	13.9
1995	Jun	13.1	13.5	15.5	14.3	16.8	14.6	15.6
1995	Jul	14.1	14.5	16.6	15.5	17.5	15.9	17.5

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM
1995	Aug	14.7	15.1	17.0	16.0	18.0	16.3	18.3
1995	Sep	15.1	15.3	16.6	15.9	17.7	16.1	17.5
1995	Oct	15.2	15.0	17.2	15.4	17.7	15.9	19.6
1995	Nov	14.9	14.3	15.7	13.7	15.6	13.5	15.8
1995	Dec	12.5	11.8	13.8	11.0	13.0	10.6	12.7
1996	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1996	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1996	Mar	10.6	10.6	11.9	10.9	12.2	11.0	12.0
1996	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1996	May	12.1	12.4	14.0	13.1	15.3	13.3	14.6
1996	Jun	13.1	13.7	15.7	14.9	17.2	15.5	16.9
1996	Jul	14.1	14.8	16.8	16.6	18.5	17.5	19.6
1996	Aug	14.7	15.4	17.2	16.9	18.9	17.7	20.2
1996	Sep	15.1	15.5	16.8	16.4	18.3	16.9	19.0
1996	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1996	Nov	14.9	14.5	15.8	14.1	15.9	14.1	16.1
1996	Dec	12.5	12.4	14.4	12.2	14.1	12.2	14.1
1997	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.6
1997	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1997	Mar	10.6	10.7	12.1	11.1	12.4	11.4	12.7
1997	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1997	May	12.1	12.7	14.4	14.1	15.9	14.8	16.6
1997	Jun	13.1	13.9	15.9	15.7	17.6	16.5	18.6
1997	Jul	14.1	15.0	17.0	17.8	19.6	19.7	22.6
1997	Aug	14.7	15.6	17.4	18.0	19.9	19.6	23.0
1997	Sep	15.1	15.6	17.0	17.1	19.1	18.1	21.1
1997	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1997	Nov	14.9	14.4	15.8	14.0	15.8	13.9	16.0
1997	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1998	Jan	10.3	10.1	11.1	9.8	11.4	9.8	11.2
1998	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1998	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9
1998	Apr	11.3	11.5	13.1	12.0	14.3	12.1	13.7
1998	May	12.1	12.3	13.9	12.9	15.2	13.0	14.2
1998	Jun	13.1	13.6	15.5	14.4	16.9	14.7	15.8
1998	Jul	14.1	14.5	16.6	15.6	17.6	16.1	17.8
1998	Aug	14.7	15.1	17.0	16.1	18.1	16.5	18.6
1998	Sep	15.1	15.3	16.6	15.9	17.8	16.1	17.7
1998	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.6
1998	Nov	14.9	14.3	15.7	13.7	15.6	13.5	15.8
1998	Dec	12.5	11.8	13.8	11.0	13.0	10.7	12.8
1999	Jan	10.3	10.0	11.1	9.8	11.4	9.8	11.2
1999	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1999	Mar	10.6	10.7	12.0	10.9	12.3	11.1	12.2
1999	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1999	May	12.1	12.5	14.2	13.5	15.6	13.9	15.4
1999	Jun	13.1	13.7	15.7	15.0	17.2	15.5	17.0
1999	Jul	14.1	14.7	16.8	16.3	18.2	17.1	19.0
1999	Aug	14.7	15.3	17.2	16.6	18.6	17.2	19.6
1999	Sep	15.1	15.4	16.7	16.3	18.2	16.7	18.6
1999	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1999	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1999	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
2000	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
2000	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
2000	Mar	10.6	10.7	12.0	10.9	12.3	11.2	12.3
2000	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
2000	May	12.1	12.7	14.4	14.0	15.9	14.7	16.4
2000	Jun	13.1	13.9	15.9	15.7	17.6	16.6	18.7
2000	Jul	14.1	15.0	17.0	17.6	19.4	19.1	21.7
2000	Aug	14.7	15.5	17.3	17.8	19.6	19.1	22.2
2000	Sep	15.1	15.6	17.0	16.9	18.9	17.8	20.5
2000	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
2000	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
2000	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
2001	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
2001	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
2001	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
2001	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
2001	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
2001	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
2001	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
2001	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
2001	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
2001	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
2001	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
2001	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
2002	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
2002	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
2002	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
2002	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
2002	May	12.1	13.0	14.8	15.1	16.6	16.3	18.7
2002	Jun	13.1	14.2	16.3	16.8	18.2	18.2	21.2
2002	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
2002	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
2002	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM	Monthly Mean	Monthly Max 7DADM
2002	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
2002	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
2002	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
2003	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
2003	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
2003	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
2003	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
2003	May	12.1	12.9	14.7	14.9	16.5	16.0	18.2
2003	Jun	13.1	14.1	16.1	16.4	18.0	17.8	20.5
2003	Jul	14.1	15.2	17.1	19.0	20.8	22.6	26.5
2003	Aug	14.7	15.7	17.5	19.2	20.9	22.5	26.9
2003	Sep	15.1	15.8	17.2	17.8	19.8	20.2	24.6
2003	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
2003	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
2003	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
2004	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
2004	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
2004	Mar	10.6	10.7	12.1	11.0	12.4	11.4	12.7
2004	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
2004	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
2004	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
2004	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
2004	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
2004	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
2004	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
2004	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
2004	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
2005	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
2005	Feb	9.9	9.9	11.0	10.1	11.1	10.2	11.3
2005	Mar	10.6	10.6	11.9	10.8	12.2	11.0	12.0
2005	Apr	11.3	11.6	13.3	12.4	14.5	12.8	14.6
2005	May	12.1	12.4	14.0	13.0	15.3	13.3	14.6
2005	Jun	13.1	13.6	15.6	14.6	17.0	15.0	16.2
2005	Jul	14.1	14.7	16.7	16.1	18.1	16.8	18.6
2005	Aug	14.7	15.3	17.1	16.5	18.5	17.1	19.5
2005	Sep	15.1	15.4	16.7	16.2	18.1	16.5	18.3
2005	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
2005	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
2005	Dec	12.5	12.3	14.3	12.1	14.0	12.0	14.0
2006	Jan	10.3	10.2	11.2	10.1	11.5	10.1	11.5
2006	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
2006	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9
2006	Apr	11.3	11.4	13.0	11.7	14.1	11.8	13.1

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM
2006	May	12.1	12.3	13.9	12.8	15.1	13.0	14.1
2006	Jun	13.1	13.6	15.6	14.5	16.9	14.9	16.0
2006	Jul	14.1	14.7	16.7	16.3	18.2	17.1	19.1
2006	Aug	14.7	15.3	17.1	16.7	18.6	17.3	19.7
2006	Sep	15.1	15.4	16.7	16.3	18.2	16.7	18.6
2006	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.6
2006	Nov	14.9	14.3	15.7	13.7	15.6	13.5	15.8
2006	Dec	12.5	11.8	13.8	11.0	13.0	10.7	12.8
2007	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
2007	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
2007	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
2007	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
2007	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
2007	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
2007	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
2007	Aug	14.7	15.9	17.6	20.0	21.7	24.0	29.0
2007	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
2007	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
2007	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
2007	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
2008	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
2008	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
2008	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
2008	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
2008	May	12.1	13.1	15.0	15.6	16.9	17.0	19.5
2008	Jun	13.1	14.7	16.8	19.4	19.6	23.5	29.6
2008	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
2008	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
2008	Sep	15.1	16.0	17.5	18.5	20.6	21.5	26.9
2008	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
2008	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
2008	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
2009	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
2009	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
2009	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
2009	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
2009	May	12.1	12.9	14.7	15.0	16.5	16.2	18.5
2009	Jun	13.1	14.1	16.2	16.6	18.1	18.0	21.0
2009	Jul	14.1	15.3	17.2	19.8	21.5	24.8	29.6
2009	Aug	14.7	15.8	17.5	19.9	21.5	24.0	29.0
2009	Sep	15.1	15.8	17.3	18.2	20.3	21.5	26.9
2009	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
2009	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM
2009	Dec	12.5	12.2	14.2	11.9	13.8	11.8	13.8

5.5 Case 5: Cumulative Effects

Modeling output from EBMUDSIM for the cumulative effects case (presented in Section 4.5) was formulated into the necessary input to SSTEMP along with the meteorology presented in Table 3.3-11 and the calibrated parameters from Table 3.3-13. SSTEMP model output was monthly mean water temperature for the downstream stations Elliott, Golf, and Frandy. Then MM7DADM is estimated using the regression models from Section 3.3.5. The monthly mean temperatures and the estimated MM7DADM for each month of the hydrologic POR (1921-2009) are presented in Table 5.5-1.

Table 5.5-1. Simulated Monthly Average and Estimated Monthly Maximum of 7-Day Average of Daily Maximum (7DADM) Water Temperature [°C], Cumulative Effects Case

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM	Monthly Mean	Max 7DADM
1921	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.5
1921	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1921	Mar	10.6	10.7	12.0	10.9	12.3	11.2	12.3
1921	Apr	11.3	11.7	13.4	13.6	15.2	14.1	16.6
1921	May	12.1	12.5	14.2	14.4	16.1	14.8	16.6
1921	Jun	13.1	13.6	15.6	15.1	17.3	15.4	16.9
1921	Jul	14.1	14.8	16.8	17.9	19.7	18.7	21.3
1921	Aug	14.7	15.4	17.2	18.1	19.9	18.8	21.9
1921	Sep	15.1	15.5	16.8	17.3	19.3	17.8	20.4
1921	Oct	15.2	15.0	17.2	15.5	17.9	15.9	19.7
1921	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1921	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1922	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1922	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1922	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1922	Apr	11.3	11.8	13.5	13.0	14.9	13.7	16.0
1922	May	12.1	12.3	13.9	12.9	15.2	13.2	14.4
1922	Jun	13.1	13.5	15.5	14.2	16.8	14.5	15.4
1922	Jul	14.1	14.7	16.8	16.4	18.3	17.1	19.1
1922	Aug	14.7	15.3	17.2	16.7	18.7	17.4	19.8
1922	Sep	15.1	15.4	16.8	16.3	18.2	16.7	18.6
1922	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1922	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1922	Dec	12.5	11.9	13.9	11.2	13.2	11.0	13.1
1923	Jan	10.3	10.0	11.1	9.7	11.4	9.7	11.1
1923	Feb	9.9	9.9	11.0	10.1	11.1	10.3	11.4
1923	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1923	Apr	11.3	11.8	13.5	13.1	14.9	13.8	16.2
1923	May	12.1	12.7	14.4	14.1	16.0	14.8	16.6
1923	Jun	13.1	13.8	15.8	15.4	17.4	16.1	17.9
1923	Jul	14.1	14.9	16.9	17.1	18.9	18.2	20.6
1923	Aug	14.7	15.5	17.3	17.3	19.2	18.3	21.2
1923	Sep	15.1	15.5	16.9	16.7	18.6	17.3	19.7
1923	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1923	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1923	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1924	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1924	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1924	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1924	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1924	May	12.1	13.4	15.4	17.5	18.1	21.1	25.1
1924	Jun	13.1	14.7	16.8	19.3	19.6	23.5	29.6
1924	Jul	14.1	15.7	17.5	21.2	22.7	24.9	29.7
1924	Aug	14.7	16.2	17.9	20.8	22.4	24.0	29.0
1924	Sep	15.3	16.2	17.8	18.7	20.9	21.6	26.9
1924	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1924	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1924	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1925	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1925	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1925	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1925	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1925	May	12.1	12.8	14.6	14.6	16.2	15.5	17.5
1925	Jun	13.1	14.0	16.0	16.1	17.8	17.2	19.6
1925	Jul	14.1	15.1	17.0	18.0	19.8	20.0	23.0
1925	Aug	14.7	15.6	17.4	18.2	20.0	19.9	23.3
1925	Sep	15.1	15.7	17.0	17.2	19.2	18.3	21.4
1925	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1925	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1925	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1926	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1926	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1926	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1926	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1926	May	12.1	13.1	15.0	15.6	16.9	16.9	19.5
1926	Jun	13.1	14.7	16.8	19.3	19.6	23.5	29.6

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1926	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1926	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
1926	Sep	15.1	16.0	17.5	18.5	20.6	21.5	26.9
1926	Oct	15.2	15.0	17.1	15.4	17.6	15.7	19.4
1926	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1926	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1927	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1927	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1927	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1927	Apr	11.3	11.7	13.4	12.8	14.8	13.3	15.4
1927	May	12.1	12.5	14.1	13.4	15.5	13.8	15.3
1927	Jun	13.1	13.6	15.6	14.6	17.0	14.9	16.1
1927	Jul	14.1	14.8	16.8	16.5	18.4	17.3	19.4
1927	Aug	14.7	15.3	17.2	16.8	18.8	17.5	20.0
1927	Sep	15.1	15.5	16.8	16.3	18.3	16.8	18.8
1927	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1927	Nov	14.9	14.4	15.7	13.9	15.8	13.8	15.9
1927	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1928	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1928	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1928	Mar	10.6	10.7	12.0	10.9	12.3	11.1	12.2
1928	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1928	May	12.1	12.9	14.8	15.1	16.6	16.2	18.6
1928	Jun	13.1	14.0	16.1	16.0	17.8	16.9	19.3
1928	Jul	14.1	15.3	17.2	19.7	21.4	23.8	28.1
1928	Aug	14.7	15.8	17.6	19.8	21.4	23.9	28.9
1928	Sep	15.1	15.8	17.3	18.1	20.2	21.4	26.7
1928	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.3
1928	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1928	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1929	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1929	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1929	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1929	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1929	May	12.1	13.1	15.0	15.6	16.9	16.9	19.5
1929	Jun	13.1	14.7	16.8	19.3	19.6	23.5	29.6
1929	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1929	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
1929	Sep	15.1	16.0	17.5	18.5	20.6	21.5	26.9
1929	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1929	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1929	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1930	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1930	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1930	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1930	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1930	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1930	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1930	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1930	Aug	14.7	15.8	17.6	20.0	21.6	24.0	29.0
1930	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1930	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1930	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1930	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1931	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1931	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1931	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1931	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1931	May	12.1	13.4	15.4	17.5	18.1	21.1	25.1
1931	Jun	13.1	14.7	16.8	19.3	19.6	23.5	29.6
1931	Jul	14.6	16.2	17.8	21.3	22.9	24.9	29.7
1931	Aug	15.8	17.0	18.6	21.1	22.6	24.0	29.0
1931	Sep	16.6	17.2	19.0	19.0	21.2	21.6	26.9
1931	Oct	17.0	16.1	18.1	16.1	18.6	16.8	21.1
1931	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1931	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1932	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1932	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1932	Mar	11.5	11.7	14.4	12.2	13.8	13.8	16.6
1932	Apr	11.7	12.3	14.1	13.8	15.3	14.7	17.5
1932	May	12.1	13.0	14.8	15.1	16.6	16.3	18.6
1932	Jun	13.1	14.2	16.2	16.7	18.2	18.1	21.1
1932	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1932	Aug	14.7	15.8	17.6	20.0	21.6	24.0	29.0
1932	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1932	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1932	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1932	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1933	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1933	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1933	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1933	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1933	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1933	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1933	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1933	Aug	14.7	15.8	17.6	20.0	21.6	24.0	29.0

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1933	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1933	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1933	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1933	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1934	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1934	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1934	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1934	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1934	May	12.1	13.1	15.0	15.6	16.9	16.9	19.5
1934	Jun	13.1	14.7	16.8	19.3	19.6	23.5	29.6
1934	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1934	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
1934	Sep	15.1	16.0	17.5	18.5	20.6	21.5	26.9
1934	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1934	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1934	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1935	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1935	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1935	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1935	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1935	May	12.1	12.9	14.8	15.1	16.6	16.3	18.6
1935	Jun	13.1	14.2	16.2	16.7	18.2	18.1	21.1
1935	Jul	14.1	15.3	17.2	20.0	21.6	24.9	29.6
1935	Aug	14.7	15.8	17.6	19.9	21.6	24.0	29.0
1935	Sep	15.1	15.8	17.3	18.3	20.4	21.5	26.9
1935	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.3
1935	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1935	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1936	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1936	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1936	Mar	10.6	10.7	12.1	11.0	12.4	11.4	12.6
1936	Apr	11.3	11.7	13.4	12.6	14.7	13.1	15.1
1936	May	12.1	12.4	14.1	13.2	15.4	13.5	14.9
1936	Jun	13.1	13.7	15.6	14.7	17.1	15.2	16.5
1936	Jul	14.1	14.8	16.8	16.5	18.4	17.3	19.4
1936	Aug	14.7	15.3	17.2	16.8	18.8	17.5	20.1
1936	Sep	15.1	15.5	16.8	16.3	18.3	16.8	18.8
1936	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
1936	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1936	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1937	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1937	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1937	Mar	10.6	10.7	12.1	11.1	12.4	11.4	12.7

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1937	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1937	May	12.1	12.6	14.3	13.8	15.8	14.4	16.0
1937	Jun	13.1	13.8	15.8	15.3	17.4	16.0	17.8
1937	Jul	14.1	14.9	16.9	16.9	18.8	17.9	20.2
1937	Aug	14.7	15.4	17.3	17.2	19.1	18.1	20.8
1937	Sep	15.1	15.5	16.8	16.5	18.5	17.1	19.4
1937	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1937	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1937	Dec	12.5	12.3	14.3	12.0	13.9	11.9	13.9
1938	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1938	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1938	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9
1938	Apr	11.3	11.5	13.1	11.8	14.2	12.0	13.4
1938	May	12.1	12.3	13.9	12.8	15.1	13.0	14.2
1938	Jun	13.1	13.5	15.5	14.3	16.8	14.6	15.6
1938	Jul	14.1	14.7	16.7	16.1	18.1	16.8	18.7
1938	Aug	14.7	15.3	17.1	16.5	18.5	17.1	19.5
1938	Sep	15.1	15.4	16.7	16.2	18.1	16.6	18.4
1938	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1938	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1938	Dec	12.5	11.8	13.8	11.0	13.1	10.7	12.8
1939	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1939	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1939	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1939	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1939	May	12.1	13.1	15.0	15.6	16.9	16.9	19.5
1939	Jun	13.1	14.7	16.8	19.3	19.6	23.5	29.6
1939	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1939	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
1939	Sep	15.1	16.0	17.5	18.5	20.6	21.5	26.9
1939	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1939	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1939	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1940	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1940	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1940	Mar	10.6	10.6	11.9	10.8	12.2	11.0	12.0
1940	Apr	11.3	11.7	13.4	12.8	14.8	13.3	15.4
1940	May	12.1	12.5	14.1	13.3	15.4	13.7	15.1
1940	Jun	13.1	13.8	15.8	15.1	17.3	15.7	17.3
1940	Jul	14.1	14.9	16.9	17.1	18.9	18.2	20.6
1940	Aug	14.7	15.5	17.3	17.3	19.3	18.4	21.2
1940	Sep	15.1	15.5	16.9	16.7	18.6	17.3	19.7
1940	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1940	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1940	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1941	Jan	10.3	10.0	11.1	9.7	11.4	9.7	11.1
1941	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1941	Mar	10.6	10.7	12.0	10.9	12.3	11.2	12.4
1941	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1941	May	12.1	12.5	14.2	13.5	15.6	13.9	15.4
1941	Jun	13.1	13.7	15.6	14.7	17.0	15.1	16.5
1941	Jul	14.1	14.7	16.8	16.4	18.3	17.1	19.1
1941	Aug	14.7	15.3	17.2	16.7	18.7	17.4	19.8
1941	Sep	15.1	15.4	16.8	16.3	18.2	16.7	18.6
1941	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1941	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1941	Dec	12.5	12.0	14.0	11.4	13.4	11.2	13.3
1942	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1942	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1942	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1942	Apr	11.3	11.8	13.5	13.1	14.9	13.8	16.1
1942	May	12.1	12.4	14.0	13.1	15.3	13.3	14.6
1942	Jun	13.1	13.6	15.5	14.4	16.9	14.7	15.8
1942	Jul	14.1	14.7	16.7	16.2	18.1	16.9	18.8
1942	Aug	14.7	15.3	17.1	16.6	18.6	17.1	19.5
1942	Sep	15.1	15.4	16.7	16.2	18.1	16.6	18.5
1942	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
1942	Nov	14.9	14.5	15.8	14.1	15.8	14.0	16.0
1942	Dec	12.5	12.0	13.9	11.4	13.4	11.2	13.2
1943	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1943	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1943	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9
1943	Apr	11.3	11.6	13.3	12.5	14.6	12.8	14.7
1943	May	12.1	12.4	14.0	13.2	15.4	13.5	14.8
1943	Jun	13.1	13.7	15.7	14.9	17.2	15.5	16.9
1943	Jul	14.1	14.8	16.8	16.7	18.6	17.6	19.7
1943	Aug	14.7	15.4	17.2	17.0	18.9	17.8	20.4
1943	Sep	15.1	15.5	16.8	16.5	18.4	17.0	19.1
1943	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
1943	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1943	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1944	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1944	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1944	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1944	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1944	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1944	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1944	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1944	Aug	14.7	15.8	17.6	20.0	21.6	24.0	29.0
1944	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1944	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1944	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1944	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1945	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1945	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1945	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1945	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1945	May	12.1	12.6	14.3	13.8	15.8	14.4	16.0
1945	Jun	13.1	13.8	15.8	15.2	17.3	15.9	17.6
1945	Jul	14.1	14.8	16.8	16.7	18.6	17.6	19.7
1945	Aug	14.7	15.4	17.2	17.0	18.9	17.7	20.3
1945	Sep	15.1	15.5	16.8	16.5	18.4	16.9	19.0
1945	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1945	Nov	14.9	14.5	15.8	14.1	15.8	14.0	16.0
1945	Dec	12.5	12.3	14.2	12.0	13.9	11.9	13.9
1946	Jan	10.3	10.1	11.1	9.8	11.4	9.8	11.2
1946	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1946	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1946	Apr	11.3	11.8	13.5	13.1	14.9	13.8	16.2
1946	May	12.1	12.7	14.5	14.3	16.1	15.0	16.9
1946	Jun	13.1	13.8	15.8	15.3	17.4	16.0	17.8
1946	Jul	14.1	15.0	16.9	17.3	19.2	18.7	21.2
1946	Aug	14.7	15.5	17.3	17.6	19.5	18.8	21.8
1946	Sep	15.1	15.6	16.9	16.8	18.8	17.6	20.2
1946	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1946	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1946	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1947	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1947	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1947	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1947	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1947	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1947	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1947	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1947	Aug	14.7	15.8	17.6	20.0	21.6	24.0	29.0
1947	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1947	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1947	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1947	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1948	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1948	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1948	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1948	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1948	May	12.1	12.9	14.7	15.0	16.5	16.2	18.5
1948	Jun	13.1	14.1	16.2	16.6	18.1	18.0	21.0
1948	Jul	14.1	15.3	17.2	19.8	21.5	24.8	29.6
1948	Aug	14.7	15.8	17.5	19.9	21.5	24.0	29.0
1948	Sep	15.1	15.8	17.3	18.2	20.3	21.5	26.9
1948	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1948	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1948	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1949	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1949	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1949	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1949	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1949	May	12.1	13.0	14.8	15.1	16.6	16.3	18.6
1949	Jun	13.1	14.2	16.2	16.7	18.2	18.1	21.1
1949	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1949	Aug	14.7	15.8	17.6	20.0	21.6	24.0	29.0
1949	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1949	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1949	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1949	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1950	Jan	10.3	9.8	10.9	9.4	11.3	9.2	10.7
1950	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1950	Mar	10.6	10.8	12.3	11.4	12.8	12.1	13.9
1950	Apr	11.3	11.8	13.5	13.1	14.9	13.8	16.1
1950	May	12.1	12.6	14.3	13.7	15.7	14.2	15.8
1950	Jun	13.1	13.8	15.8	15.1	17.3	15.8	17.4
1950	Jul	14.1	14.8	16.8	16.6	18.5	17.5	19.6
1950	Aug	14.7	15.4	17.2	16.9	18.8	17.7	20.2
1950	Sep	15.1	15.5	16.8	16.4	18.3	16.9	18.9
1950	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1950	Nov	14.9	14.8	16.0	14.8	16.1	14.8	16.4
1950	Dec	12.5	12.4	14.4	12.4	14.2	12.4	14.3
1951	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1951	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1951	Mar	10.6	10.7	12.1	11.1	12.5	11.5	12.8
1951	Apr	11.3	11.7	13.4	12.8	14.8	13.3	15.4
1951	May	12.1	12.6	14.4	14.0	15.9	14.6	16.4
1951	Jun	13.1	13.9	15.9	15.6	17.5	16.3	18.3
1951	Jul	14.1	15.1	17.0	18.1	19.9	20.3	23.3

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1951	Aug	14.7	15.6	17.4	18.3	20.1	20.3	23.8
1951	Sep	15.1	15.7	17.1	17.3	19.3	18.6	21.8
1951	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1951	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1951	Dec	12.5	12.1	14.1	11.7	13.6	11.5	13.5
1952	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1952	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1952	Mar	10.6	10.6	11.9	10.9	12.2	11.0	12.0
1952	Apr	11.3	11.4	13.1	11.8	14.2	11.9	13.3
1952	May	12.1	12.3	13.9	12.8	15.1	13.0	14.1
1952	Jun	13.1	13.6	15.6	14.4	16.9	14.8	15.9
1952	Jul	14.1	14.6	16.7	15.9	17.8	16.4	18.1
1952	Aug	14.7	15.2	17.1	16.2	18.2	16.7	18.9
1952	Sep	15.1	15.4	16.7	16.0	17.9	16.4	18.0
1952	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.6
1952	Nov	14.9	14.3	15.7	13.7	15.6	13.5	15.8
1952	Dec	12.5	11.8	13.8	11.0	13.0	10.7	12.8
1953	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1953	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1953	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1953	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1953	May	12.1	12.7	14.5	14.3	16.1	15.1	17.0
1953	Jun	13.1	13.9	16.0	15.8	17.7	16.7	19.0
1953	Jul	14.1	15.0	16.9	17.4	19.3	18.9	21.5
1953	Aug	14.7	15.5	17.3	17.7	19.5	18.9	21.9
1953	Sep	15.1	15.6	16.9	16.9	18.9	17.7	20.3
1953	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1953	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1953	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1954	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1954	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1954	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1954	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1954	May	12.1	13.0	14.8	15.1	16.6	16.3	18.6
1954	Jun	13.1	14.2	16.2	16.7	18.2	18.1	21.1
1954	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1954	Aug	14.7	15.8	17.6	20.0	21.6	24.0	29.0
1954	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1954	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1954	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1954	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1955	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
1955	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1955	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
1955	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1955	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1955	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1955	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1955	Aug	14.7	15.8	17.6	20.0	21.6	24.0	29.0
1955	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1955	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1955	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1955	Dec	12.5	12.4	14.4	12.3	14.1	12.2	14.2
1956	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.5
1956	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1956	Mar	10.6	10.8	12.2	11.3	12.7	11.9	13.5
1956	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1956	May	12.1	12.4	14.0	13.1	15.3	13.3	14.6
1956	Jun	13.1	13.6	15.6	14.5	16.9	14.9	16.0
1956	Jul	14.1	14.7	16.7	16.2	18.1	16.8	18.7
1956	Aug	14.7	15.3	17.1	16.6	18.5	17.1	19.5
1956	Sep	15.1	15.4	16.7	16.2	18.1	16.6	18.4
1956	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1956	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1956	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1957	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1957	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1957	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1957	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1957	May	12.1	12.9	14.7	15.0	16.5	16.1	18.3
1957	Jun	13.1	14.1	16.1	16.5	18.0	17.9	20.7
1957	Jul	14.1	15.2	17.1	19.3	21.0	23.5	27.8
1957	Aug	14.7	15.7	17.5	19.4	21.1	23.4	28.2
1957	Sep	15.1	15.8	17.2	17.9	20.0	21.1	26.2
1957	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1957	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1957	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1958	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1958	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1958	Mar	10.6	10.7	12.0	10.9	12.2	11.1	12.1
1958	Apr	11.3	11.5	13.1	11.9	14.3	12.1	13.6
1958	May	12.1	12.3	13.9	12.9	15.2	13.1	14.3
1958	Jun	13.1	13.6	15.6	14.4	16.9	14.8	15.9
1958	Jul	14.1	14.7	16.7	16.0	18.0	16.7	18.5
1958	Aug	14.7	15.2	17.1	16.4	18.4	16.9	19.2
1958	Sep	15.1	15.4	16.7	16.1	18.0	16.5	18.2

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1958	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1958	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1958	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1959	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1959	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1959	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1959	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1959	May	12.1	13.1	15.0	15.6	16.9	16.9	19.5
1959	Jun	13.1	14.7	16.8	19.3	19.6	23.5	29.6
1959	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1959	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
1959	Sep	15.1	16.0	17.5	18.5	20.6	21.5	26.9
1959	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1959	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1959	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1960	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1960	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1960	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1960	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1960	May	12.1	13.1	15.0	15.6	16.9	16.9	19.5
1960	Jun	13.1	14.7	16.8	19.3	19.6	23.5	29.6
1960	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1960	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
1960	Sep	15.1	16.0	17.5	18.5	20.6	21.5	26.9
1960	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1960	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1960	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1961	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1961	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1961	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1961	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1961	May	12.1	13.4	15.4	17.5	18.1	21.1	25.1
1961	Jun	13.5	15.0	17.1	19.4	19.7	23.5	29.6
1961	Jul	15.1	16.5	18.1	20.9	22.5	24.9	29.6
1961	Aug	16.4	17.5	18.9	20.9	22.5	24.0	29.0
1961	Sep	17.3	17.7	19.7	19.1	21.3	21.6	27.0
1961	Oct	16.6	15.9	17.9	16.0	18.5	16.7	21.0
1961	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1961	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1962	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1962	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1962	Mar	11.5	11.7	14.5	12.3	13.8	13.8	16.6
1962	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1962	May	12.1	13.0	14.8	15.1	16.6	16.3	18.6
1962	Jun	13.1	14.2	16.2	16.7	18.2	18.1	21.1
1962	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1962	Aug	14.7	15.8	17.6	20.0	21.6	24.0	29.0
1962	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1962	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1962	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1962	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1963	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1963	Feb	9.9	9.9	11.0	10.1	11.1	10.2	11.4
1963	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1963	Apr	11.3	11.8	13.5	13.1	14.9	13.8	16.2
1963	May	12.1	12.5	14.1	13.3	15.5	13.7	15.1
1963	Jun	13.1	13.7	15.7	14.8	17.1	15.2	16.6
1963	Jul	14.1	14.7	16.8	16.4	18.3	17.1	19.1
1963	Aug	14.7	15.3	17.2	16.7	18.7	17.4	19.8
1963	Sep	15.1	15.4	16.8	16.3	18.2	16.7	18.6
1963	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1963	Nov	14.9	14.5	15.8	14.2	15.9	14.1	16.1
1963	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1964	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1964	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1964	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1964	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1964	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1964	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1964	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1964	Aug	14.7	15.8	17.6	20.0	21.6	24.0	29.0
1964	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1964	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1964	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1964	Dec	12.5	12.4	14.4	12.3	14.2	12.3	14.3
1965	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.5
1965	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1965	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.8
1965	Apr	11.3	11.8	13.5	12.9	14.8	13.6	15.8
1965	May	12.1	12.5	14.1	13.3	15.5	13.7	15.1
1965	Jun	13.1	13.6	15.6	14.7	17.0	15.1	16.4
1965	Jul	14.1	14.7	16.7	16.1	18.0	16.7	18.6
1965	Aug	14.7	15.3	17.1	16.5	18.5	17.1	19.4
1965	Sep	15.1	15.4	16.7	16.1	18.1	16.5	18.3
1965	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
1965	Nov	14.9	14.5	15.8	14.1	15.9	14.0	16.0

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1965	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1966	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1966	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1966	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1966	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1966	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1966	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1966	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1966	Aug	14.7	15.8	17.6	20.0	21.6	24.0	29.0
1966	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1966	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1966	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1966	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1967	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.6
1967	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
1967	Mar	10.6	10.7	12.0	10.9	12.2	11.1	12.2
1967	Apr	11.3	11.5	13.2	12.2	14.4	12.4	14.1
1967	May	12.1	12.3	13.9	12.8	15.1	13.0	14.1
1967	Jun	13.1	13.6	15.6	14.5	16.9	14.9	16.1
1967	Jul	14.1	14.6	16.7	15.8	17.8	16.3	18.1
1967	Aug	14.7	15.2	17.1	16.2	18.2	16.7	18.8
1967	Sep	15.1	15.4	16.7	16.0	17.9	16.3	17.9
1967	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1967	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1967	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1968	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1968	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1968	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1968	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1968	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1968	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1968	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1968	Aug	14.7	15.8	17.6	20.0	21.6	24.0	29.0
1968	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1968	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1968	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1968	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1969	Jan	10.3	10.2	11.2	10.1	11.5	10.1	11.5
1969	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1969	Mar	10.6	10.7	12.0	10.9	12.3	11.1	12.2
1969	Apr	11.3	11.5	13.1	11.8	14.2	12.0	13.4
1969	May	12.1	12.3	13.9	12.7	15.1	12.9	14.0
1969	Jun	13.1	13.6	15.6	14.5	16.9	14.9	16.1

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1969	Jul	14.1	14.6	16.7	15.9	17.9	16.5	18.2
1969	Aug	14.7	15.2	17.1	16.3	18.3	16.8	19.1
1969	Sep	15.1	15.4	16.7	16.1	18.0	16.4	18.1
1969	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.6
1969	Nov	14.9	14.3	15.7	13.7	15.6	13.5	15.8
1969	Dec	12.5	11.9	13.8	11.1	13.1	10.7	12.8
1970	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.5
1970	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.3
1970	Mar	10.6	10.7	12.1	11.0	12.4	11.4	12.6
1970	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1970	May	12.1	12.7	14.5	14.3	16.0	15.0	16.9
1970	Jun	13.1	13.9	15.9	15.8	17.6	16.7	18.8
1970	Jul	14.1	15.0	17.0	18.0	19.7	19.9	22.8
1970	Aug	14.7	15.6	17.4	18.1	20.0	19.8	23.2
1970	Sep	15.1	15.6	17.0	17.1	19.1	18.3	21.3
1970	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
1970	Nov	14.9	14.5	15.8	14.2	15.9	14.1	16.1
1970	Dec	12.5	12.2	14.2	11.8	13.7	11.6	13.7
1971	Jan	10.3	10.1	11.1	9.9	11.5	9.8	11.2
1971	Feb	9.9	9.9	11.0	10.1	11.1	10.2	11.3
1971	Mar	10.6	10.7	12.1	11.0	12.4	11.3	12.5
1971	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1971	May	12.1	12.6	14.3	13.9	15.8	14.5	16.3
1971	Jun	13.1	13.9	15.9	15.6	17.5	16.4	18.4
1971	Jul	14.1	14.9	16.9	17.1	18.9	18.3	20.7
1971	Aug	14.7	15.5	17.3	17.3	19.2	18.3	21.2
1971	Sep	15.1	15.5	16.9	16.7	18.6	17.3	19.7
1971	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1971	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1971	Dec	12.5	11.9	13.9	11.2	13.2	11.0	13.1
1972	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1972	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1972	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1972	Apr	11.3	11.8	13.6	13.3	15.0	14.1	16.6
1972	May	12.1	13.0	14.8	15.1	16.6	16.3	18.6
1972	Jun	13.1	14.2	16.2	16.7	18.2	18.1	21.1
1972	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1972	Aug	14.7	15.8	17.6	20.0	21.6	24.0	29.0
1972	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1972	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1972	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1972	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1973	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1973	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1973	Mar	10.6	10.7	12.0	10.9	12.3	11.2	12.4
1973	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1973	May	12.1	12.6	14.3	13.9	15.8	14.5	16.2
1973	Jun	13.1	13.8	15.8	15.3	17.4	16.0	17.8
1973	Jul	14.1	14.9	16.9	17.0	18.8	18.1	20.4
1973	Aug	14.7	15.4	17.3	17.2	19.2	18.2	20.9
1973	Sep	15.1	15.5	16.9	16.6	18.5	17.2	19.5
1973	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1973	Nov	14.9	14.7	15.9	14.5	16.0	14.5	16.2
1973	Dec	12.5	12.2	14.2	11.9	13.8	11.8	13.8
1974	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1974	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1974	Mar	10.6	10.7	12.0	10.9	12.2	11.1	12.2
1974	Apr	11.3	11.6	13.3	12.5	14.6	13.0	14.9
1974	May	12.1	12.5	14.1	13.4	15.5	13.8	15.2
1974	Jun	13.1	13.7	15.7	14.8	17.1	15.2	16.6
1974	Jul	14.1	14.7	16.7	16.2	18.2	16.9	18.8
1974	Aug	14.7	15.3	17.1	16.6	18.6	17.2	19.6
1974	Sep	15.1	15.4	16.7	16.2	18.2	16.6	18.5
1974	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1974	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1974	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1975	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1975	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1975	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1975	Apr	11.3	11.8	13.5	13.1	14.9	13.8	16.2
1975	May	12.1	12.5	14.2	13.6	15.6	14.1	15.6
1975	Jun	13.1	13.7	15.7	15.0	17.2	15.5	17.0
1975	Jul	14.1	14.7	16.7	16.1	18.0	16.8	18.6
1975	Aug	14.7	15.3	17.1	16.5	18.5	17.0	19.4
1975	Sep	15.1	15.4	16.7	16.1	18.1	16.5	18.3
1975	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1975	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1975	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1976	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1976	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1976	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1976	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1976	May	12.1	13.4	15.4	17.5	18.1	21.1	25.1
1976	Jun	13.1	14.7	16.8	19.3	19.6	23.5	29.6
1976	Jul	14.1	15.7	17.5	21.2	22.7	24.9	29.7
1976	Aug	14.7	16.2	17.9	20.8	22.4	24.0	29.0

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1976	Sep	15.1	16.0	17.6	18.7	20.8	21.6	26.9
1976	Oct	15.3	15.0	17.1	15.4	17.7	15.8	19.6
1976	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1976	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1977	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1977	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1977	Mar	12.9	12.8	17.0	12.8	14.5	13.3	15.8
1977	Apr	14.3	14.5	16.9	15.4	16.2	16.4	20.1
1977	May	15.5	16.2	19.3	18.6	18.8	21.1	25.1
1977	Jun	17.2	18.1	20.6	20.8	20.4	23.5	29.6
1977	Jul	18.8	19.7	20.5	22.5	24.0	24.9	29.7
1977	Aug	20.0	20.5	21.4	22.1	23.6	24.0	29.0
1977	Sep	20.6	20.2	23.1	19.9	22.1	21.6	27.0
1977	Oct	20.7	18.7	20.4	17.1	20.0	17.3	22.0
1977	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1977	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1978	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1978	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1978	Mar	18.0	16.3	25.1	14.7	16.6	14.8	18.3
1978	Apr	19.7	18.8	22.2	17.6	17.4	17.8	22.2
1978	May	20.5	20.2	24.9	20.0	19.7	21.2	25.2
1978	Jun	21.6	21.6	24.6	22.2	21.2	23.6	29.7
1978	Jul	22.5	22.7	22.7	23.5	24.9	24.9	29.7
1978	Aug	23.2	22.9	23.4	22.8	24.2	24.0	29.0
1978	Sep	23.6	22.4	25.9	20.4	22.7	21.6	27.0
1978	Oct	23.7	20.8	22.3	17.9	21.1	17.7	22.6
1978	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1978	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1979	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1979	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1979	Mar	18.0	16.3	25.1	14.6	16.6	14.8	18.3
1979	Apr	19.7	18.8	22.2	17.6	17.4	17.8	22.2
1979	May	18.6	18.7	22.7	19.5	19.3	21.1	25.2
1979	Jun	17.7	18.4	21.0	20.8	20.4	23.5	29.6
1979	Jul	18.5	19.2	20.1	21.9	23.4	24.9	29.6
1979	Aug	18.8	19.4	20.5	21.5	23.0	24.0	29.0
1979	Sep	18.4	18.5	20.8	19.4	21.5	21.6	27.0
1979	Oct	17.7	16.8	18.7	16.4	19.0	16.9	21.4
1979	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1979	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1980	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1980	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1980	Mar	10.6	10.7	12.1	11.0	12.4	11.3	12.5

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1980	Apr	11.3	11.7	13.4	12.8	14.8	13.3	15.4
1980	May	12.1	12.5	14.1	13.3	15.5	13.7	15.1
1980	Jun	13.1	13.6	15.6	14.7	17.0	15.1	16.4
1980	Jul	14.1	14.7	16.7	16.1	18.0	16.7	18.6
1980	Aug	14.7	15.3	17.1	16.5	18.5	17.0	19.4
1980	Sep	15.1	15.4	16.7	16.1	18.0	16.5	18.2
1980	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1980	Nov	14.9	14.4	15.7	14.0	15.8	13.8	16.0
1980	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1981	Jan	10.3	10.0	11.1	9.7	11.4	9.7	11.1
1981	Feb	9.9	9.9	11.0	10.1	11.1	10.2	11.3
1981	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1981	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1981	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1981	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1981	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1981	Aug	14.7	15.8	17.6	20.0	21.6	24.0	29.0
1981	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1981	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1981	Nov	14.9	14.2	15.6	13.5	15.6	13.4	15.8
1981	Dec	12.5	12.4	14.3	12.2	14.0	12.1	14.1
1982	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1982	Feb	9.9	9.9	11.0	10.0	11.1	10.0	11.2
1982	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9
1982	Apr	11.3	11.4	13.0	11.7	14.2	11.8	13.2
1982	May	12.1	12.3	13.9	12.9	15.2	13.0	14.2
1982	Jun	13.1	13.6	15.6	14.6	17.0	15.0	16.3
1982	Jul	14.1	14.6	16.7	16.0	17.9	16.6	18.3
1982	Aug	14.7	15.2	17.1	16.4	18.4	16.9	19.2
1982	Sep	15.1	15.4	16.7	16.1	18.0	16.5	18.2
1982	Oct	15.2	15.0	17.2	15.4	17.7	15.9	19.6
1982	Nov	14.9	14.7	15.9	14.5	16.0	14.4	16.2
1982	Dec	12.5	12.3	14.3	12.1	14.0	12.0	14.0
1983	Jan	10.3	10.1	11.2	10.0	11.5	10.0	11.4
1983	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1983	Mar	10.6	10.6	11.9	10.7	12.0	10.8	11.7
1983	Apr	11.3	11.5	13.1	12.0	14.3	12.2	13.8
1983	May	12.1	12.2	13.8	12.6	15.0	12.8	13.9
1983	Jun	13.1	13.4	15.4	14.0	16.6	14.2	15.0
1983	Jul	14.1	14.5	16.6	15.3	17.3	15.7	17.2
1983	Aug	14.7	15.1	17.0	15.8	17.9	16.1	18.0
1983	Sep	15.1	15.3	16.6	15.8	17.7	16.0	17.4
1983	Oct	15.2	15.0	17.2	15.4	17.7	15.9	19.6

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1983	Nov	14.9	14.8	16.0	14.7	16.1	14.6	16.3
1983	Dec	12.5	12.4	14.4	12.3	14.1	12.2	14.2
1984	Jan	10.3	10.2	11.2	10.1	11.5	10.0	11.4
1984	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
1984	Mar	10.6	10.7	12.1	11.1	12.5	11.5	12.9
1984	Apr	11.3	11.7	13.4	12.8	14.8	13.3	15.4
1984	May	12.1	12.6	14.3	13.8	15.8	14.4	16.0
1984	Jun	13.1	13.8	15.8	15.2	17.3	15.8	17.4
1984	Jul	14.1	14.8	16.8	16.8	18.7	17.8	20.1
1984	Aug	14.7	15.4	17.2	17.1	19.0	17.9	20.6
1984	Sep	15.1	15.5	16.8	16.5	18.5	17.1	19.2
1984	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1984	Nov	14.9	14.5	15.8	14.1	15.8	14.0	16.0
1984	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1985	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1985	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1985	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1985	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
1985	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
1985	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
1985	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1985	Aug	14.7	15.8	17.6	20.0	21.6	24.0	29.0
1985	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
1985	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1985	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
1985	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
1986	Jan	10.3	9.9	11.0	9.4	11.3	9.3	10.8
1986	Feb	9.9	9.9	11.0	10.0	11.0	10.0	11.2
1986	Mar	10.6	10.6	11.9	10.7	12.1	10.8	11.7
1986	Apr	11.3	11.7	13.4	12.8	14.8	13.3	15.5
1986	May	12.1	12.4	14.0	13.2	15.4	13.5	14.8
1986	Jun	13.1	13.7	15.7	14.8	17.1	15.3	16.7
1986	Jul	14.1	14.7	16.8	16.4	18.3	17.3	19.3
1986	Aug	14.7	15.3	17.2	16.8	18.8	17.5	20.0
1986	Sep	15.1	15.4	16.8	16.3	18.3	16.8	18.8
1986	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.6
1986	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1986	Dec	12.5	11.8	13.8	11.0	13.0	10.7	12.8
1987	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1987	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1987	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1987	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1987	May	12.1	13.4	15.4	17.5	18.1	21.1	25.1

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1987	Jun	13.1	14.7	16.8	19.3	19.6	23.5	29.6
1987	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
1987	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
1987	Sep	15.1	16.0	17.5	18.6	20.8	21.6	26.9
1987	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1987	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1987	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1988	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1988	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1988	Mar	11.4	11.6	14.1	11.9	13.5	12.6	14.6
1988	Apr	12.6	13.1	15.1	14.6	15.8	16.0	19.4
1988	May	13.2	14.4	16.7	17.9	18.4	21.1	25.1
1988	Jun	14.3	15.6	17.8	19.7	19.8	23.5	29.6
1988	Jul	15.1	16.6	18.2	21.5	23.0	24.9	29.7
1988	Aug	15.6	16.9	18.5	21.0	22.6	24.0	29.0
1988	Sep	15.7	16.5	18.2	18.8	21.0	21.6	26.9
1988	Oct	15.5	15.0	17.2	15.6	18.0	16.6	20.8
1988	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1988	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1989	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1989	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1989	Mar	12.0	12.0	15.2	12.4	14.0	13.9	16.8
1989	Apr	12.2	12.6	14.6	14.0	15.4	14.9	17.8
1989	May	12.1	13.0	14.8	15.1	16.6	16.3	18.6
1989	Jun	13.1	14.2	16.2	16.7	18.2	18.1	21.1
1989	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
1989	Aug	14.9	16.0	17.7	20.1	21.7	24.0	29.0
1989	Sep	15.4	16.1	17.6	18.4	20.5	21.5	26.9
1989	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
1989	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1989	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1990	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1990	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1990	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
1990	Apr	11.5	12.1	13.9	13.6	15.2	14.6	17.4
1990	May	13.0	13.9	16.0	16.1	17.2	17.3	20.0
1990	Jun	14.3	15.6	17.8	19.7	19.8	23.5	29.6
1990	Jul	15.3	16.7	18.2	21.0	22.5	24.9	29.6
1990	Aug	16.1	17.2	18.7	20.8	22.4	24.0	29.0
1990	Sep	16.2	16.9	18.6	18.8	20.9	21.5	26.9
1990	Oct	15.4	15.1	17.2	15.5	17.8	15.9	19.7
1990	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1990	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1991	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
1991	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
1991	Mar	12.8	12.7	16.7	12.7	14.4	13.2	15.6
1991	Apr	14.3	14.5	16.9	15.2	16.1	15.9	19.3
1991	May	14.8	15.4	18.2	17.1	17.9	18.2	21.2
1991	Jun	15.4	16.5	18.9	20.1	20.1	23.5	29.6
1991	Jul	15.9	17.2	18.6	21.2	22.7	24.9	29.6
1991	Aug	16.1	17.2	18.7	20.8	22.4	24.0	29.0
1991	Sep	15.9	16.6	18.3	18.7	20.8	21.5	26.9
1991	Oct	15.4	15.0	17.1	15.6	18.0	16.5	20.7
1991	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1991	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1992	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1992	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1992	Mar	11.5	11.7	14.4	12.2	13.8	13.7	16.5
1992	Apr	12.6	13.0	15.0	14.2	15.6	15.1	18.1
1992	May	13.5	14.4	16.8	16.4	17.4	17.6	20.4
1992	Jun	14.6	15.9	18.2	19.9	19.9	23.5	29.6
1992	Jul	15.6	16.9	18.4	21.1	22.7	24.9	29.6
1992	Aug	16.2	17.3	18.8	20.9	22.4	24.0	29.0
1992	Sep	16.3	16.9	18.7	18.8	21.0	21.5	26.9
1992	Oct	16.0	15.5	17.5	15.8	18.2	16.6	20.9
1992	Nov	14.9	13.7	15.3	12.7	15.2	12.6	15.4
1992	Dec	12.5	11.1	13.1	9.7	11.8	9.2	11.4
1993	Jan	10.3	9.6	10.7	8.9	11.1	8.8	10.3
1993	Feb	9.9	10.0	11.1	10.3	11.3	10.9	12.0
1993	Mar	10.6	11.0	12.8	11.9	13.4	13.6	16.3
1993	Apr	11.3	11.9	13.6	13.4	15.1	14.3	16.9
1993	May	12.1	12.6	14.3	13.7	15.7	14.2	15.8
1993	Jun	13.1	13.8	15.8	15.1	17.3	15.7	17.3
1993	Jul	14.1	14.8	16.8	16.6	18.5	17.5	19.6
1993	Aug	14.7	15.4	17.2	16.9	18.9	17.7	20.2
1993	Sep	15.1	15.5	16.8	16.4	18.3	16.9	18.9
1993	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1993	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1993	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1994	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1994	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
1994	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
1994	Apr	11.3	12.0	13.7	14.0	15.4	15.6	18.8
1994	May	12.1	13.4	15.4	17.5	18.1	21.1	25.1
1994	Jun	13.1	14.7	16.8	19.3	19.6	23.5	29.6
1994	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1994	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
1994	Sep	15.1	16.0	17.5	18.6	20.8	21.6	26.9
1994	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
1994	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
1994	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
1995	Jan	10.3	9.8	10.9	9.2	11.2	9.0	10.6
1995	Feb	9.9	9.9	11.0	10.2	11.3	10.7	11.8
1995	Mar	10.6	10.6	11.9	10.7	12.1	10.8	11.7
1995	Apr	11.3	11.4	13.1	11.8	14.2	11.9	13.3
1995	May	12.1	12.2	13.8	12.6	15.0	12.8	13.9
1995	Jun	13.1	13.5	15.5	14.3	16.8	14.6	15.7
1995	Jul	14.1	14.5	16.6	15.5	17.5	15.9	17.5
1995	Aug	14.7	15.1	17.0	16.0	18.0	16.4	18.4
1995	Sep	15.1	15.3	16.6	15.9	17.8	16.1	17.6
1995	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.6
1995	Nov	14.9	14.3	15.7	13.7	15.6	13.5	15.8
1995	Dec	12.5	11.8	13.8	11.0	13.0	10.6	12.8
1996	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
1996	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1996	Mar	10.6	10.6	11.9	10.9	12.2	11.0	12.0
1996	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1996	May	12.1	12.4	14.0	13.1	15.3	13.4	14.7
1996	Jun	13.1	13.7	15.7	15.0	17.2	15.5	17.0
1996	Jul	14.1	14.8	16.8	16.8	18.6	17.7	20.0
1996	Aug	14.7	15.4	17.2	17.1	19.0	17.9	20.6
1996	Sep	15.1	15.5	16.8	16.5	18.5	17.1	19.2
1996	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1996	Nov	14.9	14.5	15.8	14.1	15.8	14.0	16.0
1996	Dec	12.5	12.4	14.4	12.2	14.1	12.2	14.1
1997	Jan	10.3	10.2	11.3	10.2	11.6	10.2	11.6
1997	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1997	Mar	10.6	10.7	12.1	11.1	12.4	11.4	12.7
1997	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1997	May	12.1	12.7	14.5	14.3	16.1	15.1	17.1
1997	Jun	13.1	13.9	16.0	15.8	17.7	16.8	19.0
1997	Jul	14.1	15.1	17.0	18.3	20.1	20.8	24.0
1997	Aug	14.7	15.6	17.4	18.4	20.2	20.6	24.3
1997	Sep	15.1	15.7	17.0	17.3	19.3	18.8	22.2
1997	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.5
1997	Nov	14.9	14.4	15.7	13.9	15.8	13.8	15.9
1997	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
1998	Jan	10.3	10.0	11.1	9.8	11.4	9.7	11.1
1998	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
1998	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9
1998	Apr	11.3	11.5	13.1	12.0	14.3	12.1	13.7
1998	May	12.1	12.3	13.9	12.9	15.2	13.0	14.2
1998	Jun	13.1	13.6	15.5	14.4	16.9	14.8	15.9
1998	Jul	14.1	14.6	16.6	15.7	17.6	16.1	17.8
1998	Aug	14.7	15.1	17.0	16.1	18.1	16.5	18.6
1998	Sep	15.1	15.4	16.6	15.9	17.8	16.2	17.8
1998	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.6
1998	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1998	Dec	12.5	11.8	13.8	11.0	13.0	10.7	12.8
1999	Jan	10.3	10.0	11.1	9.7	11.4	9.7	11.1
1999	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
1999	Mar	10.6	10.7	12.0	10.9	12.3	11.1	12.2
1999	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
1999	May	12.1	12.5	14.2	13.6	15.6	14.1	15.6
1999	Jun	13.1	13.7	15.7	15.0	17.2	15.6	17.1
1999	Jul	14.1	14.8	16.8	16.5	18.3	17.2	19.2
1999	Aug	14.7	15.3	17.2	16.8	18.7	17.4	19.9
1999	Sep	15.1	15.4	16.8	16.3	18.2	16.8	18.7
1999	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
1999	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
1999	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
2000	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
2000	Feb	9.9	9.9	11.0	10.0	11.1	10.2	11.3
2000	Mar	10.6	10.7	12.0	10.9	12.3	11.2	12.3
2000	Apr	11.3	11.7	13.4	12.8	14.8	13.4	15.5
2000	May	12.1	12.7	14.4	14.1	16.0	14.8	16.6
2000	Jun	13.1	14.0	16.0	16.0	17.8	17.1	19.5
2000	Jul	14.1	15.0	17.0	17.9	19.7	19.7	22.7
2000	Aug	14.7	15.6	17.4	18.1	19.9	19.7	23.0
2000	Sep	15.1	15.6	17.0	17.1	19.1	18.2	21.2
2000	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
2000	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
2000	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
2001	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
2001	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
2001	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
2001	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
2001	May	12.1	13.1	15.0	15.6	16.9	16.9	19.5
2001	Jun	13.1	14.7	16.8	19.3	19.6	23.5	29.6
2001	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
2001	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
2001	Sep	15.1	16.0	17.5	18.5	20.6	21.5	26.9

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
2001	Oct	15.2	15.0	17.1	15.4	17.6	15.7	19.4
2001	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
2001	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
2002	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
2002	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
2002	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
2002	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
2002	May	12.1	13.0	14.8	15.1	16.6	16.3	18.6
2002	Jun	13.1	14.2	16.2	16.7	18.2	18.1	21.1
2002	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
2002	Aug	14.7	15.8	17.6	20.0	21.6	24.0	29.0
2002	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
2002	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
2002	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
2002	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
2003	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
2003	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
2003	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
2003	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
2003	May	12.1	12.8	14.6	14.8	16.4	15.8	18.0
2003	Jun	13.1	14.1	16.1	16.3	17.9	17.6	20.3
2003	Jul	14.1	15.1	17.1	18.7	20.4	21.5	25.1
2003	Aug	14.7	15.7	17.5	18.8	20.5	21.4	25.4
2003	Sep	15.1	15.7	17.1	17.5	19.6	19.4	23.2
2003	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.4
2003	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
2003	Dec	12.5	11.8	13.8	11.1	13.1	10.8	12.9
2004	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
2004	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
2004	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
2004	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
2004	May	12.1	13.0	14.9	15.5	16.8	16.9	19.4
2004	Jun	13.1	14.5	16.6	19.0	19.4	23.5	29.5
2004	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
2004	Aug	14.7	15.8	17.6	20.0	21.6	24.0	29.0
2004	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
2004	Oct	15.2	15.0	17.1	15.4	17.7	16.0	19.8
2004	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7
2004	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
2005	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
2005	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
2005	Mar	10.6	10.6	11.9	10.8	12.2	11.0	12.0
2005	Apr	11.3	11.6	13.3	12.4	14.6	12.8	14.7

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Mean	Monthly	Monthly Mean	Monthly
				Max 7DADM		Max 7DADM		Max 7DADM
2005	May	12.1	12.4	14.0	13.1	15.3	13.3	14.6
2005	Jun	13.1	13.6	15.6	14.6	17.0	15.0	16.3
2005	Jul	14.1	14.7	16.7	16.3	18.2	17.0	18.9
2005	Aug	14.7	15.3	17.1	16.6	18.6	17.2	19.6
2005	Sep	15.1	15.4	16.7	16.2	18.2	16.6	18.5
2005	Oct	15.2	15.0	17.2	15.4	17.6	15.7	19.5
2005	Nov	14.9	14.3	15.7	13.7	15.7	13.6	15.8
2005	Dec	12.5	12.3	14.3	12.1	14.0	12.0	14.0
2006	Jan	10.3	10.2	11.2	10.1	11.5	10.1	11.5
2006	Feb	9.9	9.9	11.0	10.0	11.1	10.1	11.2
2006	Mar	10.6	10.6	11.9	10.8	12.1	10.9	11.9
2006	Apr	11.3	11.4	13.0	11.7	14.1	11.8	13.1
2006	May	12.1	12.3	13.9	12.8	15.1	13.0	14.1
2006	Jun	13.1	13.6	15.6	14.5	16.9	14.9	16.1
2006	Jul	14.1	14.7	16.8	16.4	18.3	17.2	19.2
2006	Aug	14.7	15.3	17.2	16.8	18.7	17.5	20.0
2006	Sep	15.1	15.4	16.8	16.3	18.3	16.8	18.8
2006	Oct	15.2	15.0	17.2	15.4	17.7	15.8	19.6
2006	Nov	14.9	14.3	15.7	13.7	15.6	13.5	15.8
2006	Dec	12.5	11.8	13.8	11.0	13.0	10.7	12.8
2007	Jan	10.3	9.9	11.0	9.5	11.3	9.4	10.9
2007	Feb	9.9	9.9	11.0	10.1	11.2	10.3	11.5
2007	Mar	10.6	10.8	12.2	11.2	12.6	11.7	13.2
2007	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
2007	May	12.1	13.1	15.0	15.6	16.9	16.9	19.5
2007	Jun	13.1	14.7	16.8	19.3	19.6	23.5	29.6
2007	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
2007	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
2007	Sep	15.1	16.0	17.5	18.5	20.6	21.5	26.9
2007	Oct	15.2	15.0	17.1	15.4	17.6	15.7	19.4
2007	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
2007	Dec	12.5	11.7	13.6	10.8	12.8	10.5	12.6
2008	Jan	10.3	9.8	10.9	9.4	11.3	9.3	10.8
2008	Feb	9.9	9.9	11.0	10.1	11.2	10.5	11.6
2008	Mar	10.6	10.8	12.3	11.4	12.8	12.0	13.6
2008	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
2008	May	12.1	13.1	15.0	15.6	16.9	16.9	19.5
2008	Jun	13.1	14.7	16.8	19.3	19.6	23.5	29.6
2008	Jul	14.1	15.6	17.4	20.5	22.1	24.9	29.6
2008	Aug	14.7	16.1	17.8	20.4	22.0	24.0	29.0
2008	Sep	15.1	16.0	17.5	18.5	20.6	21.5	26.9
2008	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
2008	Nov	14.9	14.1	15.5	13.4	15.5	13.2	15.7

Year	Month	McIntire	Elliott		Golf		Frandy	
		Monthly Mean	Monthly Mean	Monthly	Monthly Max 7DADM	Monthly Max 7DADM	Monthly Mean	Monthly
				Max 7DADM				Max 7DADM
2008	Dec	12.5	11.6	13.5	10.6	12.6	10.2	12.4
2009	Jan	10.3	9.8	10.9	9.3	11.3	9.2	10.7
2009	Feb	9.9	9.9	11.0	10.2	11.2	10.5	11.6
2009	Mar	10.6	10.8	12.4	11.4	12.8	12.1	13.9
2009	Apr	11.3	11.9	13.6	13.5	15.1	14.5	17.2
2009	May	12.1	13.0	14.8	15.1	16.6	16.3	18.6
2009	Jun	13.1	14.2	16.2	16.7	18.2	18.1	21.1
2009	Jul	14.1	15.4	17.2	20.1	21.7	24.9	29.6
2009	Aug	14.7	15.8	17.6	20.0	21.6	24.0	29.0
2009	Sep	15.1	15.9	17.3	18.3	20.4	21.5	26.9
2009	Oct	15.2	15.0	17.1	15.4	17.7	15.8	19.6
2009	Nov	14.9	14.1	15.6	13.5	15.6	13.3	15.7
2009	Dec	12.5	12.1	14.1	11.7	13.7	11.6	13.6

Chapter 6

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Attachment to Appendix E
**Permit 10478 Time Extension Project without
Mokelumne Aqueduct Outage**

Attachment to Appendix E

Permit 10478 Time Extension Project without Mokelumne Aqueduct Outage

1.1 Introduction

As noted in Chapter 2, Project Description, Baseline, and Alternatives, and Appendix E, the Modeling Technical Appendix, the analytical assumptions in the Permit 10478 Time Extension Project (Project) include an aqueduct outage scenario that describes what could happen in the event of an aqueduct outage.

On September 26, 1980, EBMUD experienced a near-catastrophic event when floodwaters in Lower Jones Tract eroded the railroad embankment adjacent to the Mokelumne Aqueducts. This event nearly undermined the aqueduct supports in the area. Had the supports been undermined, the aqueducts could have collapsed, cutting off up to 90% of the water supply to EBMUD's service area. In June 2004, a structural failure of the levee at the Upper Jones Tract, 15 miles south of the Mokelumne Aqueducts, resulted in another levee breach. Flooding in the area temporarily halted construction of EBMUD's Mokelumne Aqueduct Seismic Upgrade Project along a section of the aqueducts. The resulting flood submerged about 5.25 miles of the elevated Mokelumne Aqueducts for several months and exposed the aqueducts to potentially damaging wave action.

To recognize the continuing risks of an aqueduct failure associated with seismic events or flooding in the Sacramento–San Joaquin Delta (Delta), most of the EBMUDSIM simulations include an aqueduct outage scenario. This scenario assumes that all three aqueducts are out of service following the September 1980 flood, from November 1980 through April 1981. Following this period, only Aqueduct 3 would be available from May 1981 through April 1982. Significant drawdown of the East Bay terminal reservoirs would be necessary to meet service area demands. Starting in May 1982, all three aqueducts are assumed to be restored to service and fully used at 325 MGD until the terminal reservoirs are refilled.

The aqueduct outage scenario is included in the EBMUDSIM simulations for the Project and the Baseline. To investigate the hydrological effects associated with the aqueduct outage, the Project was also simulated without an aqueduct outage scenario. Comparison of the Project with and Project without the aqueduct outage makes it possible to distinguish and the effects of an aqueduct outage.

This Attachment to Appendix E evaluates the impacts of the Project without the aqueduct outage as compared to the Project with an aqueduct outage. Under this scenario, with the exception of the aqueduct outage, all assumptions remain the same as the Project. Therefore, the evaluation in this Attachment is limited to the period beginning in 1980, before the aqueduct outage is initiated, through 1985, when refill after the outage has been completed. The analytical framework and specific assumptions related to this scenario is included in Appendix E, the Technical Modeling Appendix.

The evaluation below focuses on the hydrologic differences between the results for the Project with the aqueduct outage and the Project without the aqueduct outage. This evaluation also includes an assessment of the effects of these differences on the resource areas analyzed for the Project with an

aqueduct outage (i.e., fish; vegetation, wetland, and wildlife; agricultural; recreational; and visual resources).

1.2 Comparison of Permit 10478 Time Extension Project with and without an Aqueduct Outage

Comparison of EBMUDSIM results for the Project with and without the aqueduct outage indicates that the effect of the aqueduct outage on overall hydrologic results for the Mokelumne River watershed is relatively small. One reason for the minimal effect of the aqueduct outage is that the period of time affected by the outage is relatively short compared to the overall simulation period of January 1921 to December 2009. Under the aqueduct outage scenario, full aqueduct outage only occurred from November 1980 through April 1981, with partial outage occurring one additional year (May 1981 to April 1982) (Figure AO-1). Residual effects from the aqueduct outage extended for approximately 1 more year.

While an aqueduct outage could be devastating to EBMUD's water supply, the effect of an outage on the Mokelumne River would be less severe. An outage would temporarily reduce EBMUD's use of Mokelumne River water until aqueduct use could be restored, at which point additional water would be diverted from Pardee Reservoir until the East Bay terminal reservoirs could be refilled. The rate of these diversions would be consistent with EBMUD's existing water rights, and would be limited by numerous factors including hydrology, aqueduct capacity (325 million gallons per day [MGD] or 504 cubic feet per second), and downstream obligations.

Under the Project with an aqueduct outage scenario, storage in Pardee Reservoir was minimally affected (Figure AO-2) when compared to the Project without an aqueduct scenario. Reduced withdrawals from Pardee Reservoir under the Project with an aqueduct outage scenario resulted in higher storage in Camanche Reservoir for approximately 1 year (November 1980 to November 1981), with a maximum difference of approximately 72,000 acre-feet (Figure AO-3).

During the period of aqueduct outage, releases from Camanche Dam to the Mokelumne River were intermittently higher than if there had been no aqueduct outage (Figure AO-4). However, once full aqueduct capacity was restored, flow in the Mokelumne River below Camanche Dam under the aqueduct outage scenario was slightly less than the flow under the no aqueduct outage scenario until EBMUD terminal reservoirs were refilled. This recovery took approximately 1 year. River flow under the two scenarios was approximately the same by May of 1983 (Figure AO-4 and AO-5).

The aqueduct outage had no effect on the North San Joaquin Water Conservation District (NSJWCD) allocations.

As expected, the Project with an aqueduct outage has the effect of slightly increasing water in the Mokelumne River system during the outage months, but slightly decreasing water in the river in the year following the aqueduct outage.

The inclusion of the aqueduct outage has a small and variable effect on water temperature (Figures AO-6 and AO-7). Because the water surface elevation at Camanche Reservoir was greater than 190 feet in both the simulation with and without the aqueduct outage during the period affected by the outage, the outage did not affect simulated water temperature just downstream of Camanche Dam at Station McIntire. The only temperature differences were caused by changes in

river flows. During the period of outage, flows in the river were intermittently higher than expected if there had been no outage. Higher flows tend to keep downstream river temperatures closer to the release temperatures. Higher releases allows river temperatures to stay cooler during the warmer months (March to October), but because many of the affected months occurred during the late fall and winter (November through January), when river temperatures may decrease along the length of the river, the higher flows tended to result in slightly warmer temperatures (0.1°C at Station McIntire and Station Elliot). After the aqueduct outage was repaired, the aqueduct outage scenario results in slightly lower river flows because aqueduct flows were increased to fill terminal reservoirs. These slightly lower flows resulted in slightly warmer temperatures during 4 of 9 months (i.e., all months without longitudinal cooling). Because the effect of flow on water temperature is largest at Station Frandy, the largest temperature effects associated with the aqueduct outage occurred at Station Frandy. However, even these effects were small, with a maximum monthly mean temperature difference of 0.7°C.

1.3 Effects of Permit 10478 Extension Project with and without an Aqueduct Outage

As described above, the Project with an aqueduct outage (as compared to the Project without an aqueduct outage) has the following small effects on the 89-year simulations of hydrology and water temperature:

- Approximately 1 year of higher storage in Camanche Reservoir.
- Approximately 1.5 years of Mokelumne River flows that were slightly higher followed by approximately 1 year of Mokelumne River flows that were generally slightly lower.
- Water temperatures that were slightly higher or lower depending on location, time of year, and flow difference.

Many resources are affected by flow in the Mokelumne River. For example, river flow could affect floodplain inundation, water quality, fish habitat, fish passage, agricultural diversions, and vegetation growth. The magnitude of the changes in flow associated with the Project with an aqueduct outage compared to the Project without an aqueduct outage (Figures AO-4 and AO-5) would not be sufficient to cause a catastrophic event. The effect of the aqueduct outage on river flow would have minimal environmental consequences because of the relatively short duration of the effect and because increases in river flow would subsequently be balanced by decreases in flow.

Because of the relatively small and variable effects on water temperature (Figures AO-6 and AO-7), the effect of the Project with an aqueduct outage compared to the Project without an aqueduct outage is not expected to cause any harm to fish.

Changes in reservoir storage also could affect some resources. For example, changes in reservoir storage could affect reservoir fish, recreation, scenic vistas, and the potential for flooding. As shown in Figure AO-2, storage in Pardee Reservoir is nearly identical under both scenarios (i.e., the Project with an aqueduct outage and the Project without an aqueduct outage). Figure AO-3, however, shows that there would be a temporary increase in Camanche Reservoir storage associated with the Project with an aqueduct outage scenario, although compared to the Project without an aqueduct outage this would be unlikely to have a large effect on the resources mentioned earlier. Temporary increases in reservoir storage for the Camanche Reservoir could temporarily improve conditions for

reservoir fish, recreation, and scenic vistas, and probably would not cause increased flooding because flood-control releases would continue as required by the U.S. Army Corps of Engineers.

Because of the minimal duration, and small and variable magnitude of the effects of the aqueduct outage (depending on whether a month is before or after aqueduct repairs are made and, for water temperature, depending on time of year), the inclusion or lack of inclusion of an aqueduct outage with the Project does not change conclusions about any project-related impacts on the resources analyzed in this EIR (i.e., water; fish; vegetation, wetland, and wildlife resources; agricultural; recreational; and visual resources).

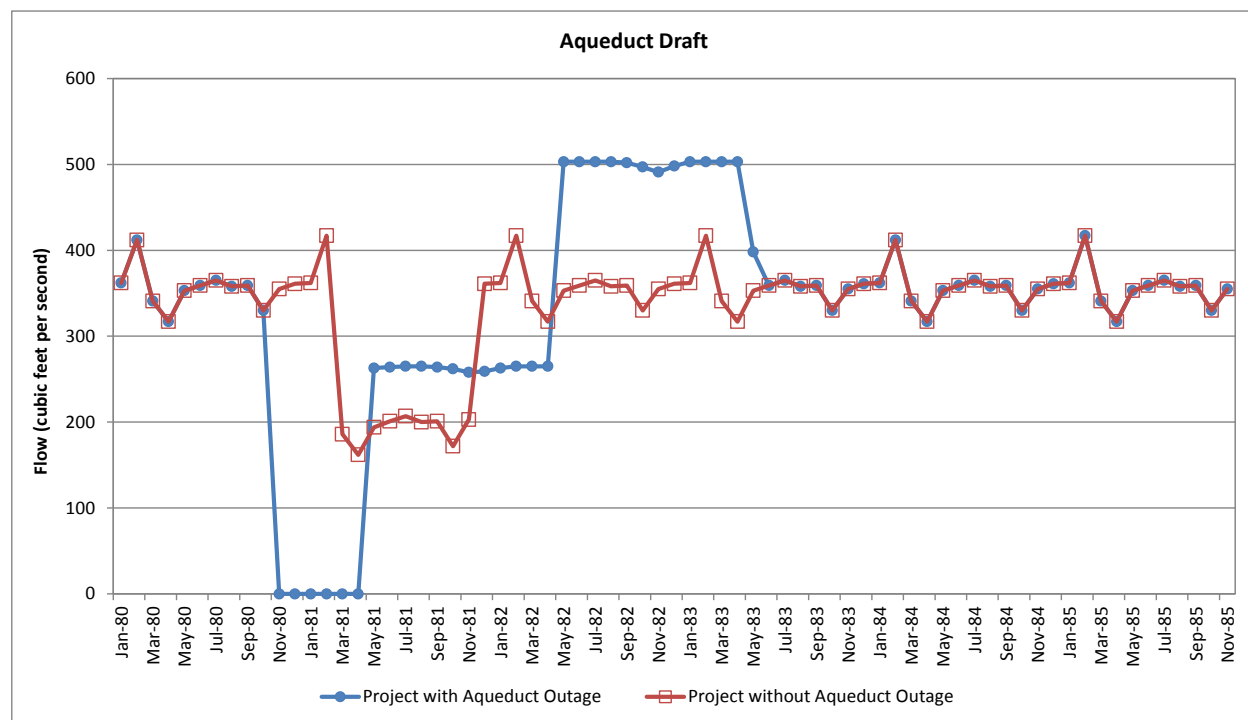


Figure AO-1. Aqueduct Flow Simulated for the Project with and without an Aqueduct Outage

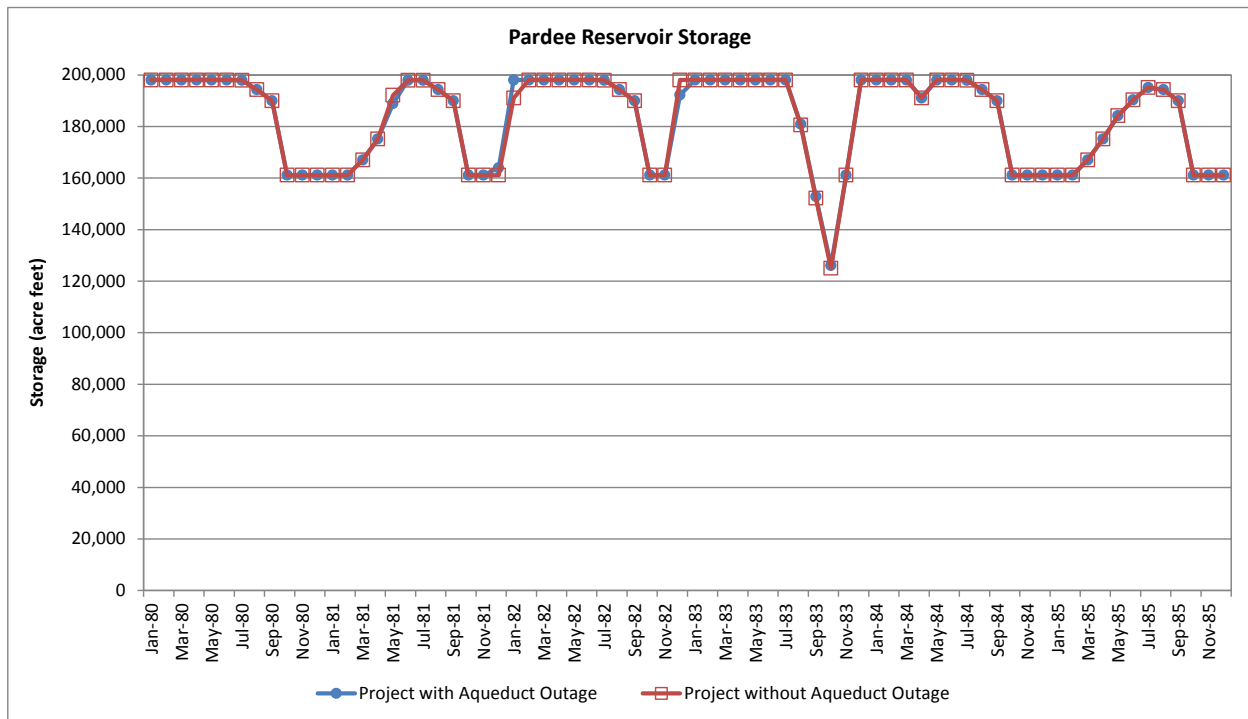


Figure AO-2. Pardee Reservoir Storage Simulated for the Project with and without an Aqeduct Outage

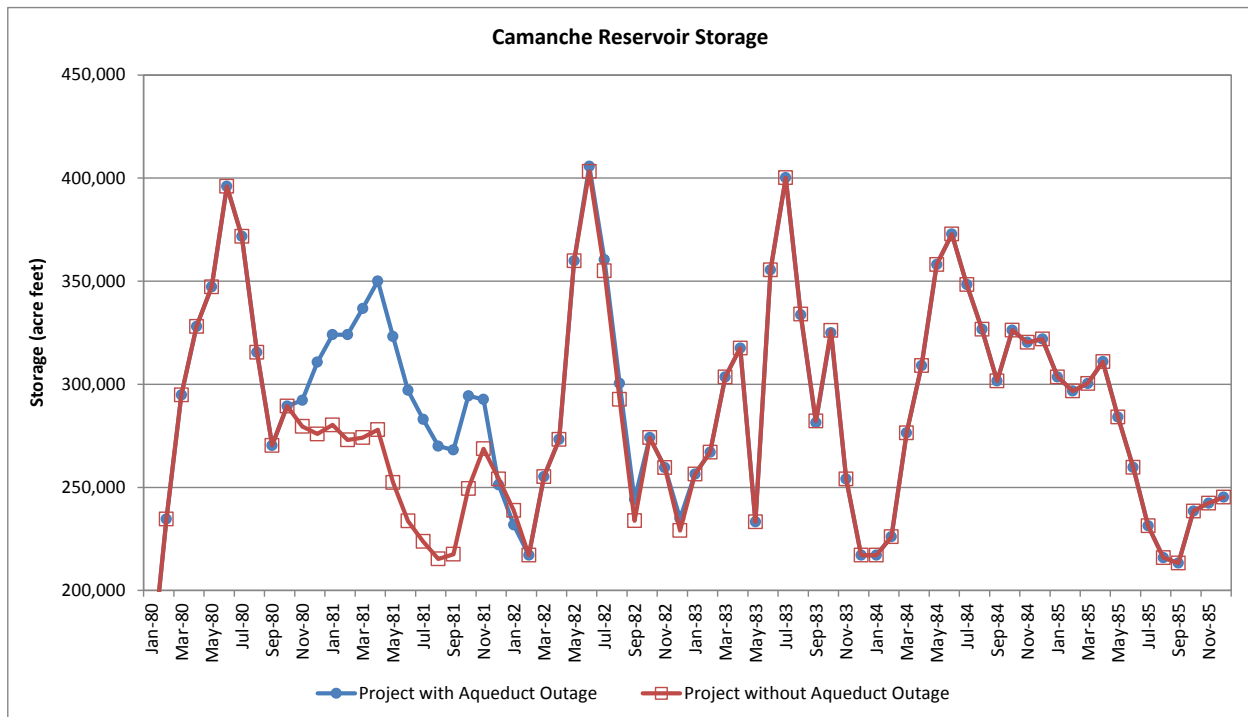


Figure AO-3. Camanche Reservoir Storage Simulated for the Project with and without an Aqeduct Outage

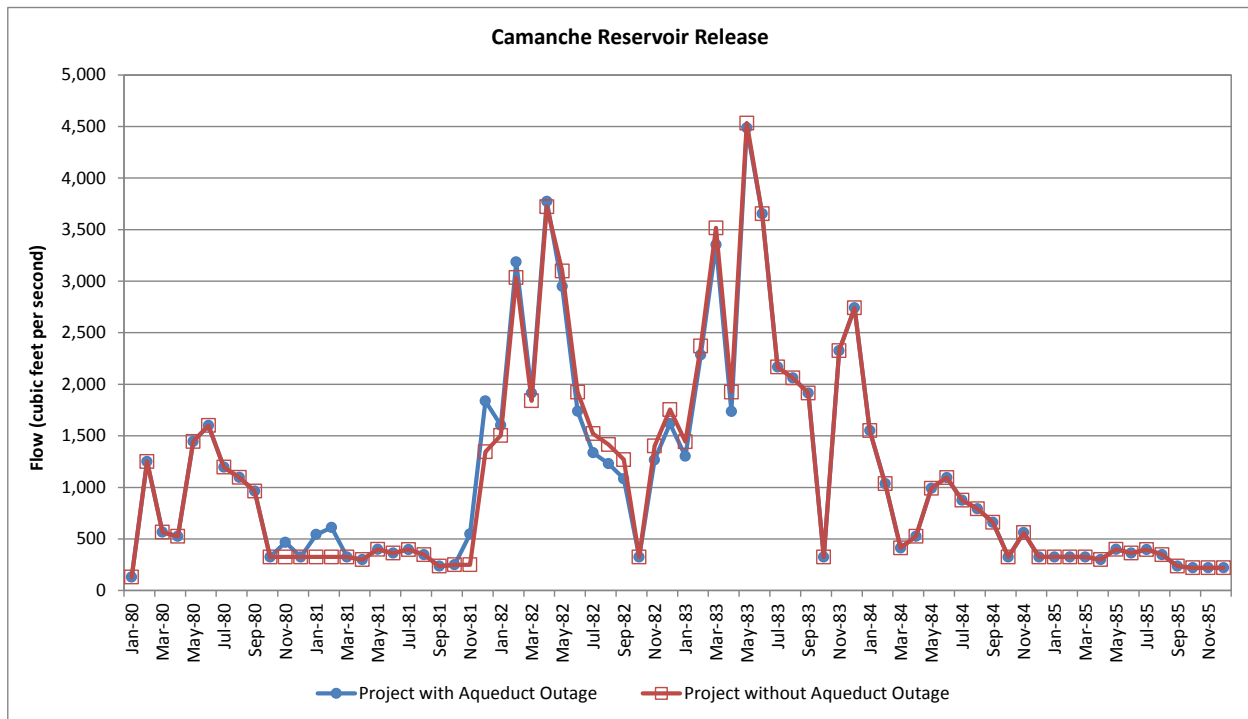


Figure AO-4. Camanche Reservoir Releases Simulated for the Project with and without an Aqeduct Outage

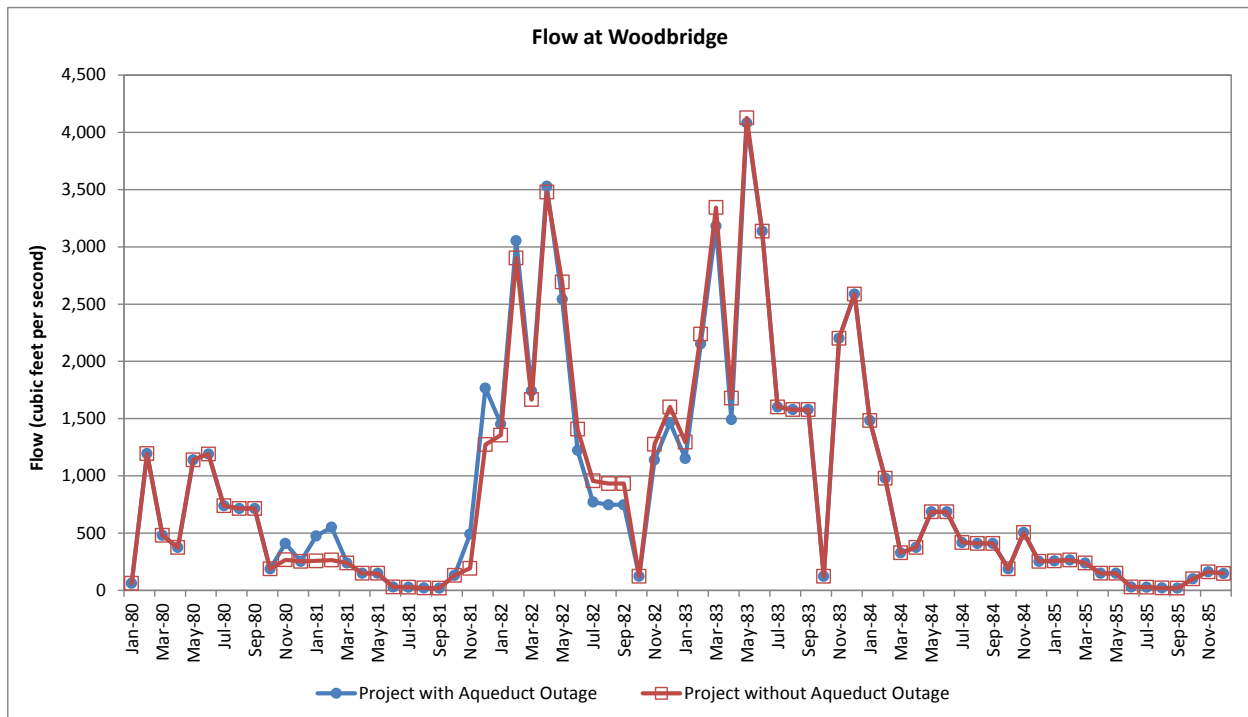


Figure AO-5. Flow at Woodbridge Simulated for the Project with and without an Aqeduct Outage

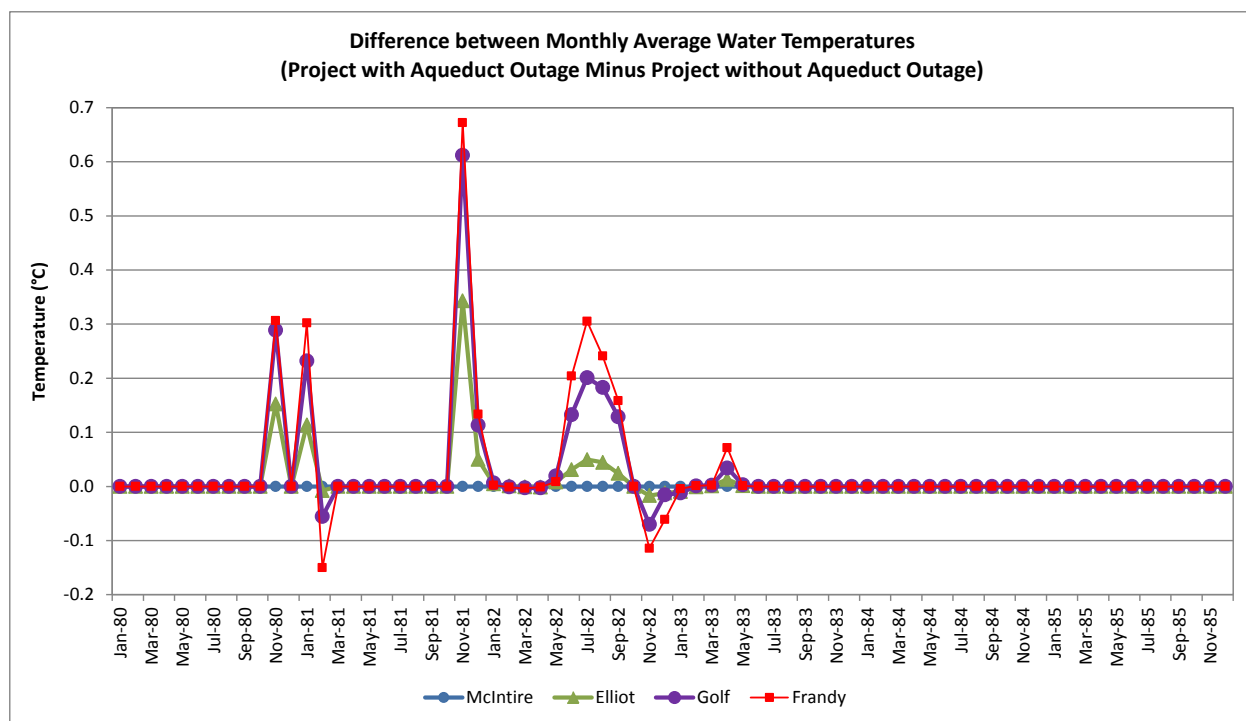


Figure AO-6. Differences between Monthly Average Water Temperatures Simulated for the Project with and without an Aqueduct Outage

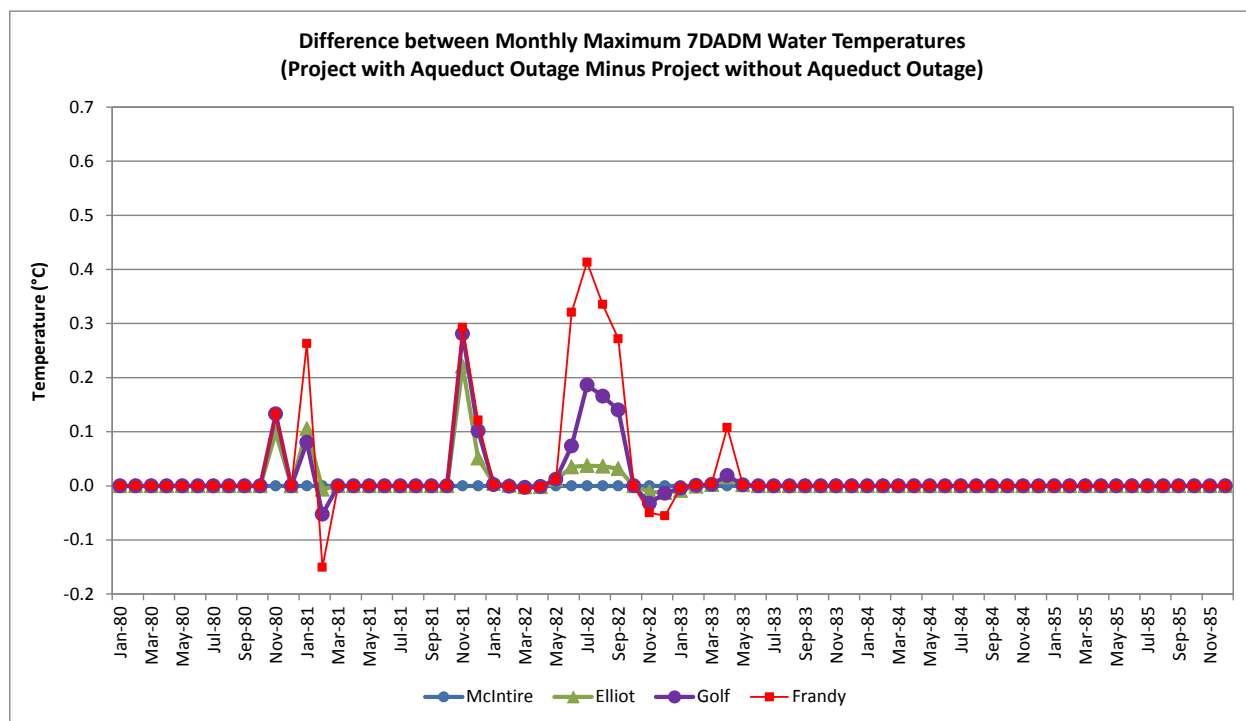
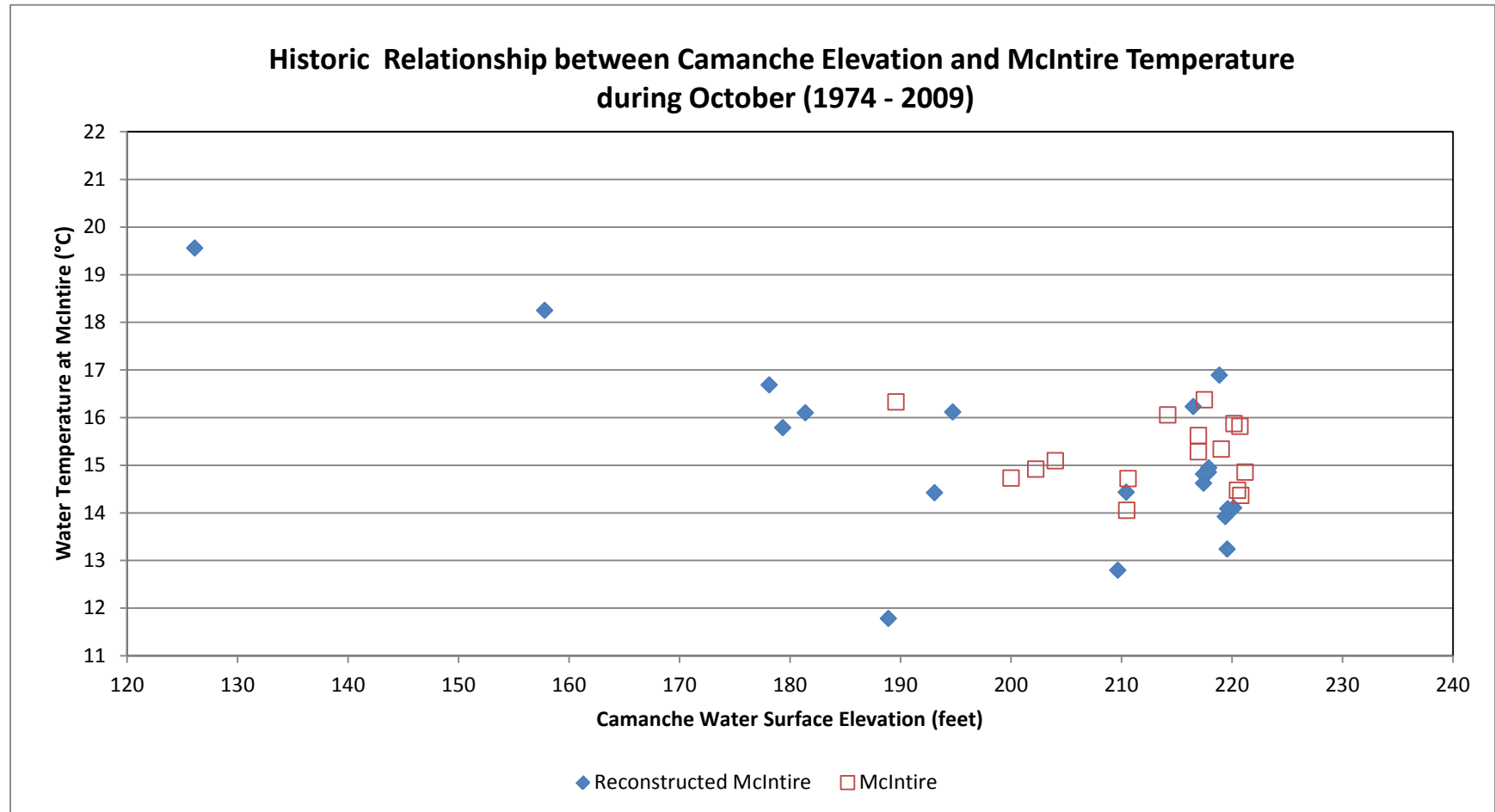


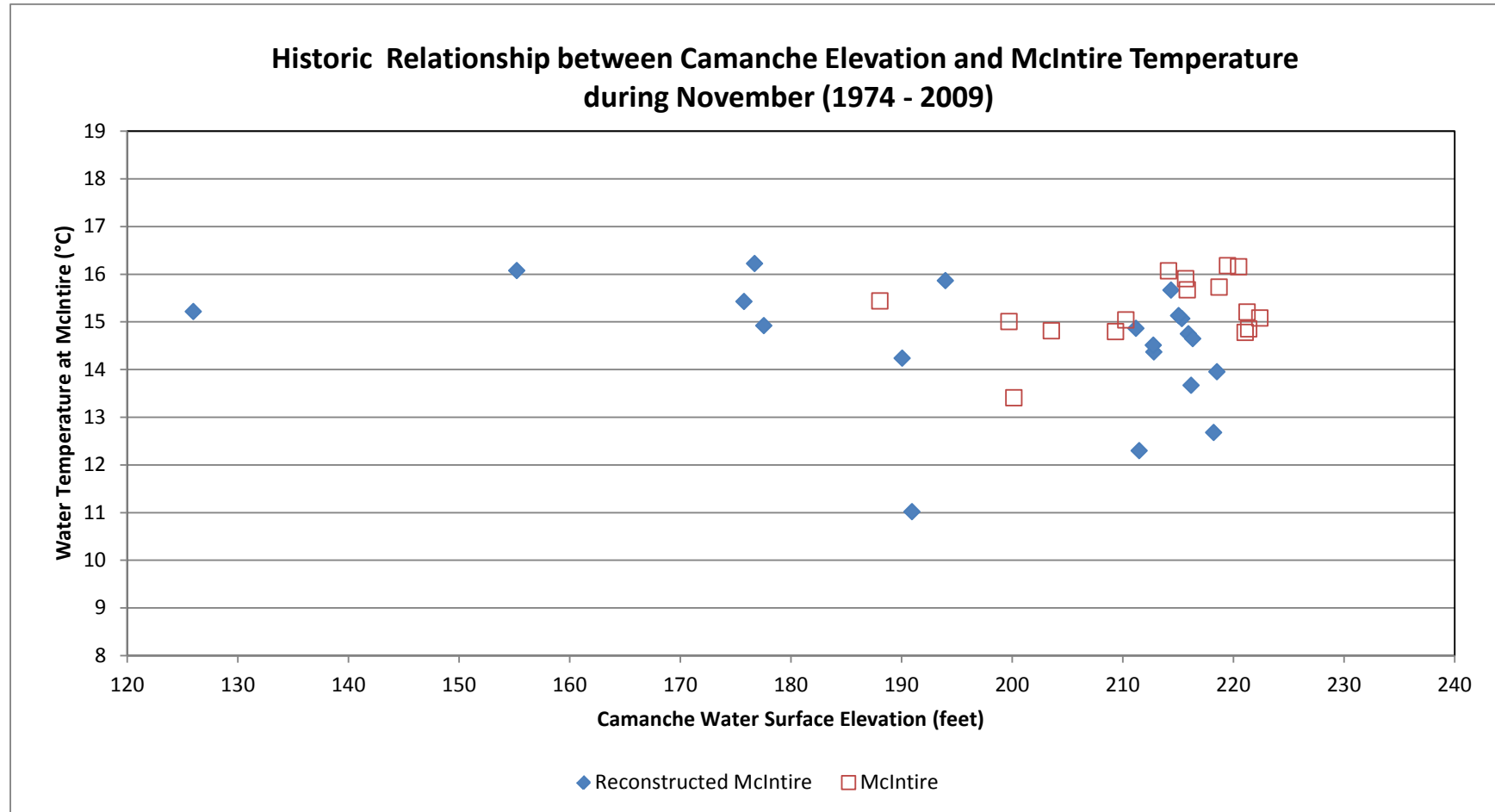
Figure AO-7. Differences between Monthly Maximums of the Seven-Day Moving Average of the Daily Maximum Water Temperatures Simulated for the Project with and without an Aqueduct Outage

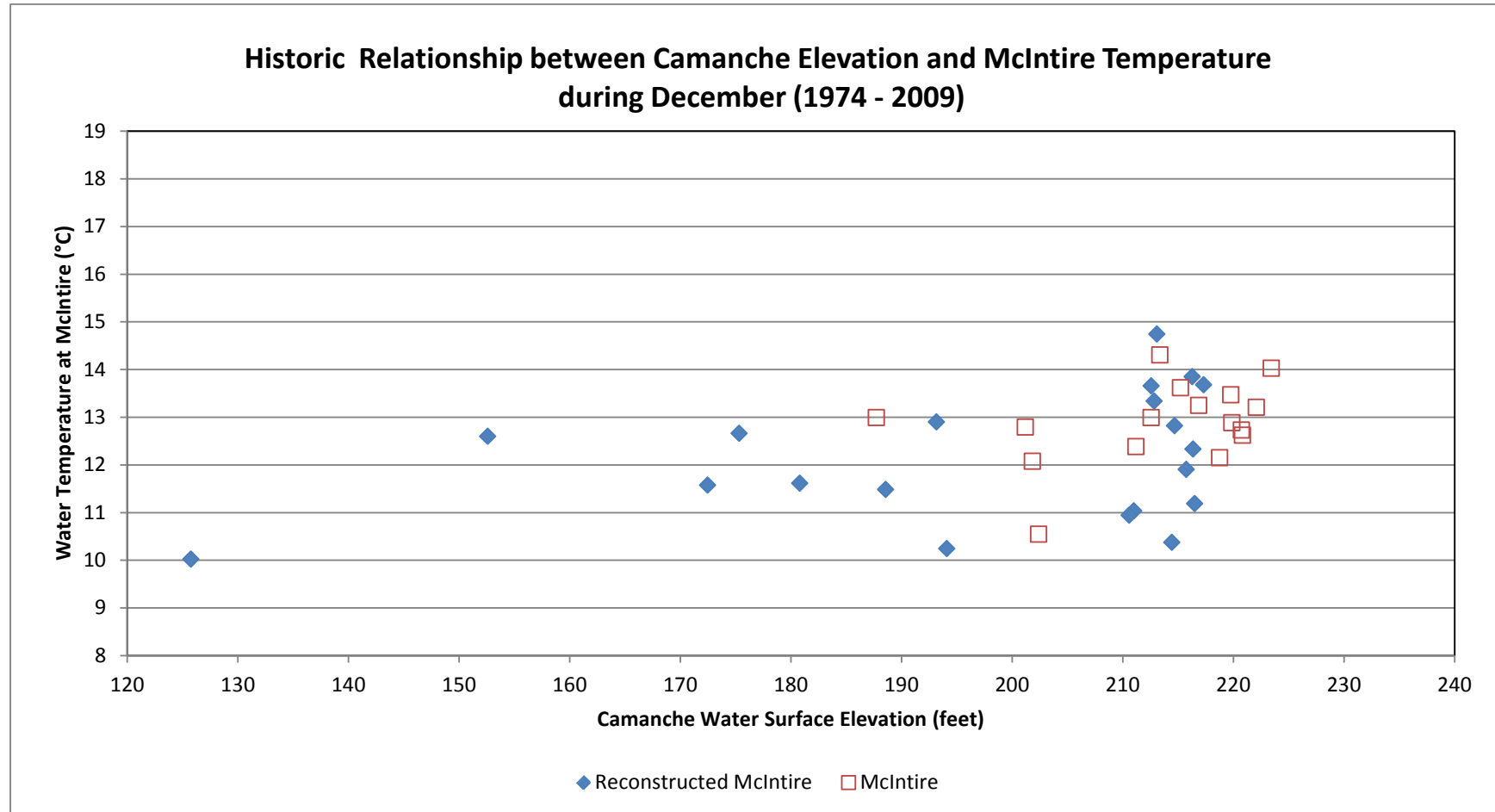
Appendix F

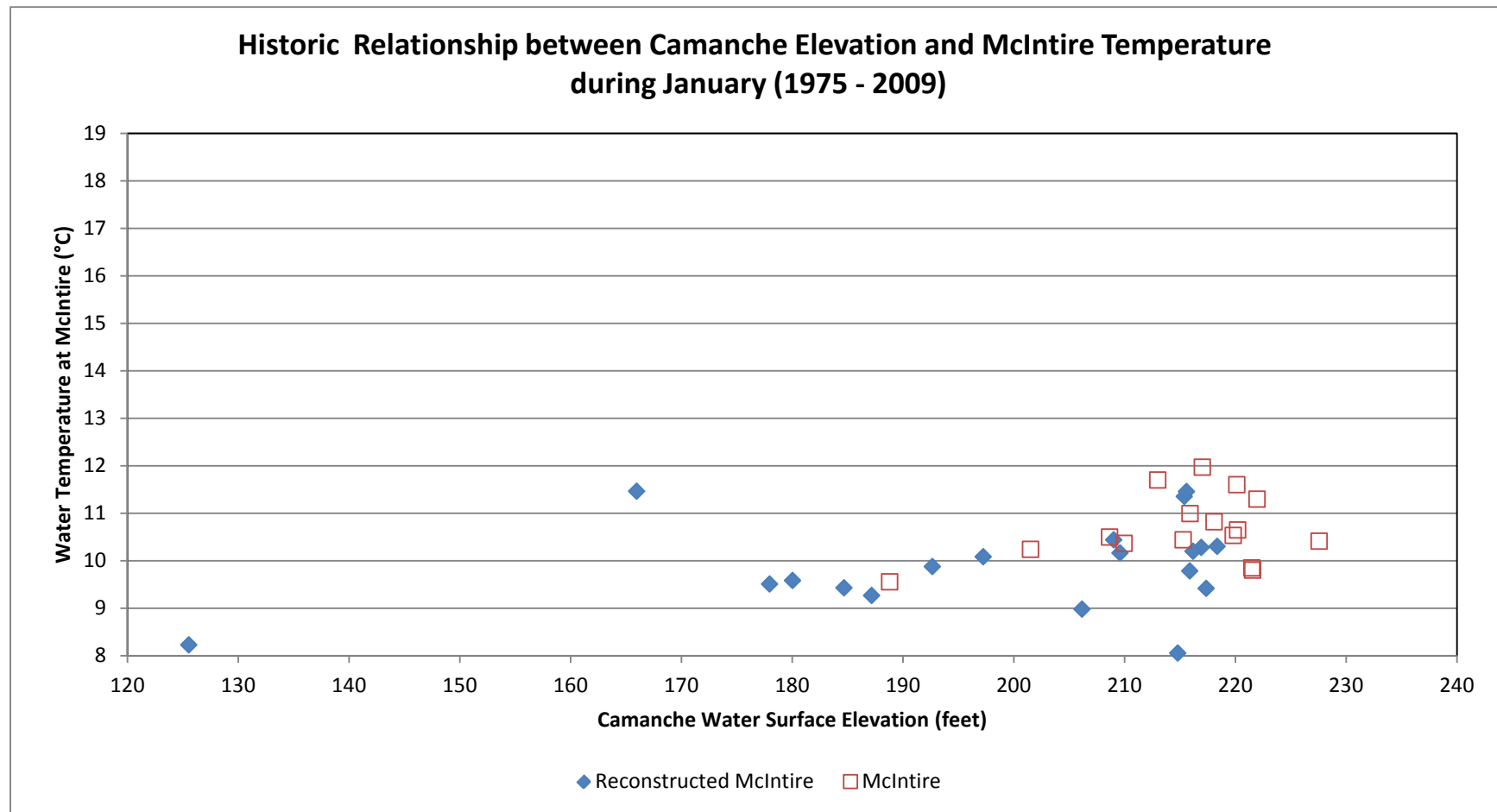
**Comparison of End-of-Month Water-Surface
Elevations at Camanche Reservoir to Average Water
Temperature at Station McIntire for
October 1974 to December 2009**

Note: Reconstructed Station McIntire temperatures are derived from hatchery temperatures

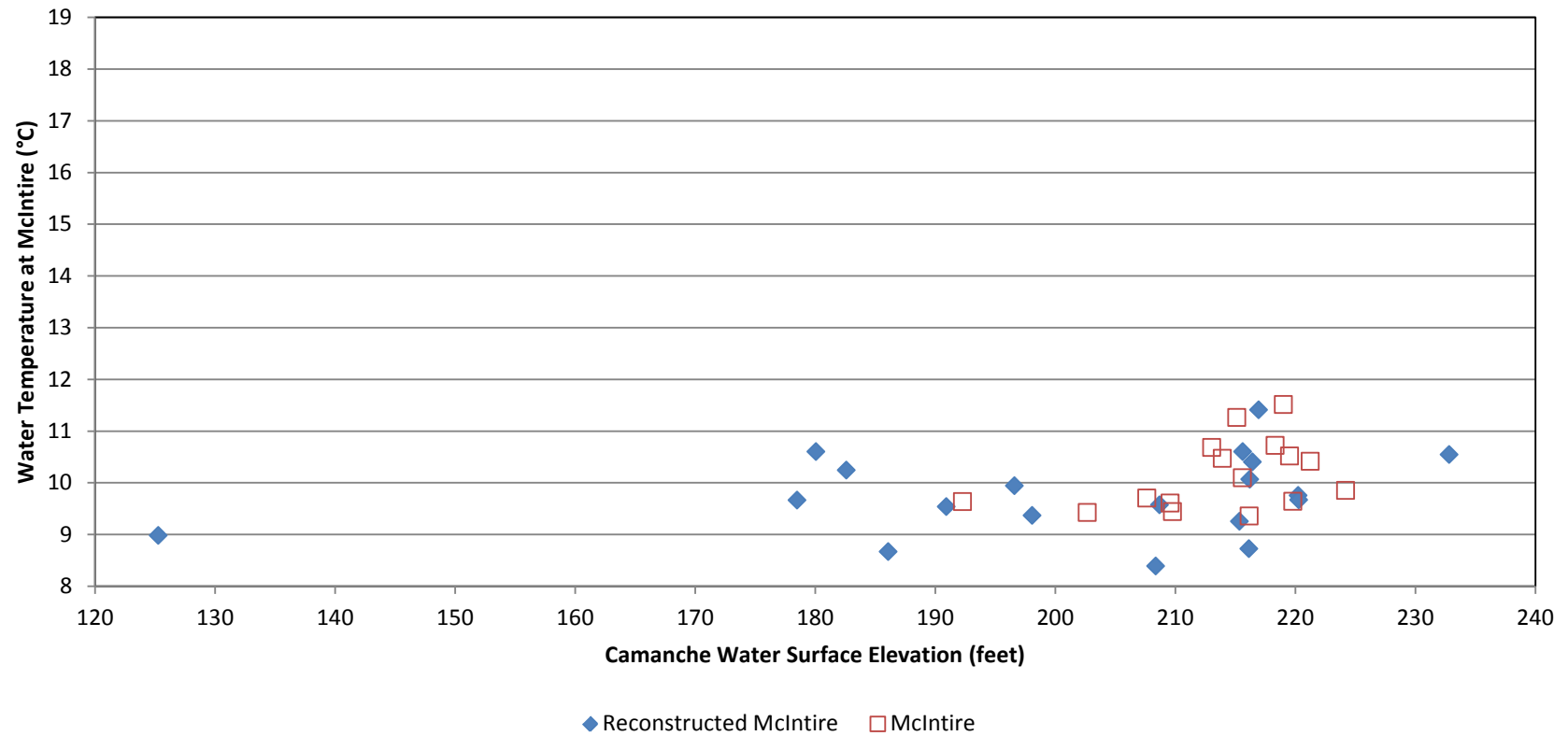


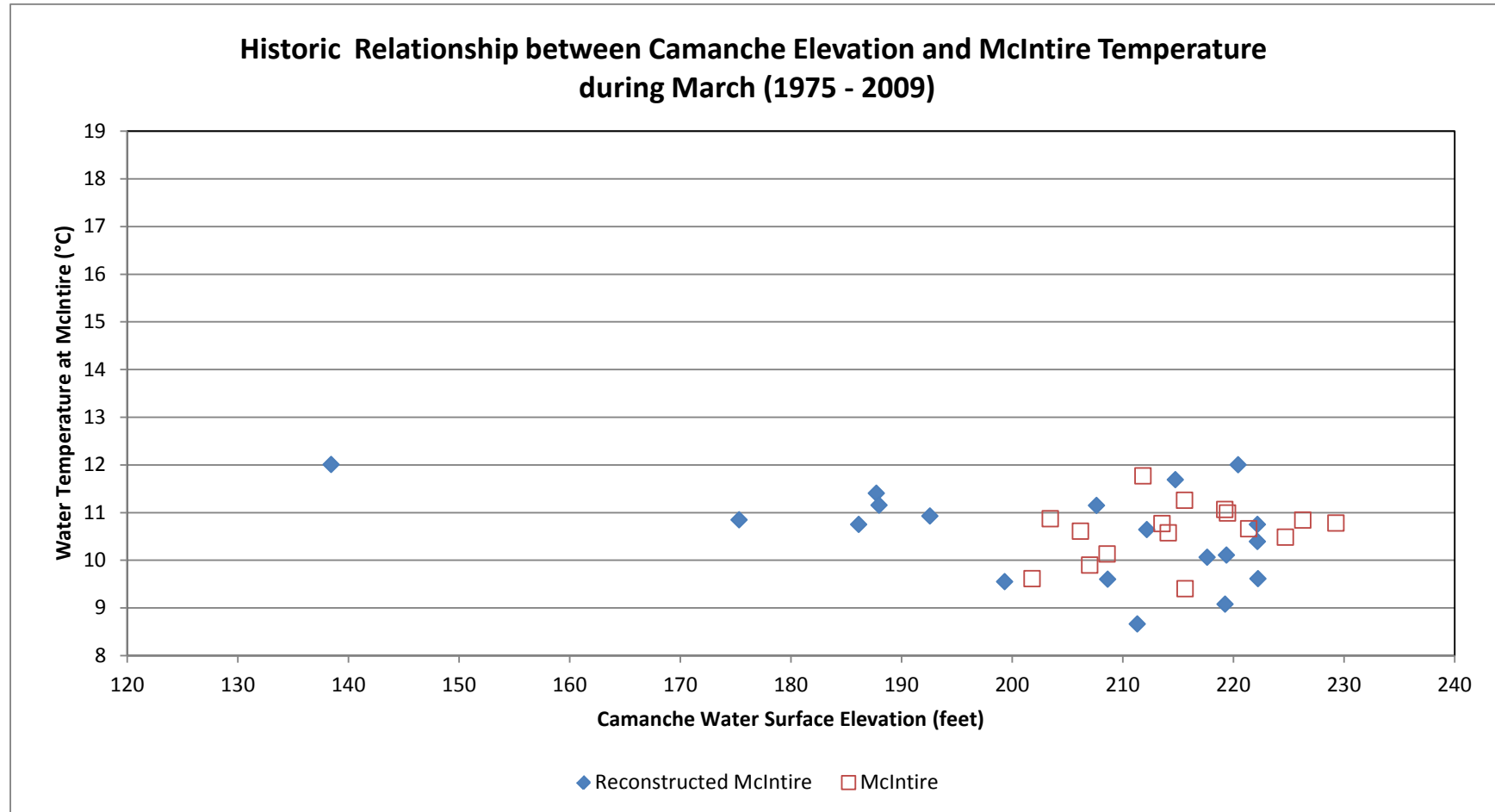


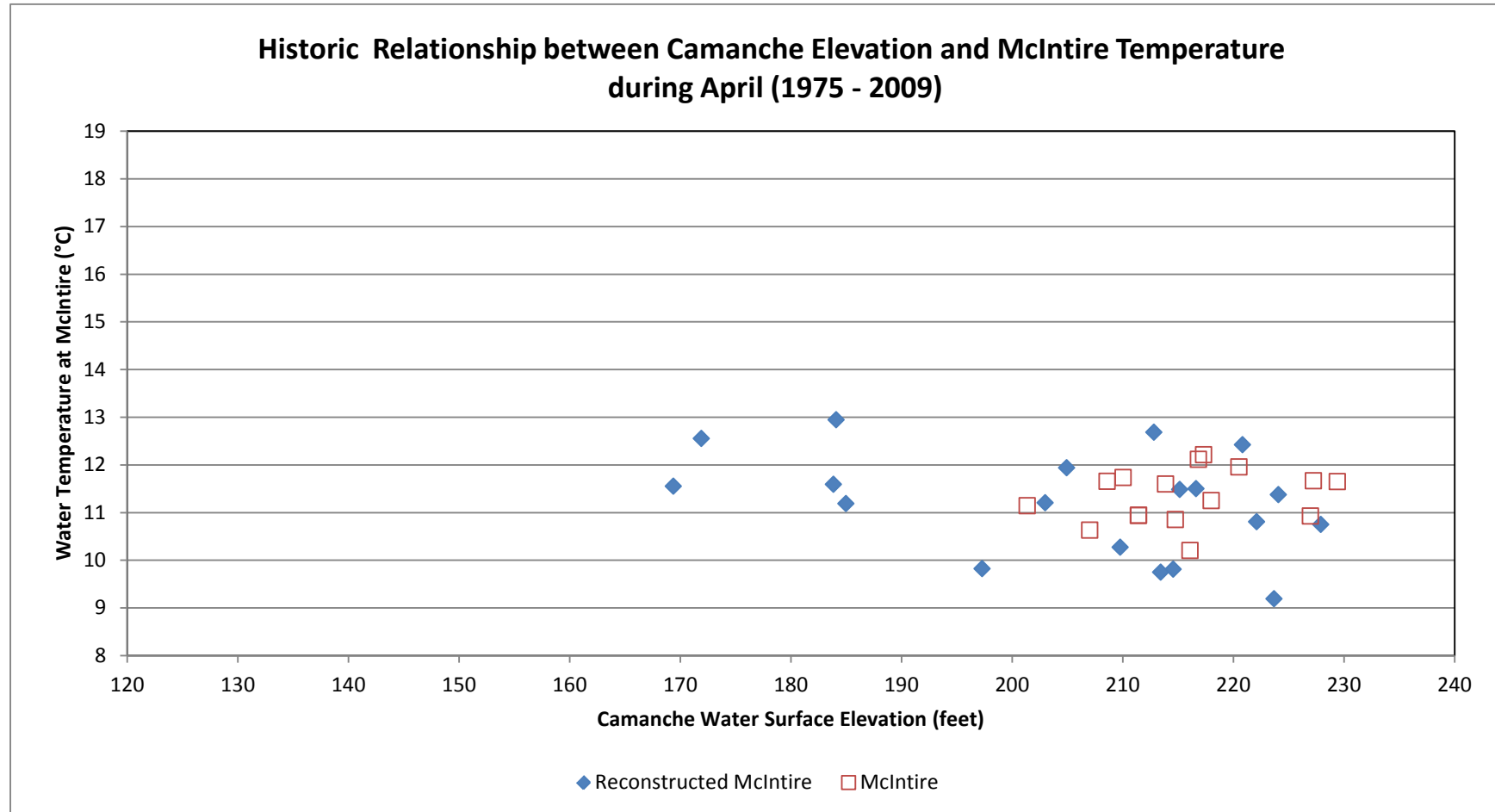


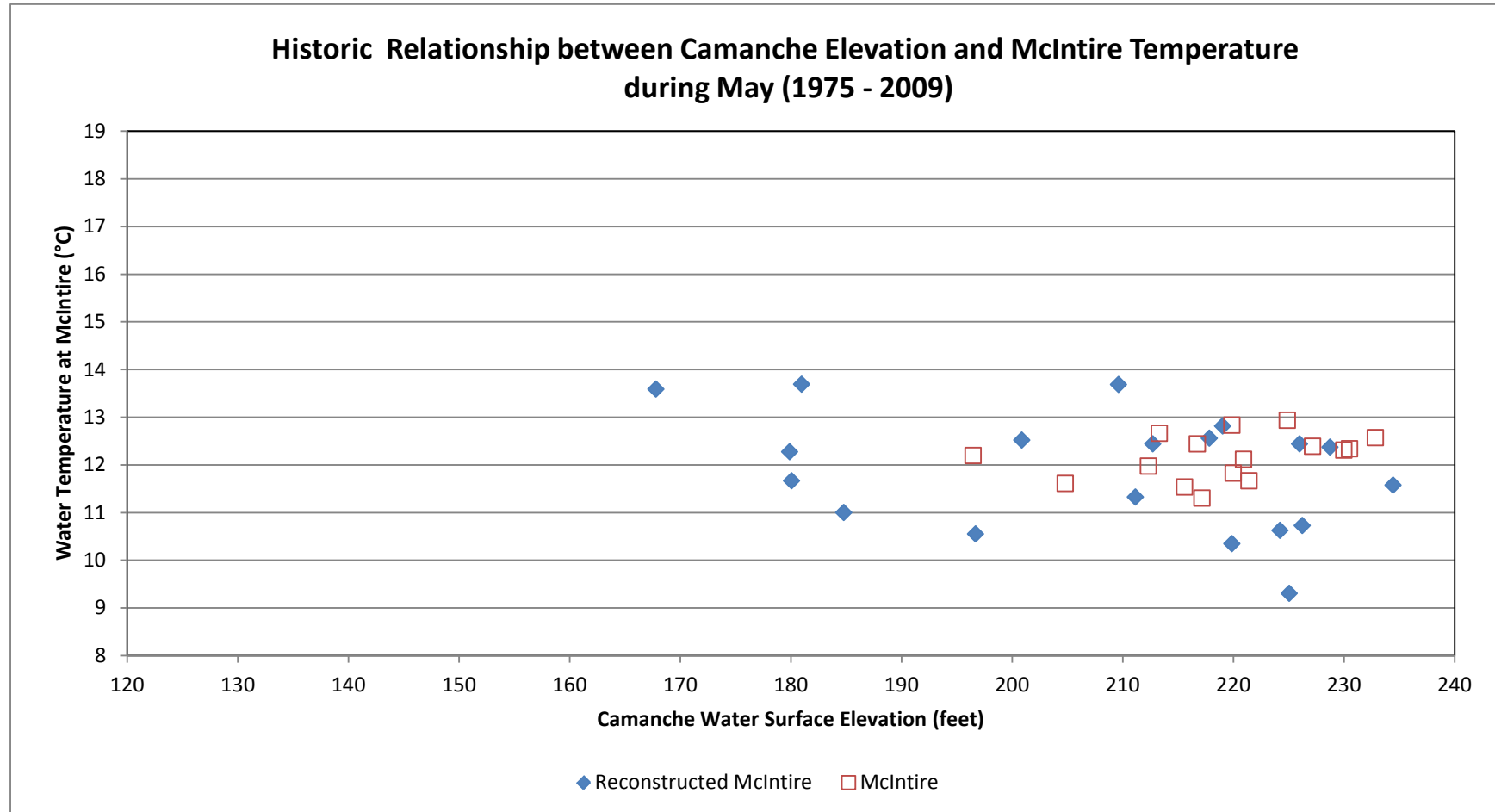


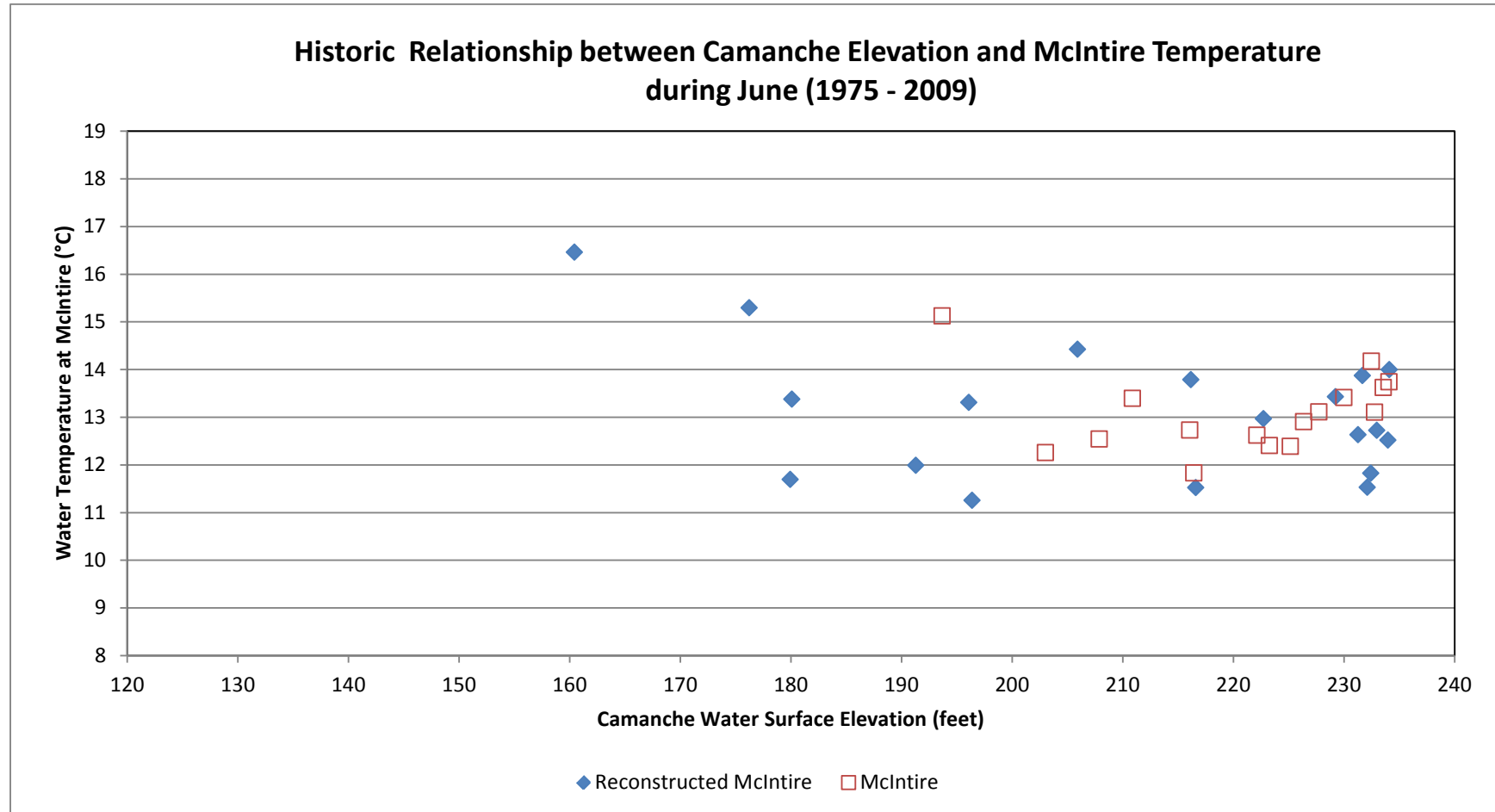
Historic Relationship between Camanche Elevation and McIntire Temperature during February (1975 - 2009)

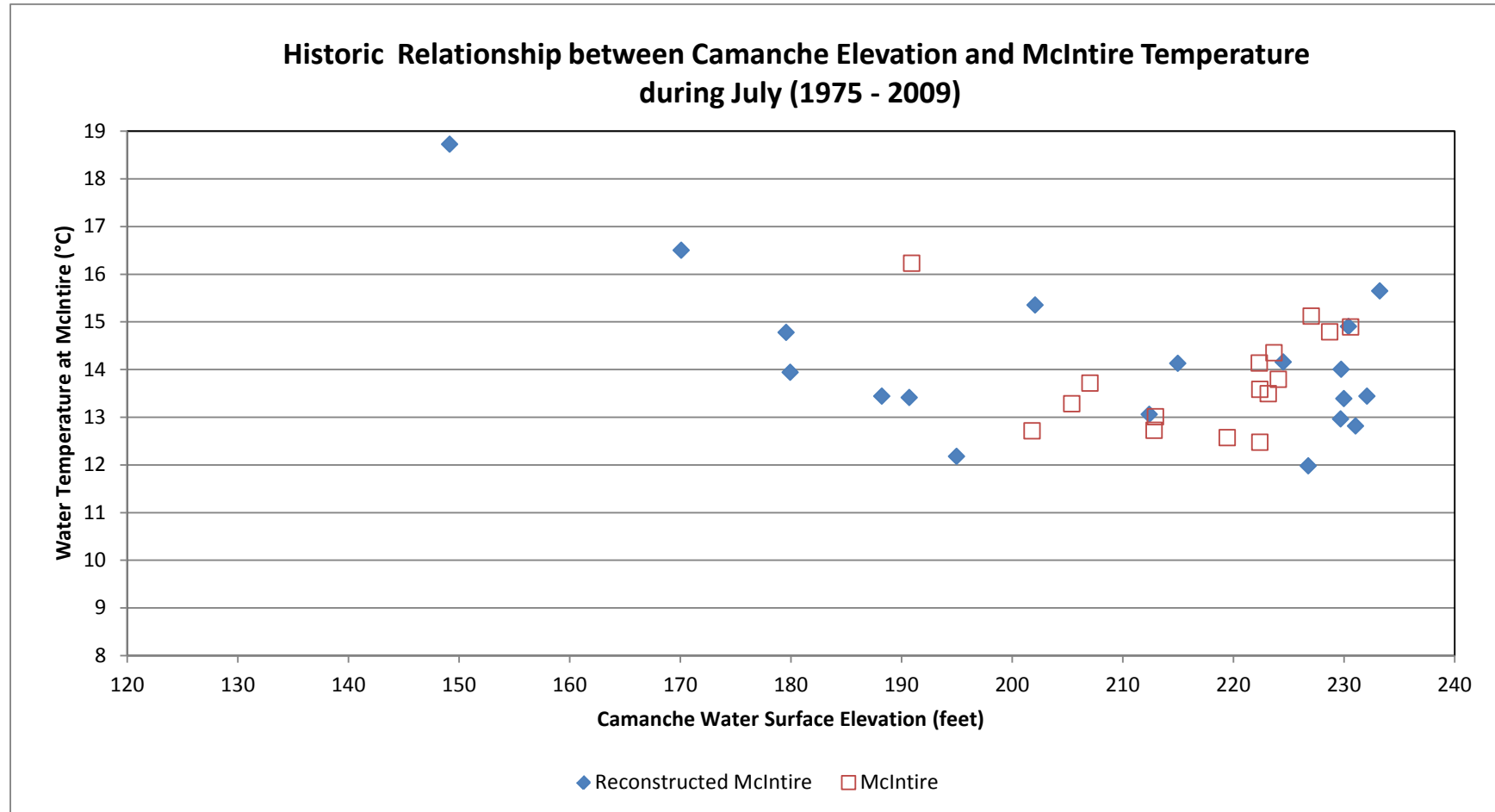


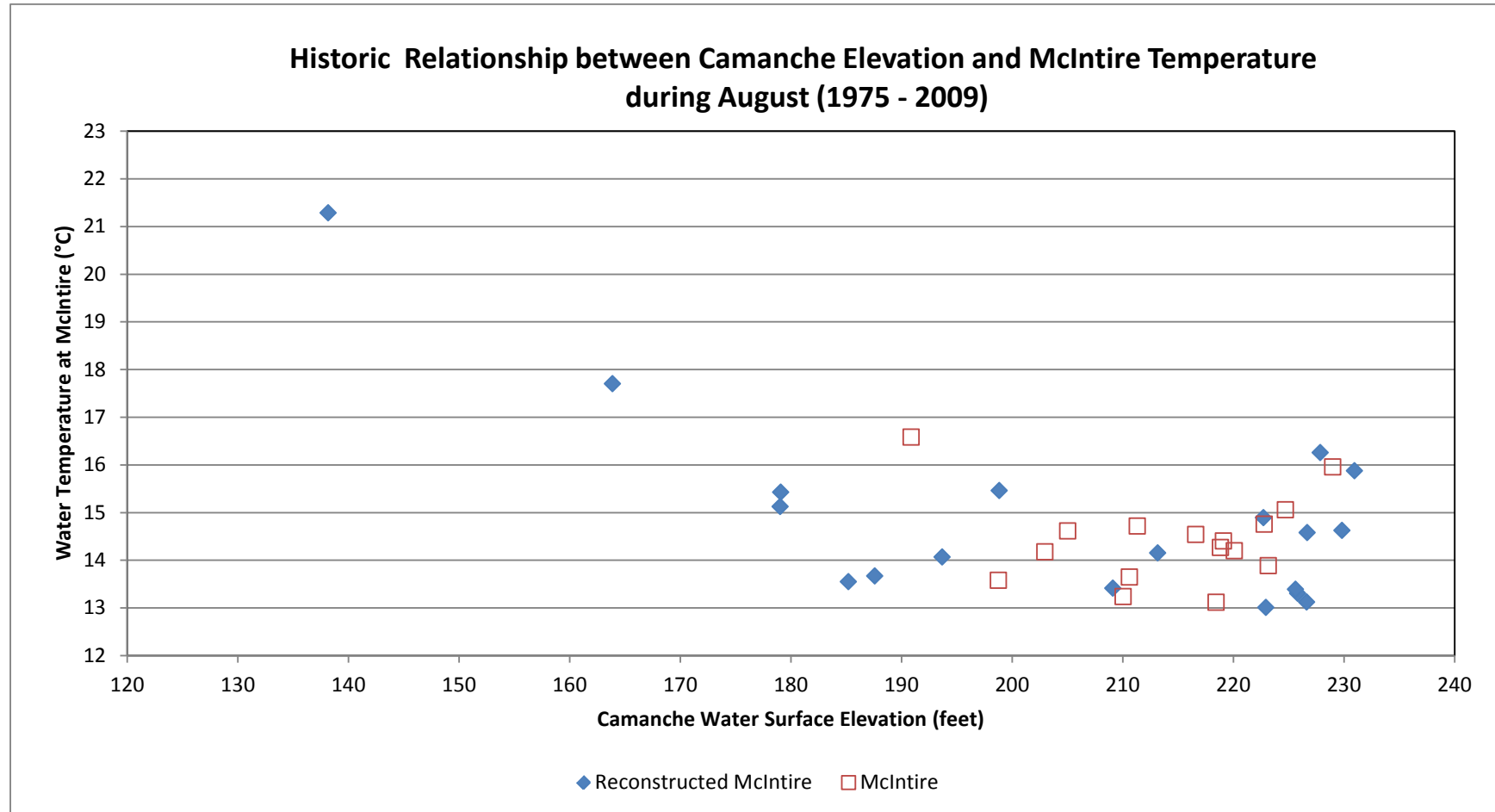


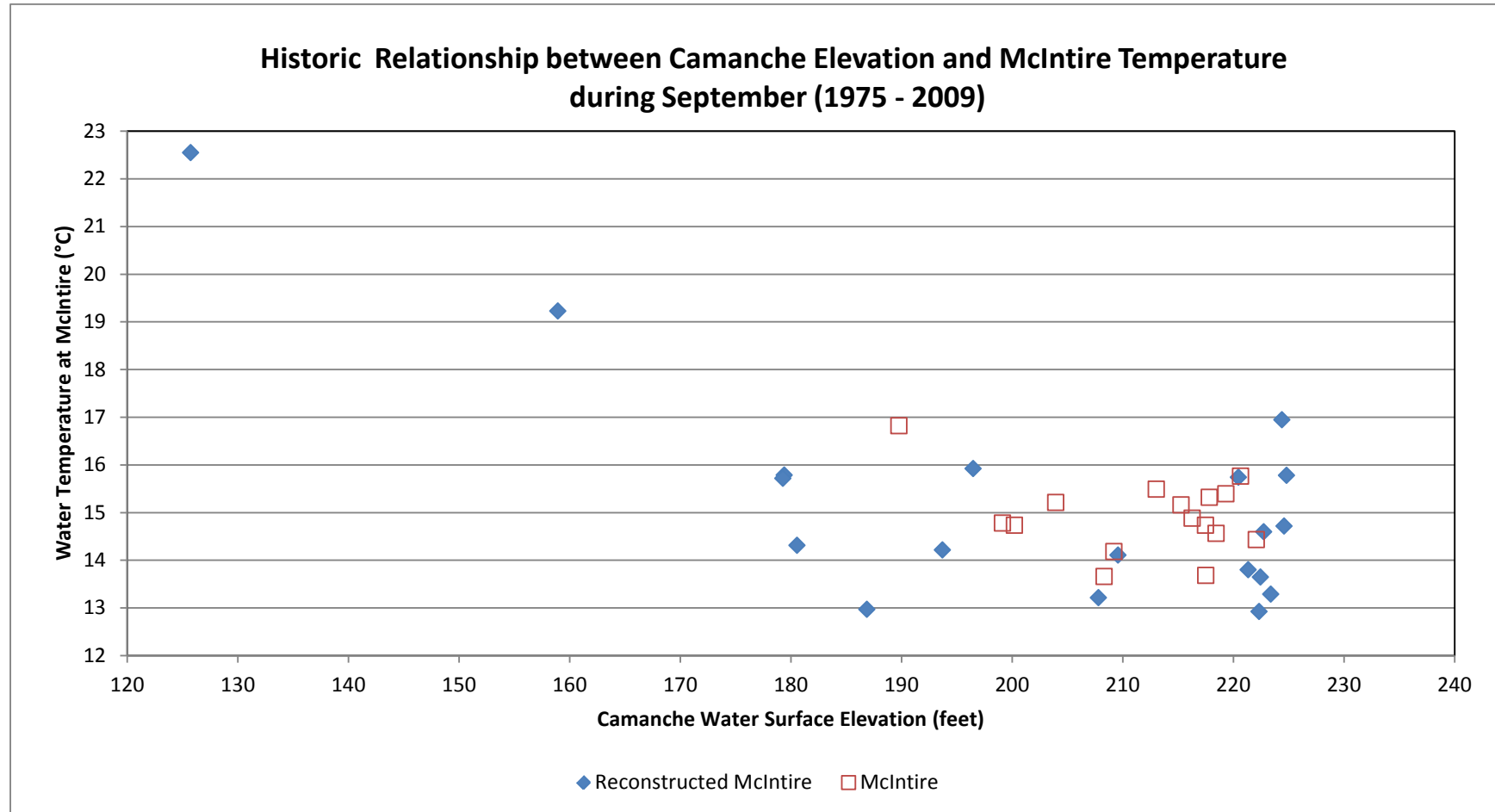










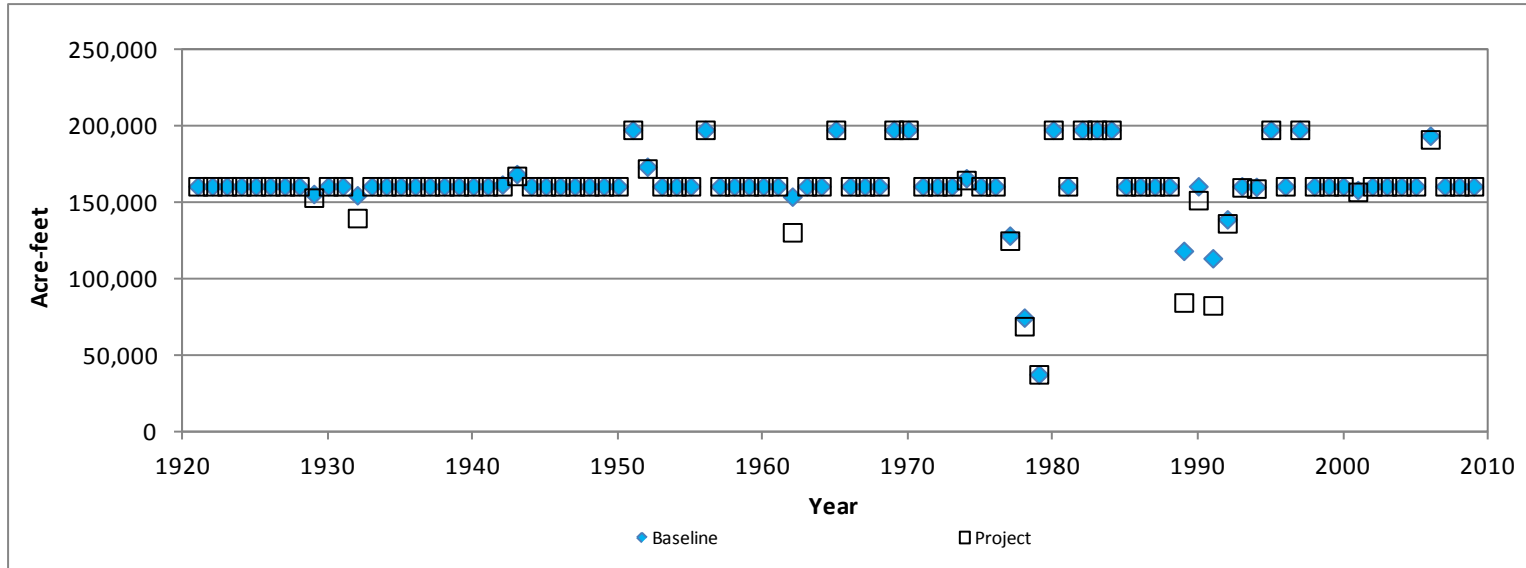


Appendix G

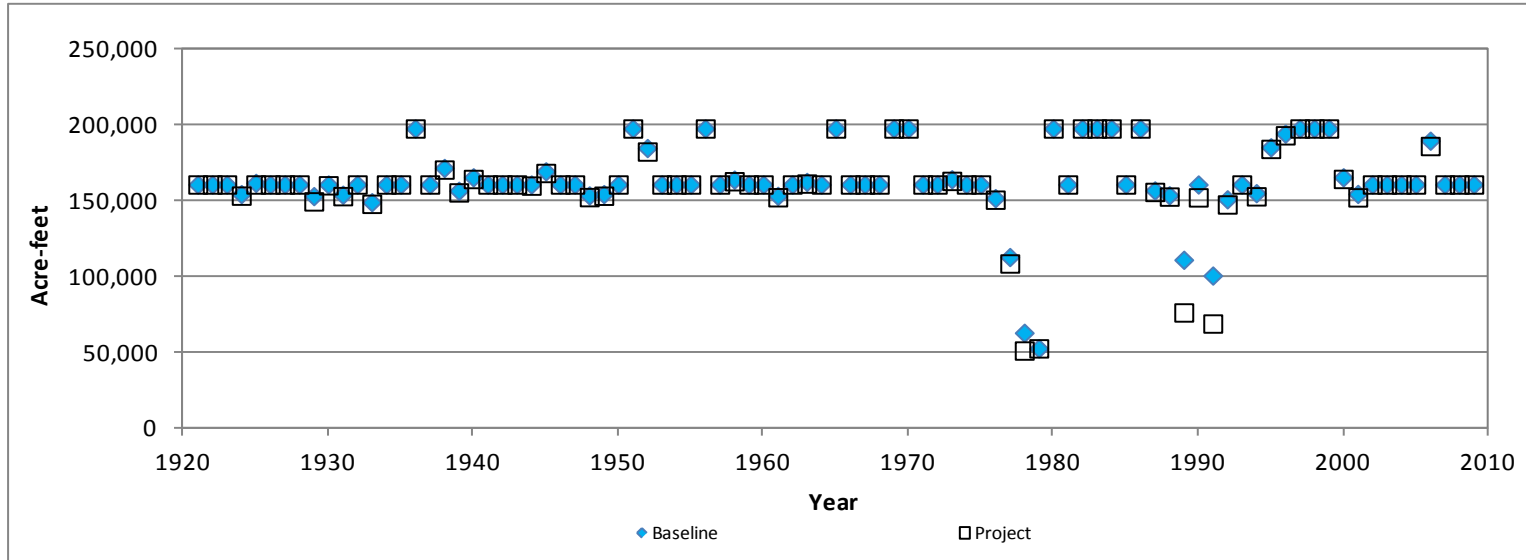
**Monthly Graphs of Baseline and Permit 10478 Time
Extension Project EBMUDSIM Results for
Pardee Reservoir Storage, Camanche Reservoir
Storage, Camanche Release Flows, and
Flows below Woodbridge**

G.1 Pardee Reservoir Storage

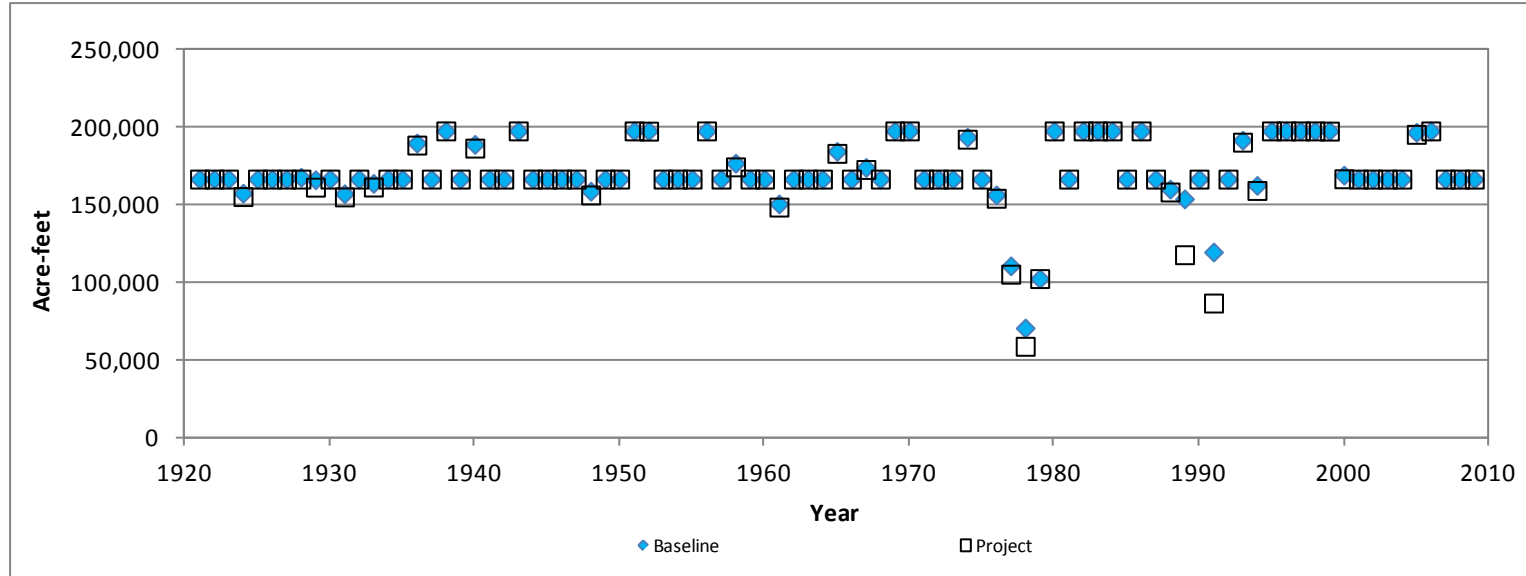
January



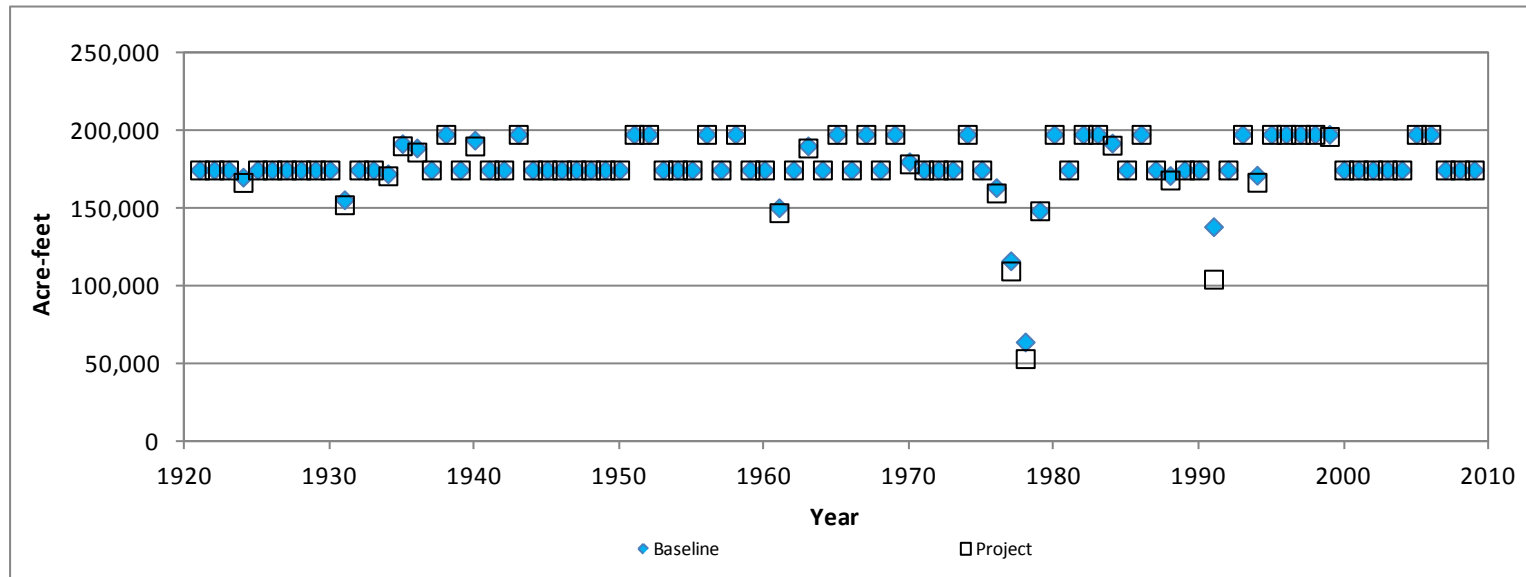
February



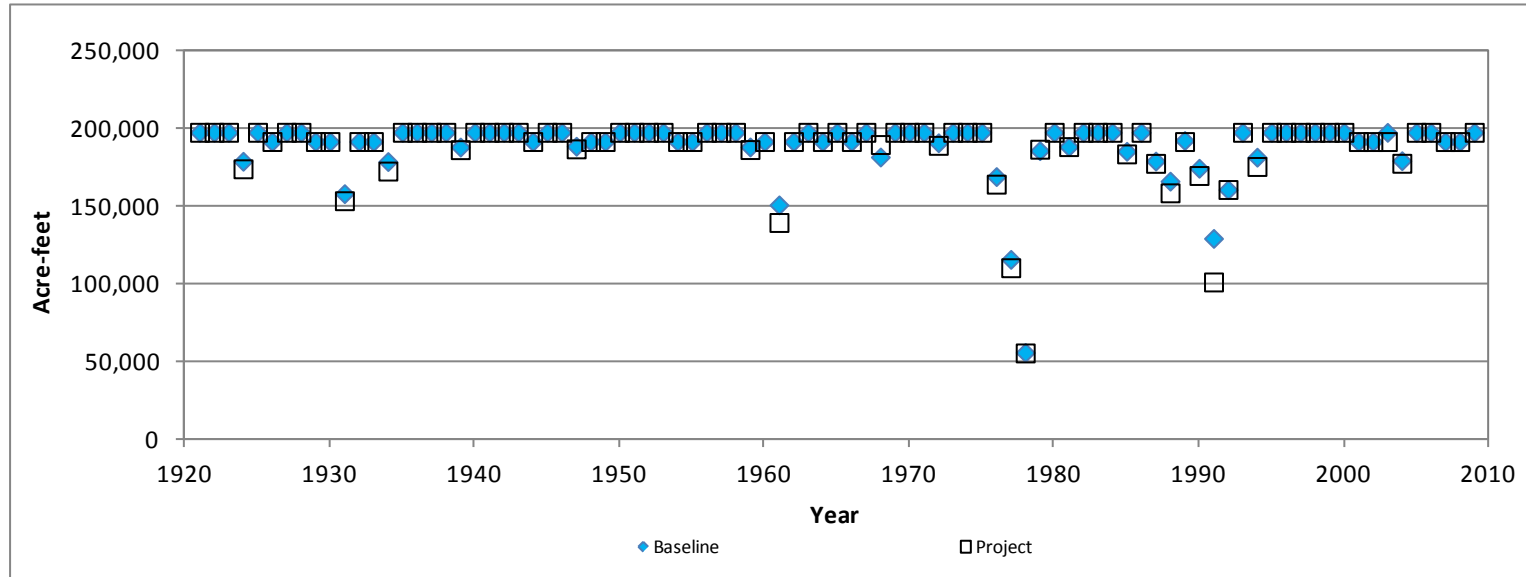
March



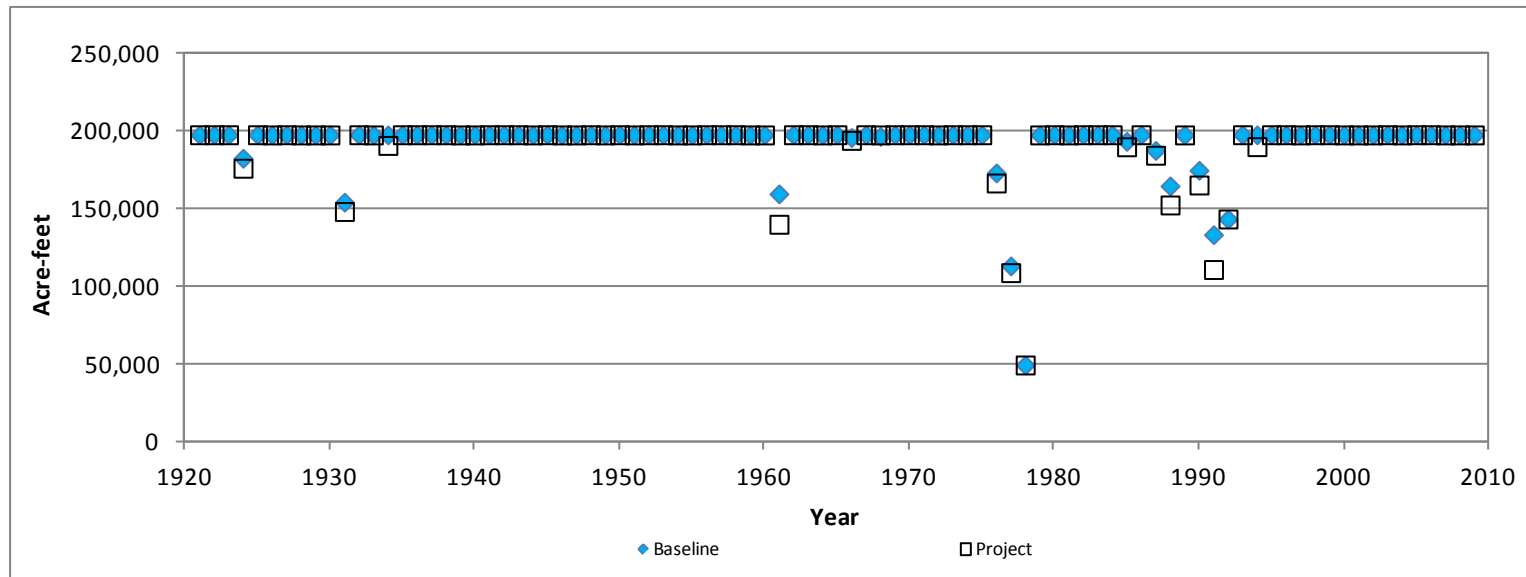
April



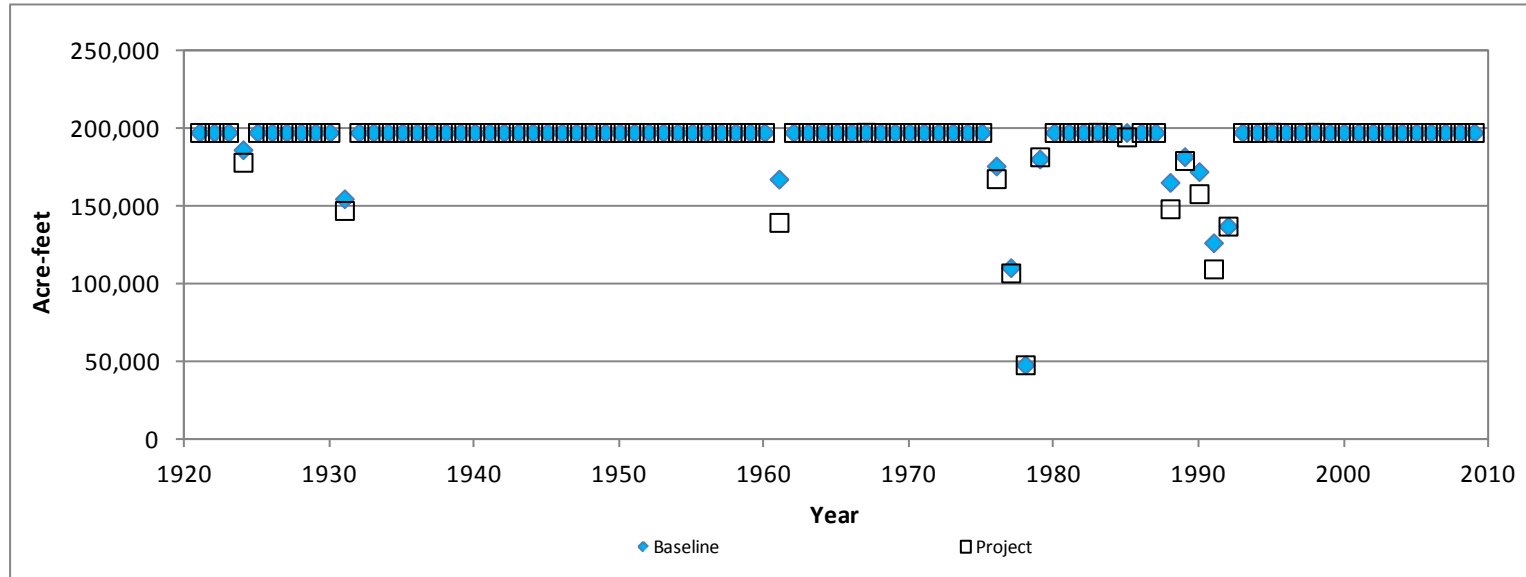
May



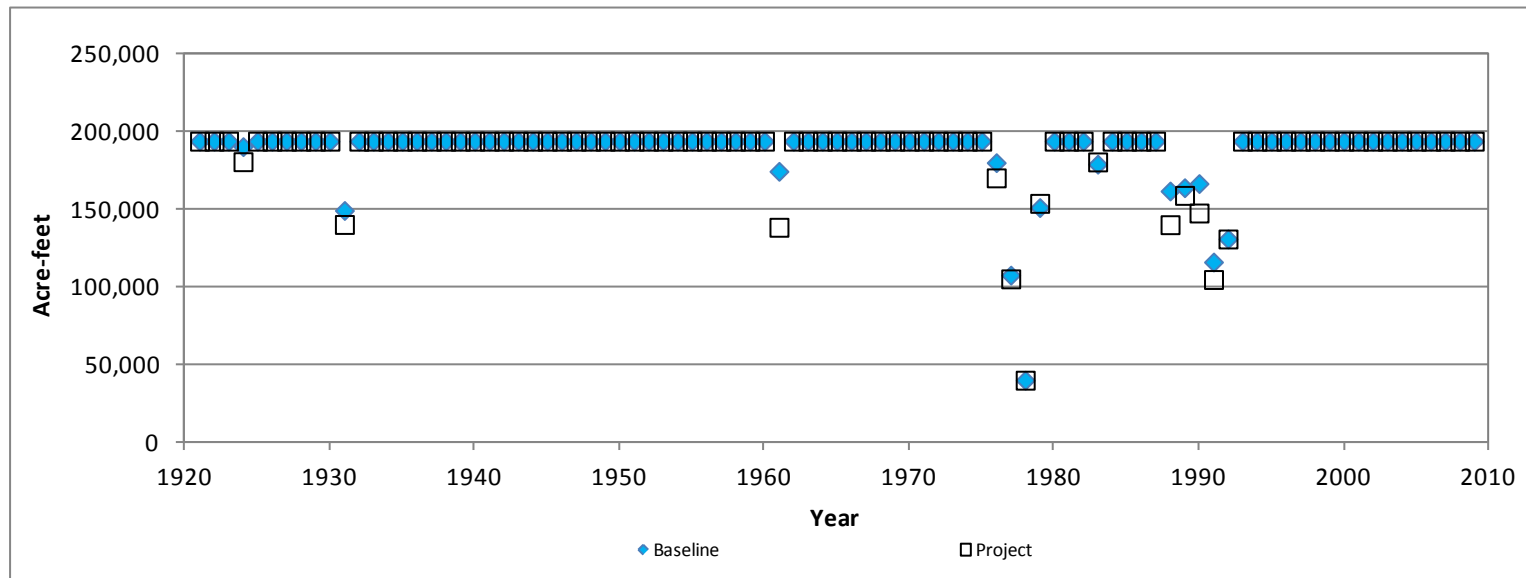
June



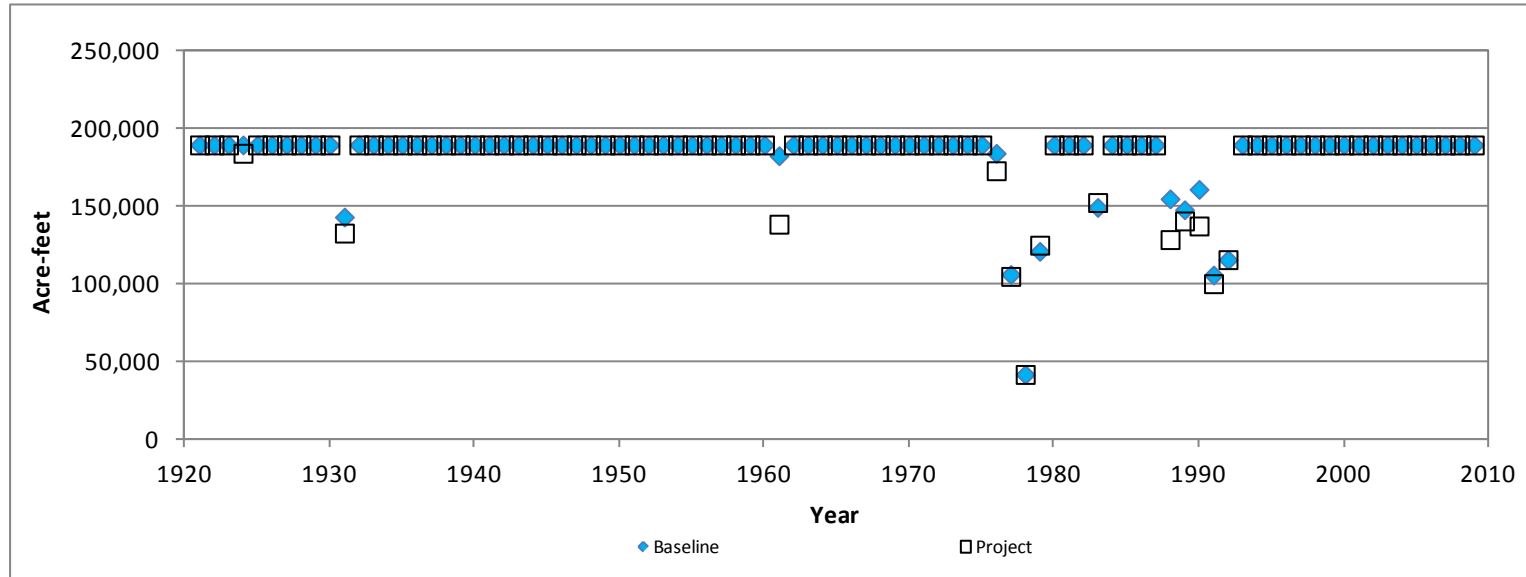
July



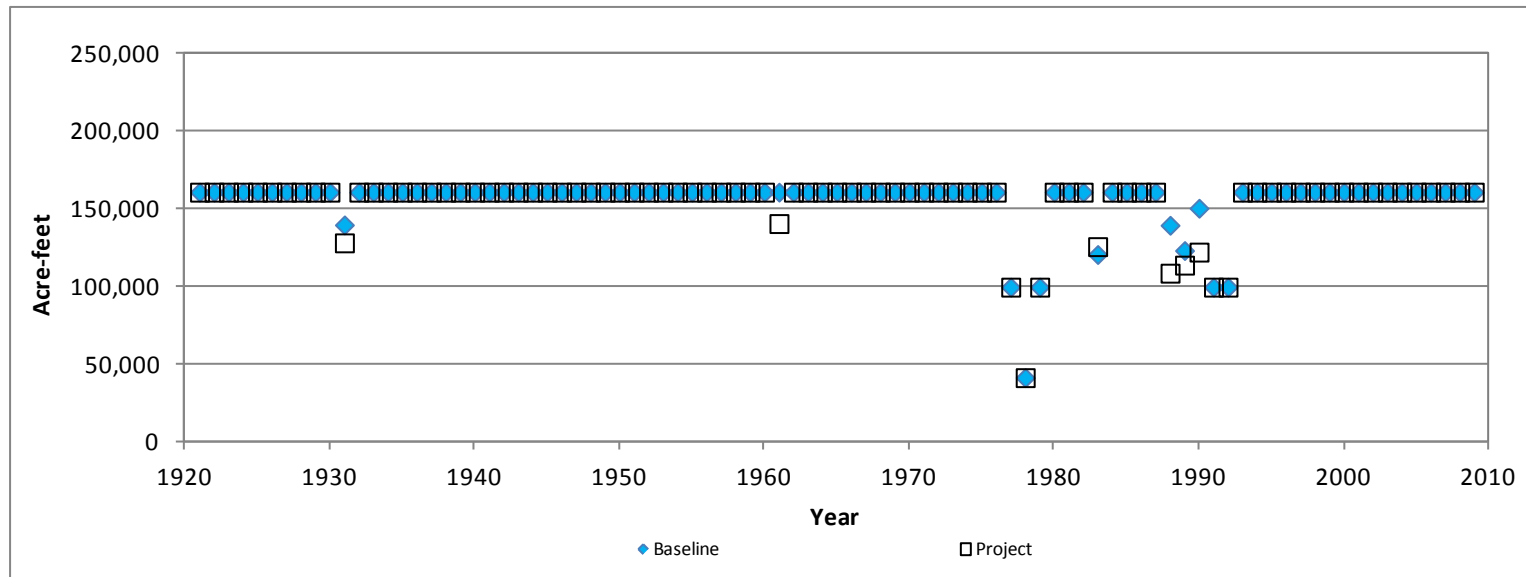
August



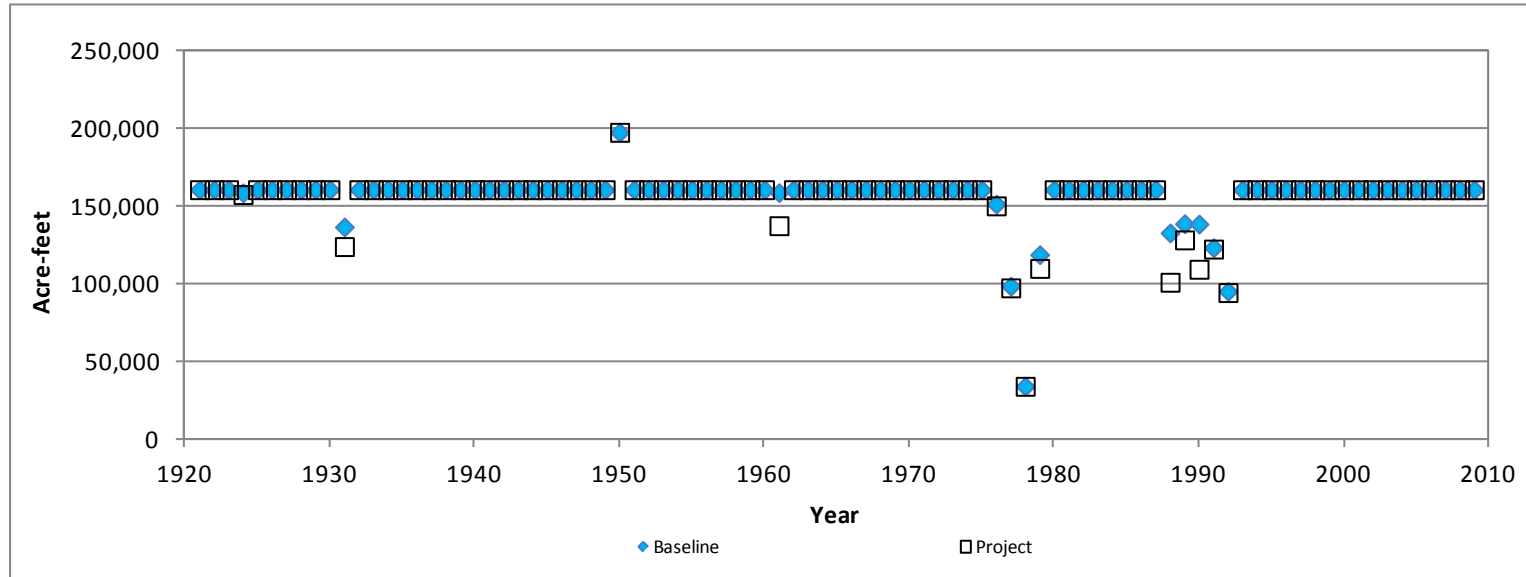
September



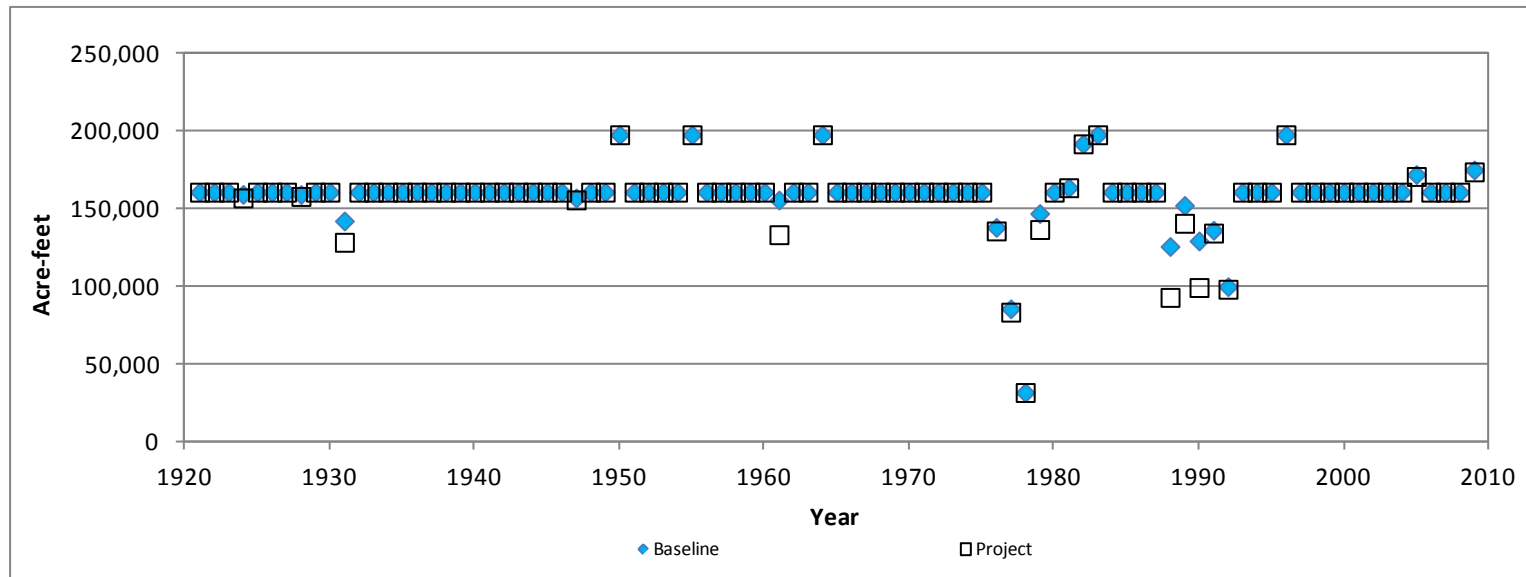
October



November

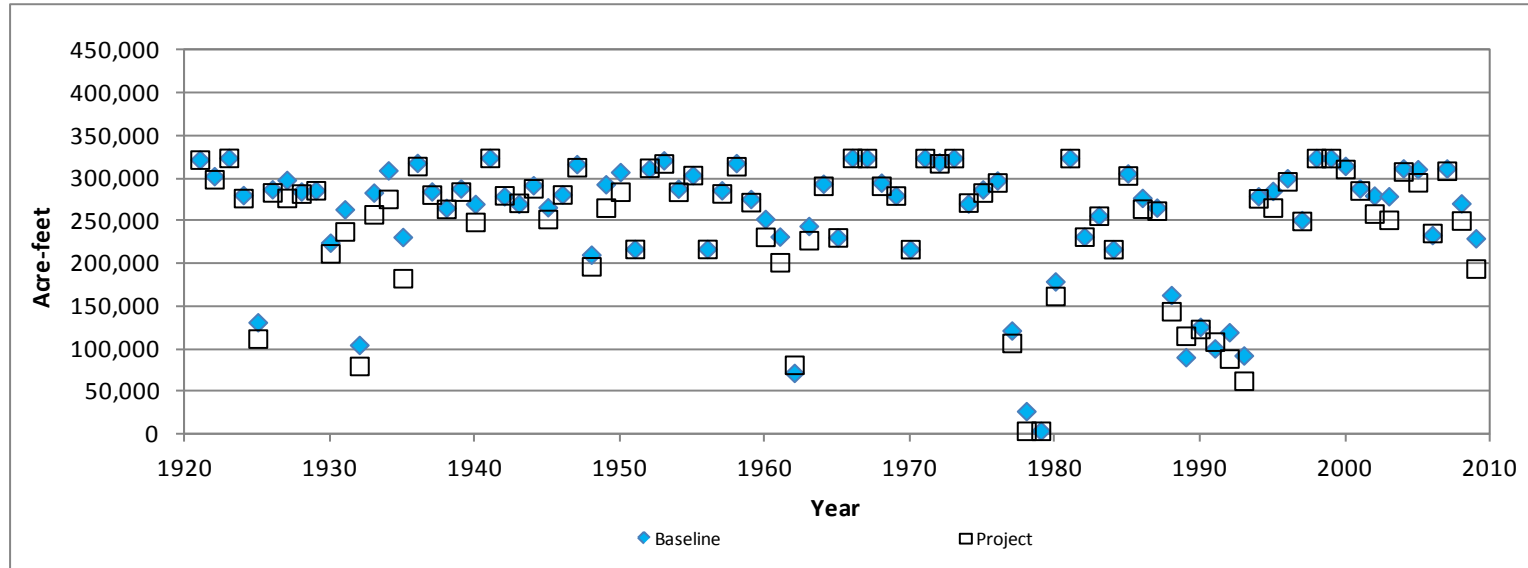


December

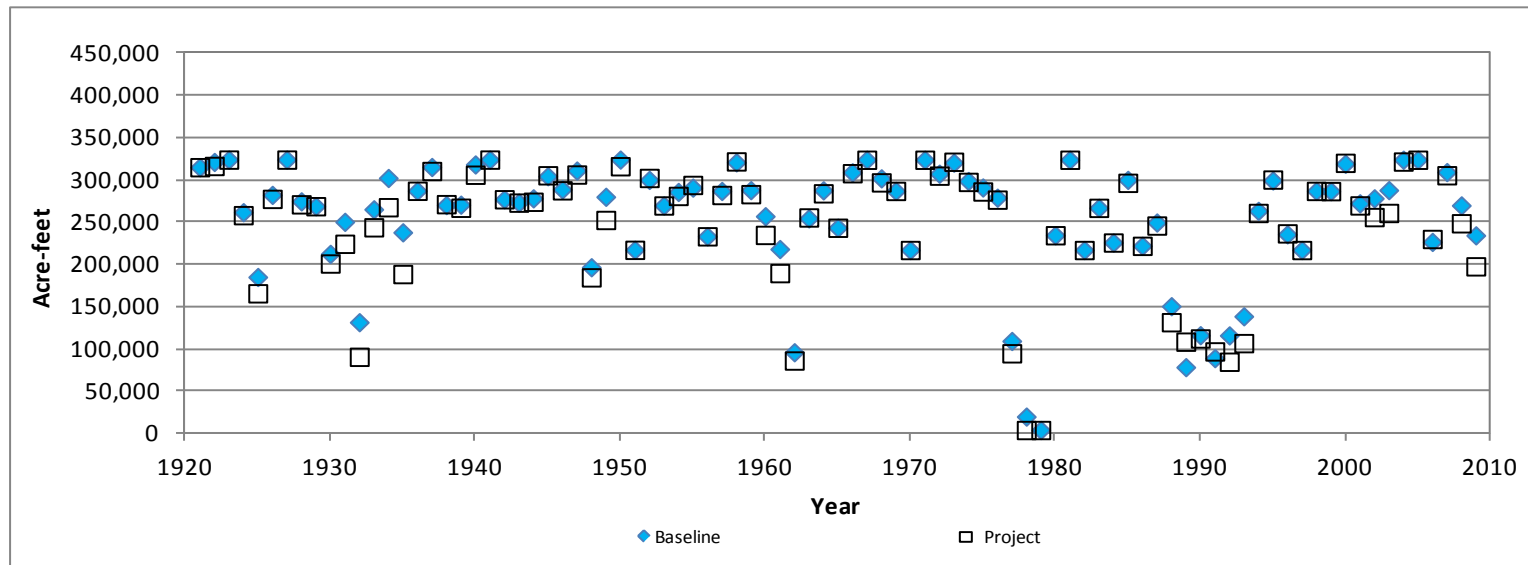


G.2 Camanche Reservoir Storage

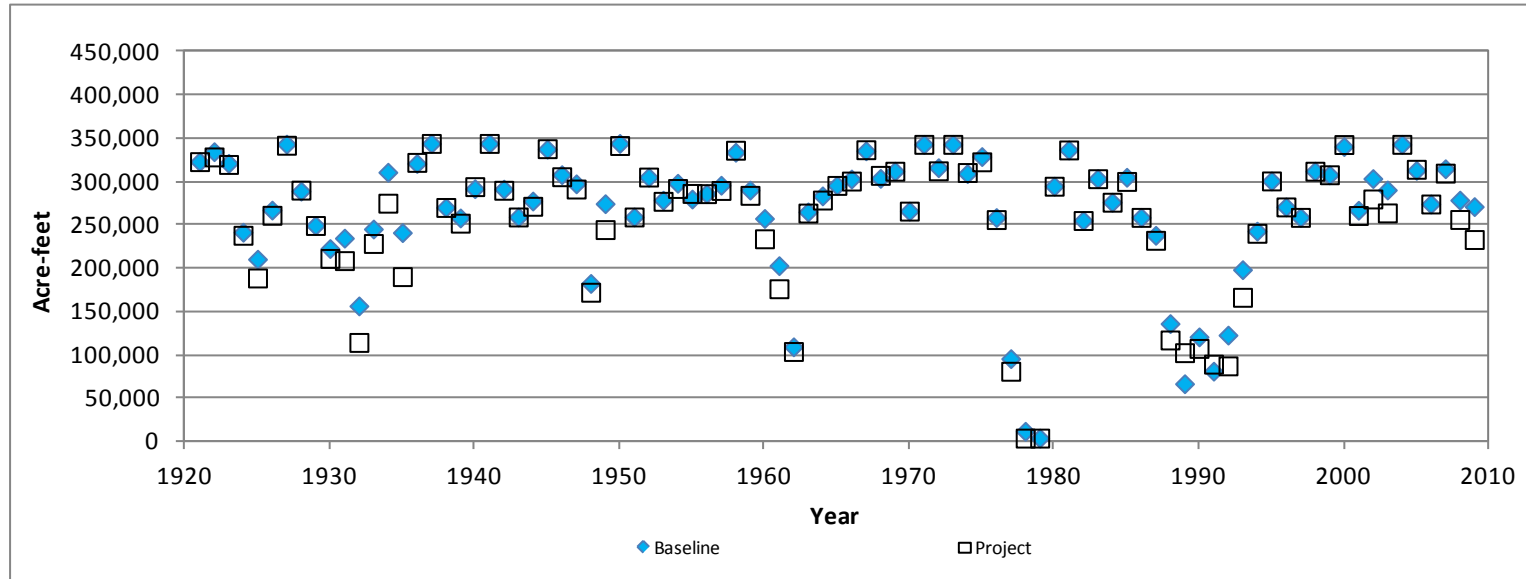
January



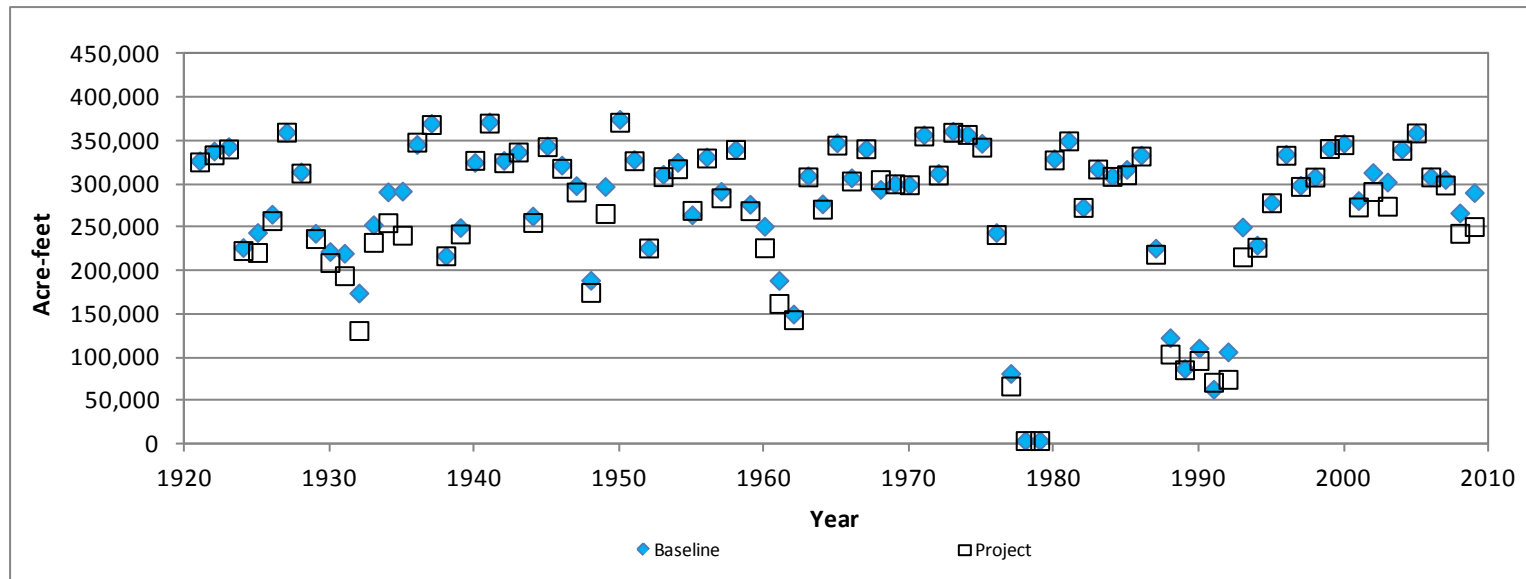
February



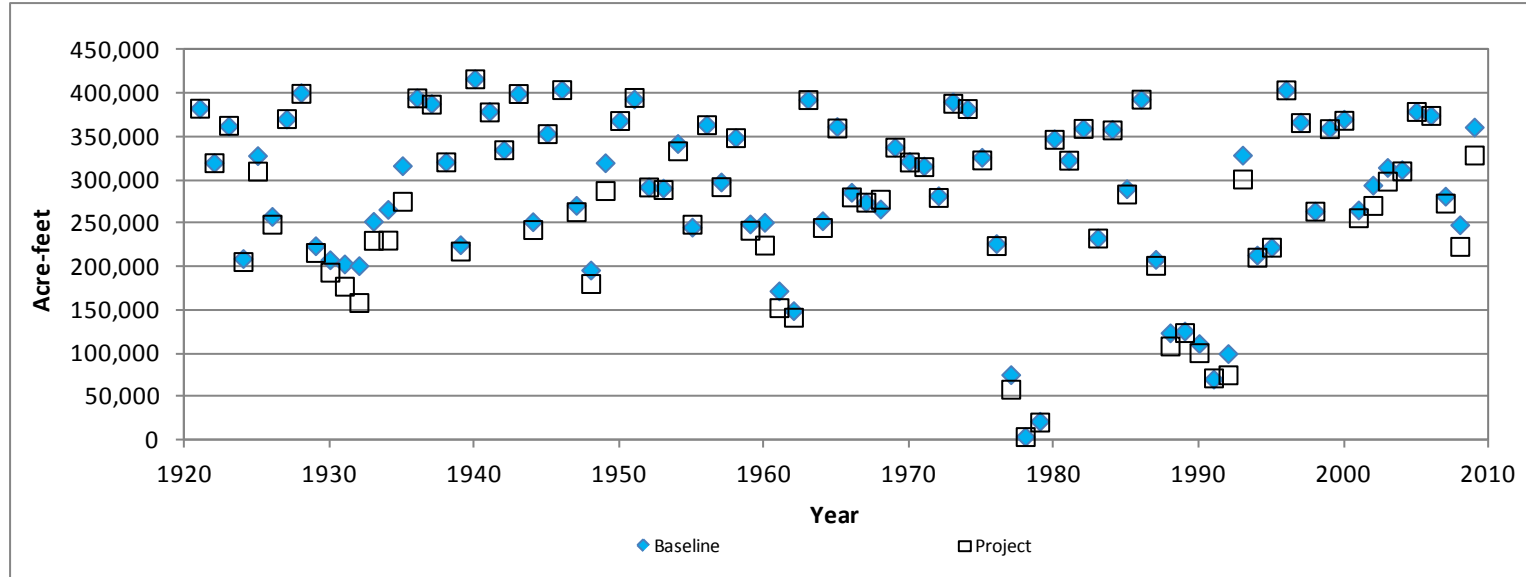
March



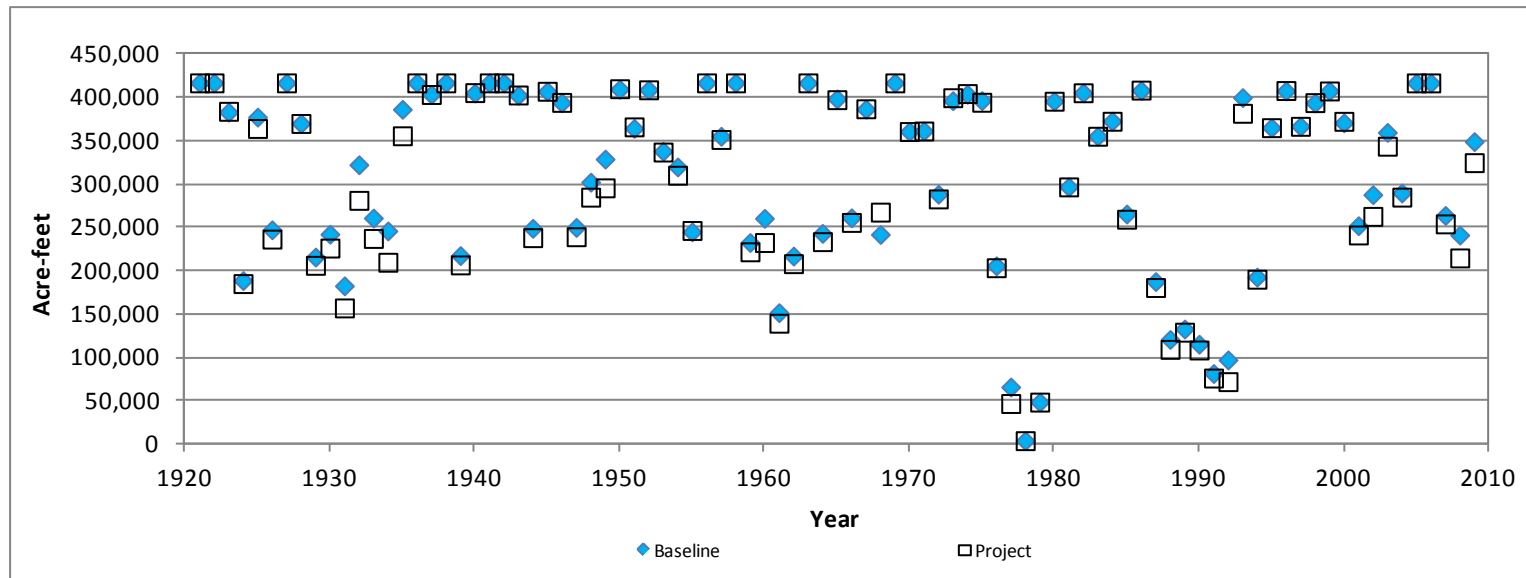
April



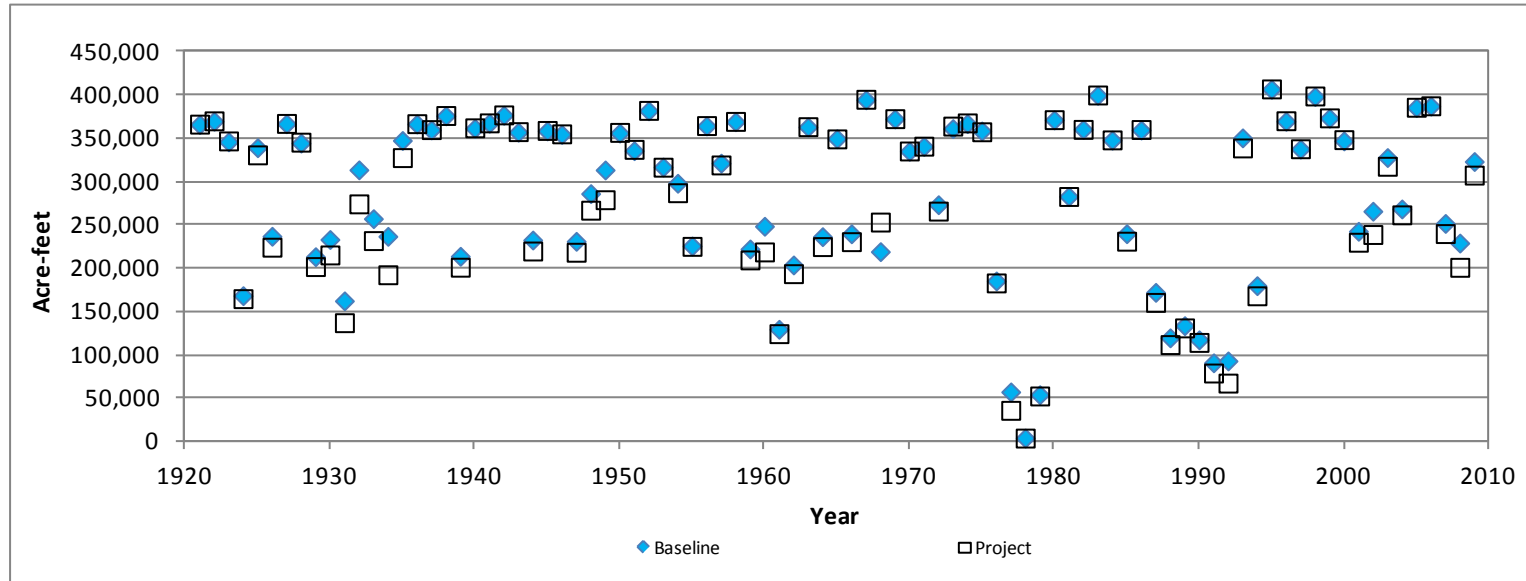
May



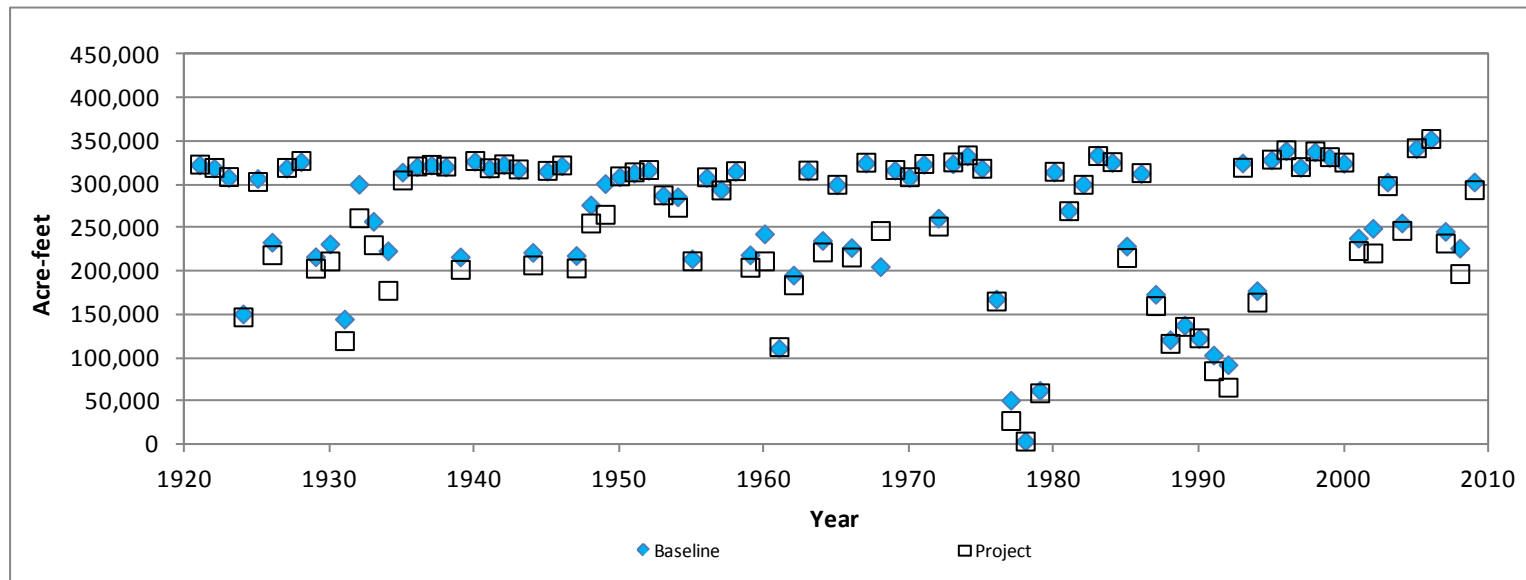
June



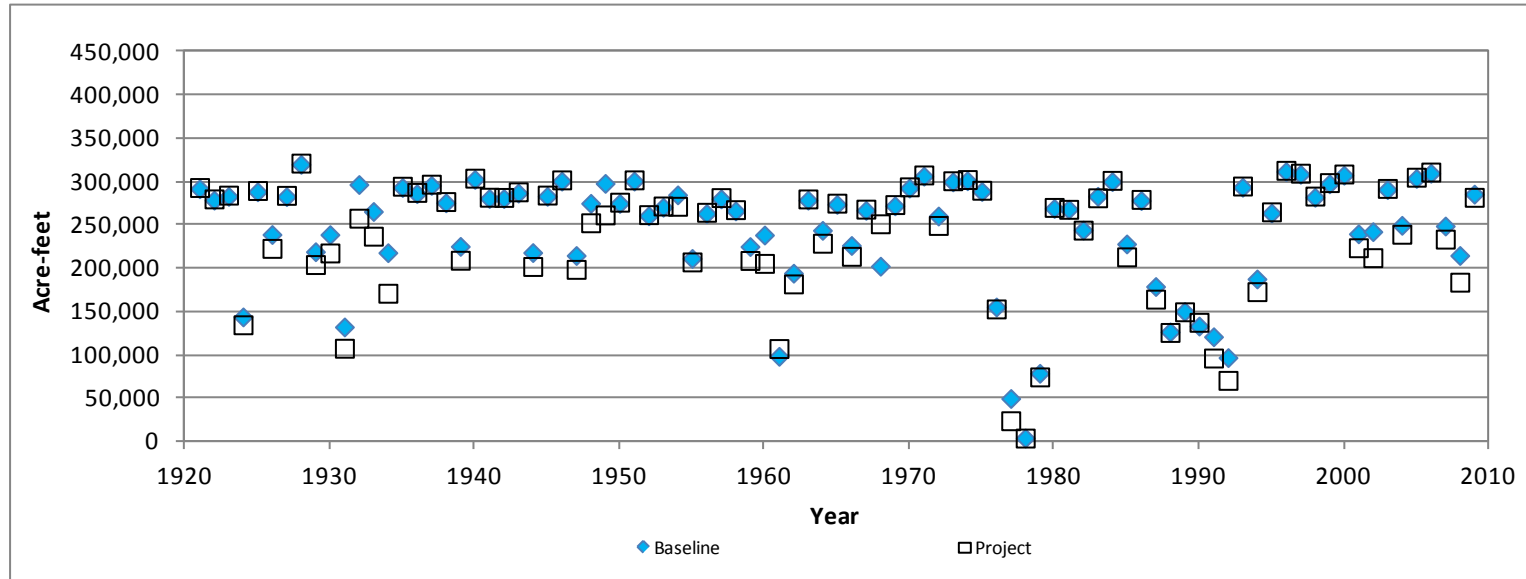
July



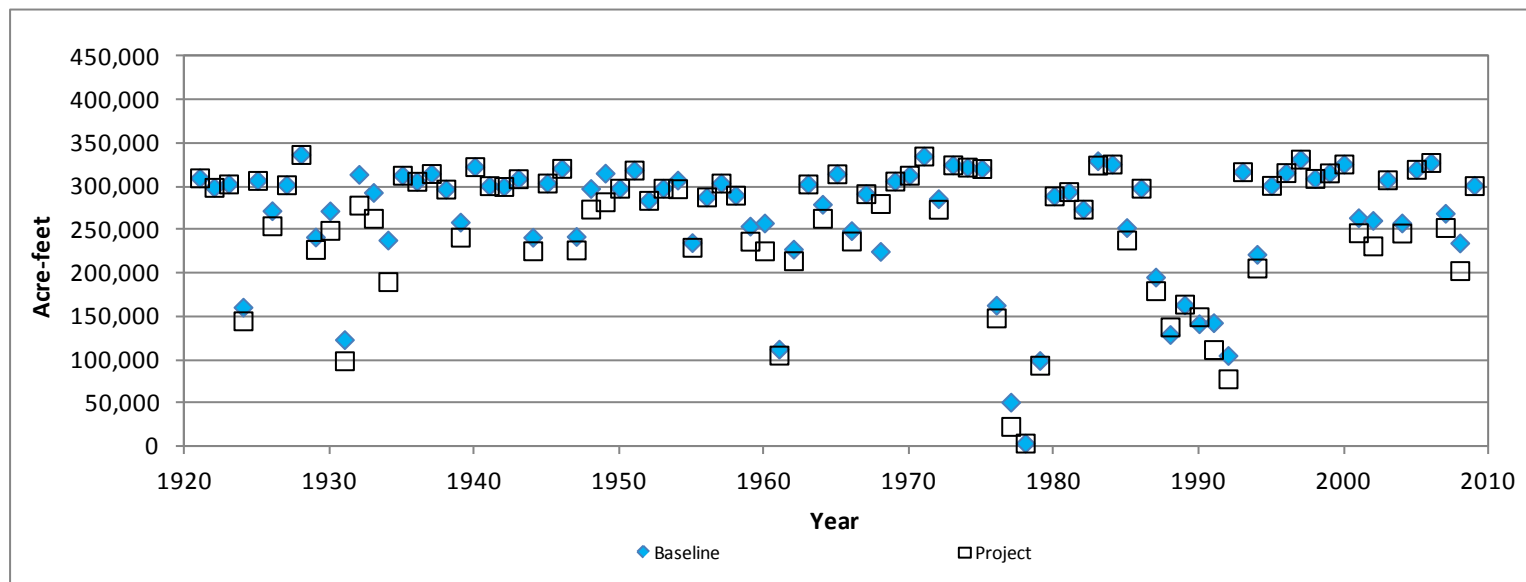
August

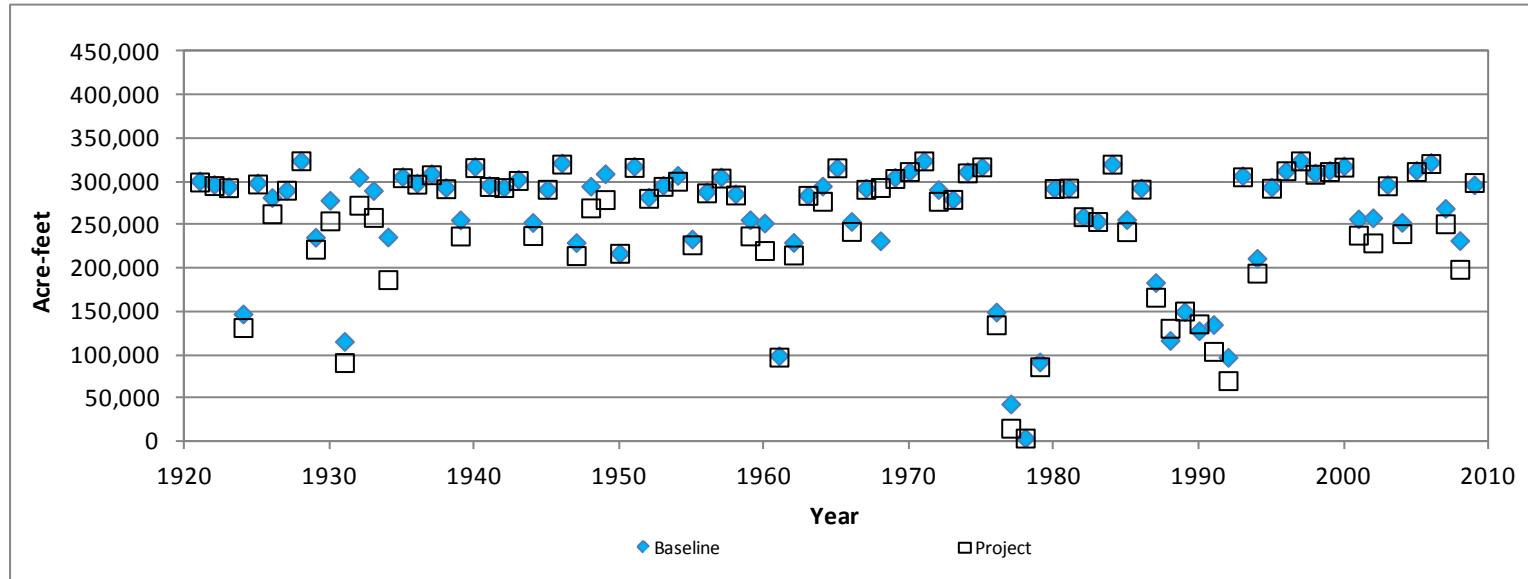
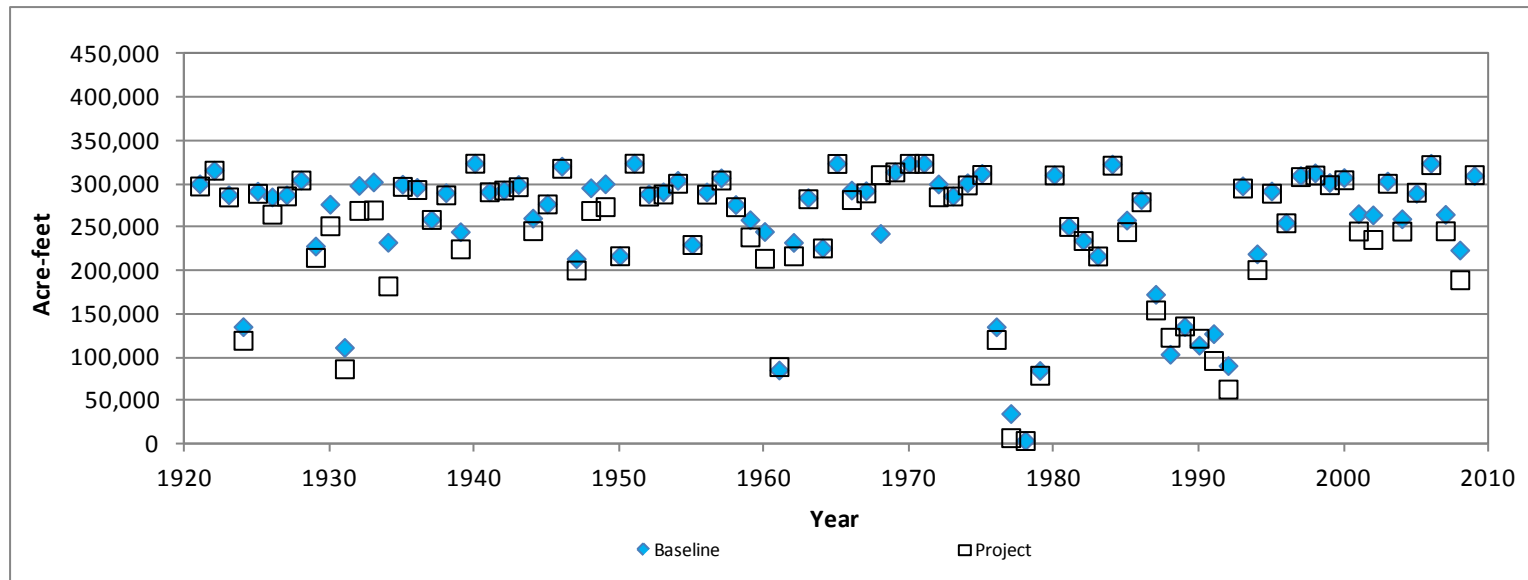


September



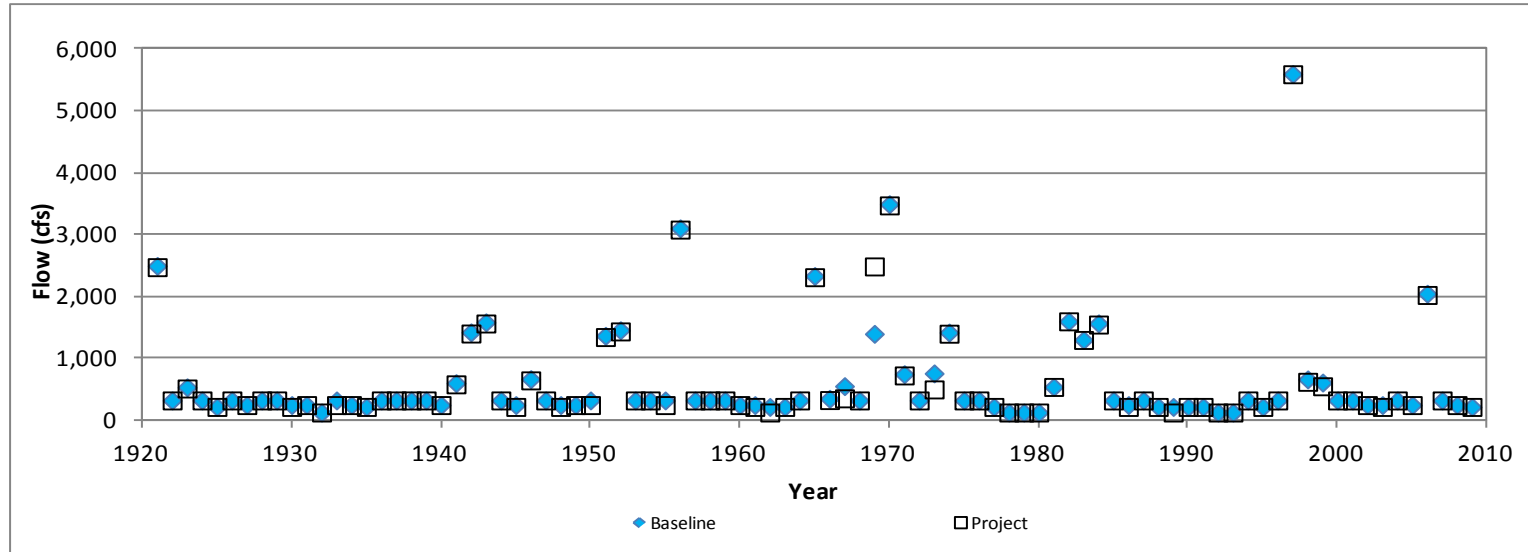
October



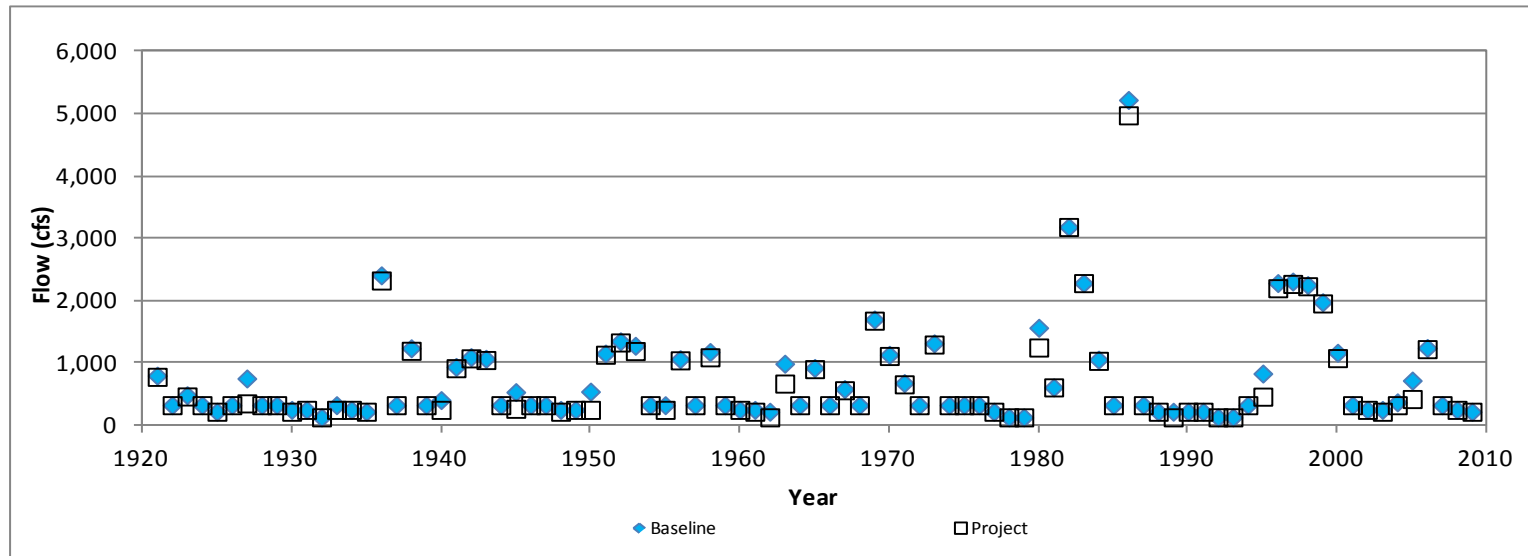
November**December**

G.3 Camanche Reservoir Releases to the Lower Mokelumne River

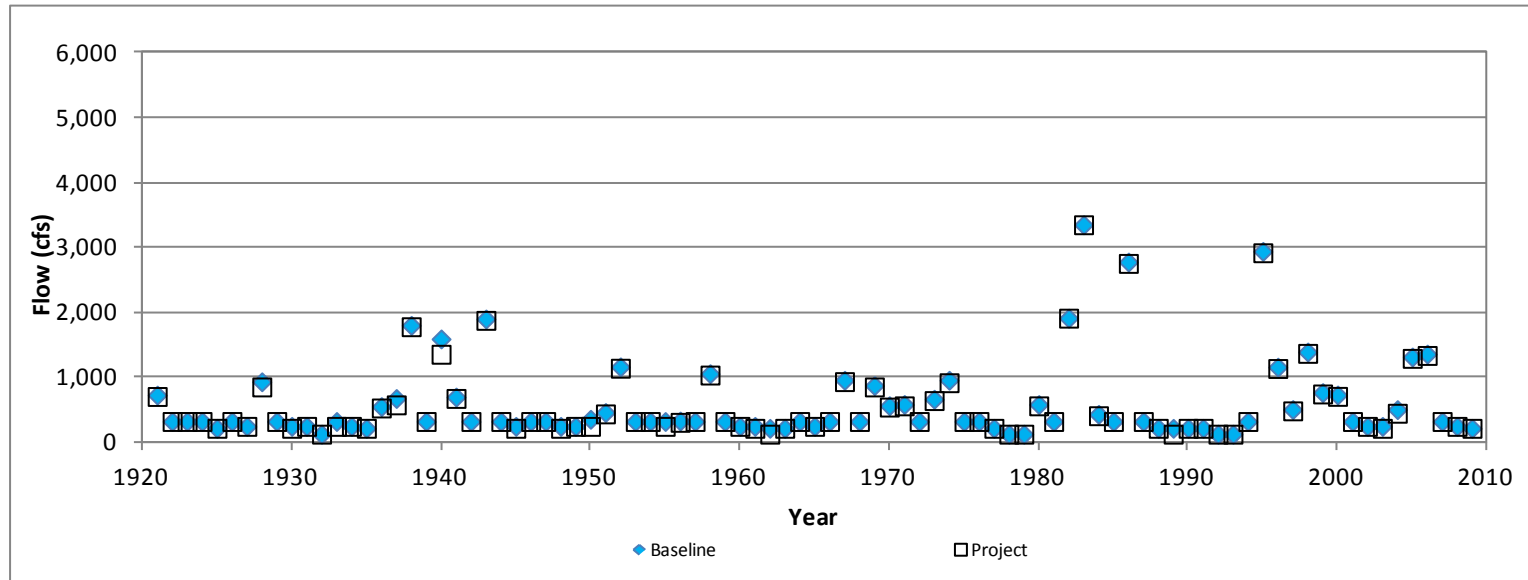
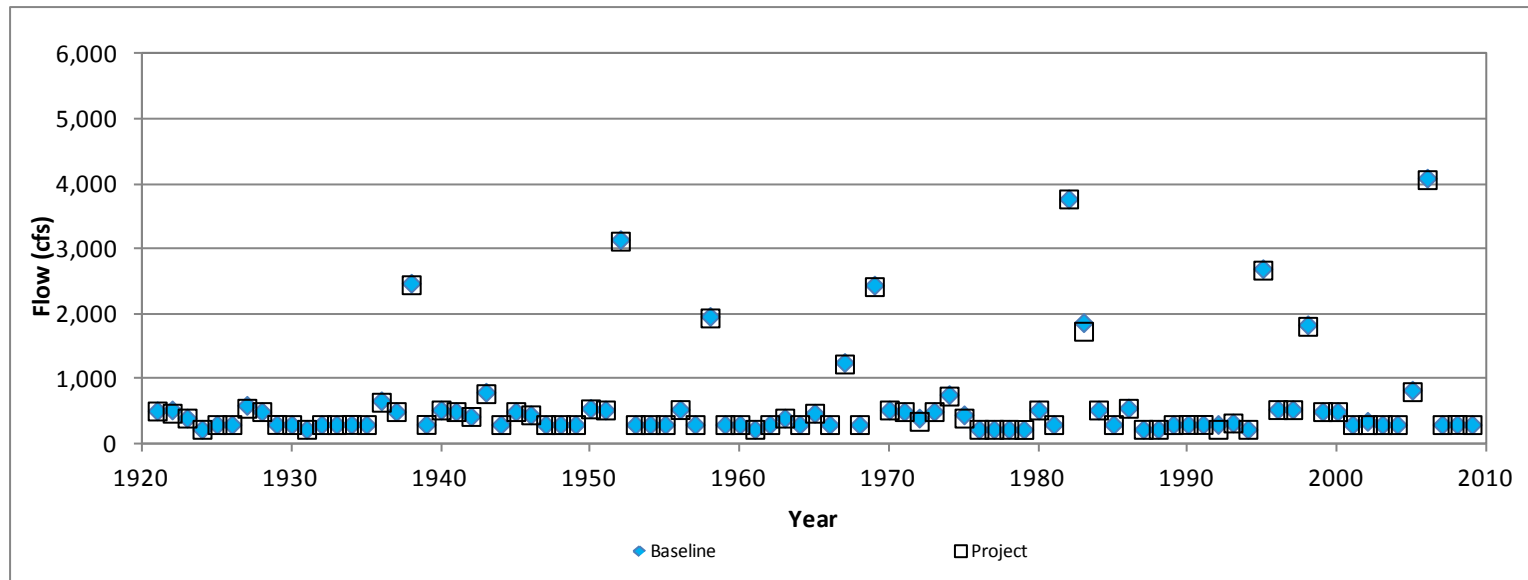
January



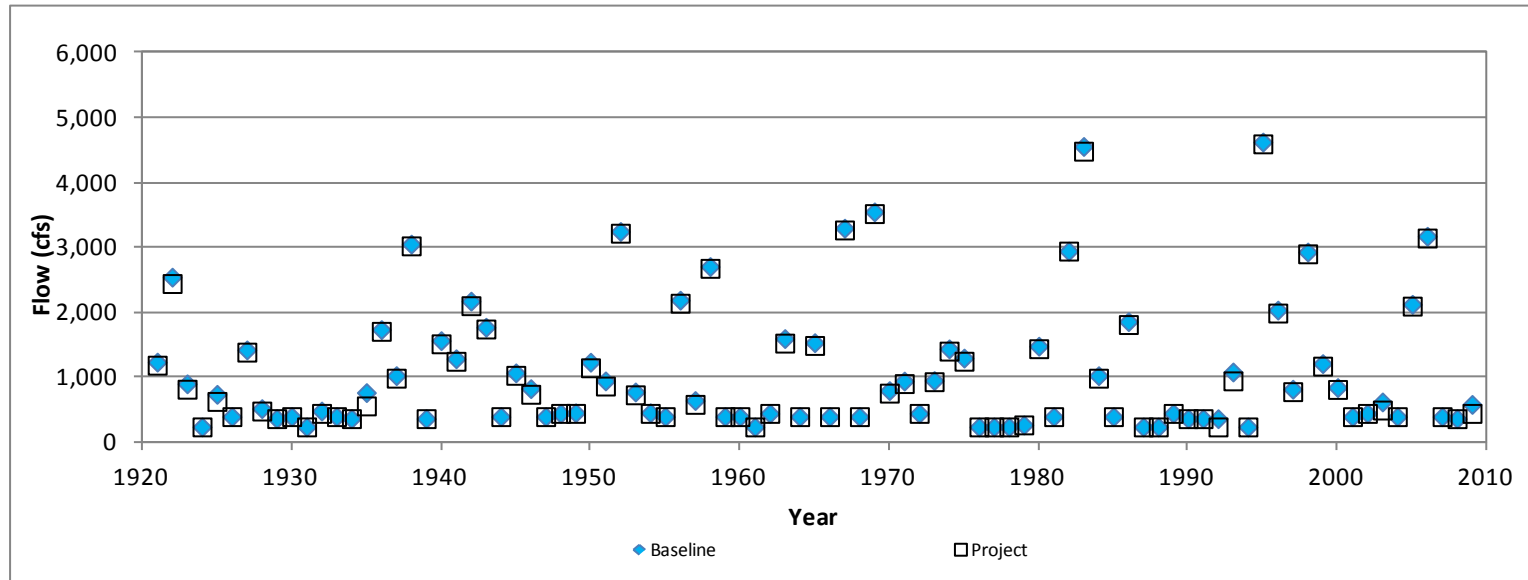
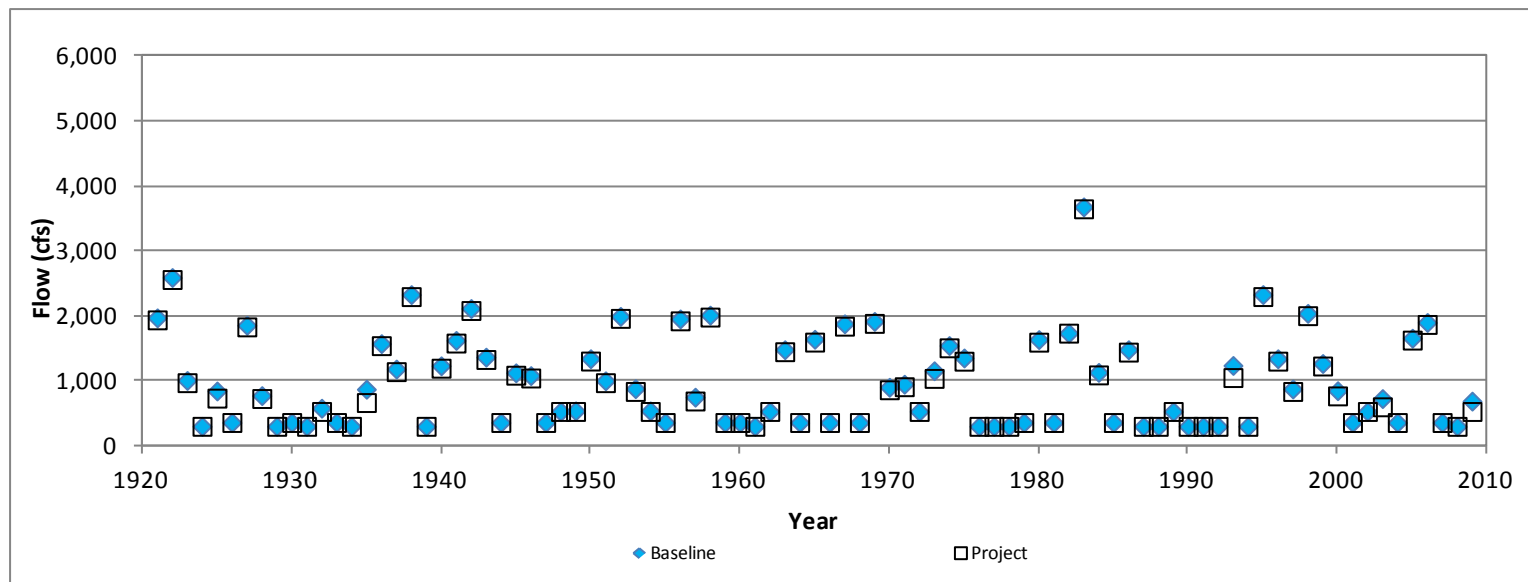
February



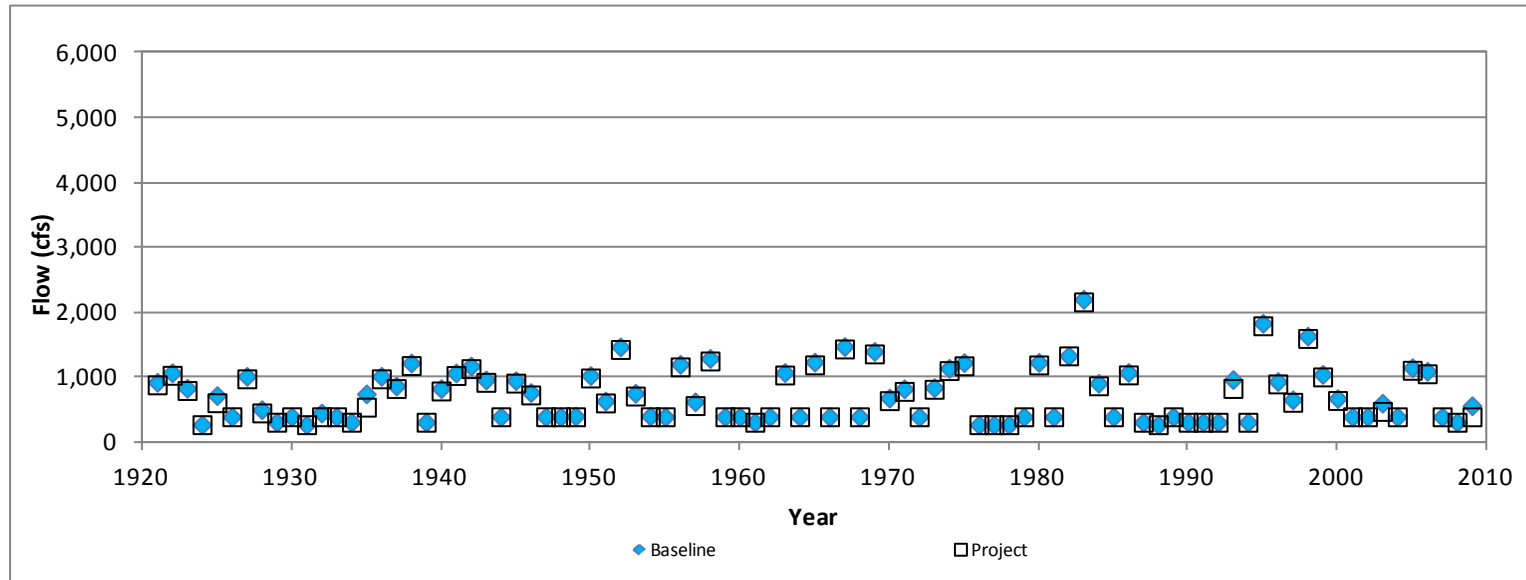
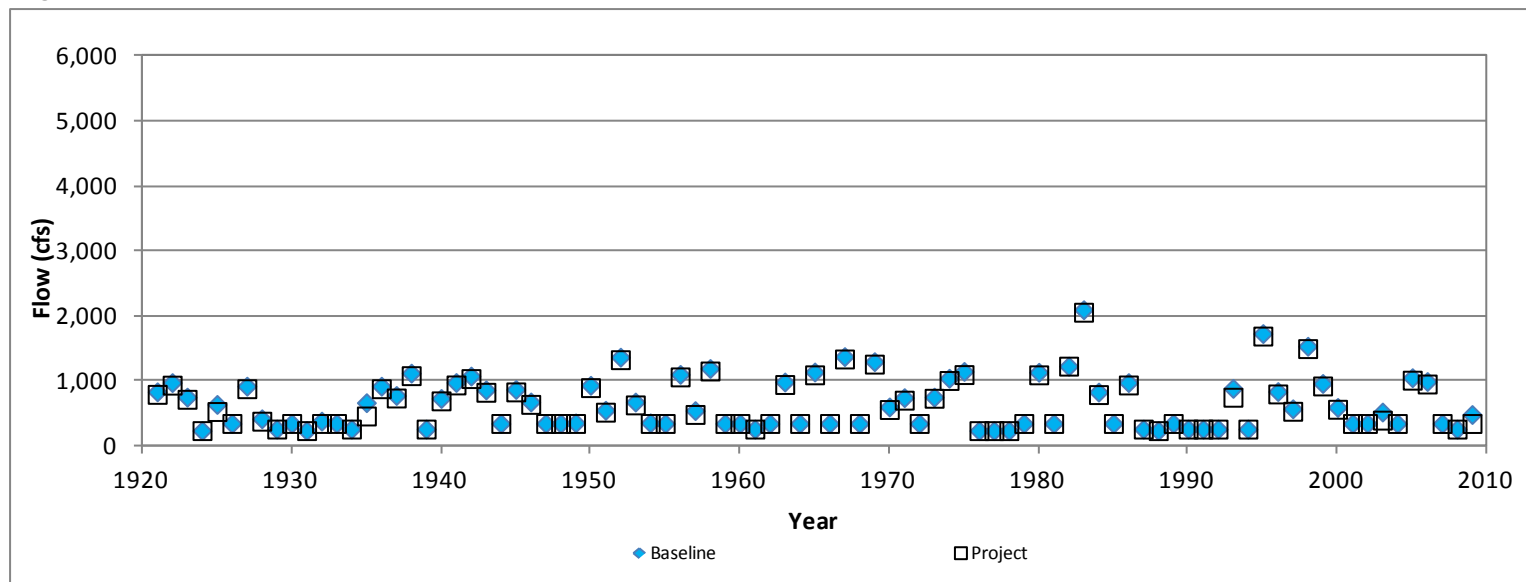
Note: cfs = cubic feet per second

March**April**

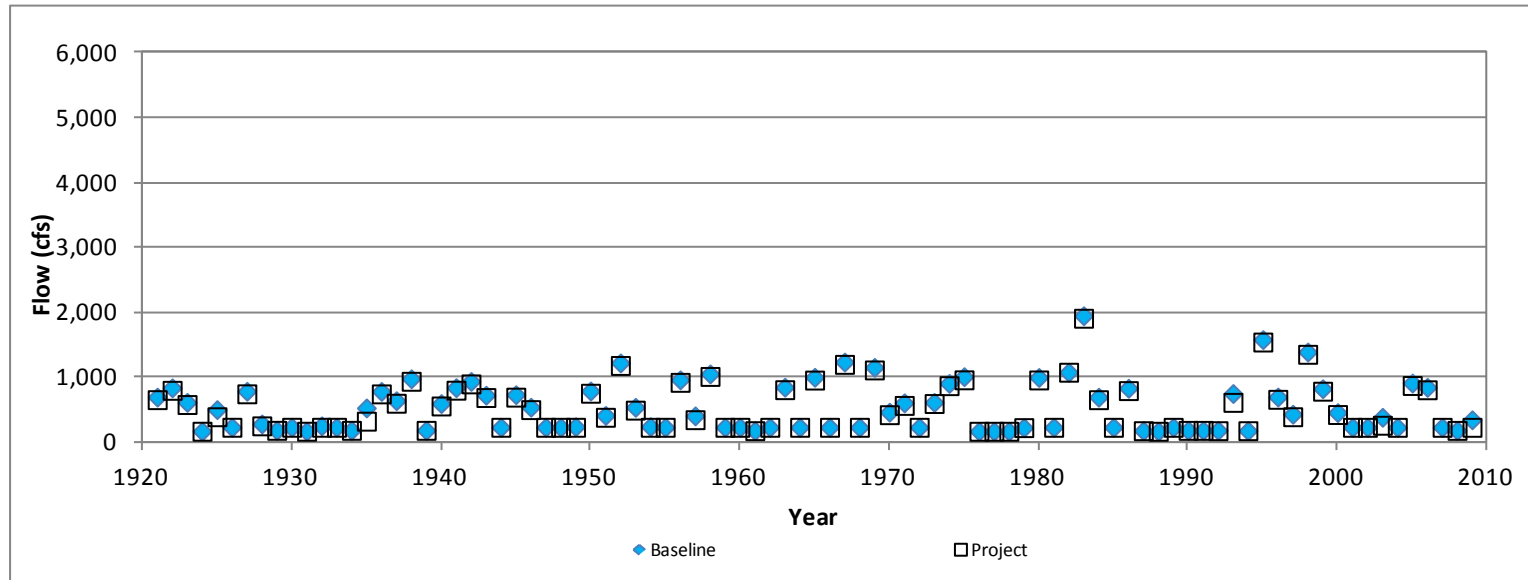
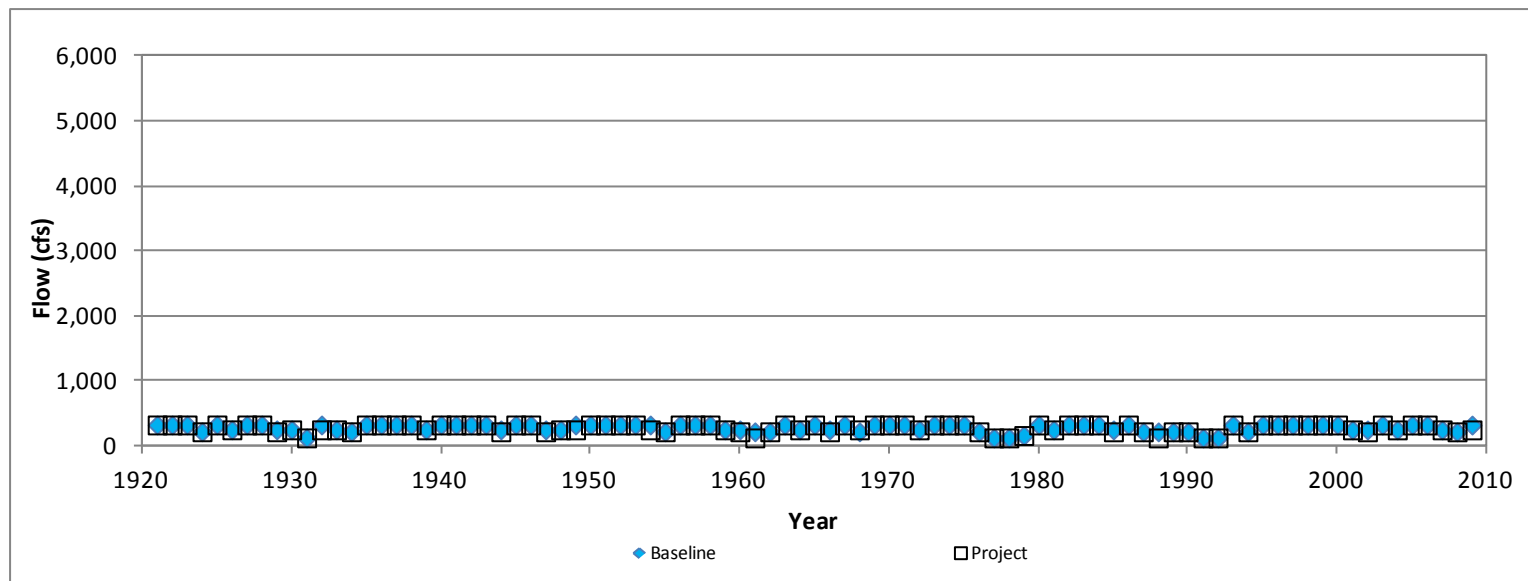
Note: cfs = cubic feet per second

May**June**

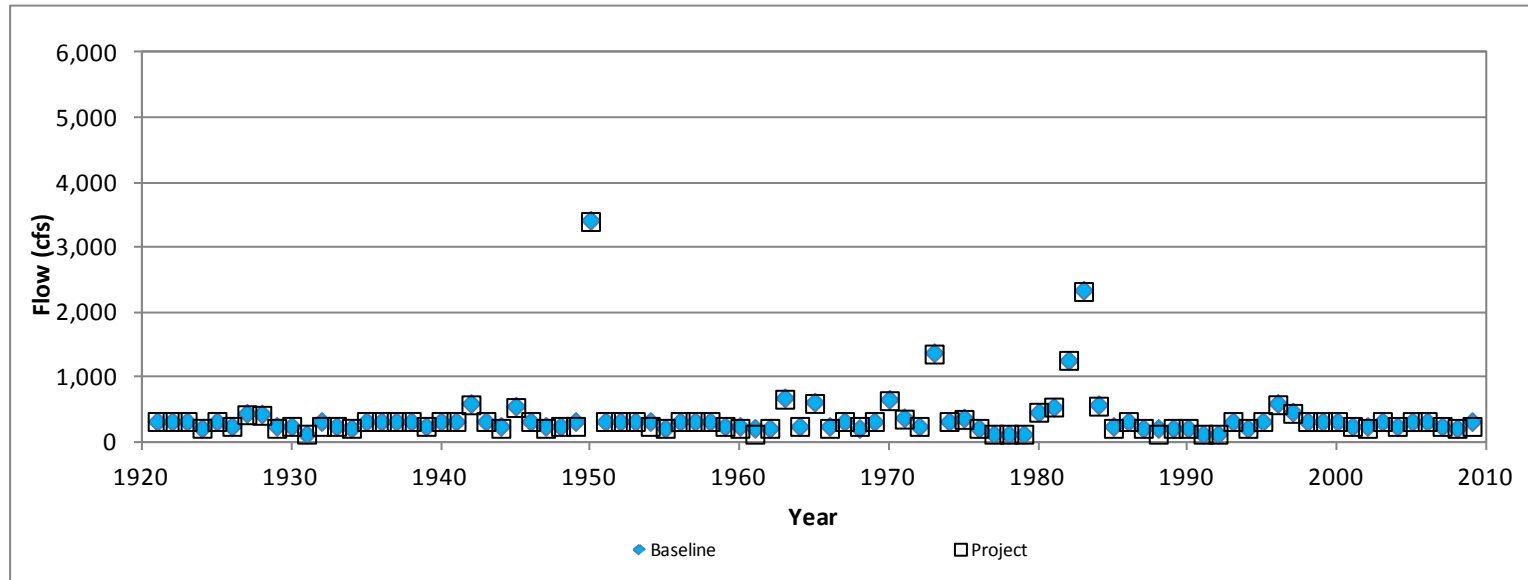
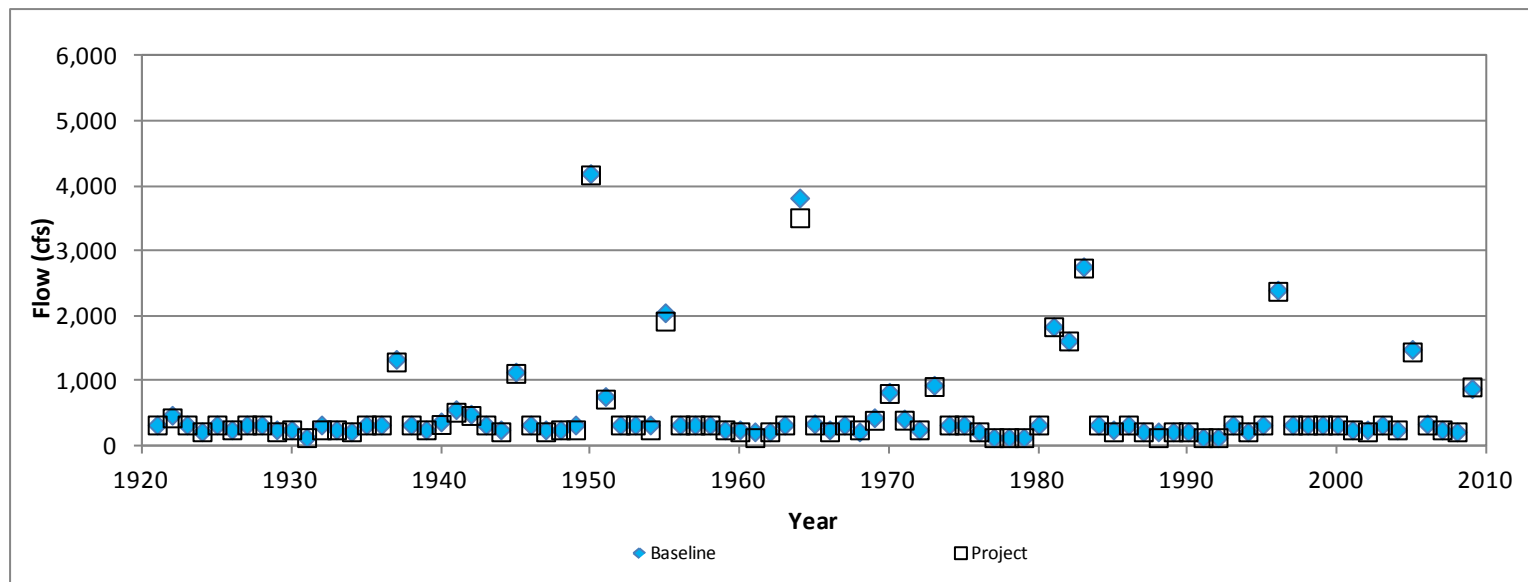
Note: cfs = cubic feet per second

July**August**

Note: cfs = cubic feet per second

September**October**

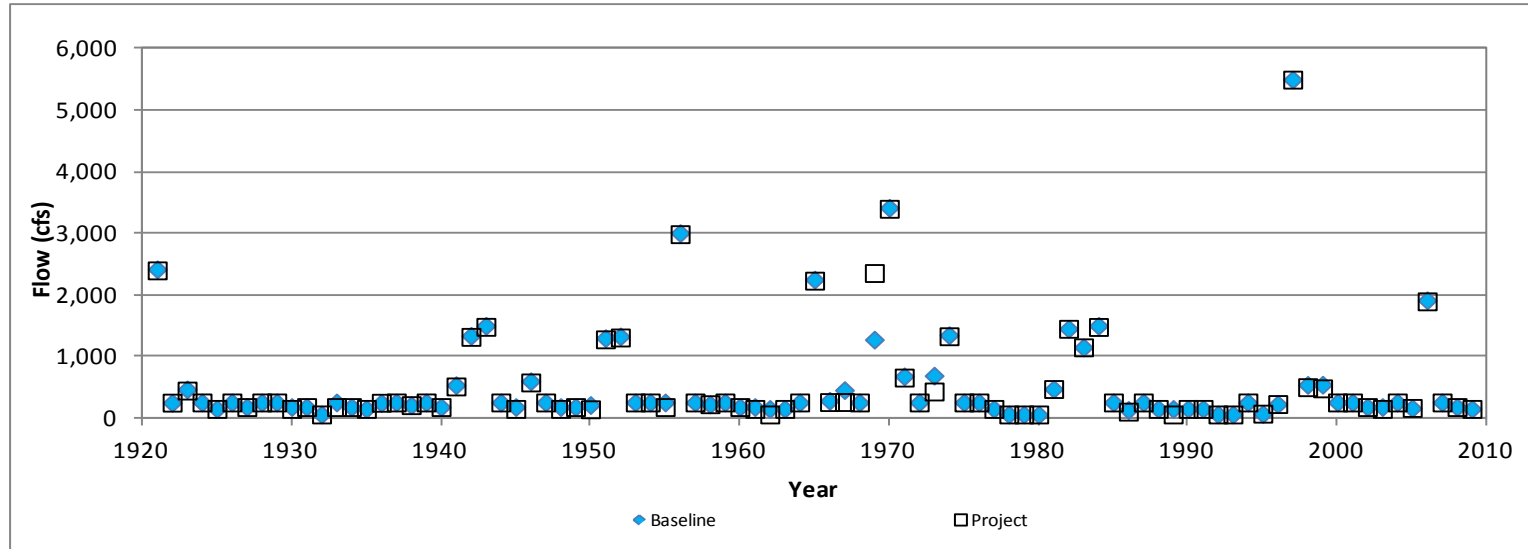
Note: cfs = cubic feet per second

November**December**

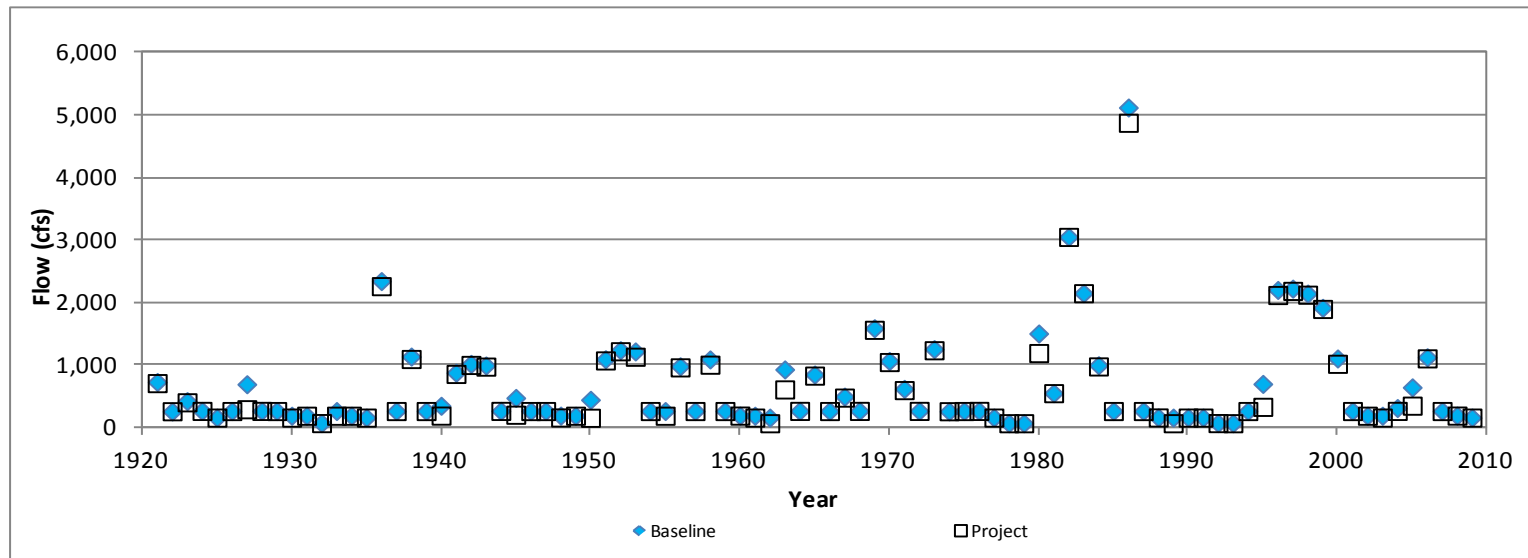
Note: cfs = cubic feet per second

G.4 Mokelumne River Flows below Woodbridge

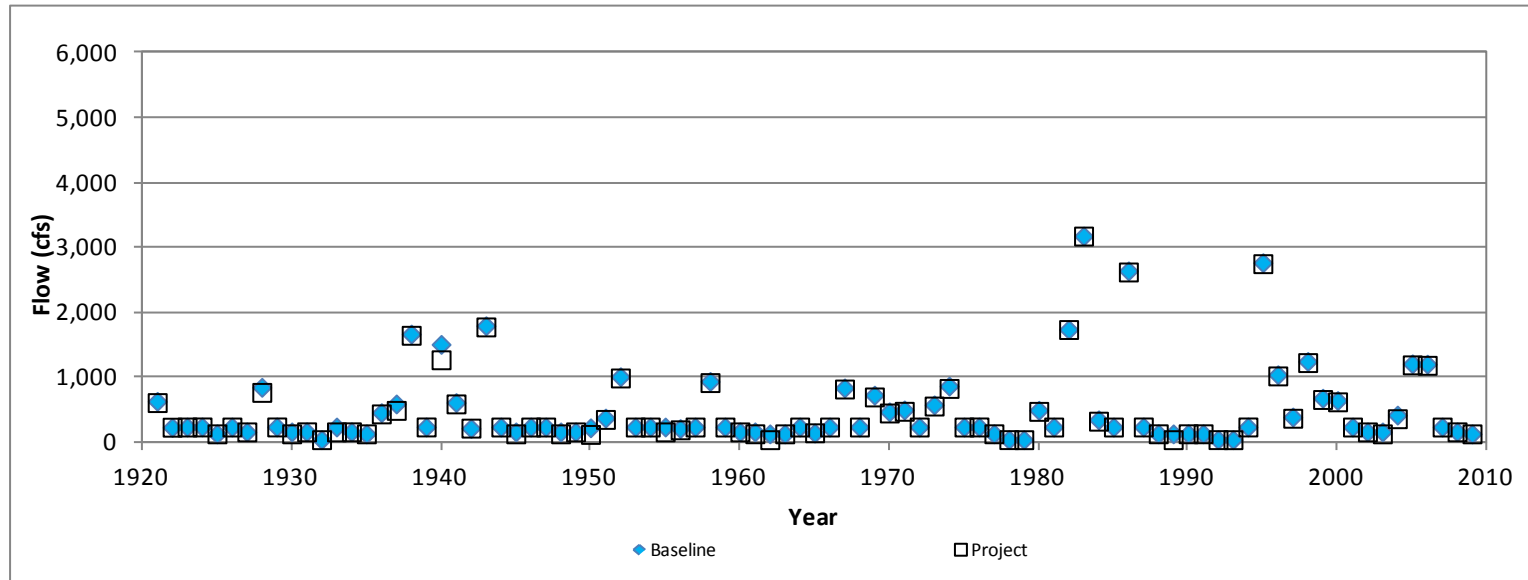
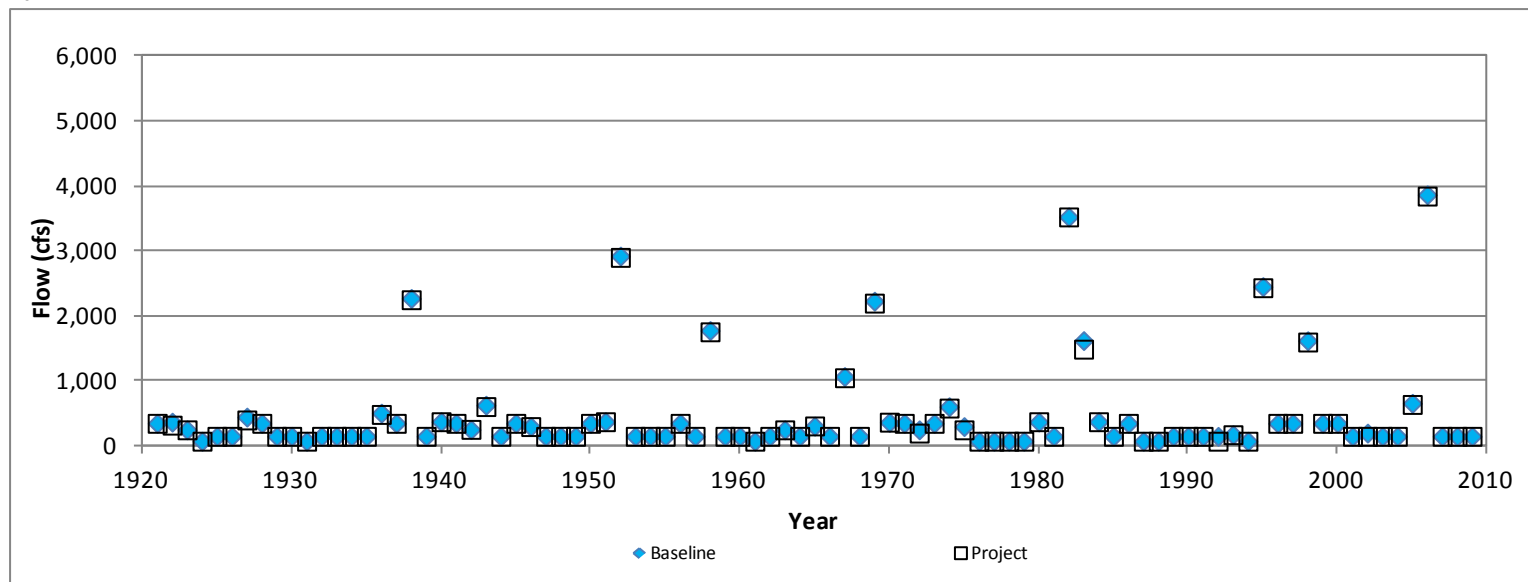
January



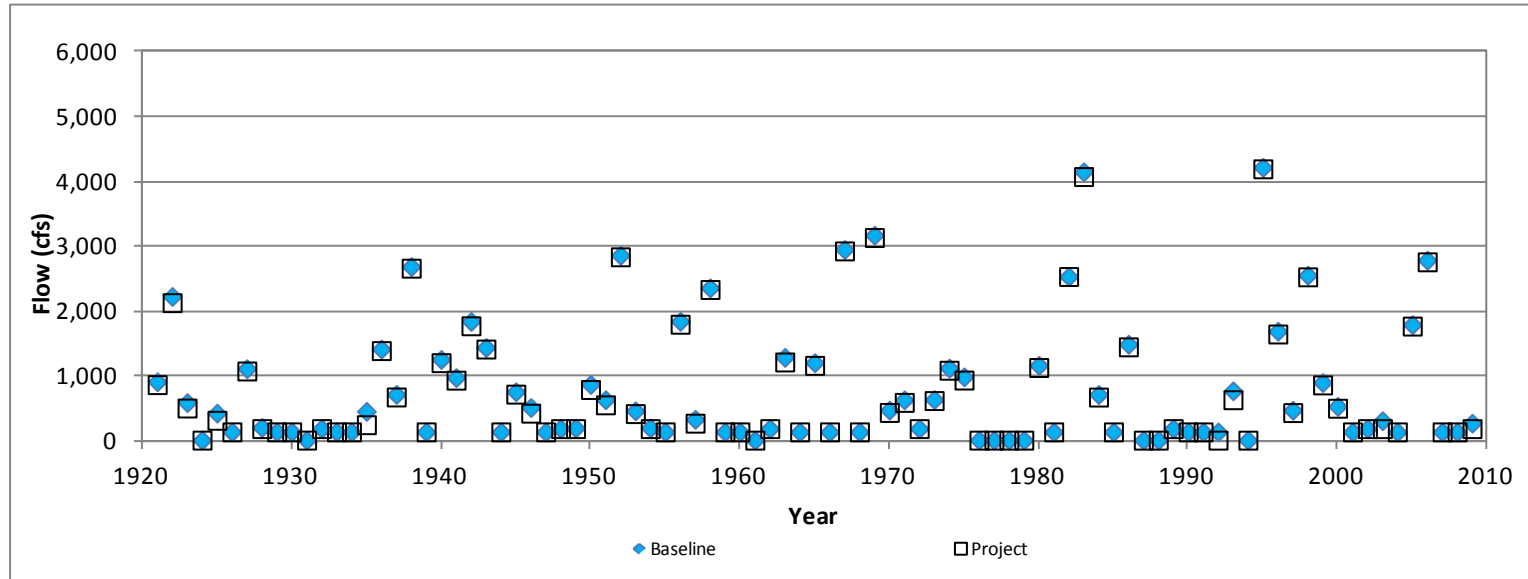
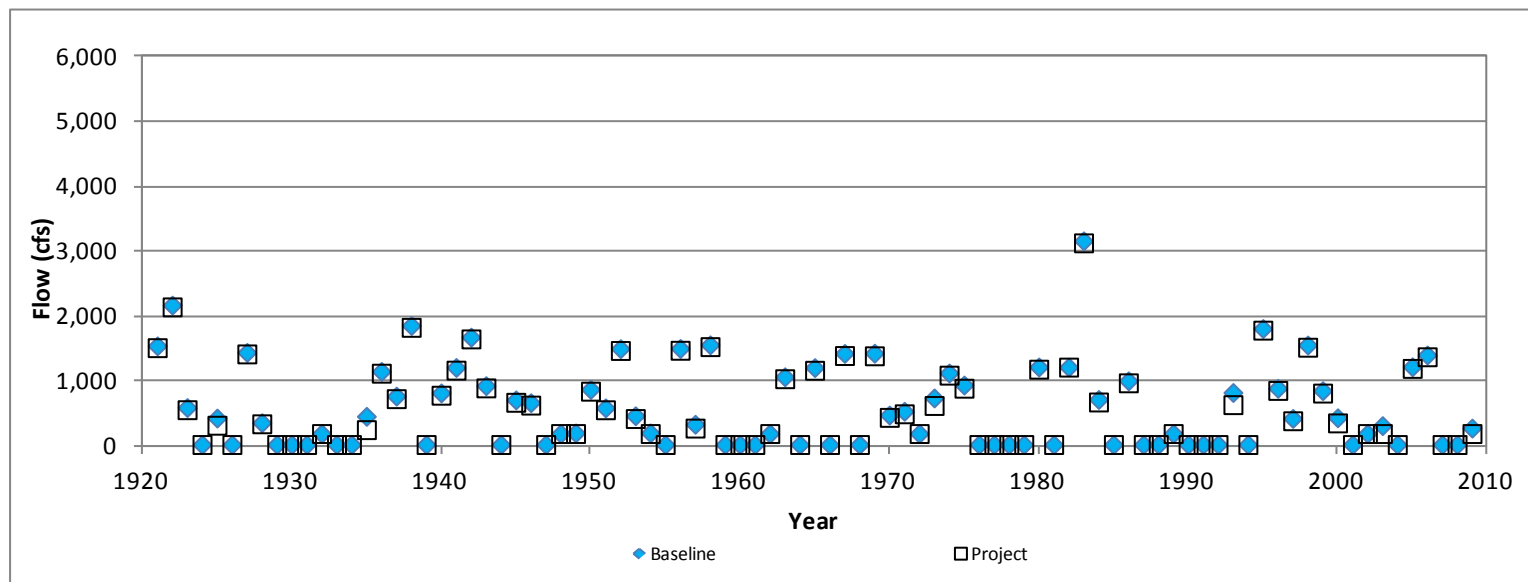
February



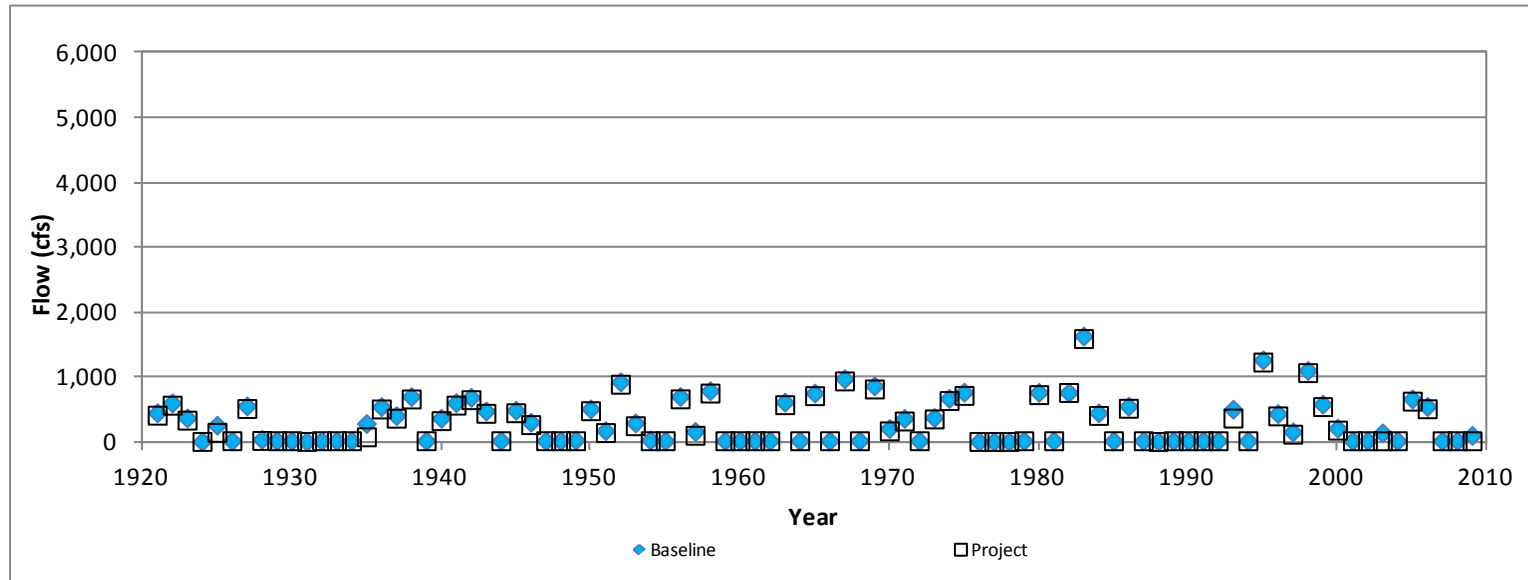
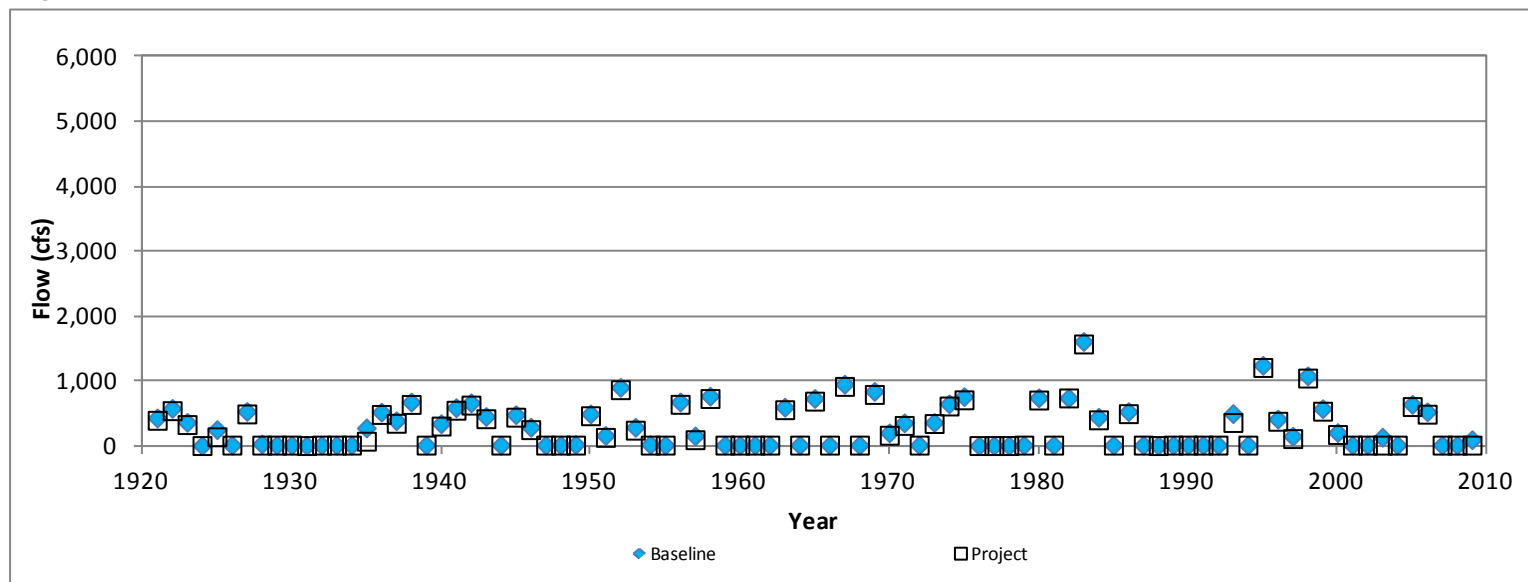
Note: cfs = cubic feet per second

March**April**

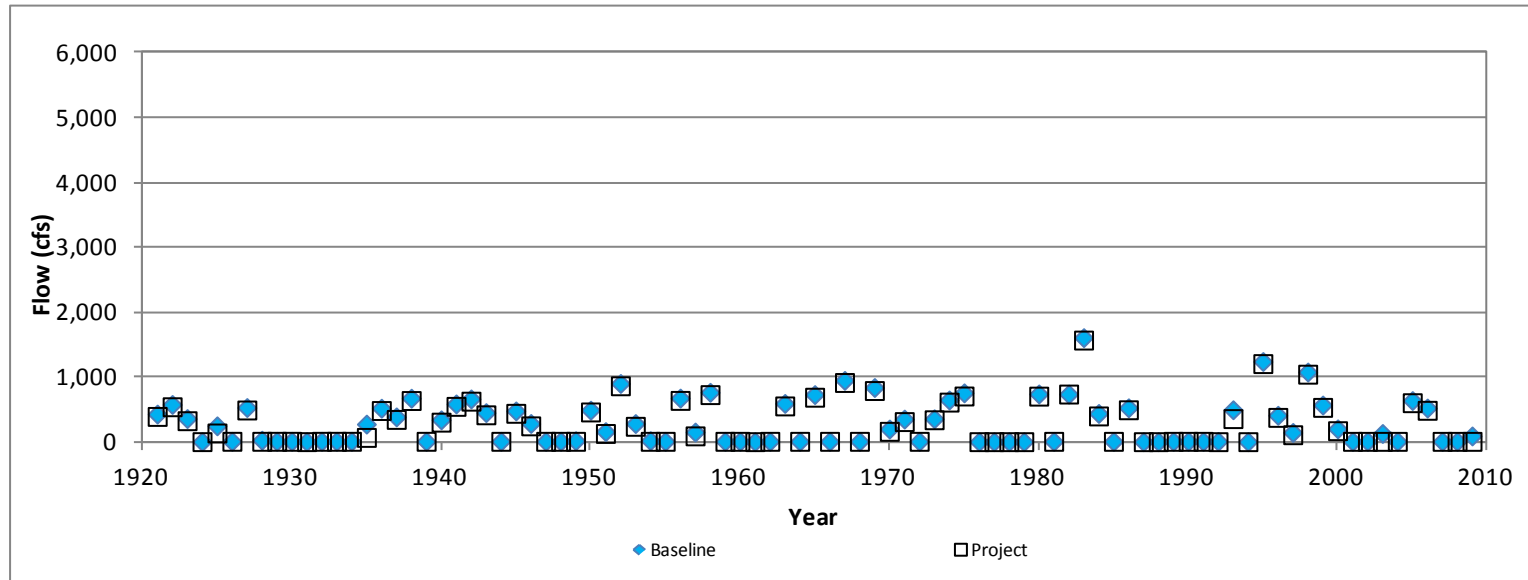
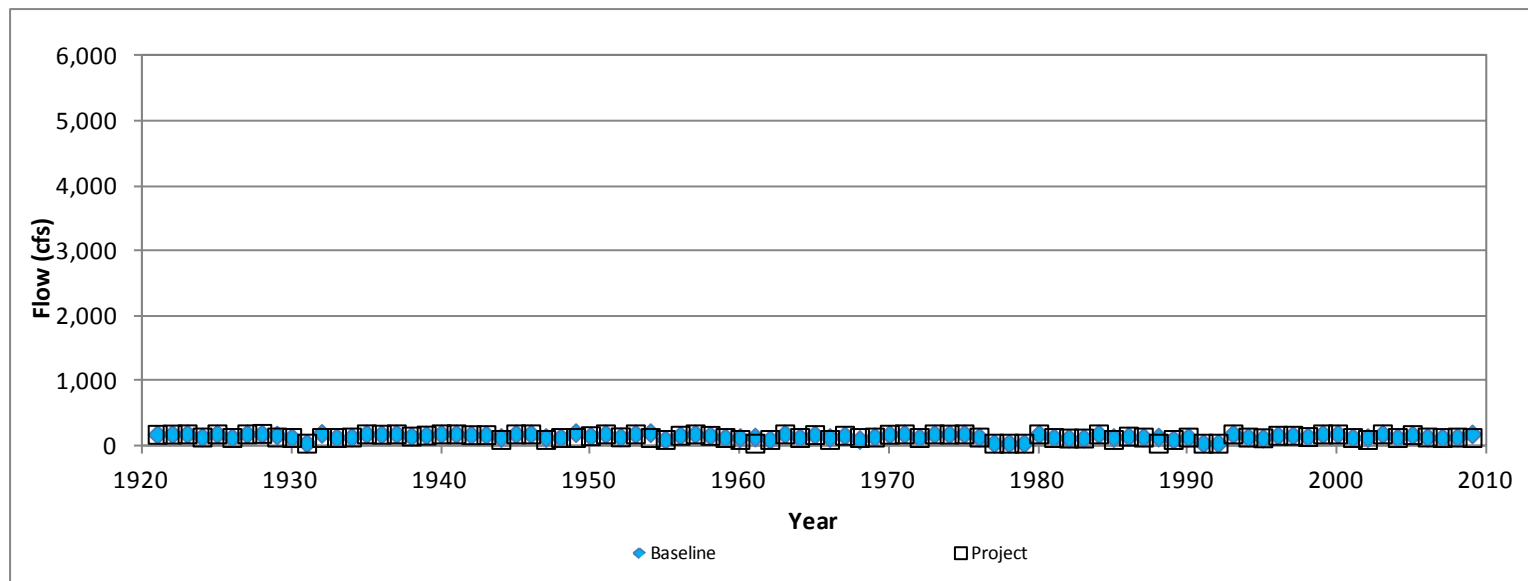
Note: cfs = cubic feet per second

May**June**

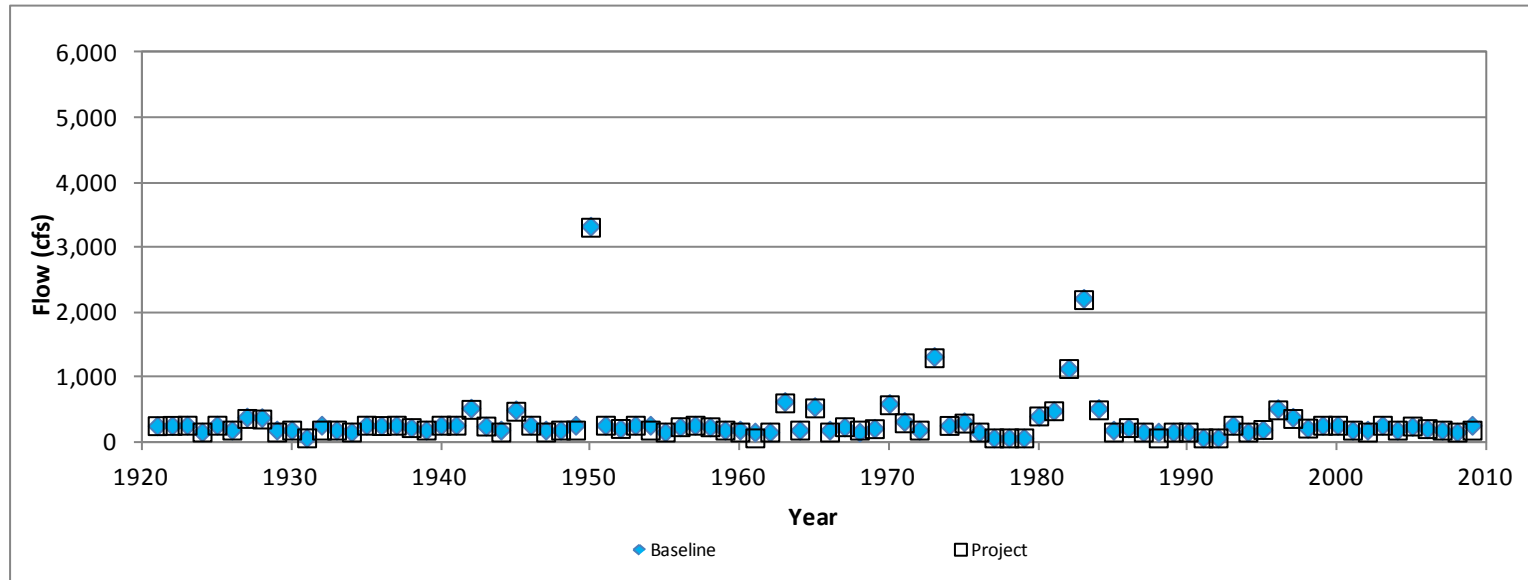
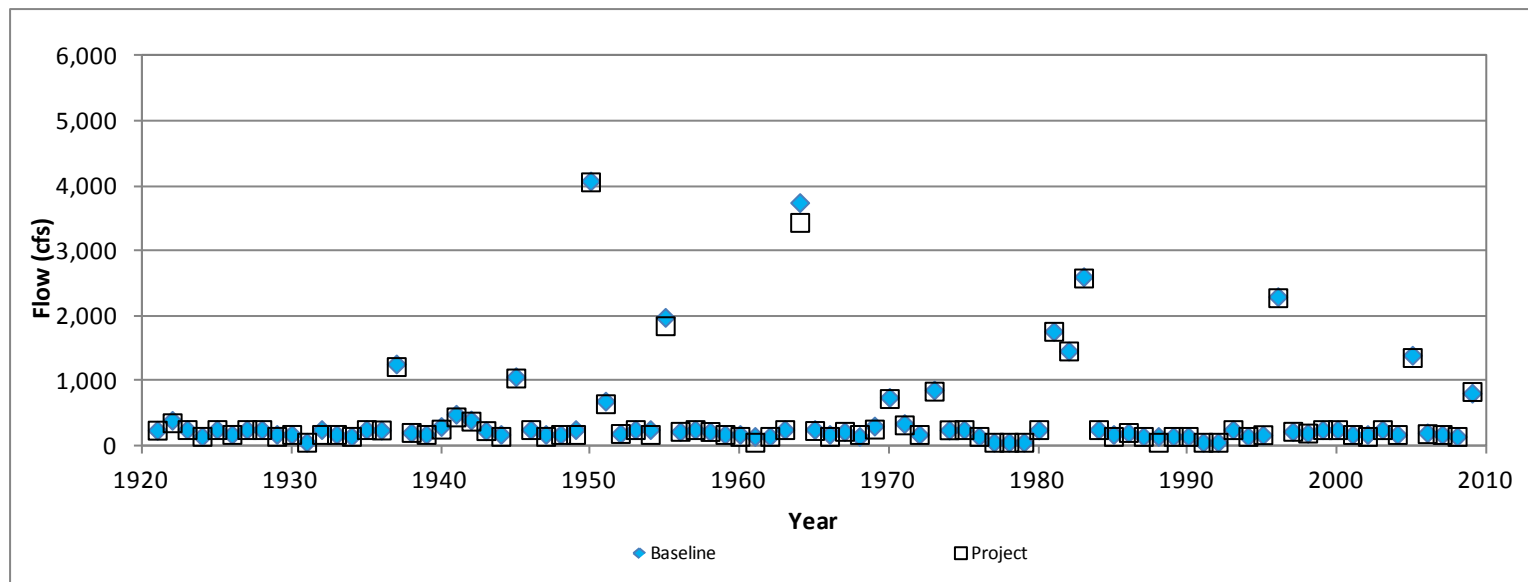
Note: cfs = cubic feet per second

July**August**

Note: cfs = cubic feet per second

September**October**

Note: cfs = cubic feet per second

November**December**

Note: cfs = cubic feet per second

Appendix H

**Evaluation of the Distribution of Baseline and Permit
10478 Time Extension Project EBMUDSIM
Hydrologic Results**

Appendix H.1

**Comparison of Baseline and Permit 10478 Time
Extension Project EBMUDSIM Results as Illustrated
with Percentile Plots and Tables**

H.1-1 Mokelumne Aqueduct Flow

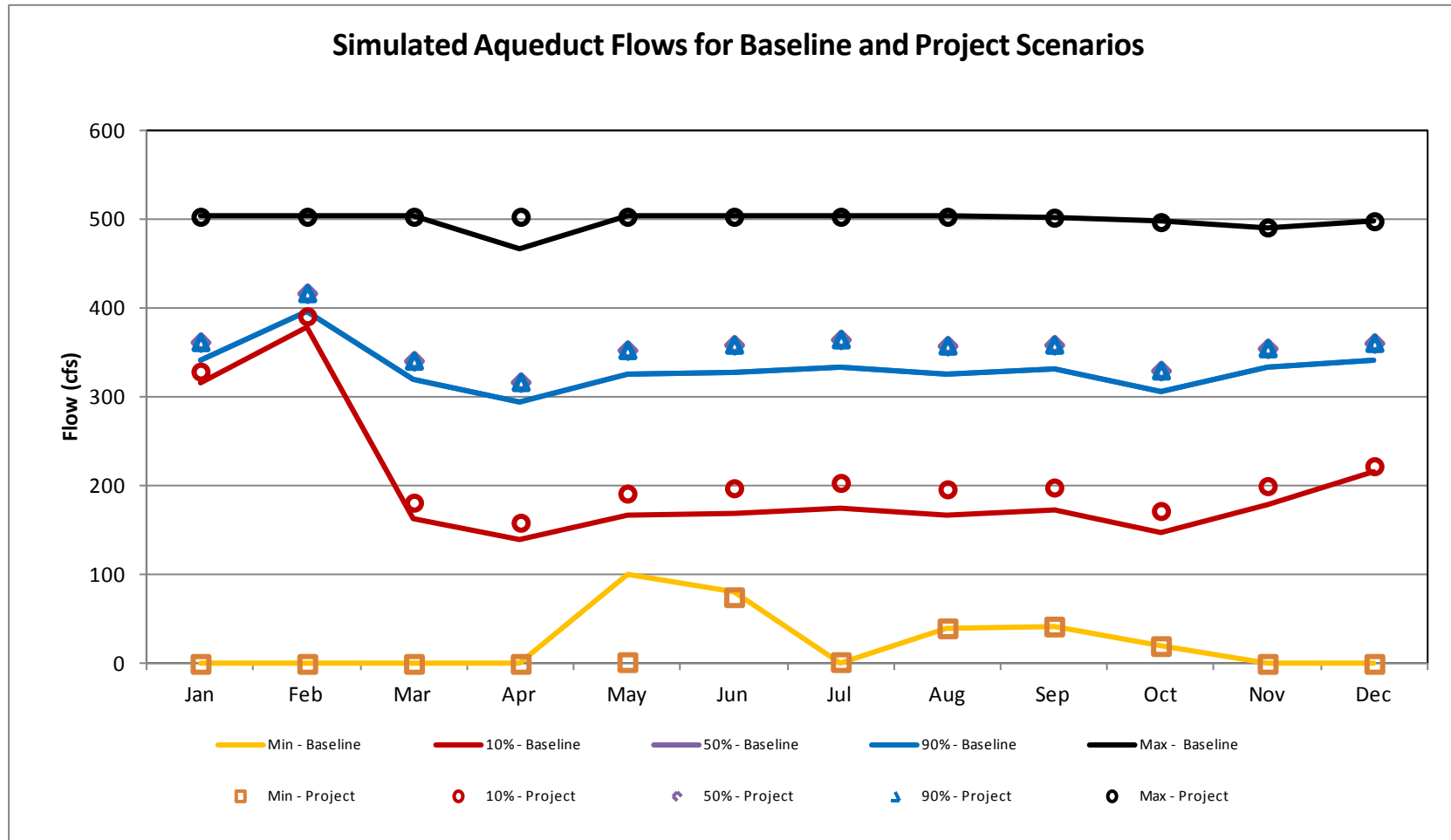


Table H.1-1. Mokelumne Aqueduct - Modeled Monthly Average Flow

	Mokelumne Aqueduct – Baseline (cfs)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	0	0	0	0	101	80	1	40	42	20	0	0
10th Percentile	315	379	162	139	167	170	175	168	173	148	179	217
20th Percentile	342	392	165	139	167	170	175	168	228	278	319	330
30th Percentile	342	392	313	287	325	328	333	326	330	306	334	342
40th Percentile	342	397	320	294	325	328	333	326	331	306	334	342
50th Percentile	342	397	320	294	325	328	333	326	331	306	334	342
60th Percentile	342	397	320	294	325	328	333	326	331	306	334	342
70th Percentile	342	397	320	294	325	328	333	326	331	306	334	342
80th Percentile	342	397	320	294	325	328	333	326	331	306	334	342
90th Percentile	342	397	320	294	325	328	333	326	331	306	334	342
Maximum	503	503	503	467	503	503	503	503	502	497	491	498

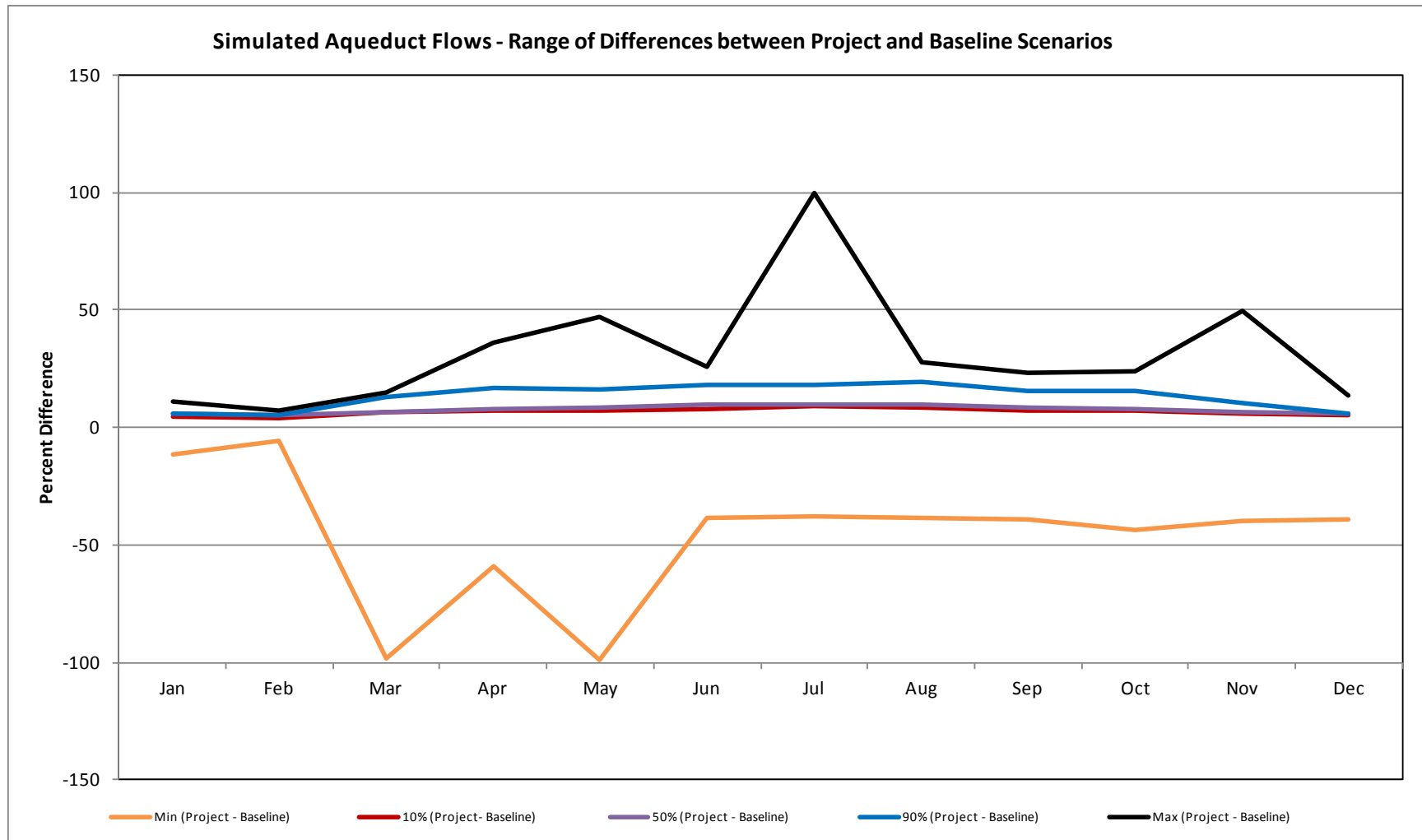
	Mokelumne Aqueduct – Project (cfs)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	0	0	0	0	2	75	2	40	42	20	0	0
10th Percentile	329	391	181	159	192	198	204	196	198	172	200	222
20th Percentile	359	412	186	162	194	201	207	200	201	288	336	344
30th Percentile	362	412	325	301	331	335	341	334	355	327	355	361
40th Percentile	362	417	341	317	353	359	365	358	359	330	355	361
50th Percentile	362	417	341	317	353	359	365	358	359	330	355	361
60th Percentile	362	417	341	317	353	359	365	358	359	330	355	361
70th Percentile	362	417	341	317	353	359	365	358	359	330	355	361
80th Percentile	362	417	341	317	353	359	365	358	359	330	355	361
90th Percentile	362	417	341	317	353	359	365	358	359	330	355	361
Maximum	503	503	503	503	503	503	503	503	502	497	491	498

Notes: cfs = cubic feet per second

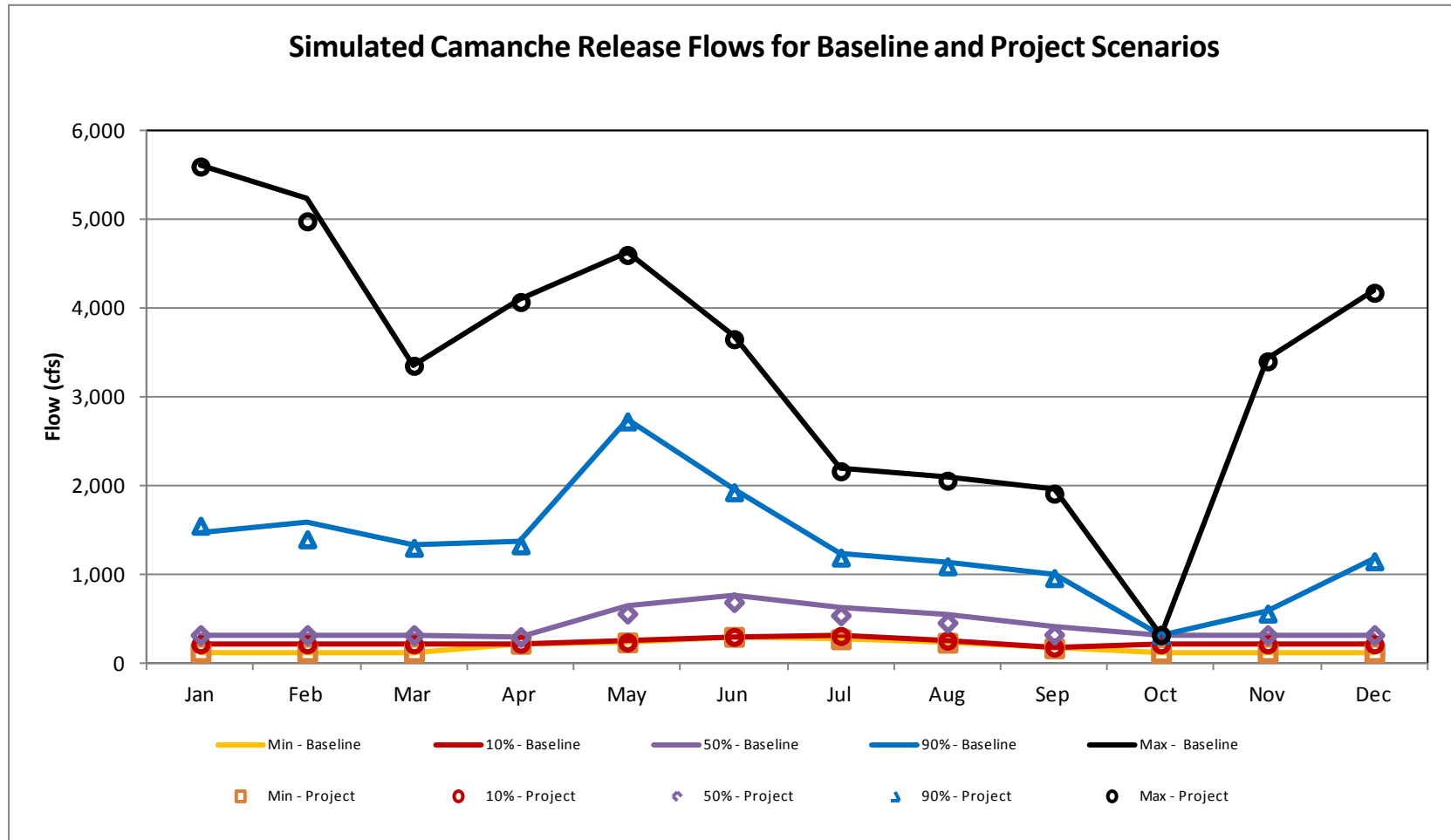
Table H.1-2. Percent Differences between Project and Baseline Mokelumne Aqueduct Flow Percentiles (positive values indicate increase)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	NC	NC	NC	NC	-98.0%	-6.3%	100.0%	0.0%	0.0%	0.0%	NC	NC
10th Percentile	4.4%	3.1%	11.7%	14.4%	14.7%	16.4%	16.5%	17.0%	14.9%	16.2%	11.7%	2.6%
20th Percentile	5.1%	5.1%	12.7%	16.5%	16.2%	18.2%	18.3%	19.0%	-11.7%	3.7%	5.3%	4.1%
30th Percentile	5.8%	5.1%	3.8%	5.1%	1.8%	2.2%	2.3%	2.3%	7.4%	6.9%	6.3%	5.6%
40th Percentile	5.8%	5.0%	6.6%	7.8%	8.6%	9.5%	9.6%	9.8%	8.5%	7.8%	6.3%	5.6%
50th Percentile	5.8%	5.0%	6.6%	7.8%	8.6%	9.5%	9.6%	9.8%	8.5%	7.8%	6.3%	5.6%
60th Percentile	5.8%	5.0%	6.6%	7.8%	8.6%	9.5%	9.6%	9.8%	8.5%	7.8%	6.3%	5.6%
70th Percentile	5.8%	5.0%	6.6%	7.8%	8.6%	9.5%	9.6%	9.8%	8.5%	7.8%	6.3%	5.6%
80th Percentile	5.8%	5.0%	6.6%	7.8%	8.6%	9.5%	9.6%	9.8%	8.5%	7.8%	6.3%	5.6%
90th Percentile	5.8%	5.0%	6.6%	7.8%	8.6%	9.5%	9.6%	9.8%	8.5%	7.8%	6.3%	5.6%
Maximum	0.0%	0.0%	0.0%	7.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Note: NC = not calculable due to zero in denominator



H.1-2 Camanche Reservoir Releases



Note: cfs = cubic feet per second

Table H.1-3. Camanche Reservoir Releases - Modeled Monthly Average Flow

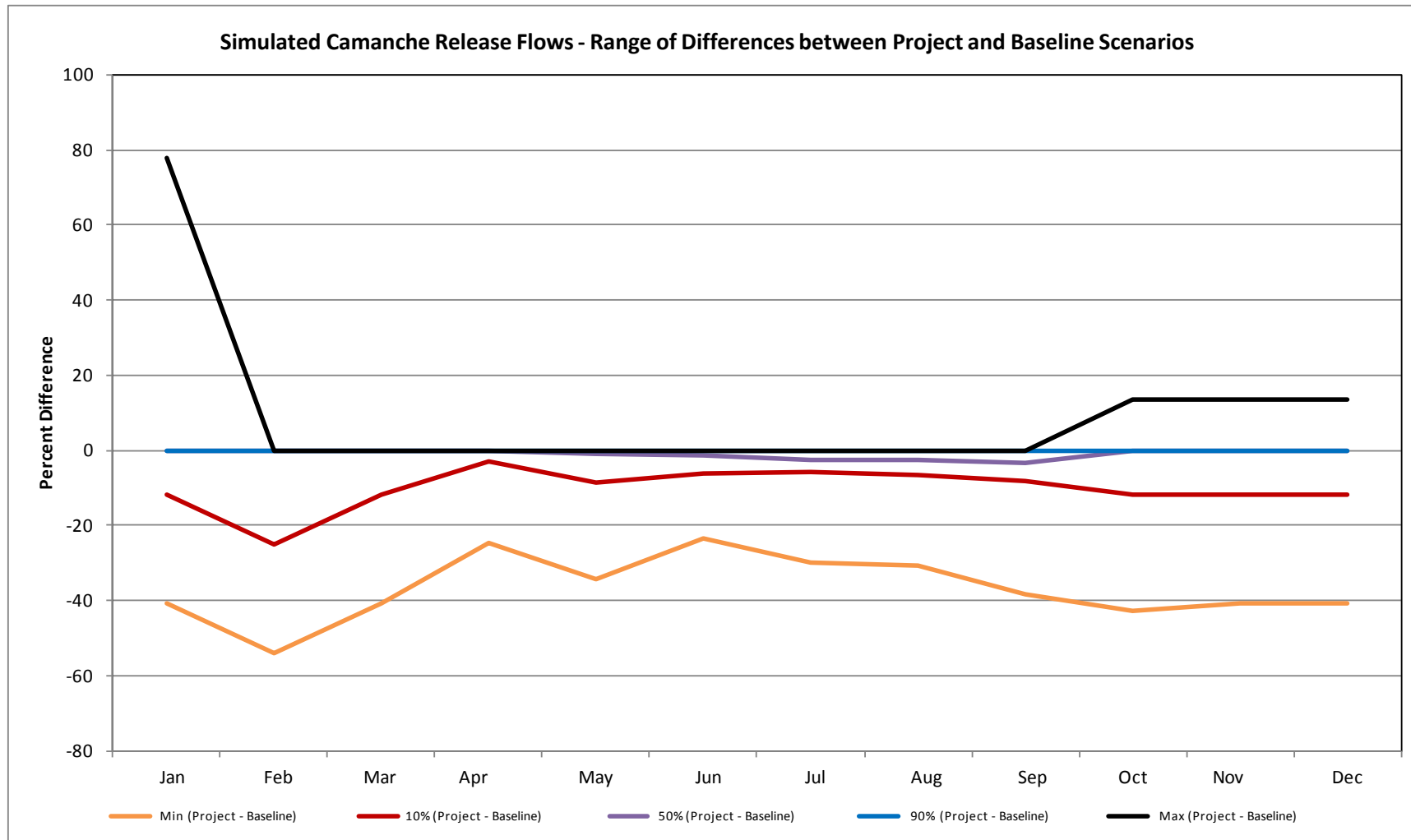
	Camanche Release – Baseline (cfs)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	130	130	130	225	242	304	276	238	175	126	130	130
10th Percentile	220	220	220	227	267	304	314	262	188	220	220	220
20th Percentile	250	250	250	300	400	363	398	348	236	220	220	238
30th Percentile	250	325	250	300	400	363	398	348	236	250	250	250
40th Percentile	325	325	325	300	450	533	398	348	236	250	250	325
50th Percentile	325	325	325	302	648	777	628	546	412	325	325	325
60th Percentile	325	469	325	470	939	1,009	817	722	590	325	325	325
70th Percentile	325	819	536	508	1,239	1,316	961	869	735	325	325	325
80th Percentile	667	1,142	748	534	1,657	1,632	1,079	982	848	325	347	426
90th Percentile	1,481	1,595	1,327	1,372	2,756	1,961	1,236	1,143	1,008	325	587	1,178
Maximum	5,598	5,226	3,354	4,094	4,628	3,683	2,206	2,100	1,954	325	3,424	4,195

	Camanche Release – Project (cfs)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	130	130	130	225	242	304	276	238	175	126	130	130
10th Percentile	220	220	220	227	242	304	314	262	184	220	220	220
20th Percentile	220	238	220	300	400	363	398	348	236	220	220	220
30th Percentile	250	250	250	300	400	363	398	348	236	250	250	250
40th Percentile	325	325	325	300	450	533	398	348	236	250	250	250
50th Percentile	325	325	325	302	565	694	546	463	330	325	325	325
60th Percentile	325	325	325	470	861	976	778	685	553	325	325	325
70th Percentile	325	667	515	500	1,186	1,277	911	818	683	325	325	325
80th Percentile	601	1,086	727	531	1,604	1,592	1,042	944	810	325	338	398
90th Percentile	1,554	1,402	1,306	1,334	2,728	1,931	1,196	1,098	965	325	566	1,154
Maximum	5,595	4,979	3,354	4,071	4,600	3,653	2,167	2,061	1,915	325	3,404	4,175

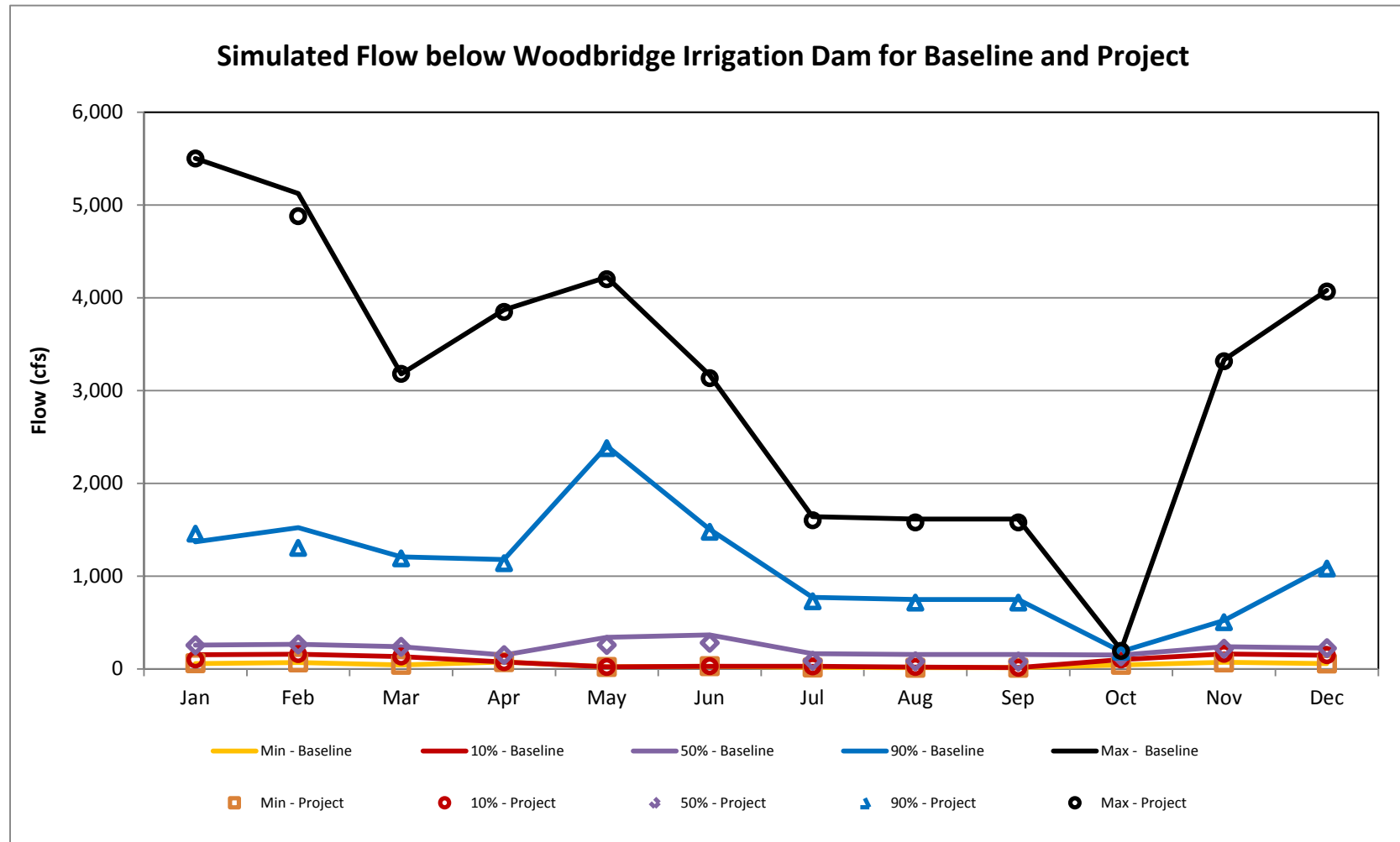
Notes: cfs = cubic feet per second

Table H.1-4. Percent Differences between Project and Baseline Camanche Reservoir Releases Flow Percentiles (positive values indicate increase)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10th Percentile	0.0%	0.0%	0.0%	0.0%	-9.3%	0.0%	0.0%	0.0%	-2.1%	0.0%	0.0%	0.0%
20th Percentile	-12.0%	-4.8%	-12.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-7.6%
30th Percentile	0.0%	-23.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
40th Percentile	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-23.1%
50th Percentile	0.0%	0.0%	0.0%	0.0%	-12.8%	-10.7%	-13.1%	-15.2%	-19.9%	0.0%	0.0%	0.0%
60th Percentile	0.0%	-30.8%	0.0%	0.0%	-8.3%	-3.3%	-4.8%	-5.1%	-6.3%	0.0%	0.0%	0.0%
70th Percentile	0.0%	-18.6%	-3.8%	-1.6%	-4.2%	-2.9%	-5.1%	-5.9%	-7.0%	0.0%	0.0%	0.0%
80th Percentile	-9.8%	-4.9%	-2.8%	-0.6%	-3.2%	-2.5%	-3.5%	-3.9%	-4.5%	0.0%	-2.4%	-6.5%
90th Percentile	4.9%	-12.1%	-1.6%	-2.8%	-1.0%	-1.5%	-3.2%	-3.9%	-4.2%	0.0%	-3.6%	-2.0%
Maximum	-0.1%	-4.7%	0.0%	-0.6%	-0.6%	-0.8%	-1.8%	-1.9%	-2.0%	0.0%	-0.6%	-0.5%



H.1-3 Flow below Woodbridge Irrigation Dam



Note: cfs = cubic feet per second

Table H.1-5. Flow below Woodbridge Irrigation Dam - Modeled Monthly Average Flow

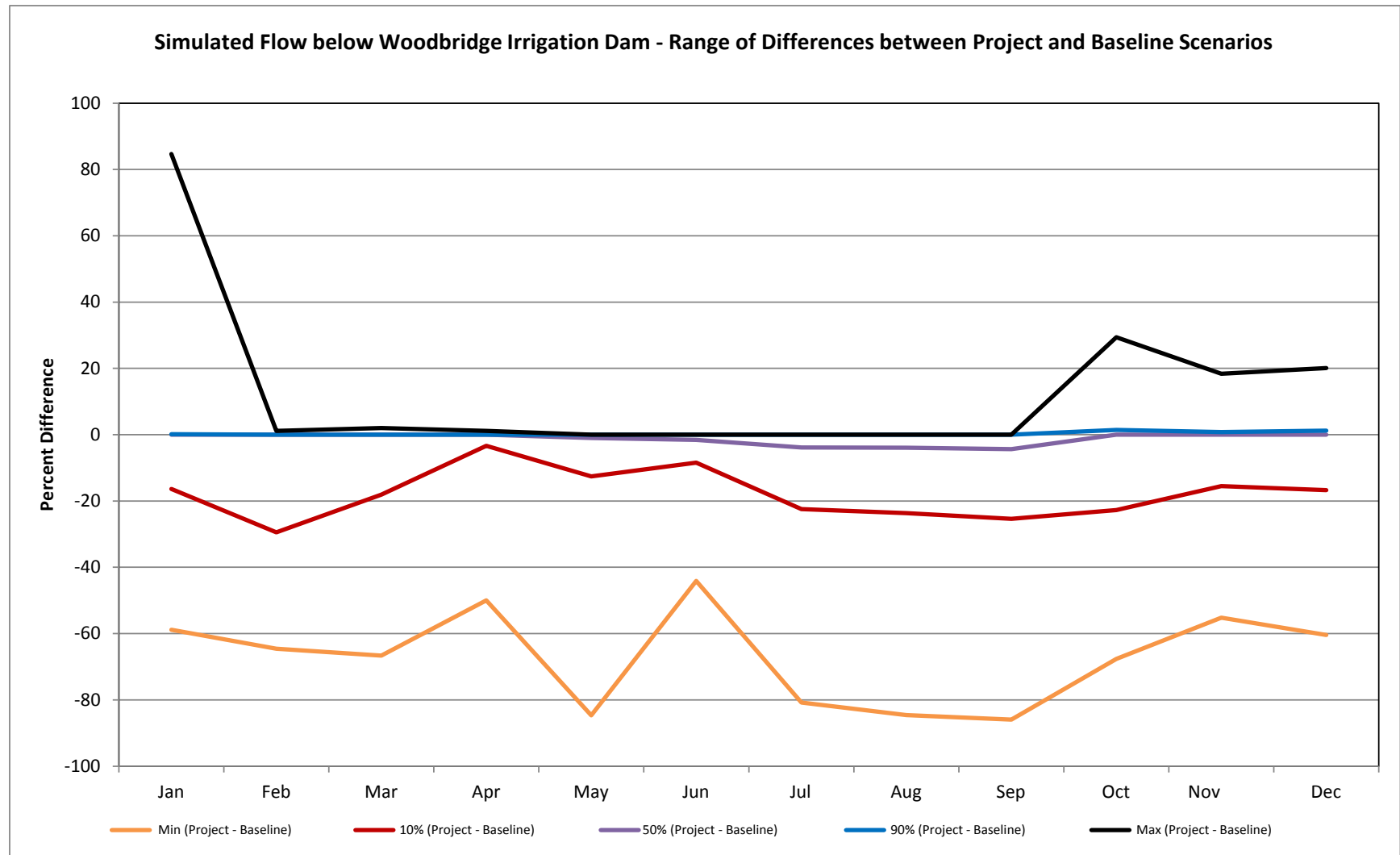
	Flow below Woodbridge Irrigation Dam – Baseline (cfs)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	59	71	45	75	23	31	18	15	15	45	73	59
10th Percentile	153	161	135	75	23	31	29	22	15	102	163	149
20th Percentile	160	191	165	150	150	31	29	22	20	132	163	163
30th Percentile	183	266	166	150	150	31	29	22	20	132	193	179
40th Percentile	233	266	240	150	200	200	29	22	20	139	193	182
50th Percentile	258	268	240	150	343	367	166	158	158	152	242	225
60th Percentile	258	410	241	306	634	599	360	340	340	172	266	254
70th Percentile	258	719	446	350	917	872	493	479	478	185	268	254
80th Percentile	568	1,077	662	373	1,348	1,216	613	591	591	188	290	324
90th Percentile	1,371	1,524	1,209	1,180	2,402	1,508	772	748	748	188	524	1,107
Maximum	5,502	5,124	3,180	3,869	4,222	3,167	1,641	1,617	1,617	207	3,332	4,081

	Flow below Woodbridge Irrigation Dam – Project (cfs)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	63	71	45	75	23	31	18	15	15	45	73	59
10th Percentile	102	161	135	75	23	31	29	22	15	102	163	149
20th Percentile	153	163	136	150	150	31	29	22	20	124	163	149
30th Percentile	183	193	165	150	150	31	29	22	20	132	193	179
40th Percentile	217	266	240	150	200	200	29	22	20	133	193	179
50th Percentile	258	266	240	150	260	284	89	82	80	139	218	225
60th Percentile	258	268	241	308	556	567	322	304	304	167	260	253
70th Percentile	258	608	415	350	875	840	439	421	421	182	268	254
80th Percentile	511	1,014	642	375	1,296	1,175	576	555	554	188	281	288
90th Percentile	1,460	1,304	1,191	1,140	2,381	1,480	729	717	716	188	505	1,083
Maximum	5,501	4,880	3,180	3,849	4,200	3,136	1,602	1,579	1,579	195	3,316	4,068

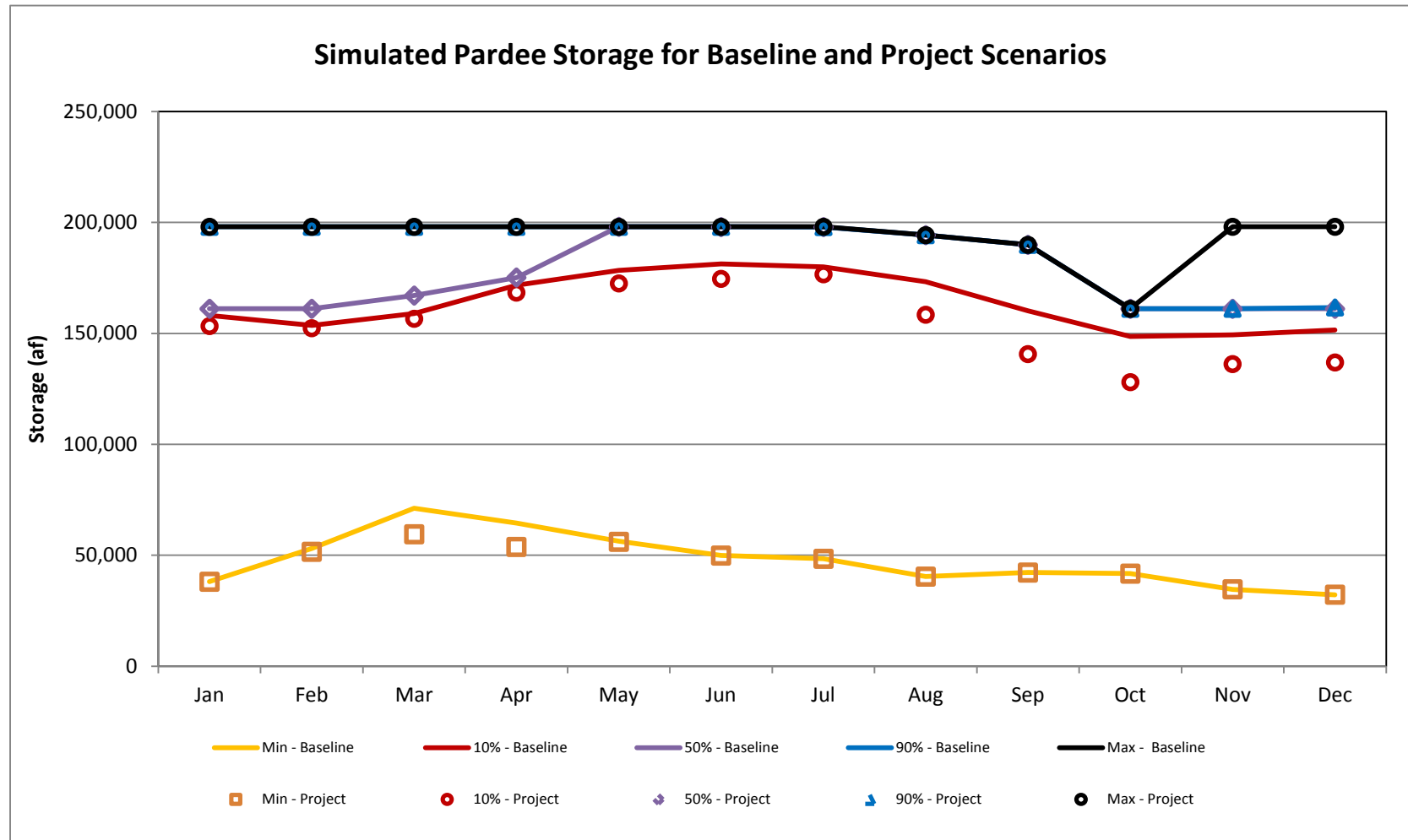
Notes: cfs = cubic feet per second

Table H.1-6. Percent Differences between Project and Baseline Flow below Woodbridge Irrigation Dam Percentiles (positive values indicate increase)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	6.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10th Percentile	-33.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
20th Percentile	-4.1%	-14.7%	-17.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-6.1%	0.0%	-8.5%
30th Percentile	0.0%	-27.4%	-0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
40th Percentile	-6.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-4.0%	0.0%	-1.4%
50th Percentile	0.0%	-0.7%	0.0%	0.0%	-24.2%	-22.6%	-46.4%	-48.1%	-49.4%	-8.6%	-9.9%	0.0%
60th Percentile	0.0%	-34.6%	0.0%	0.8%	-12.3%	-5.4%	-10.7%	-10.6%	-10.7%	-3.0%	-2.4%	-0.2%
70th Percentile	0.0%	-15.4%	-6.9%	0.0%	-4.5%	-3.6%	-10.9%	-12.0%	-11.8%	-1.3%	0.0%	0.0%
80th Percentile	-10.1%	-5.9%	-3.0%	0.6%	-3.9%	-3.4%	-5.9%	-6.2%	-6.1%	0.0%	-2.9%	-11.2%
90th Percentile	6.5%	-14.4%	-1.5%	-3.4%	-0.9%	-1.9%	-5.6%	-4.2%	-4.3%	0.0%	-3.7%	-2.2%
Maximum	0.0%	-4.8%	0.0%	-0.5%	-0.5%	-1.0%	-2.4%	-2.4%	-2.4%	-5.8%	-0.5%	-0.3%



H.1-4 Pardee Reservoir Storage



Note: af = acre-feet

Table H.1-7. Pardee Reservoir Storage - Modeled Monthly Storage

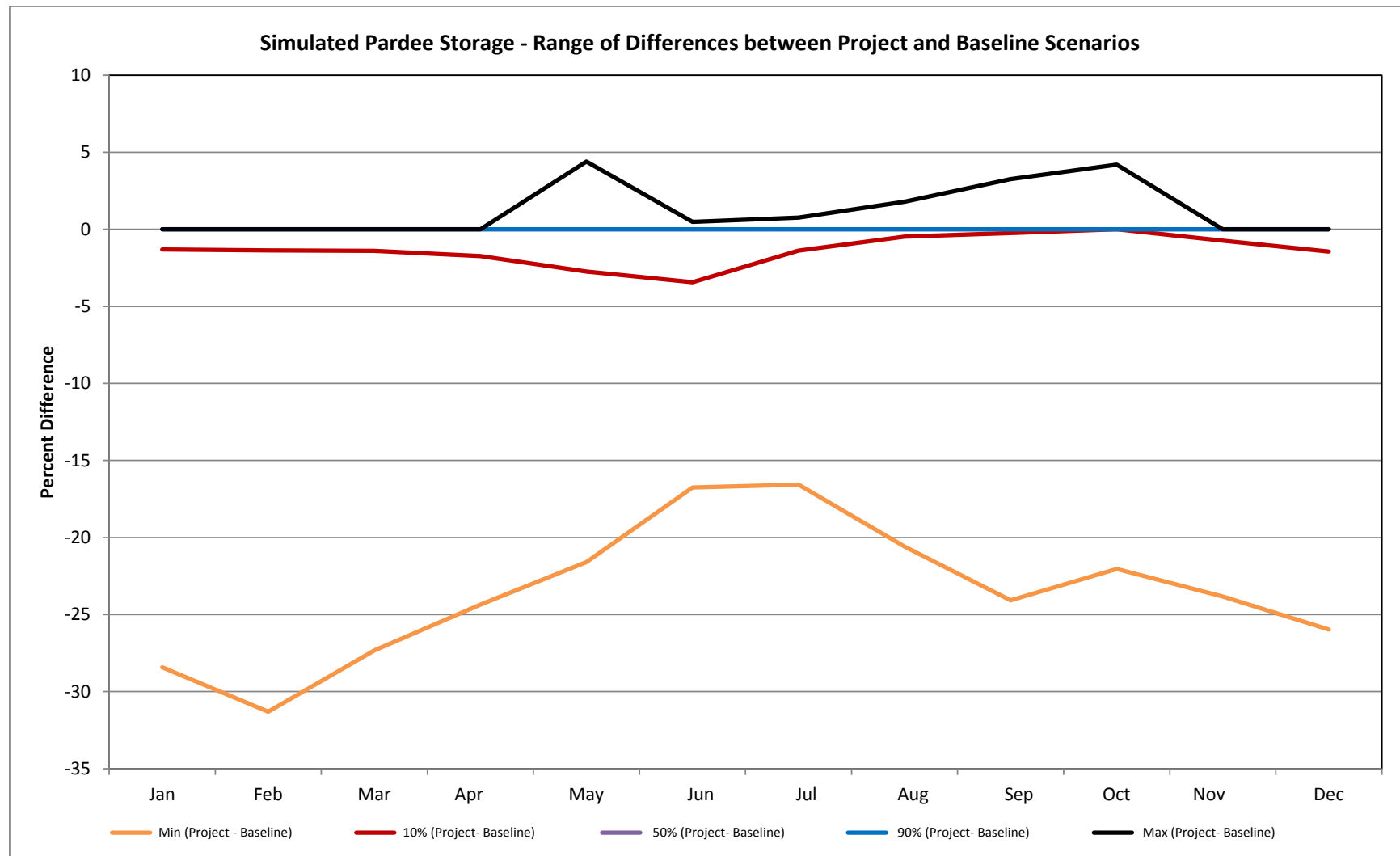
	Pardee Reservoir – Baseline (af)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	38,100	53,042	71,214	64,456	56,387	49,880	48,457	40,440	42,254	41,748	34,613	32,187
10th Percentile	158,152	153,606	158,994	171,722	178,376	181,361	180,005	173,309	160,145	148,631	149,363	151,538
20th Percentile	161,130	157,118	167,052	175,156	188,616	197,954	197,954	194,304	189,940	161,130	161,130	161,130
30th Percentile	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
40th Percentile	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
50th Percentile	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
60th Percentile	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
70th Percentile	161,130	161,130	169,065	185,761	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
80th Percentile	161,130	177,298	197,513	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
90th Percentile	198,065	198,065	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,700
Maximum	198,065	198,065	198,065	198,065	198,065	198,065	198,065	194,304	189,940	161,130	198,065	198,065

	Pardee Reservoir – Project (af)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	38,100	51,607	59,447	53,729	56,074	49,891	48,457	40,440	42,254	41,748	34,613	32,187
10th Percentile	153,359	152,323	156,639	168,390	172,545	174,613	176,664	158,378	140,626	128,013	136,140	136,893
20th Percentile	161,130	155,054	167,052	175,156	187,320	197,954	197,954	194,304	189,940	161,130	161,130	161,130
30th Percentile	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
40th Percentile	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
50th Percentile	161,130	161,130	167,052	175,156	198,065	197,954	197,954	194,304	189,940	161,130	161,130	161,130
60th Percentile	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
70th Percentile	161,130	161,130	167,181	183,635	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
80th Percentile	161,130	175,731	196,682	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
90th Percentile	198,065	198,065	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,700
Maximum	198,065	198,065	198,065	198,065	198,065	198,065	198,065	194,304	189,940	161,130	198,065	198,065

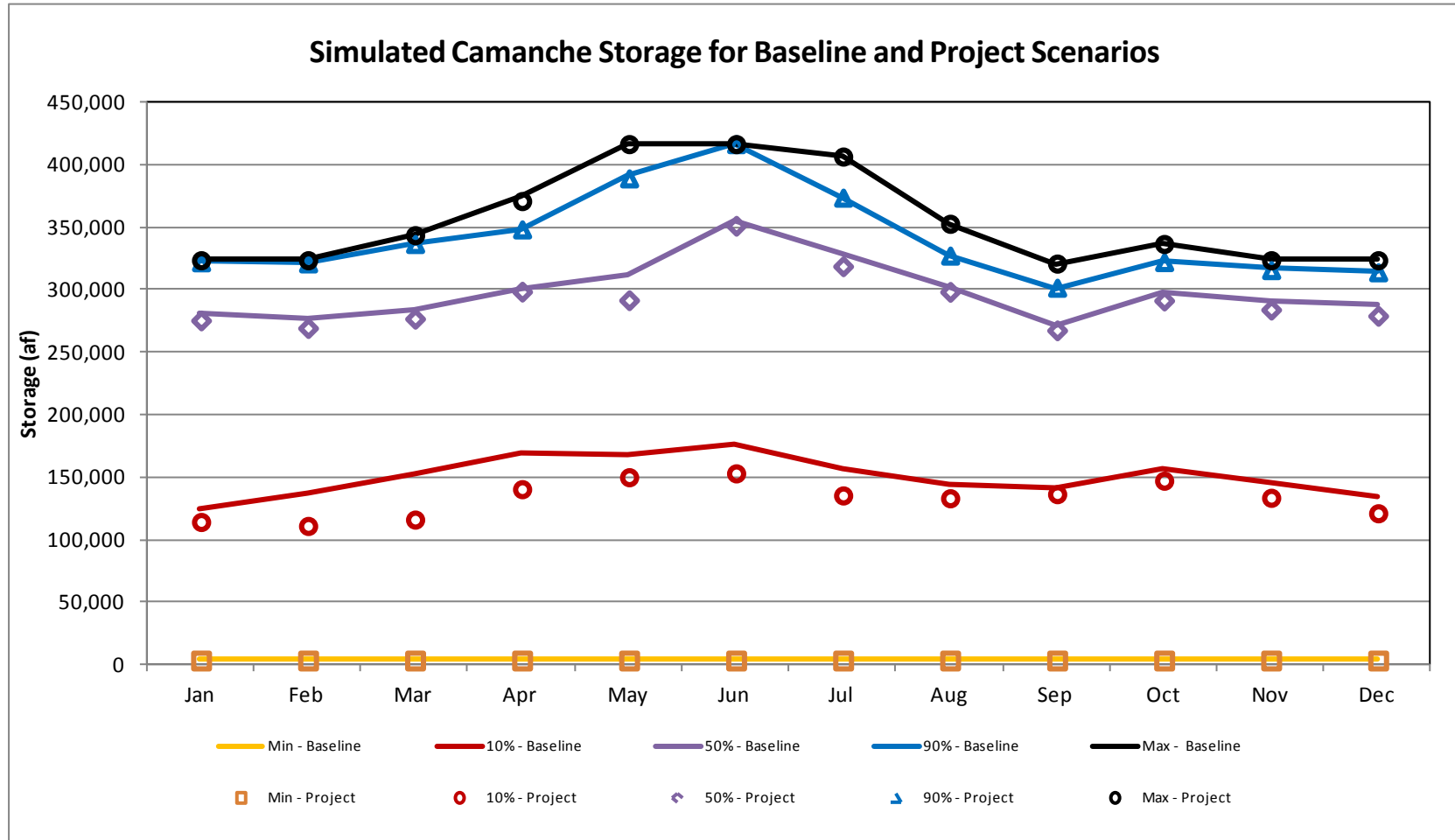
Note: af = acre-feet

Table H.1-8. Percent Differences between Project and Baseline Pardee Reservoir Storage Percentiles (positive values indicates increase)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	0.0%	-2.7%	-16.5%	-16.6%	-0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10th Percentile	-3.0%	-0.8%	-1.5%	-1.9%	-3.3%	-3.7%	-1.9%	-8.6%	-12.2%	-13.9%	-8.9%	-9.7%
20th Percentile	0.0%	-1.3%	0.0%	0.0%	-0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
30th Percentile	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
40th Percentile	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
50th Percentile	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
60th Percentile	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
70th Percentile	0.0%	0.0%	-1.1%	-1.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
80th Percentile	0.0%	-0.9%	-0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
90th Percentile	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Maximum	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%



H.1-5 Camanche Reservoir Storage



Note: af = acre-feet

Table H.1-9. Camanche Reservoir - Modeled Monthly Storage

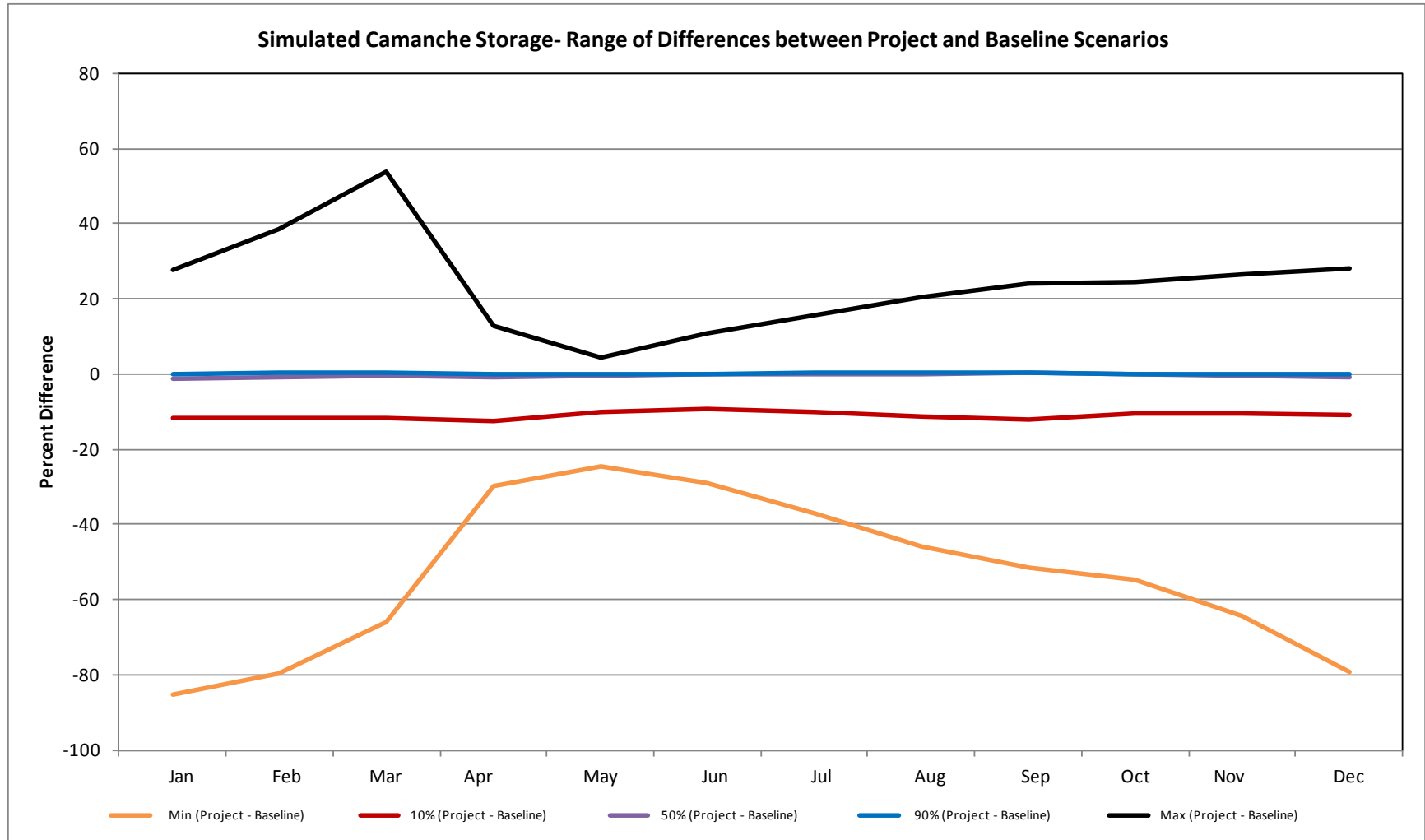
	Camanche Reservoir – Baseline (af)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025
10th Percentile	125,129	137,300	152,569	169,567	167,689	176,590	156,753	143,474	141,821	157,331	144,901	133,720
20th Percentile	221,809	217,958	241,572	228,571	223,721	238,008	221,138	216,757	214,809	237,260	231,899	225,399
30th Percentile	251,795	240,290	258,883	263,839	252,299	251,064	238,204	232,393	238,654	258,631	254,872	247,721
40th Percentile	270,683	267,487	271,023	290,508	276,088	291,489	275,370	263,167	260,454	284,682	280,070	265,243
50th Percentile	280,627	277,283	283,698	300,480	312,179	355,539	327,887	301,309	270,579	297,984	291,290	287,758
60th Percentile	287,378	287,122	295,958	312,358	325,855	372,581	347,573	313,378	279,954	302,180	294,730	292,042
70th Percentile	298,107	295,820	305,252	327,294	356,859	396,667	359,274	318,144	285,295	307,920	300,081	299,840
80th Percentile	311,607	309,293	315,491	340,316	369,413	407,498	366,803	322,786	293,475	315,440	309,267	304,633
90th Percentile	322,622	321,981	336,935	348,252	391,161	417,148	373,927	326,663	300,820	322,792	317,267	314,629
Maximum	324,253	324,253	344,291	374,926	417,148	417,148	406,740	352,532	320,112	337,233	324,253	324,253

	Camanche Reservoir – Project (af)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025
10th Percentile	114,870	111,684	116,761	141,103	150,672	153,752	136,092	133,836	137,127	147,891	134,204	121,827
20th Percentile	215,181	217,148	230,946	222,541	217,603	213,031	201,798	203,075	200,850	226,033	216,624	215,095
30th Percentile	236,846	234,830	255,699	242,907	242,586	240,311	227,310	217,616	215,463	243,700	239,020	237,376
40th Percentile	259,607	256,629	263,913	271,621	273,835	283,571	266,331	252,960	249,929	274,154	264,449	256,224
50th Percentile	276,096	269,985	277,430	299,123	292,269	351,809	319,427	298,955	268,153	292,014	284,719	279,731
60th Percentile	282,527	282,112	291,377	309,004	321,217	369,625	346,898	313,278	279,122	301,058	292,639	288,401
70th Percentile	290,310	291,689	304,698	326,619	351,980	395,498	359,855	318,730	283,973	306,443	297,363	294,882
80th Percentile	308,653	305,961	313,354	339,558	369,073	407,609	367,225	323,120	293,688	315,076	306,639	304,863
90th Percentile	322,622	321,743	337,255	348,922	389,728	417,148	374,315	327,974	302,275	322,792	316,381	314,629
Maximum	324,253	324,253	344,291	371,580	417,148	417,148	407,184	353,409	321,567	337,233	324,253	324,253

Note: af = acre-feet

Table H.1-10. Percent Differences between Project and Baseline Camanche Reservoir Storage Percentiles (positive values indicates increase)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10th Percentile	-8.2%	-18.7%	-23.5%	-16.8%	-10.1%	-12.9%	-13.2%	-6.7%	-3.3%	-6.0%	-7.4%	-8.9%
20th Percentile	-3.0%	-0.4%	-4.4%	-2.6%	-2.7%	-10.5%	-8.7%	-6.3%	-6.5%	-4.7%	-6.6%	-4.6%
30th Percentile	-5.9%	-2.3%	-1.2%	-7.9%	-3.9%	-4.3%	-4.6%	-6.4%	-9.7%	-5.8%	-6.2%	-4.2%
40th Percentile	-4.1%	-4.1%	-2.6%	-6.5%	-0.8%	-2.7%	-3.3%	-3.9%	-4.0%	-3.7%	-5.6%	-3.4%
50th Percentile	-1.6%	-2.6%	-2.2%	-0.5%	-6.4%	-1.0%	-2.6%	-0.8%	-0.9%	-2.0%	-2.3%	-2.8%
60th Percentile	-1.7%	-1.7%	-1.5%	-1.1%	-1.4%	-0.8%	-0.2%	0.0%	-0.3%	-0.4%	-0.7%	-1.2%
70th Percentile	-2.6%	-1.4%	-0.2%	-0.2%	-1.4%	-0.3%	0.2%	0.2%	-0.5%	-0.5%	-0.9%	-1.7%
80th Percentile	-0.9%	-1.1%	-0.7%	-0.2%	-0.1%	0.0%	0.1%	0.1%	0.1%	-0.1%	-0.9%	0.1%
90th Percentile	0.0%	-0.1%	0.1%	0.2%	-0.4%	0.0%	0.1%	0.4%	0.5%	0.0%	-0.3%	0.0%
Maximum	0.0%	0.0%	0.0%	-0.9%	0.0%	0.0%	0.1%	0.2%	0.5%	0.0%	0.0%	0.0%



Appendix H.2

**Joint Settlement Agreement Year Type Classifications
as Simulated by EBMUDSIM**

Year	Baseline Year Types		Permit 10478 Time Extension Project Year Types		Cumulative Year Types	
	April-September	October-March	April-September	October-March	April-September	October-March
1921	BNorm	Norm	BNorm	Norm	BNorm	Norm
1922	Norm	Norm	Norm	Norm	Norm	Norm
1923	BNorm	Norm	BNorm	Norm	BNorm	Norm
1924	Crit	Dry	Crit	Dry	Crit	Dry
1925	BNorm	Norm	BNorm	Norm	BNorm	Norm
1926	Dry	BNorm	Dry	BNorm	Dry	BNorm
1927	Norm	Norm	Norm	Norm	Norm	Norm
1928	BNorm	Norm	BNorm	Norm	BNorm	Norm
1929	Dry	BNorm	Dry	Dry	Dry	Dry
1930	Dry	BNorm	Dry	BNorm	Dry	Dry
1931	Crit	Crit	Crit	Crit	Crit	Crit
1932	BNorm	Norm	BNorm	BNorm	BNorm	BNorm
1933	Dry	BNorm	Dry	BNorm	Dry	BNorm
1934	Dry	Dry	Dry	Dry	Dry	Dry
1935	BNorm	Norm	BNorm	Norm	BNorm	Norm
1936	Norm	Norm	Norm	Norm	Norm	Norm
1937	BNorm	Norm	BNorm	Norm	BNorm	Norm
1938	Norm	Norm	Norm	Norm	Norm	Norm
1939	Dry	BNorm	Dry	BNorm	Dry	Dry
1940	Norm	Norm	Norm	Norm	Norm	Norm
1941	BNorm	Norm	BNorm	Norm	BNorm	Norm
1942	Norm	Norm	Norm	Norm	Norm	Norm
1943	Norm	Norm	Norm	Norm	Norm	Norm
1944	Dry	BNorm	Dry	Dry	Dry	BNorm
1945	BNorm	Norm	BNorm	Norm	BNorm	Norm
1946	BNorm	Norm	BNorm	Norm	BNorm	Norm
1947	Dry	BNorm	Dry	Dry	Dry	BNorm
1948	BNorm	BNorm	BNorm	BNorm	BNorm	Norm

Year	Baseline Year Types		Permit 10478 Time Extension Project Year Types		Cumulative Year Types	
	April-September	October-March	April-September	October-March	April-September	October-March
1949	BNorm	Norm	BNorm	BNorm	BNorm	BNorm
1950	BNorm	Norm	BNorm	Norm	BNorm	Norm
1951	Norm	Norm	Norm	Norm	Norm	Norm
1952	Norm	Norm	Norm	Norm	Norm	Norm
1953	BNorm	Norm	BNorm	Norm	BNorm	Norm
1954	BNorm	Norm	BNorm	BNorm	BNorm	BNorm
1955	Dry	Dry	Dry	Dry	Dry	BNorm
1956	Norm	Norm	Norm	Norm	Norm	Norm
1957	BNorm	Norm	BNorm	Norm	BNorm	Norm
1958	Norm	Norm	Norm	Norm	Norm	Norm
1959	Dry	BNorm	Dry	BNorm	Dry	Dry
1960	Dry	BNorm	Dry	Dry	Dry	Dry
1961	Crit	Dry	Crit	Crit	Crit	Crit
1962	BNorm	Dry	BNorm	Dry	BNorm	Dry
1963	BNorm	Norm	BNorm	Norm	BNorm	Norm
1964	Dry	BNorm	Dry	BNorm	Dry	BNorm
1965	Norm	Norm	Norm	Norm	Norm	Norm
1966	Dry	BNorm	Dry	Dry	Dry	Dry
1967	Norm	Norm	Norm	Norm	Norm	Norm
1968	Dry	Dry	Dry	BNorm	Dry	BNorm
1969	Norm	Norm	Norm	Norm	Norm	Norm
1970	Norm	Norm	Norm	Norm	Norm	Norm
1971	BNorm	Norm	BNorm	Norm	BNorm	Norm
1972	BNorm	BNorm	BNorm	BNorm	BNorm	BNorm
1973	BNorm	Norm	BNorm	Norm	BNorm	Norm
1974	Norm	Norm	Norm	Norm	Norm	Norm
1975	BNorm	Norm	BNorm	Norm	BNorm	Norm
1976	Crit	Dry	Crit	Dry	Crit	Dry

Year	Baseline Year Types		Permit 10478 Time Extension Project Year Types		Cumulative Year Types	
	April-September	October-March	April-September	October-March	April-September	October-March
1977	Crit	Crit	Crit	Crit	Crit	Crit
1978	Crit	Crit	Crit	Crit	Crit	Crit
1979	Crit	Crit	Crit	Crit	Crit	Crit
1980	Norm	Norm	Norm	Norm	Norm	Norm
1981	Dry	BNorm	Dry	BNorm	Dry	BNorm
1982	Norm	Norm	Norm	Norm	Norm	Norm
1983	Norm	Norm	Norm	Norm	Norm	Norm
1984	Norm	Norm	Norm	Norm	Norm	Norm
1985	Dry	BNorm	Dry	Dry	Dry	BNorm
1986	Norm	Norm	Norm	Norm	Norm	Norm
1987	Crit	Dry	Crit	Dry	Crit	Dry
1988	Crit	Dry	Crit	Crit	Crit	Crit
1989	BNorm	Dry	BNorm	Dry	BNorm	Dry
1990	Dry	Dry	Dry	Dry	Dry	Dry
1991	Dry	Crit	Dry	Crit	Dry	Crit
1992	Dry	Crit	Crit	Crit	Dry	Crit
1993	Norm	Norm	Norm	Norm	Norm	Norm
1994	Crit	Dry	Crit	Dry	Crit	Dry
1995	Norm	Norm	Norm	Norm	Norm	Norm
1996	Norm	Norm	Norm	Norm	Norm	Norm
1997	Norm	Norm	Norm	Norm	Norm	Norm
1998	Norm	Norm	Norm	Norm	Norm	Norm
1999	BNorm	Norm	BNorm	Norm	BNorm	Norm
2000	BNorm	Norm	BNorm	Norm	BNorm	Norm
2001	Dry	BNorm	Dry	BNorm	Dry	BNorm
2002	BNorm	BNorm	BNorm	Dry	BNorm	BNorm
2003	BNorm	Norm	BNorm	Norm	BNorm	Norm
2004	Dry	BNorm	Dry	BNorm	Dry	Dry

Year	Baseline Year Types		Permit 10478 Time Extension Project Year Types		Cumulative Year Types	
	April-September	October-March	April-September	October-March	April-September	October-March
2005	Norm	Norm	Norm	Norm	Norm	Norm
2006	Norm	Norm	Norm	Norm	Norm	Norm
2007	Dry	BNorm	Dry	BNorm	Dry	BNorm
2008	Dry	Dry	Dry	Dry	Dry	Dry
2009	BNorm	Norm	BNorm	BNorm	BNorm	BNorm

Notes: Grey highlighting of the Project and cumulative year types indicates a drier year classification compared to the baseline year classification.

A box around the Project and cumulative year types indicates a wetter year classification compared to the baseline year classification.

Norm above normal / normal
 BNorm below normal
 Crit critically dry

Appendix H.3

Evaluation of when End-of-Month Camanche Elevation Falls below 190 Feet

Grey highlighting indicates months when end-of-month elevation is less than 190 feet. For these months, historic Camanche Reservoir release temperatures might not accurately represent release temperatures under the Baseline, Permit 10478 Time Extension Project, and Cumulative scenarios.

HISTORICAL				MODELED BASELINE CASE		MODELED PERMIT 10478 TIME EXTENSION PROJECT		MODELED CUMULATIVE	
Year	Month	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)
1974	10	217.4	304,259	222.1	322,683	222.1	322,683	222.1	322,683
1974	11	215.3	291,060	220.4	311,458	220.2	310,215	220.0	308,670
1974	12	214.7	287,019	218.9	301,626	218.5	299,167	218.0	295,992
1975	1	215.9	294,441	216.6	287,262	216.1	283,615	215.3	278,795
1975	2	220.2	322,430	217.3	291,207	216.5	286,475	215.5	280,336
1975	3	222.2	335,406	223.1	329,080	222.2	323,049	221.1	315,866
1975	4	222.1	334,869	225.8	347,197	225.1	342,791	223.8	333,921
1975	5	225.1	354,970	222.7	326,525	222.2	323,475	221.6	319,205
1975	6	231.3	399,262	232.7	396,703	232.5	394,766	232.1	391,672
1975	7	229.7	387,910	227.4	358,584	227.3	357,716	227.0	355,916
1975	8	225.8	360,313	221.5	318,813	221.6	319,043	221.5	318,606
1975	9	222.5	337,291	216.9	288,731	217.1	290,185	217.3	291,481
1975	10	217.9	307,335	221.9	321,053	221.9	321,053	221.9	321,053
1975	11	215.1	289,316	221.3	317,189	221.3	317,189	221.3	317,189
1975	12	216.4	297,400	220.6	312,447	220.4	311,231	220.1	309,601
1976	1	216.9	301,073	218.3	297,707	217.9	295,405	218.9	301,675
1976	2	216.4	297,968	215.3	279,133	215.0	276,831	216.0	283,100
1976	3	214.8	287,391	212.0	258,655	211.6	256,355	212.6	262,617
1976	4	212.8	275,564	209.5	244,185	209.1	241,891	210.1	247,866
1976	5	209.6	256,606	206.4	226,857	206.0	224,578	207.0	230,192
1976	6	205.9	235,469	202.5	205,971	202.1	203,708	203.1	208,956
1976	7	202.1	214,670	198.4	185,426	198.0	183,188	199.0	188,078
1976	8	198.8	197,800	194.8	167,961	194.3	165,745	195.3	170,285
1976	9	196.5	186,137	192.0	155,347	191.5	153,150	192.5	157,492
1976	10	194.7	177,779	193.8	163,268	190.4	148,572	189.6	145,106
1976	11	194.0	174,155	190.6	149,487	187.1	134,835	186.3	131,381
1976	12	193.2	170,393	187.3	135,308	183.5	120,706	182.6	117,264
1977	1	192.7	168,050	183.8	121,681	179.8	107,092	178.8	103,653
1977	2	190.9	160,296	180.4	109,456	176.1	94,872	175.0	91,435

HISTORICAL				MODELED BASELINE CASE		MODELED PERMIT 10478 TIME EXTENSION PROJECT		MODELED CUMULATIVE	
Year	Month	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)
1977	3	187.7	146,450	176.4	95,754	171.5	81,197	170.2	77,767
1977	4	184.1	131,599	171.6	81,481	165.9	67,045	164.3	63,373
1977	5	181.0	119,547	169.4	75,533	162.2	58,728	161.1	56,424
1977	6	176.2	102,450	165.5	66,003	156.1	46,936	155.6	45,992
1977	7	170.1	82,826	161.5	57,311	149.7	36,069	150.0	36,488
1977	8	163.9	65,966	158.4	51,159	143.9	27,761	145.2	29,518
1977	9	158.9	54,778	157.6	49,680	140.9	24,045	143.5	27,272
1977	10	157.8	52,510	158.5	51,321	140.3	23,311	144.2	28,138
1977	11	155.2	47,632	154.1	43,333	132.8	15,428	137.6	20,236
1977	12	152.6	43,056	149.1	35,146	123.0	7,342	129.2	12,129
1978	1	166.0	71,227	143.3	27,098	118.6	4,025	118.7	4,111
1978	2	180.1	116,120	137.3	19,925	118.6	4,025	118.6	4,025
1978	3	192.6	167,730	128.9	11,884	118.6	4,025	118.6	4,025
1978	4	203.0	219,410	118.6	4,025	118.6	4,025	118.6	4,025
1978	5	212.7	274,898	118.6	4,025	118.6	4,025	118.6	4,025
1978	6	229.2	384,450	118.6	4,025	118.6	4,025	118.6	4,025
1978	7	229.8	388,199	118.6	4,025	118.6	4,025	118.6	4,025
1978	8	226.7	366,257	118.6	4,025	118.6	4,025	118.6	4,025
1978	9	222.7	339,180	118.6	4,025	118.6	4,025	118.6	4,025
1978	10	217.9	307,142	118.6	4,025	118.6	4,025	118.6	4,025
1978	11	216.0	294,880	118.6	4,025	118.6	4,025	118.6	4,025
1978	12	215.7	293,499	118.6	4,025	118.6	4,025	118.6	4,025
1979	1	218.4	310,169	118.6	4,025	118.6	4,025	118.6	4,025
1979	2	220.3	322,760	118.6	4,025	118.6	4,025	118.6	4,025
1979	3	222.2	335,810	118.6	4,025	118.6	4,025	118.6	4,025
1979	4	227.9	374,943	118.6	4,025	118.6	4,025	118.6	4,025
1979	5	234.4	422,767	138.9	21,728	138.1	20,797	135.0	17,598
1979	6	234.0	419,303	157.0	48,570	157.0	48,561	151.6	39,141
1979	7	231.1	397,724	159.9	54,057	159.2	52,660	152.7	40,988

HISTORICAL				MODELED BASELINE CASE		MODELED PERMIT 10478 TIME EXTENSION PROJECT		MODELED CUMULATIVE	
Year	Month	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)
1979	8	226.6	365,976	164.0	62,503	162.7	59,746	155.5	45,863
1979	9	223.4	343,587	170.6	78,763	169.0	74,660	162.2	58,716
1979	10	219.6	318,097	177.5	99,419	175.8	93,943	169.5	75,944
1979	11	216.2	296,328	175.1	91,864	173.3	86,385	166.5	68,377
1979	12	216.3	297,021	172.8	84,874	170.8	79,388	163.4	61,356
1980	1	215.4	291,435	197.2	179,285	193.5	162,217	188.0	138,262
1980	2	215.6	292,873	207.8	234,674	207.8	234,674	207.8	234,674
1980	3	212.2	271,761	217.8	294,865	217.8	294,865	217.8	294,865
1980	4	215.2	289,876	223.1	329,441	222.9	328,085	222.9	327,814
1980	5	217.8	306,757	225.9	347,889	225.8	347,269	225.7	346,471
1980	6	222.7	338,978	232.7	396,079	232.6	395,986	232.6	395,503
1980	7	224.5	351,247	229.2	371,326	229.3	371,703	229.3	371,626
1980	8	222.7	339,045	220.9	314,695	221.0	315,555	221.0	315,547
1980	9	220.5	323,882	213.7	269,132	213.9	270,360	214.0	271,052
1980	10	216.5	298,411	217.0	289,479	217.0	289,479	217.0	289,479
1980	11	214.4	285,041	217.4	292,195	217.4	292,195	217.4	292,195
1980	12	213.1	277,141	220.3	310,727	220.3	310,727	220.1	309,097
1981	1	215.6	292,623	222.3	324,072	222.3	324,072	222.3	324,072
1981	2	217.0	301,200	222.3	324,072	222.3	324,072	222.3	324,072
1981	3	220.4	323,749	224.2	336,754	224.2	336,754	224.1	335,729
1981	4	220.8	326,329	226.2	350,085	226.2	350,085	225.8	347,366
1981	5	219.0	314,575	222.2	323,177	222.2	323,177	221.7	320,144
1981	6	216.2	296,139	218.2	297,061	218.2	297,061	217.5	292,726
1981	7	215.0	288,943	216.0	283,003	216.0	283,003	214.2	272,002
1981	8	213.2	277,689	213.8	270,047	213.8	270,047	211.6	256,345
1981	9	209.6	256,315	213.5	268,153	213.5	268,153	210.9	252,243
1981	10	210.4	261,291	217.8	294,418	217.8	294,418	215.4	279,327
1981	11	212.8	275,503	217.5	292,678	217.5	292,678	217.5	292,678
1981	12	212.6	274,052	210.7	251,233	210.7	251,233	211.0	252,852

HISTORICAL				MODELED BASELINE CASE		MODELED PERMIT 10478 TIME EXTENSION PROJECT		MODELED CUMULATIVE	
Year	Month	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)
1982	1	209.0	253,122	207.3	231,837	207.3	231,837	207.5	233,193
1982	2	216.2	296,517	204.6	217,148	204.6	217,148	204.6	217,148
1982	3	219.4	316,921	211.4	255,261	211.4	255,261	211.4	255,261
1982	4	224.1	348,228	214.4	273,252	214.4	273,252	214.4	273,252
1982	5	228.7	380,933	227.6	359,886	227.6	359,886	227.6	359,886
1982	6	234.1	420,280	234.0	405,747	234.0	405,747	234.0	405,864
1982	7	230.4	393,056	227.7	360,471	227.7	360,471	227.7	360,792
1982	8	227.9	374,659	218.7	300,510	218.7	300,510	218.8	301,111
1982	9	224.4	350,491	209.5	244,128	209.5	244,128	209.7	245,422
1982	10	218.9	313,405	214.5	274,144	214.5	274,144	214.5	274,144
1982	11	211.2	265,844	212.1	259,655	212.1	259,655	212.1	259,655
1982	12	211.0	264,598	207.9	234,971	207.9	234,971	208.1	236,585
1983	1	214.8	287,639	211.6	256,408	211.6	256,408	211.6	256,408
1983	2	216.1	296,013	213.4	267,094	213.4	267,094	213.4	267,094
1983	3	217.6	305,603	219.2	303,559	219.2	303,559	219.2	303,559
1983	4	209.8	257,481	221.4	317,565	221.4	317,565	221.4	317,565
1983	5	211.2	265,547	207.5	233,286	207.5	233,286	207.5	233,286
1983	6	231.7	402,126	227.0	355,539	227.0	355,539	227.0	355,539
1983	7	233.2	413,835	233.2	399,783	233.2	400,192	233.3	400,714
1983	8	230.9	396,847	223.9	334,314	223.8	333,709	223.7	333,403
1983	9	224.8	353,244	216.0	283,153	215.7	281,464	215.5	280,379
1983	10	217.4	304,323	223.2	330,096	222.5	325,025	221.8	320,430
1983	11	212.8	275,261	211.2	254,082	211.2	254,082	211.1	253,548
1983	12	210.6	262,234	204.6	217,148	204.6	217,148	204.6	217,148
1984	1	206.2	236,807	204.6	217,148	204.6	217,148	204.6	217,148
1984	2	208.4	249,319	206.2	226,041	206.2	226,041	206.2	226,041
1984	3	211.3	266,558	214.9	276,391	214.9	276,391	214.9	276,391
1984	4	214.6	286,153	220.1	309,056	220.1	309,056	220.1	309,056
1984	5	226.2	363,244	227.4	358,758	227.3	358,135	227.3	357,936

HISTORICAL				MODELED BASELINE CASE		MODELED PERMIT 10478 TIME EXTENSION PROJECT		MODELED CUMULATIVE	
Year	Month	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)
1984	6	232.4	407,737	229.5	372,955	229.4	372,844	229.1	370,567
1984	7	232.1	405,222	225.9	348,010	225.9	348,349	225.7	347,088
1984	8	229.8	388,777	222.6	325,864	222.7	326,684	222.7	326,512
1984	9	224.6	351,729	218.7	300,139	218.9	301,593	219.1	302,889
1984	10	220.2	322,035	222.7	326,245	222.7	326,245	222.7	326,245
1984	11	218.2	309,394	221.8	320,329	221.8	320,329	221.8	320,329
1984	12	216.5	298,410	222.2	323,166	222.0	321,949	221.8	320,318
1985	1	216.2	296,330	219.6	305,995	219.2	303,591	218.7	300,489
1985	2	215.4	291,120	218.7	300,217	218.1	296,739	217.4	292,158
1985	3	219.3	316,010	219.4	305,166	218.7	300,396	219.3	304,321
1985	4	223.7	345,630	221.3	317,089	220.3	310,979	222.1	322,405
1985	5	219.9	320,000	217.1	290,196	216.1	284,116	217.9	295,161
1985	6	216.6	298,980	213.1	265,769	212.1	259,726	215.0	276,908
1985	7	212.4	273,030	208.7	239,961	207.2	231,369	212.2	259,959
1985	8	209.1	253,530	206.8	229,211	204.4	215,965	211.2	253,986
1985	9	207.8	246,120	206.6	228,122	203.9	213,270	211.9	258,124
1985	10	209.7	256,900	211.0	252,941	208.5	238,537	217.4	291,876
1985	11	211.5	267,630	211.5	256,231	209.1	242,348	218.9	301,649
1985	12	214.4	285,470	211.9	258,512	209.7	245,251	220.3	310,623
1986	1	217.4	303,810	215.0	277,294	213.0	264,671	222.3	324,072
1986	2	232.8	410,780	205.5	222,117	205.5	222,117	207.1	230,517
1986	3	222.2	335,470	212.0	258,883	212.0	258,883	212.0	258,883
1986	4	216.6	299,110	223.8	333,652	223.6	332,569	223.3	330,408
1986	5	226.0	361,500	232.3	393,633	232.3	393,633	232.3	393,633
1986	6	233.0	411,750	234.3	408,446	234.4	408,820	234.4	408,907
1986	7	230.0	390,010	227.6	359,650	227.7	360,335	227.6	360,172
1986	8	225.6	358,920	220.7	313,027	220.8	314,037	220.8	313,740
1986	9	222.3	336,420	215.2	278,240	215.4	279,615	215.4	279,743
1986	10	219.4	317,050	218.4	298,353	218.4	298,353	218.4	298,353

HISTORICAL				MODELED BASELINE CASE		MODELED PERMIT 10478 TIME EXTENSION PROJECT		MODELED CUMULATIVE	
Year	Month	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)
1986	11	216.3	297,270	217.5	292,660	217.3	291,418	217.0	289,874
1986	12	212.8	275,690	215.8	282,189	215.4	279,731	214.9	276,559
1987	1	209.6	256,430	213.2	265,903	212.6	262,349	213.4	267,090
1987	2	208.7	251,160	210.4	249,728	209.8	246,168	211.0	253,349
1987	3	207.6	245,150	208.4	238,143	207.4	232,401	209.3	243,107
1987	4	204.9	229,940	206.3	226,108	205.0	219,144	206.5	227,730
1987	5	200.9	208,320	203.0	208,671	201.7	201,751	203.3	209,958
1987	6	196.1	184,200	198.9	187,735	197.5	180,873	199.1	188,688
1987	7	190.7	159,280	195.7	172,247	193.2	160,690	194.2	165,227
1987	8	185.2	136,000	196.0	173,562	193.1	160,450	192.6	157,911
1987	9	180.6	117,940	197.1	178,946	194.0	164,460	193.0	159,711
1987	10	178.1	109,080	200.5	195,773	197.3	180,019	196.0	173,621
1987	11	176.7	104,210	198.1	183,511	194.5	166,647	193.0	159,989
1987	12	175.3	99,430	195.8	172,811	191.9	154,813	190.2	147,465
1988	1	178.0	108,520	193.8	163,283	189.4	144,330	189.6	144,932
1988	2	178.5	110,440	190.9	150,635	186.4	131,708	186.5	132,308
1988	3	175.3	99,400	187.5	136,199	182.6	117,323	182.8	117,922
1988	4	171.9	88,330	184.1	122,742	178.8	103,886	178.9	104,213
1988	5	167.8	76,260	184.4	123,817	180.2	108,658	180.2	108,623
1988	6	160.4	57,960	183.6	120,910	180.4	109,448	180.3	109,054
1988	7	149.2	37,670	183.3	119,746	181.2	111,977	181.0	111,254
1988	8	138.2	22,670	183.6	120,992	182.5	116,854	182.2	115,807
1988	9	125.7	9,630	185.1	126,560	184.9	125,986	184.6	124,757
1988	10	126.1	9,980	185.8	129,436	188.0	138,169	187.6	136,876
1988	11	126.0	9,860	182.5	116,704	186.1	130,793	185.8	129,500
1988	12	125.8	9,650	178.7	103,611	184.2	123,256	183.9	121,961
1989	1	125.6	9,470	174.6	90,382	182.1	115,535	181.8	114,242
1989	2	125.3	9,220	170.5	78,464	180.2	108,634	179.8	107,339
1989	3	138.4	23,000	165.8	66,772	178.5	102,679	178.1	101,378

HISTORICAL				MODELED BASELINE CASE		MODELED PERMIT 10478 TIME EXTENSION PROJECT		MODELED CUMULATIVE	
Year	Month	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)
1989	4	169.4	80,710	173.5	87,077	173.1	85,786	182.6	117,159
1989	5	184.8	134,270	184.9	125,873	184.4	124,123	192.0	155,469
1989	6	191.3	161,950	186.7	132,982	185.8	129,302	195.6	171,845
1989	7	188.2	148,480	186.9	133,779	186.3	131,252	192.5	157,395
1989	8	187.6	145,820	187.9	137,868	187.6	136,477	188.8	141,440
1989	9	186.9	142,890	190.8	150,120	190.7	149,843	187.8	137,390
1989	10	188.9	151,430	193.8	163,658	194.0	164,490	191.1	151,650
1989	11	190.9	160,340	190.7	149,871	190.9	150,701	190.9	150,464
1989	12	194.1	174,720	187.3	135,499	187.5	136,326	189.9	146,167
1990	1	197.2	189,860	184.9	125,991	184.3	123,497	191.2	152,019
1990	2	196.6	186,770	182.4	116,310	181.3	112,447	190.5	148,662
1990	3	199.3	200,340	183.6	120,867	179.9	107,573	191.0	150,916
1990	4	197.3	190,060	180.8	110,739	176.6	96,497	187.7	137,270
1990	5	196.7	187,160	181.0	111,406	177.9	100,919	182.4	116,372
1990	6	196.4	185,650	182.1	115,428	180.2	108,730	180.6	110,038
1990	7	195.0	178,970	182.7	117,428	181.9	114,488	179.1	104,925
1990	8	193.7	172,760	184.0	122,514	184.2	123,271	178.7	103,341
1990	9	193.7	172,850	186.8	133,279	187.9	137,688	180.3	109,035
1990	10	193.1	170,070	188.9	141,865	190.7	149,912	188.8	141,584
1990	11	190.1	156,500	185.4	127,888	187.4	135,907	185.3	127,608
1990	12	188.6	149,970	181.8	114,105	183.9	122,107	181.7	113,826
1991	1	187.2	144,140	177.9	100,681	180.2	108,665	177.8	100,403
1991	2	186.1	139,630	174.2	89,131	176.8	97,117	174.1	88,852
1991	3	186.1	139,750	171.5	81,279	174.3	89,431	171.4	80,995
1991	4	183.9	130,610	164.3	63,269	167.7	71,365	164.1	62,716
1991	5	179.9	115,460	167.3	70,413	167.9	71,788	167.0	69,591
1991	6	180.1	116,230	171.6	81,590	169.7	76,328	171.2	80,501
1991	7	179.6	114,280	174.8	90,893	170.7	79,144	174.4	89,573
1991	8	179.1	112,530	178.7	103,373	172.9	85,234	178.2	101,822

HISTORICAL				MODELED BASELINE CASE		MODELED PERMIT 10478 TIME EXTENSION PROJECT		MODELED CUMULATIVE	
Year	Month	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)
1991	9	179.4	113,730	183.6	120,960	176.6	96,440	183.2	119,316
1991	10	181.4	121,130	189.1	143,097	181.2	112,016	188.8	141,467
1991	11	177.6	107,100	187.2	135,047	178.9	104,111	186.8	133,423
1991	12	180.8	118,910	185.3	127,367	176.6	96,458	184.9	125,745
1992	1	180.0	116,010	183.3	119,701	174.1	88,795	182.8	118,079
1992	2	182.6	125,680	182.3	116,056	172.8	84,869	181.8	114,421
1992	3	188.0	147,460	184.1	122,915	173.6	87,438	182.3	116,012
1992	4	185.0	135,120	179.6	106,446	169.0	74,725	178.5	102,707
1992	5	180.1	116,160	177.6	99,869	169.3	75,363	177.4	99,138
1992	6	180.0	115,710	176.8	97,293	168.1	72,176	177.5	99,536
1992	7	179.9	115,640	175.5	93,058	166.1	67,503	177.1	98,238
1992	8	179.0	112,390	175.2	92,233	165.6	66,251	177.8	100,299
1992	9	179.3	113,220	176.7	96,888	167.4	70,649	180.0	107,975
1992	10	179.4	113,510	179.2	105,236	170.4	78,254	183.2	119,507
1992	11	175.8	100,920	176.8	97,151	167.3	70,348	181.0	111,341
1992	12	172.5	90,150	174.7	90,500	164.4	63,432	179.1	104,812
1993	1	184.7	133,910	175.3	92,394	164.1	62,749	179.1	104,740
1993	2	198.1	194,030	188.1	138,700	179.7	106,913	189.0	142,369
1993	3	208.6	250,870	201.0	198,459	194.5	166,580	201.8	202,137
1993	4	213.4	279,210	210.6	250,588	204.4	216,172	210.3	249,170
1993	5	224.2	349,260	223.1	328,996	218.9	301,449	223.0	328,665
1993	6	232.1	405,440	233.2	400,181	230.7	382,044	233.3	400,409
1993	7	226.8	354,160	226.3	350,621	224.6	339,050	226.4	351,428
1993	8	222.9	328,040	222.5	325,175	221.7	320,161	222.7	326,672
1993	9	221.3	317,500	217.6	293,595	217.9	295,051	218.1	296,348
1993	10	219.6	306,350	221.3	317,431	221.3	317,431	221.3	317,431
1993	11	218.5	299,210	219.7	306,912	219.5	305,669	219.3	304,123
1993	12	217.3	291,580	218.3	298,012	218.0	295,551	217.4	292,374
1994	1	215.3	278,840	215.3	279,234	214.9	276,771	214.4	273,592

HISTORICAL				MODELED BASELINE CASE		MODELED PERMIT 10478 TIME EXTENSION PROJECT		MODELED CUMULATIVE	
Year	Month	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)
1994	2	213.9	270,560	212.8	263,517	212.4	261,048	211.8	257,861
1994	3	211.8	257,950	209.3	242,952	208.8	240,488	208.3	237,309
1994	4	208.6	239,150	206.9	229,654	206.5	227,195	205.8	223,750
1994	5	204.8	218,240	203.9	213,593	203.5	211,147	202.8	207,395
1994	6	203.0	208,660	200.0	192,918	199.5	190,453	198.6	186,408
1994	7	201.8	202,410	197.3	179,954	194.9	168,307	193.9	163,768
1994	8	198.8	186,940	196.8	177,696	194.0	164,487	189.7	145,521
1994	9	199.1	188,880	198.9	187,679	195.9	173,085	191.7	154,052
1994	10	200.0	193,230	205.5	222,041	202.5	206,179	198.8	187,173
1994	11	200.2	193,980	203.5	211,465	200.3	194,448	196.1	174,288
1994	12	202.4	205,520	205.0	219,542	201.6	201,374	197.2	179,554
1995	1	210.0	247,060	216.4	285,482	213.2	265,951	209.3	243,195
1995	2	209.8	245,900	218.6	299,526	218.7	300,599	217.3	291,280
1995	3	221.4	317,900	218.8	300,963	218.8	300,963	218.8	300,963
1995	4	214.8	275,700	215.2	278,625	215.2	278,625	215.2	278,625
1995	5	220.0	308,680	205.6	222,721	205.6	222,721	205.6	222,721
1995	6	227.7	360,840	228.4	365,440	228.4	365,440	228.4	365,440
1995	7	230.6	381,230	234.1	406,740	234.2	407,184	234.2	407,461
1995	8	229.0	369,690	223.0	328,699	223.2	329,597	223.3	330,203
1995	9	220.7	312,980	212.8	263,797	213.1	265,253	213.3	266,550
1995	10	214.2	272,210	218.9	301,613	218.9	301,613	218.9	301,613
1995	11	214.1	271,840	217.7	293,725	217.5	292,483	217.2	290,939
1995	12	213.4	267,110	217.4	292,055	217.0	289,591	216.5	286,410
1996	1	217.0	289,690	218.7	300,388	218.1	296,727	217.4	291,887
1996	2	215.1	277,910	208.0	235,760	208.2	236,873	208.4	238,177
1996	3	206.2	225,750	214.0	270,958	214.0	270,958	214.0	270,958
1996	4	210.0	247,460	223.9	334,610	223.7	333,447	223.5	331,969
1996	5	230.0	376,860	233.8	404,380	233.8	404,380	233.8	404,380
1996	6	232.8	396,810	234.3	407,945	234.3	408,315	234.3	408,443

HISTORICAL				MODELED BASELINE CASE		MODELED PERMIT 10478 TIME EXTENSION PROJECT		MODELED CUMULATIVE	
Year	Month	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)
1996	7	224.1	335,770	229.0	369,770	229.1	370,446	229.1	370,378
1996	8	219.1	303,060	224.6	339,399	224.8	340,399	224.7	340,199
1996	9	216.3	285,050	220.5	311,718	220.7	313,173	220.7	313,220
1996	10	219.0	302,540	221.2	316,344	221.2	316,344	221.2	316,344
1996	11	221.2	316,840	220.6	312,661	220.6	312,661	220.6	312,661
1996	12	219.9	307,970	211.4	255,442	211.4	255,442	211.4	255,442
1997	1	227.6	359,720	210.7	251,267	210.5	250,264	210.3	248,874
1997	2	209.6	244,750	204.6	217,148	204.6	217,148	204.6	217,148
1997	3	207.0	230,280	212.0	258,883	212.0	258,883	212.0	258,883
1997	4	211.4	255,470	218.4	298,704	218.3	297,507	218.0	295,985
1997	5	220.9	314,810	228.6	367,083	228.6	366,589	228.8	368,168
1997	6	222.1	322,720	228.6	367,017	228.6	367,013	228.8	368,329
1997	7	219.4	305,120	224.4	337,674	224.4	338,099	224.5	338,815
1997	8	218.4	298,700	221.7	320,090	221.9	320,964	221.9	321,149
1997	9	217.5	292,840	220.0	308,562	220.2	309,872	220.3	310,913
1997	10	220.8	313,960	223.5	331,920	223.5	331,920	223.5	331,920
1997	11	222.4	324,510	222.3	324,072	222.3	324,072	222.3	324,072
1997	12	219.8	307,190	220.2	309,975	220.0	308,758	219.8	307,127
1998	1	222.0	321,590	222.3	324,072	222.3	324,072	222.3	324,072
1998	2	218.3	297,930	216.6	287,137	216.6	287,137	216.6	287,137
1998	3	208.6	239,210	220.5	312,192	220.5	312,192	220.5	312,192
1998	4	211.4	255,640	219.9	308,268	219.9	308,268	219.9	308,268
1998	5	216.8	288,050	212.9	264,317	212.9	264,317	212.9	264,317
1998	6	233.6	402,690	232.4	393,996	232.4	394,364	232.4	394,493
1998	7	223.7	333,070	233.0	398,362	233.1	399,033	233.1	399,380
1998	8	211.3	254,940	224.4	338,083	224.6	339,079	224.7	339,708
1998	9	213.0	265,180	215.8	281,985	216.0	283,440	216.2	284,737
1998	10	217.5	292,840	220.1	309,643	220.1	309,643	220.1	309,643
1998	11	218.7	300,490	220.2	309,857	220.0	308,613	219.7	307,067

HISTORICAL				MODELED BASELINE CASE		MODELED PERMIT 10478 TIME EXTENSION PROJECT		MODELED CUMULATIVE	
Year	Month	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)
1998	12	218.8	300,740	220.7	313,045	220.3	310,584	219.8	307,408
1999	1	221.5	318,420	222.3	324,072	222.3	324,072	222.3	324,072
1999	2	216.2	284,300	216.6	286,896	216.6	286,896	216.6	286,896
1999	3	215.6	281,070	219.9	307,966	219.9	308,083	220.1	309,107
1999	4	216.1	283,800	224.9	341,185	224.9	341,264	225.0	342,014
1999	5	217.2	290,570	227.6	360,153	227.6	359,590	227.4	358,575
1999	6	225.2	343,100	234.3	407,881	234.3	407,820	234.2	407,173
1999	7	222.4	324,510	229.5	373,382	229.6	373,761	229.5	373,577
1999	8	218.8	301,260	223.5	331,615	223.6	332,462	223.6	332,402
1999	9	217.5	292,590	218.3	297,537	218.5	298,993	218.7	300,289
1999	10	220.5	312,130	221.1	316,042	221.1	316,042	221.1	316,042
1999	11	221.4	317,900	220.7	312,974	220.5	311,730	220.2	310,184
1999	12	220.7	313,430	218.9	301,859	218.6	299,401	218.1	296,229
2000	1	220.1	309,520	220.9	314,855	220.4	311,197	219.6	306,362
2000	2	219.0	302,290	221.6	319,326	221.8	320,402	222.0	321,708
2000	3	215.6	280,820	224.8	340,630	225.1	342,990	225.2	343,204
2000	4	217.3	291,580	225.7	347,058	225.5	345,701	225.3	344,004
2000	5	224.9	341,190	229.1	370,458	228.9	369,236	228.8	368,221
2000	6	226.4	351,330	229.2	371,086	229.4	372,768	229.3	372,122
2000	7	222.4	324,510	225.7	347,095	226.0	348,617	225.9	348,433
2000	8	220.1	309,260	222.4	324,784	222.7	326,184	222.7	326,538
2000	9	218.4	298,700	219.8	307,485	220.0	308,937	220.2	309,816
2000	10	221.2	316,580	222.7	326,305	222.7	326,305	222.7	326,305
2000	11	221.1	315,790	221.4	318,096	221.2	316,853	221.0	315,309
2000	12	220.8	314,220	219.8	307,563	219.4	305,106	218.9	301,934
2001	1	218.1	296,400	216.8	288,458	216.4	285,998	215.9	282,822
2001	2	215.6	280,820	214.2	272,450	213.8	269,985	213.3	266,802
2001	3	213.6	268,320	213.4	267,061	212.4	261,048	211.1	253,890
2001	4	213.9	270,260	215.6	281,112	214.5	273,755	213.0	264,796

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Year	Month	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)
2001	5	212.3	260,860	213.1	265,715	211.6	256,719	210.1	247,495
2001	6	207.9	235,140	210.9	252,306	209.0	241,551	207.5	233,050
2001	7	205.4	221,430	209.2	242,760	207.0	230,152	205.9	224,007
2001	8	203.0	208,400	208.5	238,425	205.9	224,015	205.2	220,424
2001	9	200.2	194,180	208.7	239,782	205.8	223,777	205.3	220,719
2001	10	202.2	204,640	212.9	264,297	209.9	246,908	209.1	242,157
2001	11	199.7	191,770	211.7	256,945	208.4	238,325	207.3	232,033
2001	12	201.8	202,560	213.2	265,864	209.8	245,947	208.8	240,227
2002	1	208.6	239,440	215.5	280,032	212.0	258,921	210.7	251,551
2002	2	207.6	233,800	215.2	278,377	211.5	256,173	210.0	247,491
2002	3	214.1	271,720	219.2	303,653	215.5	280,138	215.5	279,956
2002	4	218.0	295,890	220.7	313,430	217.3	291,593	218.5	298,927
2002	5	215.6	280,820	217.8	294,371	214.0	270,938	216.4	285,698
2002	6	216.4	286,050	216.8	288,129	212.7	263,020	216.2	284,603
2002	7	212.8	263,970	213.2	265,921	208.6	239,080	213.4	267,274
2002	8	210.0	247,460	210.4	249,748	205.4	221,236	211.5	256,050
2002	9	208.3	237,620	209.1	242,310	203.7	212,312	211.2	253,951
2002	10	210.5	250,020	212.4	261,209	207.3	231,754	215.1	277,561
2002	11	210.3	248,850	211.9	258,218	206.8	229,354	214.1	271,758
2002	12	212.6	262,300	212.9	264,512	208.1	236,174	214.7	275,243
2003	1	215.9	282,800	215.3	279,244	210.7	251,593	216.6	287,129
2003	2	219.5	305,630	216.8	288,094	212.4	261,039	217.6	293,602
2003	3	219.2	303,830	217.1	290,506	212.8	264,032	217.7	293,703
2003	4	220.5	312,130	219.0	302,498	214.6	274,634	219.1	302,641
2003	5	227.2	356,870	220.9	314,781	218.5	298,974	221.1	316,103
2003	6	230.0	376,860	227.6	359,993	225.3	344,030	227.8	361,154
2003	7	222.4	324,250	222.9	327,887	221.4	317,854	223.1	328,895
2003	8	216.6	287,050	219.1	303,178	218.5	298,955	219.3	304,149
2003	9	215.3	278,840	217.2	290,821	217.4	292,276	217.6	293,107

HISTORICAL				MODELED BASELINE CASE		MODELED PERMIT 10478 TIME EXTENSION PROJECT		MODELED CUMULATIVE	
Year	Month	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)
2003	10	217.0	289,310	219.9	308,073	219.9	308,073	219.9	308,073
2003	11	215.8	282,310	218.1	296,536	217.9	295,293	217.7	293,749
2003	12	216.9	288,810	219.2	303,517	218.8	301,050	218.3	297,866
2004	1	220.2	310,040	220.5	311,957	219.9	308,301	219.2	303,469
2004	2	221.2	316,840	222.3	324,072	222.0	321,919	221.1	315,764
2004	3	226.3	350,780	225.2	343,204	225.2	343,204	225.2	343,204
2004	4	227.2	357,420	224.8	340,483	224.6	339,127	224.3	337,431
2004	5	219.9	307,970	220.5	312,179	220.3	310,829	220.0	308,816
2004	6	216.1	283,740	217.1	290,096	216.3	285,257	215.8	282,326
2004	7	213.0	264,700	213.6	268,538	212.5	261,783	211.0	253,142
2004	8	210.6	250,720	211.5	255,923	210.0	247,308	208.1	236,146
2004	9	209.2	242,630	210.4	249,599	208.6	239,348	206.3	226,144
2004	10	210.6	250,720	211.9	258,280	209.9	246,585	207.6	233,718
2004	11	209.4	243,550	211.0	252,985	208.7	240,063	206.8	229,113
2004	12	211.2	254,230	212.2	260,001	209.8	245,829	207.9	235,068
2005	1	219.8	307,450	220.4	311,017	218.0	295,603	216.3	284,996
2005	2	224.2	336,580	222.3	324,072	222.3	324,072	222.2	323,491
2005	3	229.3	371,740	220.7	313,112	220.9	314,397	221.0	315,422
2005	4	229.4	372,590	227.5	359,221	227.5	359,221	227.5	359,221
2005	5	232.8	397,400	230.4	379,446	230.4	379,446	230.4	379,446
2005	6	234.1	406,540	235.5	417,148	235.5	417,148	235.5	417,148
2005	7	228.7	367,790	231.2	385,556	231.3	385,999	231.3	386,273
2005	8	222.8	327,180	225.0	341,853	225.1	342,748	225.2	343,350
2005	9	217.8	294,870	219.2	303,770	219.5	305,225	219.7	306,522
2005	10	220.2	310,040	221.7	320,147	221.7	320,147	221.7	320,147
2005	11	219.5	305,380	220.7	312,988	220.5	311,745	220.2	310,201
2005	12	223.4	331,460	217.0	289,457	217.2	290,677	217.4	292,312
2006	1	213.0	264,940	207.6	233,701	208.1	236,114	208.6	239,403
2006	2	213.0	265,180	206.4	226,744	207.0	230,231	207.8	234,824

HISTORICAL				MODELED BASELINE CASE		MODELED PERMIT 10478 TIME EXTENSION PROJECT		MODELED CUMULATIVE	
Year	Month	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)
2006	3	224.7	340,100	214.5	274,339	214.5	274,339	214.5	274,339
2006	4	227.0	355,480	220.0	308,449	220.0	308,449	220.0	308,449
2006	5	230.5	380,580	229.7	374,858	229.7	374,858	229.7	374,858
2006	6	232.5	394,760	235.5	417,148	235.5	417,148	235.5	417,148
2006	7	227.0	356,040	231.5	387,276	231.5	387,704	231.5	387,963
2006	8	224.7	340,100	226.5	352,532	226.7	353,409	226.7	353,993
2006	9	219.3	304,340	220.2	309,731	220.4	311,186	220.5	312,067
2006	10	220.7	313,430	222.9	328,056	222.9	328,056	222.9	328,056
2006	11	220.5	311,870	222.1	322,215	221.9	320,972	221.6	319,428
2006	12	222.1	322,390	222.3	324,072	222.1	322,601	221.6	319,423
2007	1	221.6	318,950	220.5	311,837	220.1	309,180	219.3	304,358
2007	2	219.8	307,450	220.1	309,448	219.5	305,707	218.6	299,564
2007	3	219.5	305,380	221.0	314,994	220.2	309,975	219.1	302,817
2007	4	216.8	288,560	219.5	305,490	218.5	299,123	217.0	289,748
2007	5	213.3	266,870	215.7	281,636	214.4	273,618	212.8	263,558
2007	6	210.9	252,350	212.9	264,139	211.2	254,352	209.6	245,018
2007	7	207.0	230,450	210.8	251,808	208.8	240,156	207.5	233,186
2007	8	205.0	219,480	209.8	246,192	207.4	232,730	206.7	228,320
2007	9	204.0	213,630	210.3	248,791	207.6	233,731	206.9	229,860
2007	10	204.0	213,950	213.7	269,430	211.0	252,978	210.0	247,415
2007	11	203.6	211,560	213.7	269,087	210.7	251,431	210.0	247,244
2007	12	201.2	199,270	213.0	265,088	209.8	246,187	208.8	240,529
2008	1	201.5	200,860	214.0	270,869	210.6	250,761	209.3	243,435
2008	2	202.7	206,880	213.8	270,004	210.3	248,831	208.8	240,204
2008	3	203.5	210,980	215.3	278,774	211.6	256,440	209.9	246,823
2008	4	201.4	200,140	213.3	266,836	209.3	243,308	207.3	231,630
2008	5	196.5	175,890	210.2	248,586	205.8	223,653	203.3	210,235
2008	6	193.7	162,910	209.0	241,458	204.2	215,043	201.1	198,876
2008	7	190.9	150,660	206.8	229,132	201.6	201,189	197.8	182,348

HISTORICAL				MODELED BASELINE CASE		MODELED PERMIT 10478 TIME EXTENSION PROJECT		MODELED CUMULATIVE	
Year	Month	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)	Camanche Reservoir Surface Elevation (ft)	Camanche Reservoir Storage (AF)
2008	8	190.9	150,490	206.4	226,878	200.8	197,452	196.6	176,746
2008	9	189.8	145,770	204.2	214,767	198.2	184,018	195.3	170,395
2008	10	189.6	145,000	207.9	235,182	202.0	203,211	201.3	199,543
2008	11	188.1	138,560	207.3	231,940	201.1	198,849	201.9	202,868
2008	12	187.7	137,200	205.9	223,893	199.3	189,654	200.8	197,205
2009	1	188.8	141,640	206.9	229,865	200.2	194,394	201.4	200,305
2009	2	192.3	156,580	207.8	234,516	200.9	197,851	201.8	202,478
2009	3	201.8	202,460	214.1	271,283	207.6	233,313	208.2	236,918
2009	4	207.0	230,340	217.1	290,330	210.7	251,112	211.0	253,011
2009	5	221.4	318,090	227.8	361,383	223.1	329,157	223.0	328,802
2009	6	223.3	330,250	226.1	349,387	222.5	325,050	222.1	322,233
2009	7	223.2	329,580	222.2	323,286	219.8	307,664	219.0	301,993
2009	8	223.2	329,580	219.1	303,240	217.8	294,318	216.4	285,895
2009	9	222.1	322,320	216.4	285,594	215.8	281,984	214.1	271,310
2009	10	217.0	289,310	218.9	301,794	218.9	301,349	217.2	290,658
2009	11	215.7	281,380	218.1	296,286	218.5	299,057	216.6	286,847
2009	12	215.2	278,470	220.2	309,802	220.4	311,020	220.6	312,652

Notes:

AF acre-feet
ft feet

Appendix I

**Native and Recreationally Important Fish Species
Occurring in the Lower Mokelumne River**

Appendix I

Native and Recreationally Important Fish Species Occurring in the Lower Mokelumne River

The following fish species descriptions are from the California Fish Website (<http://calfish.ucdavis.edu>), developed by the University of California Cooperative Extension at UC Davis, except where noted. All except American shad and striped bass are native species.

American shad (*Alosa sapidissima*) are an anadromous fish native to the Atlantic Coast. They only appear in freshwater during their first 2 years of life and when they return to spawn as adults. Their life at sea is poorly understood but their ability to return to their original spawning ground is known to be exceptional. In the fall, mature shad (3-4 years old for males and 4-5 years old for females) return to estuaries where their bodies transition to the fresh water environment. Runs up river to spawn begin with un-ripe males in March and April when water temperatures reach 14°C (57°F), and peak in late May and early June when the water is between 17°C (63°F) and 24°C (75°F). By the first week of July most spawning is complete. Spawning occurs in the main channels of the river where the flow is between 1,095 and 3,200 cfs, dissolved oxygen is greater than 5 mg/L, and the water depth is anywhere between 3 and 30 feet, but usually under 10 feet. Sand or gravel bottoms are preferred but a variety of substrates can be used. The reported water temperature range for American shad spawning is 16°C (60°F) to 24°C (75°F) (USFWS 1995). Embryos float with the current downstream before hatching 3-12 days later depending on water temperature. Shad will remain freshwater fish until they metamorphose out of their larval stage approximately 4 weeks after hatching. In the Sacramento River, juvenile American shad reportedly prefer water temperatures between 17°C (62.6°F) and 25°C (77°F) (Moyle 2002). Young American shads usually leave their rivers of birth sometime between September and November but if it is a particularly wet year and overflows are high they may leave as early as June. In the Sacramento-San Joaquin river system, American shad emigration starts in late June and extends to November (Painter et al. 1979). Some stay in estuaries for 1-2 years before heading to open waters but the majority of American shad head directly to the sea. American shad are found in the Mokelumne River downstream of Woodbridge Dam to the Delta primarily from May through November.

Delta smelt (*Hypomesus transpacificus*) are endemic to the upper San Francisco estuary, principally the Delta and Suisun Bay. This near-annual fish (most live only one year) was once abundant in the estuary (Moyle 2002). However, increased variability in climate, introduction of non-native species into the estuary, combined with other human-caused changes to the estuary, have resulted in the species being listed as threatened under both the federal ESA and state CESA. They live in water with salinities ranging from 0 to 18.4 ppt and can tolerate salinities up to 19.0 ppt. Suisun Bay, CA is usually the location of this mixing zone, though changes in streamflow can affect how far downstream these low salinity waters occur. Delta smelt can live in water temperatures ranging from 6°C to 28°C (43°-82°F) with lethal levels at 29°C (84°F), though their success seems to have little relation to water temperatures. Smelt are short burst swimmers that feed on plankton and therefore they are typically found in places with low water velocities where the water is cool and well oxygenated. Delta smelt grow quickly and the growth rate is largely food dependant. The most rapid growth occurs when they reach 30mm FL and are large enough to prey on a wider variety of food sources. In 7-9 months they reach lengths of 2.2-2.8 inches (standard length) with growth slowing in the several months that follow. A few smelt live a second year and reach lengths of 3.5-

4.7 inches. In spring smelt populations are dominated spawning adults, and by summer they have died and given rise to the next generation of juveniles. Spawning occurs in upstream spawning grounds from February to July, though fish begin moving up the delta as early as September or October. Delta smelt spawn mostly at night during low tide in freshwater sloughs and shallow edge waters. In the Sacramento River fish typically spawn above Rio Vista. Smelt have also been recorded spawning in different parts of Suisun Bay and the Napa River Estuary. The eggs hatch in 9-13 days at a water temperature of 15°-17°C (59°-62°F). The emergent larvae begin feeding on rotifers and minuscule prey in 4-5 days. The larvae have an oil sac that keeps them semi-buoyant till their swimbladders develop several weeks later. At that point they are capable of rising into the water column where they are washed downstream by the current into the mixing zone. Delta smelt are found in Delta year-round. Two delta smelt have been observed in the Mokelumne River between Frandy and Woodbridge Dam since 1990.

Green sturgeon (*Acipenser medirostris*) are an anadromous fish with limited distribution in California. Historically the Klamath and Sacramento River systems had the greatest spawning populations of these fish. Today the Klamath River and its tributaries are home to the largest remaining spawning populations. The Eel River and South Fork Trinity had spawning populations at one time, though they are seemingly non-existent now. The lower reaches of the San Joaquin may have also had spawners at one time. Green Sturgeon have been observed as visitors in the Mad River, Smith River, and Salmon River. The southern Distinct Population Segment (DPS) of green sturgeon, which includes the Sacramento-San Joaquin Delta, are listed as threatened under the federal ESA. Green Sturgeon are anadromous though they are considered the most marine of the sturgeon species and their life in freshwater may be relatively limited. Green sturgeon hatch in freshwater and may leave as yearlings or stay in a river for up to 3 years. Most juveniles migrate downstream during the summer and fall of their second year. The juvenile fish usually remain in the estuary for a period before dispersing into the Pacific. They grow at a rate of approximately 2.8 inches per year until they reach maturity which is typically at an age of 15-20 years. Green sturgeon spend 3-13 years in the ocean before returning to their natal streams. Males tend to spend less time at sea than females, and they mature earlier in life. Mature males do not become as large as mature females of the same age. Green sturgeon of the Klamath river begin moving upstream in late February to late July and spawning takes place between March and July. In the Klamath River, the water temperature tolerance of upmigrating adult green sturgeon reportedly probably ranges from 7°C to 16°C (44°F to 61°F) (USFWS 1995). Sturgeon spawning occurs above cobble in deep, fast water. Green sturgeon reportedly can spawn in water temperatures ranging from 8°C to 14°C (46°F to 57°F) (Moyle 2002, SWRI 2002). Most green sturgeon reportedly spawn between April and June (Beamesderfer and Webb 2002). Each female produces 60,000 to 140,000 eggs which presumably hatch after only 200 hours of incubation time. Green sturgeon are found in the lower Delta year-round, but have not been observed in the Lower Mokelumne River.

Hardhead (*Mylopharodon conocephalus*) are typically found in small to large streams in a low to mid-elevation environment. Hardhead may also inhabit lakes or reservoirs. Within a stream hardhead tend to prefer warmer temperatures than salmonids and they are often found associated with pikeminnows and suckers. Their preferred stream temperature might easily exceed 20°C (68°F), though these fish do not favor low dissolved oxygen levels. Under laboratory conditions, their reported optimum water temperature range is 24°C to 28°C (75°F to 82°F) (Moyle 2002). Therefore the hardhead minnow is usually found in clear deep streams with a slow but present flow. Most hardhead reach sexual maturity at 3 years and spawn in the spring around April and May, though spawning may take place as late as August. In small streams Hardhead tend to spawn near

their resident pools, while fish in larger rivers or lakes often move up to 20-50 miles to find suitable spawning grounds. Though spawning may occur in pools, runs, or riffles, the bedding area will typically be characterized by gravel and rocky substrate. Temperatures for hardhead spawning reportedly range from 15°C to 18°C (59°F to 64°F) (Wang 1986). Females usually produce 7,000-24,000 eggs per year, though some fisheries biologists believe that the eggs may take two years to develop within the female. Upon hatching, young larval hardhead remain under vegetative cover along stream or lake margins. As the juveniles grow they may move to deeper water or be swept downstream to larger rivers below. Water temperatures where juveniles and adults were observed in the Pit River ranged from 17°C to 20°C (62°F to 68°F) (Baltz et al. 1987). Adult hardhead may live up to 9 or 10 years. Hardhead are found in very limited numbers in the Mokelumne River downstream of Camanche Dam to the Delta year-round.

Hitch (*Lavinia exilicauda*) are most often found in slow warm water, including lakes and quiet stretches of rivers. Hitch are sometimes found in cool and clear, low-gradient streams, hiding among aquatic vegetation in sandy runs or pools. They are the most heat tolerant of the native Central Valley fishes and can withstand water temperatures greater than 30°C under some conditions. They have also been found living in brackish water with a salinities as high as 9 ppt. Juveniles typically live in shallow vegetated areas near shore, while the older fish (>80 days) live in deeper offshore waters. Young hitch may shoal for the first two months of residency in a lake. Growth rates in hitch vary depending upon the environmental conditions; though in general females reach sexual maturity in 2-3 years, while males may reach sexual maturity in years 1-3. Spawning typically happens in the tributaries to lakes and rivers, and may begin as early as February and end as late as July. Optimal water temperatures for hitch spawning reportedly range from 14°C to 18°C (57°F to 64°F) (Moyle 2002). Most hitch spawning reportedly takes place between March and June (Wang 1986). The reported preferred water temperature for hitch egg incubation ranges from 15°C to 22°C (59°F to 72°F) (Moyle 2002). Fecundity in hitch is relatively high as one female may produce 3,000 to 63,000 eggs, depending upon body size. When spawning adults reach a suitable riffle for breeding one female may be surrounded by 1-5 males. A ripe female releases her eggs into the current and the males immediately fertilize the eggs. The eggs then settle into the gravel substrate where the size of the ova will increase and help lodge it into the rock particles. In 3-7 days the embryos hatch, and 3-4 days after the hatch the embryos begin to swim freely. The young hitch may swim downstream to a lake or slough, or reside within the stream under the cover of aquatic plants. The preferred water temperature for rearing hitch reportedly ranges from 27°C to 29°C (81°F to 84°F) (Moyle 2002). Hitch are found in the Mokelumne River downstream of Camanche Dam to the Delta year-round.

Longfin smelt (*Spirinchus thaleichthys*) in California are primarily an anadromous estuarine species that can tolerate salinities ranging from freshwater to nearly pure seawater. The California Fish and Game Commission made a finding in 2009 that the petitioned action to list the longfin smelt as threatened is warranted. This determination still needs to be finalized by the Office of Administrative Law. Most longfin smelt occupy the middle or bottom of a water column and tend to favor temperatures in the range of 16°-18°C (61°-64°F) and salinities ranging from 15-30 ppt. Their spatial distribution within a bay or estuary is seasonally variable. Generally speaking longfin smelt are found closer to the ocean during summer whereas they move upstream in cool seasons. They can survive summer temperatures up to 20°C (68°F). Longfin smelt may also make daily migrations; remaining deep during the day and rising to the surface at night. Longfin smelt move into freshwater to spawn, with the peak breeding season occurring between February and April. Spawning in the San Francisco Bay-Delta Estuary takes place in fresh or slightly brackish water over

sandy or gravel substrates and at temperatures ranging from 7° to 14.5°C (45° -58° F) (Bay Institute, et. al. 2007). Older and larger fish tend to spawn in the later stages of the spawning season. Males are first to move into areas with gravel or sandy substrate where rocks and aquatic plants are present. Smelt typically die after spawning though a few females may survive another year. The eggs hatch in around 40 days and the larvae are washed downstream into the estuary. In the San Francisco estuary high stream flows seem to lead to higher resulting populations of smelt. Larvae are mobile and move according to salinity preferences. In 30-60 days the larvae morph into juvenile fish. According to Baxter (1999), the mean temperature at which age-0 longfin smelt were found ranged from 16° to 18°C (61°-68°F) in late spring, summer and fall, to about 11.5°C (53°F) in winter. Longfin smelt are found in the lower Delta year-round, but have not been observed in the Lower Mokelumne River.

Pacific lampreys (*Lampetra tridentata*) are usually anadromous with two very distinct parts of their life cycle, though some landlocked forms of lamprey exist. Pacific lampreys begin their life cycle as an ammocoete or larvae, usually within a freshwater stream. The larval lampreys often move around the stream in their 5-7 year stay in freshwater. When the ammocoetes reach a length of around 5.5-6.3 inches (total length) they begin a drastic change in physiology and physical appearance. The larval lampreys take on a silvery form with large eyes and a sucking disc. The newly morphed lampreys swim downstream to the Pacific Ocean where they take on a new predatory lifestyle in an estuarine or saltwater environment. Lampreys rarely stray far from the mouth of their home stream. Pacific lampreys attack and feed on fish including salmon and flatfish. The stay at sea usually lasts 3-4 years in Canada but may be shortened in more southern populations. Like salmon, the lampreys return to freshwater and migrate upstream to spawn and die. The upstream migration of adult Pacific lamprey reportedly takes place from May through June (Moyle 2002). Reported water temperature extremes in which migrating adult Pacific lamprey can survive range from 6°C to 16°C (42°F to 60°F), as observed under laboratory conditions (Close 2001). Most upstream movement occurs during the night under high flow conditions, and some streams have different runs of lampreys. Runs may be different in the timing of entry to freshwater or in the amount of time spent in freshwater before breeding occurs. In Oregon, Pacific lamprey spawning reportedly occurs in May through July, when water temperatures reach 10°C to 15°C (50°F to 59°F) (Close et al. 2002). Breeding males and females dig a nest in moderately swift water by removing rock and gravel from the stream floor. Usually the male and female then die, though studies have shown that some adult lampreys live to spawn again the following year. The embryos hatch after roughly 19 days, and the resulting ammocoetes often stay within the safety of the gravel substrate before venturing into the current. The water temperature range for juvenile growth of Pacific lamprey is 10°C to 18°C (50°F to 64.4°F), as observed in laboratory conditions (Meeuwig et al. 2002). Pacific lamprey emigration peaks during winter and spring (Moyle 2002). Pacific lamprey are found in the Mokelumne River downstream of Camanche Dam to the Delta year-round

The **prickly sculpin** (*Cottus asper*) is adaptable to environments ranging from fresh to saltwater, and from small cool stream to large warm rivers and lakes. The Prickly sculpin has a variety of forms as some are coastal, others live in the valley, and some are limited to Clear Lake proper. In the Central Valley of California these fish inhabit low elevation waters. The limitation to the spread of these fish seems to be water quality, as the Prickly sculpin is not found in highly polluted waters. In stream these fish use a variety of habitats though good cover or overhanging vegetation is a common thread. The Prickly sculpin spend most of the day sedentarily hiding and they then become active in feeding and movement at night. When the Prickly sculpin reach sexual maturity after 2, 3, or 4 years they move to a suitable place in freshwater to spawn and hide the eggs under loose rock

substrate. Most spawning occurs between February and June. The male will guard the fertilized eggs until they hatch. When the larvae emerge they are quickly washed downstream to an estuary or deep slow pool. In lakes and in estuaries the larvae become pelagic. As the larvae develop into juvenile fish they begin to move to area of prosperous feeding, often times moving upstream a considerable distance. In many cases the movement of fish an especially young Prickly sculpin is limited by man-made barriers or diversions. After hatching, larvae swim up into the water column, eventually transform into juveniles, which settle onto the bottom and move into areas with plenty of food and cover (Moyle 2002). In lowland rivers they may experience summer temperatures of 28-30°C (82° -86° F) (Moyle 2002). Prickly sculpin are found in the Mokelumne River downstream of Camanche Dam to the Delta year-round.

Sacramento blackfish (*Orthodon microlepidotus*) are native to the Sacramento and San Joaquin drainages as well as to Clear Lake. These fish however are found in other various streams and reservoirs in California, and have extended into parts of Nevada. Sacramento blackfish prefer warm turbid waters in small to large streams, and often share habitat with an array of non-natives. Sacramento blackfish prefer water temperatures in the range of 22°-28°C (72°-82°F). They have shown a great ability to adapt to extreme environments including water temperatures exceeding 30°C (86°F) and salinities in excess of 9 ppt. Sacramento Blackfish may become sexually mature in their first, second, third, or fourth years, depending upon their growth rate. Males tend to reach sexual maturity before the females, and the production of eggs in females seems to be directly related to body size. Spawning generally occurs in spring but may happen anytime between March and July when water temperature are in the range of 12°-24°C (54°-75°F). Spawning beds are usually found in areas of thick vegetation and shallow water. The eggs will cling to the local substrate till the larvae emerge and begin foraging in the same region. Sacramento blackfish are found in the Mokelumne River primarily below Woodbridge Dam downstream to the Delta year-round.

Sacramento pikeminnows (*Ptychocheilus grandis*), formerly known as “squawfish”, are typically found in clear low to mid-elevation streams and rivers. Pikeminnows favor streams with deep pools and slow runs that have cover in the form of undercut banks or aquatic vegetation. While pikeminnows are often found in association with native fishes in slightly disturbed streams, they are rarely found in highly polluted rivers or sharing habitat with centrarchids in lakes. They are found where water temperatures are usually in the range of 18°-28°C (64°-82°F), though they are capable of withstanding extremes up to 38°C (100°F) and salinities as high as 8 ppt. Pikeminnows grow most rapidly in the first five years of life, especially in the summer months. At age 3-4 Sacramento pikeminnows become sexually mature and begin spawning in April –May. Ideal spawning grounds are riffles and pool tails with gravel substrate. Residents of small streams might only move to a nearby riffle whereas residents of lakes and large rivers usually move up into a small tributary stream. Male pikeminnows arrive at spawning grounds before female fish when water temperatures reach a range of 15°-20°C (59°-68°F). Spawning may occur annually or less frequently when adverse conditions exist. The eggs hatch in a week or less (4-7 days) under favorable conditions. Young fish gradually spread out into small schools and move into deeper water with time, often occupying protected riffles and fast water. Juvenile Sacramento pikeminnows in Eel River tributaries were sampled at maximum weekly average water temperatures of 18°C–25°C (64°F–76°F) (Harvey et al. 2002). Sacramento pikeminnows are found in the Mokelumne River downstream of Camanche Dam to the Delta year-round.

Sacramento splittail (*Pogonichthys macrolepidotus*) are hearty minnows that live in fluctuating environments and can tolerate relatively high salinities and low oxygen levels (< 1.0 mg/L). Typically they are found in estuarine environments and are commonly found in water with salinities from 10-18 ppt. They prefer slightly lower salinities but can survive short term exposures to water with a salinity as high as 29 ppt. Splittail are usually found where water temperatures range from 5-24°C (41°-75°F), though under laboratory conditions they have shown an ability to survive short exposures to temperatures as high as 33°C (91°F). These adaptations make splittail well suited for slow moving rivers, sloughs, and alkaline lakes. Sacramento splittail live relatively long lives of up to 5-7 years, possibly longer. Females live longer than males and reach greater total lengths. Splittail typically reach sexual maturity by the end of their second year (around 6.7 inches standard length). Males may mature in their first year (4.3 inches standard length) while females may not mature until their third (8.5 inches standard length). After their third year splittail grow an average of 1.4 inches/year for the remainder of their life. During winter and spring adult splittail move upstream to forage and later spawn between late February and early July. Spawning is presumably triggered by day length, increased flows, and water temperatures rising to a range of 14°-19°C (57°-66°F). Spawning occurs in flooded vegetation with older fish spawning first. Peak reproduction occurs in March and April though splittail are fractional spawners, so the process may take months. Typically egg production increases with body size and one large female may produce over 100,000 eggs. Fertilized eggs stick to the flooded vegetation till the embryos hatch 3-7 days later. Hatch time is temperature dependent. Active feeding and swim bladder function in the larvae begins 5-7 days after the hatch. The larvae remain in the vegetation for 10-14 days where they have adequate cover and access to small prey. Lab studies conducted by Young and Cech (1986), show the preferred water temperature for juvenile Sacramento splittail was 22°C to 24°C (72°F to 75°F), depending on acclimated water temperature. Young-of-year splittail move into the estuary in April-August where they occupy water less than 7 feet deep. Splittail have been observed in the Mokelumne River upstream of Woodbridge Dam in January through May and downstream year-round.

Sacramento suckers (*Catostomus occidentalis*) are capable of thriving in diverse conditions within streams, lakes, and mild estuarine environments. Most suckers are found in clear cool streams and in lakes at moderate elevations. Sacramento suckers often share waters with pikeminnow, roach, and hardhead. Sacramento suckers are found in a wide range of water temperature regimes, including streams with temperatures that rarely exceed 15 to 16°C (61°F) and streams where temperatures are as high as 29°C to 30°C (84°-86°F) (Cech, et al. 1990, Moyle 2002). Preferred temperatures appear to be about 20° to 25°C (68° -77° F) (Knight 1985). Young larvae typically begin their life in streams or lake tributaries by hiding and remaining in the gravel substrate. The post-larval and juvenile fish are often swept downstream in the current when they enter the main flow. Young fish may stay in this warm water for several years before moving into lakes or larger rivers. Adult fish typically rest or hold in the deeper water during the day and feed during the first and last hours of the day. The larger fish may occupy pools, runs, or riffles in area where vegetation or rocks provide cover from birds and other predators. At age 4-6 Sacramento suckers become sexually mature and begin a spawning ritual that may involve a migration to a warmer and smaller stream. Spawning is triggered by the onset of warmer water temperatures and usually occurs between February and June. Suckers spawn in groups, sending fertilized eggs down into the substrate and out into the current. The eggs settle in gravel and slackwater areas, hatching after 2-4 weeks. Sacramento suckers are found in the Mokelumne River downstream of Camanche Dam to the Delta year-round.

Striped bass (*Morone saxatilis*) are native to streams and bays of the Atlantic Coast. They move readily between salt and fresh water spending most of their life cycle in estuaries. Temperatures up to 34°C (93°F) can be withstood for short periods of time, but temperatures greater than 25°C (77°F) are stressful, and 30°C (86°F) for longer times is lethal. Adults can also withstand the rapid changes in temperature that come with changes in salinity. Dissolved oxygen levels as low as 3-5 mg/L can also be survived for short periods. Striped bass need three very specific habitat structures: (1) a large cool river for spawning, with enough flow to keep larvae suspended into the estuary, (2) a large water body with plenty of fish to eat, and (3) a protective estuary for juveniles to grow by feeding on invertebrates. In California the only area that satisfies these criteria is the San Francisco Estuary and its surrounding water bodies. These striped bass populations spend the majority of their time in bays, but will move out into ocean during El Nino years, and winter in the Sacramento-San Joaquin Delta until the end of the spawning season. Juveniles feed mainly on invertebrates, especially amphipods and copepods, gradually incorporating more fish in their diet as they get larger. Once they become large enough, striped bass are almost entirely piscivorous, and are both voracious and opportunistic. Males mature in 2-3 years, females in 4-6 years, and spawning usually begins in April. Striped bass spawning reportedly occurs from April through June (Wang 1986). When conditions are right, including temperatures between 14°C and 21°C (57°-70°F), groups of 5-30 individuals, composed of some females but mostly males, swim to the surface. There the group releases their eggs and milt simultaneously, so that the eggs are fertilized as they float downward. The eggs need to stay suspended in the water column to survive, and therefore hatch quickly (after approximately 48 hours). The larvae will live off their yolk sac for the next 7-8 days as they are pushed by the current downstream to where fresh and brackish water meet. These areas are usually the most productive, resulting in large amounts of zooplankton for the young striped bass to eat. Migration of striped bass larvae into the water column reportedly occurs from April to mid-June in the Sacramento River (Stevens 1966). The reported optimal water temperature for juveniles lies between 24°C and 26°C (75°F and 79°F), as determined through laboratory experiments (Hill et al. 1989). Striped bass emigration typically occurs in late-summer and fall (Bell 1991). Growth is most rapid in the first 4 years, but varies with food availability. Striped bass are found in the Mokelumne River downstream of Woodbridge Irrigation Dam to the Delta year-round.

Tule perch (*Hysterocarpus traski*) are most often found in low-elevation lakes, streams, and estuarine environments. They typically require cool, well oxygenated water. These fish prefer water temperatures below 22°C (72°F) and are scarce in water that exceeds 25°C (77°F). Tule perch have a high salinity tolerance and have been found in water with a salinity as high as 30 ppt. Within a river or stream tule perch tend to occupy deep pools that have complex cover in the form of aquatic and overhanging vegetation. They feed on invertebrates, plants, and zooplankton, mostly by swimming along the bottom of the stream. The perch may move into faster water for feeding by occupying small eddies and backwaters behind rocks and boulders. Tule perch tend to share habitat with other native fish. Tule perch may form shoals or schools, and are often found associated with centrarchids. Tule perch have a relatively elaborate reproductive cycle. Male perch may “court” females in order to attract them for breeding. Males then inject sperm into the female with a modified anal spine, and each female may mate with multiple males. While the sperm may be injected in July-September, the sperm is not released to fertilize within the female till January. Young perch then begin to develop within her, slowly at first, and more rapidly in the final two months. In around May or June the female bears 10-60 live fish. The number of young produced increases with body size and may vary from one environment to another. Tule perch grow most rapidly during the first 18 months of life, and may live up to 7 or 8 years. Tule Perch are found in the Mokelumne River downstream of Camanche Dam to the Delta year-round.

White sturgeon (*Acipenser transmontanus*) are anadromous fish that spend most of their lives within an estuary, usually returning to freshwater only to spawn. When sturgeon larvae hatch in a stream they begin swimming around in a vertical position as they are suspended by a yolk sac, making them more susceptible to be carried down to the estuary in the current. After they consume the sac they begin swimming freely and feeding through their mouth. In general the distribution of sturgeon in an estuary is age dependent and a factor of salinity tolerance. The younger fish are found on the upstream or freshwater end an estuary where the older fish are found on the ocean side. Once white sturgeon have adapted to the changes in salinity they may move around a bay or estuary to find an optimal type of brackish water. They grow quickly in their first year, up to 12 inches (fork length) in the San Francisco Bay estuary and the growth rate generally decreases with age. Male sturgeon reach sexual maturity before the females, though time of onset of maturity for both varies with photoperiod and temperature. Typically males are at least 10-12 years old and have a fork length of 30-41 inches. Females mature when they are 12-16 years old and have a fork length of 37-53 inches. White sturgeon don't necessarily breed annually and only a small percentage of the adult population spawn in a given season. Males may spawn every 1-2 years and females every 2-4 years. The sturgeon begin migrating in streams during winter, with large peak flows triggering the spawning between February and early June. The optimal water temperature for spawning falls in the range of 8°-19°C (46°-66°F). Fish biologists believe the white sturgeon pick deep swiftwater areas to spawn such as riffles or pools with rock and gravel substrate. Female sturgeon produce many eggs, with the Sacramento white sturgeon producing an average of 5,648 eggs per kilogram of body weight. Male sturgeon fertilize the eggs, giving them a tacky property that allows the eggs to stick to the substrate till the larvae emerge 4-12 days later. The median water temperature at which spawning occurred in the Columbia River (14°C, 57°F) is reported as the optimal water temperature for white sturgeon egg development (Parsley et al. 1993). White sturgeon larvae reportedly emerge from gravel from June through November (Parsley et al. 1993). Moyle (2002) reported that 18°C (64°F) is the preferred water temperature for rearing white sturgeon. White sturgeon are found in the Delta year-round. One white sturgeon was observed in the Mokelumne River at Woodbridge Irrigation Dam in January 2003.

Appendix J

**Analysis of Potential Impacts on Resident Coldwater
Fish Species in Pardee and Camanche Reservoirs due
to the Permit 10478 Time Extension Project**

Analysis of Potential Impacts on Resident Coldwater Fish Species in Pardee and Camanche Reservoirs due to the Permit 10478 Time Extension Project

This appendix provides an analysis of the potential impacts to resident coldwater fish species in Pardee and Camanche Reservoirs resulting from the Permit 10478 Time Extension Project (Project).

J.1 Temperature Criteria

Maximum suitable temperatures of resident fish species in Pardee and Camanche Reservoirs are shown in Table 1, which was reproduced from Table 3.2-2 in Section 3.2, Fish Resources, of Permit 10478 Time Extension Project Draft Environmental Impact Report (EIR).

Table 1. Maximum Suitable Temperatures of Resident Fish Species for Pardee and Camanche Reservoirs

Resident Fish Family	Pardee Reservoir	Camanche Reservoir
Clupeidae: Herrings		24°
Cyprinidae: Minnows	22°	22°
Catostomidae: Suckers	25°	25°
Ictaluridae: Catfish	28°	28°
Salmonidae: Salmon and Trout	15°	18°
Poeciliidae: Livebearers		30°
Cottidae: Sculpins	26°	26°
Centrarchidae: Sunfish	24°	24°
Source: Moyle 2002.		

The maximum temperature threshold is, therefore, defined as the lowest temperature of the range reported for resident fish species (Moyle 2002) for each reservoir; 18 degrees Celsius (°C) for Camanche Reservoir and 15°C for Pardee Reservoir.

J.2 Reservoir Depth Criteria

Reservoir depth criteria were also established for both Pardee and Camanche Reservoirs to compare baseline reservoir water temperature conditions to conditions under the Project and cumulative scenarios. The maximum depth at which the coldwater temperature criteria, listed above, are met was assumed to be the worst case under which cold water would be available in all years of record. The estimated criteria were based on actual reservoir temperature measurements. The methodology used to develop the criteria and the results are described in the Methodology section.

J.3 Methodology

To determine the maximum reservoir depth criteria for each reservoir (Pardee and Camanche) independently, the following three steps are performed.

1. For each manual profile measurement, calculate the threshold depth from the reservoir water surface where the maximum temperature threshold (presented above) is crossed. The collection of threshold depths is then aggregated by calendar month. The critical depth is then taken as the maximum value for each of the 12 calendar months.
2. For each month with non-zero critical depth, convert the critical depth to critical storage by first adding the critical depth to the elevation of the bottom of the reservoir behind the dam to obtain the critical elevation. Then determine the corresponding critical storage from the critical elevation using the reservoir's elevation, area, capacity tables and linear interpolation between table entries. Figure 1 demonstrates how Camanche Reservoir storage; elevation and depth are related with examples for determining the critical values.

Camanche Reservoir minimum elevation	100.00 feet mean sea level (ft msl) ¹
Pardee Reservoir minimum elevation	240.00 ft msl ²

3. For Base Case, Project Case, and Cumulative Case determine the number of months—if any—where simulated end-of-month reservoir storage is below the critical storage estimated in Step 2. Compare the number of months between Base, Project and Cumulative Cases.

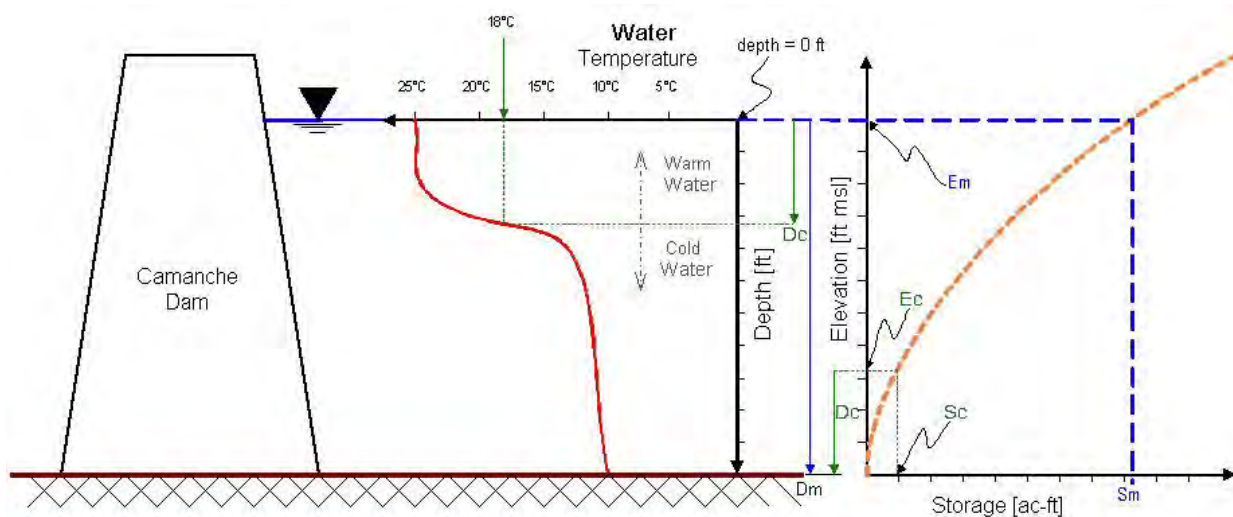


Figure 1. Stratified Camanche Reservoir Schematic Showing Relationship Between Depth, Elevation, and Storage. Subscript c indicates “critical” depth (corresponding to 18°C), elevation, and storage (respectively Dc, Ec, and Sc) where subscript m indicates arbitrary simulated values. Adequate cold water pool is available when $D_c < D_m \leftrightarrow E_c < E_m \leftrightarrow S_c < S_m$ otherwise when $D_c > D_m \leftrightarrow E_c > E_m \leftrightarrow S_m > S_c$ there is no cold water pool available.

¹ From Camanche Dam Outlet Works Outlet Structure General Arrangement As-Built Drawing No: 4462-G-345. Prepared by Bechtel Corporation for East Bay Municipal Utility District, October 28, 1961.

² The minimum elevation of 240 ft msl is based on the manual profile dataset as inferred from water surface elevation and depth measurements, taking the minimum value, and then rounding up to the nearest 10 ft interval (=237.4 ft msl rounded to 240.0 ft msl).

Note that storage is zero when the elevation is equal to the reservoir bottom behind the dam.

J.4 Data Sources

• Camanche manual profile database	916 profiles from February 1988 to December 2008
• Pardee manual profile database	447 profiles from January 1992 to December 2008
• EBMUDSIM Base Case model simulation	214MGD, 2005LOD, 1921-2009
• EBMUDSIM Project Case model simulation	230MGD, 2005LOD, 1921-2009
• EBMUDSIM Cumulative Case model simulation	230MGD, 2040LOD, 1921-2009

J.5 Results

A processing routine written in FORTRAN90 was developed to carry out Step 1. For months in which more than one manual profile is available, the maximum depth estimate among the sample set is retained. A blank entry is used to indicate one of two conditions. One possible condition is that there are simply no manual profile measurements available for the particular month. While there are a handful of months where no data are available, there is a sufficiently long data set for both reservoirs such that these gaps do not significantly inhibit the analysis. The second possible condition that results in a blank entry is when the surface water temperature is below the maximum threshold temperature. In this instance, the entire water column is below the maximum temperature threshold and, thus, the associated threshold depth is zero or undefined.

Table 1 presents the threshold depth estimate for each month from 1988 through 2008 for Camanche Reservoir applying a maximum temperature threshold of 18°C. January, February, March, and December all meet the required temperature target at all depths, hence the entire column corresponding to each month is blank. The final row of Table 1 is the maximum depth for each column corresponding to each month which is defined as the critical depth. The critical depth is taken as the significance criteria as this represents the worst-case (i.e., the maximum depth) above which cold water would be available in all years of record. The critical depth increases steadily from a maximum value of 16 feet in April to nearly 56 feet in November. The minimum elevation is added to the critical depth to determine the critical elevation. The elevation-area-capacity table is then used to convert the critical elevation to critical storage, the final row of the table.

The manual profile database for Pardee Reservoir was also processed to estimate the critical depth, but this time for a maximum temperature threshold of 15°C. Table 2 presents the threshold depth estimates for Pardee Reservoir. In the case of Pardee, January, February, and December always meet the temperature target at all depths. Only one month, March 2004, was flagged as having a non-zero threshold depth. The final row of Table 3 is the critical depth of each column of the table which yields the worst-case (i.e., maximum value) estimate for Pardee Reservoir by month. Note that the critical depth grows in magnitude from March to October. In the case of Pardee, the critical depth tends to decrease from October to November.

Table 2. Camanche Reservoir Threshold Depth (feet) corresponding to 18°C by month from Manual Profile Database and Corresponding Critical Storage (acre-feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1988				3.28	26.25	36.09	42.65	39.37	32.81	26.25		
1989				6.56	6.56		19.69	26.25	26.57	39.37		
1990					23.29	26.57	26.57	29.86	29.53	39.37		
1991						23.62	22.97	29.50	26.25	26.25		
1992				6.56	26.25	29.53	29.53	26.25	26.25	36.09		
1993					19.70	19.70	22.97	23.30	26.60	36.10		
1994				6.60	26.60	29.20	26.60	29.50	29.80	26.20		
1995						16.40	23.00	26.20	29.50	42.60	55.80	
1996					19.70	23.30	26.20	36.10	42.60	39.70		
1997				3.30	19.70	23.30	29.80	36.10	36.40	42.60	36.10	
1998				13.10	13.10	16.70	22.60	32.80	42.60	45.90		
1999					19.70	19.70	29.20	33.00	39.40	42.90	55.80	
2000				10.23	20.00	25.90	29.60	36.40	43.23	42.90		
2001					23.00	32.80	36.30	39.60	42.90	39.93	9.90	
2002					26.73	26.40	29.50	36.63	39.93	36.63		
2003					23.10	32.80	36.30	42.90	46.20	49.40		
2004				16.40	26.50	32.90	36.30	39.50	39.40	39.27		
2005					20.10	22.90	26.20	33.00	36.00	42.90	49.50	
2006					23.20	19.80	23.10	33.00	36.60	42.90		
2007						29.70	36.60	39.60	37.60	49.50		
2008					26.20	29.80	39.60	39.70	36.40	33.10		
Critical Depth (feet)	0.00	0.00	0.00	16.40	26.73	36.09	42.65	42.90	46.20	49.50	55.80	0.00
Critical Storage (acre-feet)	N/A	N/A	N/A	2,856	10,231	18,666	26,230	26,547	30,927	35,794	46,315	N/A

Note: Blank values indicate the entire water column is below the temperature threshold or no manual profile is available for the particular month.

Table 3. Pardee Reservoir Threshold Depth (feet) Corresponding to 15°C by Month from Manual Profile Database and Corresponding Critical Storage (acre-feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992					32.81	49.54	65.29	98.43	114.83	131.23		
1993				9.80	23.00	19.70	82.00	114.80	213.20	239.80	147.60	
1994				33.10	33.50	49.20	65.90	82.30	82.00	114.80	131.20	
1995				6.60	13.10	13.10	23.00	82.00	180.40	147.90	65.60	
1996				16.40	23.00	49.20	82.00	115.10	147.60	246.00	180.40	
1997				16.70	16.10	49.20	65.60	82.00	98.70	164.00	229.60	
1998				3.30	6.90	16.40	82.70	114.80	181.40	213.50	149.60	
1999				9.80	19.70	65.60	98.70	149.16	164.30	262.70	132.20	
2000				16.50	29.50	66.33	98.60	115.50	115.50	198.66		
2001				16.50	33.10	49.83	66.00	82.50	82.50	116.16	132.00	
2002				23.10	33.00	65.80	82.70	82.40	99.70	164.30	180.60	
2003				6.60	29.60	82.00	82.83	98.20	124.60	181.17	196.50	
2004			16.40	16.30	33.00	49.90	66.00	82.50	98.30	133.32	86.13	
2005				13.10	16.50	26.60	65.30	114.80	114.50	198.70		
2006						16.50	83.50		132.00	165.00		
2007					33.00		66.30	82.50	115.20	148.50	82.40	
2008				16.50	36.60	49.60	50.10	66.20	66.30	82.20	82.20	
Critical Depth (feet)	0.00	0.00	16.40	33.10	36.60	82.00	98.70	149.16	213.20	262.70	229.60	0.00
Critical Storage (acre-feet)	N/A	N/A	245	429	481	1,859	2,916	10,295	37,894	85,095	50,010	N/A

Note: Blank values indicate the entire water column is below the temperature threshold or no manual profile is available for the particular month.

The next step is to compare the simulated reservoir storage for each modeling case with the critical storage reported in the last row of Tables 2 and 3 for Camanche and Pardee, respectively. When the simulated storage is greater than the critical storage, then an adequate coldwater pool is available; however, when simulated storage is less than the critical storage, there is an inadequate supply of cold water available. Tables 4, 5, 6, 7, 8 and 9 respectively present the simulated end-of-month storage for Base Case Camanche Reservoir, Base Case Pardee Reservoir, Project Case Camanche Reservoir, Project Case Pardee Reservoir, Cumulative Case Camanche Reservoir and Cumulative Case Pardee Reservoir. Cells are highlighted for those months in which the simulated storage is less than the critical storage identified for Camanche and Pardee in respective Tables 2 and 3.

J.6 Analysis

In the Base Case, there were 8 months when the simulated Camanche Reservoir storage was less than the critical storage. These were November 1977 and the consecutive months of May through November during (the modified) 1978 of East Bay Municipal Utility District's Drought Planning Sequence. For the Base Case simulation of Pardee Reservoir, there were only 2 months in which simulated Pardee Reservoir storage would be less than the critical storage from Table 3. These were the consecutive months of October and November of (the modified) 1978.

For the Project Case, the same 8 months as well as two additional months (September and October 1977) were the months where simulated Camanche storage was less than the critical storage (from Table 1). The simulated Pardee Reservoir storage dropped below the critical storage in the same 2 months for the Project Case as for the Base Case; October and November of (the modified) 1978.

The minimum simulated elevation for Camanche Reservoir is 118.6 ft msl corresponding to a minimum storage value of 4,025 acre-feet. In the Base Case, the minimum simulated storage for Camanche is reached by the end of April of (the modified) 1978 and remains at this minimum value through April of 1979. In the Project Case the minimum simulated storage is reached 3 months earlier at the end of January; however, the critical storage is not applicable in the first 3 months of the year. The minimum simulated elevation for Pardee Reservoir is 444.0 ft msl corresponding to a minimum storage value of 32,187 acre-feet.³ This minimum storage is reached only once in both the Base Case and the Project Case occurring at the end of December of modified 1978 of the Drought Planning Sequence.

In the Cumulative Case, the number of months where Camanche Reservoir is less than the critical storage from Table 2 increases from 8 months in the Base Case to 10 months in the Cumulative Case. The simulated Camanche Reservoir storage is below the critical storage from September through November of 1977, and May through November of 1978 in the Cumulative Case.

With respect to Pardee Reservoir, the Cumulative Case model results show the same 2 months where simulated Pardee Reservoir storage drops below the critical storage relative to the Base Case. The simulated storage for Pardee Reservoir is below the critical storage (i.e., the last row of Table 3) in October through November of 1978.

³ The gainsharing provision of East Bay Municipal Utility District's Joint Settlement Agreement is modeled by adding 20 TAF to the minimum operating storage for Pardee Reservoir, which explains the relatively high minimum storage value.

J.7 Simulated Reservoir Storage Values

Table 4. Base Case Modeled Camanche Reservoir Storage (acre-feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	322,260	315,257	323,282	327,012	383,189	417,148	366,156	322,950	291,937	310,246	301,000	300,455
1922	302,824	321,458	334,749	338,378	320,282	417,148	369,944	319,079	278,788	299,259	296,839	316,223
1923	324,253	324,253	321,305	343,402	362,609	383,333	346,134	308,261	283,145	303,243	294,392	287,828
1924	280,627	261,991	241,764	226,946	209,624	188,851	168,496	150,804	143,957	160,890	147,365	135,538
1925	131,345	185,243	210,607	244,241	328,437	377,590	339,327	307,137	288,469	307,288	298,702	291,991
1926	287,407	282,473	267,303	265,362	258,260	247,498	237,083	233,610	239,099	272,300	281,800	285,347
1927	298,374	324,253	343,467	360,154	370,736	417,148	366,989	319,114	282,875	302,277	290,263	287,758
1928	284,792	274,801	289,207	314,234	401,096	370,204	344,663	326,580	320,112	337,233	324,253	304,886
1929	286,246	269,061	249,539	243,382	224,387	216,004	213,489	216,815	219,222	241,936	235,884	228,661
1930	224,743	212,604	222,890	222,296	208,181	242,432	233,351	231,582	238,941	272,109	278,566	276,920
1931	263,888	250,539	234,930	220,299	203,383	182,781	162,496	144,875	132,370	123,459	115,634	111,547
1932	104,766	131,698	156,661	174,429	201,384	322,606	313,765	300,524	296,805	314,291	305,166	298,621
1933	283,508	265,401	245,464	253,244	252,547	261,097	257,406	257,721	265,689	293,411	289,865	302,681
1934	309,592	302,475	311,026	291,220	266,325	246,211	236,976	223,676	218,114	238,426	236,194	232,986
1935	231,422	238,118	241,284	292,064	316,823	386,610	347,692	314,545	293,395	313,265	305,929	299,999
1936	318,330	287,319	321,119	345,992	395,143	417,148	366,679	320,807	286,286	306,262	298,461	296,343
1937	284,834	315,490	344,291	370,296	388,477	403,837	359,905	322,677	295,771	315,257	309,337	259,353
1938	265,581	270,411	270,354	217,408	321,248	417,148	376,106	320,668	275,694	297,266	293,231	290,211
1939	288,373	270,880	258,234	249,988	225,568	217,715	213,960	216,669	225,376	259,158	255,954	245,148
1940	270,193	318,489	292,008	325,204	417,148	405,423	361,656	326,994	302,708	323,226	317,580	324,253
1941	324,253	324,253	344,291	371,966	379,522	417,148	367,610	318,730	280,692	301,251	295,790	291,290
1942	279,192	277,283	291,477	327,482	335,254	417,148	376,801	323,254	280,618	300,285	293,282	293,282
1943	270,339	273,299	259,366	337,246	400,154	402,787	357,227	317,265	286,918	309,280	302,746	299,601
1944	292,175	278,370	277,751	263,263	252,134	249,210	232,714	221,872	218,223	241,650	252,965	260,863
1945	266,311	304,594	337,658	344,181	354,010	407,242	358,710	315,647	283,183	304,270	291,290	277,283

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1946	281,328	288,935	308,198	322,088	404,712	394,294	354,708	321,905	300,734	321,234	321,654	320,854
1947	316,946	311,285	297,633	298,377	271,030	250,236	231,222	218,314	214,837	242,600	229,759	214,058
1948	210,685	196,777	182,616	189,056	196,336	302,473	286,294	276,685	275,072	297,984	294,815	295,884
1949	293,286	280,200	274,683	297,363	320,218	329,146	313,626	301,309	298,095	315,714	309,221	300,492
1950	307,624	324,253	344,291	374,926	368,717	409,819	356,198	309,150	274,974	298,293	217,408	217,408
1951	217,408	217,408	259,366	328,519	393,781	364,623	335,856	313,466	300,749	319,242	317,800	324,253
1952	311,454	300,210	305,309	226,403	292,269	409,149	381,893	316,683	260,717	284,287	282,121	288,769
1953	321,384	269,918	278,713	311,434	290,924	338,157	317,001	287,760	270,579	298,293	295,915	291,194
1954	288,126	285,936	298,273	325,300	342,420	320,113	298,252	286,112	284,846	307,690	307,361	304,465
1955	304,025	291,089	280,053	264,703	245,849	245,164	225,832	214,505	211,456	235,511	233,860	230,388
1956	217,408	233,406	286,292	331,511	364,172	417,148	364,470	308,294	263,287	288,271	288,424	291,021
1957	286,211	287,063	295,998	291,719	298,011	355,524	321,469	294,319	280,246	304,270	305,497	307,309
1958	318,130	321,024	334,057	340,204	349,200	417,148	369,279	315,377	266,331	290,263	285,962	276,498
1959	276,000	288,063	290,344	276,855	249,565	232,832	222,376	219,104	225,136	254,542	256,049	258,932
1960	252,586	257,213	257,631	251,437	251,431	260,733	248,600	243,341	238,462	258,161	252,231	245,380
1961	231,921	218,324	203,115	188,937	172,258	151,826	129,638	111,014	98,404	112,496	99,058	85,436
1962	71,940	96,112	109,412	150,120	149,415	217,181	203,934	195,717	194,382	227,974	229,865	232,800
1963	244,332	254,653	265,168	309,784	393,150	417,148	363,203	316,088	278,712	303,243	284,287	284,453
1964	293,909	287,828	283,698	277,351	253,237	243,396	236,569	235,672	243,851	279,802	294,937	226,403
1965	230,931	243,549	295,800	347,794	362,000	398,631	349,655	299,922	273,836	314,955	316,103	324,072
1966	324,253	309,189	303,180	307,441	286,136	261,356	239,886	227,446	226,395	249,382	254,151	293,195
1967	324,072	324,072	335,729	340,989	274,701	386,861	394,545	325,017	266,928	292,014	292,489	292,444
1968	295,191	302,036	303,922	294,024	266,822	242,172	219,281	205,489	202,463	225,399	231,837	243,095
1969	280,074	287,137	312,192	300,480	338,212	417,148	372,500	316,802	272,176	306,564	305,011	314,231
1970	217,166	217,166	266,128	299,403	321,716	361,073	335,178	308,442	292,678	313,325	311,756	324,072
1971	324,072	324,072	343,204	357,056	316,343	361,696	340,773	323,719	306,412	335,482	324,072	324,072
1972	319,056	307,544	316,237	312,589	282,104	288,599	273,462	261,447	260,388	286,261	290,919	300,223
1973	324,072	320,624	343,204	361,204	390,664	396,612	361,346	324,264	299,822	325,279	279,638	286,400
1974	270,636	298,896	309,416	357,531	382,351	404,095	367,068	333,372	301,103	322,683	311,458	301,626
1975	287,262	291,207	329,080	347,197	326,525	396,703	358,584	318,813	288,731	321,053	317,189	312,447
1976	297,707	279,133	258,655	244,185	226,857	205,971	185,426	167,961	155,347	163,268	149,487	135,308

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977	121,681	109,456	95,754	81,481	75,533	66,003	57,311	51,159	49,680	51,321	43,333	35,146
1978	27,098	19,925	11,884	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025
1979	4,025	4,025	4,025	4,025	21,728	48,570	54,057	62,503	78,763	99,419	91,864	84,874
1980	179,285	234,674	294,865	329,441	347,889	396,079	371,326	314,695	269,132	289,479	292,195	310,727
1981	324,072	324,072	336,754	350,085	323,177	297,061	283,003	270,047	268,153	294,418	292,678	251,233
1982	231,837	217,148	255,261	273,252	359,886	405,747	360,471	300,510	244,128	274,144	259,655	234,971
1983	256,408	267,094	303,559	317,565	233,286	355,539	399,783	334,314	283,153	330,096	254,082	217,148
1984	217,148	226,041	276,391	309,056	358,758	372,955	348,010	325,864	300,139	326,245	320,329	323,166
1985	305,995	300,217	305,166	317,089	290,196	265,769	239,961	229,211	228,122	252,941	256,231	258,512
1986	277,294	222,117	258,883	333,652	393,633	408,446	359,650	313,027	278,240	298,353	292,660	282,189
1987	265,903	249,728	238,143	226,108	208,671	187,735	172,247	173,562	178,946	195,773	183,511	172,811
1988	163,283	150,635	136,199	122,742	123,817	120,910	119,746	120,992	126,560	129,436	116,704	103,611
1989	90,382	78,464	66,772	87,077	125,873	132,982	133,779	137,868	150,120	163,658	149,871	135,499
1990	125,991	116,310	120,867	110,739	111,406	115,428	117,428	122,514	133,279	141,865	127,888	114,105
1991	100,681	89,131	81,279	63,269	70,413	81,590	90,893	103,373	120,960	143,097	135,047	127,367
1992	119,701	116,056	122,915	106,446	99,869	97,293	93,058	92,233	96,888	105,236	97,151	90,500
1993	92,394	138,700	198,459	250,588	328,996	400,181	350,621	325,175	293,595	317,431	306,912	298,012
1994	279,234	263,517	242,952	229,654	213,593	192,918	179,954	177,696	187,679	222,041	211,465	219,542
1995	285,482	299,526	300,963	278,625	222,721	365,440	406,740	328,699	263,797	301,613	293,725	292,055
1996	300,388	235,760	270,958	334,610	404,380	407,945	369,770	339,399	311,718	316,344	312,661	255,442
1997	251,267	217,148	258,883	298,704	367,083	367,017	337,674	320,090	308,562	331,920	324,072	309,975
1998	324,072	287,137	312,192	308,268	264,317	393,996	398,362	338,083	281,985	309,643	309,857	313,045
1999	324,072	286,896	307,966	341,185	360,153	407,881	373,382	331,615	297,537	316,042	312,974	301,859
2000	314,855	319,326	340,630	347,058	370,458	371,086	347,095	324,784	307,485	326,305	318,096	307,563
2001	288,458	272,450	267,061	281,112	265,715	252,306	242,760	238,425	239,782	264,297	256,945	265,864
2002	280,032	278,377	303,653	313,430	294,371	288,129	265,921	249,748	242,310	261,209	258,218	264,512
2003	279,244	288,094	290,506	302,498	314,781	359,993	327,887	303,178	290,821	308,073	296,536	303,517
2004	311,957	324,072	343,204	340,483	312,179	290,096	268,538	255,923	249,599	258,280	252,985	260,001
2005	311,017	324,072	313,112	359,221	379,446	417,148	385,556	341,853	303,770	320,147	312,988	289,457
2006	233,701	226,744	274,339	308,449	374,858	417,148	387,276	352,532	309,731	328,056	322,215	324,072
2007	311,837	309,448	314,994	305,490	281,636	264,139	251,808	246,192	248,791	269,430	269,087	265,088

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	270,869	270,004	278,774	266,836	248,586	241,458	229,132	226,878	214,767	235,182	231,940	223,893
2009	229,865	234,516	271,283	290,330	361,383	349,387	323,286	303,240	285,594	301,794	296,286	309,802
Min	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025
Max	324,253	324,253	344,291	374,926	417,148	417,148	406,740	352,532	320,112	337,233	324,253	324,253
Mean	256,566	255,002	265,846	277,396	288,425	312,033	288,584	263,357	246,105	267,757	260,753	256,133
Median	280,627	277,283	283,698	300,480	312,179	355,539	327,887	301,309	270,579	297,984	291,290	287,758

Table 5. Base Case Modeled Pardee Reservoir Storage (acre-feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1922	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1923	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1924	161,130	154,790	157,971	170,522	179,413	182,915	186,834	190,775	189,940	161,130	159,114	159,658
1925	161,130	162,185	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1926	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1927	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1928	161,130	161,130	168,224	175,156	198,065	197,954	197,954	194,304	189,940	161,130	161,130	159,579
1929	156,090	153,468	166,629	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1930	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1931	161,130	154,378	157,613	155,977	158,576	154,661	155,262	149,688	143,517	140,048	137,148	142,587
1932	155,263	161,130	167,052	175,156	192,122	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1933	161,130	149,454	164,295	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1934	161,130	161,130	167,052	172,671	179,232	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1935	161,130	161,130	167,052	192,063	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1936	161,130	198,065	190,224	189,319	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1937	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1938	161,130	172,048	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1939	161,130	156,978	167,052	175,156	188,572	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1940	161,130	165,868	189,391	194,347	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1941	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1942	162,241	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1943	169,102	161,130	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1944	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1945	161,130	169,801	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1946	161,130	161,130	167,052	175,156	198,065	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1947	161,130	161,130	167,052	175,156	189,091	197,954	197,954	194,304	189,940	161,130	161,130	157,359
1948	161,130	153,921	159,250	175,156	192,122	198,065	197,954	194,304	189,940	161,130	161,130	161,130

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1949	161,130	154,794	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1950	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	198,065	198,065
1951	198,065	198,065	198,065	198,065	198,065	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1952	173,929	185,173	198,065	198,065	198,065	198,065	198,065	194,304	189,940	161,130	161,130	161,130
1953	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1954	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1955	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	198,065
1956	198,065	198,065	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1957	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1958	161,130	164,359	177,287	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1959	161,130	161,130	167,052	175,156	188,646	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1960	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1961	161,130	153,640	151,051	150,826	151,360	160,005	167,914	174,885	182,994	161,130	159,232	156,048
1962	154,356	161,130	167,052	175,156	192,122	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1963	161,130	162,812	167,052	190,646	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1964	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	198,065
1965	198,065	198,065	184,896	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1966	161,130	161,130	167,052	175,156	192,122	196,271	197,954	194,304	189,940	161,130	161,130	161,130
1967	161,130	161,130	174,528	198,065	198,065	198,065	198,065	194,304	189,940	161,130	161,130	161,130
1968	161,130	161,130	167,052	175,156	182,174	196,990	197,954	194,304	189,940	161,130	161,130	161,130
1969	198,065	198,065	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1970	198,065	198,065	198,065	180,424	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1971	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1972	161,130	161,130	167,052	175,156	191,356	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1973	161,130	164,578	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1974	166,389	161,130	194,018	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1975	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1976	161,130	152,131	156,901	163,783	169,591	173,475	176,375	180,469	184,577	161,130	151,883	138,422
1977	128,853	113,278	111,220	116,706	116,302	113,646	110,936	108,076	106,600	100,000	99,063	86,065
1978	75,216	63,318	71,214	64,456	56,387	49,880	48,457	40,440	42,254	41,748	34,613	32,187
1979	38,100	53,042	103,025	148,876	186,268	197,954	180,912	151,559	121,483	100,000	119,341	147,361

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980	198,065	198,065	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1981	161,130	161,130	167,052	175,156	188,865	197,954	197,954	194,304	189,940	161,130	161,130	163,980
1982	198,065	198,065	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	192,213
1983	198,065	198,065	198,065	198,065	198,065	198,065	198,065	179,486	149,747	120,996	161,130	198,065
1984	198,065	198,065	198,065	192,443	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1985	161,130	161,130	167,052	175,156	185,858	193,813	197,954	194,304	189,940	161,130	161,130	161,130
1986	161,130	198,065	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1987	161,130	157,212	167,052	175,156	179,570	187,952	197,954	194,304	189,940	161,130	161,130	161,130
1988	161,130	154,012	160,605	171,574	166,647	165,092	165,838	162,219	155,275	139,805	133,365	126,147
1989	118,883	111,464	154,320	175,156	192,804	197,954	182,406	164,336	148,251	123,539	139,284	152,582
1990	161,130	161,130	167,052	175,156	174,951	175,146	172,785	167,005	161,362	150,777	139,049	129,720
1991	114,039	101,066	120,120	138,648	129,802	133,736	126,996	116,505	106,246	100,000	123,846	136,608
1992	139,498	151,345	167,052	175,156	161,183	143,769	137,696	131,376	116,097	100,000	95,780	100,308
1993	161,130	161,130	192,106	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1994	160,727	155,411	163,004	171,759	182,072	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1995	198,065	185,676	198,065	198,065	198,065	198,065	198,065	194,304	189,940	161,130	161,130	161,130
1996	161,130	194,685	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	198,065
1997	198,065	198,065	198,065	198,065	198,065	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1998	161,130	198,065	198,065	198,065	198,065	198,065	198,065	194,304	189,940	161,130	161,130	161,130
1999	161,130	198,065	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
2000	161,130	165,876	169,626	175,156	198,065	197,954	197,954	194,304	189,940	161,130	161,130	161,130
2001	158,668	154,891	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
2002	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
2003	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
2004	161,130	161,130	167,052	175,156	179,818	197,954	197,954	194,304	189,940	161,130	161,130	161,130
2005	161,130	161,130	197,145	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	172,442
2006	194,208	189,997	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
2007	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
2008	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
2009	161,130	161,130	167,052	175,156	198,065	197,954	197,954	194,304	189,940	161,130	161,130	175,400
Min	38,100	53,042	71,214	64,456	56,387	49,880	48,457	40,440	42,254	41,748	34,613	32,187

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max	198,065	198,065	198,065	198,065	198,065	198,065	198,065	194,304	189,940	161,130	198,065	198,065
Mean	162,184	163,419	171,363	178,430	189,257	191,898	191,634	187,460	182,514	155,575	156,580	159,029
Median	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130

Table 6. Project Case Modeled Camanche Reservoir Storage (acre-feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	322,260	315,257	323,282	325,803	383,189	417,148	366,583	323,826	293,392	310,246	299,757	297,990
1922	299,170	316,711	328,713	333,974	320,282	417,148	370,376	319,960	280,243	299,259	295,595	316,223
1923	324,253	324,253	320,022	340,760	363,417	384,299	347,184	309,430	284,601	303,243	293,150	285,369
1924	277,089	258,453	238,229	223,423	206,124	185,380	165,065	147,413	134,883	145,165	131,681	119,814
1925	112,210	165,916	188,933	221,217	310,570	364,502	331,092	303,758	289,924	307,288	297,459	289,532
1926	283,757	277,736	261,294	257,998	249,259	236,741	224,473	219,199	223,099	254,902	263,101	265,453
1927	277,249	324,253	342,184	360,154	371,193	417,148	367,401	319,971	284,329	302,277	290,263	286,541
1928	282,387	271,281	290,379	312,877	400,330	370,278	345,754	328,004	321,567	337,233	324,253	304,886
1929	286,246	269,061	249,539	237,264	216,629	206,467	202,092	203,611	204,424	227,604	222,142	215,541
1930	212,230	201,199	211,507	209,588	193,870	226,408	215,526	212,006	217,813	249,624	254,870	252,062
1931	237,945	224,568	208,979	194,429	177,668	157,278	137,302	120,006	107,774	99,040	91,238	86,915
1932	80,103	90,745	114,514	131,092	158,815	281,499	274,505	261,846	257,966	278,767	272,939	269,792
1933	258,023	244,088	228,764	232,901	230,623	237,511	232,089	230,721	237,183	263,536	258,840	270,299
1934	276,096	267,868	275,288	255,605	230,877	210,014	192,653	178,052	171,285	190,433	187,008	182,623
1935	183,059	188,704	190,512	241,168	275,716	356,046	327,911	305,510	294,855	313,265	304,686	297,539
1936	314,669	287,319	322,404	348,631	395,143	417,148	367,108	321,685	287,741	306,262	297,218	293,879
1937	281,176	310,737	344,291	368,940	387,856	403,727	360,244	323,499	297,226	315,257	308,093	259,353
1938	264,392	271,487	270,354	217,408	321,248	417,148	376,532	321,543	277,149	297,266	291,988	287,753
1939	284,724	267,227	252,219	242,639	218,252	206,960	201,357	202,271	209,379	241,777	237,384	225,386
1940	249,088	306,342	294,409	327,599	417,148	405,892	362,304	327,967	304,163	323,226	316,337	324,253
1941	324,253	324,253	344,291	370,609	378,901	417,148	368,022	319,587	282,148	301,251	294,547	291,290
1942	280,302	277,283	290,193	324,841	335,254	417,148	377,231	324,132	281,919	300,285	293,282	293,282
1943	271,529	273,299	259,366	337,246	400,154	403,154	357,896	318,260	288,374	309,280	301,503	297,142
1944	288,524	274,331	271,694	255,857	243,086	238,407	220,059	207,420	202,182	226,057	237,866	246,387
1945	252,510	305,669	338,219	343,385	353,834	407,468	359,271	316,577	284,637	304,270	291,290	277,283
1946	281,328	287,862	305,839	318,381	404,670	394,621	355,335	322,868	302,189	321,234	320,410	318,393
1947	313,299	306,565	291,627	291,032	263,723	239,484	218,618	203,912	198,851	227,033	214,759	200,918
1948	196,996	184,799	172,447	175,109	180,761	285,187	267,189	255,817	252,650	274,195	269,843	269,666

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1949	265,880	252,762	244,801	266,235	288,107	295,940	279,275	265,862	261,718	282,640	279,412	274,101
1950	284,566	316,403	341,876	371,580	368,965	410,389	357,029	310,242	276,428	298,293	217,408	217,408
1951	217,408	217,408	259,366	327,163	395,613	366,360	337,416	314,885	302,204	319,242	316,555	324,253
1952	312,644	302,514	305,458	226,403	292,269	409,149	382,430	317,558	262,039	284,287	280,878	286,303
1953	317,727	269,918	277,430	308,795	289,282	337,279	316,833	288,334	272,034	298,293	294,672	288,734
1954	284,476	281,212	292,255	317,936	334,007	310,500	287,354	273,976	271,671	297,721	300,617	301,105
1955	304,083	294,240	286,523	269,813	249,251	246,720	225,415	212,172	207,449	230,074	227,188	230,388
1956	217,408	233,406	286,292	330,302	364,172	417,148	364,897	309,169	264,742	288,271	287,182	288,563
1957	282,562	282,337	289,977	284,352	292,595	351,809	319,427	293,975	281,703	304,270	304,254	304,848
1958	314,473	322,099	336,422	340,204	349,200	417,148	369,708	316,256	267,788	290,263	284,719	274,041
1959	272,347	283,325	284,329	269,500	242,252	222,078	209,772	204,704	209,117	237,156	237,482	239,178
1960	231,600	235,064	234,178	226,676	225,144	232,814	218,994	212,097	205,750	225,997	220,597	214,426
1961	201,781	189,850	176,484	162,370	152,886	139,646	124,617	113,060	107,428	105,580	97,510	89,420
1962	81,455	86,318	104,036	143,606	141,818	208,396	193,885	184,449	182,057	214,589	215,448	217,320
1963	227,673	255,728	263,883	308,497	393,150	417,148	363,614	316,944	280,166	303,243	284,287	283,237
1964	291,501	284,312	278,901	271,213	245,445	233,830	225,139	222,429	229,008	263,535	277,450	226,403
1965	230,931	243,549	295,800	345,153	360,357	397,763	349,510	300,520	275,292	314,955	316,103	323,972
1966	324,253	308,115	300,825	303,736	280,768	256,023	230,835	216,560	213,897	237,340	242,636	282,279
1967	324,072	324,072	337,014	340,989	274,701	387,235	395,229	326,027	268,383	292,014	291,245	289,983
1968	291,532	297,262	307,395	305,341	278,083	267,931	253,468	247,119	251,470	280,640	293,350	311,020
1969	280,074	287,137	312,192	300,480	338,212	417,148	372,863	317,600	273,631	306,564	303,767	314,231
1970	217,166	217,166	266,128	299,403	321,094	360,974	335,541	309,288	294,133	313,325	311,756	324,072
1971	324,072	324,072	343,204	355,700	315,721	361,587	341,112	324,541	307,868	335,482	324,072	324,072
1972	317,868	305,243	312,658	310,633	280,157	283,167	266,117	252,246	249,544	274,012	277,409	285,489
1973	324,072	321,699	343,204	359,981	388,873	400,022	364,286	326,369	301,155	325,279	279,638	286,400
1974	271,825	297,823	310,701	357,531	382,809	404,807	367,965	334,478	302,557	322,683	310,215	299,167
1975	283,615	286,475	323,049	342,791	323,475	394,766	357,716	319,043	290,185	321,053	317,189	311,231
1976	295,405	276,831	256,355	241,891	224,578	203,708	183,188	165,745	153,150	148,572	134,835	120,706
1977	107,092	94,872	81,197	67,045	58,728	46,936	36,069	27,761	24,045	23,311	15,428	7,342
1978	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025
1979	4,025	4,025	4,025	4,025	20,797	48,561	52,660	59,746	74,660	93,943	86,385	79,388

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980	162,217	234,674	294,865	328,085	347,269	395,986	371,703	315,555	270,360	289,479	292,195	310,727
1981	324,072	324,072	336,754	350,085	323,177	297,061	283,003	270,047	268,153	294,418	292,678	251,233
1982	231,837	217,148	255,261	273,252	359,886	405,747	360,471	300,510	244,128	274,144	259,655	234,971
1983	256,408	267,094	303,559	317,565	233,286	355,539	400,192	333,709	281,464	325,025	254,082	217,148
1984	217,148	226,041	276,391	309,056	358,135	372,844	348,349	326,684	301,593	326,245	320,329	321,949
1985	303,591	296,739	300,396	310,979	284,116	259,726	231,369	215,965	213,270	238,537	242,348	245,251
1986	264,671	222,117	258,883	332,569	393,633	408,820	360,335	314,037	279,615	298,353	291,418	279,731
1987	262,349	246,168	232,401	219,144	201,751	180,873	160,690	160,450	164,460	180,019	166,647	154,813
1988	144,330	131,708	117,323	103,886	108,658	109,448	111,977	116,854	125,986	138,169	130,793	123,256
1989	115,535	108,634	102,679	85,786	124,123	129,302	131,252	136,477	149,843	164,490	150,701	136,326
1990	123,497	112,447	107,573	96,497	100,919	108,730	114,488	123,271	137,688	149,912	135,907	122,107
1991	108,665	97,117	89,431	71,365	71,788	76,328	79,144	85,234	96,440	112,016	104,111	96,458
1992	88,795	84,869	87,438	74,725	75,363	72,176	67,503	66,251	70,649	78,254	70,348	63,432
1993	62,749	106,913	166,580	216,172	301,449	382,044	339,050	320,161	295,051	317,431	305,669	295,551
1994	276,771	261,048	240,488	227,195	211,147	190,453	168,307	164,487	173,085	206,179	194,448	201,374
1995	265,951	300,599	300,963	278,625	222,721	365,440	407,184	329,597	265,253	301,613	292,483	289,591
1996	296,727	236,873	270,958	333,447	404,380	408,315	370,446	340,399	313,173	316,344	312,661	255,442
1997	250,264	217,148	258,883	297,507	366,589	367,013	338,099	320,964	309,872	331,920	324,072	308,758
1998	324,072	287,137	312,192	308,268	264,317	394,364	399,033	339,079	283,440	309,643	308,613	310,584
1999	324,072	286,896	308,083	341,264	359,590	407,820	373,761	332,462	298,993	316,042	311,730	299,401
2000	311,197	320,402	342,990	345,701	369,236	372,768	348,617	326,184	308,937	326,305	316,853	305,106
2001	285,998	269,985	261,048	273,755	256,719	241,551	230,152	224,015	223,777	246,908	238,325	245,947
2002	258,921	256,173	280,138	291,593	270,938	263,020	239,080	221,236	212,312	231,754	229,354	236,174
2003	251,593	261,039	264,032	274,634	298,974	344,030	317,854	298,955	292,276	308,073	295,293	301,050
2004	308,301	321,919	343,204	339,127	310,829	285,257	261,783	247,308	239,348	246,585	240,063	245,829
2005	295,603	324,072	314,397	359,221	379,446	417,148	385,999	342,748	305,225	320,147	311,745	290,677
2006	236,114	230,231	274,339	308,449	374,858	417,148	387,704	353,409	311,186	328,056	320,972	322,601
2007	309,180	305,707	309,975	299,123	273,618	254,352	240,156	232,730	233,731	252,978	251,431	246,187
2008	250,761	248,831	256,440	243,308	223,653	215,043	201,189	197,452	184,018	203,211	198,849	189,654
2009	194,394	197,851	233,313	251,112	329,157	325,050	307,664	294,318	281,984	301,349	299,057	311,020
Min	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max	324,253	324,253	344,291	371,580	417,148	417,148	407,184	353,409	321,567	337,233	324,253	324,253
Mean	248,632	248,519	259,443	269,942	281,628	305,570	282,181	257,153	240,141	260,669	253,461	249,000
Median	276,096	269,985	277,430	299,123	292,269	351,809	319,427	298,955	268,153	292,014	284,719	279,731

Table 7. Project Case Modeled Pardee Reservoir Storage (acre-feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1922	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1923	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1924	161,130	153,780	155,795	167,117	174,568	176,514	178,773	181,092	184,559	161,130	157,985	157,420
1925	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1926	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1927	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1928	161,130	161,130	167,052	175,156	198,065	197,954	197,954	194,304	189,940	161,130	161,130	158,361
1929	153,682	149,986	161,859	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1930	161,130	160,594	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1931	161,130	153,450	155,573	152,767	154,033	148,680	147,752	140,684	133,198	128,499	124,522	128,862
1932	140,338	161,130	167,052	175,156	192,122	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1933	161,130	148,380	161,937	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1934	161,130	161,130	167,052	171,396	173,113	191,199	197,954	194,304	189,940	161,130	161,130	161,130
1935	161,130	161,130	167,052	190,705	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1936	161,130	198,065	188,940	186,680	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1937	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1938	161,130	170,972	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1939	161,130	155,904	167,052	175,156	186,889	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1940	161,130	164,755	186,990	190,593	198,065	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1941	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1942	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1943	167,911	161,130	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1944	161,130	160,393	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1945	161,130	168,727	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1946	161,130	161,130	167,052	175,156	198,065	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1947	161,130	161,130	167,052	175,156	187,408	197,954	197,954	194,304	189,940	161,130	161,130	156,142
1948	161,130	152,809	156,850	175,156	192,122	198,065	197,954	194,304	189,940	161,130	161,130	161,130

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1949	161,130	153,720	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1950	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	198,065	198,065
1951	198,065	198,065	198,065	198,065	198,065	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1952	172,739	182,869	197,916	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1953	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1954	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1955	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	198,065
1956	198,065	198,065	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1957	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1958	161,130	163,284	174,921	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1959	161,130	161,130	167,052	175,156	186,963	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1960	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1961	161,130	152,722	149,034	147,651	140,031	140,448	140,093	138,869	138,943	140,915	137,966	133,743
1962	131,025	161,130	167,052	175,156	192,122	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1963	161,130	161,737	167,052	189,288	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1964	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	198,065
1965	198,065	198,065	183,612	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1966	161,130	161,130	167,052	175,156	192,122	194,446	197,954	194,304	189,940	161,130	161,130	161,130
1967	161,130	161,130	173,242	198,065	198,065	198,065	198,065	194,304	189,940	161,130	161,130	161,130
1968	161,130	161,130	167,052	175,156	190,198	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1969	198,065	198,065	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1970	198,065	198,065	198,065	179,067	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1971	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1972	161,130	161,130	167,052	175,156	189,673	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1973	161,130	163,503	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1974	165,200	161,130	192,733	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1975	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1976	161,130	151,112	154,708	160,349	164,699	167,008	168,230	170,678	173,340	161,130	150,745	136,171
1977	125,555	109,034	105,848	110,152	110,918	109,319	107,556	105,667	105,341	100,000	97,968	83,901
1978	69,593	51,607	59,447	53,729	56,074	49,891	48,457	40,440	42,254	41,748	34,613	32,187
1979	38,100	53,042	103,025	148,876	187,189	197,954	182,299	154,273	125,442	100,000	110,492	137,073

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980	198,065	198,065	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1981	161,130	161,130	167,052	175,156	188,865	197,954	197,954	194,304	189,940	161,130	161,130	163,980
1982	198,065	198,065	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	192,213
1983	198,065	198,065	198,065	198,065	198,065	198,065	198,065	180,943	152,888	126,067	161,130	198,065
1984	198,065	198,065	198,065	191,087	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1985	161,130	161,130	167,052	175,156	184,175	190,311	195,119	194,304	189,940	161,130	161,130	161,130
1986	161,130	198,065	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1987	161,130	156,224	167,052	175,156	178,089	184,872	197,954	194,304	189,940	161,130	161,130	161,130
1988	161,130	153,154	158,756	168,678	159,121	152,865	148,859	140,537	129,037	108,988	101,577	93,391
1989	85,099	76,729	118,389	175,156	192,122	197,954	179,919	159,404	141,047	114,164	128,836	141,091
1990	152,065	152,629	167,052	175,156	170,272	165,727	158,578	148,056	137,808	122,550	109,947	99,742
1991	83,201	69,423	87,288	104,871	101,762	111,329	110,168	105,245	100,654	100,000	122,929	134,793
1992	136,875	147,957	167,052	175,156	161,261	143,850	137,709	131,340	116,132	100,000	94,935	98,632
1993	160,404	161,130	190,821	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1994	159,631	153,322	159,733	167,239	176,078	190,409	197,954	194,304	189,940	161,130	161,130	161,130
1995	198,065	184,603	198,065	198,065	198,065	198,065	198,065	194,304	189,940	161,130	161,130	161,130
1996	161,130	193,572	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	198,065
1997	198,065	198,065	198,065	198,065	198,065	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1998	161,130	198,065	198,065	198,065	198,065	198,065	198,065	194,304	189,940	161,130	161,130	161,130
1999	161,130	198,065	197,947	196,704	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
2000	161,130	164,800	167,267	175,156	198,065	197,954	197,954	194,304	189,940	161,130	161,130	161,130
2001	157,479	152,626	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
2002	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
2003	161,130	161,130	167,052	175,156	192,122	198,065	197,954	194,304	189,940	161,130	161,130	161,130
2004	161,130	161,130	167,052	175,156	178,136	197,954	197,954	194,304	189,940	161,130	161,130	161,130
2005	161,130	161,130	195,859	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	171,221
2006	191,795	186,509	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
2007	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
2008	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
2009	161,130	161,130	167,052	175,156	198,065	197,954	197,954	194,304	189,940	161,130	161,130	174,182
Min	38,100	51,607	59,447	53,729	56,074	49,891	48,457	40,440	42,254	41,748	34,613	32,187

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max	198,065	198,065	198,065	198,065	198,065	198,065	198,065	194,304	189,940	161,130	198,065	198,065
Mean	160,655	161,958	169,955	177,462	188,214	190,678	190,432	186,116	181,080	154,506	155,241	157,506
Median	161,130	161,130	167,052	175,156	198,065	197,954	197,954	194,304	189,940	161,130	161,130	161,130

Table 8. Cumulative Effects Case Modeled Camanche Reservoir Storage (acre-feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	322,260	315,257	323,282	324,266	383,189	417,148	366,424	323,577	293,440	310,246	298,213	294,808
1922	294,339	310,551	321,523	328,352	320,282	417,148	370,642	320,137	280,707	299,259	294,049	316,223
1923	324,253	324,253	318,999	338,038	362,223	381,319	344,910	308,133	284,648	303,243	291,606	282,196
1924	281,826	263,480	243,252	228,157	210,503	189,399	168,736	150,740	138,019	147,865	138,927	127,079
1925	121,212	173,693	195,689	226,273	314,930	367,899	333,161	304,588	289,972	307,288	295,915	286,358
1926	278,934	271,590	253,724	249,034	240,028	228,235	218,324	215,605	220,040	252,358	259,001	259,727
1927	269,862	321,310	338,219	356,342	368,498	417,148	367,226	319,702	284,377	302,277	290,263	284,909
1928	279,107	266,695	290,379	311,180	398,114	367,697	343,312	324,498	316,615	332,667	323,774	304,407
1929	285,766	268,581	249,060	229,941	206,809	193,883	186,833	185,781	190,913	217,504	210,563	202,349
1930	206,886	199,842	209,662	206,052	188,113	218,237	204,567	198,363	201,972	235,650	241,156	238,759
1931	226,279	214,556	200,818	186,025	169,278	148,923	129,040	111,849	99,843	91,420	83,627	79,222
1932	72,399	92,569	115,311	130,191	155,676	275,922	266,517	251,135	245,031	265,431	258,094	253,317
1933	240,099	226,169	210,846	210,782	206,370	210,981	202,952	199,076	203,748	238,098	238,957	248,676
1934	262,466	261,607	268,135	248,208	223,192	202,062	179,398	162,419	153,713	171,372	166,502	160,760
1935	162,874	172,611	173,368	223,704	260,748	345,476	321,982	302,878	294,897	313,265	303,142	294,364
1936	309,831	287,319	323,427	351,079	395,143	417,148	366,953	321,439	287,789	306,262	295,675	290,700
1937	276,339	304,571	344,291	367,243	385,566	406,511	362,172	324,260	297,274	315,257	306,547	259,353
1938	262,742	272,793	270,354	217,408	321,248	417,148	376,790	321,710	277,612	297,266	290,445	284,580
1939	279,905	262,404	251,356	239,675	214,976	198,532	190,160	188,411	194,156	228,830	224,722	213,084
1940	236,886	295,813	296,741	329,925	417,148	406,007	362,205	327,735	304,211	323,226	314,793	321,514
1941	324,253	324,253	344,291	368,911	377,888	417,148	368,264	319,736	282,772	301,251	293,002	291,290
1942	280,302	277,283	289,170	322,391	335,254	417,148	377,492	324,303	282,607	300,285	293,282	293,282
1943	273,179	273,299	259,366	337,246	400,154	403,278	357,820	318,051	288,421	309,280	299,959	293,968
1944	283,698	269,488	274,054	265,735	260,363	262,473	250,698	244,648	246,224	277,765	295,622	309,538
1945	312,093	306,973	335,348	338,825	352,992	406,949	358,754	316,140	284,684	304,270	291,290	277,283
1946	281,328	286,558	303,511	317,335	404,173	394,361	354,989	322,515	302,237	321,234	318,864	315,217
1947	308,478	300,443	294,010	300,923	275,891	262,762	248,475	240,365	242,111	278,874	272,404	259,570
1948	263,422	249,570	235,562	234,279	235,457	334,326	309,883	293,363	286,513	303,243	292,818	286,421

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1949	276,376	259,103	244,211	263,952	283,589	288,987	269,505	253,381	247,024	267,967	263,218	256,292
1950	265,032	295,541	319,980	354,329	356,742	405,720	354,067	308,634	276,475	298,293	217,408	217,408
1951	217,408	218,593	260,722	325,737	394,217	367,671	338,110	315,046	302,834	319,242	315,009	324,253
1952	314,294	305,470	309,444	226,403	292,269	409,149	382,690	317,728	263,296	284,287	279,333	283,121
1953	312,892	269,918	276,407	306,075	287,455	336,022	316,246	288,077	273,330	298,293	293,127	285,560
1954	279,651	275,082	285,090	309,086	322,949	296,849	270,936	254,902	251,855	276,701	278,071	276,871
1955	278,126	266,972	267,806	258,506	245,575	249,984	235,452	228,995	231,222	261,543	264,493	230,388
1956	217,408	233,406	286,292	328,764	364,172	417,148	365,155	309,336	265,206	288,271	285,638	285,391
1957	277,740	276,205	282,808	275,498	291,028	346,859	315,982	292,105	281,751	304,270	302,710	301,671
1958	309,640	323,404	338,757	340,204	349,200	417,148	369,970	316,427	268,252	290,263	283,176	270,869
1959	267,517	277,176	277,165	260,128	234,538	213,270	202,812	200,308	205,253	236,348	236,916	238,993
1960	231,613	235,500	235,435	226,118	224,271	233,018	221,470	217,129	211,253	231,426	224,481	216,674
1961	211,855	199,924	186,559	172,148	155,253	134,655	112,409	93,761	81,221	103,023	94,961	86,874
1962	78,910	97,939	114,711	152,601	148,429	212,435	194,961	182,670	177,932	210,293	209,678	209,968
1963	218,679	256,334	262,859	307,199	393,150	417,148	363,441	316,679	281,462	303,243	284,287	281,608
1964	288,219	279,732	273,301	263,934	237,030	221,108	209,673	204,323	209,015	244,085	256,636	226,403
1965	230,931	243,549	295,800	342,703	358,746	396,679	349,056	300,757	276,589	314,955	316,103	322,340
1966	321,354	304,756	295,605	296,833	271,653	246,645	218,054	199,206	196,033	218,277	222,004	259,961
1967	308,522	324,072	338,039	340,989	274,701	387,376	395,603	326,269	269,680	292,014	289,700	286,806
1968	286,697	291,118	300,222	296,493	268,954	253,661	236,462	227,473	229,667	259,695	270,833	287,006
1969	280,074	287,137	312,192	300,480	338,212	417,148	373,150	318,218	274,927	306,564	302,222	314,231
1970	217,166	218,373	266,128	299,403	320,295	360,499	335,072	308,888	294,181	313,325	311,756	324,072
1971	324,072	324,072	343,204	354,004	314,709	360,943	340,931	324,899	309,165	335,482	324,072	324,072
1972	316,221	302,293	308,689	304,975	274,203	272,873	253,041	236,498	231,585	256,087	257,909	264,348
1973	316,735	323,005	343,204	358,284	387,860	399,377	364,102	326,308	301,957	325,279	279,638	286,400
1974	273,474	296,520	311,726	357,531	383,148	405,190	368,478	335,187	303,853	322,683	308,670	295,992
1975	278,795	280,336	315,866	333,921	319,205	391,672	355,916	318,606	291,481	321,053	317,189	309,601
1976	301,675	283,100	262,617	247,866	230,192	208,956	188,078	170,285	157,492	145,106	131,381	117,264
1977	103,653	91,435	77,767	63,373	56,424	45,992	36,488	29,518	27,272	28,138	20,236	12,129
1978	4,111	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025
1979	4,025	4,025	4,025	4,025	17,598	39,141	40,988	45,863	58,716	75,944	68,377	61,356

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980	138,262	234,674	294,865	327,814	346,471	395,503	371,626	315,547	271,052	289,479	292,195	309,097
1981	324,072	324,072	335,729	347,366	320,144	292,726	272,002	256,345	252,243	279,327	292,678	252,852
1982	233,193	217,148	255,261	273,252	359,886	405,864	360,792	301,111	245,422	274,144	259,655	236,585
1983	256,408	267,094	303,559	317,565	233,286	355,539	400,714	333,403	280,379	320,430	253,548	217,148
1984	217,148	226,041	276,391	309,056	357,936	370,567	347,088	326,512	302,889	326,245	320,329	320,318
1985	300,489	292,158	304,321	322,405	295,161	276,908	259,959	253,986	258,124	291,876	301,649	310,623
1986	324,072	230,517	258,883	330,408	393,633	408,907	360,172	313,740	279,743	298,353	289,874	276,559
1987	267,090	253,349	243,107	227,730	209,958	188,688	165,227	157,911	159,711	173,621	159,989	147,465
1988	144,932	132,308	117,922	104,213	108,623	109,054	111,254	115,807	124,757	136,876	129,500	121,961
1989	114,242	107,339	101,378	117,159	155,469	171,845	157,395	141,440	137,390	151,650	150,464	146,167
1990	152,019	148,662	150,916	137,270	116,372	110,038	104,925	103,341	109,035	141,584	127,608	113,826
1991	100,403	88,852	80,995	62,716	69,591	80,501	89,573	101,822	119,316	141,467	133,423	125,745
1992	118,079	114,421	116,012	102,707	99,138	99,536	98,238	100,299	107,975	119,507	111,341	104,812
1993	104,740	142,369	202,137	249,170	328,665	400,409	351,428	326,672	296,348	317,431	304,123	292,374
1994	273,592	257,861	237,309	223,750	207,395	186,408	163,768	145,521	154,052	187,173	174,288	179,554
1995	243,195	291,280	300,963	278,625	222,721	365,440	407,461	330,203	266,550	301,613	290,939	286,410
1996	291,887	238,177	270,958	331,969	404,380	408,443	370,378	340,199	313,220	316,344	312,661	255,442
1997	248,874	217,148	258,883	295,985	368,168	368,329	338,815	321,149	310,913	331,920	324,072	307,127
1998	324,072	287,137	312,192	308,268	264,317	394,493	399,380	339,708	284,737	309,643	307,067	307,408
1999	324,072	286,896	309,107	342,014	358,575	407,173	373,577	332,402	300,289	316,042	310,184	296,229
2000	306,362	321,708	343,204	344,004	368,221	372,122	348,433	326,538	309,816	326,305	315,309	301,934
2001	282,822	266,802	253,890	264,796	247,495	233,050	224,007	220,424	220,719	242,157	232,033	240,227
2002	251,551	247,491	279,956	298,927	285,698	284,603	267,274	256,050	253,951	277,561	271,758	275,243
2003	287,129	293,602	293,703	302,641	316,103	361,154	328,895	304,149	293,107	308,073	293,749	297,866
2004	303,469	315,764	343,204	337,431	308,816	282,326	253,142	236,146	226,144	233,718	229,113	235,068
2005	284,996	323,491	315,422	359,221	379,446	417,148	386,273	343,350	306,522	320,147	310,201	292,312
2006	239,403	234,824	274,339	308,449	374,858	417,148	387,963	353,993	312,067	328,056	319,428	319,423
2007	304,358	299,564	302,817	289,748	263,558	245,018	233,186	228,320	229,860	247,415	247,244	240,529
2008	243,435	240,204	246,823	231,630	210,235	198,876	182,348	176,746	170,395	199,543	202,868	197,205
2009	200,305	202,478	236,918	253,011	328,802	322,233	301,993	285,895	271,310	290,658	286,847	312,652
Min	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max	324,253	324,253	344,291	368,911	417,148	417,148	407,461	353,993	316,615	335,482	324,072	324,253
Mean	248,748	248,821	260,175	270,364	281,878	305,760	281,891	256,195	239,287	260,556	253,378	248,439
Median	276,339	268,581	276,391	298,927	292,269	346,859	321,982	300,757	268,252	290,658	285,638	277,283

Table 9. Cumulative Effects Case Modeled Pardee Reservoir Storage (acre-feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1921	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1922	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1923	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1924	161,130	161,130	161,735	171,238	176,398	175,845	175,601	175,507	176,912	161,130	161,130	160,813
1925	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1926	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1927	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1928	161,130	161,130	167,052	175,156	198,065	197,954	197,954	194,304	189,940	161,130	161,130	156,729
1929	150,426	145,446	155,902	174,802	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1930	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1931	159,628	150,613	157,720	162,250	170,316	171,192	171,066	161,014	150,950	144,175	138,620	141,343
1932	151,181	161,130	167,052	175,156	192,122	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1933	160,874	146,820	159,352	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1934	161,130	161,130	167,052	169,680	172,609	188,391	197,954	194,304	189,940	161,130	161,130	161,130
1935	161,130	161,130	167,052	189,277	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1936	161,130	198,065	187,916	184,232	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1937	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1938	161,130	169,665	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1939	161,130	160,884	167,052	175,156	184,561	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1940	161,130	163,450	184,658	186,839	198,065	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1941	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1942	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1943	166,261	161,130	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1944	161,130	159,088	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1945	161,130	167,422	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1946	161,130	161,130	167,052	175,156	198,065	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1947	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1948	161,130	151,505	154,103	175,156	192,122	198,065	197,954	194,304	189,940	161,130	161,130	161,130

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1949	161,130	152,417	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1950	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	198,065	198,065
1951	198,065	196,880	196,709	198,065	198,065	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1952	171,089	179,913	193,930	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1953	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1954	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1955	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	198,065
1956	198,065	198,065	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1957	161,130	161,130	167,052	175,156	192,906	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1958	161,130	161,979	172,586	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1959	161,130	161,130	167,052	175,156	184,626	197,436	197,954	194,304	189,940	161,130	161,130	161,130
1960	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1961	161,130	159,975	164,317	170,230	168,530	173,170	176,939	179,905	184,582	161,130	156,560	150,643
1962	146,337	161,130	167,052	175,156	192,122	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1963	161,130	161,130	167,052	187,861	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1964	161,130	161,130	167,052	175,156	190,630	197,954	197,954	194,304	189,940	161,130	161,130	198,065
1965	198,065	198,065	182,588	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1966	161,130	160,285	167,052	175,156	192,122	191,891	196,033	194,304	189,940	161,130	161,130	161,130
1967	161,130	161,130	172,217	198,065	198,065	198,065	198,065	194,304	189,940	161,130	161,130	161,130
1968	161,130	161,130	167,052	175,156	187,861	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1969	198,065	198,065	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1970	198,065	196,858	198,065	177,642	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1971	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1972	161,130	161,130	167,052	175,156	187,751	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1973	161,130	162,197	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1974	163,551	161,130	191,709	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1975	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1976	161,130	158,745	160,918	164,734	166,774	166,565	165,262	165,273	165,855	161,130	158,438	151,648
1977	148,915	136,483	131,850	134,260	130,966	125,070	118,983	112,874	108,717	100,000	99,876	93,702
1978	90,487	74,838	80,743	69,480	69,203	60,413	56,114	46,112	45,273	43,431	34,558	32,187
1979	36,555	50,369	99,088	143,054	183,332	197,954	182,256	153,857	125,020	100,000	108,982	132,993

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980	198,065	198,065	198,065	196,910	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1981	161,130	161,130	167,052	175,156	186,539	194,095	197,954	194,304	189,940	161,130	161,130	162,361
1982	196,709	198,065	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	190,600
1983	198,065	198,065	198,065	198,065	198,065	198,065	198,065	182,371	155,682	130,661	161,665	198,065
1984	198,065	198,065	198,065	189,661	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1985	160,956	161,130	167,052	175,156	191,545	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1986	161,130	198,065	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1987	161,130	161,130	167,052	175,156	175,814	180,118	193,615	194,304	189,940	161,130	159,890	161,130
1988	161,130	157,613	161,853	170,016	158,308	149,705	143,360	132,785	119,366	100,000	100,342	100,133
1989	99,235	94,518	143,792	175,156	198,065	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1990	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	155,848	145,905
1991	137,004	130,360	146,985	162,381	149,600	149,263	138,091	123,307	109,341	100,000	121,159	138,907
1992	138,962	148,389	167,052	175,156	163,376	147,479	143,055	138,490	122,575	100,000	92,993	94,658
1993	154,759	161,130	189,796	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
1994	158,100	150,588	155,691	161,492	168,258	180,332	185,879	194,304	189,940	161,130	160,851	161,130
1995	197,135	187,757	198,065	198,065	198,065	198,065	198,065	194,304	189,940	161,130	161,130	161,130
1996	161,130	192,268	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	198,065
1997	198,065	198,065	198,065	198,065	198,065	197,954	197,954	194,304	189,940	161,130	161,130	161,130
1998	161,130	198,065	198,065	198,065	198,065	198,065	198,065	194,304	189,940	161,130	161,130	161,130
1999	161,130	198,065	196,924	194,256	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
2000	161,130	163,494	167,052	175,156	198,065	197,954	197,954	194,304	189,940	161,130	161,130	161,130
2001	155,830	149,669	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
2002	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
2003	161,130	161,130	167,052	175,156	197,654	198,065	197,954	194,304	189,940	161,130	161,130	161,130
2004	161,130	161,130	167,052	175,156	175,989	194,880	197,954	194,304	189,940	161,130	161,130	161,130
2005	161,130	161,130	194,835	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	169,586
2006	188,507	181,916	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
2007	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
2008	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
2009	161,130	161,130	167,052	175,156	198,065	197,954	197,954	194,304	189,940	161,130	161,130	172,550
Min	36,555	50,369	80,743	69,480	69,203	60,413	56,114	46,112	45,273	43,431	34,558	32,187

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max	198,065	198,065	198,065	198,065	198,065	198,065	198,065	194,304	189,940	161,130	198,065	198,065
Mean	162,042	163,496	171,398	178,699	189,808	192,150	192,036	187,946	182,917	155,840	156,546	158,898
Median	161,130	161,130	167,052	175,156	198,065	197,954	197,954	194,304	189,940	161,130	161,130	161,130

Appendix K

**Safe Harbor Agreement for East Bay Municipal Utility
District Lands in San Joaquin, Amador, and
Calaveras Counties**

SAFE HARBOR AGREEMENT FOR EAST BAY MUNICIPAL UTILITY DISTRICT LANDS IN SAN JOAQUIN, AMADOR AND CALAVERAS COUNTIES

1. INTRODUCTION

This Safe Harbor Agreement (Agreement) is entered into between the East Bay Municipal Utility District (EBMUD) and the U.S. Fish and Wildlife Service (Service); hereinafter collectively called the “Parties.” The purposes of this Agreement are (1) to promote the enhancement and management of habitat for California red-legged frog (*Rana aurora draytonii*), California tiger salamander (*Ambystoma californiense*), and valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) on EBMUD watershed lands in San Joaquin, Amador and Calaveras counties; and (2) to provide certain regulatory assurances to EBMUD. This Agreement follows the Service’s Safe Harbor Agreement policy (64 FR 32717) and regulations (64 FR 32706), both of which implement section 10(a)(1)(A) of the Endangered Species Act (ESA).

Upon approval, this Agreement will serve as the basis for the Service to issue an enhancement of survival permit (Permit) pursuant to Section 10(a)(1)(A) of the ESA. The Permit authorizes the incidental taking of California red-legged frog, California tiger salamander, and valley elderberry longhorn beetle associated with the enhancement and conservation management of these species’ habitats, other lawful uses of the property (as described in Section 10 of this Agreement), and the potential future return of any eligible land to pre-Agreement conditions (baseline) within the period during which the Permit is in effect.

2. LIST OF COVERED SPECIES

This Agreement covers the following federally listed species, which are hereafter referred to as the “covered species”: the California red-legged frog (CRLF), the California tiger salamander (CTS), and the valley elderberry longhorn beetle (VELB).

3. DESCRIPTION OF ENROLLED PROPERTY

The property subject to this Agreement consists of approximately 28,000 acres (11,330 hectares) of East Bay Municipal Utility District lands in San Joaquin, Calaveras and Amador counties, California, hereafter referred to as the “enrolled property.” The enrolled property, which consists of about 19,710 acres of land and 9,034 acres of water surface (7,977 and 3,656 hectares respectively), is more precisely indicated on the attached map (Exhibit 1). The enrolled property borders and includes Camanche and Pardee dams and reservoirs, extending from less than 50 feet (15 m) to about 3 miles (4.8 km) from the high-water surface elevation of Camanche and Pardee reservoirs. It also includes the lands adjacent to the lower Mokelumne River for approximately ½ mile (0.8 km) below Camanche Dam. Current and recent land use practices on the enrolled property include management for water supply, flood control, grazing, aquaculture, hydroelectric power, wastewater treatment, facility maintenance, residential use, and recreation. Habitat types¹ (and approximate area²) of the enrolled property include Annual Grassland (7,851 acres, 3,177 hectares), Blue Oak

¹ As defined in the “California Wildlife Habitat Relationships System” and adopted by the California Department of Fish and Game. It is an adaptation of Mayer and Laudenslayer (1988).

² As determined by the USDA Forest Service Region 5 CALVEG GIS maps (USDA Forest Service 1981).

Woodland (4,564 acres, 1,847 hectares); Blue Oak-Foothill Pine (2,692 acres, 1,089 hectares); Chamise-Redshank Chaparral (1,623 acres, 657 hectares); Montane Hardwood (1,580 acres, 639 hectares); Mixed Chaparral (1,140 acres, 461 hectares); Barren (198 acres, 80 hectares); Urban (61 acres, 25 hectares); and, Ponderosa Pine (2 acres, 1 hectare). The amount of habitat to be restored and enhanced within the property is approximately 220 acres.

4. BASELINE DETERMINATION

The Parties agree that the baseline conditions applicable to this agreement are as detailed in this Section and in Exhibit 2. In order to receive the assurances regarding take of covered species specified in Section 10 hereof, EBMUD must maintain on the property at least as much habitat for the covered species as is shown in Exhibit 2 (Baseline Habitat).

Due to the size of the property, the difficulty of accessing much of it, the uncertainty regarding whether potentially suitable breeding sites are actually utilized by listed amphibians, and the general compatibility of existing land uses on the covered property with the conservation of such species, the baseline of upland habitat will be considered to be maintained so long as no major changes to existing uses of the property (such as conversion to row crops, commercial housing construction, or developments of comparable magnitude) are made.

5. MANAGEMENT ACTIVITIES

EBMUD will undertake the conservation management activities described in Exhibit 3 (Conservation Management Activities) on the enrolled property. The objective of such activities is to restore and maintain healthy, contiguous native plant communities that include elderberry bushes (*Sambucus* sp.) for VELB; restore and maintain suitable breeding ponds, moist refuge habitat, and upland dispersal habitat for CTS and CRLF; manage vegetation and grazing appropriate to the conservation needs of the covered species, consistent with water quality protection and fire management; control non-native predators; and implement related protection and conservation measures. It is anticipated that these activities will enhance the probability that local populations of the covered species will persist and increase. Implementation of these management activities will be initiated within 1 year after execution of this Agreement, and all Conservation Management Activities entailing restoration, development, or enhancement of habitat will be completed within 5 years after execution of this Agreement. The Conservation Management Activities – including maintenance of the restored, newly-developed, and/or enhanced habitat – will be maintained for a minimum of thirty years after execution of this Agreement.

6. NET CONSERVATION BENEFIT

Implementation of this Agreement is expected to provide a “net conservation benefit” to the covered species, because the collective management activities performed by EBMUD pursuant to this Agreement are expected to provide an increase in the covered species’ populations by restoring and maintaining the covered species’ habitat.

Implementation of the conservation management activities in this Agreement are expected to enhance the probability that local metapopulations of VELB will persist by increasing the amount of elderberry bush habitat and by increasing the connectivity of habitats through replacement of non-native invasive species with native trees, shrubs (including elderberry bushes), sedges and grasses.

Both CRLF and CTS are known to breed in freshwater ponds; in some areas of the enrolled property, stock ponds represent a significant portion of available breeding sites. The stock ponds to be restored pursuant to this Agreement are existing ponds that have experienced sedimentation, have need of spillway or levee repair, or are otherwise impaired. Removal of sediments as described in Exhibit 3 (Conservation Management Activities) will increase the availability of deep water habitats for the covered species, prolong the useful life of the pond, reduce the risk of spillway or levee failure, and lessen the risk of drying out before metamorphosis of larvae. Similarly, spillway and levee repairs will also prolong the expected useful life of the ponds and reduce the risk of pond failure. Associated vegetation and grazing management will improve breeding and upland dispersal habitat conditions. The control of non-native predators will dramatically improve the ability of a pond to serve as a breeding site for CRLF and CTS. Shallow water development and management will increase useful breeding habitat, enhance and improve moist refuge habitat, and provide connectivity between and among suitable breeding habitats. The protection and management of adjacent upland habitat as provided in Exhibit 3 (Conservation Management Activities) will further enhance connectivity. Together, these measures are expected to result in an increase in the quantity and quality of breeding habitat capable of producing larger local populations that in turn are capable of dispersing over broader areas.

7. OTHER RESPONSIBILITIES OF THE PARTIES

A. In addition to carrying out the management activities set forth in Section 5 (Management Activities), EBMUD agrees to:

1. Notify the Service 30 days in advance of any planned activity on the enrolled property that EBMUD reasonably anticipates will result in “take” (i.e., death, injury, or other harm) of the covered species or a reduction in the number of living elderberry bushes with 1 or more stems of 1 inch or greater in diameter at the base; and provide the Service the opportunity to assist on avoidance and minimization measures, and capture and/or relocate the potentially affected animals or bushes, if appropriate. Emergency situations, such as wild fires, floods, epidemic disease, or other factors, may require management actions not specified in this Agreement. In these situations, the Parties acknowledge that it may be impossible to provide the 30-day notice required by the Agreement prior to initiation of activities that could result in take of covered species. However, EBMUD will notify the Service as soon as reasonably possible after discovering such a situation (except for wild fires < 20 acres in size, which will be provided to the Service in the annual monitoring report), and will make reasonable accommodations to the Service to attempt to relocate affected individuals of the Covered Species or their host plant prior to the emergency management actions. The Parties acknowledge that relocation efforts

may be precluded by certain emergency situations. EBMUD and the Service will work cooperatively to avoid impacts to Covered Species.

2. Allow the Service, or those authorized by the Service (which may include EBMUD personnel), to monitor the populations of covered species in the areas where the management activities described in Section 5 are being carried out.
3. Allow access to the enrolled property upon reasonable notice by the Service or its agents for purposes related to this agreement, including capture and relocation of the covered species. Relocation shall be to locations deemed appropriate by EBMUD.
4. Provide the Service with the annual reports described in Exhibits 4 and 5, due by March 31 of each year, which summarize the actions undertaken pursuant to this Agreement, maintenance of baseline conditions, and any observations of listed species during the preceding year.
5. Notify the Service of any injured or killed specimens of the covered species of which it becomes aware as a result of the implementation of the management actions.
6. Notify the Service of any transfer of ownership of all or portions of the enrolled property, so that the Service can attempt to contact the new owner, explain the baseline responsibilities applicable to the enrolled property, and seek to interest the new owner in signing the existing Agreement or a new one to benefit listed species on the enrolled property.

B. In consideration of the foregoing, the Service agrees to:

1. Upon execution of the Agreement, issue to EBMUD a permit in accordance with ESA section 10(a)(1)(A), and valid for a period of 30 years, authorizing take of the covered species as a result of implementing management activities, or as a result of other lawful activities on the enrolled property after the management activities have been initiated, provided that such taking shall be consistent with maintaining baseline conditions on the enrolled property.
2. Provide to EBMUD technical assistance, to the maximum extent practicable, when requested; and provide information on Federal funding programs.

8. OTHER LANDOWNERS WHO MAY SECURE INCIDENTAL TAKE AUTHORIZATION

Landowners who own land adjoining the enrolled property may, without committing to undertake any management activities described in Section 5 (Management Activities) hereof on such adjoining land, secure the incidental take authority conferred by the permit issued by the Service to EBMUD pursuant to Section 7.B.1, provided: (1) a survey undertaken on the adjoining land by a qualified person satisfactory to the Service establishes the baseline conditions on the adjoining property; and (2) the owner of the adjoining property enters into a written agreement with the Service, in which the owner agrees to maintain baseline conditions.

9. AGREEMENT AND PERMIT DURATION

The Agreement becomes effective upon issuance by the Service of the ESA section 10(a)(1)(A) permit described in Section 7 hereof, and will be in effect for 30 years. The permit will have a term of 30 years.

10. ASSURANCES REGARDING TAKE OF COVERED SPECIES

Provided that such take is consistent with maintaining the baseline conditions identified in Section 4 (Baseline Determination) hereof, the ESA section 10(a)(1)(A) permit referenced in Section 7 shall

authorize the taking of covered species incidental to otherwise lawful activities by EBMUD, by its employees or agents, by neighboring landowners who have entered into agreements pursuant to Section 8 hereof, and by those authorized by law to control flooding in the Mokelumne River watershed in the following circumstances:

1. Implementing the management activities identified in Section 5 (Management Activities) hereof; or
2. Making any lawful use of the enrolled property after the management activities identified in Section 5 have been initiated, including but not limited to grazing and grazing management; growing forage crops within the Camanche Hills Hunt Club; use of registered pesticides and herbicides (provided that such use is in accordance with label restrictions and activities specified in Exhibit 3 (Conservation Management Activities)); recreation; fire prevention and control; emergency fire-fighting; prescribed burns (provided that such burns follow the procedures listed in Exhibit 3)); construction, use, and maintenance of fences, access roads, paths and trails; dam, dike, spillway, causeway, aqueduct, and powerhouse operation and maintenance; water supply and flood control operation and maintenance; existing wastewater treatment; operation and maintenance of facilities, residences, and hatchery.

11. MODIFICATIONS

A. Modification of the Agreement. Either party may propose amendments to this Agreement by providing written notice to, and obtaining the written concurrence of, the other Party. Such notice shall include a statement of the proposed modification, the reason for it, and its expected results. The Parties will respond to proposed modifications within 60 days of receipt of such notice. Proposed modifications will become effective upon the other Parties' written concurrence.

B. Termination of the Agreement. As provided for in Part 12 of the Service's Safe Harbor Policy (64 FR 32717), EBMUD may terminate this Agreement for circumstances beyond its control, without affecting its rights under this Agreement, by giving written notice to the Service. In such circumstances, EBMUD may, pursuant to the permit referenced in Section 7.B.1 hereof, return the enrolled property to baseline conditions even if the management activities identified in Section 5 have not been fully implemented.

C. Permit Suspension or Revocation. The Service may suspend or revoke the permit referenced in Section 7.B.1 above for cause in accordance with the laws and regulations in force at the time of such suspension or revocation. EBMUD has the right to appeal any suspension or revocation to a mutually agreed upon arbitrator.

D. Baseline Adjustment. The baseline conditions for the enrolled property may be adjusted by mutual agreement of the Parties if, during the term of this Agreement and for reasons beyond the control of EBMUD (e.g., droughts, floods, wild fires, epidemic disease, climate change, etc.) the amount of suitable habitat for covered species on the enrolled property is diminished.

12. OTHER MEASURES

A. Remedies. No party shall be liable in monetary damages for any breach of this Agreement, any performance or failure to perform an obligation under this Agreement or any other cause of action arising from this Agreement.

B. Dispute Resolution. The Parties agree to work together in good faith to resolve any disputes, using dispute resolution procedures agreed upon by all Parties.

C. Succession and Transfer. As provided in Part 11 of the Service's Safe Harbor Agreement Policy, if EBMUD transfers its interest in the enrolled property to another non-Federal entity, the Service will regard the new owner as having the same rights and responsibilities, including baseline responsibilities, with respect to the enrolled property as EBMUD, if the new owner agrees and commits in writing to become a party to this Agreement and the permit referenced in Section 7 above in place of EBMUD.

D. Availability of Funds. Implementation of this Agreement is subject to the requirements of the Anti-Deficiency Act and the availability of appropriated funds. Nothing in this Agreement will be construed by the Parties to require the obligation, appropriation, or expenditure of any funds from the U.S. Treasury. The Parties acknowledge that the Service will not be required under this Agreement to expend any Federal agency's appropriated funds unless and until an authorized official of that agency affirmatively acts to commit to such expenditures as evidenced in writing.

E. No Third-Party Beneficiaries. This Agreement does not create any new right or interest in any member of the public as a third-party beneficiary, nor shall it authorize anyone not a party to this Agreement to maintain a suit for personal injuries or damages pursuant to the provisions of this Agreement. The duties, obligations, and responsibilities of the Parties to this Agreement with respect to third parties shall remain as imposed under existing law. In the event that any third party successfully challenges the permit referenced in Section 7.B.1 hereof, the Service shall, at the request of EBMUD, allow EBMUD to return the enrolled property to its baseline conditions.

F. Other Listed Species, Candidate Species, and Species of Concern. In the event that other species not initially covered by this Agreement are subsequently listed as threatened or endangered under the ESA, provided that such other species are associated with habitats of the covered species, the Parties may agree to amend this Agreement and associated permit to include such other species as covered species. In addition, it is possible that other listed, proposed, or candidate species, or species of concern may occur in the future on the enrolled property as a direct result of the management actions specified in Section 5 above. If that occurs, and EBMUD so requests, the Parties may agree to amend the Agreement and associated permit to include such additional species as covered species. The amendment of the Agreement pursuant to this provision shall specify as the baseline for such subsequently covered species the lesser of the following: the amount of habitat for that species on the enrolled property that existed at the time the Agreement was signed, as determined by the baseline habitat described in Exhibit 2; or the amount of habitat for that species on the enrolled property at the time of the amendment of the Agreement, determined in a manner approved by the Parties.

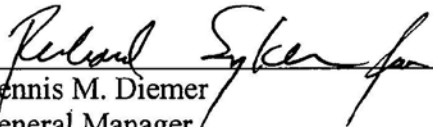
G. Notices and Reports. Any notices and reports, including monitoring and annual reports, required by this Agreement shall be delivered to the persons listed below, as appropriate:

Safe Harbor Program Coordinator
U.S. Fish and Wildlife Service
2800 Cottage Way, Room W-2605
Sacramento, California 95825

H. Nothing in this Agreement precludes EBMUD from expanding Pardee and/or Camanche reservoirs in the future. Should EBMUD elect to raise dam heights and enlarge reservoir capacity at Pardee and/or Camanche reservoirs, EBMUD will obtain all necessary federal or state authorizations, including authorization for take of listed species.

I. Because a portion of the enrolled property is already enrolled in the Lower Mokelumne River Safe Harbor Agreement for Valley elderberry longhorn beetle, nothing in this Agreement enlarges or diminishes any right or responsibility of EBMUD under that prior agreement, and vice versa.

IN WITNESS WHEREOF, THE PARTIES HERETO have executed this Safe Harbor Agreement to be in effect as of the date that Service issues the permit referred to in Section 7.B.1 above.



Dennis M. Diemer
General Manager
East Bay Municipal Utility District

6/2/09
Date



Susan Moore
Field Supervisor
U.S. Fish and Wildlife Service

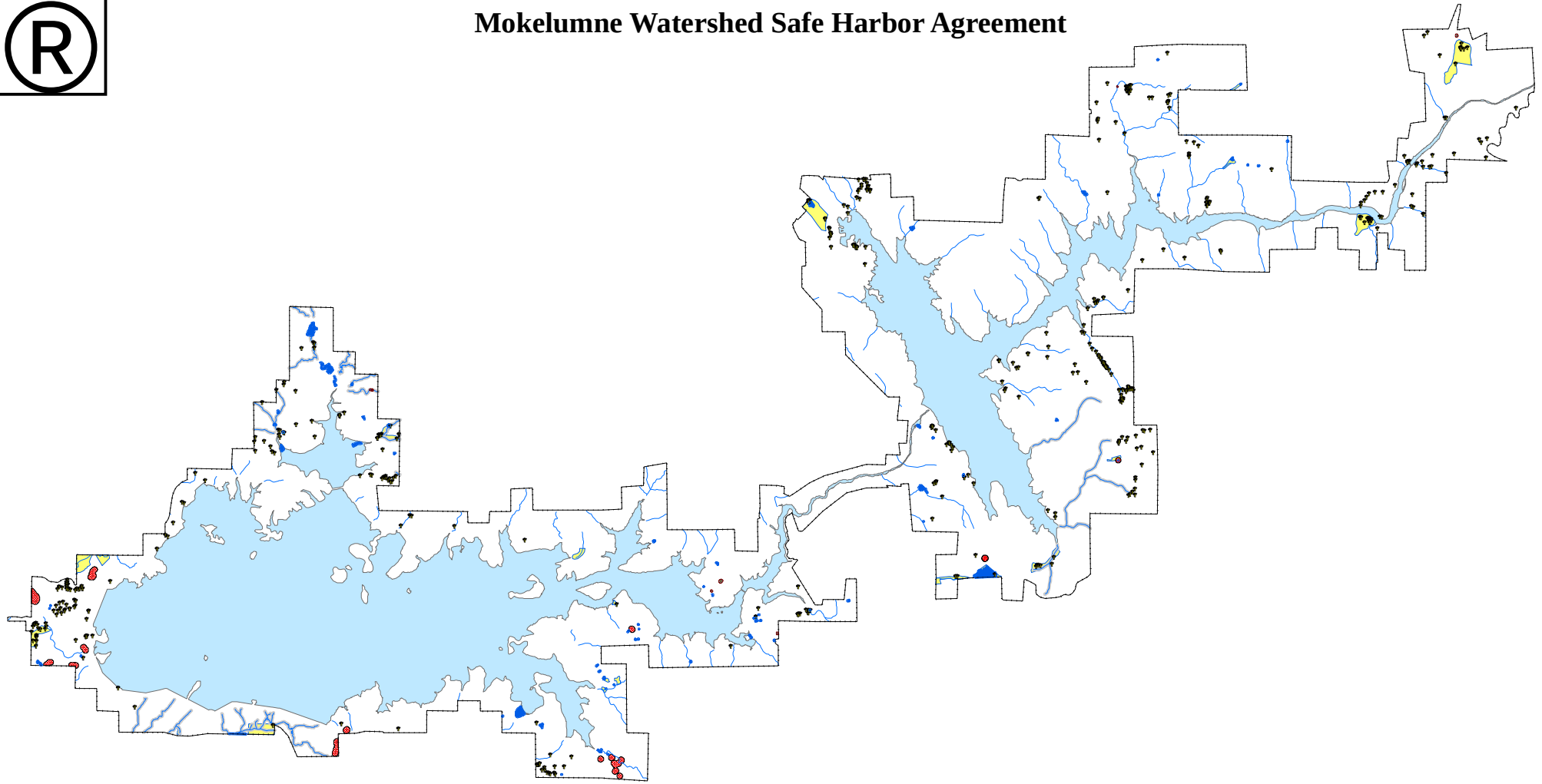
6/2/09
Date

Exhibit 1

**MAP OF THE ENROLLED PROPERTY, BASELINE HABITAT, AND
CONSERVATION MANAGEMENT SITES**

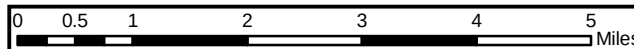


Mokelumne Watershed Safe Harbor Agreement



Conservation Management Activities

-  Pond Restoration/Maintenance
-  Other Breeding Habitat Restoration
-  Elderberry Habitat
-  Shallow Water Habitat Development
-  Camanche & Pardee Reservoirs



Baseline Habitat 2008 (Dry Year)

-  Enrolled Property Boundary
-  Observed Elderberry Bushes (Estimated # = 893)
-  Streams, Creeks, and Springs
-  Vernal Pool Complexes
-  Potential Breeding Ponds (#68)

Exhibit 2

BASELINE HABITAT

In order to maintain the baseline, the amounts of habitat on the enrolled property in each category must remain at least as large as recorded below. The methods that will be used to determine these baseline habitat amounts are shown under “Methods”, below. EBMUD has provided to Service maps (Exhibit 1) showing the current locations of baseline habitat.

VERNAL POOL COMPLEXES

The number of vernal pool complexes is 12, composed of 37 pools with a combined maximum surface acreage of approximately 10.3 acres (4.17 hectares) (to the nearest 1/10 acre, 0.04 hectare) as measured in a “Dry” water year type³.

BREEDING POND HABITAT FOR CALIFORNIA TIGER SALAMANDER AND CALIFORNIA RED-LEGGED FROG

The number of ponds that provide breeding habitat is 68, with a combined maximum surface acreage of approximately 35.8 acres (14.48 hectares) (to the nearest 1/10 acre, 0.04 hectare) as measured in a “Dry” water year type³.

OTHER BREEDING HABITAT FOR CALIFORNIA RED-LEGGED FROGS

The number of sites other than ponds and vernal pools that may provide suitable breeding habitat (streams, creeks, springs) is approximately 157,524 linear feet (48,013 meters) (to the nearest foot, meter) as measured in a “Dry” water year type³.

VALLEY ELDERBERRY LONGHORN BEETLE HABITAT

The number of elderberry bushes that have 1 or more stems 1 inch (2.54 cm) or greater in diameter at the base is 893. EBMUD shall be deemed to have maintained baseline conditions with respect to the VELB if it maintains at least that amount of elderberry bushes on the enrolled property, regardless of the location of such bushes.

METHODS

1. The acreage of vernal pool complexes, breeding pond habitat, and other breeding habitat recorded as the baseline reflect the maximum wetted acreage in the water year type(s) in which the baseline is assessed. In order to maintain the baseline, the same amount of acreage must be maintained – measured as maximum wetted acreage in the comparable water year type(s) ³.
2. Baseline vernal pool complexes: Vernal pools are seasonal depression wetlands that are covered by shallow water for two or more consecutive weeks during winter and/or spring, but may be completely dry for most of the summer and fall. Although generally isolated, they are sometimes connected to each other by vernal swales, which – if present – are included in the baseline surface area. Beneath vernal pools lies either bedrock or a hard clay layer in the soil that helps keep water in the pool. In order to maintain the baseline, the wetted acreage of vernal pool complexes on the enrolled property must be at least as much as measured above in a

³ Water year types are defined by the unimpaired runoff into Pardee Reservoir as determined by the April 1st Bulletin 120 Report of the California Department of Water Resources.

comparable water year type³. These baseline amounts were identified based on aerial photography and visual inspection.

3. Baseline breeding pond habitat for California tiger salamander and California red-legged frog: Breeding pond habitat shall not include reservoirs, wastewater ponds, or recreation ponds. Breeding pond habitat shall include standing bodies of fresh water (natural and man-made ponds, and other ephemeral or permanent water bodies) on enrolled property that:
 - (a) Become inundated during winter rains and hold water for a minimum of 12 weeks in the winter or spring⁴;
 - (b) Are bordered at least in part by 173 m (567 ft) wide buffers of terrestrial habitat suitable for burrowing mammals⁵; and,
 - (c) Either retain water during the dry season or have moist refuge habitat available within 200 m (656 feet)⁶.

In order to maintain the baseline, the number of ponds and the combined maximum acreage on the enrolled property must be at least as much as measured above in a comparable water year type⁷. These baseline amounts were identified based on aerial photography and visual inspection.

4. Baseline “Other” breeding habitat: “Other habitat will be included if it provides standing or slow-moving water from March through July during comparable water year types³. Such habitat may include streams, deep pools or backwaters within streams and creeks, marshes, and major springs. These baseline amounts identified based on aerial photography and/or visual inspection as appropriate.
5. Baseline elderberry bush habitat: In order to be included in the baseline, an elderberry bush must have 1 or more stems 1 inch (2.54 cm) or greater in diameter. For purposes of determining the baseline, a group of shoots that originates from the same root system or a group of shoots that occurs within a 5-meter (16.4 feet) radius shall be considered one bush. The baseline was calculated by estimating the number of elderberry bushes occurring in each habitat type⁸ and the area of each habitat type⁹ occurring on enrolled property (to the nearest 10 acres, 4 hectares). Such estimates were derived from GIS based on aerial photography,

⁴ Note that pond management that mimics the natural water cycle, where possible, will be the most beneficial for the California red-legged frog (USFWS 2002).

⁵ Trenham et al. (2001) recommended that plans to maintain local populations of California tiger salamanders should include pond(s) surrounded by at least 173-m (567-ft) wide buffers of terrestrial habitat occupied by burrowing mammals.

⁶ Post-metamorphic CRLF and CTS spend much of each year on land and providing appropriate upland habitat conditions is essential to maintaining healthy populations. CRLF require above-ground vegetation for shelter. They need moist microhabitats where they can find refuge when moving around on land, especially if the pond is dry. Bulger et al. (2003) found that CRLF use dense patches of shrubs and herbaceous vegetation and, based on radio tracking, recommended protecting these resources within 100m of ponds. They also observed CRLF moving among ponds up to 3 km apart, but found no clear habitat preferences during migration. Outside of the breeding season, CTS live exclusively on land, primarily in the burrows of ground squirrels and gophers. CTS have been found up to 2 km from any known breeding pond, although CTS adults remain more concentrated within 200 m of the pond. A moist refuge may be formed by debris piles, dead and down trees, a trough, seep wetland, polunge pool, riparian area or the like, and must be available and moist year-round.

⁷ Trenham and Shaffer (2005) estimate that in optimal habitat, 95% of CTS remain within 630m of breeding ponds.

⁸ As defined in the “California Wildlife Habitat Relationships System” adopted by the California Department of Fish and Game. It is an adaptation of Mayer and Laudenslayer (1988).

⁹ As determined by the USDA Forest Service Region 5 CALVEG GIS maps (USDA Forest Service 1981).

combined with visual field surveys. In order to maintain the baseline, the total number of elderberry bushes on the enrolled property must be at least as much as estimated above.

Exhibit 3

CONSERVATION MANAGEMENT ACTIVITIES

- The following conservation management activities reflect current understanding of the habitat requirements of the covered species. Any conservation management activities may be changed by mutual agreement of EBMUD and the Service to reflect improved understanding of the covered species' needs or other considerations. EBMUD has provided to the Service maps (Exhibit 1) showing potential sites for Conservation Management Activities.

Conservation management activities for the benefit of the Valley elderberry longhorn beetle

- Develop 200 acres of elderberry habitat in the areas shown on Exhibit 1 or in substantially similar areas if restoration in the areas shown proves impractical.
- In these areas:
 - Plant and maintain native species typical of the canopy, subcanopy, shrub, and herbaceous layers found in Valley Foothill Riparian habitats¹⁰, preferably with stock obtained from local sources; if elderberries already exist on the site, encourage recruitment and growth of additional elderberries via natural processes, and/or
 - Plant and maintain elderberry bushes, using local stock when practical, at a density of at least 24 bushes per acre (59 per hectare), or at a density appropriate for conditions at the site with the goal of increasing Valley elderberry longhorn beetle dispersal opportunities.
- Limit pesticide and herbicide use within these restored areas to those contact herbicides necessary to control invasive weeds; do not use aerial application of pesticides or herbicides within 100 feet (30.5 meters) of the restored area.
- Remove non-native invasive species as appropriate to facilitate restoration.
- When prescribed burns are initiated by EBMUD, take all practical measures to protect elderberry shrubs and riparian areas from damage. Whenever feasible, such prescribed burns also should be managed to foster restoration of native riparian and upland vegetation.

Conservation management activities for the benefit of the California red-legged frog and California tiger salamander

- Allow reintroduction of California red-legged frogs on the enrolled property with advance notice and in locations deemed appropriate and approved by EBMUD, if requested by the Service.
- Maintain 10.3 acres (4.17 hectares) of vernal pool complexes.
- Develop 2 acres of new shallow water habitat between 1,300 and 3,900 feet (400 and 1,200 meters) from existing breeding pond habitat¹¹ in the areas shown on Exhibit 1 or in substantially similar areas if restoration in the areas shown proves impractical. Any new ponds

¹⁰ As defined in the "California Wildlife Habitat Relationships System" adopted by the California Department of Fish and Game. It is an adaptation of the description in Mayer and Laudenslayer (1988).

¹¹ Marsh and Trenham (2001) determined that aggregations of amphibians at individual breeding ponds may not represent distinct populations and in many cases should not be managed as distinct units. Groups of ponds may often be a more meaningful unit of management than individual ponds. Since CTS and CRLF have been shown to disperse from 0.4 to 1.2 km from breeding ponds (Service 2002, 2004), development of shallow water habitat within the dispersal range may benefit any metapopulations on the enrolled property or neighboring properties.

will incorporate the features described below for the restoration and maintenance of existing constructed ponds.

- Restore, and then maintain 17.3 acres of existing constructed ponds in the areas shown on Exhibit 1 or in substantially similar areas if restoration in the areas shown proves impractical. The ponds may be used to provide livestock water and will incorporate the following features when feasible:
 - Ponds will be sized and/or managed to retain sufficient water for tadpole development during the entire rearing season (January, or whenever rains commence, through late July or early August, in most years a minimum of 20 weeks); ponds can be allowed to dry during the fall (typically mid-August through early December).
 - Ponds will contain a shallow water area for tadpole and juvenile rearing. This shallow area (25 – 50 cm (10 – 20 inches) deep) should be unshaded and contain no or very short emergent plants. The shallow area will be designed so that the water warms quickly in the winter sun but is of sufficient water depth to provide aquatic habitat throughout spring.
 - Ponds also will contain a deep water escape area with portions deeper than 1 meter (3.3 feet). This deep water area should contain a mosaic of open water and dense aquatic vegetation, or dense patches of shoreline vegetation adjacent to deep water.
 - When possible, the areal extent of the shallow and deep portions of the pond should be about equal.
 - Plant species commonly found in CTS and CRLF ponds should be present, be expected to regenerate or colonize naturally, or be planted. These species include spike rushes (*Eleocharis* spp.), rushes (*Juncus* spp.), bulrushes (*Scirpus* spp.), cattails (*Typha* spp.), and willows (*Salix* spp.).
 - Partially submerged rocks, logs or other structures may be added to the pond as basking sites.
 - To the extent feasible, vegetative buffers, a sediment trap, grazing management, or other management techniques will be used upstream of the pond to reduce sediment loading.
 - Routine pond maintenance activities will be conducted outside of the CRLF and CTS breeding seasons (December through July) employing impact and avoidance and minimization measures¹².
 - When vegetation management is required, mechanical methods will be used preferentially; chemical methods also may be used September through November.
 - If mosquito control is required, bacterial larvicides will be used.

¹² When conducting conservation management activities at CRLF and CTS breeding sites, or other aquatic habitats, utilize the following measures to avoid or reduce potential impacts. Prior to entering sites, remove mud, snails, algae, and other debris from nets, traps, boots, vehicle tires, and all other surfaces. Between sites, boots, nets, traps, etc. should then be scrubbed with 70 percent ethanol solution and rinsed clean with sterilized water. Avoid cleaning equipment in the immediate vicinity of a pond or wetland. Qualified biologists will perform surveys within 10 days prior to conservation management activity. CTS and CRLF found in the project site will be avoided through rescheduling activity or the CTS and CRLF adults will be temporarily held (no more than 12 hours) at the site or moved to an unaffected area. To avoid breeding and larval CTS and CRLF, conservation management activities will only be performed when the site is dry or when CTS or CRLF are absent.

- Enhance, and then maintain other breeding habitat, and/or other shallow water habitat in the areas shown on Exhibit 1, for a total of 1,500 linear feet (457 m). Restoration shall consist of: restoring native vegetation typical of the canopy, subcanopy, shrub, and herbaceous layers found in those habitats; and controlling nonnative invasive species to the extent feasible.
- Manage pesticide applications as follows near vernal pool complexes, breeding habitat described in Exhibit 2, and new or restored shallow water habitat and ponds described in Exhibit 3:
 - Prohibit aerial application of pesticides on enrolled lands within 200 feet (61 m).
 - Prohibit ground use of contact pesticides on enrolled lands within 60 feet (18.3 m).
 - Exceptions to these prohibitions include the use of approved pesticides for the purpose of public health vector control when such program is administered by a public entity, and/or use of approved pesticides for the purpose of controlling state-designated invasive species and noxious weeds when such program is administered by a public entity, provided application of the pesticides shall be limited to localized spot treatments using hand-held devices and may not occur within 15 feet (4.6 m) of vernal pools or breeding ponds, nor when precipitation is occurring or is forecast to occur within 24 hours.
 - Prohibit use of fumigants on enrolled lands; poison bait is allowed only if it is broadcast or put in confined bait stations.
- Control non-native predators (including, but not limited to, bullfrogs, mosquitofish catfish, crayfish) in breeding habitats described in Exhibit 2 and in new or restored shallow water habitats and ponds described in Exhibit 3 as follows:
 - Drain the ponds in the fall and winter as necessary to eliminate predatory species (typically after the first fall rains).
 - Use alternative methods to control non-native predators in shallow water habitat where such draining is inappropriate.
 - In no case will non-native predators be introduced into extant, restored or created standing bodies of freshwater (does not include reservoirs, wastewater ponds or recreation ponds).
- Enhance and/or maintain existing suitable upland dispersal and aestivation habitat within 2,067 ft (630m) of the vernal pool complexes, breeding habitats described in Exhibit 2, or new or enhanced shallow water habitats and ponds described in Exhibit 3. Enhancement may include the following features:
 - Dense patches of shrubs and low-growing grassland vegetation within 650 ft (200 m) of breeding ponds to provide habitat for CRLF.
 - Moist refuge habitat (e.g., debris piles, dead and down trees, seeps, wetland, plunge pool, riparian area, densely packed piles of rocks, or other microhabitat) available year-round within 650 ft (200 m) of breeding ponds.
 - Low-growing grassland with brushy areas and/or stands of riparian and oak woodlands within 2,067 ft (630 m) to provide habitat for CTS. This area will be managed to encourage ground squirrel and rodent burrows (>5 burrows per 323 ft¹¹).
- Maintenance of upland habitat does not preclude continuation of past land use practices and normal operations such as those listed in Section 10.2 of the Agreement. For purposes of this

section, suitable upland habitat must be on the enrolled property and must not currently be impacted by disking or significant vehicular traffic.

- Manage livestock grazing activities according to the guidelines in Exhibit 5.
- Prohibit disking and/or grading in existing suitable upland habitats within 2,067 ft (630m) of new or restored shallow water habitats and ponds described in Exhibit 3. Exceptions to this prohibition include areas where livestock congregate or move in large numbers; growing forage crops within the Camanche Hills Hunt Club; fire prevention and control (including emergency fire fighting); construction, use, and maintenance of access roads, paths and trails; dam, dike, spillway, causeway, aqueduct, and powerhouse operation and maintenance; water supply operation and maintenance; existing wastewater treatment; operation and maintenance of facilities, residences, and hatchery.

References

- Bulger J.B., N.J. Scott, and R.B. Seymour. 2003. Terrestrial activity and conservation of adult California red-legged frogs *Rana aurora draytonii* in coastal forests and grasslands. *Biological Conservation* 110:85-95.
- Marsh, D.M, and P.C. Trenham. 2001. Metapopulation dynamics and amphibian conservation. *Conservation Biology* 15(1): 40-49.
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- Trenham, P.C., and H.B. Shaffer. 2005. Amphibian upland habitat use and its consequences for population viability. *Ecological Applications* 15(4):1158-1168.
- USDA Forest Service. 1981. *CALVEG: A Classification of California Vegetation*. Pacific Southwest Region, Regional Ecology Group, San Francisco CA. 168 pp.
- U.S. Fish and Wildlife Service (Service). 2002. Recovery Plan for the California red-legged frog (*Rana aurora draytonii*). U.S. Fish and Wildlife Service, Portland, Oregon. vii + 173 pp.
- _____. 2004. Endangered and threatened plants and animals; Determination of threatened status for the California tiger salamander; and special rule exemption for existing routine ranching activities; Final Rule. FR 69 (149): 47212-47248.
- Trenham, P.C., W.D. Koenig, and H.B. Shaffer. 2001. Spatially autocorrelated demography and interpond dispersal in the salamander *Ambystoma californiense*. *Ecology* 82(12):3519-3530.

Exhibit 4**MONITORING ACTIVITIES**

EBMUD will monitor the following annually and provide Service with a summary report.

- For each habitat type listed in Exhibits 2 and 3,
 - the amount of habitat maintained and/or restored during the previous year; and
 - a general summary of the condition (e.g., excellent, good, fair, poor) of these habitats.
- The month and year when management activities are initiated; and the month and year when management activities entailing restoration, development, or enhancement of habitat are completed.
- Any observations of covered species on the enrolled property.
- Any wildfires occurring on the enrolled property.
- Photos from photo points established by mutual agreement of EBMUD and Service.

EBMUD also will provide to Service the results of its monitoring for ecological indicators developed pursuant to the Mokelumne Watershed Master Plan.

Exhibit 5

LIVESTOCK GRAZING GUIDELINES

These guidelines shall apply only to the upland habitats included in Exhibit 2 (i.e., included in the baseline) and in existing, suitable upland dispersal and aestivation habitat within 2,067 ft (630m) of the new or restored shallow water habitats and ponds described in Exhibit 3. These guidelines may be changed from time to time by mutual agreement of Service and EBMUD.

EBMUD shall:

- Ensure that all pastures will not be overgrazed and that a layer of Residual Dry Matter will be maintained to minimize soil erosion and enhance the quality and quantity of forage produced.
 - Residual Dry Matter (RDM) shall mean the amount of standing, dead plant material and litter from the previous year's growth of herbaceous plants and shall be expressed in pounds per acre.
- The amount of RDM, as measured during the month of September in dry annual grassland¹³ shall be as follows:

Flat Slopes (0-10%)	300 Pounds/Acre
Medium Slopes (10-20%)	400 Pounds/Acre
Moderate Slopes (20-40%)	500 Pounds/Acre
Steep Slopes (>40%)	600 Pounds/Acre

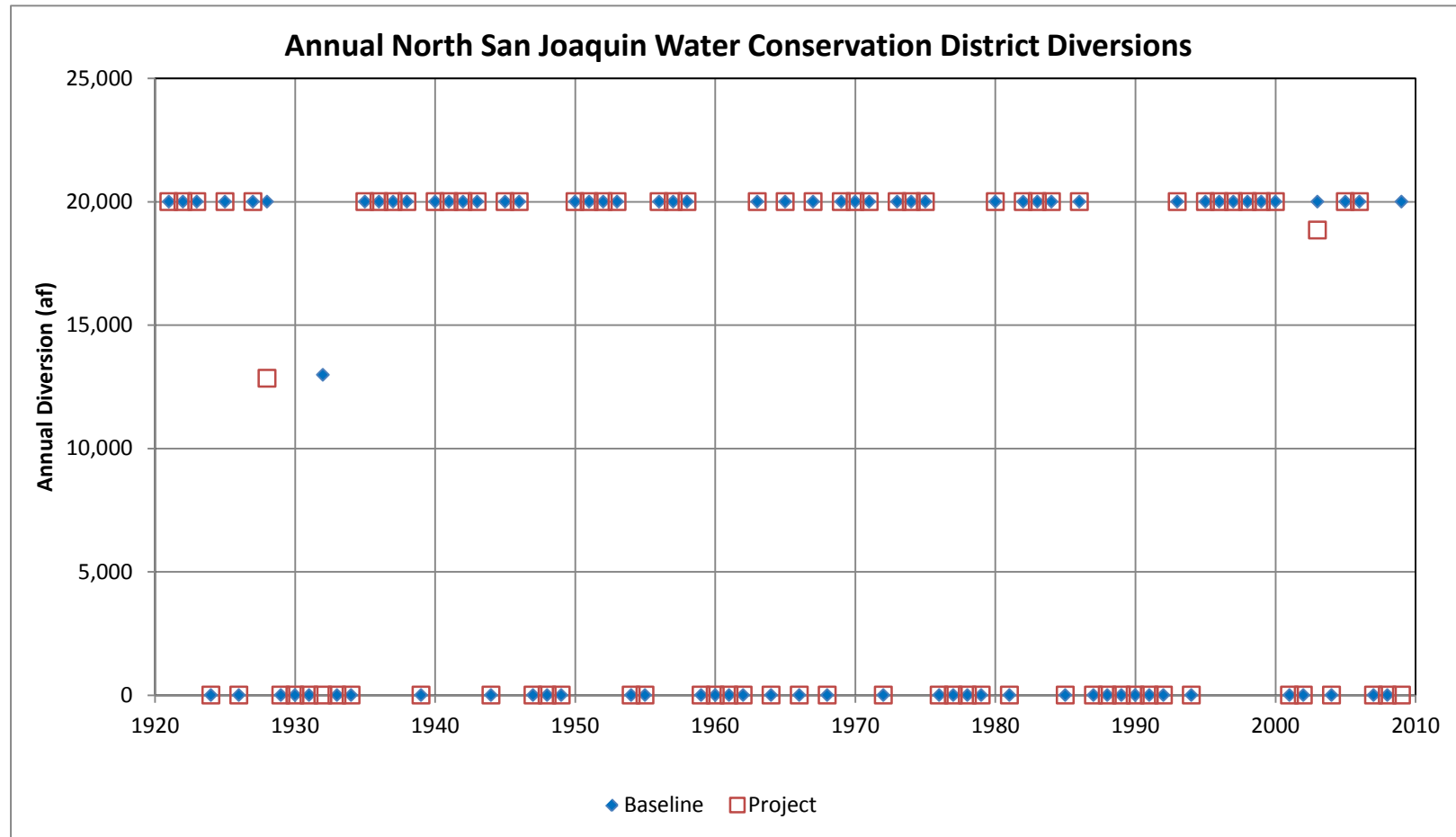
- It is recognized that local over-utilization may occur adjacent to watering facilities, corrals and salting areas. These areas will not be used to determine the RDM levels of a pasture. If the RDM levels drop below the amounts specified above, then all livestock shall be immediately removed from the affected pasture(s) until such time as EBMUD determines that said pasture(s) have recovered sufficiently for restocking.

EBMUD will provide monitoring results to Service annually, and provide copies of annual grazing plans to Service upon request. If the above thresholds are not met in a particular year, Service may require that the portions of the Annual Grazing Plans for the following year that are relevant to the upland habitats described above be reviewed by Service.

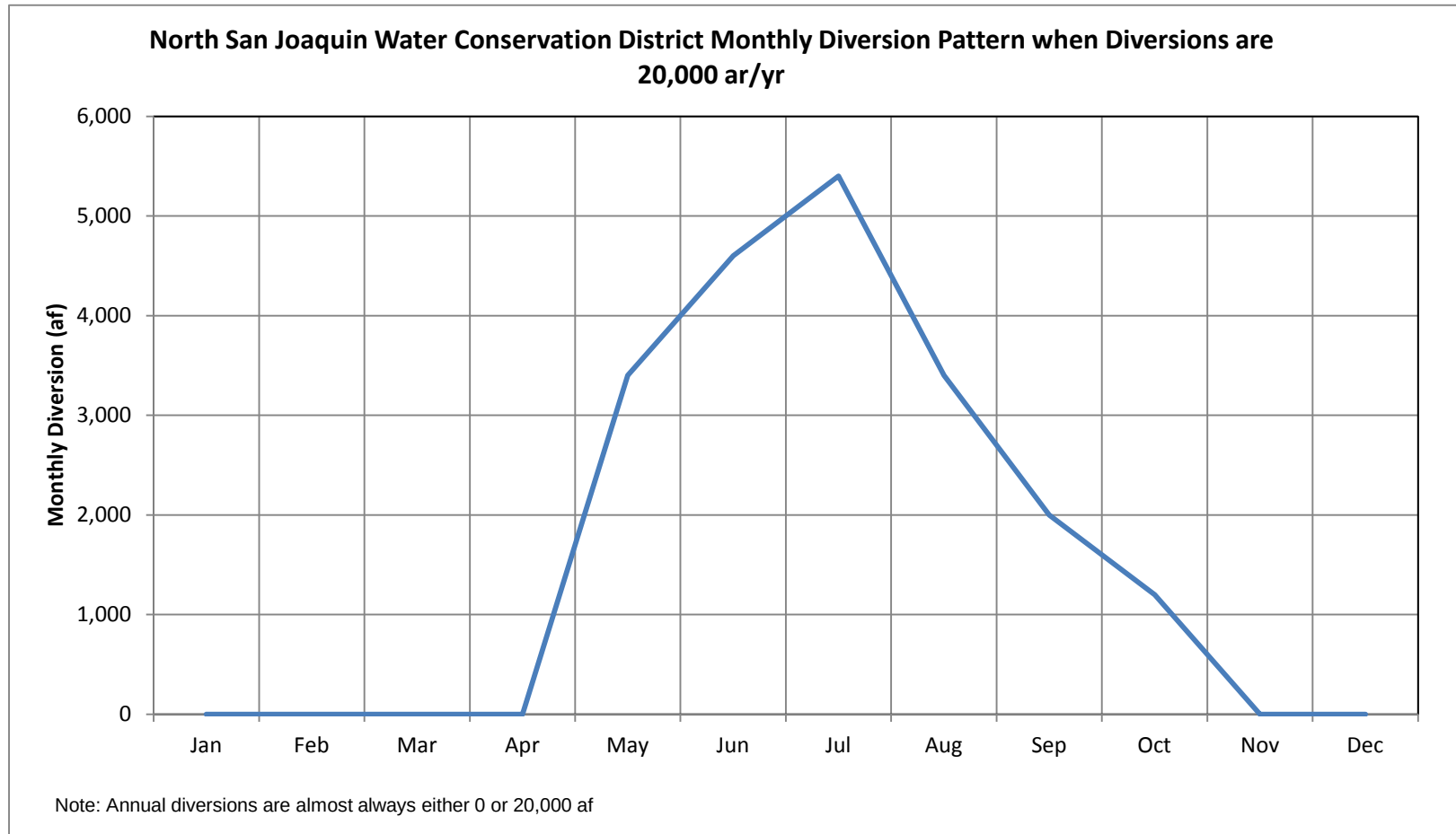
¹³ Bartolome, J.W., W.E. Frost, N.K. McDougald, and M. Conner. 2002. California Guidelines for Residual Dry Matter (RDM) Management on Coastal and Foothill Annual Rangelands. University of California, Division of Agriculture and Natural Resources, Publication 8092.

Appendix L

**Allocations to the North San Joaquin Water
Conservation District under Baseline and
Permit 10478 Time Extension Project Conditions**



Note: af = acre-feet



Note: af = acre-feet

L.1 Baseline Conditions, North San Joaquin Water Conservation District Allocations (acre-feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1921	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1922	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1923	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1926	0	0	0	0	0	0	0	0	0	0	0	0	0
1927	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1928	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	2208	2987	3507	2208	1299	779	0	0	12988
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1936	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1937	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1938	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1939	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1941	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1942	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1943	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1944	0	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
													Total
1946	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1947	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1951	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1952	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1953	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1954	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1957	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1958	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1959	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1970	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1971	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1974	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
													Total
1975	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1983	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1984	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1996	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1997	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1998	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1999	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
2000	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
2001	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
													Total
2003	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
2004	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
2006	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
2007	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000

L.2 Permit 10478 Time Extension Project Conditions, North San Joaquin Water Conservation District Allocations (acre-feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1921	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1922	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1923	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1926	0	0	0	0	0	0	0	0	0	0	0	0	0
1927	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1928	0	0	0	0	2184	2955	3468	2184	1285	771	0	0	12846
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1936	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1937	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1938	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1939	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1941	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1942	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1943	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1944	0	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1946	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1947	0	0	0	0	0	0	0	0	0	0	0	0	0

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1948	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1951	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1952	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1953	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1954	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1957	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1958	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1959	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1970	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1971	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1974	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1975	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1980	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1983	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1984	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1996	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1997	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1998	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1999	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
2000	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
2001	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	3204	4334	5088	3204	1885	1131	0	0	18845
2004	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
2006	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
2007	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix M

**Number of Months when
Reservoir Storage Falls below
Recreation Opportunity Thresholds under Baseline
and Permit 10478 Time Extension Project Conditions**

Table M-1. Number of Months when Pardee Reservoir Falls Below Recreation Opportunity Threshold at Pardee Recreation Area during the 89-Year Simulation (801 months)^{a, b}

	Baseline (months)	Permit 10478 Time Extension Project (months)
Main Boat Launch (540 ft msl, 142,420 AF)		
February	5	5
March	4	5
April	3	3
May	3	4
June	3	4
July	4	5
August	4	7
September	5	10
October	9	11
TOTAL	40	54
Low Water Boat Launch (495 ft msl, 75,480 AF)		
February	2	3
March	1	1
April	1	1
May	1	1
June	1	1
July	1	1
August	1	1
September	1	1
October	1	1
TOTAL	10	11

Notes:

^a Data obtained from EBMUDSIM modeling results that were based on historic runoff for 1921 through 2009 (Appendix E).

^b The Pardee Recreation Area is open to the public from the first Friday in February through the last Sunday in October (i.e., 9 months out of the year).

AF = acre-feet

ft msl = feet above mean sea level

Table M-2. Number of Months when Camanche Reservoir Falls Below Recreation Opportunity Threshold at Camanche Reservoir North Shore Recreation Area during the 89-Year Simulation (1,068 months)^{a, b}

	Baseline (months)	Permit 10478 Time Extension Project (months)
Main Ramp (210 ft msl, 247,231 AF)		
January	26	28
February	28	32
March	21	24
April	22	28
May	23	29
June	24	29
July	30	33
August	32	34
September	33	35
October	22	29
November	22	30
December	27	33
TOTAL	310	364
Main Ramp (194 ft msl, 164,370 AF)		
January	12	13
February	11	11
March	10	10
April	9	11
May	9	11
June	9	10
July	10	11
August	11	12
September	12	12
October	12	11
November	12	12
December	12	13
TOTAL	129	137
Main Ramp, Low-Water Ramp (160 ft msl, 54,246 AF)		
January	2	2
February	2	2
March	2	2
April	2	2
May	2	2
June	2	3
July	2	3
August	2	2
September	2	2

	Baseline (months)	Permit 10478 Time Extension Project (months)
October	2	2
November	2	2
December	2	2
TOTAL	24	26

Notes:

^a Data obtained from EBMUDSIM modeling results that were based on historic runoff for 1921 through 2009 (Appendix E).

^b The Camanche North Shore Recreation Area is open year round (i.e., 12 months out of the year).

AF = acre-feet

ft msl = feet above mean sea level

Table M-3. Number of Months when Camanche Reservoir Falls Below Recreation Opportunity Threshold at Camanche Reservoir South Shore Recreation Area during the 89-Year Simulation (1,068 months)^{a, b}

	Baseline (months)	Permit 10478 Time Extension Project (months)
Main Ramp (205 ft msl, 219,265 AF)		
January	18	22
February	19	21
March	14	17
April	13	17
May	17	19
June	17	19
July	17	23
August	21	28
September	22	28
October	13	17
November	15	19
December	16	22
TOTAL	202	252
Main Ramp Low-Water Ramp (175 ft msl, 91,528 AF)		
January	4	6
February	4	5
March	4	5
April	5	6
May	4	5
June	4	5
July	4	5
August	3	5
September	3	4
October	2	3
November	2	5
December	5	6
TOTAL	44	60
Main Ramp, Low-Water Ramp (160 ft msl, 54,246 AF)		
January	2	2
February	2	2
March	2	2
April	2	2
May	2	2
June	2	3
July	2	3
August	2	2
September	2	2
October	2	2

	Baseline (months)	Permit 10478 Time Extension Project (months)
November	2	2
December	2	2
TOTAL	24	26

Notes:

^a Data obtained from EBMUDSIM modeling results that were based on historic runoff for 1921 through 2009 (Appendix E).

^b The Camanche South Shore Recreation Area is open year round (i.e., 12 months out of the year).

AF = acre-feet

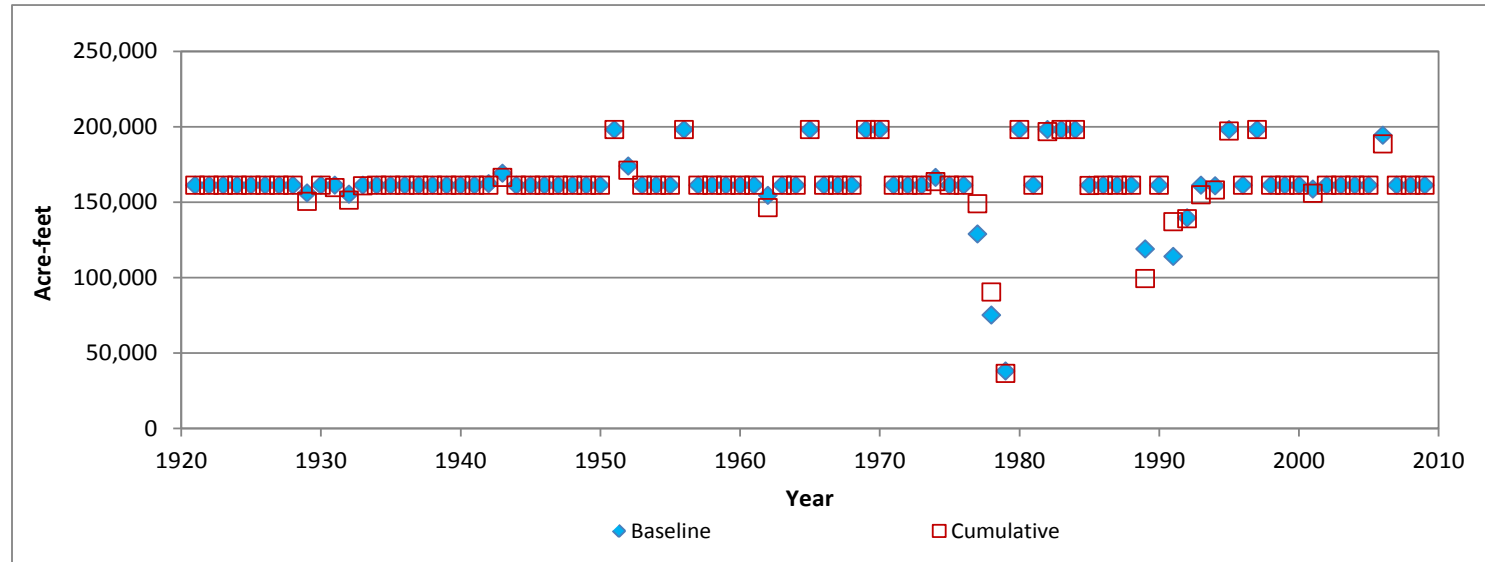
ft msl = feet above mean sea level

Appendix N

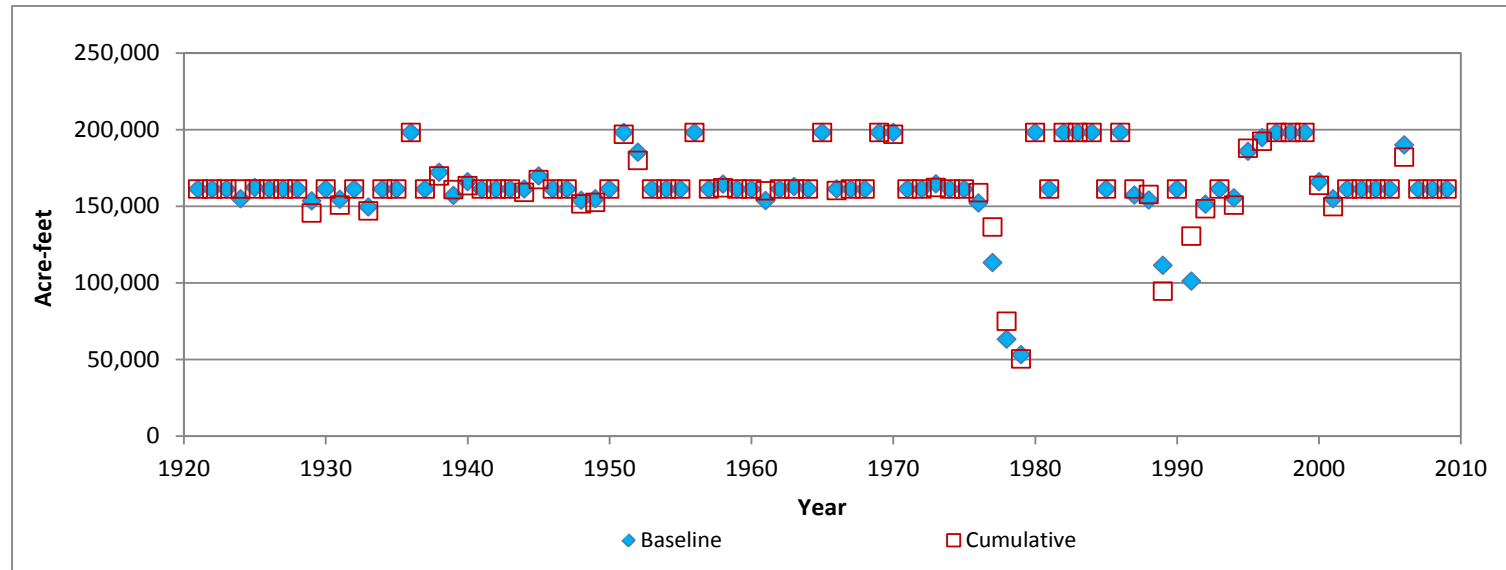
**Monthly Graphs of Baseline and Cumulative
EBMUDSIM Results for Pardee Reservoir Storage,
Camanche Reservoir Storage, Camanche Release
Flows, and Flows below Woodbridge**

N.1 Pardee Reservoir Storage

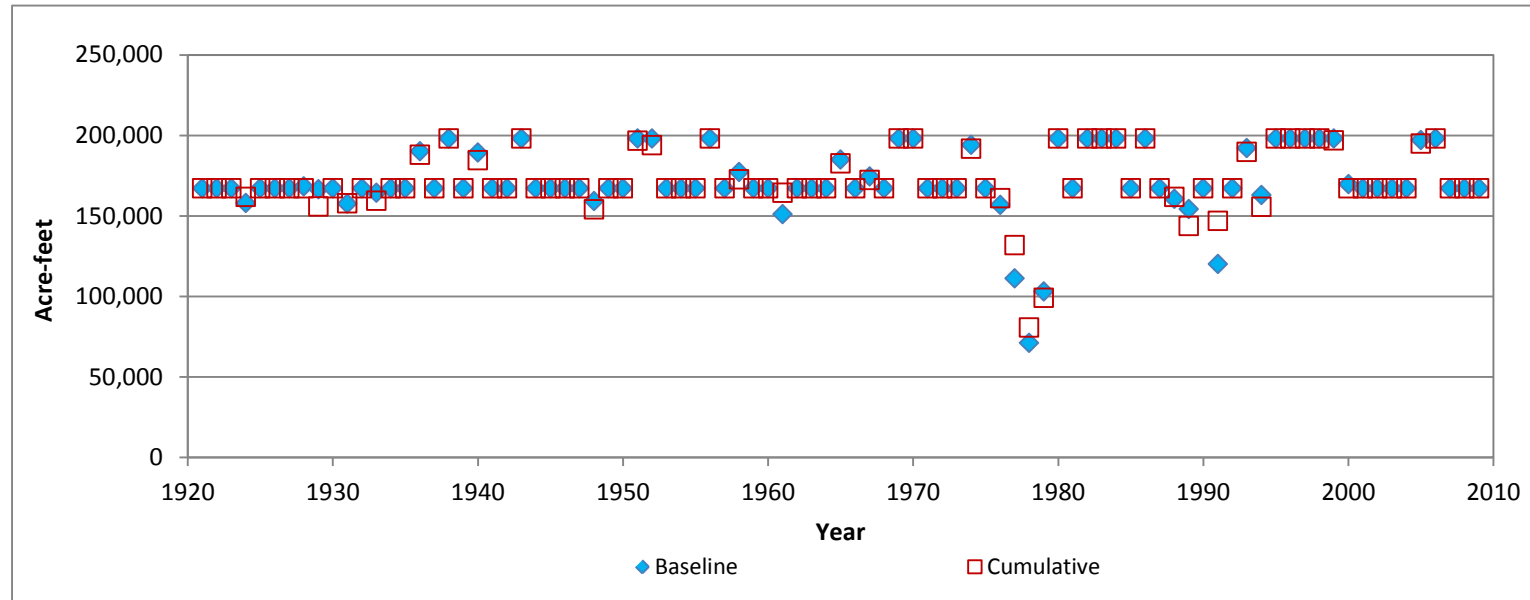
January



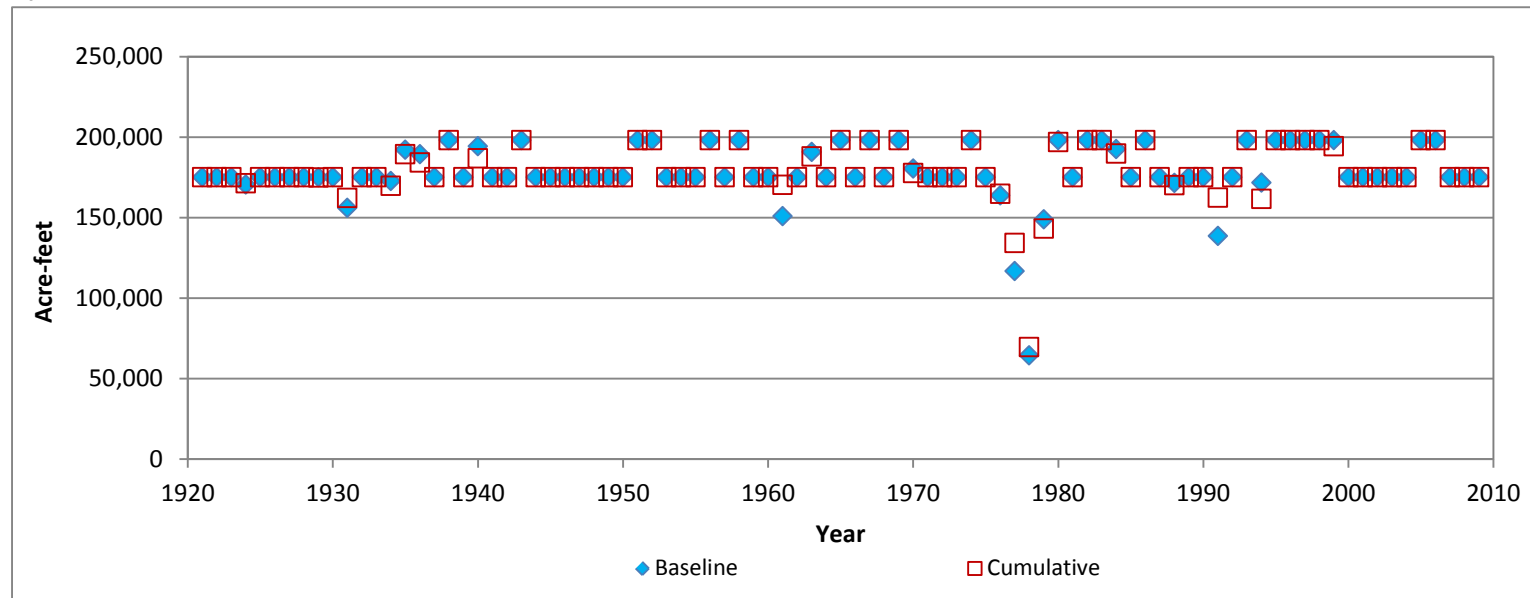
February



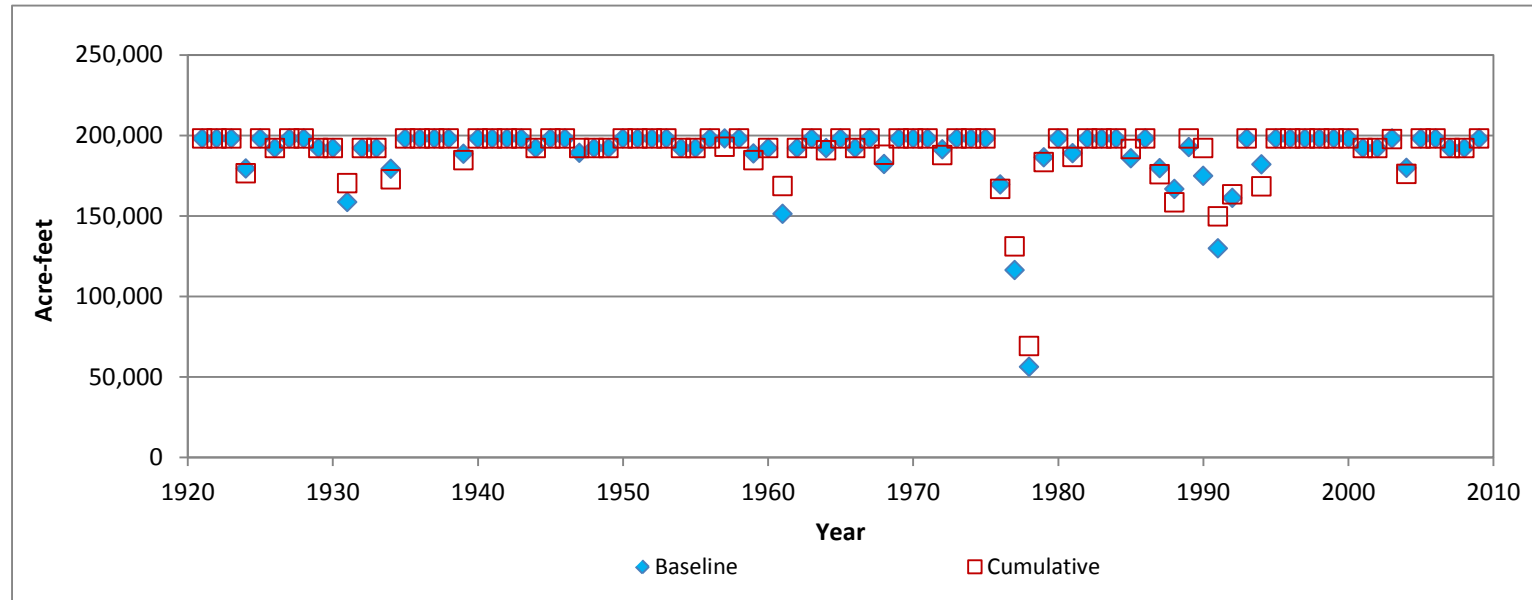
March



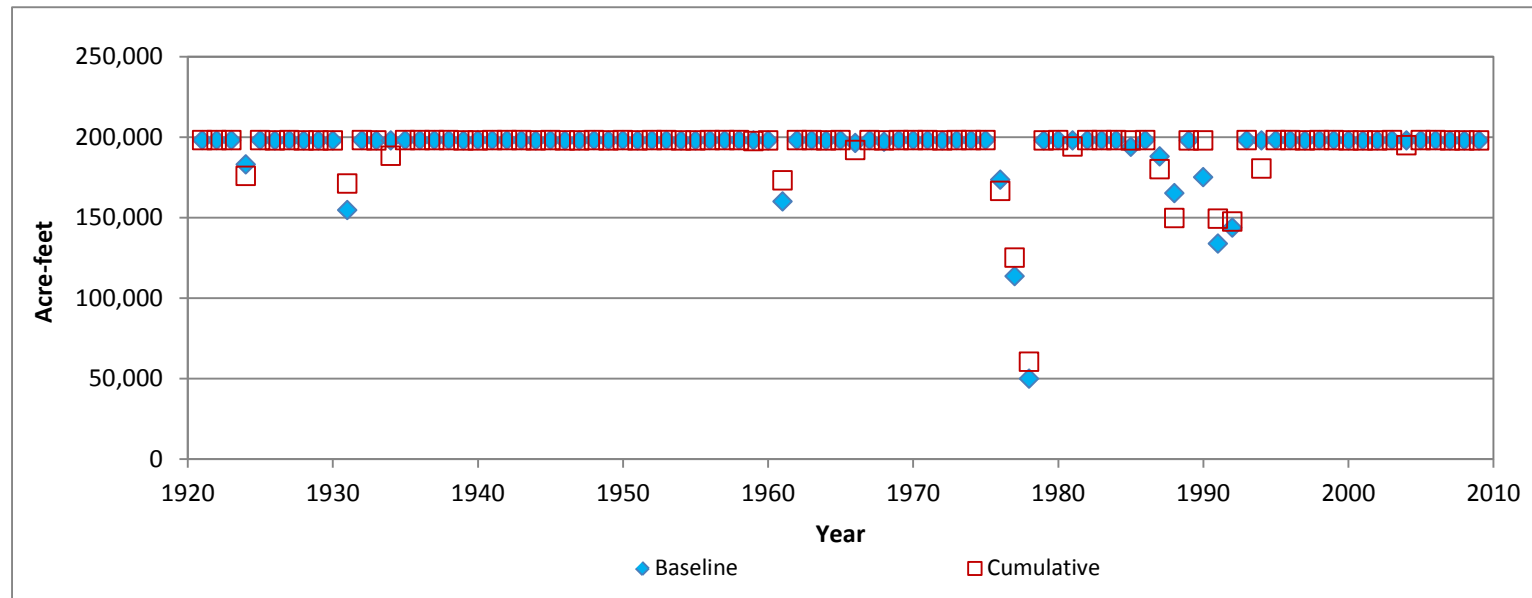
April



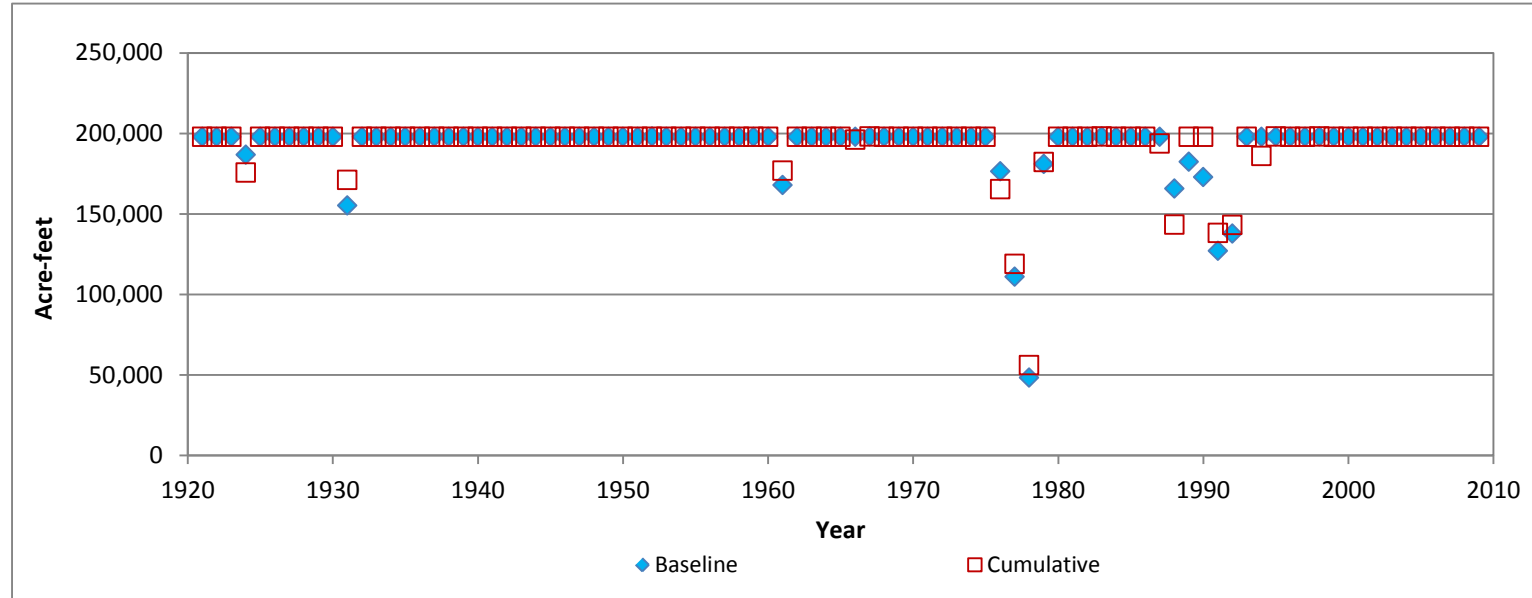
May



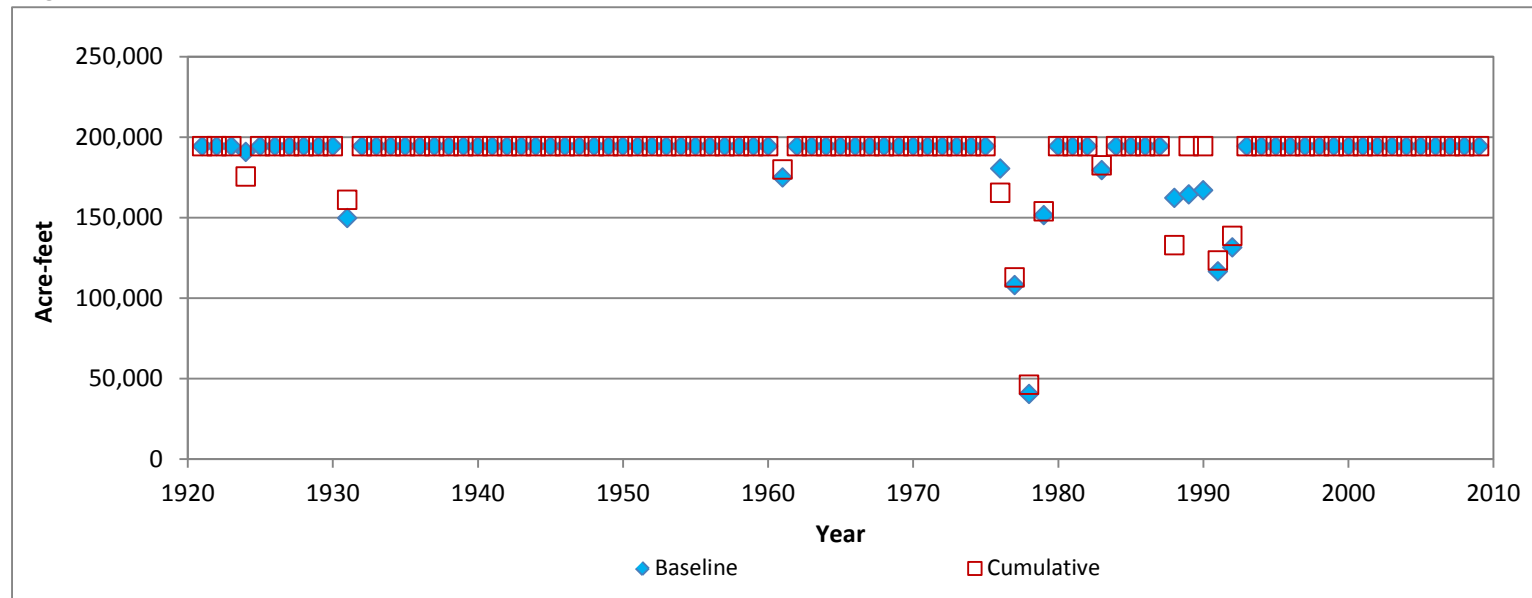
June



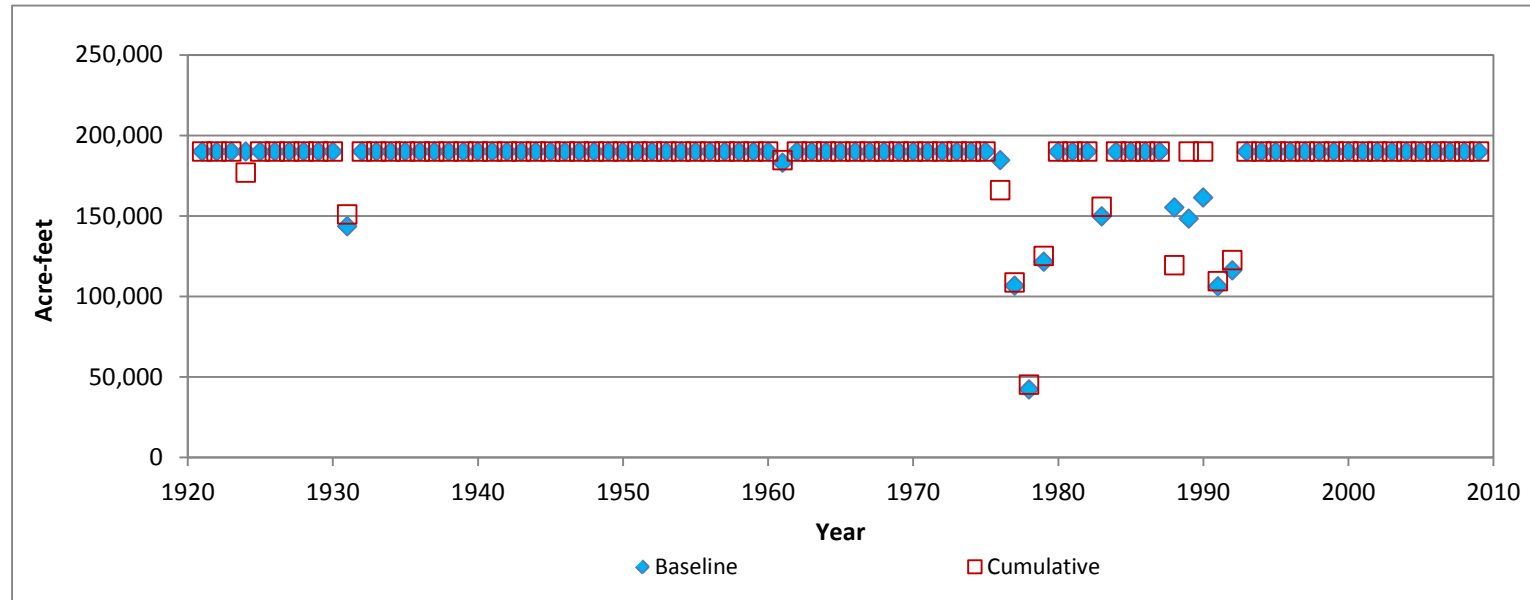
July



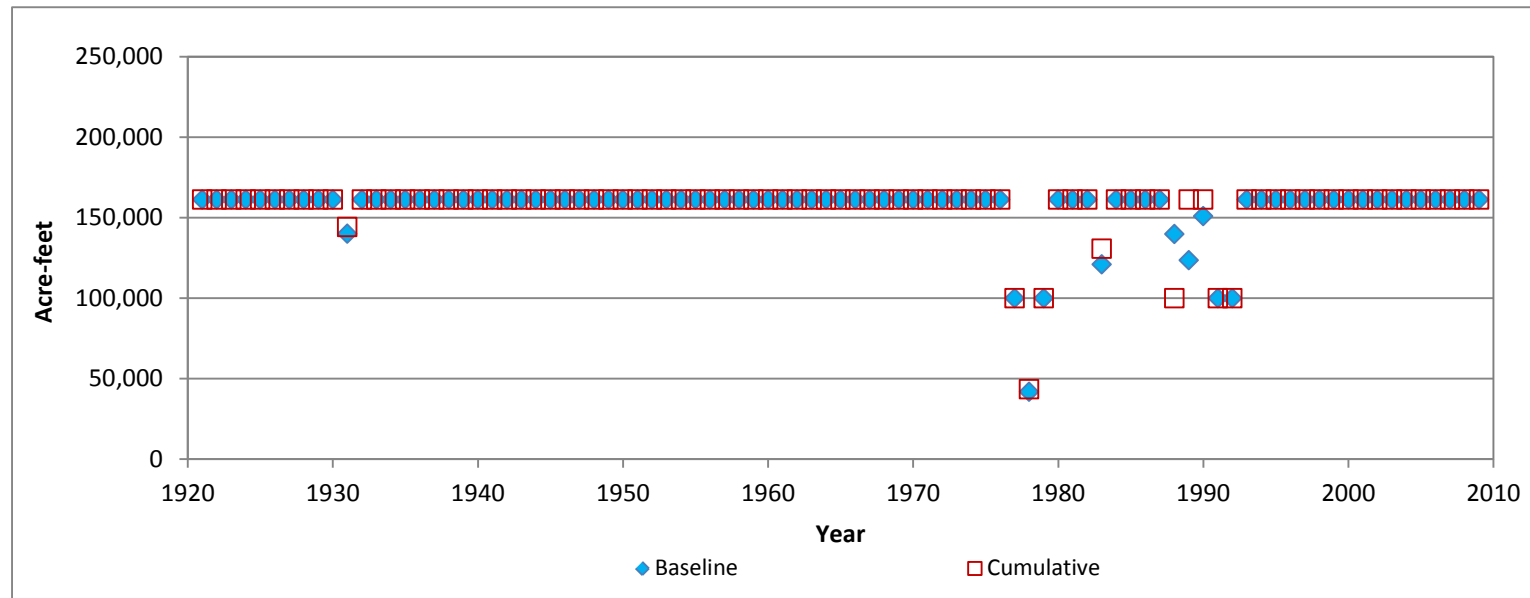
August



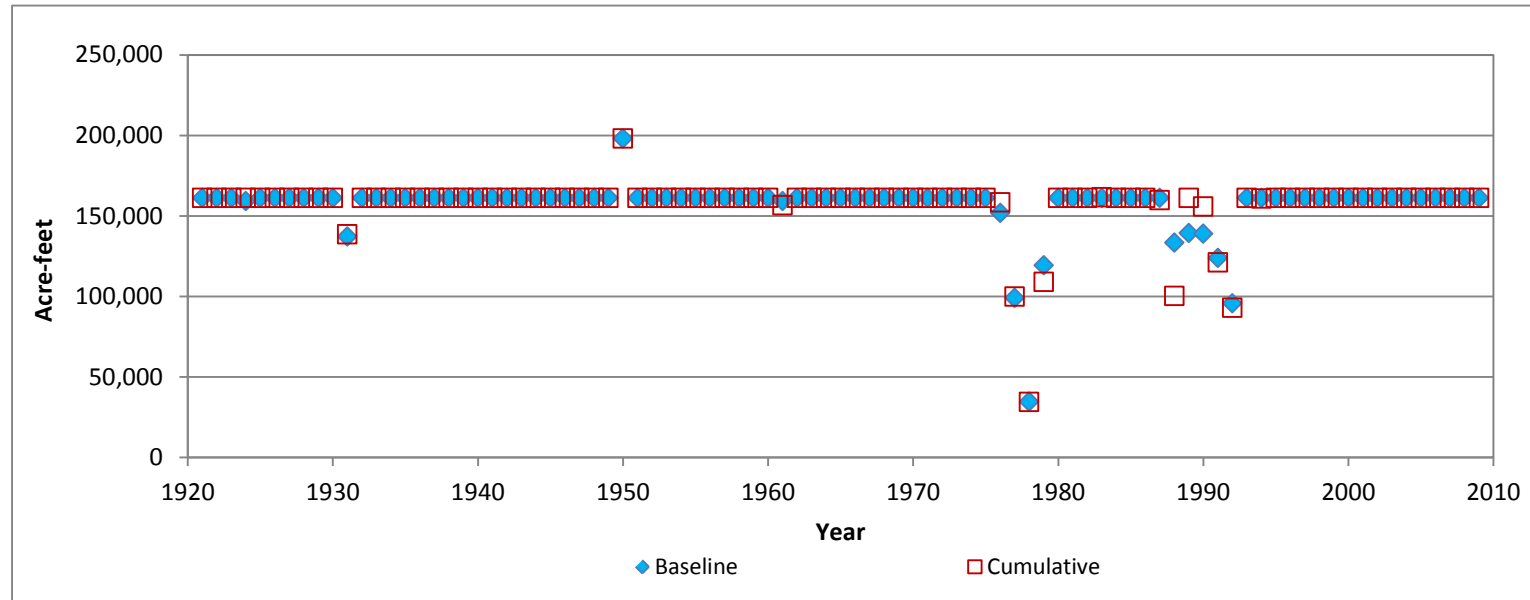
September



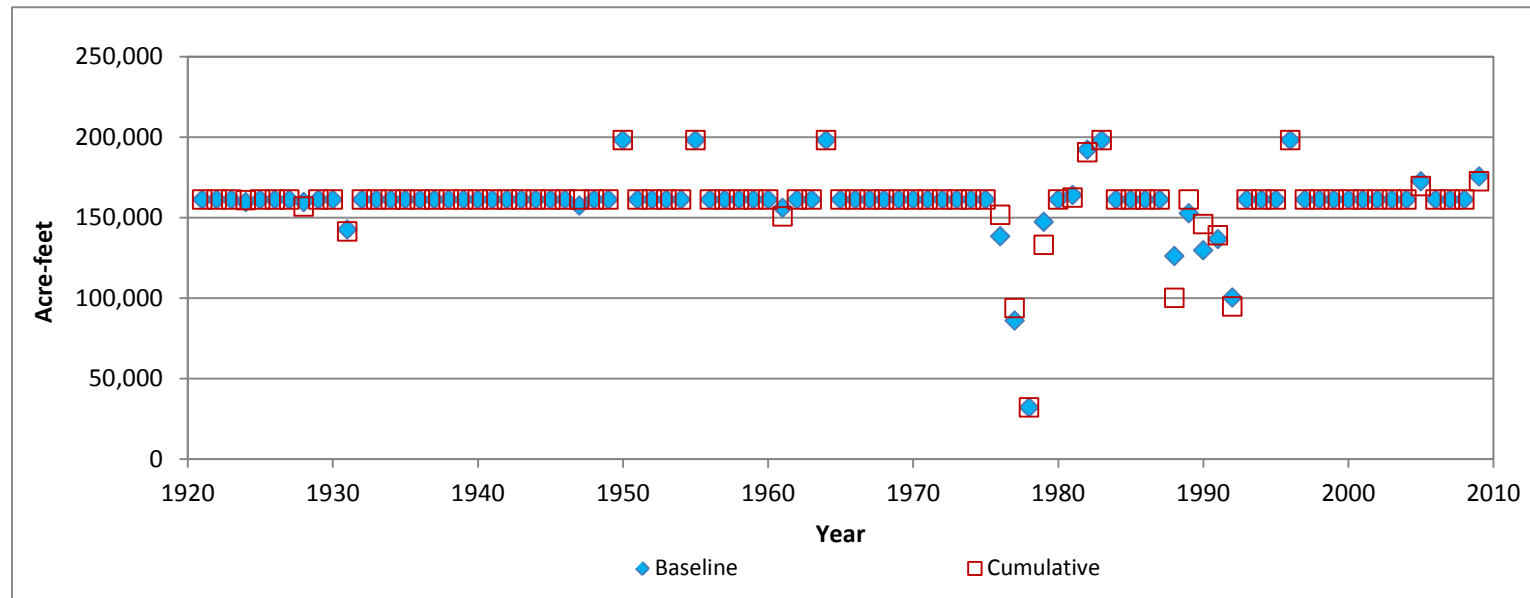
October



November

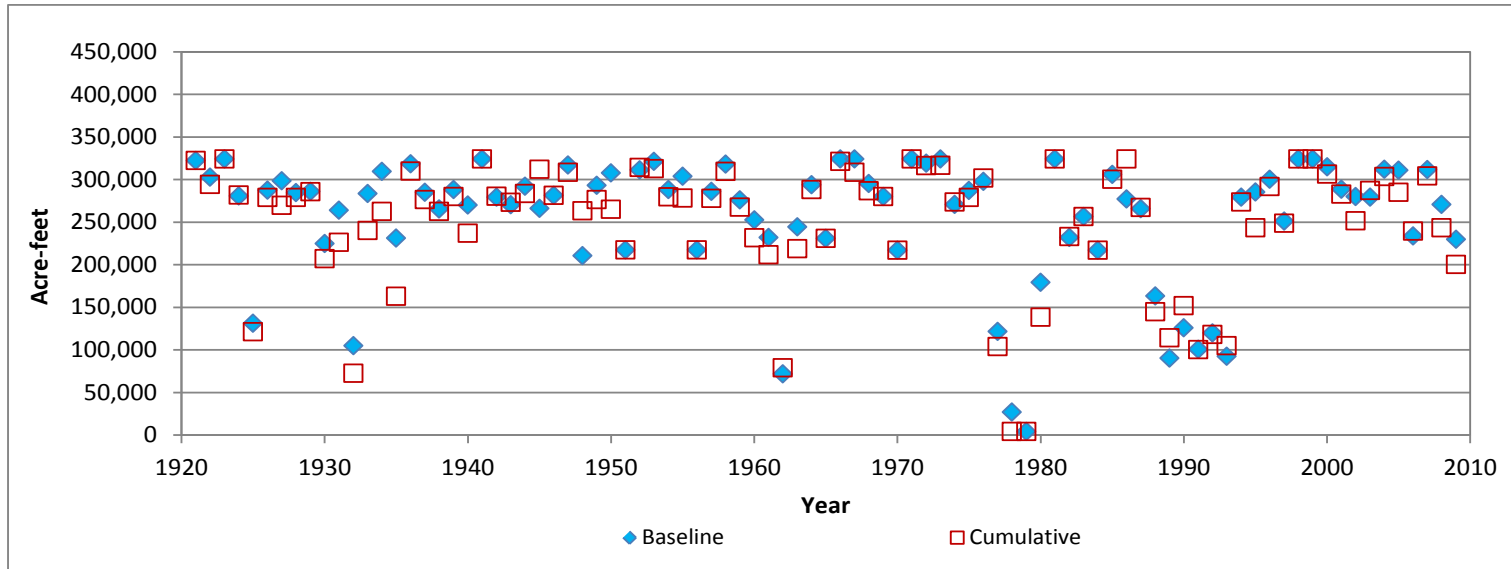


December

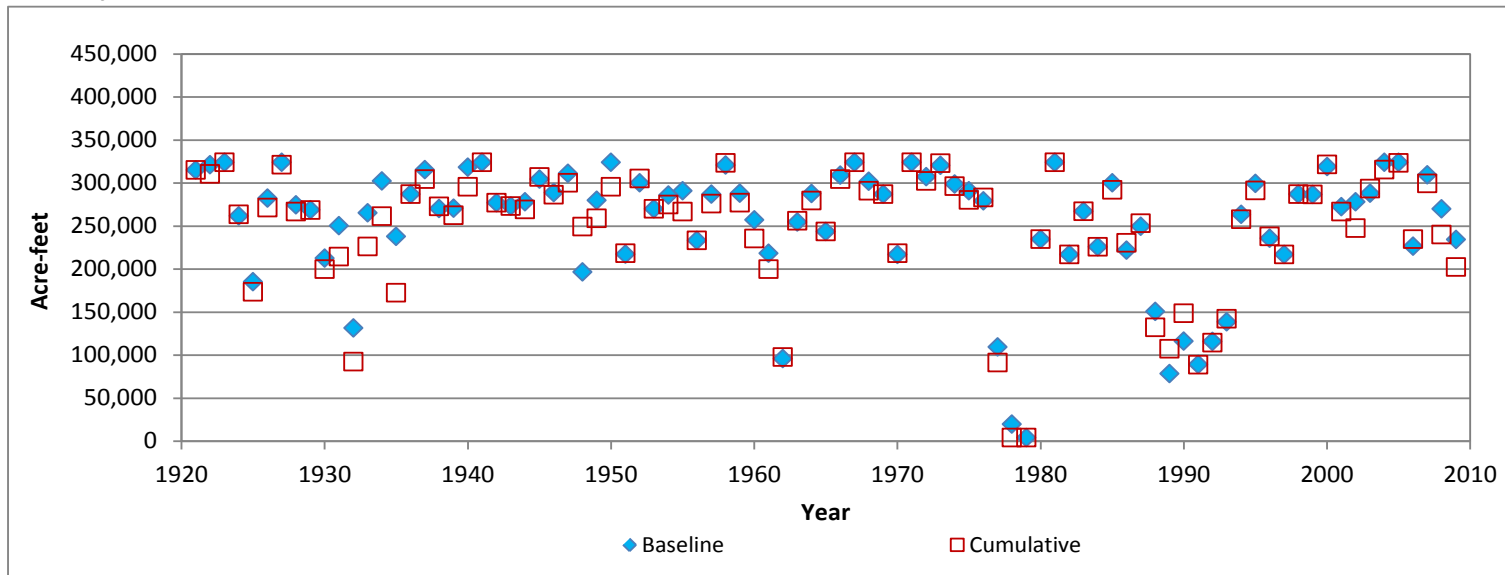


N.2 Camanche Reservoir Storage

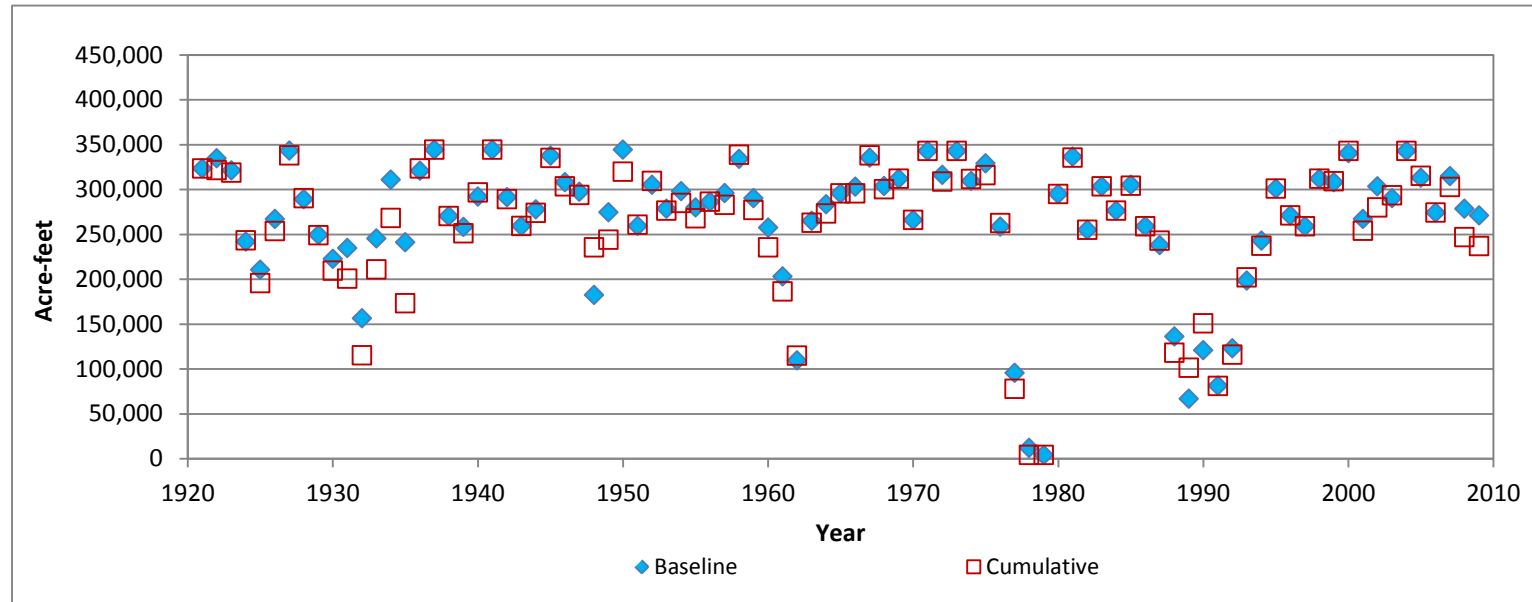
January



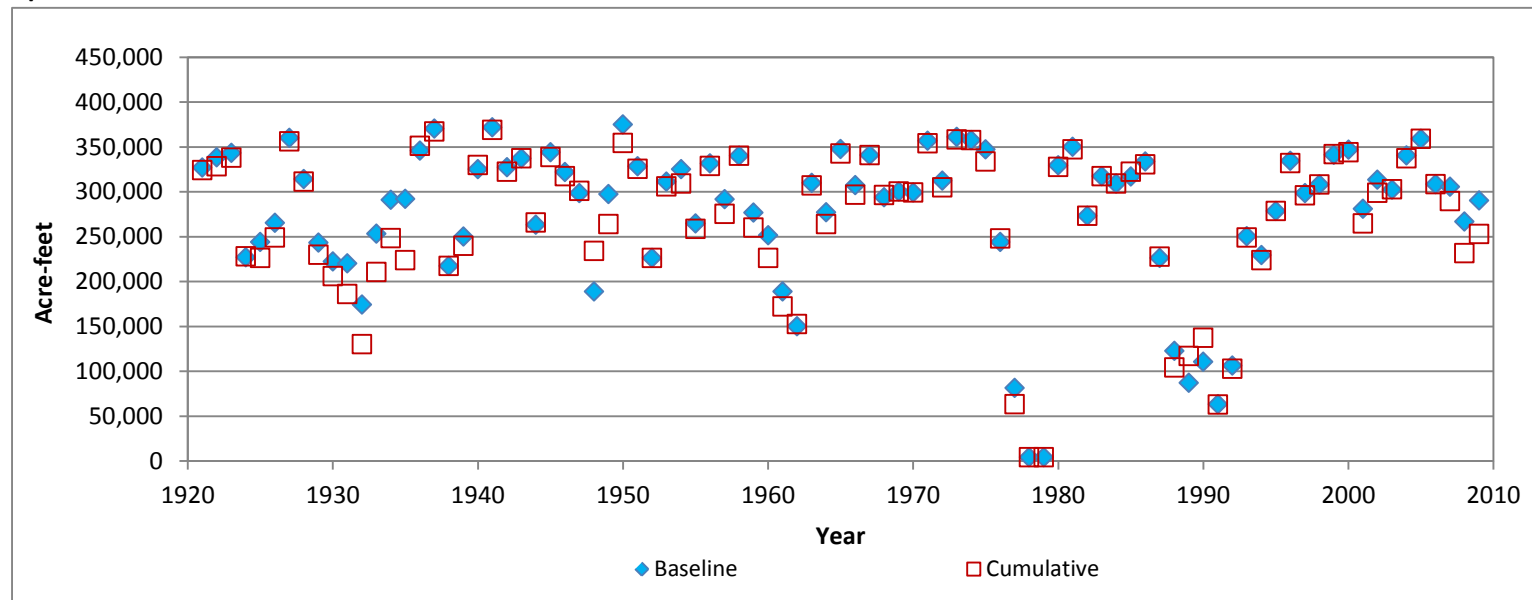
February



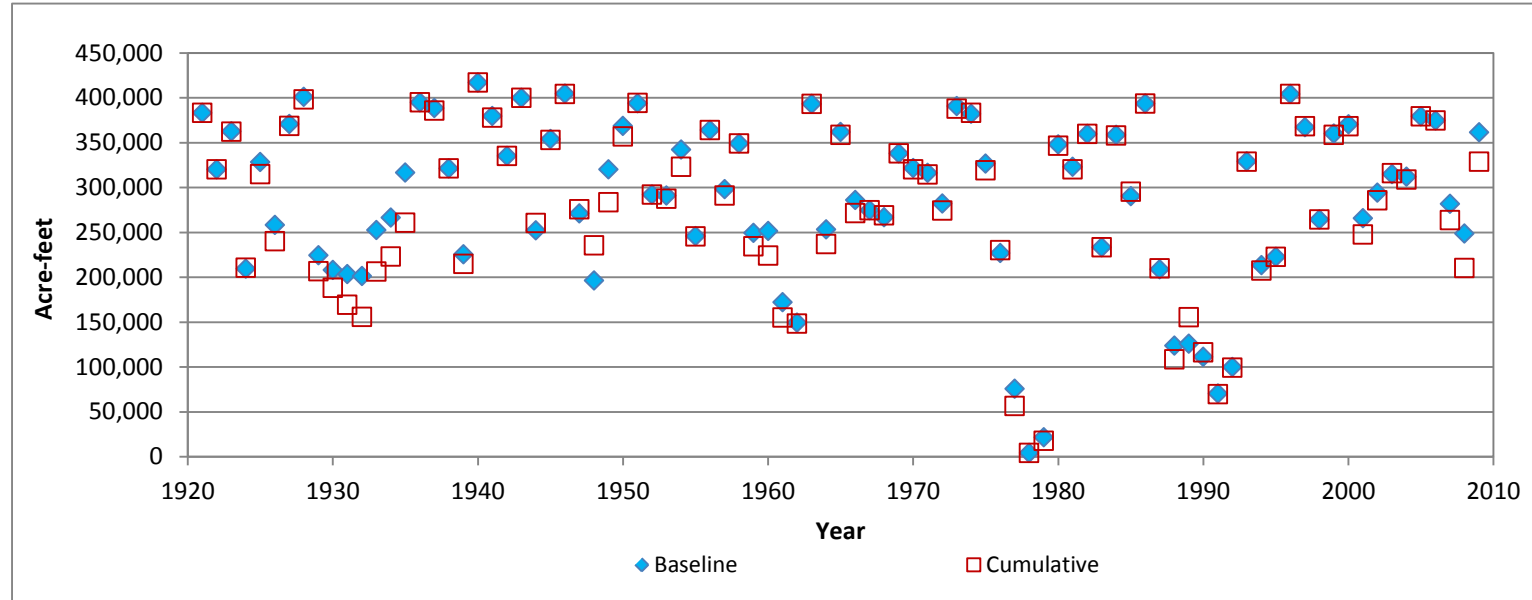
March



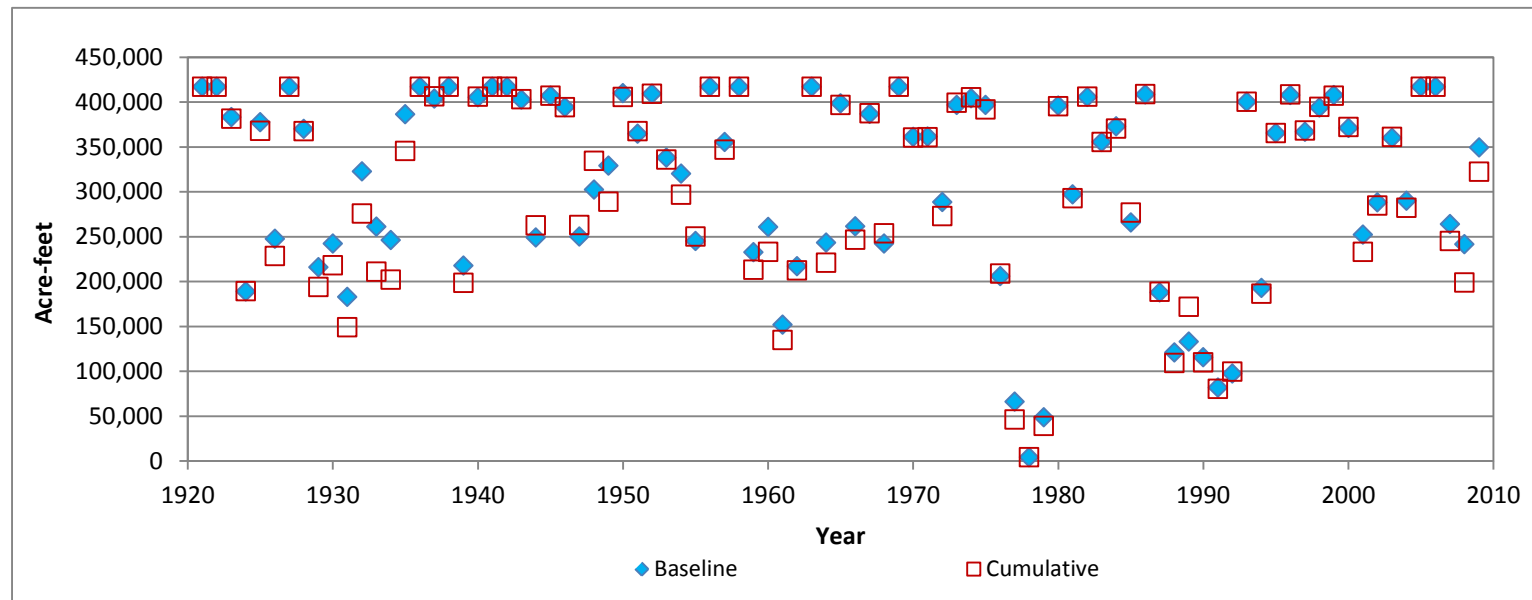
April



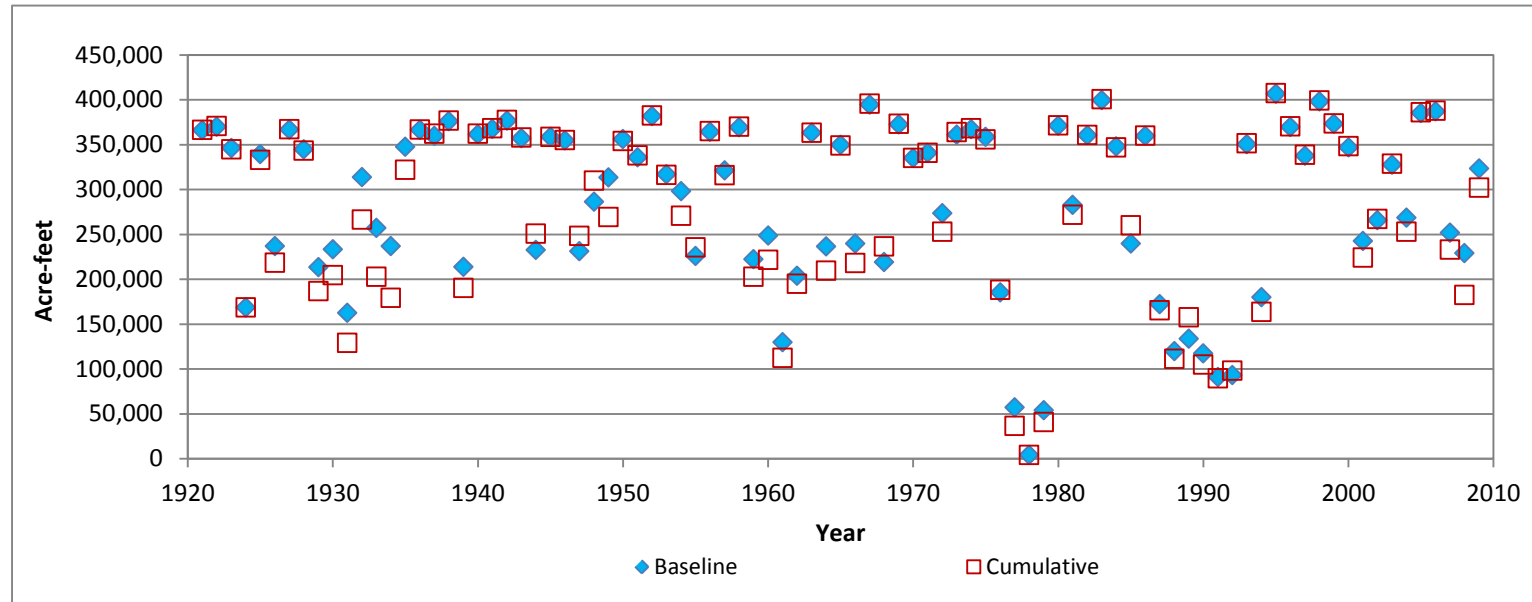
May



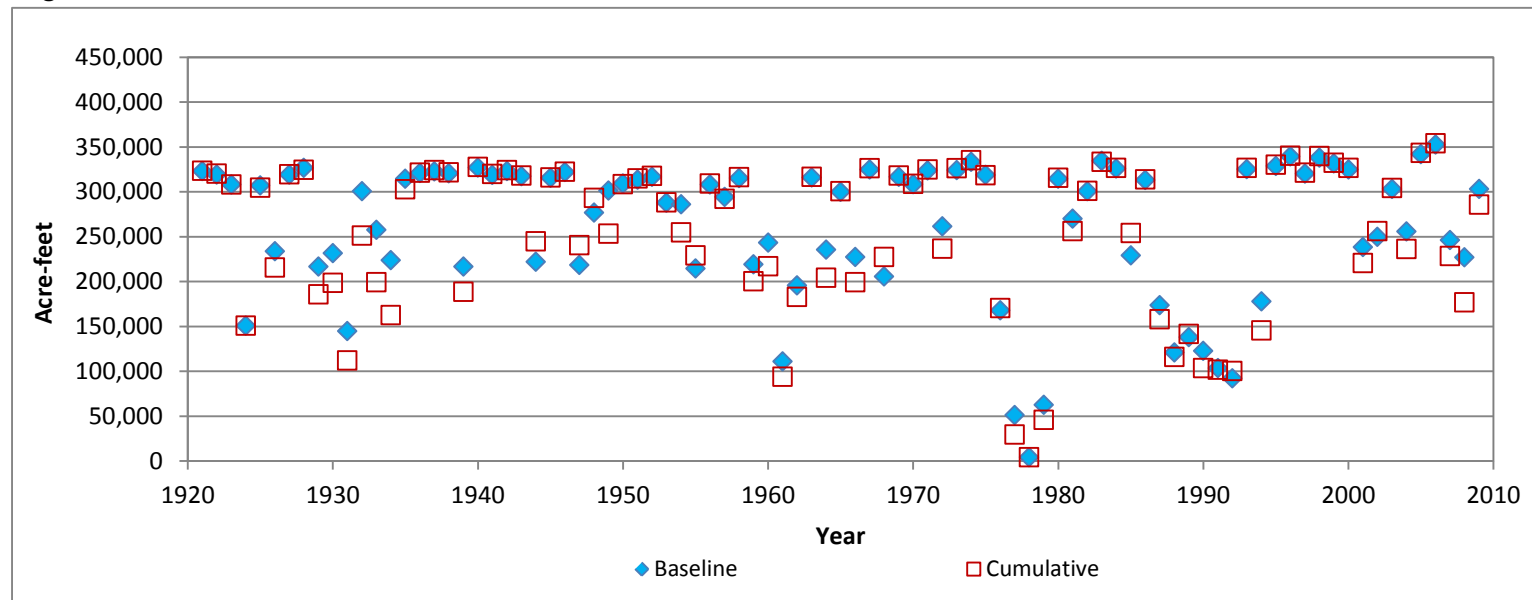
June



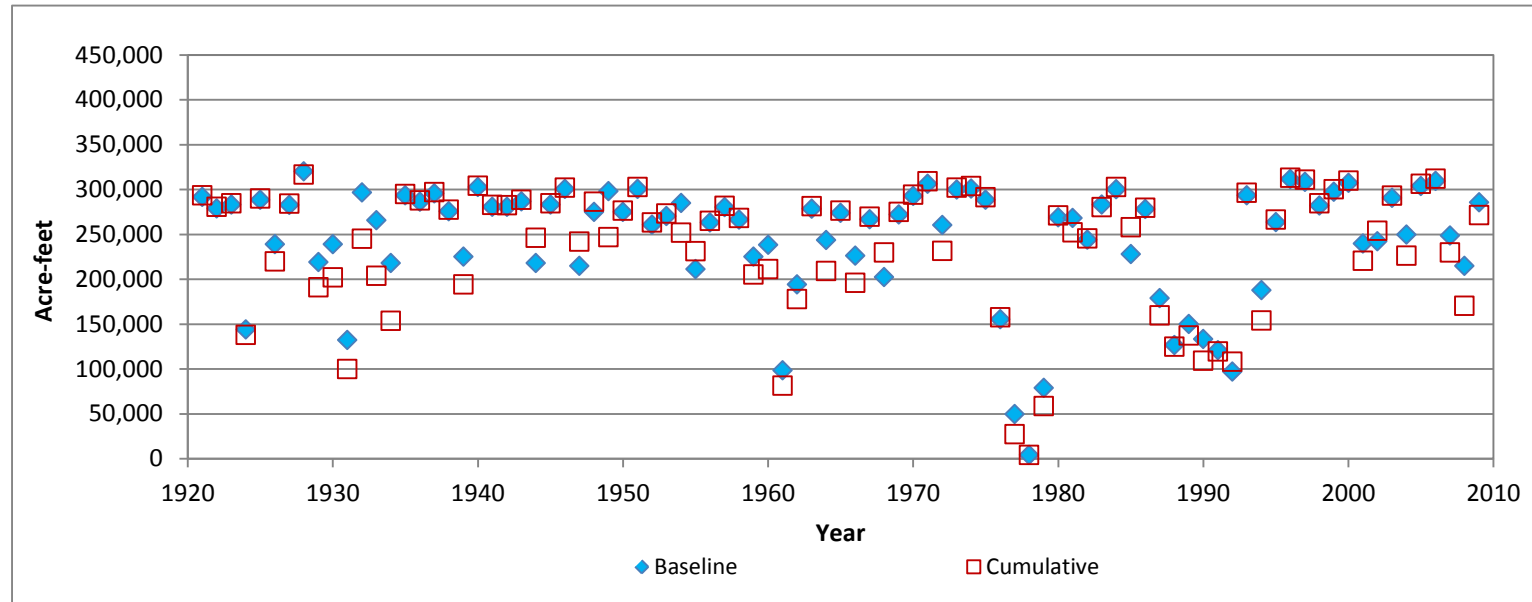
July



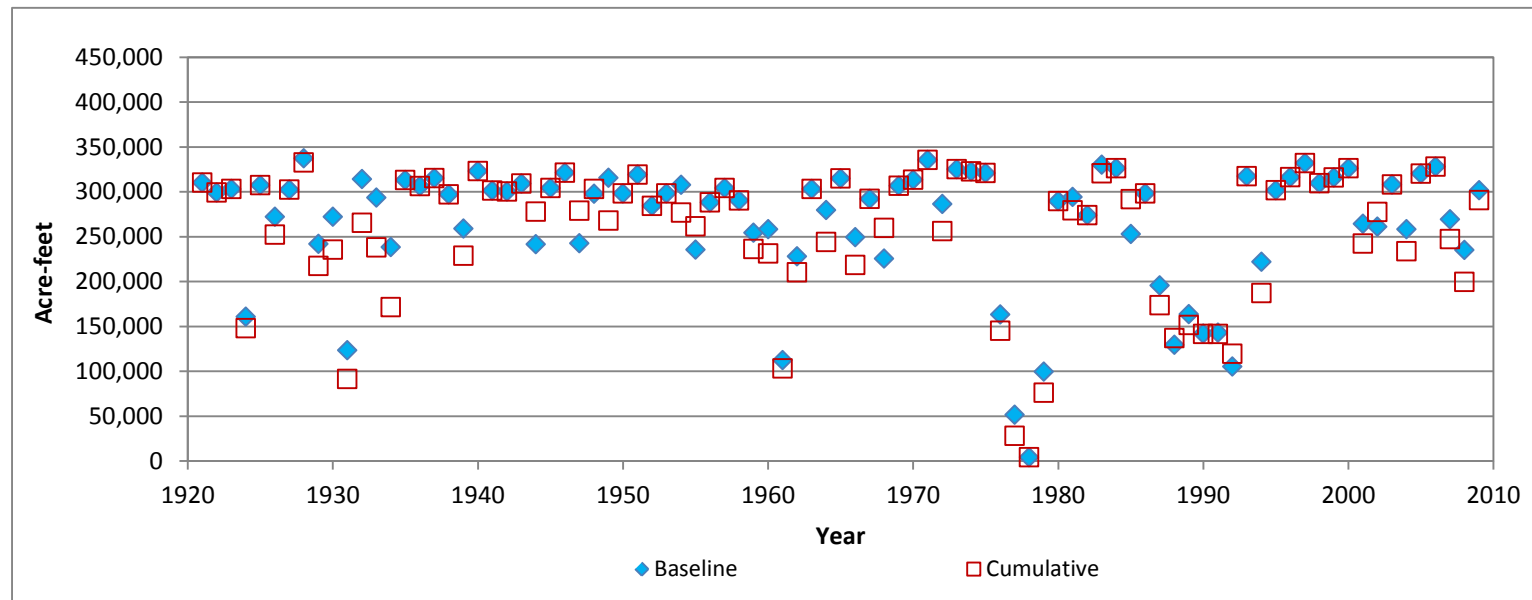
August



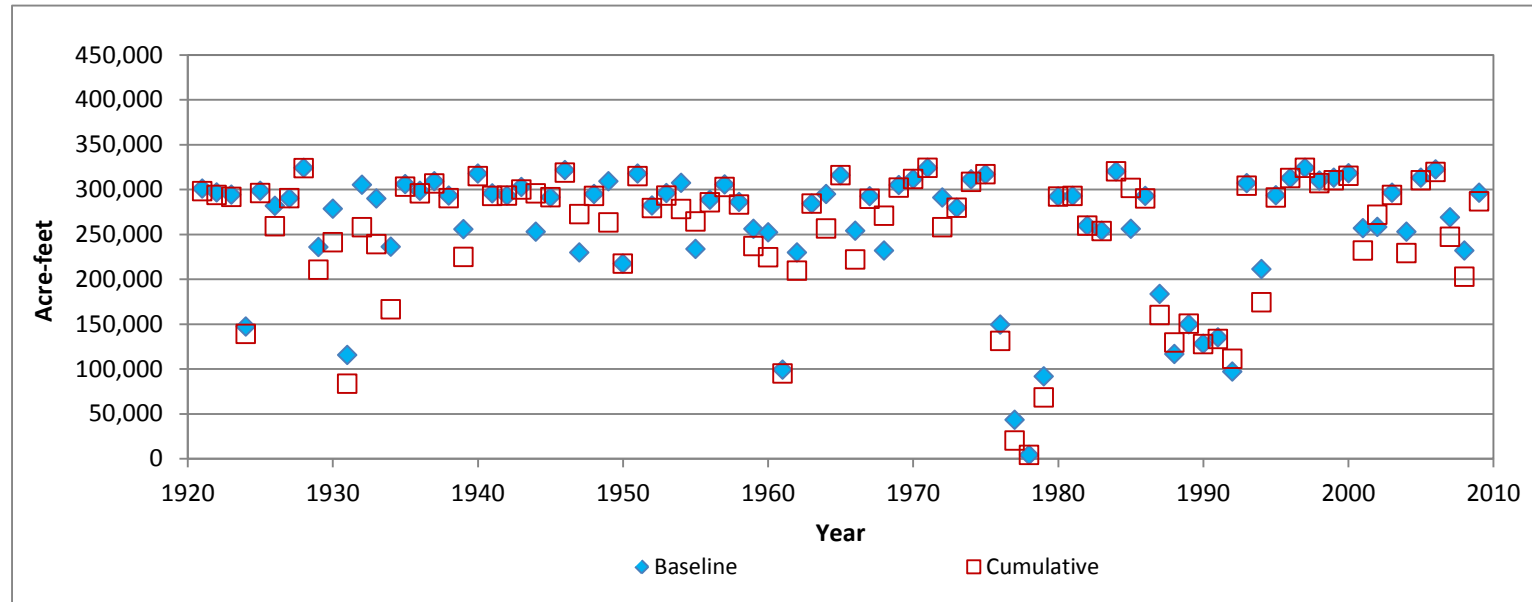
September



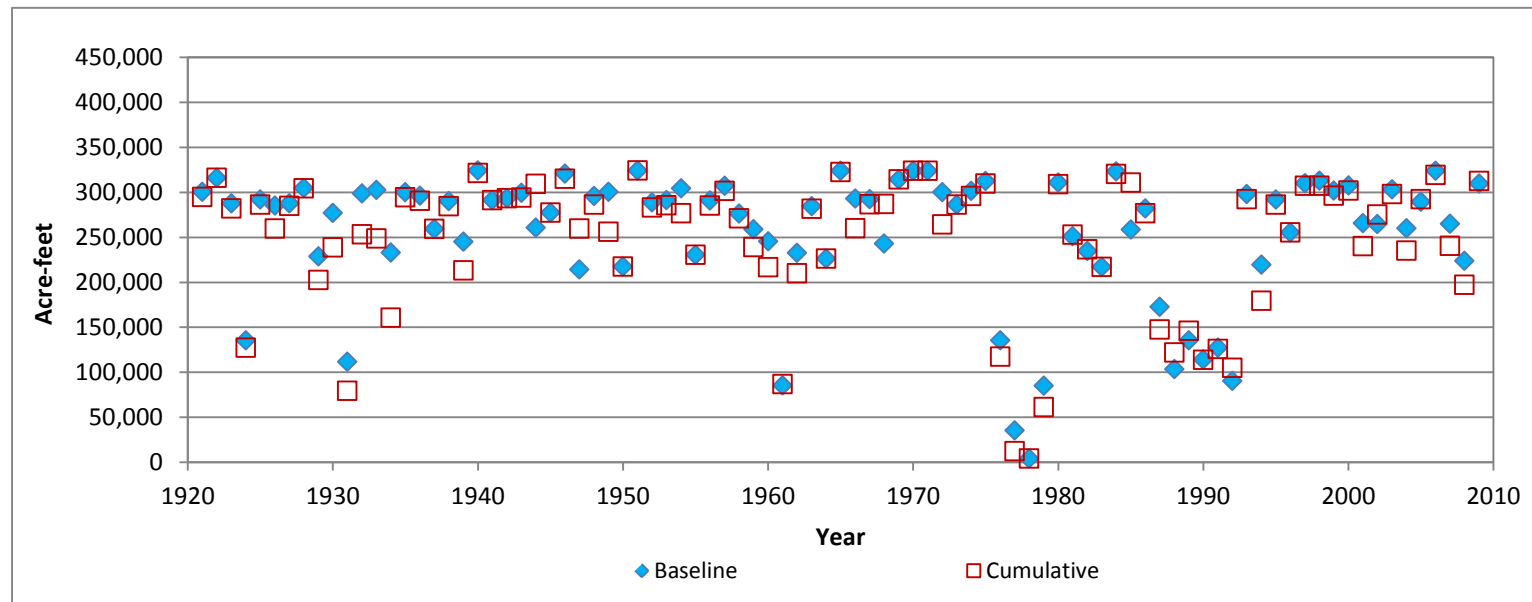
October



November

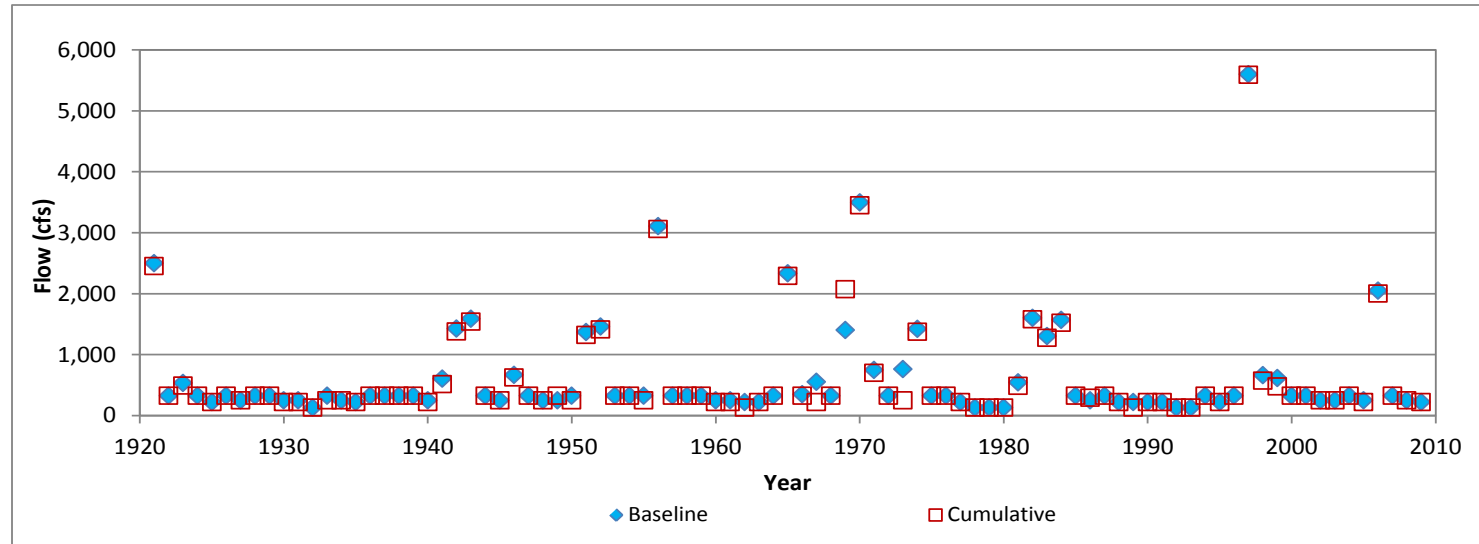


December

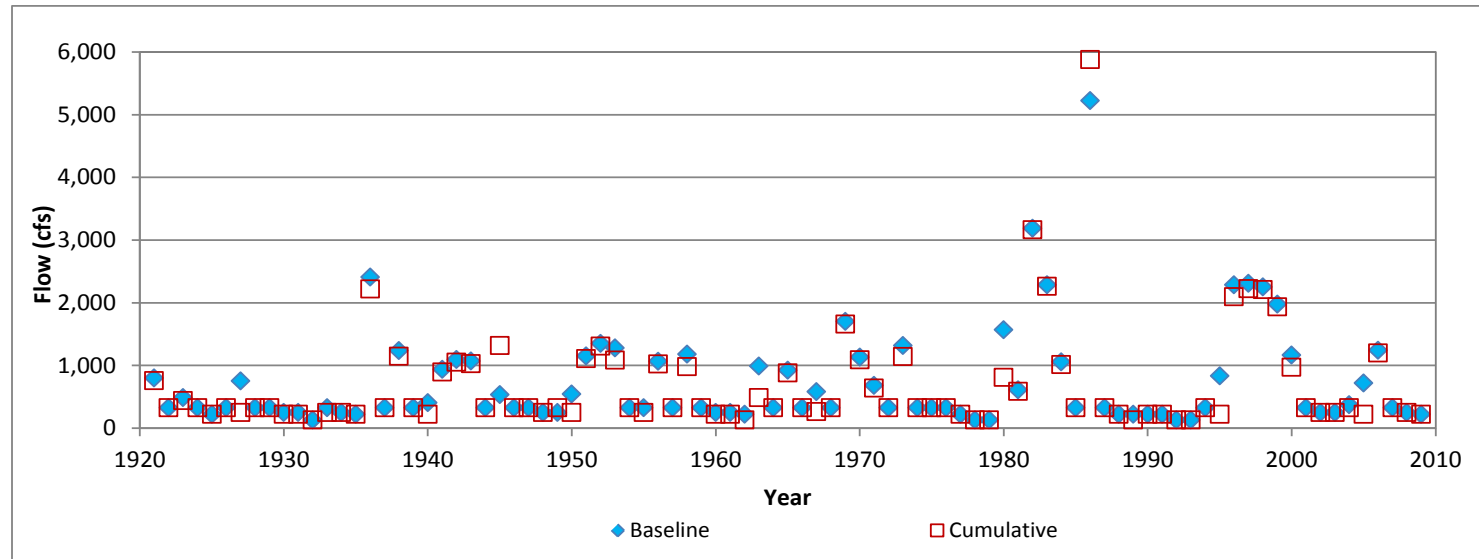


N.3 Camanche Releases to the Lower Mokelumne River

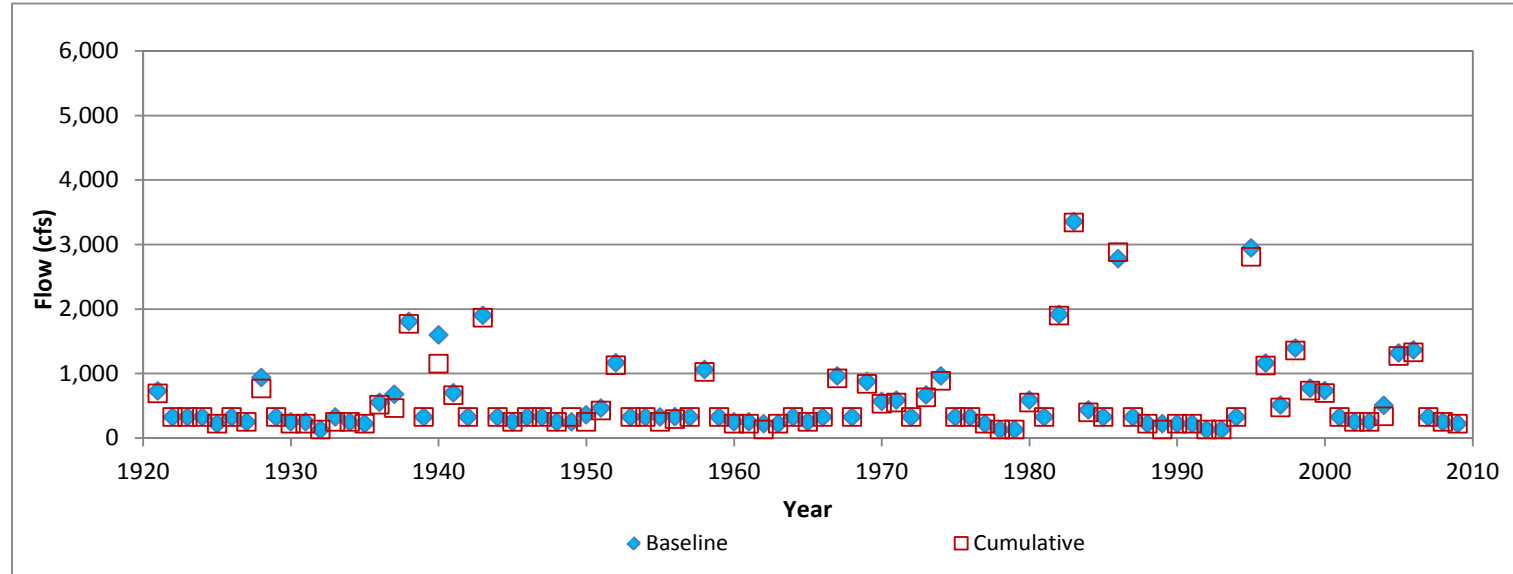
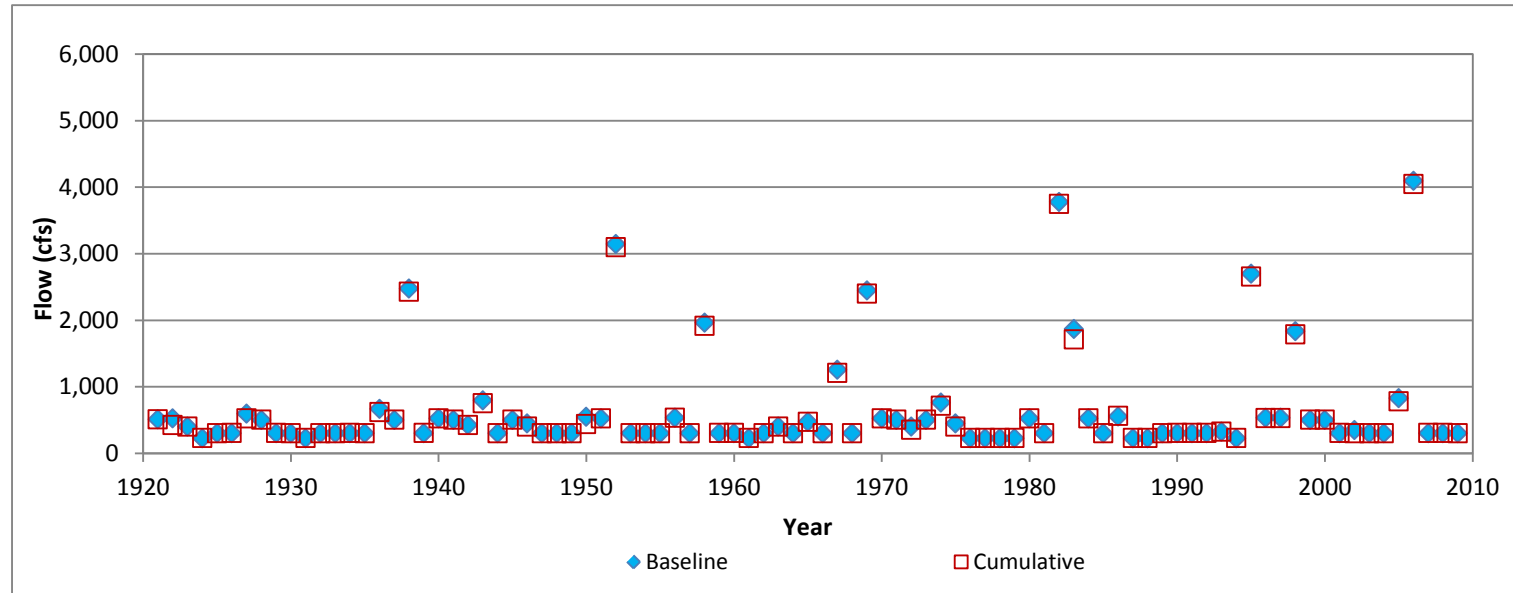
January



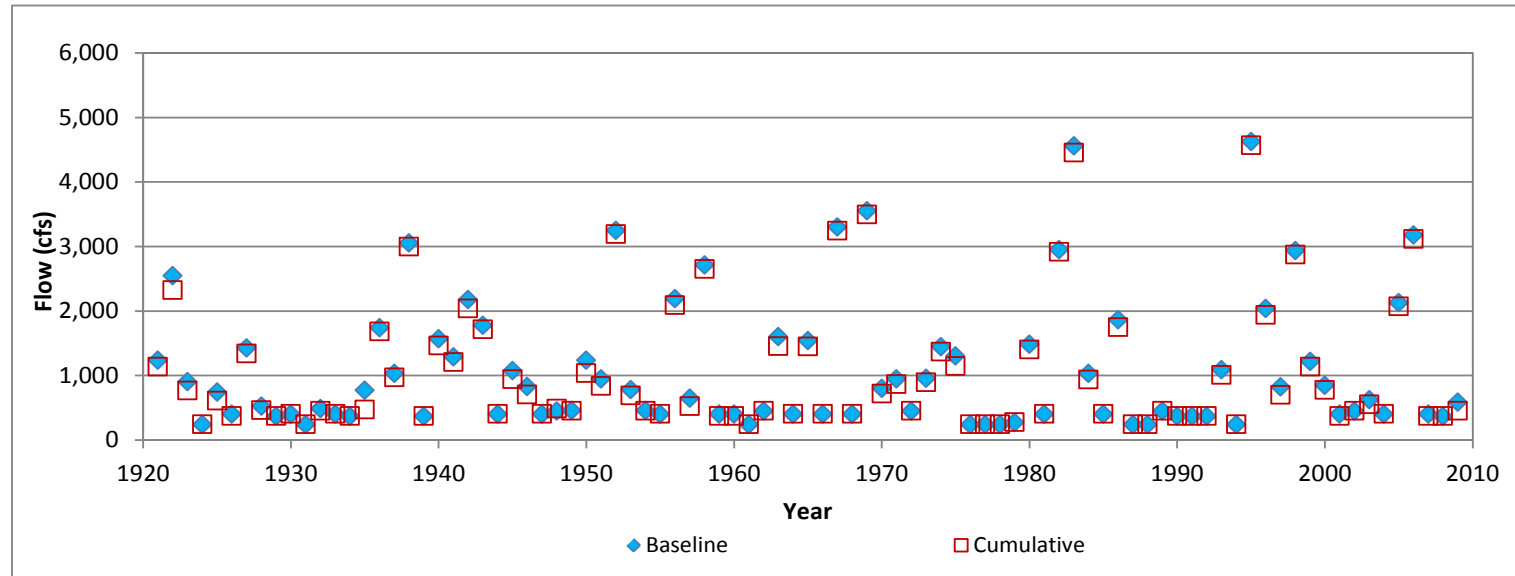
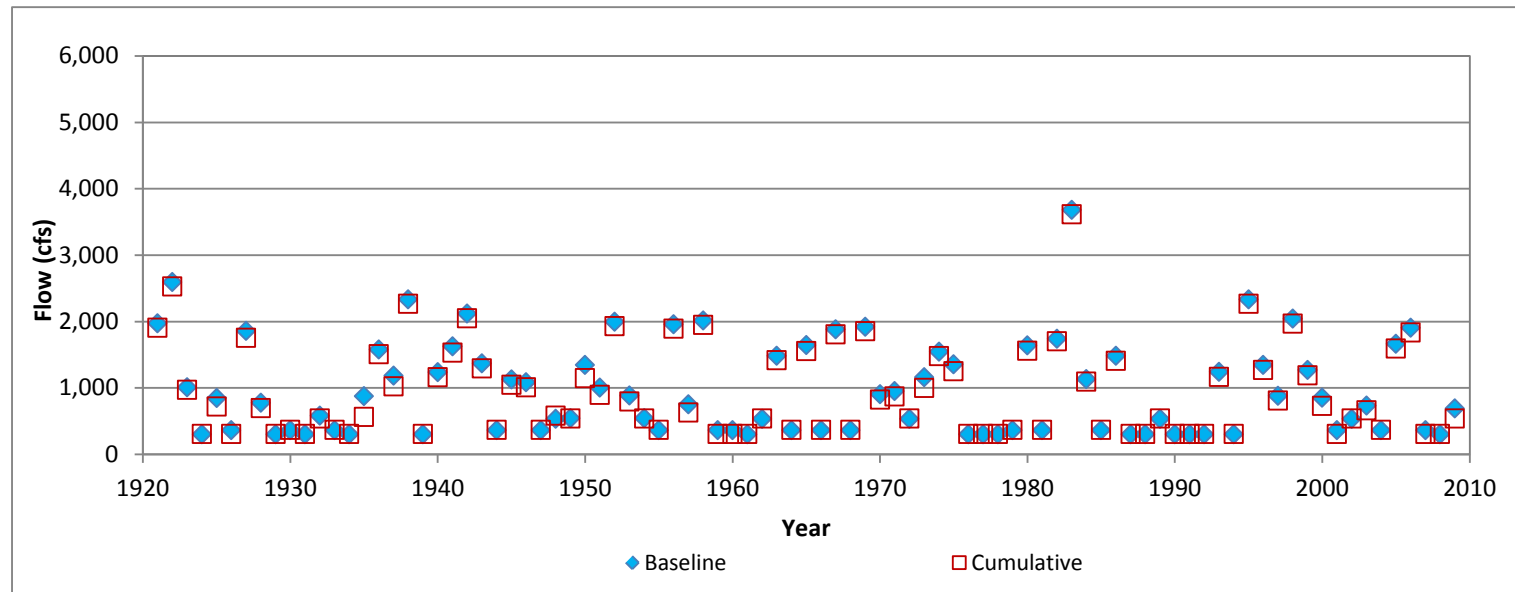
February



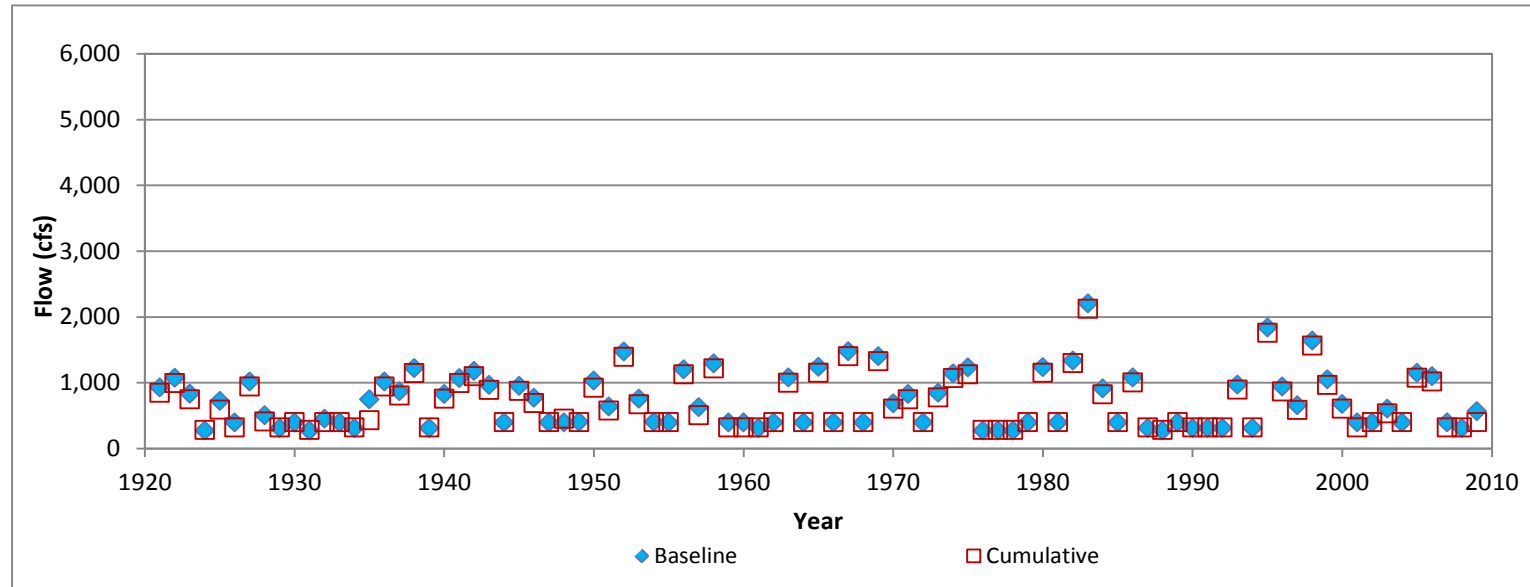
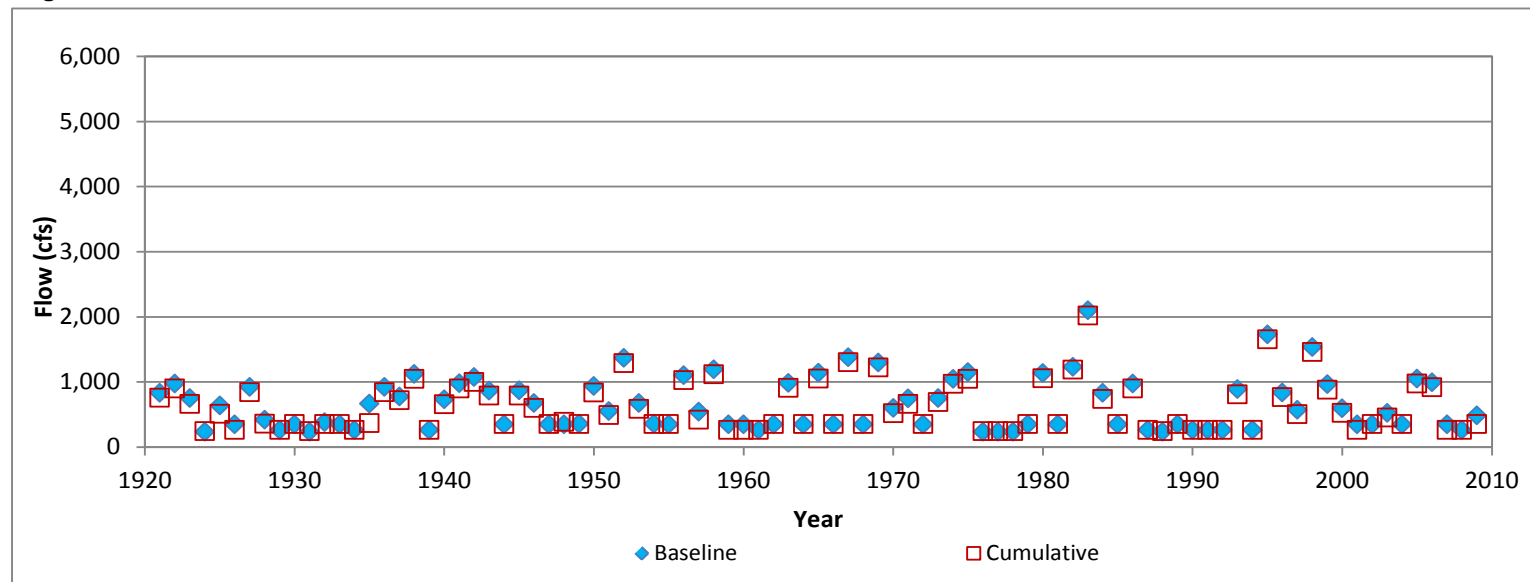
Note: cfs = cubic feet per second

March**April**

Note: cfs = cubic feet per second

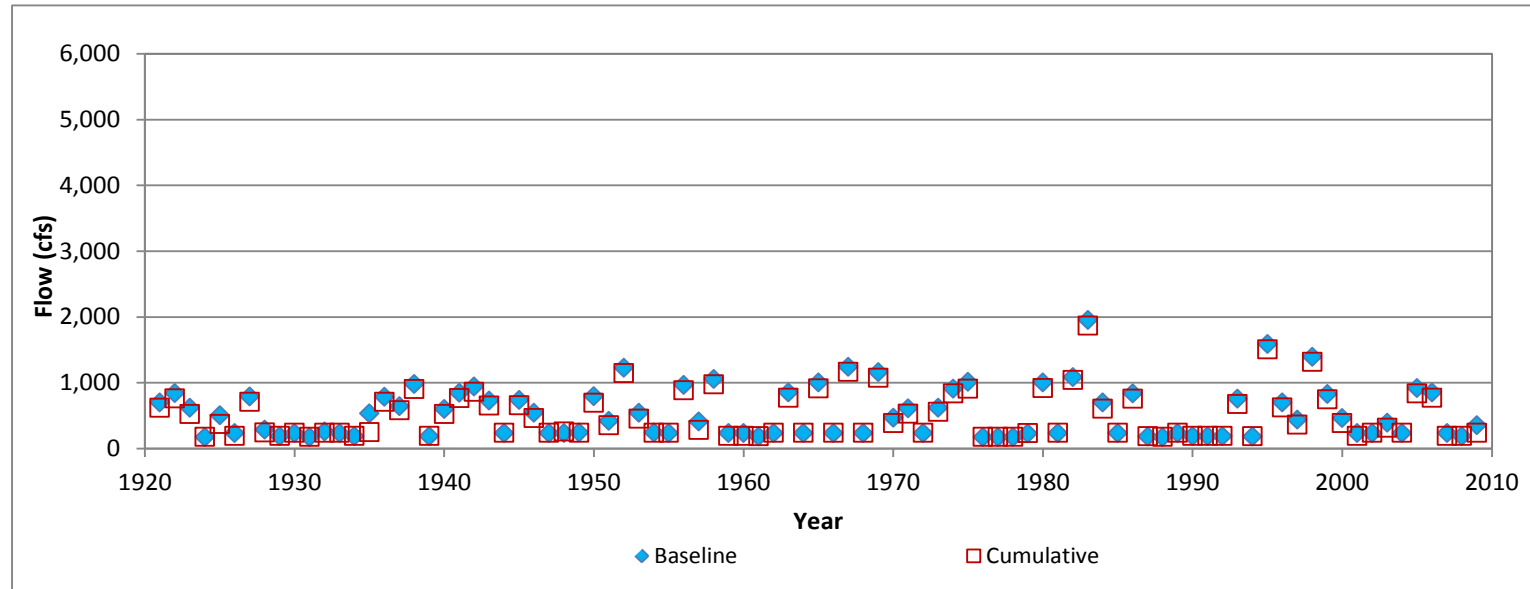
May**June**

Note: cfs = cubic feet per second

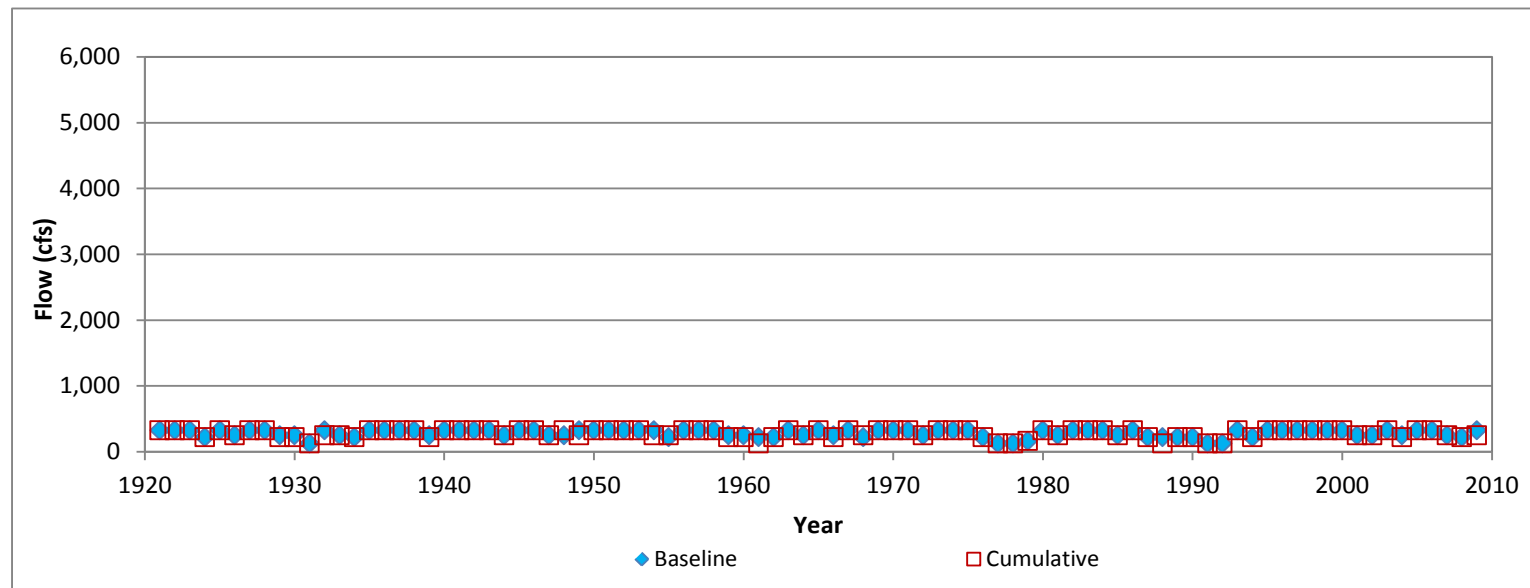
July**August**

Note: cfs = cubic feet per second

September

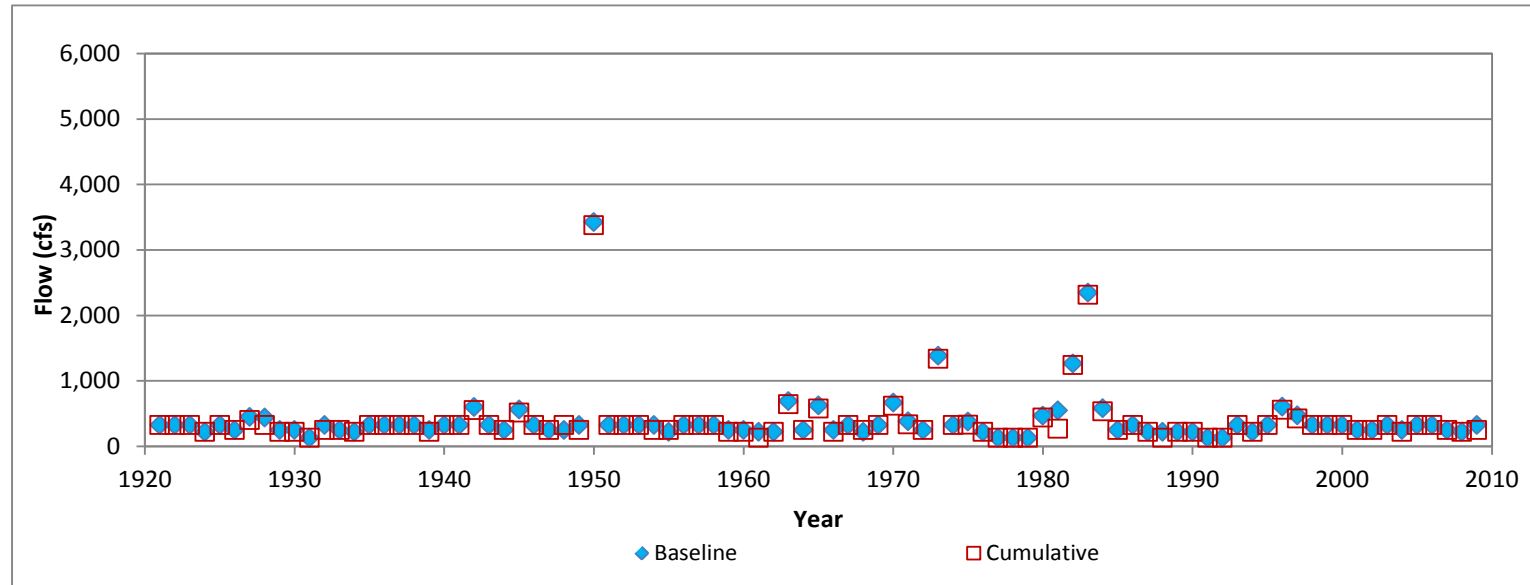


October

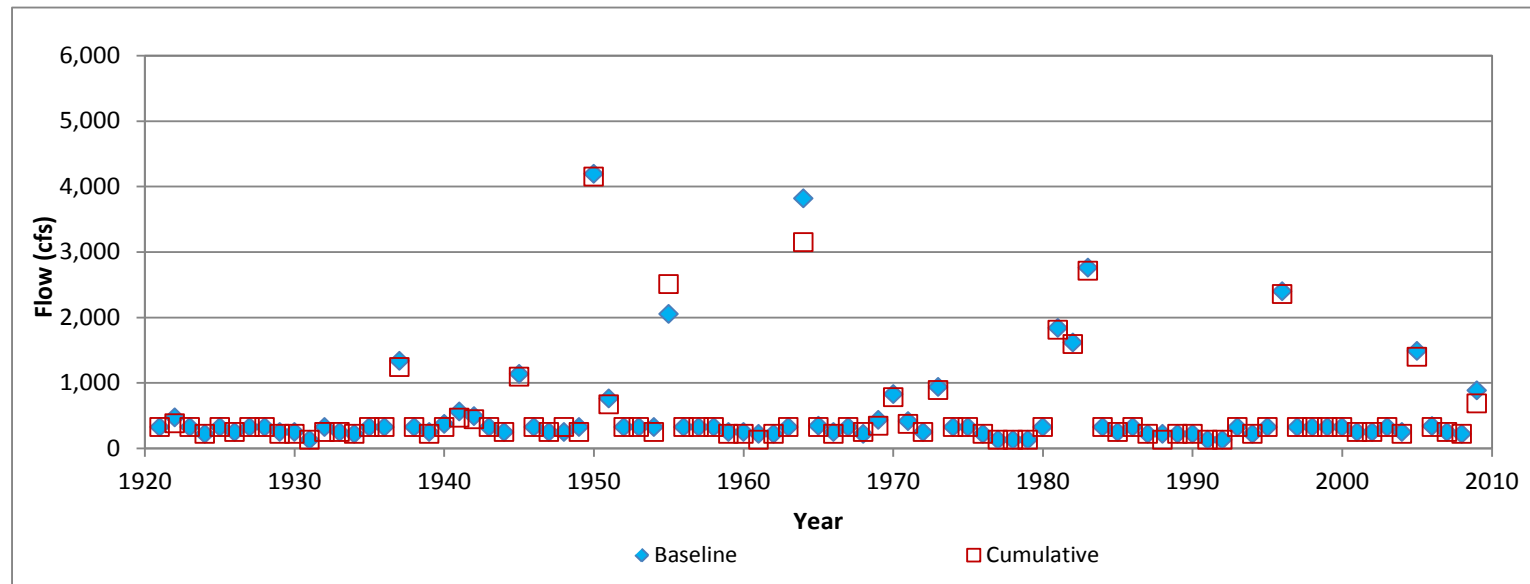


Note: cfs = cubic feet per second

November



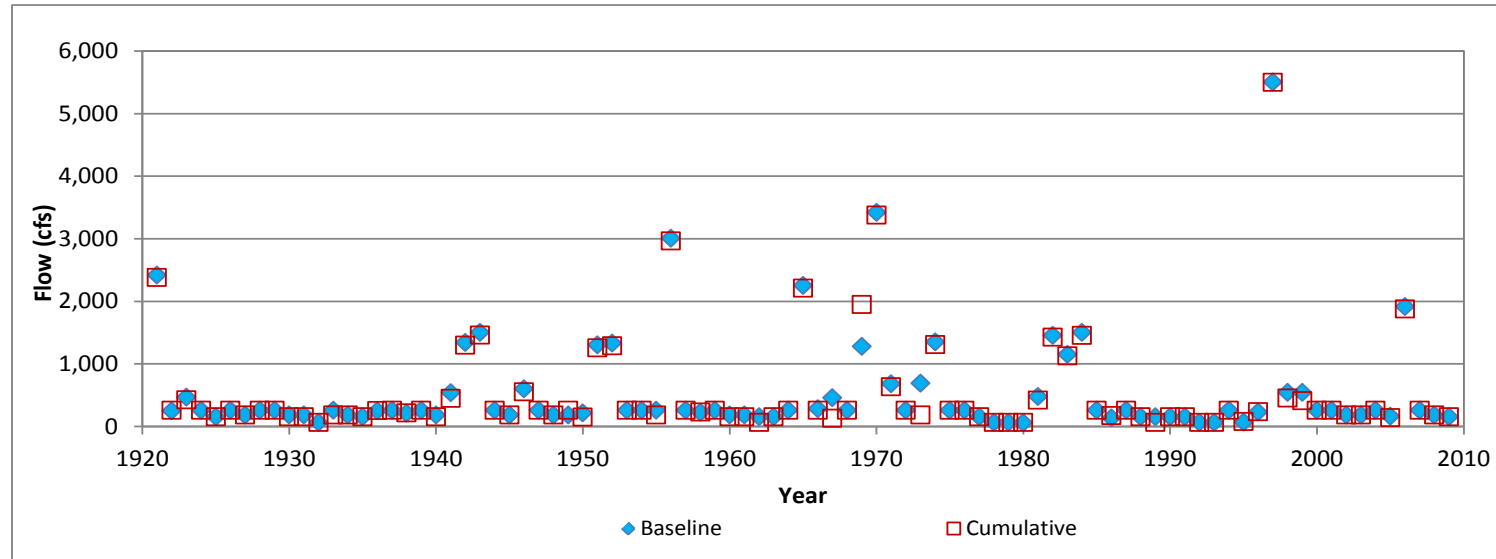
December



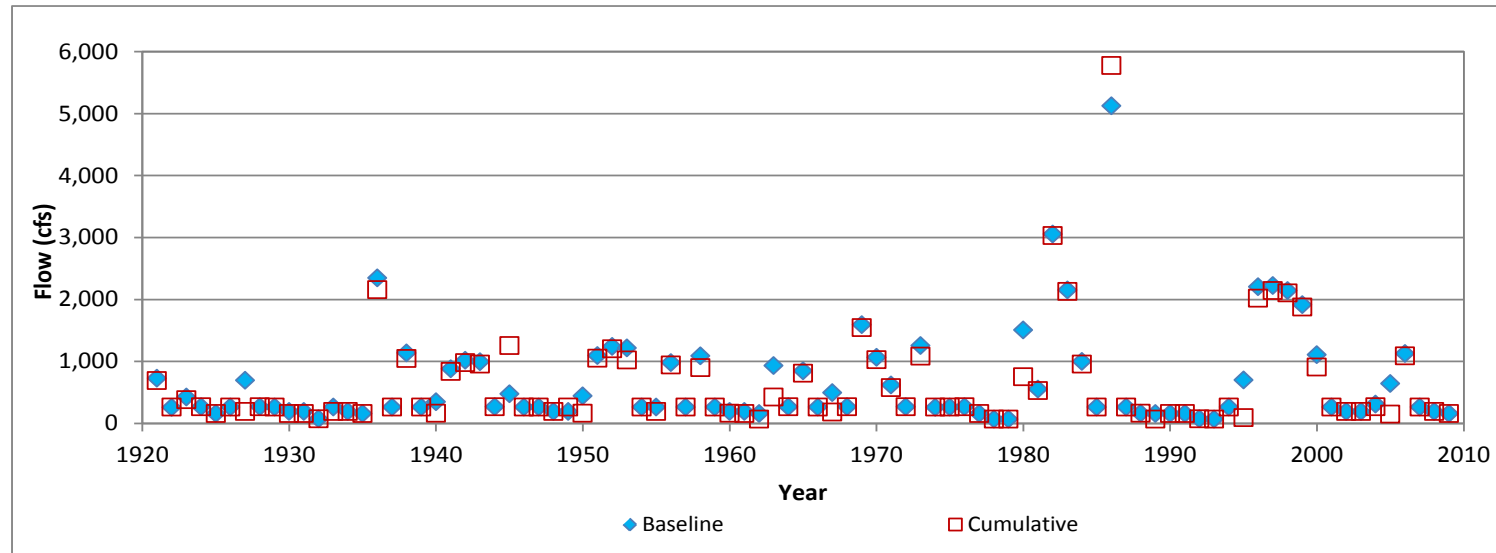
Note: cfs = cubic feet per second

N.4 Flows below Woodbridge

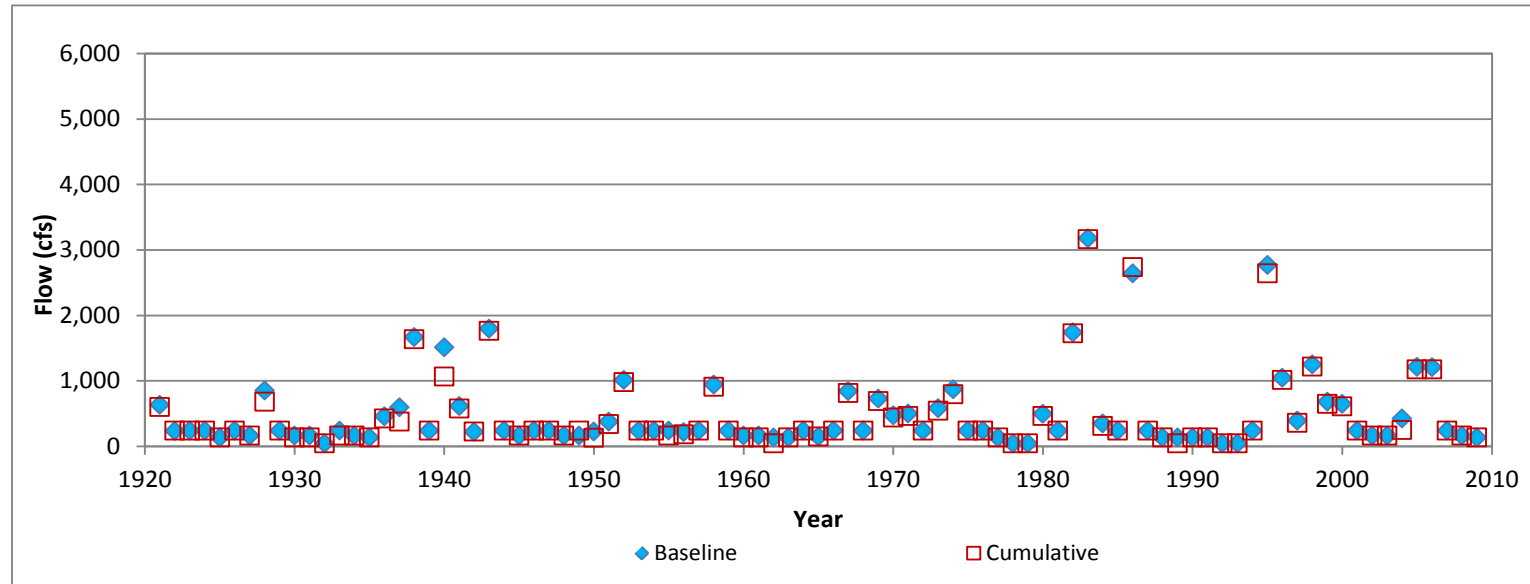
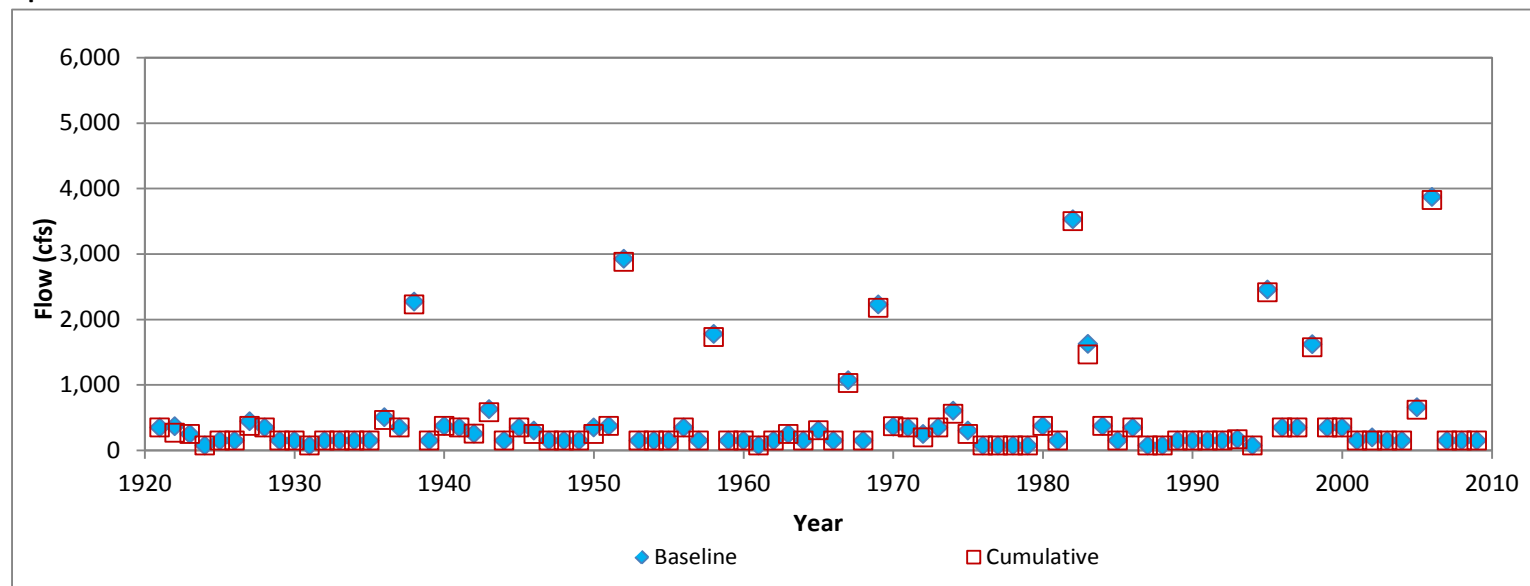
January



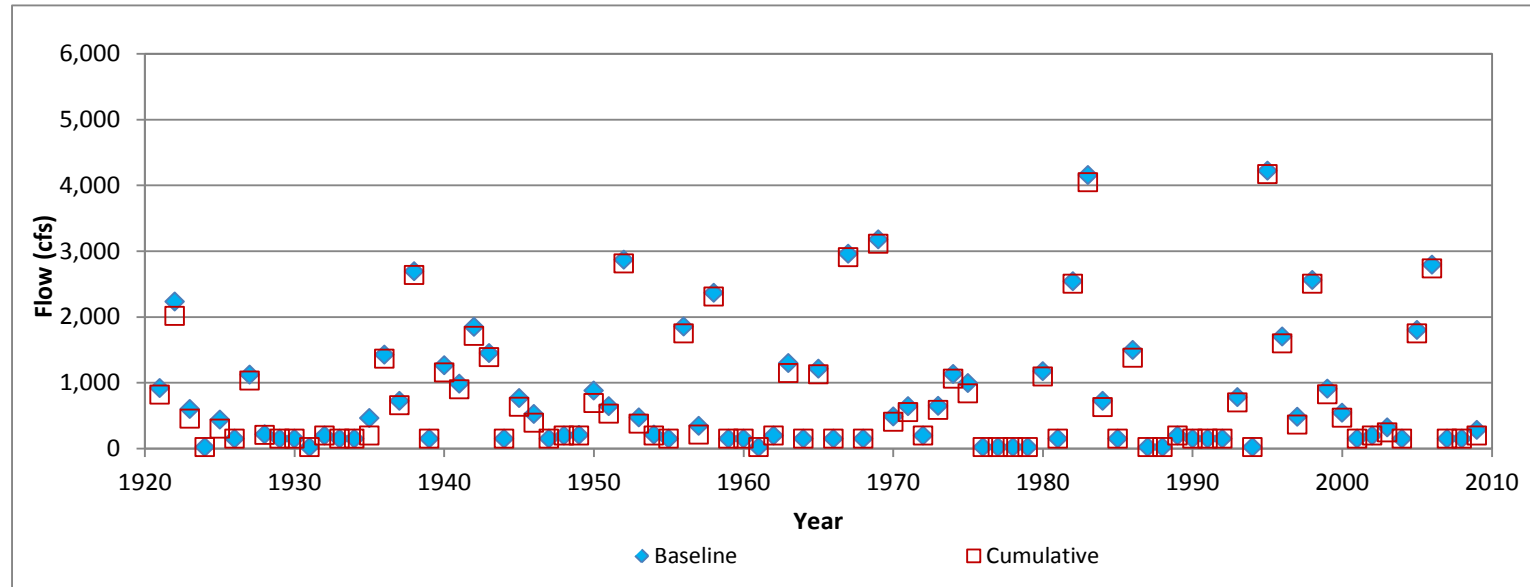
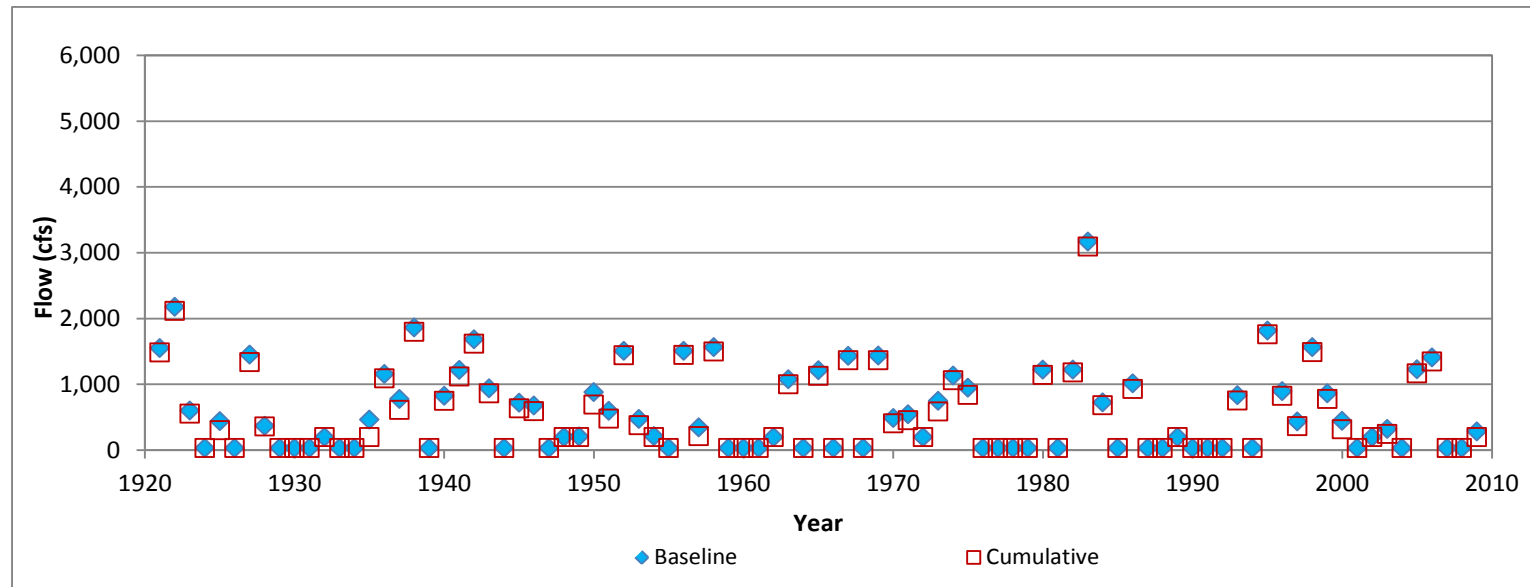
February



Note: cfs = cubic feet per second

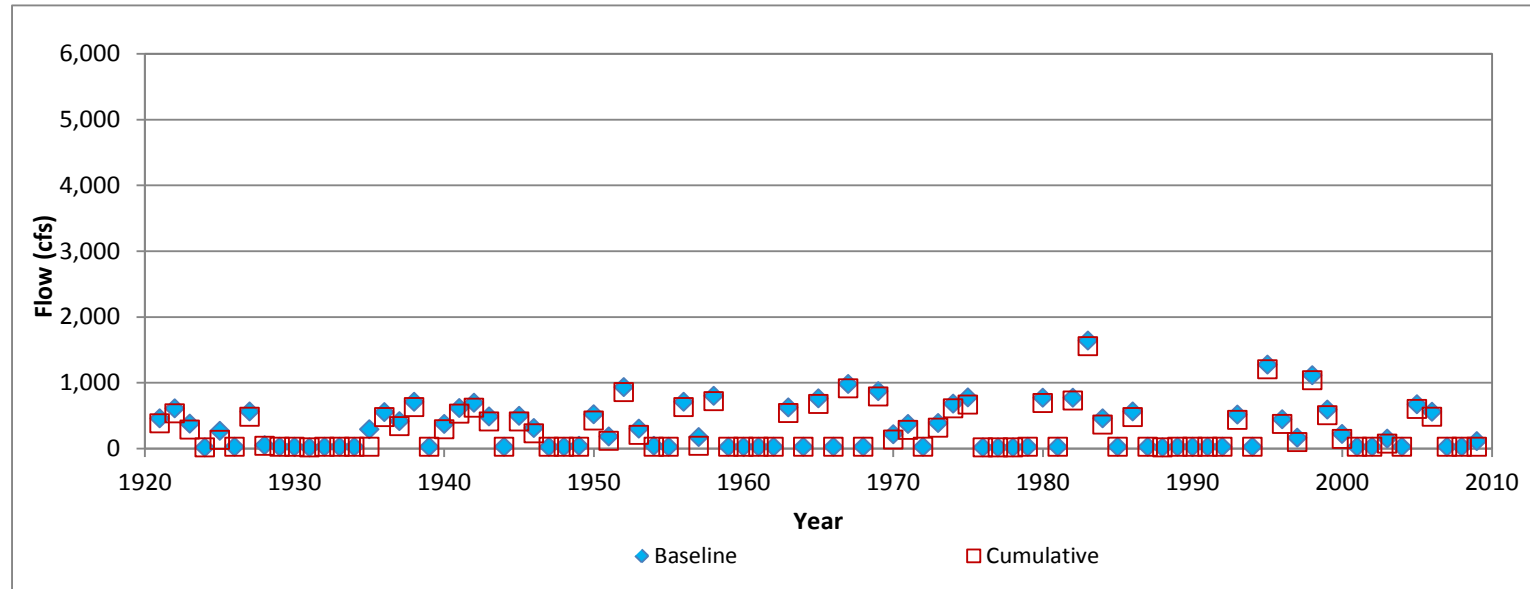
March**April**

Note: cfs = cubic feet per second

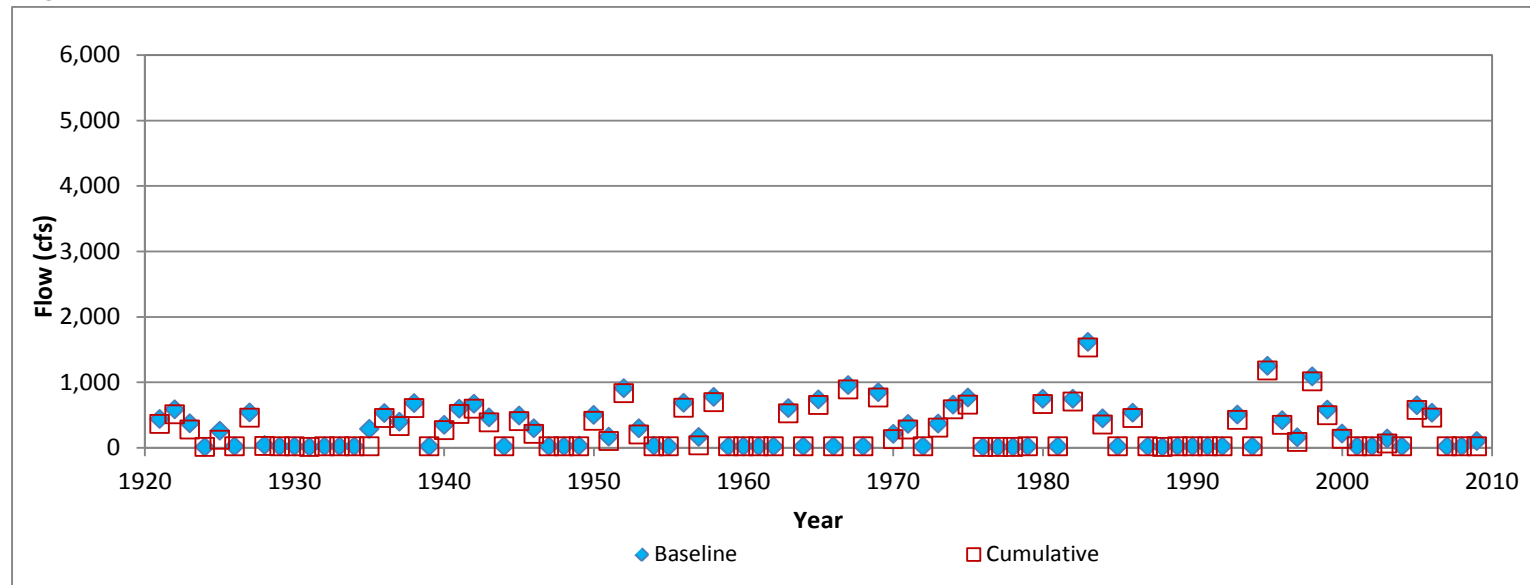
May**June**

Note: cfs = cubic feet per second

July

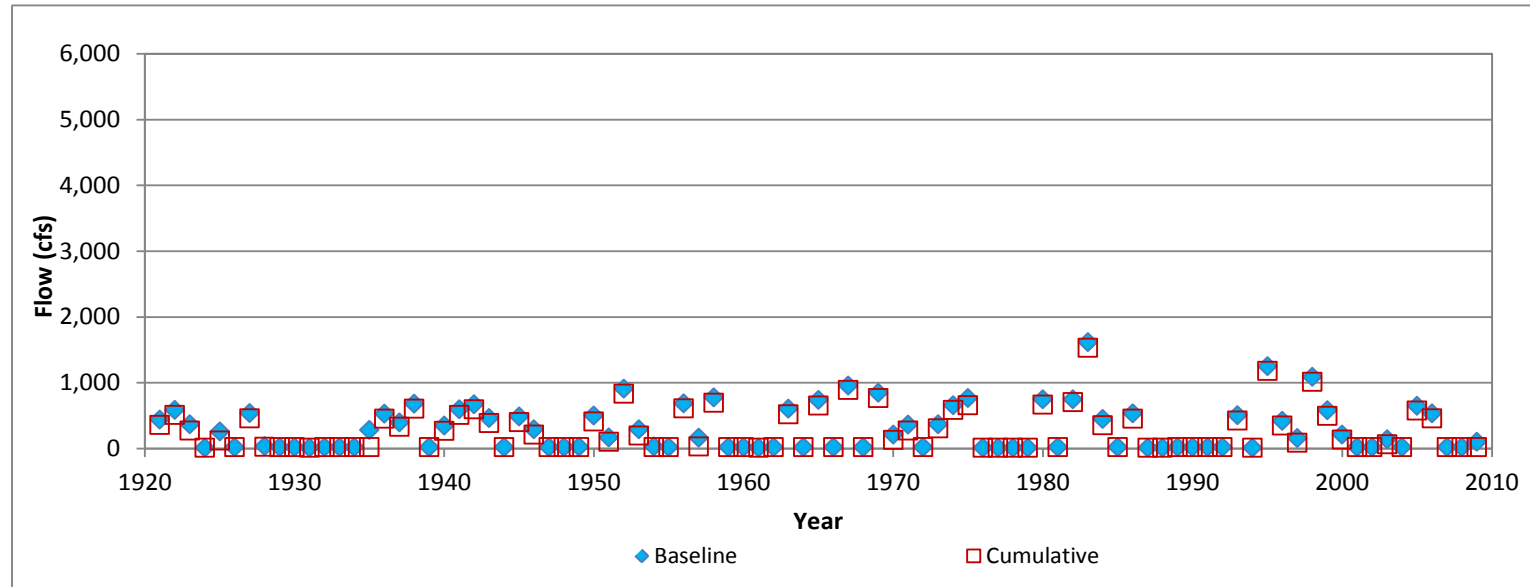


August

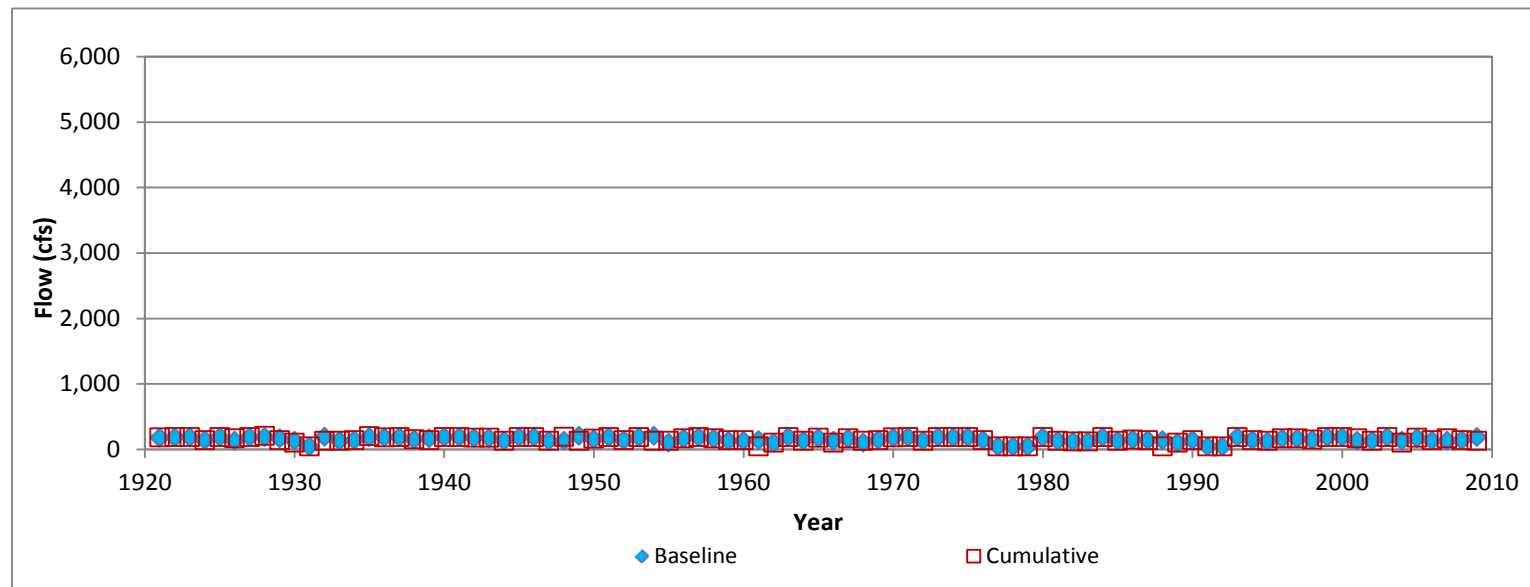


Note: cfs = cubic feet per second

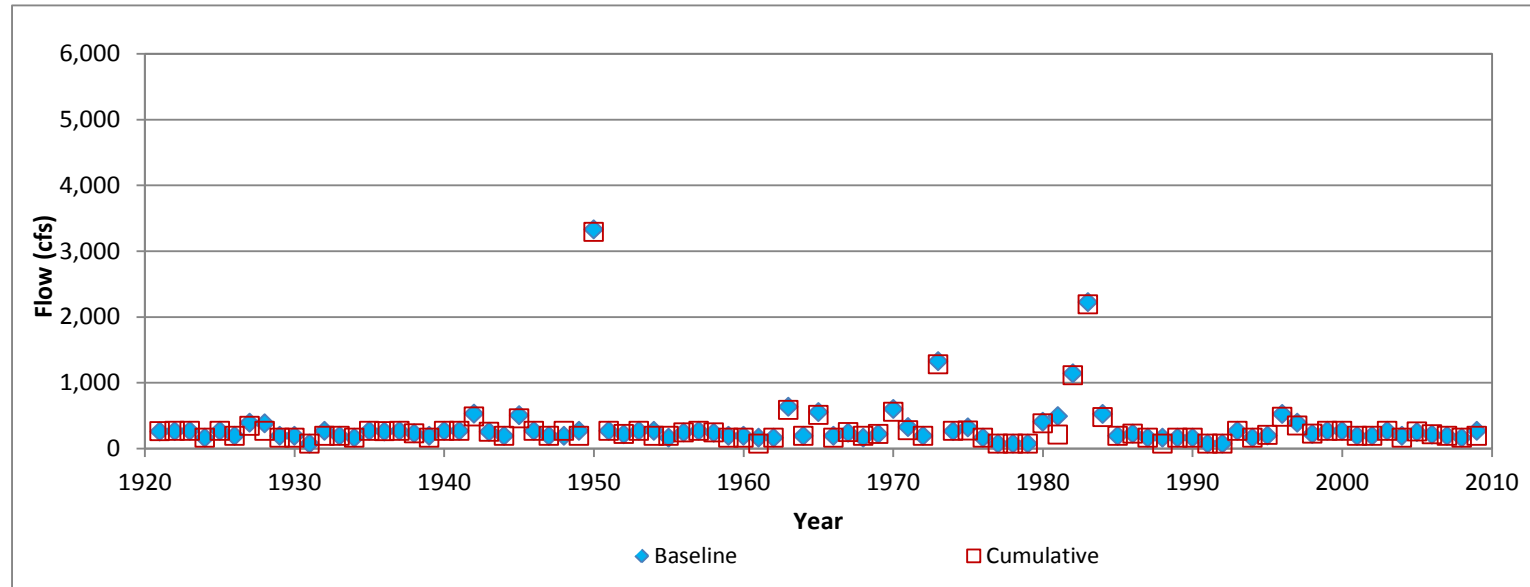
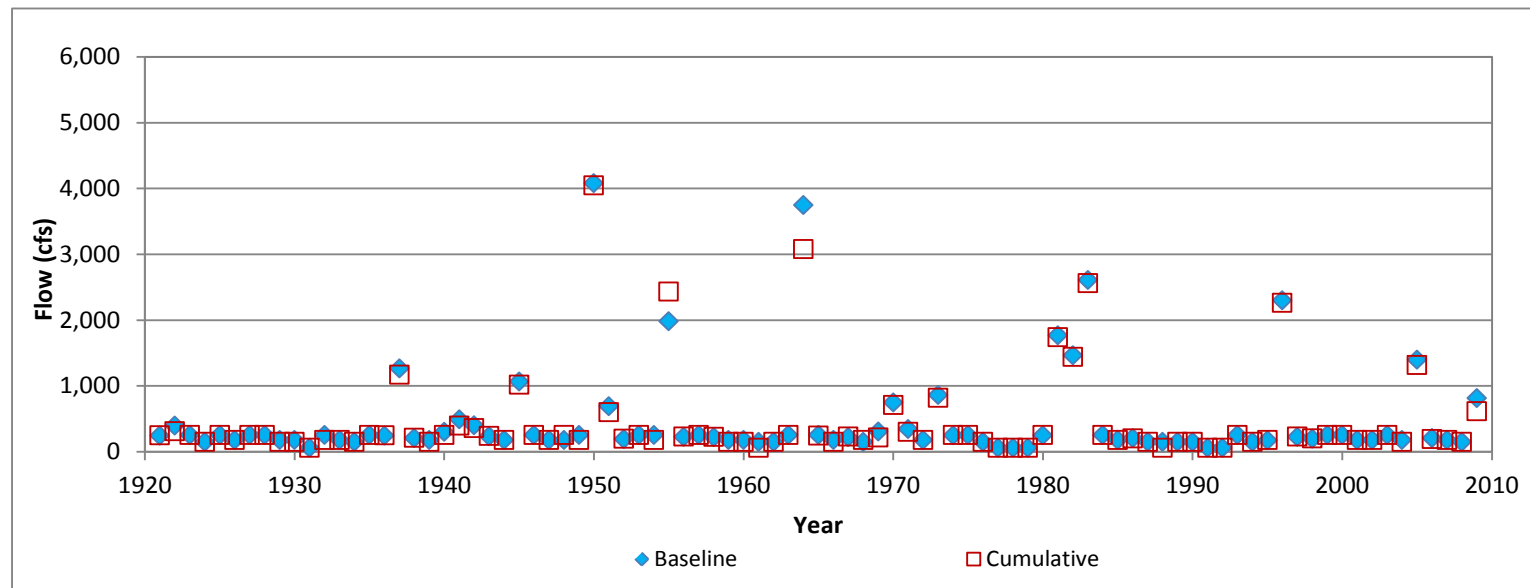
September



October



Note: cfs = cubic feet per second

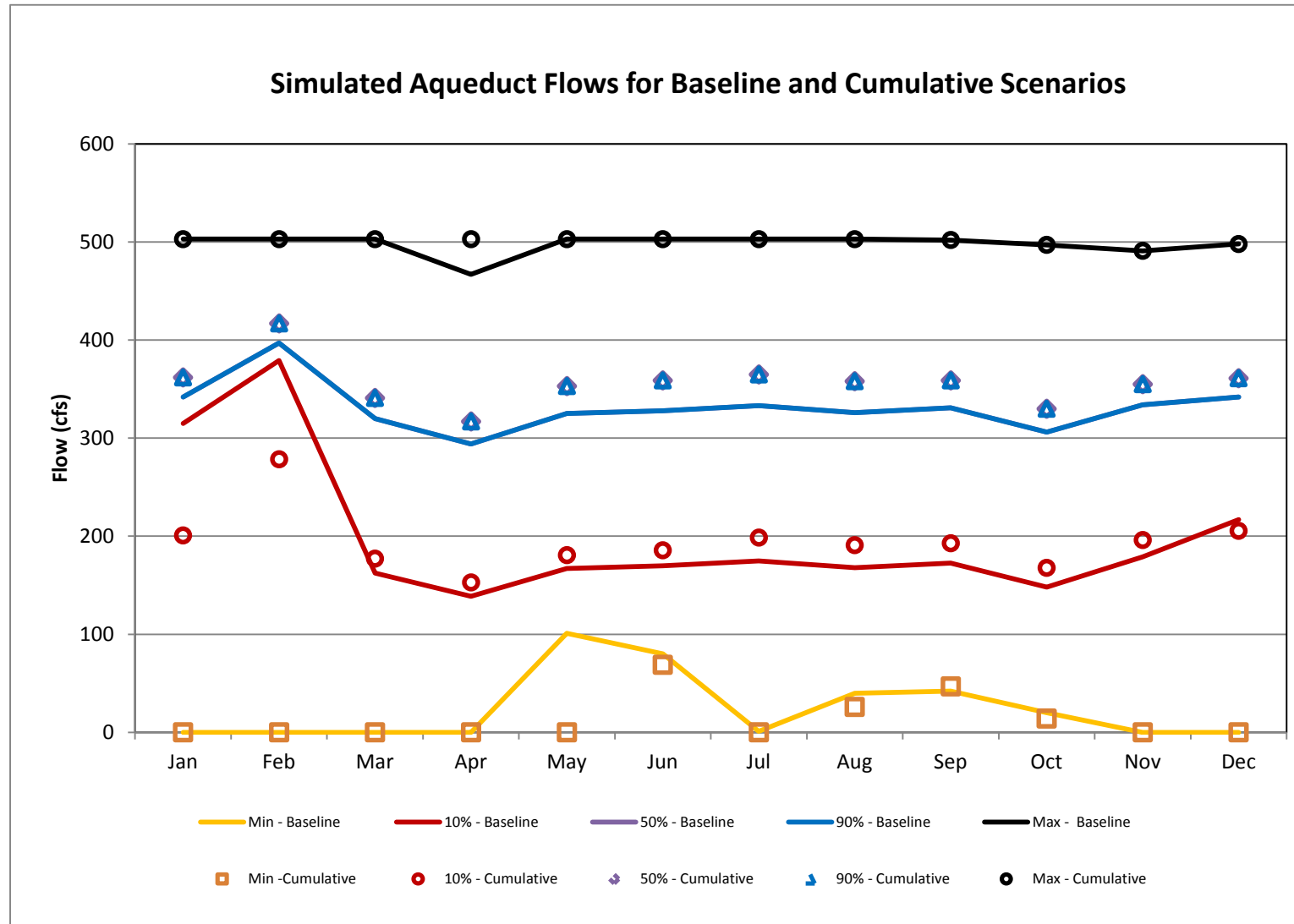
November**December**

Note: cfs = cubic feet per second

Appendix O

**Comparison of Baseline and Cumulative EBMUDSIM
Results as Illustrated with Percentile
Plots and Tables**

O.1 Mokelumne Aqueduct Flow



Note: cfs = cubic feet per second

Table O-1. Mokelumne Aqueduct - Modeled Monthly Average Flow

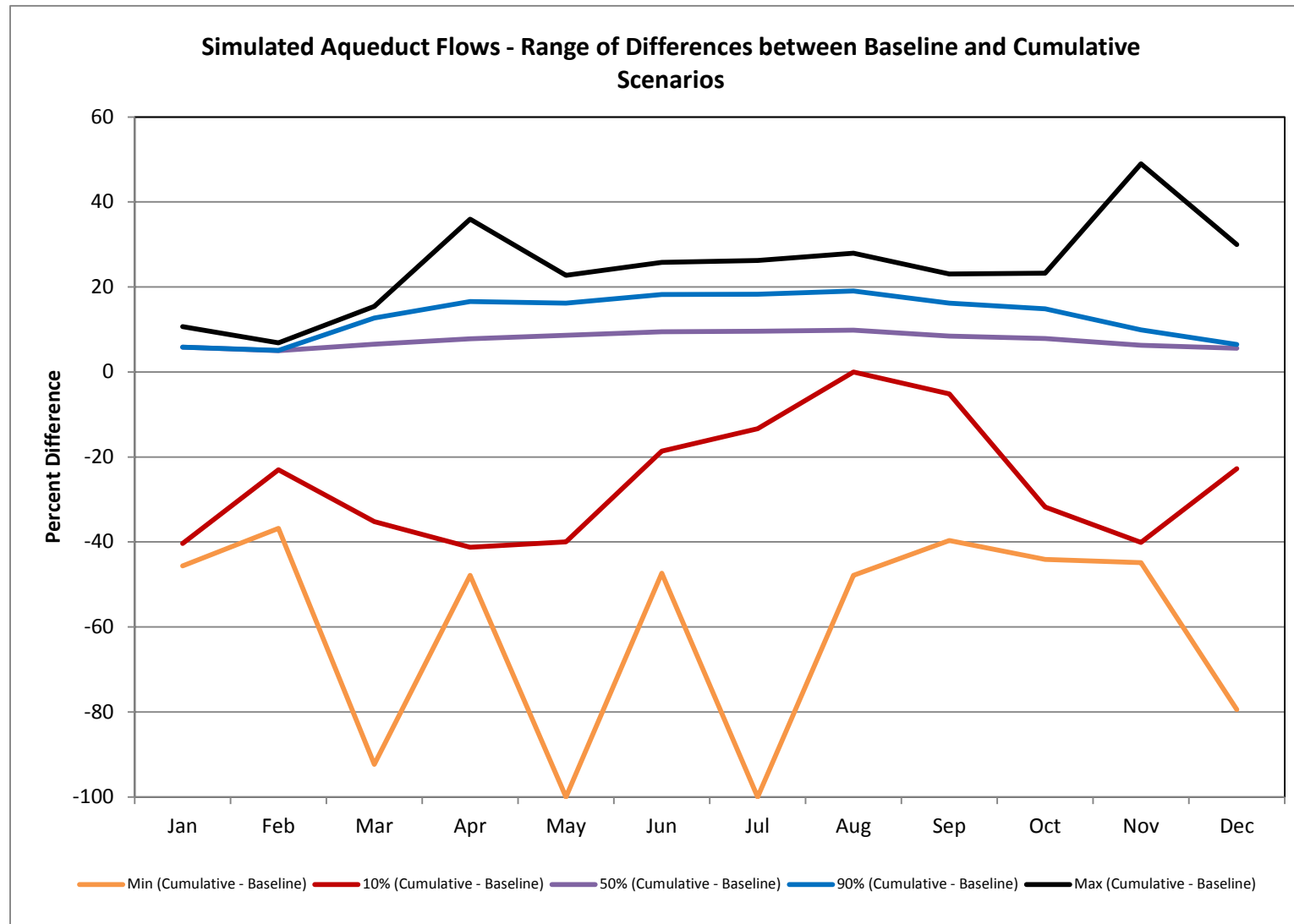
Percentile	Baseline Case (cubic feet per second)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	0	0	0	0	101	80	1	40	42	20	0	0
10th Percentile	315	379	162	139	167	170	175	168	173	148	179	217
20th Percentile	342	392	165	139	167	170	175	168	228	278	319	330
30th Percentile	342	392	313	287	325	328	333	326	330	306	334	342
40th Percentile	342	397	320	294	325	328	333	326	331	306	334	342
50th Percentile	342	397	320	294	325	328	333	326	331	306	334	342
60th Percentile	342	397	320	294	325	328	333	326	331	306	334	342
70th Percentile	342	397	320	294	325	328	333	326	331	306	334	342
80th Percentile	342	397	320	294	325	328	333	326	331	306	334	342
90th Percentile	342	397	320	294	325	328	333	326	331	306	334	342
Maximum	503	503	503	467	503	503	503	503	502	497	491	498

Percentile	Cumulative Case (cubic feet per second)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	0	0	0	0	0	69	0	26	47	14	0	0
10th Percentile	201	279	177	153	181	186	199	191	193	168	196	205
20th Percentile	243	320	186	162	194	201	207	200	201	172	200	244
30th Percentile	362	412	186	162	194	201	207	204	226	278	342	356
40th Percentile	362	412	341	317	353	359	365	358	359	330	355	361
50th Percentile	362	417	341	317	353	359	365	358	359	330	355	361
60th Percentile	362	417	341	317	353	359	365	358	359	330	355	361
70th Percentile	362	417	341	317	353	359	365	358	359	330	355	361
80th Percentile	362	417	341	317	353	359	365	358	359	330	355	361
90th Percentile	362	417	341	317	353	359	365	358	359	330	355	361
Maximum	503	503	503	503	503	503	503	503	502	497	491	498

Table O-2. Percent Difference between Cumulative and Baseline Aqueduct Flow Percentiles (positive indicates increase)

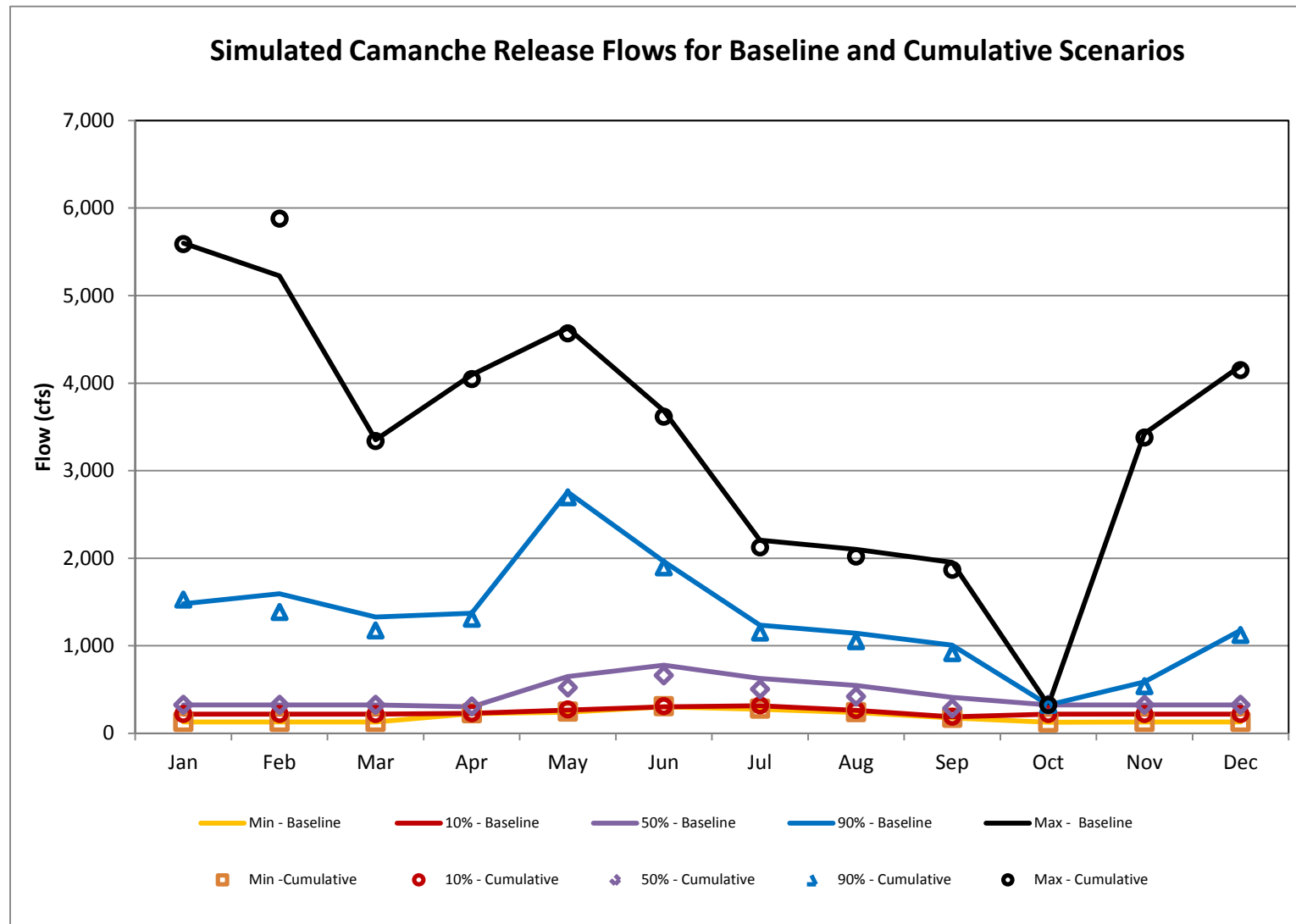
Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	NC	NC	NC	NC	-100.0%	-13.8%	-100.0%	-35.0%	11.9%	-30.0%	NC	NC
10th Percentile	-36.3%	-26.5%	9.0%	10.2%	8.3%	9.3%	13.6%	13.7%	11.7%	13.4%	9.5%	-5.3%
20th Percentile	-28.9%	-18.4%	12.7%	16.3%	16.2%	18.2%	18.3%	19.0%	-11.7%	-38.1%	-37.4%	-26.2%
30th Percentile	5.8%	5.1%	-40.7%	-43.5%	-40.3%	-38.7%	-37.8%	-37.4%	-31.5%	-9.2%	2.5%	4.0%
40th Percentile	5.8%	3.8%	6.6%	7.8%	8.6%	9.5%	9.6%	9.8%	8.5%	7.8%	6.3%	5.6%
50th Percentile	5.8%	5.0%	6.6%	7.8%	8.6%	9.5%	9.6%	9.8%	8.5%	7.8%	6.3%	5.6%
60th Percentile	5.8%	5.0%	6.6%	7.8%	8.6%	9.5%	9.6%	9.8%	8.5%	7.8%	6.3%	5.6%
70th Percentile	5.8%	5.0%	6.6%	7.8%	8.6%	9.5%	9.6%	9.8%	8.5%	7.8%	6.3%	5.6%
80th Percentile	5.8%	5.0%	6.6%	7.8%	8.6%	9.5%	9.6%	9.8%	8.5%	7.8%	6.3%	5.6%
90th Percentile	5.8%	5.0%	6.6%	7.8%	8.6%	9.5%	9.6%	9.8%	8.5%	7.8%	6.3%	5.6%
Maximum	0.0%	0.0%	0.0%	7.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Note: NC = not calculable due to zero in denominator



Note: These values show the range (minimum, 10th percentile, 50th percentile [median], 90th percentile, and maximum) of the percent differences between the cumulative and baseline scenarios calculated for each month of the 89-year simulation. In contrast, the percent differences in the table above are based on the percentile distributions presented in the two tables above it.

0.2 Camanche Reservoir Releases



Note: cfs = cubic feet per second

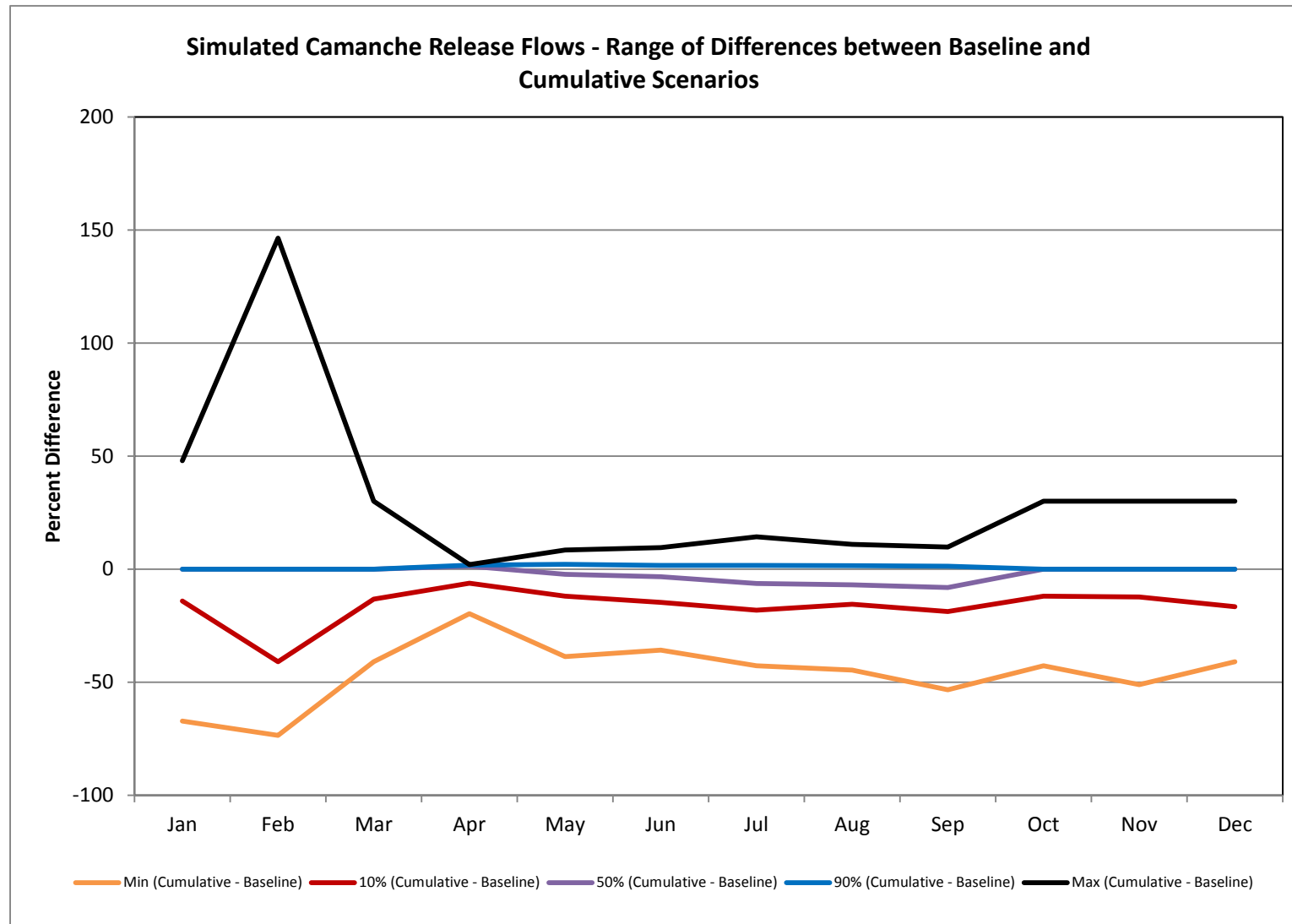
Table O-3. Camanche Reservoir Releases - Modeled Monthly Average Flow

Percentile	Baseline Case (cubic feet per second)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	130	130	130	225	242	304	276	238	175	126	130	130
10th Percentile	220	220	220	227	267	304	314	262	188	220	220	220
20th Percentile	250	250	250	300	400	363	398	348	236	220	220	238
30th Percentile	250	325	250	300	400	363	398	348	236	250	250	250
40th Percentile	325	325	325	300	450	533	398	348	236	250	250	325
50th Percentile	325	325	325	302	648	777	628	546	412	325	325	325
60th Percentile	325	469	325	470	939	1,009	817	722	590	325	325	325
70th Percentile	325	819	536	508	1,239	1,316	961	869	735	325	325	325
80th Percentile	667	1,142	748	534	1,657	1,632	1,079	982	848	325	347	426
90th Percentile	1,481	1,595	1,327	1,372	2,756	1,961	1,236	1,143	1,008	325	587	1,178
Maximum	5,598	5,226	3,354	4,094	4,628	3,683	2,206	2,100	1,954	325	3,424	4,195

Percentile	Cumulative Case (cubic feet per second)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	130	130	130	229	247	309	281	243	177	126	130	130
10th Percentile	220	220	220	231	272	309	319	266	190	220	220	220
20th Percentile	220	220	220	304	374	309	319	266	191	220	220	220
30th Percentile	250	250	250	304	405	369	403	353	239	250	250	250
40th Percentile	299	325	325	306	455	538	403	353	239	250	250	250
50th Percentile	325	325	325	306	524	661	504	421	285	325	325	325
60th Percentile	325	325	325	425	827	956	736	647	511	325	325	325
70th Percentile	325	709	469	504	1,136	1,180	883	791	655	325	325	325
80th Percentile	537	1,038	710	528	1,552	1,542	1,003	905	769	325	325	356
90th Percentile	1,527	1,386	1,174	1,310	2,697	1,895	1,152	1,053	917	325	540	1,123
Maximum	5,590	5,878	3,338	4,047	4,569	3,617	2,123	2,018	1,869	325	3,378	4,149

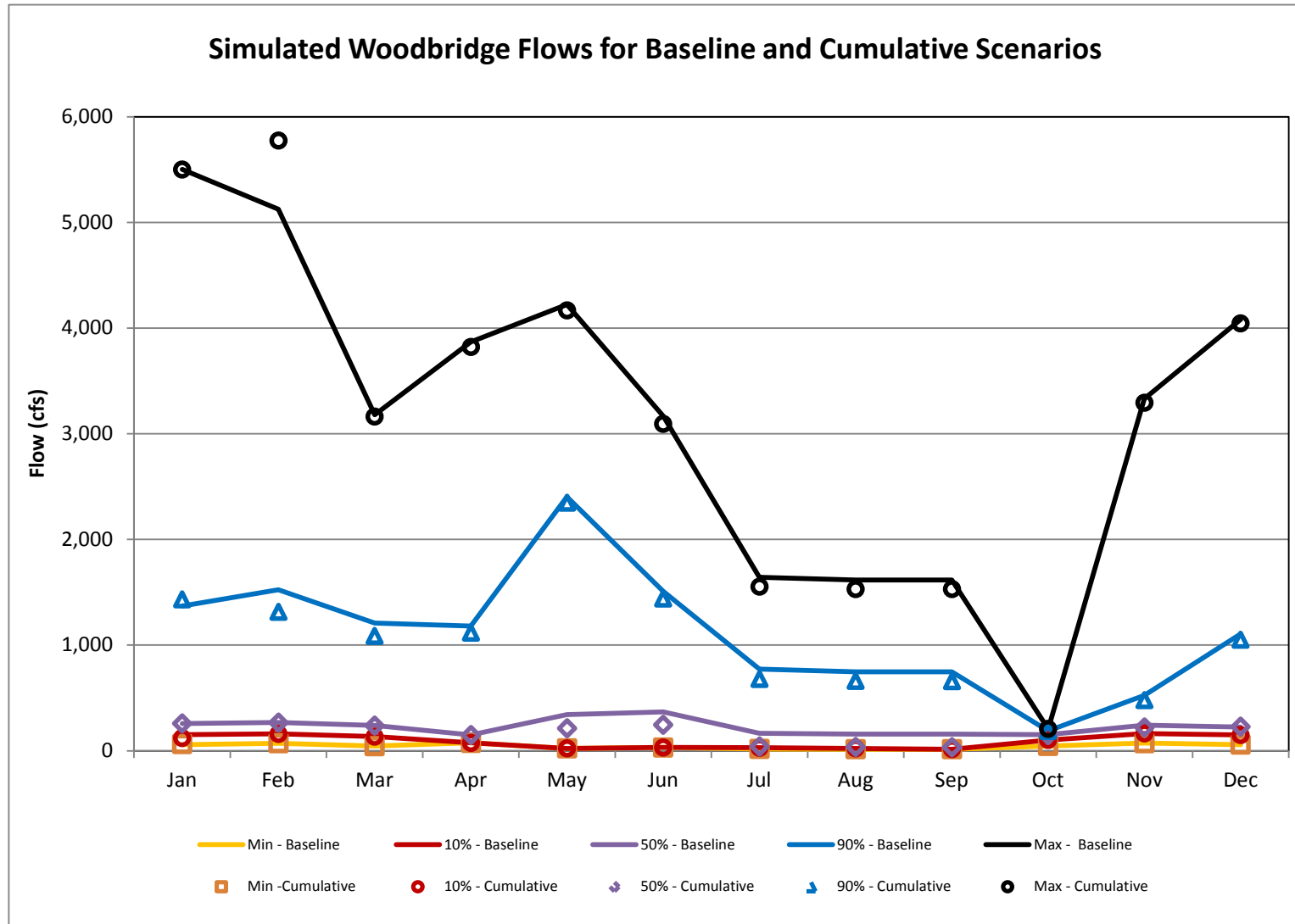
Table O-4. Percent Difference between Cumulative and Baseline Camanche Release Percentiles (positive indicates increase)

Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	0.0%	0.0%	0.0%	1.8%	2.1%	1.6%	1.8%	2.1%	1.1%	0.0%	0.0%	0.0%
10th Percentile	0.0%	0.0%	0.0%	1.8%	1.9%	1.6%	1.6%	1.5%	1.1%	0.0%	0.0%	0.0%
20th Percentile	-12.0%	-12.0%	-12.0%	1.3%	-6.5%	-14.9%	-19.8%	-23.6%	-19.1%	0.0%	0.0%	-7.6%
30th Percentile	0.0%	-23.1%	0.0%	1.3%	1.3%	1.7%	1.3%	1.4%	1.3%	0.0%	0.0%	0.0%
40th Percentile	-8.1%	0.0%	0.0%	2.0%	1.1%	0.9%	1.3%	1.4%	1.3%	0.0%	0.0%	-23.1%
50th Percentile	0.0%	0.0%	0.0%	1.3%	-19.1%	-14.9%	-19.7%	-22.9%	-30.8%	0.0%	0.0%	0.0%
60th Percentile	0.0%	-30.8%	0.0%	-9.6%	-12.0%	-5.3%	-9.9%	-10.5%	-13.3%	0.0%	0.0%	0.0%
70th Percentile	0.0%	-13.5%	-12.5%	-0.8%	-8.3%	-10.3%	-8.0%	-9.0%	-10.9%	0.0%	0.0%	0.0%
80th Percentile	-19.4%	-9.1%	-5.1%	-1.2%	-6.3%	-5.5%	-7.1%	-7.9%	-9.4%	0.0%	-6.2%	-16.3%
90th Percentile	3.1%	-13.1%	-11.5%	-4.5%	-2.1%	-3.4%	-6.8%	-7.9%	-9.0%	0.0%	-8.0%	-4.7%
Maximum	-0.1%	12.5%	-0.5%	-1.1%	-1.3%	-1.8%	-3.8%	-3.9%	-4.4%	0.0%	-1.3%	-1.1%



Note: These values show the range (minimum, 10th percentile, 50th percentile [median], 90th percentile, and maximum) of the percent differences between the cumulative and baseline scenarios calculated for each month of the 89-year simulation. In contrast, the percent differences in the table above are based on the percentile distributions presented in the two tables above it.

0.3 Woodbridge Flow



Note: cfs = cubic feet per second

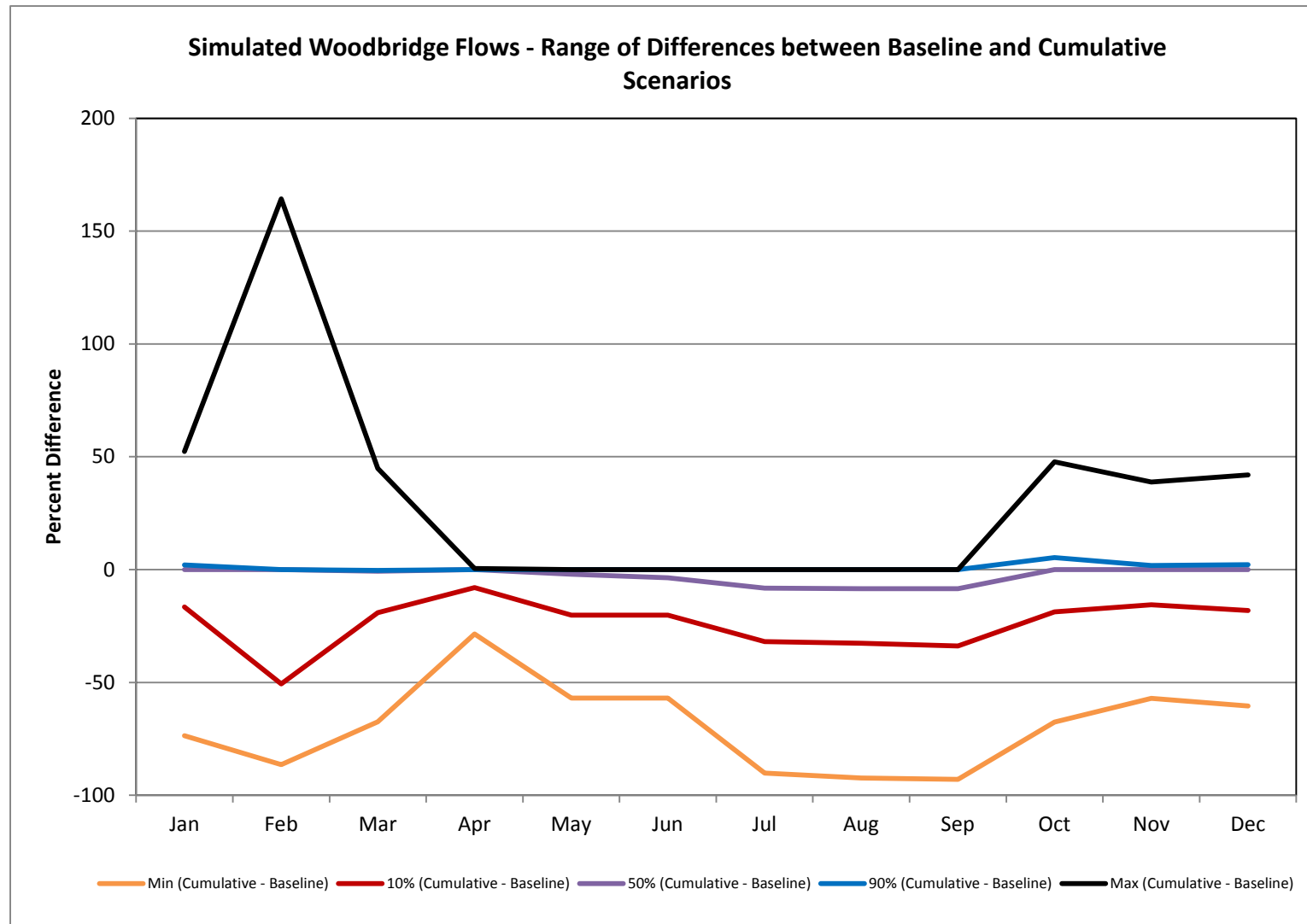
Table O-5. Woodbridge Flow - Modeled Monthly Average Flow

Percentile	Baseline Case (cubic feet per second)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	59	71	45	75	23	31	18	15	15	45	73	59
10th Percentile	153	161	135	75	23	31	29	22	15	102	163	149
20th Percentile	160	191	165	150	150	31	29	22	20	132	163	163
30th Percentile	183	266	166	150	150	31	29	22	20	132	193	179
40th Percentile	233	266	240	150	200	200	29	22	20	139	193	182
50th Percentile	258	268	240	150	343	367	166	158	158	152	242	225
60th Percentile	258	410	241	306	634	599	360	340	340	172	266	254
70th Percentile	258	719	446	350	917	872	493	479	478	185	268	254
80th Percentile	568	1,077	662	373	1,348	1,216	613	591	591	188	290	324
90th Percentile	1,371	1,524	1,209	1,180	2,402	1,508	772	748	748	188	524	1,107
Maximum	5,502	5,124	3,180	3,869	4,222	3,167	1,641	1,617	1,617	207	3,332	4,081

Percentile	Cumulative Case (cubic feet per second)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	63	71	44	75	23	31	18	15	15	45	73	59
10th Percentile	121	159	134	75	23	31	29	22	15	102	163	149
20th Percentile	153	162	135	150	150	31	29	22	20	132	163	149
30th Percentile	183	191	164	150	150	31	29	22	20	132	193	179
40th Percentile	190	266	239	150	200	200	29	22	20	139	193	179
50th Percentile	258	266	239	150	213	245	42	35	33	148	220	228
60th Percentile	258	268	240	254	516	540	274	260	259	169	262	254
70th Percentile	258	646	371	350	822	765	412	398	397	185	268	254
80th Percentile	450	967	625	371	1,240	1,122	534	513	512	187	268	273
90th Percentile	1,434	1,316	1,087	1,117	2,348	1,441	679	660	659	187	480	1,051
Maximum	5,500	5,774	3,163	3,823	4,169	3,095	1,554	1,530	1,530	207	3,294	4,046

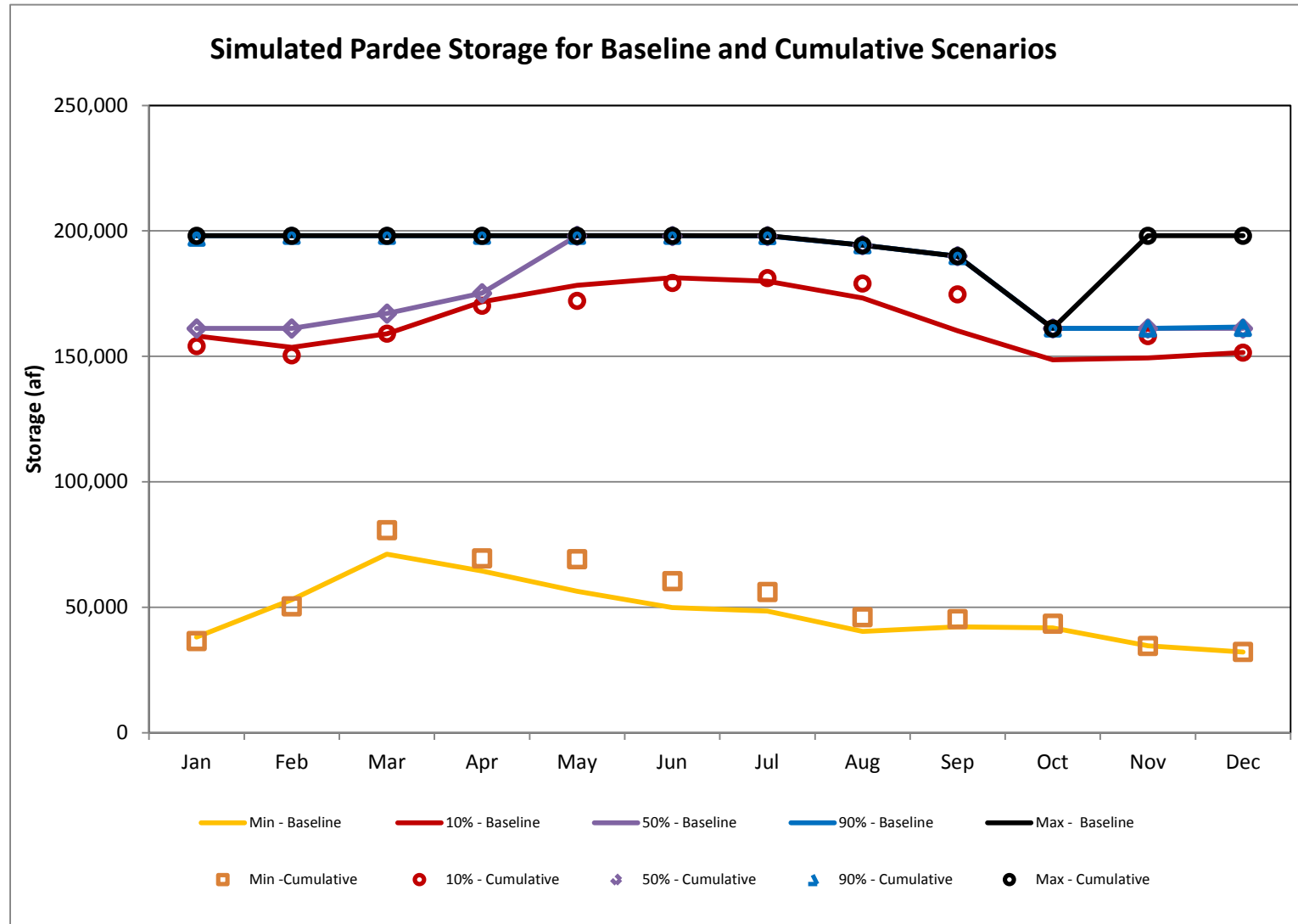
Table O-6. Percent Difference between Cumulative and Baseline Woodbridge Flow Percentiles (positive indicates increase)

Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	6.8%	0.0%	-2.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10th Percentile	-21.0%	-1.1%	-0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
20th Percentile	-4.1%	-15.1%	-18.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-8.5%
30th Percentile	0.0%	-28.2%	-1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
40th Percentile	-18.6%	0.0%	-0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-1.4%
50th Percentile	0.0%	-0.7%	-0.4%	0.0%	-37.9%	-33.2%	-74.7%	-77.8%	-79.1%	-2.6%	-9.1%	1.3%
60th Percentile	0.0%	-34.6%	-0.4%	-16.9%	-18.6%	-9.9%	-23.9%	-23.7%	-23.7%	-1.9%	-1.5%	-0.1%
70th Percentile	0.0%	-10.0%	-16.9%	0.0%	-10.3%	-12.2%	-16.4%	-16.9%	-16.8%	0.0%	0.0%	0.0%
80th Percentile	-20.8%	-10.2%	-5.7%	-0.4%	-8.0%	-7.7%	-12.9%	-13.2%	-13.2%	-0.5%	-7.5%	-15.9%
90th Percentile	4.6%	-13.6%	-10.1%	-5.4%	-2.2%	-4.4%	-12.0%	-11.8%	-11.9%	-0.5%	-8.5%	-5.1%
Maximum	0.0%	12.7%	-0.5%	-1.2%	-1.3%	-2.3%	-5.3%	-5.4%	-5.4%	0.0%	-1.1%	-0.9%



Note: These values show the range (minimum, 10th percentile, 50th percentile [median], 90th percentile, and maximum) of the percent differences between the cumulative and baseline scenarios calculated for each month of the 89-year simulation. In contrast, the percent differences in the table above are based on the percentile distributions presented in the two tables above it.

0.4 Pardee Reservoir Storage



Note: af = acre-feet

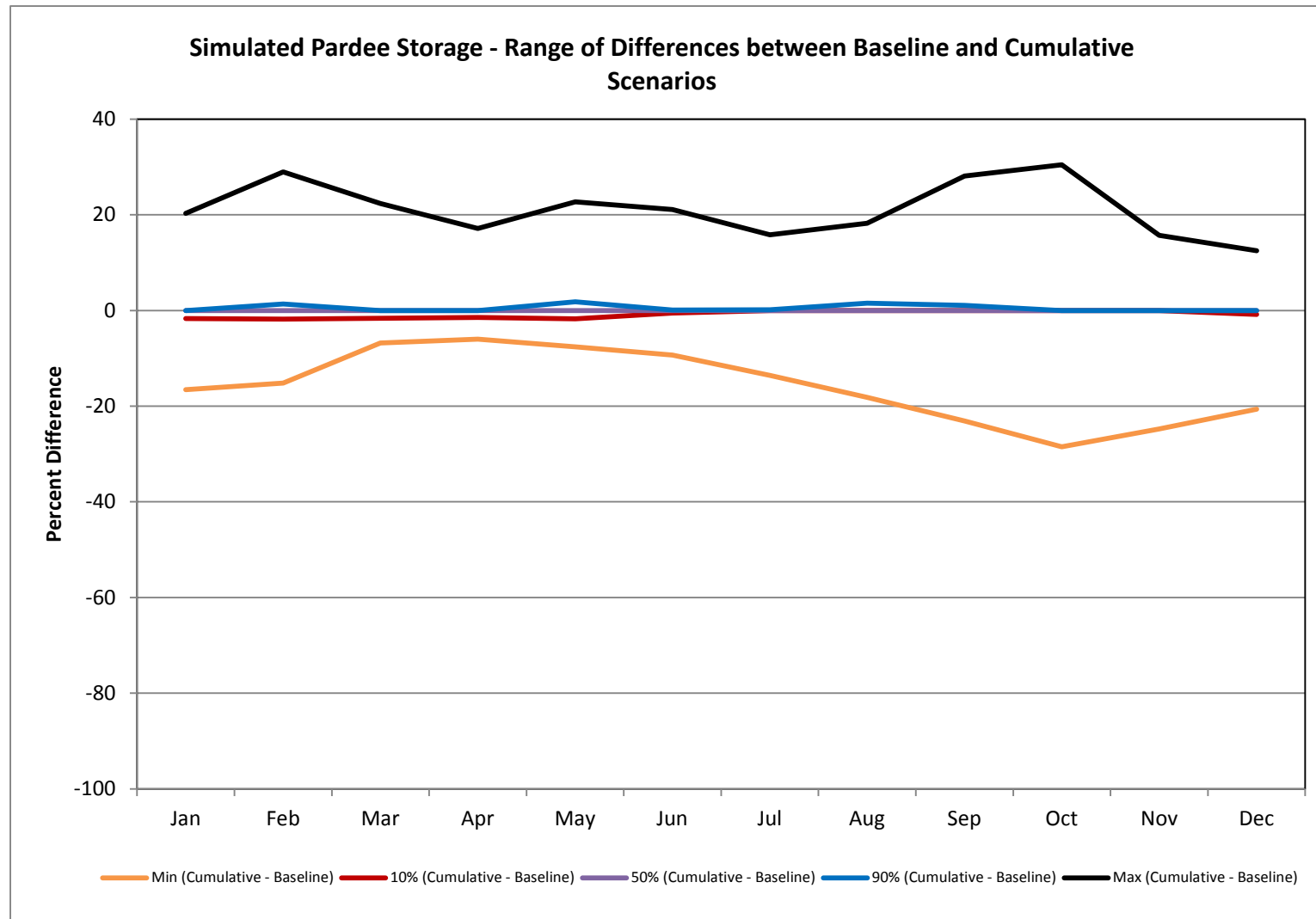
Table O-7. Pardee Reservoir Storage - Modeled Monthly Storage

Percentile	Baseline Case (acre-feet)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	38,100	53,042	71,214	64,456	56,387	49,880	48,457	40,440	42,254	41,748	34,613	32,187
10th Percentile	158,152	153,606	158,994	171,722	178,376	181,361	180,005	173,309	160,145	148,631	149,363	151,538
20th Percentile	161,130	157,118	167,052	175,156	188,616	197,954	197,954	194,304	189,940	161,130	161,130	161,130
30th Percentile	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
40th Percentile	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
50th Percentile	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
60th Percentile	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
70th Percentile	161,130	161,130	169,065	185,761	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
80th Percentile	161,130	177,298	197,513	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
90th Percentile	198,065	198,065	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,700
Maximum	198,065	198,065	198,065	198,065	198,065	198,065	198,065	194,304	189,940	161,130	198,065	198,065

Percentile	Cumulative Case (acre-feet)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	36,555	50,369	80,743	69,480	69,203	60,413	56,114	46,112	45,273	43,431	34,558	32,187
10th Percentile	154,043	150,404	159,026	170,187	172,150	179,263	181,193	179,025	174,701	161,130	158,062	151,447
20th Percentile	161,130	160,644	167,052	175,156	187,817	197,954	197,954	194,304	189,940	161,130	161,130	161,130
30th Percentile	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
40th Percentile	161,130	161,130	167,052	175,156	192,122	197,954	197,954	194,304	189,940	161,130	161,130	161,130
50th Percentile	161,130	161,130	167,052	175,156	198,065	197,954	197,954	194,304	189,940	161,130	161,130	161,130
60th Percentile	161,130	161,130	167,052	175,156	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
70th Percentile	161,130	161,130	167,052	181,596	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
80th Percentile	161,130	173,764	194,292	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,130
90th Percentile	197,321	198,065	198,065	198,065	198,065	198,065	197,954	194,304	189,940	161,130	161,130	161,376
Maximum	198,065	198,065	198,065	198,065	198,065	198,065	198,065	194,304	189,940	161,130	198,065	198,065

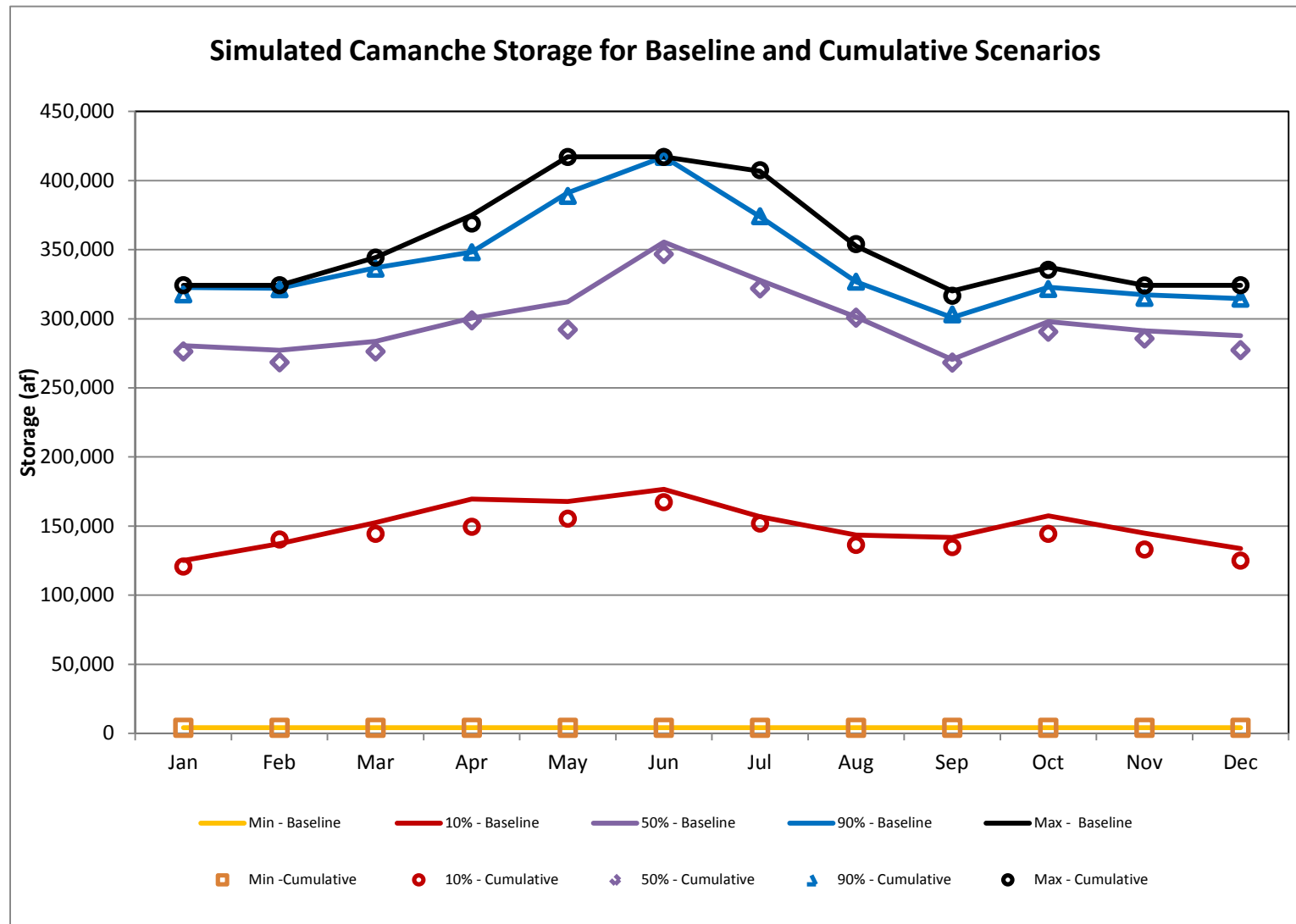
Table O-8. Percent Difference between Cumulative and Baseline Pardee Storage Percentiles (positive indicates increase)

Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	-4.1%	-5.0%	13.4%	7.8%	22.7%	21.1%	15.8%	14.0%	7.1%	4.0%	-0.2%	0.0%
10th Percentile	-2.6%	-2.1%	0.0%	-0.9%	-3.5%	-1.2%	0.7%	3.3%	9.1%	8.4%	5.8%	-0.1%
20th Percentile	0.0%	2.2%	0.0%	0.0%	-0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
30th Percentile	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
40th Percentile	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
50th Percentile	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
60th Percentile	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
70th Percentile	0.0%	0.0%	-1.2%	-2.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
80th Percentile	0.0%	-2.0%	-1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
90th Percentile	-0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.2%
Maximum	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%



Note: These values show the range (minimum, 10th percentile, 50th percentile [median], 90th percentile, and maximum) of the percent differences between the cumulative and baseline scenarios calculated for each month of the 89-year simulation. In contrast, the percent differences in the table above are based on the percentile distributions presented in the two tables above it.

0.5 Camanche Reservoir Storage



Note: af = acre-feet

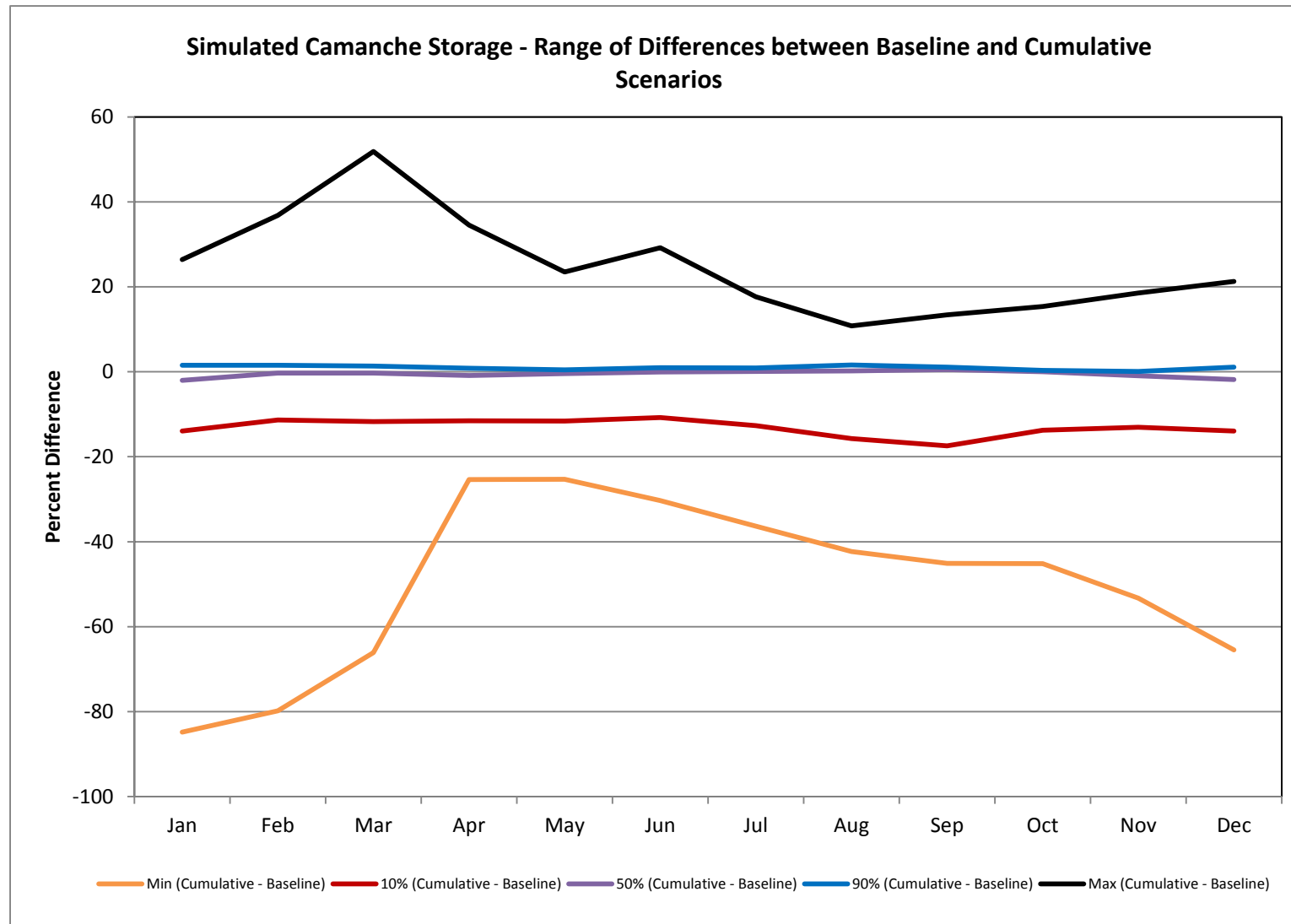
Table O-9. Camanche Reservoir - Modeled Monthly Storage

Percentile	Baseline Case (acre-feet)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025
10th Percentile	125,129	137,300	152,569	169,567	167,689	176,590	156,753	143,474	141,821	157,331	144,901	133,720
20th Percentile	221,809	217,958	241,572	228,571	223,721	238,008	221,138	216,757	214,809	237,260	231,899	225,399
30th Percentile	251,795	240,290	258,883	263,839	252,299	251,064	238,204	232,393	238,654	258,631	254,872	247,721
40th Percentile	270,683	267,487	271,023	290,508	276,088	291,489	275,370	263,167	260,454	284,682	280,070	265,243
50th Percentile	280,627	277,283	283,698	300,480	312,179	355,539	327,887	301,309	270,579	297,984	291,290	287,758
60th Percentile	287,378	287,122	295,958	312,358	325,855	372,581	347,573	313,378	279,954	302,180	294,730	292,042
70th Percentile	298,107	295,820	305,252	327,294	356,859	396,667	359,274	318,144	285,295	307,920	300,081	299,840
80th Percentile	311,607	309,293	315,491	340,316	369,413	407,498	366,803	322,786	293,475	315,440	309,267	304,633
90th Percentile	322,622	321,981	336,935	348,252	391,161	417,148	373,927	326,663	300,820	322,792	317,267	314,629
Maximum	324,253	324,253	344,291	374,926	417,148	417,148	406,740	352,532	320,112	337,233	324,253	324,253

Percentile	Cumulative Case (acre-feet)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025	4,025
10th Percentile	120,585	140,357	144,317	149,535	155,426	167,261	151,724	136,313	134,863	144,402	133,015	124,988
20th Percentile	217,159	217,148	235,511	226,211	210,396	210,171	193,041	187,359	192,859	217,968	214,670	211,838
30th Percentile	237,893	235,094	252,303	248,003	236,086	245,669	227,679	223,244	222,889	245,417	243,591	238,853
40th Percentile	262,878	258,109	263,513	264,984	269,494	282,781	266,668	253,502	246,384	276,873	265,761	259,396
50th Percentile	276,339	268,581	276,391	298,927	292,269	346,859	321,982	300,757	268,252	290,658	285,638	277,283
60th Percentile	280,040	277,262	293,038	308,413	320,292	368,243	346,652	312,859	279,317	301,058	292,077	286,392
70th Percentile	286,956	289,598	303,233	325,149	351,475	396,209	359,605	318,451	284,670	306,443	295,654	292,919
80th Percentile	307,208	301,183	313,484	337,320	368,189	406,686	367,062	323,850	293,736	315,076	305,093	302,923
90th Percentile	317,659	321,390	336,191	348,109	388,918	417,148	374,220	326,885	303,082	321,524	315,069	314,428
Maximum	324,253	324,253	344,291	368,911	417,148	417,148	407,461	353,993	316,615	335,482	324,072	324,253

Table O-10. Percent Difference between Cumulative and Baseline Camanche Storage Percentiles (positive indicates increase)

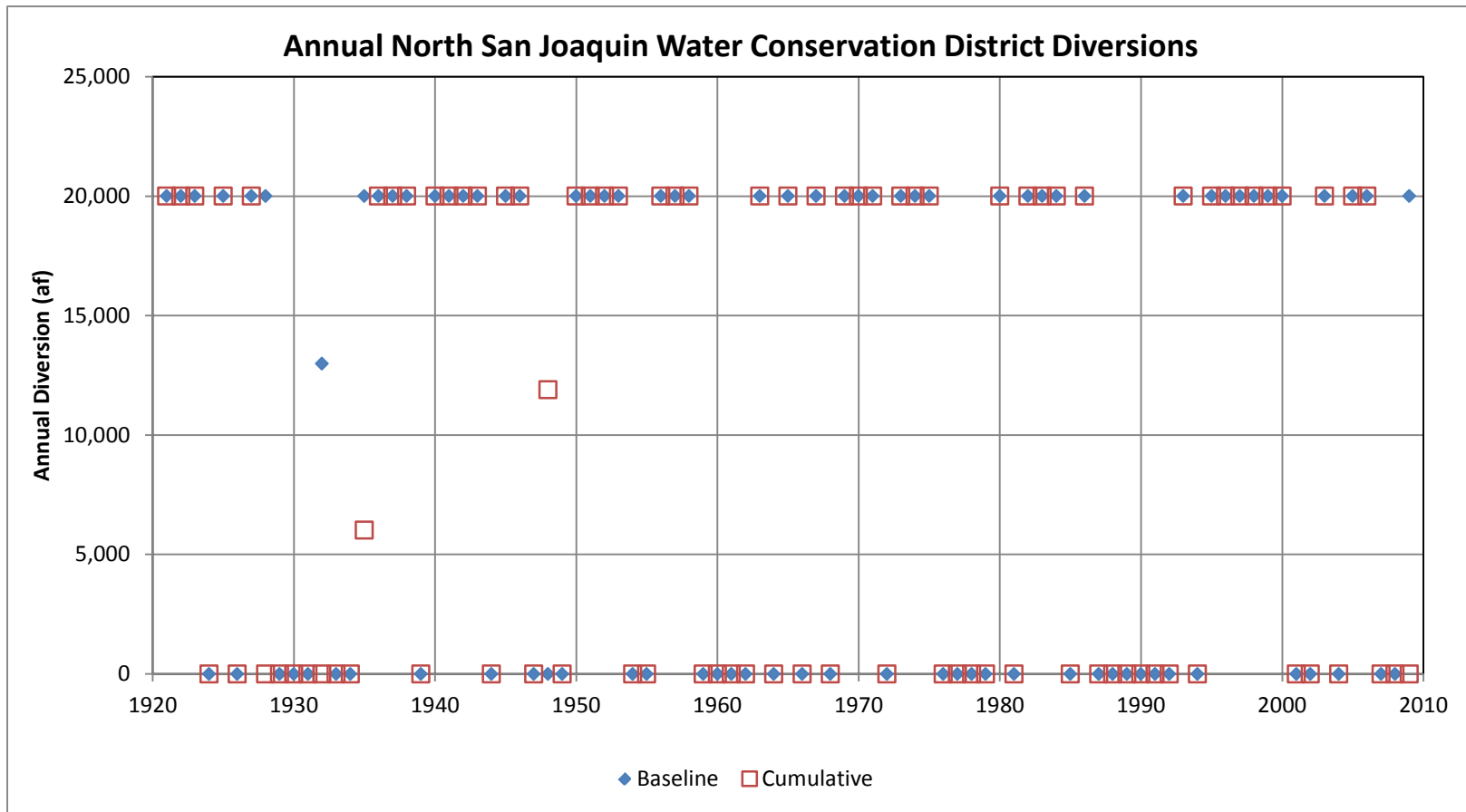
Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10th Percentile	-3.6%	2.2%	-5.4%	-11.8%	-7.3%	-5.3%	-3.2%	-5.0%	-4.9%	-8.2%	-8.2%	-6.5%
20th Percentile	-2.1%	-0.4%	-2.5%	-1.0%	-6.0%	-11.7%	-12.7%	-13.6%	-10.2%	-8.1%	-7.4%	-6.0%
30th Percentile	-5.5%	-2.2%	-2.5%	-6.0%	-6.4%	-2.1%	-4.4%	-3.9%	-6.6%	-5.1%	-4.4%	-3.6%
40th Percentile	-2.9%	-3.5%	-2.8%	-8.8%	-2.4%	-3.0%	-3.2%	-3.7%	-5.4%	-2.7%	-5.1%	-2.2%
50th Percentile	-1.5%	-3.1%	-2.6%	-0.5%	-6.4%	-2.4%	-1.8%	-0.2%	-0.9%	-2.5%	-1.9%	-3.6%
60th Percentile	-2.6%	-3.4%	-1.0%	-1.3%	-1.7%	-1.2%	-0.3%	-0.2%	-0.2%	-0.4%	-0.9%	-1.9%
70th Percentile	-3.7%	-2.1%	-0.7%	-0.7%	-1.5%	-0.1%	0.1%	0.1%	-0.2%	-0.5%	-1.5%	-2.3%
80th Percentile	-1.4%	-2.6%	-0.6%	-0.9%	-0.3%	-0.2%	0.1%	0.3%	0.1%	-0.1%	-1.3%	-0.6%
90th Percentile	-1.5%	-0.2%	-0.2%	0.0%	-0.6%	0.0%	0.1%	0.1%	0.8%	-0.4%	-0.7%	-0.1%
Maximum	0.0%	0.0%	0.0%	-1.6%	0.0%	0.0%	0.2%	0.4%	-1.1%	-0.5%	-0.1%	0.0%



Note: These values show the range (minimum, 10th percentile, 50th percentile [median], 90th percentile, and maximum) of the percent differences between the cumulative and baseline scenarios calculated for each month of the 89-year simulation. In contrast, the percent differences in the table above are based on the percentile distributions presented in the two tables above it.

Appendix P

**Allocations to the North San Joaquin Water
Conservation District under Baseline and
Cumulative Conditions**



Note: af = acre-feet

P.1 Baseline Conditions, North San Joaquin Water Conservation District Allocations (acre-feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1921	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1922	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1923	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1926	0	0	0	0	0	0	0	0	0	0	0	0	0
1927	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1928	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	2208	2987	3507	2208	1299	779	0	0	12988
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1936	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1937	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1938	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1939	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1941	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1942	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1943	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1944	0	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1946	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
													Total
1947	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1951	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1952	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1953	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1954	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1957	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1958	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1959	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1970	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1971	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1974	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1975	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
													Total
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1983	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1984	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1996	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1997	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1998	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1999	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
2000	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
2001	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
													Total
2004	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
2006	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
2007	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000

P.2 Cumulative Conditions, North San Joaquin Water Conservation District Allocations (acre-feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1921	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1922	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1923	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1926	0	0	0	0	0	0	0	0	0	0	0	0	0
1927	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1928	0	0	0	0	0	0	0	0	0	0	0	0	0
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	1023	1385	1625	1023	602	361	0	0	6020
1936	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1937	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1938	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1939	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1941	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1942	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1943	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1944	0	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1946	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1947	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	2021	2735	3210	2021	1189	713	0	0	11890
1949	0	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1951	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1952	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1953	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1954	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1957	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1958	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1959	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1970	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1971	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1974	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1975	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1983	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1984	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1996	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1997	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1998	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
1999	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
2000	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
2001	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
2004	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
2006	0	0	0	0	3400	4600	5400	3400	2000	1200	0	0	20000
2007	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Q

**Number of Months when
Reservoir Storage Falls below
Recreation Opportunity Thresholds under Baseline
and Cumulative Conditions**

Table Q-1. Number of Months when Pardee Reservoir Falls Below Recreation Opportunity Threshold at Pardee Recreation Area during the 89-Year Simulation^{a, b}

	Baseline (months)	Cumulative (months)
Main Boat Launch (540 ft msl, 142,420 AF)		
February	5	5
March	4	3
April	3	2
May	3	2
June	3	2
July	4	3
August	4	5
September	5	6
October	9	7
TOTAL	40	35
Low Water Boat Launch (495 ft msl, 75,480 AF)		
February	2	2
March	1	0
April	1	1
May	1	1
June	1	1
July	1	1
August	1	1
September	1	1
October	1	1
TOTAL	10	9
Notes:		
^a Data obtained from EBMUDSIM modeling results that were based on historic runoff for 1921 through 2009 (Appendix E).		
^b The Pardee Recreation Area is open to the public from the first Friday in February through the last Sunday in October		
AF = acre-feet		
ft msl = feet above mean sea level		

Table Q-2. Number of Months when Camanche Reservoir Falls Below Recreation Opportunity Threshold at Camanche Reservoir North Shore Recreation Area during the 89-Year Simulation^{a, b}

	Baseline (months)	Cumulative (months)
Main Ramp (210 ft msl, 247,231 AF)		
January	26	31
February	28	31
March	21	25
April	22	26
May	23	30
June	24	28
July	30	30
August	32	34
September	33	37
October	22	27
November	22	27
December	27	30
TOTAL	310	356
Main Ramp (194 ft msl, 164,370 AF)		
January	12	14
February	11	11
March	10	10
April	9	10
May	9	11
June	9	9
July	10	11
August	11	14
September	12	15
October	12	12
November	12	13
December	12	14
TOTAL	129	144
Main Ramp, Low-Water Ramp (160 ft msl, 54,246 AF)		
January	2	2
February	2	2
March	2	2
April	2	2
May	2	2
June	2	3
July	2	3
August	2	3

	Baseline (months)	Cumulative (months)
September	2	2
October	2	2
November	2	2
December	2	2
TOTAL	24	27

Notes:

^a Data obtained from EBMUDSIM modeling results that were based on historic runoff for 1921 through 2009 (Appendix E).

^b The Camanche North Shore Recreation Area is open year round.

AF = acre-feet

ft msl = feet above mean sea level

Table Q-3. Number of Months when Camanche Reservoir Falls Below Recreation Opportunity Threshold at Camanche Reservoir South Shore Recreation Area during the 89-Year Simulation^{a, b}

	Baseline Conditions (months)	Cumulative (months)
Main Ramp (205 ft msl, 219,265 AF)		
January	18	22
February	19	21
March	14	17
April	13	15
May	17	20
June	17	22
July	17	25
August	21	26
September	22	25
October	13	19
November	15	19
December	16	22
TOTAL	202	253
Main Ramp Low-Water Ramp (175 ft msl, 91,528 AF)		
January	4	4
February	4	4
March	4	4
April	5	4
May	4	4
June	4	4
July	4	4
August	3	3
September	3	4
October	2	4
November	2	4
December	5	5
TOTAL	44	48
Main Ramp, Low-Water Ramp (160 ft msl, 54,246 AF)		
January	2	2
February	2	2
March	2	2
April	2	2
May	2	2
June	2	3
July	2	3
August	2	3

	Baseline Conditions (months)	Cumulative (months)
September	2	2
October	2	2
November	2	2
December	2	2
TOTAL	24	27

Notes:

^a Data obtained from EBMUDSIM modeling results that were based on historic runoff for 1921 through 2009 (Appendix E).

^b The Camanche South Shore Recreation Area is open year round.

AF = acre-feet
ft msl = feet above mean sea level