Upper San Joaquin River Basin Storage Investigation

Phase 1 Investigation Report

A Joint Study by:

Bureau of Reclamation
Mid-Pacific Region

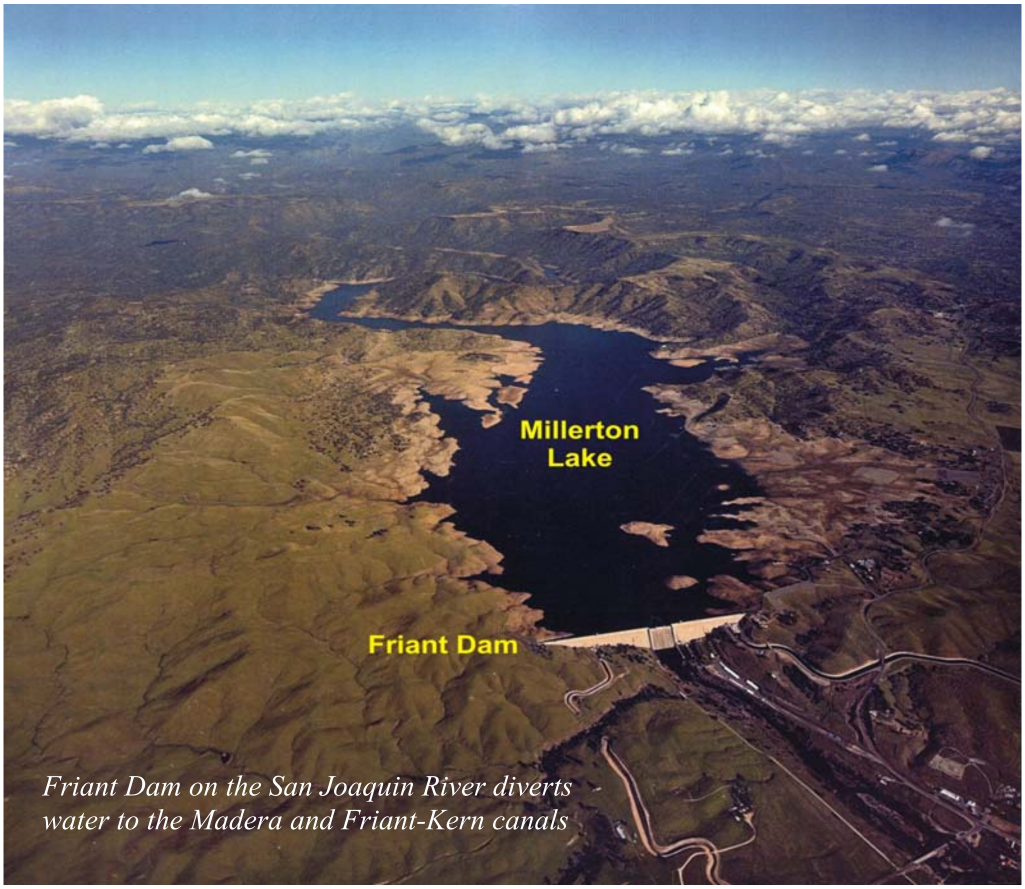
California Department of Water Resources

In Coordination with:

The California Bay-Delta Authority

October 2003

Upper San Joaquin River Basin Storage Investigation



Friant Dam on the San Joaquin River diverts water to the Madera and Friant-Kern canals

Phase 1 Investigation Report

A Joint Study by:

Bureau of Reclamation
Mid-Pacific Region

California Department of Water Resources

In Coordination with:

The California Bay-Delta Authority

Prepared By:

MWH

October 2003

UPPER SAN JOAQUIN RIVER BASIN STORAGE INVESTIGATION

Phase 1 Investigation Report

TABLE OF CONTENTS

LIST OF TECHNICAL APPENDICES

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

Basin Plan	Water Quality Control Plan for the Sacramento River and San Joaquin river basins
Bay-Delta	San Francisco Bay/Sacramento-San Joaquin Delta
BLM	U.S. Bureau of Land Management
CDEC	California Data Exchange Center
CEQA	California Environmental Quality Act
CFRF	concrete-face rockfill
cfs	cubic feet per second
CNDDB	California Natural Diversity Database
Corps	United States Army Corps of Engineers
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CWA	Clean Water Act
Delta	Sacramento-San Joaquin River Delta
DWR	Department of Water Resources
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
elevation	elevation in feet above mean sea level
FERC	Federal Energy Regulatory Commission
FWUA	Friant Water Users Authority
GWh	gigawatt-hour
Investigation	Upper San Joaquin River Basin Storage Investigation
ISI	Integrated Storage Investigation
KRCD	Kings River Conservation District
kV	kilovolt
M&I	municipal and industrial
MID	Merced Irrigation District
MW	megawatt
MWh	megawatt-hour

NEPA	National Environmental Policy Act
NOI	Notice of Intent
NOP	Notice of Preparation
NRDC	Natural Resources Defense Council
PG&E	Pacific Gas and Electric Company
RCC	roller-compacted concrete
Reclamation	Bureau of Reclamation
RM	river mile
RMC	Resources Management Coalition
ROD	Record of Decision
SCE	Southern California Energy Company
SWP	State Water Project
TAF	thousand acre-feet
TM	Technical Memorandum
TMDL	total maximum daily load

UPPER SAN JOAQUIN RIVER BASIN STORAGE INVESTIGATION
PHASE 1 INVESTIGATION REPORT

EXECUTIVE SUMMARY

The Upper San Joaquin River Basin Storage Investigation (Investigation) is a joint feasibility study by the Bureau of Reclamation and the California Department of Water Resources (DWR). The Investigation is being performed in accordance with the CALFED Programmatic Environmental Impact Statement / Environmental Impact Report (EIS/EIR) Record of Decision (ROD), which recommended evaluating water storage in the upper San Joaquin River basin to "contribute to restoration of and water quality for the San Joaquin River and to facilitate additional conjunctive management and exchanges that improve the quality of water deliveries to urban areas."

The feasibility study is being completed in two phases. The Phase 1 Investigation Report describes initial study activities that have been completed toward preparing the feasibility report. Phase 2 will include completing the feasibility report and associated EIS/EIR. Figure ES-1 shows the location of the upper San Joaquin River basin and the study area for the Investigation.

Purpose of the Phase 1 Report

- Define problems and opportunities
- Establish study objectives
- Identify potential water storage options
- Present findings of Phase 1 technical analyses
- Provide focus for Phase 2 activities

MAJOR FINDINGS AND CONCLUSIONS

Reclamation and DWR find sufficient potential for additional water storage in the upper San Joaquin River basin to warrant further study. Major findings and conclusions from Phase 1 include the following:

- Water supply in the upper San Joaquin River basin is available and could be developed with additional storage
- Water supply developed with additional storage in the upper San Joaquin River basin could contribute to restoring the San Joaquin River, improving water quality in the San Joaquin River, and increasing water supply reliability
- Six surface storage options appear technically feasible and will be further considered in Phase 2 of the feasibility study
- Preliminary costs for surface storage options are within the range of other reservoirs under consideration in California
- Public support is strong for continued evaluation of water storage in the upper San Joaquin River basin
- Regional interest in additional conjunctive management of surface water and groundwater resources is high

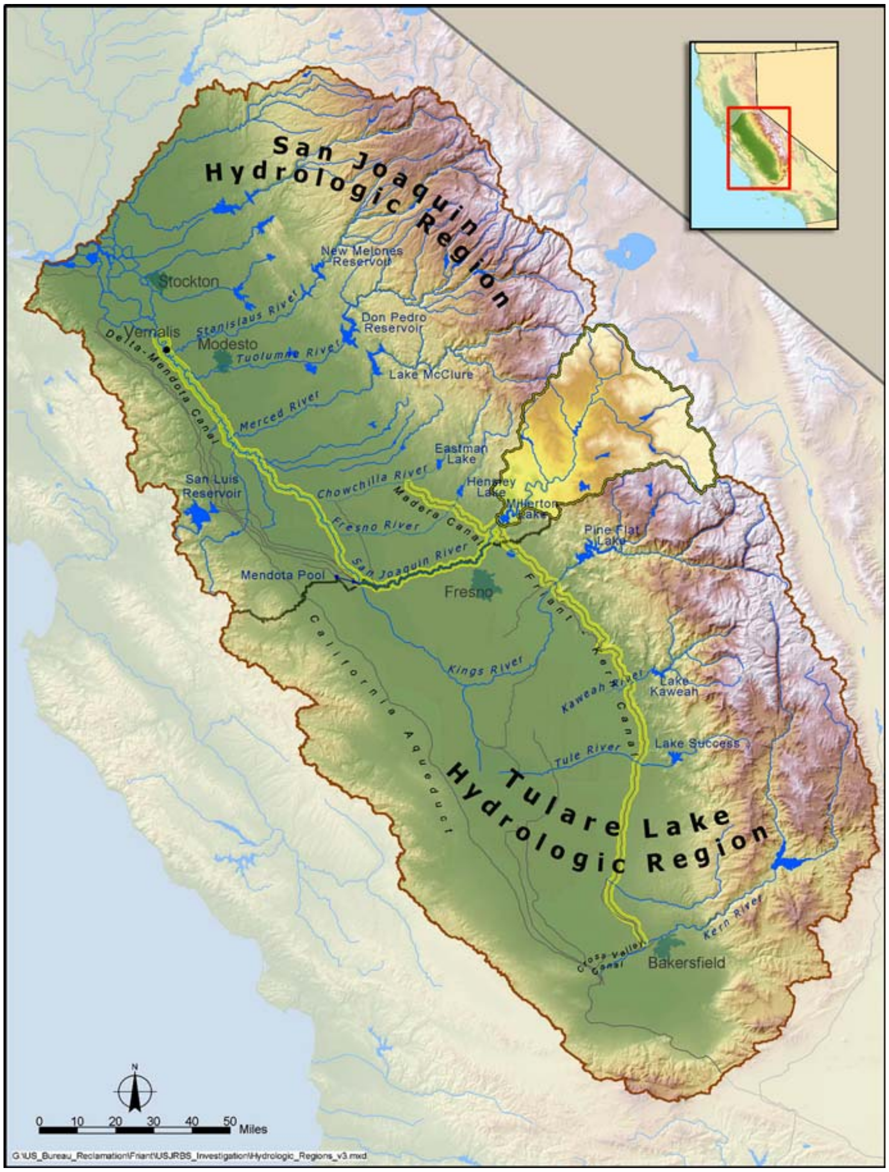


FIGURE ES-1. STUDY AREA EMPHASIS

STUDY AUTHORIZATION

Federal authorization for the feasibility study was provided in PL 108-7, the omnibus appropriations legislation for fiscal year 2003. Reclamation is the responsible Federal agency for preparing this report.

PROBLEMS AND OPPORTUNITIES

Water resources problems in the San Joaquin Valley are related to changing water needs, hydrologic variations in water availability, and the capacity of current water storage and conveyance facilities. Problems and opportunities addressed by the Investigation, described in the following sections, were identified in the CALFED ROD and from stakeholder input.

San Joaquin River Ecosystem

The reach of the San Joaquin River from Friant Dam to the Merced River confluence does not support a continuous natural riparian and aquatic ecosystem. After completion of Friant Dam, most of the water supply in the river has been diverted for agricultural and urban uses, with the exceptions of releases to satisfy riparian water rights upstream of Gravelly Ford and flood releases. Consequently, the reach from Gravelly Ford to Mendota Pool is often dry.

Problems

- San Joaquin River ecosystem
- San Joaquin River water quality
- Water supply reliability

Opportunities

- Flood control
- Hydropower generation
- Recreation
- Delta inflow

San Joaquin River Water Quality

Water quality in portions of the San Joaquin River has been a problem for several decades due to low flow, and discharges from agricultural areas, wildlife refuges, and municipal and industrial treatment plants. Requirements for water quality in the San Joaquin River have become more stringent and the number of locations along the river at which specific water quality objectives are identified has increased. One location of water quality concern is near Vernalis, where the San Joaquin River enters the Delta.

Water Supply Reliability

The CALFED program identified water supply reliability as a key problem, due to a mismatch between Bay-Delta supplies and beneficial uses that depend on the Bay-Delta system. Water supply reliability problems in the study area are evident as severe groundwater overdraft. Additional storage in the upper San Joaquin River basin could increase the reliability of deliveries to Central Valley Project (CVP) contractors or other water users who could receive water through CVP facilities, resulting in a reduction in groundwater overdraft. This improved supply reliability would provide opportunities for exchanges with urban water users that improve the quality of urban water deliveries.

Flood Control

Major storms during the past two decades have demonstrated that Friant Dam, among many other dams in the Central Valley, may not provide the level of flood protection intended at the time the flood management system was designed. Increased water storage capacity in the upper San Joaquin River basin would capture additional flood volume and reduce the frequency and magnitude of damaging flood releases from Friant Dam.

Hydropower

Although the economic feasibility of hydropower-only projects may be limited, developing new storage for water supply, water quality, ecosystem restoration, and flood damage reduction creates opportunities to add hydropower features.

Delta Inflows

Additional storage in the upper San Joaquin River basin could result in increased magnitude, duration, or frequency of inflows to the Delta from river releases intended to improve the San Joaquin River ecosystem or water quality.

INITIAL SCREENING OF SURFACE STORAGE OPTIONS

Figure ES-2 shows the locations of surface storage options in the eastern San Joaquin Valley that were first considered. Initial screening focused on potential construction-related issues that could preclude building required facilities, create environmental impacts that could not be mitigated, or create conditions under which permits issued by regulatory agencies or approved by decision-makers would be unlikely. Initial screening did not consider reservoir operations modeling or construction cost estimates.

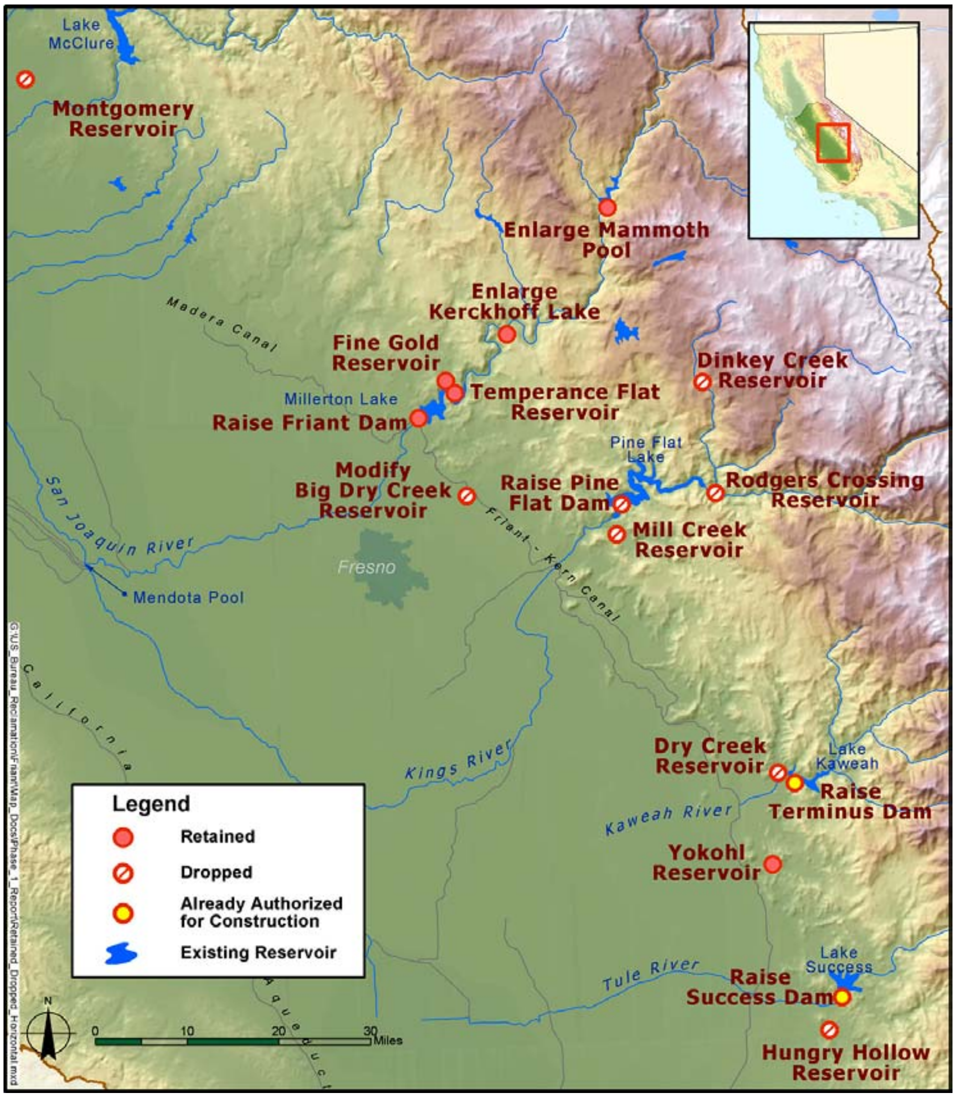


FIGURE ES-2. SURFACE STORAGE OPTIONS CONSIDERED

Table ES-1 lists surface storage options that were identified and results of initial screening. A Technical Memorandum (TM) was prepared for each surface storage option considered. As indicated in Table ES-1, six surface storage sites were retained for further analysis in Phase 2 of the feasibility study. Although cost was not a criterion for initial screening, cost information is provided in all of the TMs, which are included as appendices of the Phase 1 Report.

TABLE ES-1 INITIAL SCREENING OF SURFACE STORAGE OPTIONS

Watershed / Reservoir Site	Max Cap[1] (TAF)	Engineering Issues			Environmental Issues					Result of Initial Screening
		DS	SG	WQ	Bot	WL	AB	Rec	LU	
Merced River Watershed										
Montgomery Reservoir	241									Dropped
San Joaquin River Watershed										
Raise Friant Dam	870									Retained
Fine Gold Creek	800									Retained
Temperance Flat RM 274	2,100									Retained
Temperance Flat RM 279	2,750									Retained
Temperance Flat RM 286 (Enlarge Kerckhoff Lake)	1,400									Retained
Enlarge Mammoth Pool	35									Retained[2]
Big Dry Creek Watershed										
Big Dry Creek Dam	30									Dropped
Kings River Watershed										
Raise Pine Flat Dam	124									Dropped[3]
Mill Creek	200									Dropped
Rodgers Crossing	295									Dropped
Dinkey Creek	90									Dropped
Kaweah River Watershed										
Enlarge Lake Kaweah	n/a									Dropped[4]
Dry Creek	70									Dropped
Yokohl Valley	800									Retained
Tule River Watershed										
Enlarge Lake Success	n/a									Dropped[4]
Hungry Hollow	800									Dropped

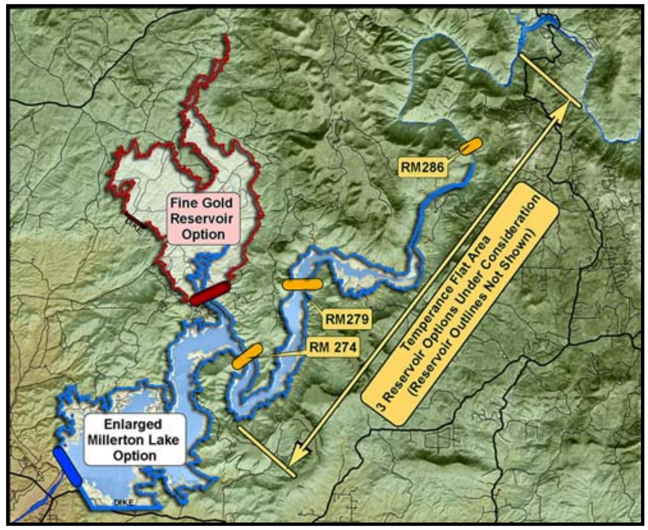
Key to Engineering Issues		Key to Assessments	
DS	Safety of existing dam	(hatched)	Unfavorable engineering or operational condition
SG	Soils and geology	(white)	Potential environmental effects not determined
WQ	Quality of developed water	(green)	Low or no likely adverse environmental effects
		(yellow)	Potential adverse effects; mitigation to be determined
Key to Environmental Issues		(red)	Potential unmitigable adverse environmental effects
AB	Aquatic biology & water quality	**Notes**	
Bot	Botany	1.	Maximum new storage capacity (thousand acre-feet).
LU	Land use	2.	Under review by others; will not be considered in Phase 2.
Rec	Recreation	3.	Potential partner not interested in pursuing project.
WL	Wildlife	4.	Authorized for construction by U.S. Army Corps of Engineers.

SUMMARY OF SURFACE STORAGE OPTIONS ANALYSES

Surface storage options that were retained were evaluated to identify potential accomplishments, costs, and impacts. Each option was evaluated using computer models to identify potential new water supplies and to estimate power generation and use, and cost estimates were prepared for major components.

Surface Storage Options Retained for Further Study

Options to be evaluated in greater detail as the feasibility study continues include the following:



Raise Friant Dam. Friant Dam is a 319-foot-high concrete gravity dam on the San Joaquin River about 20 miles northeast of Fresno. A dam raise of up to 140 feet would enlarge Millerton Lake by up to 870 thousand acre-feet (TAF).

Fine Gold Creek Reservoir. Fine Gold Creek Reservoir would be located on a small tributary of the San Joaquin River that enters Millerton Lake. Water would be pumped from Millerton Lake into Fine Gold Reservoir and released as needed. Reservoir sizes of up to 800 TAF are being considered.

Temperance Flat Reservoir. Temperance Flat is a wide, bowl-shaped area in the upper portion of Millerton Lake approximately 13 miles upstream of Friant Dam. Temperance Flat Reservoir would capture the flow of the San Joaquin River downstream of Kerckhoff Dam. Three potential dam sites are under consideration: at river mile (RM) 274, RM 279, and RM 286. Multiple sizes and dam types are under consideration at each site.

Yokohl Valley Reservoir. Yokohl Valley Reservoir, as shown in Figure ES-2, would be located approximately 15 miles east of Visalia. This reservoir would operate as a pump-back storage reservoir served by the Friant-Kern Canal. It would require construction of a 260-foot-high earthfill dam and two small saddle dams.

Water Supplies from Additional Storage

The CALSIM model was used to estimate the new water supply that each retained option could provide. New water supply is water that could be made available at Friant Dam, over and above the amount currently made available for delivery. CALSIM simulates the operation of major water projects throughout California and is widely used to identify how potential projects and actions would affect system-wide operations. During Phase 1, CALSIM was revised to reflect the decision-making process used to allocate water supplies at Friant Dam based on hydrologic conditions, and to estimate the availability of water for release to the San Joaquin River or diversion to the Friant-Kern and Madera canals.

Single-Purpose Operational Scenarios

For each surface storage option, single-purpose operational scenarios were evaluated for multiple reservoir sizes. Model simulations identified the quantity of water that would be available for each Investigation purpose (river restoration, river water quality, and water supply reliability) if the additional water supply created by new storage were operated solely to contribute to that purpose. To identify how new storage could contribute to each Investigation purpose without causing an unaccounted reallocation of existing supplies, restoration and water quality single-purpose analyses were constrained to estimate the annual amount of water that would be available without increasing or decreasing average annual deliveries to current water users.

Analysis of single-purpose operational scenarios demonstrated that even under operational scenarios focused on a particular purpose, benefits could be provided to help meet multiple purposes. For example, releases to the San Joaquin River for restoration would also improve water quality in the river, and depending on operations at Mendota Pool, could increase water supply reliability to south-of-Delta water users or increase Delta inflow. Table ES-2 shows the types of benefits that would result under operational scenarios considered. The range of water supplies developed by each storage option is provided in Table ES-3.

TABLE ES-2 POTENTIAL BENEFITS OF ADDITIONAL WATER SUPPLY AT FRIANT DAM

Potential Effect	Single–Purpose Operational Scenario[1]		
	San Joaquin River Restoration	San Joaquin River Water Quality	Water Supply Reliability
Total Friant Division water deliveries	0	0	+
Class 2 Friant Division water deliveries	+	+	+
Delivery of unstorable water (Section 215)	-	-	-
Reduction in regional groundwater overdraft	+	+	+
Water supply at Mendota Pool	+	+	-
Water quality at Mendota Pool	+	+	-
South-of-Delta supplies and/or Delta inflow	+	+	-
Year-round river releases from Friant Dam	+	+	0
Seasonal river releases from Friant Dam	+	+	0

Key:
+ positive effect
- negative effect
0 no change

Notes:
1. Phase 1 included single-purpose operational scenarios only. Phase 2 evaluations will include multiple-purpose operational scenarios.

Other Operational Considerations

Millerton Lake is operated as an annual reservoir. Each year, all available water supplies are allocated to contract deliveries based on planned evacuation of water from active storage space. Initial evaluations did not include water carried over from one year to the next. If carryover storage were included in the operation, the wide variation in water quantities between different year types would be reduced, the average new supply would be less, and more water would likely be available during critically dry years. Strategies to include carryover storage will be considered in greater detail as the feasibility study continues.

Although initial evaluations did not consider changes to flood storage rules, results show that additional storage would significantly reduce the magnitude and frequency of flood releases from Friant Dam to the San Joaquin River. As the feasibility study proceeds, potential changes to flood storage requirements and associated benefits will be evaluated.

TABLE ES-3 WATER SUPPLIES AND ESTIMATED CONSTRUCTION COSTS OF SURFACE STORAGE OPTIONS

Reservoir Site		Net Additional Storage (TAF)	Average Annual New Water Supply (TAF/year)	Estimated Construction Cost ($Million)
Raise Friant Dam		125 - 870	25 – 150	150 – 840[1]
Temperance Flat Area	River Mile 274	450 – 2,100	95 – 225	610 – 1,000
	River Mile 279	450 – 2,700	95 – 235	510 – 1,750
	River Mile 286	450 – 1,350	95 - 190	410 – 790
Fine Gold Creek		120 - 800	15 –115	200 – 540
Yokohl Valley		450 - 800	70 - 100	350[2]

1. Raise Friant Dam costs include land acquisition costs because of the relative significance of residential development at Millerton Lake. Cost estimates for other options do not include land acquisition.
2. Cost for a 450 TAF reservoir was updated from a study completed in 1975. Costs for an 800 TAF reservoir are under development.

Estimated Construction Costs

Construction costs were estimated for retained surface storage options. In most cases, previous estimates either did not exist or were considered too old to be confidently updated. Costs were based on prefeasibility-level designs and contain provisions for uncertainties. For most options, costs were estimated for different dam types and reservoir sizes.

Field costs for construction were estimated at 2003 price levels. Field costs represent the estimated costs for identified features, plus allowances for mobilization (5 percent), unlisted items (15 percent), and contingencies (25 percent). Field costs were increased by 25 percent to account for investigations, designs, administration, and construction management to obtain total estimated construction costs. Costs for road construction, relocations of existing facilities, environmental mitigation, land requirements, reservoir clearing, and finance interest during construction will be prepared during Phase 2. Table ES-3 summarizes the range of potential costs for surface storage options.

Environmental Issues

Environmental issues considered as part of Phase 1 reviews included potential impacts to terrestrial and aquatic vegetation and wildlife, recreational resources, and land uses. Initial screening did not include consultations with environmental, resource, or permitting agencies. The Phase 1 environmental review indicated that potential impacts are largely mitigable; however, further review is needed to identify specific impacts and mitigation measures. Table ES-4 summarizes Phase 1 environmental review results.

TABLE ES-4 ENVIRONMENTAL REVIEW OF SURFACE STORAGE OPTIONS

Surface Storage Option	Summary of Preliminary Environmental Review
Raise Friant Dam	• Listed aquatic and terrestrial species and species of special concern. Potential opportunities for mitigation. • Potential recreation impacts at Millerton Lake, Temperance Flat, and San Joaquin River Gorge Management Area. • Land use and cultural resources impacts on residences, former homesteads, and historic resources.
Temperance Flat Reservoir	• Listed aquatic and terrestrial species and species of special concern. Potential opportunities for mitigation. • Potential recreation impacts at Millerton Lake, Temperance Flat, San Joaquin River Gorge Management Area, and Kerckhoff Lake. • Land use and cultural resources impacts on residences, former homesteads, and historic resources.
Fine Gold Creek Reservoir	• Listed aquatic and terrestrial species and species of special concern. Potential for opportunities for mitigation. • Inundation of relatively pristine wetland and riparian habitat areas. • Potential affects of operations on aquatic species in Millerton Lake.
Yokohl Valley Reservoir	• Listed terrestrial species. Potential opportunities for mitigation. • Potential cultural resource impacts on prehistoric Native American sites and former homesteads. • Potential land use impacts.

Hydropower Issues

The San Joaquin River watershed upstream of Millerton Lake is highly developed for hydroelectric generation. In this area, Pacific Gas & Electric (PG&E) and Southern California Edison (SCE) own several hydropower generation facilities. Both the PG&E and SCE systems consist of a series of diversion reservoirs that provide water through tunnels to downstream powerhouses. Phase 1 included preliminary estimates of current generating capacity that would be affected by constructing surface storage options, potential pumping energy required for operation of off-stream surface storage options, and potential energy generation output from new powerhouses, as summarized in Table ES-5.

TABLE ES-5 POTENTIAL ENERGY GENERATION AND USE FOR RETAINED SURFACE STORAGE OPTIONS

Dam Site	Average Annual Energy Generation Potentially Affected (GWh)	Potential Average. Annual Energy Generation (GWh)	Potential Average Annual Pumping Energy (GWh)
Raise Friant Dam	530 – 580	Not analyzed[1]	n/a[2]
Temperance Flat RM 274	580 - 1,125	160 –270	n/a
Temperance Flat RM 279	1,125	330 –450	n/a
Temperance Flat RM 286	545 – 1,125	630 –740	n/a
Fine Gold Creek Reservoir	n/a	70 - 100	130 – 170
Yokohl Valley Reservoir	n/a	80 – 110	180 – 220

1. Change in power generation at Friant power plants not analyzed in Phase 1.
2. Pumping energy not applicable for this option.

Preliminary hydropower evaluations indicate that the Raise Friant Dam option and all of the Temperance Flat options would affect the operations of existing hydropower project facilities. Raising Friant Dam would affect energy generation at the PG&E Kerckhoff Project. Although an analysis of Friant power generation was not completed during Phase 1, it does not appear likely that additional generation at Friant powerhouses resulting from any raise of Friant Dam could replace the lost energy generation from the Kerckhoff Project.

Depending on the location and height of the dam, a Temperance Flat reservoir would have the potential to affect up to five powerhouses and two diversion dams upstream of Millerton Lake. Potential impacts to installed generating capacity increase as storage capacity increases at each site. Existing generation facilities would not be affected by developing Fine Gold Creek or Yokohl Valley reservoirs. However, these facilities would require power to pump water into storage. Energy generation from released water would be less than pumping requirements.

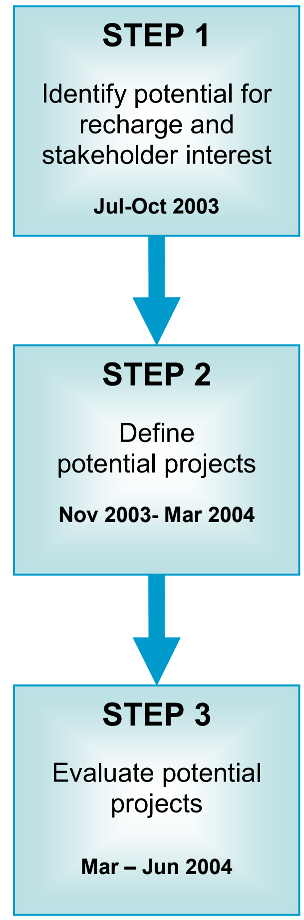
CONJUNCTIVE MANAGEMENT OPTIONS

The Investigation is also evaluating opportunities for the conjunctive management of surface water and groundwater resources. Conjunctive management actions can increase available water supplies through additional active or in-lieu recharge or development of groundwater banking projects.

A structured approach has been established to identify and evaluate conjunctive management opportunities that have the potential to support Investigation purposes. The Investigation is proceeding with a three-step evaluation, consistent with the CALFED policy of supporting voluntary, locally controlled groundwater projects.

Step 1. The study team began by identifying potential for recharge and the level of stakeholder interest; this step is largely complete. A theoretical analysis of potential recharge, given the physical constraints, indicated that the potential exists to recharge groundwater using otherwise uncaptured water from the San Joaquin River.

Stakeholders were interviewed to determine their interest in participating in regional conjunctive management and to more thoroughly define potential opportunities they have already identified. Many stakeholders demonstrated a high level of interest in regional, cooperative opportunities for groundwater storage and banking, however no specific projects were identified that could be incorporated into the Investigation. Stakeholders also stated that physical and legal constraints could affect implementation.



Conjunctive Management Evaluation Approach

Step 2. During Phase 2, DWR will lead working sessions with stakeholders to better define potential constraints; project review criteria; potential projects and policy actions; and specific project components and operations. Participants will include water managers (i.e., organizations with the capacity to carry out conjunctive management projects) and other interested parties.

Step 3. Conjunctive management projects and actions identified through this process will be evaluated using hydrologic, physical, institutional, and legal criteria to assess accomplishments and implementation requirements. Projects and actions that satisfy the criteria and would support Investigation purposes (contribute to river restoration, improve river water quality, and increase water supply reliability) will be incorporated into the Phase 2 evaluations.

PUBLIC PARTICIPATION

Phase 1 was supported by a structured public information and stakeholder participation process that was integrated with the progress of technical analysis. The study team initially engaged stakeholders concerned with local and regional water resource planning issues. As the Investigation proceeded, interested parties continued to participate in the process. Stakeholders brought a high level of experience and local knowledge and provided a variety of recommendations, responses, and reviews that aided planning. Figure ES-3 illustrates the Phase 1workshop process.

FIGURE ES-3. PHASE 1 STAKEHOLDER WORKSHOP PROCESS

In addition to public workshops, a variety of communication tools are in place to provide timely information and comment opportunities to the public through completion of the feasibility study and environmental review. The Phase 1 public involvement program featured both interactive and outreach components that included the following:

- Coordination with governmental agencies and non-governmental organizations
- Briefings for tribal representatives
- Briefings for elected officials
- Coordination with local water resources planning and management groups
- Interviews with water management agency representatives
- Tours of Millerton Lake and the upper San Joaquin River
- Informative brochures, fact sheets, and documents that provided Investigation background and progress updates
- Distribution of Investigation documents via a Web site

STAKEHOLDER VIEWS

Local support is strong for continued study of additional surface water storage in the upper San Joaquin River basin that would support Investigation purposes and provide other regional benefits. Local, state and Federal elected officials, representatives from the local business community, and county and municipal government leaders have expressed interest in the potential benefits of increased storage. During summer 2003, the San Joaquin River Resources Management Coalition, a group primarily composed of landowners along the San Joaquin River, hosted several boat tours on Millerton Lake. The tours informed participants about water supply and river restoration benefits that could be provided by additional storage.

Also participating in the public process are representatives of the environmental community, who have stated their support for river restoration and have expressed a preference for operational changes, other nonstructural actions, and conjunctive management to develop new water supplies.

The public process has engaged a large, diverse group of interested parties during Phase 1. As the feasibility study progresses, other interests, such as agencies managing land use and flood control, and hydropower operators, will become more engaged in the process. Reclamation and DWR are committed to completing the feasibility and environmental documentation process in a manner that is open to all concerned parties and fully discloses beneficial and adverse impacts of increasing storage in the upper San Joaquin River basin.

INFORMATIONAL MATERIALS AND DOCUMENT ACCESS

During Phase 1, the study team prepared and distributed a variety of informational materials, including brochures and fact sheets. A mailing list of interested parties was compiled and used to distribute postcard notifications of workshops and document releases. The project Web site, hosted by Reclamation at www.usbr.gov/mp/sccao/storage, has been a key feature in outreach efforts.

PLAN FOR PHASE 2 OF THE FEASIBILITY STUDY

Phase 2 of the feasibility study will include the necessary technical analyses to evaluate alternatives, prepare a feasibility report and supporting EIS/EIR, and identify a recommended action for consideration by decision-makers.

During Phase 2, retained surface storage options will be studied further, conjunctive management options will be identified and considered, and alternatives will be formulated and evaluated. Alternatives will be formulated as combinations of storage options and operational objectives. Following review of the costs and benefits of initial alternatives, a set of final alternatives will be defined that will be evaluated in detail in the feasibility report and associated environmental review documents.

Figure ES-4 shows the major milestones and planned schedule for completing the Upper San Joaquin River Basin Storage Investigation Feasibility Report and EIS/EIR. This plan and schedule would complete the feasibility study and environmental review to meet the 2006 schedule included in the CALFED Bay-Delta Program ROD.

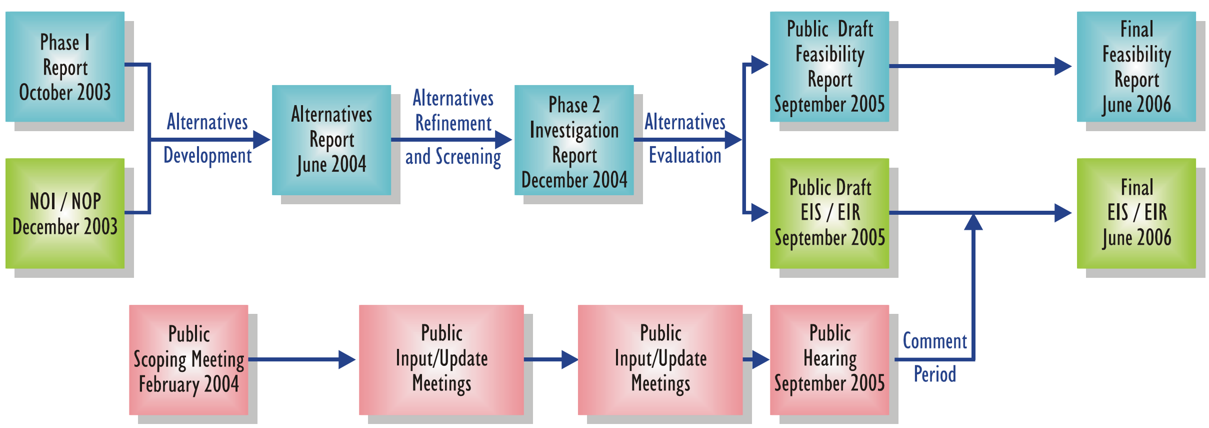


FIGURE ES-4. PHASE 2 MILESTONES

THIS PAGE LEFT BLANK INTENTIONALLY

CHAPTER 1. INTRODUCTION

Reliable high-quality water supplies are critical to maintaining California's economic vitality and the quality of life of Californians, and hydrologic conditions in the state range widely – both geographically and from year to year. Water supplies needed to meet current and future uses and support ecosystem requirements have risen in recent years.

Recognizing these needs, a consortium of State and Federal resources management agencies collaboratively developed the CALFED Bay-Delta Program to address the imbalance between water supplies and demands and provide for ecosystem restoration and protection. The principal objectives of the CALFED Bay-Delta Program are to develop a comprehensive, long-term strategy to provide reliable water supplies to our cities, agriculture, and the environment while restoring the overall health of the San Francisco Bay/Sacramento-San Joaquin rivers Delta (Delta). The CALFED Programmatic Record of Decision (ROD) of August 28, 2000, recommended numerous projects and actions to increase water supply reliability, improve ecosystem health, increase water quality, and improve delta levee stability.

GUIDANCE FOR STORAGE IN THE UPPER SAN JOAQUIN RIVER BASIN

The ROD describes an approach for reducing the imbalance between water supplies and demands in areas served by water projects that affect the Delta. A series of programs were defined that, in combination, would help attain the overall goals of the CALFED Bay-Delta Program. One of the programs, water storage, includes five investigations of potential increased surface storage capabilities at various locations in the Central Valley, including the upper San Joaquin River basin, as well as efforts to increase groundwater storage through conjunctive management. For the upper San Joaquin River basin, the ROD states:

> … 250-700 [thousand acre-feet (TAF)] of additional storage in the upper San Joaquin watershed… would be designed to contribute to restoration of and improve water quality for the San Joaquin River and facilitate conjunctive water management and water exchanges that improve the quality of water deliveries to urban communities. Additional storage could come from enlargement of Millerton Lake at Friant Dam or a functionally equivalent storage program in the region.

The ROD plan for action includes investigating new surface water storage in the upper San Joaquin River watershed and completing environmental and planning documentation by mid-2006. Consistent with this direction, the Bureau of Reclamation, Mid-Pacific Region and the California Department of Water Resources (DWR) are conducting the Upper San Joaquin River Basin Storage Investigation (Investigation) as partners. The Investigation will evaluate the range of potential accomplishments that could be provided from an enlarged Millerton Lake, and will consider options that could be included in a regional storage program to provide functionally equivalent accomplishments.

PURPOSE AND SCOPE OF THIS REPORT

The purpose of a feasibility study is to conduct necessary technical analyses sufficient to evaluate alternatives and identify a recommended action to address issues identified by a decision-maker. For this feasibility study, the CALFED ROD recommended a study of alternatives for storing water from the upper San Joaquin River basin for multiple uses. Congress provides authorization to Federal agencies to prepare feasibility reports. Generally, the findings of a feasibility study provide the basis for Congressional authorization for project construction.

This feasibility study has been organized into two phases and will be supported with appropriate environmental compliance documentation. Phase 1 of the feasibility study focused on identifying and screening potential water storage options that could be implemented to address Investigation purposes. Phase 2 will further evaluate options retained from Phase 1, formulate and evaluate alternatives, and identify a recommended alternative.

This report describes Phase 1 feasibility study activities and presents the results of initial screening of potential storage options. As the feasibility study continues, Reclamation and DWR will develop project alternatives for consideration and initiate formal environmental compliance processes for preparing an Environmental Impact Statement (EIS), an Environmental Impact Report (EIR), and a ROD.

The purpose of this report is to summarize the range of storage opportunities that the Investigation has examined, present findings, and discuss in greater detail the storage options that will continue to be evaluated in the feasibility study.

This report is organized as follows:

- Chapter 1 provides background on the feasibility study.
- Chapter 2 describes existing and future without-project conditions.
- Chapter 3 identifies problems and opportunities that storage of additional water from the upper San Joaquin River basin could help address.
- Chapter 4 describes the plan formulation, including the evaluation of surface storage options that have been considered.
- Chapter 5 describes the public involvement process that has supported work to date.
- Chapter 6 describes next steps, including primary areas of study in Phase 2 of the feasibility study, and EIS/EIR milestones.
- Chapter 7 lists the preparers of this report.
- Chapter 8 contains references used in the preparation of this report and its appendices.
- Chapter 9 contains a glossary of terms used in this report and its appendices, and defines other terms pertinent to the contents of this report.

STUDY AUTHORIZATION

Federal and State of California authorizations for preparation of this feasibility report are described below.

Federal Authorization

Federal authorization for preparing a feasibility report was provided in PL108-7, Division D, Title II, Section 215, the omnibus appropriations legislation for fiscal year 2003, enacted February 2003. In that bill, Congress authorized the Secretary of Interior to prepare a feasibility study of storage in the upper San Joaquin River basin:

> The Secretary of the Interior, in carrying out CALFED-related activities, may undertake feasibility studies for Sites Reservoir, Los Vaqueros Reservoir Enlargement, and Upper San Joaquin Storage projects. These storage studies should be pursued along with ongoing environmental and other projects in a balanced manner.

Reclamation is the Federal agency responsible for preparing the feasibility report.

State of California Authorization

Section 227 of the State of California Water Code provides authorization for DWR to participate in water resources investigations, as follows:

> The department may investigate any natural situation available for reservoirs or reservoir systems for gathering and distributing flood or other water not under beneficial use in any stream, stream system, lake, or other body of water. The department may ascertain the feasibility of projects for such reservoirs or reservoir systems, the supply of water that may thereby be made available, and the extent and character of the areas that may be thereby irrigated. The department may estimate the cost of such projects.

STUDY AREA

As described in the CALFED EIS, the upper San Joaquin River basin includes the San Joaquin River and tributary lands upstream of its confluence with the Merced River. The area of focus for the feasibility study includes the eastern portion of the San Joaquin and Tulare Lake hydrologic regions, from the Merced River into the southern limit of the valley. (see Figure 1-1). This area includes the region served by the Friant Division of the Central Valley Project (CVP) and the portion of the San Joaquin River most directly affected by the operation of Friant Dam.

The area of potential impact from developing new storage in the upper San Joaquin River basin includes the San Joaquin River downstream of Friant Dam, lands with San Joaquin River water rights, the Friant Division service area, and the eastern San Joaquin Valley groundwater basins.

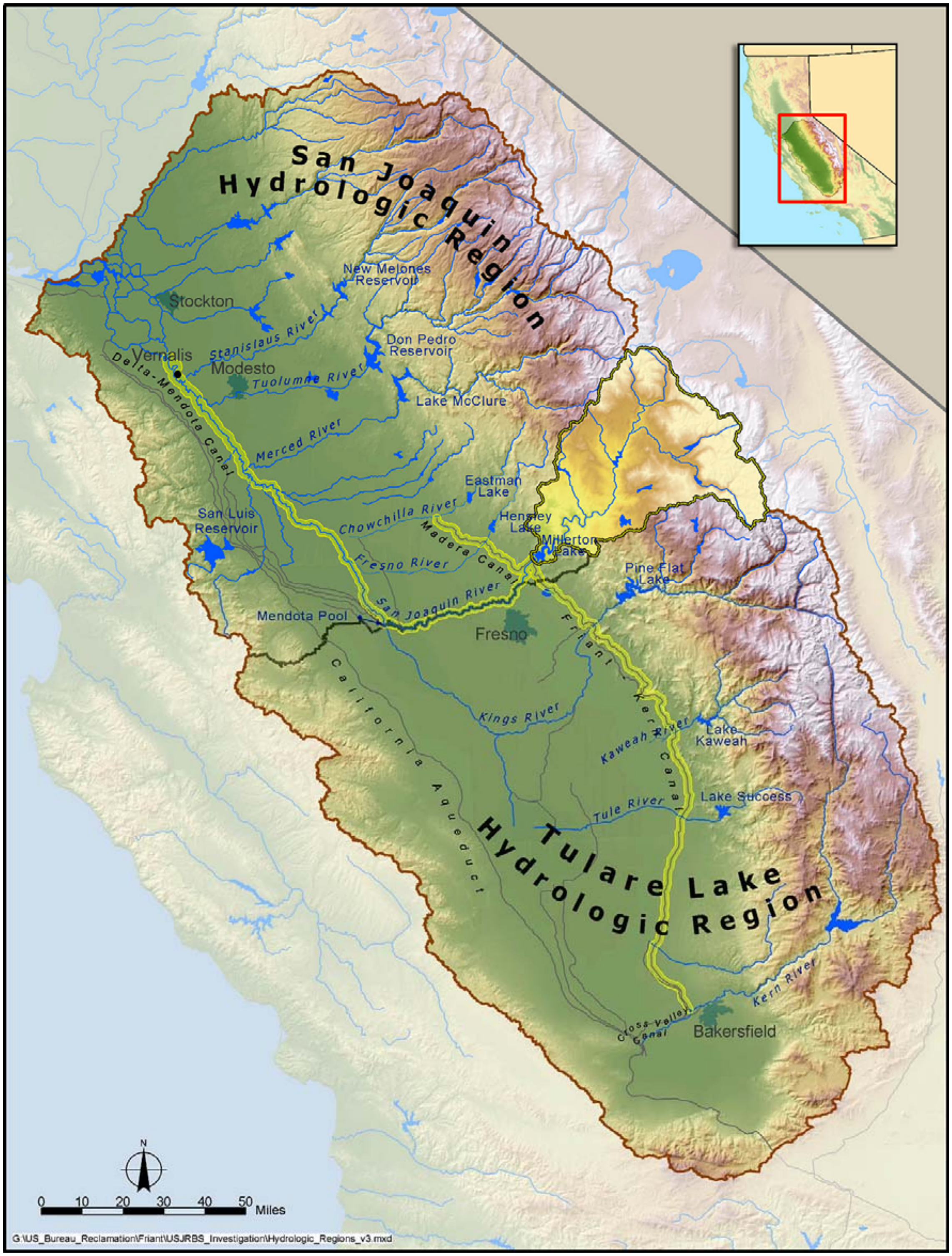


FIGURE 1-1. STUDY AREA EMPHASIS

RELATED STUDIES, PROJECTS, AND PROGRAMS

The Investigation is proceeding at a time when several studies and related programs are considering water resources problems, needs, and opportunities in the San Joaquin Valley. Many of these projects are being coordinated through the California Bay-Delta Authority and CALFED member agencies. Many of the assumptions needed for conducting the Investigation apply to other CALFED storage investigations. Accordingly, the Investigation is being coordinated with other ongoing CALFED storage and conjunctive management studies and other related projects and programs.

One major study underway when Phase 1 studies began was an effort to develop a restoration plan for the San Joaquin River below Friant Dam by the Friant Water Users Authority (FWUA) and the Natural Resources Defense Council (NRDC). This work was intended to contribute to settling litigation between Reclamation and a coalition of environmental organizations led by NRDC regarding the operation of Friant Dam. These collaborative efforts were broken off in 2003 without agreement on a suitable restoration plan or water supply strategy. However, as part of this work, the FWUA and NRDC considered water supply options that could be implemented to provide water for restoration needs. The surface storage options identified by the FWUA/NRDC study were considered and evaluated as part of the Investigation.

Other studies and ongoing programs that are, or may be, addressing some of the issues being considered in the Investigation include the following:

- CVP Yield Replacement Plan (CVPIA Section 3408(j))
- Westside Integrated Resources Plan
- San Joaquin River Management Program
- San Joaquin River Riparian Habitat Restoration Program
- San Joaquin Basin Action Plan and Grasslands Wildlife Management Area
- San Joaquin River Parkway and Conservation Trust
- San Joaquin River Conservancy
- Central Valley Habitat Joint Venture
- Vernalis Adaptive Management Plan
- Sacramento-San Joaquin River Basins Comprehensive Study
- San Joaquin Valley Drainage Program
- Conjunctive Management Program
- Other CALFED Storage Program studies

As part of the public outreach program, interested stakeholders participated in a series of workshops conducted throughout Phase 1 (see Chapter 5). The workshops provided an opportunity for the study team to meet face to face with representatives from organizations and individuals who are actively involved in many of these programs. The study team also worked closely with CALFED Conjunctive Management Program staff and CALFED program managers to coordinate assumptions and technical work. As the feasibility study proceeds, coordination with other projects and programs will continue.

THIS PAGE LEFT BLANK INTENTIONALLY

CHAPTER 2. EXISTING AND FUTURE CONDITIONS

This chapter generally describes existing water resources facilities and conditions in the study area, and describes how they are expected to change in the foreseeable future. This information is included to provide an understanding of current water management operations that could be affected by developing additional water supplies in the upper San Joaquin River basin.

EXISTING CONDITIONS

The San Joaquin Valley is approximately 250 miles long, 30 to 60 miles across, and is bounded on the north by the Sacramento-San Joaquin Rivers Delta (Delta), on the south by the Tehachapi Mountains, on the east by the Sierra Nevada foothills, and on the west by the Coast Range. Irrigated agriculture has been the mainstay of the San Joaquin Valley economy since the first water diversions for irrigation began in the 1860s. Since that time, agricultural development in the Central Valley has grown to become a major contributor to the economy of both the State of California and the Nation. Three counties in the study area – Fresno, Kern, and Tulare – consistently rank among the Nation's top four counties in agricultural revenue. Exports of cotton, citrus, and produce also contribute substantially to the international market.

Hydrology

The San Joaquin River originates in the Sierra Nevada at an elevation over 10,000 feet above mean sea level and enters the San Joaquin Valley near Friant. Below Friant Dam, the river flows west to the center of the valley, then turns sharply north at Mendota Pool and flows through the valley to the Delta. Along the valley floor, the San Joaquin River receives flow from the Merced, Tuolumne, and Stanislaus rivers, and from smaller tributaries draining the east and west sides of the valley.

The California Data Exchange Center (CDEC) maintains estimates of unimpaired flow at four locations in the upper San Joaquin River Basin. Unimpaired flow is flow that would occur at a specific location if upstream facilities were not in place. Since 1980, estimates of unimpaired flow in the San Joaquin River are provided below Friant Dam only, where the estimated annual average unimpaired runoff is about 1,800 thousand acre-feet (TAF). As indicated in Table 2-1, annual runoff from the upper San Joaquin River basin (at Friant Dam) varies widely, ranging from a recorded low of about 362 TAF in 1977 to a recorded high of 4,642 TAF in 1983.

TABLE 2-1
RUNOFF IN THE UPPER SAN JOAQUIN RIVER BASIN

Station (CDEC ID)	Record Period	Annual Runoff (TAF)		
		Maximum	Average	Minimum
Big Creek below Huntington Lake (BHN)	2/1905 – 9/1980	297.8	110.6	14.4
San Joaquin South Fork near Florence (SFR)	10/1900 – 9/1980	248.9	652.5	71.3
San Joaquin River at Mammoth Pool (SJM)	10/1905 – 9/1980	2,964.1	1,323.8	307.9
San Joaquin River below Friant Dam (SJF)	10/1900 – present	4,641.9	1,830.3	361.6

Key:
CDEC – California Data Exchange Center
TAF – thousand acre-feet

Surface Water Resources in the Study Area

The east side of the San Joaquin Valley includes numerous streams and rivers that drain the western slope of the Sierra Nevada Mountains into the Central Valley. During the past 50 years, water resources of all major rivers have been developed through construction of dams and reservoirs for water supply, flood control, and hydropower generation. Table 2-2 provides a summary of major reservoirs in the eastern San Joaquin Valley and their purposes. With the exception of the San Joaquin River, the table lists only the largest water supply and flood control reservoir on each river.

The largest reservoir on the San Joaquin River is Millerton Lake, formed by Friant Dam. These facilities are part of the Friant Division of the CVP, and their operation affects the flow in the San Joaquin River significantly. Inflow to Millerton Lake is influenced by the operation of several upstream hydropower generation projects. Dams and reservoirs upstream of Millerton Lake are listed in Table 2-2 and shown in Figure 2-1.

Friant Division of the CVP

The Friant Division of the CVP provides water to over 1 million acres of irrigable land on the east side of the southern San Joaquin Valley, from near the Chowchilla River in the north to the Tehachapi Mountains in the south. Principal features of the Friant Division were completed in the 1940s, including Friant Dam and Millerton Lake northeast of Fresno on the San Joaquin River and the Madera and Friant-Kern canals, which convey water north and south to agricultural and urban water contractors. Figure 2-2 shows the locations of Friant Division contractors and other water districts in the San Joaquin Valley.

Millerton Lake, the largest reservoir in the upper San Joaquin River basin, has a storage capacity of 520 TAF. The dam is operated to supply water to agricultural and urban areas in the eastern San Joaquin Valley and to provide flood protection to downstream areas. Minimum storage for canal diversion is about 130 TAF, resulting in active conservation storage of about 390 TAF.

TABLE 2-2
RESERVOIRS ON THE EAST SIDE OF THE SAN JOAQUIN VALLEY

Name	River or Creek	Owner	Storage (TAF)	Year Built	Operational Objectives				
					FC	WS	HP	RF	WQ
Reservoirs in the Upper San Joaquin River Watershed									
Millerton	San Joaquin	USBR	520	1942	X	X	n/a	n/a	n/a
Kerckhoff	San Joaquin	PG&E	4	1920	n/a	n/a	X	X	n/a
Redinger	San Joaquin	SCE	35	1951	n/a	n/a	X	X	n/a
Florence	South Fork San Joaquin	SCE	64	1926	n/a	n/a	X	X	n/a
Huntington	Big Creek	SCE	89	1917	n/a	n/a	X	X	n/a
Shaver	Stevenson Creek	SCE	135	1927	n/a	n/a	X	X	n/a
Thomas Edison	Mono Creek	SCE	125	1954	n/a	n/a	X	X	n/a
Mammoth Pool	San Joaquin	SCE	123	1960	n/a	n/a	X	X	n/a
Reservoirs in Other San Joaquin Valley Watersheds									
New Melones	Stanislaus	USBR	2,420	1978	X	X	X	X	X
Don Pedro	Tuolumne	MID/TID	2,030	1970	x	X	X	X	n/a
Lake McClure	Merced	MID	1,025	1967	X	X	X	X	n/a
Eastman	Chowchilla	Corps	150	1975	X	X	n/a	n/a	n/a
Hensley	Fresno	Corps	90	1975	X	X	n/a	n/a	n/a
Pine Flat	Kings	Corps	1,000	1954	X	X	n/a	n/a	n/a
Kaweah	Kaweah	Corps	143	1962	X	X	n/a	n/a	n/a
Success	Tule	Corps	82	1961	X	X	n/a	n/a	n/a
Isabella	Kern	Corps	568	1953	X	X	n/a	n/a	n/a

Key:
Owners

Corps	U.S. Army Corps of Engineers
MID	Merced Irrigation District
MID/TID	Modesto Irrigation District/Turlock Irrigation District
PG&E	Pacific Gas and Electric
SCE	Southern California Edison
USBR	Bureau of Reclamation

Operational Objectives

FC	Flood control (these reservoirs have dedicated flood control storage space)
HP	Hydropower generation
RF	Downstream river instream flow requirements
WQ	Delta water quality
WS	Water supply for irrigation, domestic, municipal, and industrial uses

n/a – operational objective not applicable
TAF – thousand acre-feet
Notes:
1. Enlargement of Kaweah and Success lakes has been authorized. Existing capacity listed.

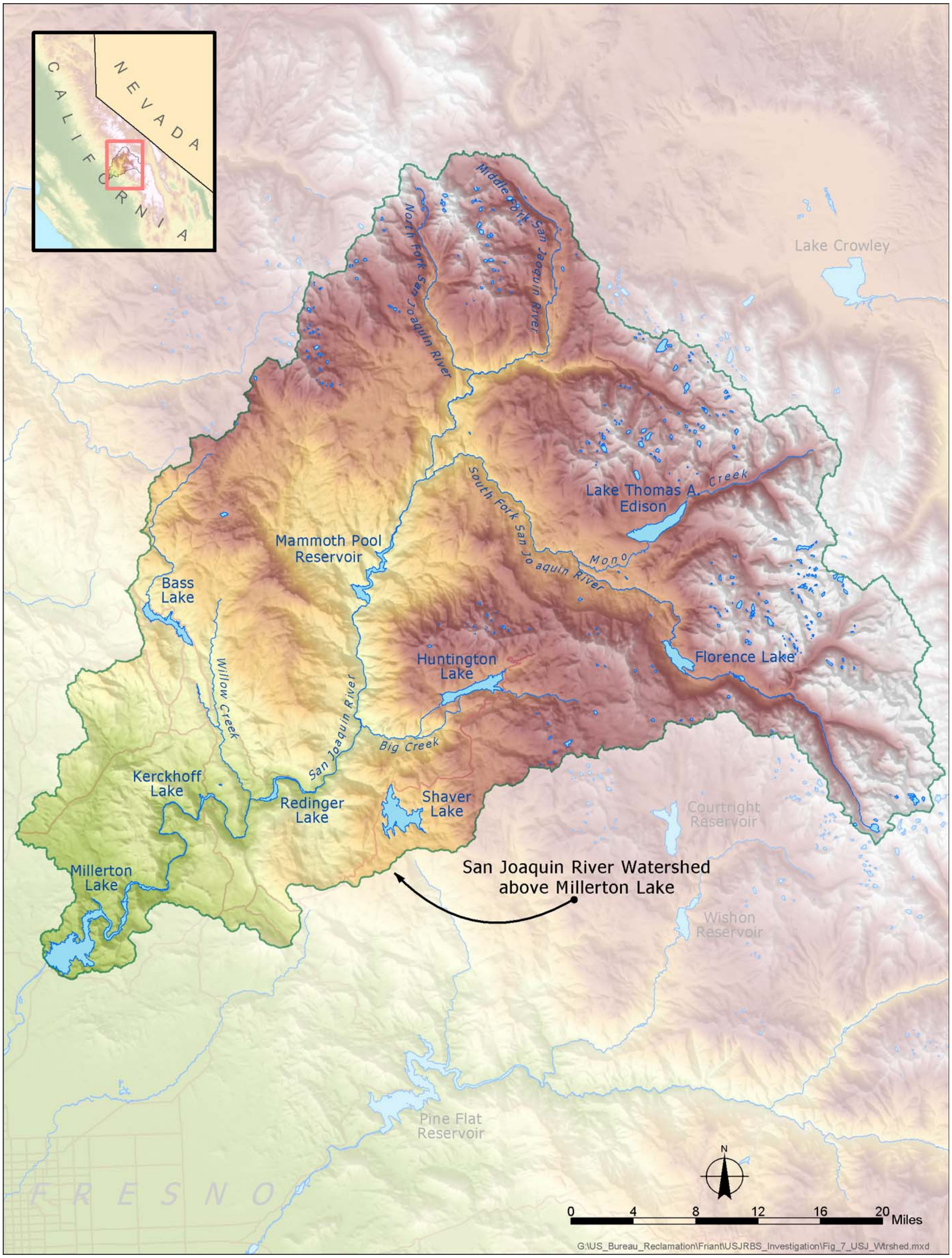


FIGURE 2-1. RESERVOIRS UPSTREAM OF MILLERTON LAKE

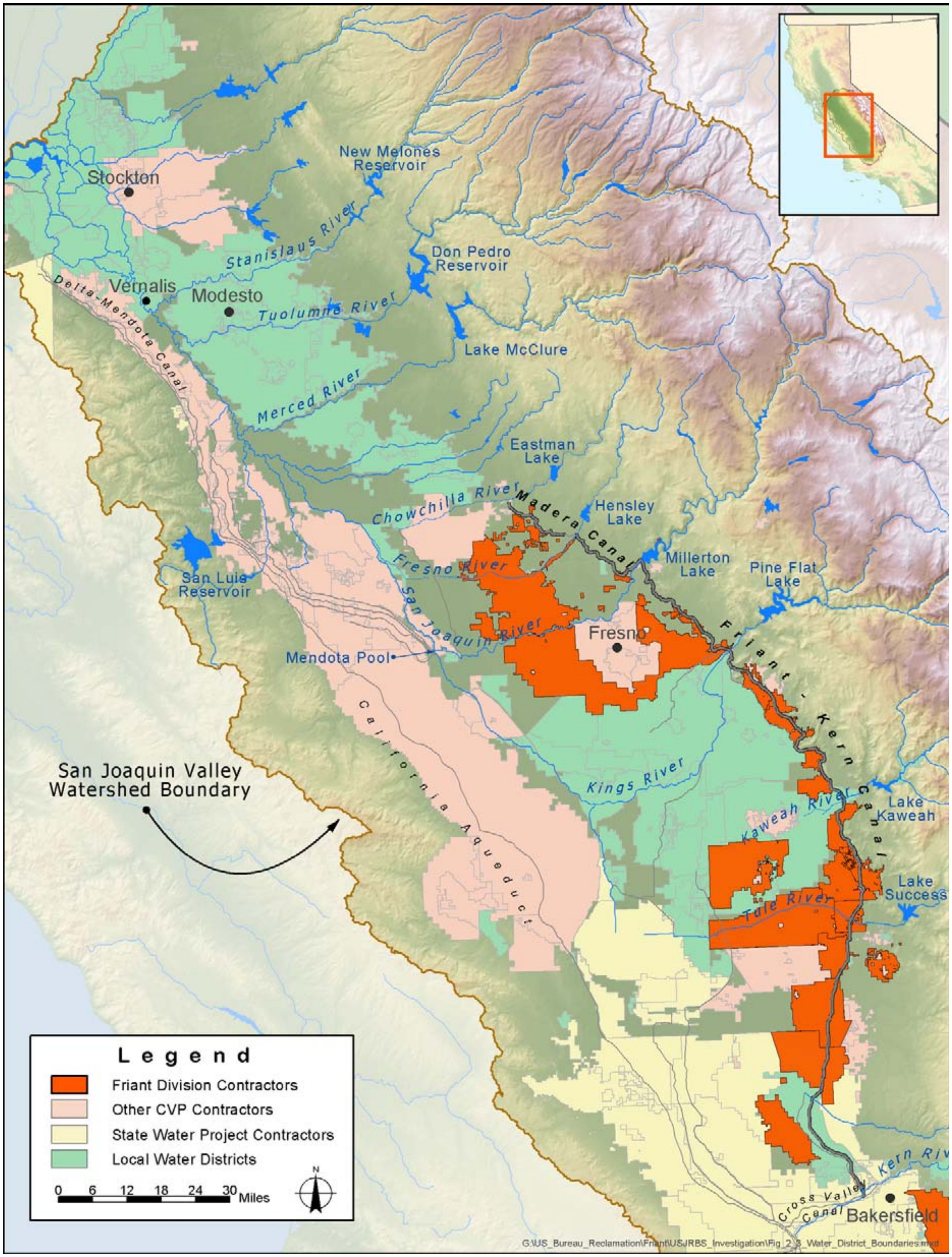


FIGURE 2-2. WATER DISTRICTS IN THE SAN JOAQUIN VALLEY

During the flood season of October through March, up to 170 TAF of available storage space must be maintained for control of rain floods. Under present operating rules, up to 85 TAF of the flood control storage required in Millerton Lake may be provided by an equal amount of space in Mammoth Pool (Figure 2-3).

The limited active conservation storage and the requirement for flood space reservation result in very little opportunity for carryover storage. Millerton Lake is operated as an annual reservoir with no specific provision for carryover storage. Annual water allocations and release schedules are developed with the intent of drawing reservoir storage to minimum levels by the end of September. When demands are lower or inflow is greater than typical, end-of-year storage may be above minimum levels, resulting in incidental carryover storage.

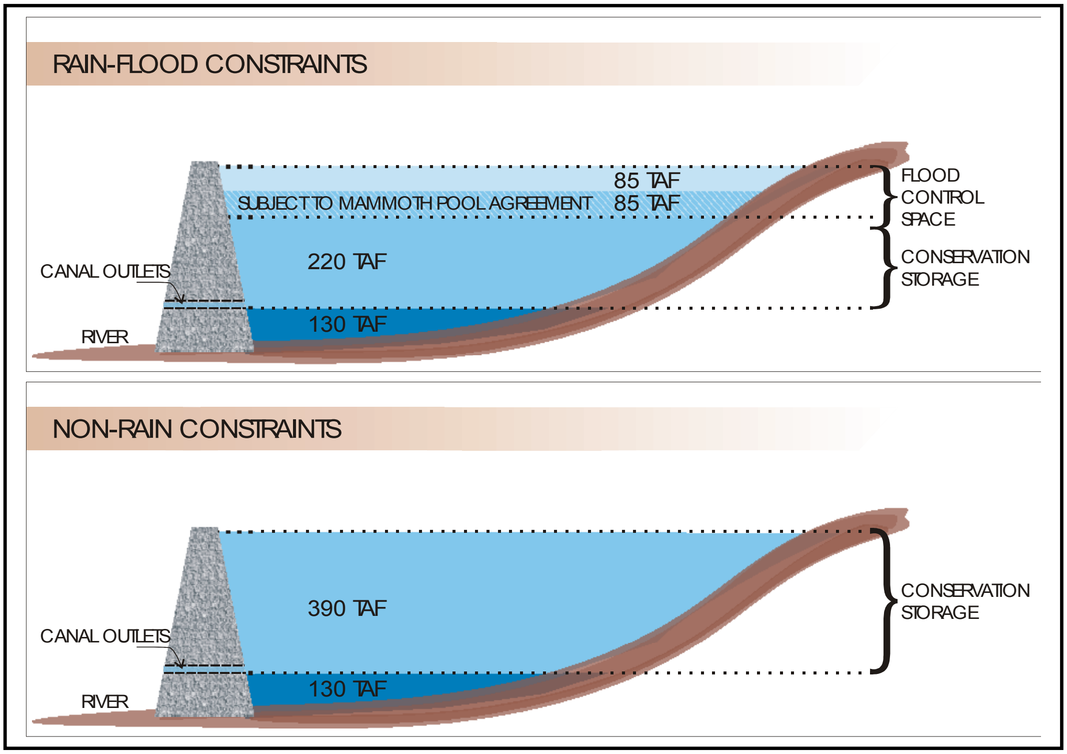


FIGURE 2-3. SCHEMATIC OF MILLERTON STORAGE REQUIREMENTS

Reclamation obtained the majority of the water rights on the San Joaquin River, allowing for the diversion of water at Friant Dam through purchase and exchange agreements with entities that held those rights at the time the project was developed. The agreement involving the largest amount of water requires annual delivery of approximately 800 TAF of water to Mendota Pool to water rights holders along the San Joaquin River. This obligation is met with water exported from the Delta via the Delta-Mendota Canal in accordance with San Joaquin River exchange contracts. If Delta water is not available to meet these commitments, Reclamation would be required to release water from Friant Dam to meet these water rights obligations. With the exception of flood control operations, water released from Friant Dam to the San Joaquin River is limited to that necessary to satisfy riparian water rights along the San Joaquin River between Friant Dam and Gravelly Ford.

Friant Division Contract Types and Water Deliveries

The Friant Division was designed and is operated to support conjunctive water management in an area that was subject to groundwater overdraft prior to construction of Friant Dam and which remains in a state of overdraft today. Reclamation employs a two-class system of water allocation to take advantage of water during wetter years. (Table 2-3 lists Friant Division contract amounts for each contractor.)

Class 1 contracts, which are based on a firm water supply, are generally assigned to municipal and industrial (M&I) and agricultural water users who have limited access to good-quality groundwater. These lands primarily include upslope areas planted in citrus or deciduous fruit trees. During project operations, the first 800 TAF of annual water supply are delivered under Class 1 contracts.

Class 2 water is a supplemental supply and is delivered directly for agricultural use or for groundwater recharge, generally in areas that experience groundwater overdraft. Class 2 contractors typically have access to good quality groundwater supplies and can use groundwater during periods of surface water deficiency. Many Class 2 contractors are in areas with high groundwater recharge capability and operate dedicated groundwater recharge facilities. Figure 2-4 shows the locations of Friant Division contractors and the percentage of Class 1 to total contract amounts.

In addition to Class 1 and Class 2 water deliveries, Reclamation is authorized to deliver water that would otherwise be released for flood control purposes. Section 215 of the Reclamation Reform Act of 1982 authorizes the delivery of unstorable irrigation water that would be released in accordance with flood control criteria or unmanaged flood flows. Delivery of Section 215 water has enabled groundwater replenishment at levels higher than could otherwise be supported with Class 1 and Class 2 contract deliveries.

Historically, the Friant Division has delivered an average of about 1,300 TAF of water annually. Since 1949, median annual release from Friant Dam to the San Joaquin River has been about 129 TAF, which is slightly more than the 117 TAF released annually to meet downstream water right diversions above Gravelly Ford.

Figure 2-5 shows the historical allocation of water to Friant Division contractors, estimated by applying historical allocation percentages to total Class 1 and Class 2 contracts amounts. As shown, annual allocation of Class 1 and Class 2 water varies widely in response to hydrologic conditions.

TABLE 2-3
FRIANT DIVISION LONG-TERM CONTRACTS

CONTRACT TYPE/CONTRACTOR	Class 1	Class 2	Cross Valley
Friant-Kern Canal Agricultural			
Arvin-Edison WSD	40,000	311,675	
Delano-Earlimart	108,800	74,500	
Exeter ID	11,500	19,000	
Fresno ID	0	75,000	
Garfield WD	3,500	0	
International WD	1,200	0	
Ivanhoe ID	7,700	7,900	
Lewis Creek WD	1,450	0	
Lindmore ID	33,000	22,000	
Lindsay-Strathmore ID	27,500	0	
Lower Tule River ID	61,200	238,000	
Orange Cove ID	39,200	0	
Porterville ID	16,000	30,000	
Saucelito ID	21,200	32,800	
Shafter-Wasco ID	50,000	39,600	
Southern San Joaquin MUD	97,000	50,000	
Stone Corral ID	10,000	0	
Tea Pot Dome WD	7,500	0	
Terra Bella ID	29,000	0	
Tulare ID	30,000	141,000	
Total Friant-Kern Canal Agricultural	**595,750**	**1,041,475**	
Madera Canal Agricultural			
Chowchilla WD	55,000	160,000	
Madera ID	85,000	186,000	
Total Madera Canal Agricultural	**140,000**	**346,000**	
San Joaquin River Agricultural			
Gravelly Ford WD	0	14,000	
Total Friant Division Agricultural	**735,750**	**1,401,475**	
Friant Division M&I			
City of Fresno	60,000		
City of Orange Cove	1,400		
City of Lindsay	2,500		
Fresno County Water Works District No. 18	150		
Madera County	200		
Total Friant Division M&I	**64,250**		
Total Friant Division Contracts	**800,000**	**1,401,475**	
Cross Valley Canal Exchange			
Fresno County			3,000
Tulare County			5,308
Hills Valley ID			3,346
Kern-Tulare WD			40,000
Lower Tule River ID			31,102
Pixley ID			31,102
Rag Gulch WD			13,300
Tri-Valley WD			1,142
Total Cross Valley Canal Exchange			**128,300**

Key:
M&I – Municipal and Industrial; ID – Irrigation District; WD – Water District; WSD – Water Storage District
Source: Friant Water Users Authority Informational Report

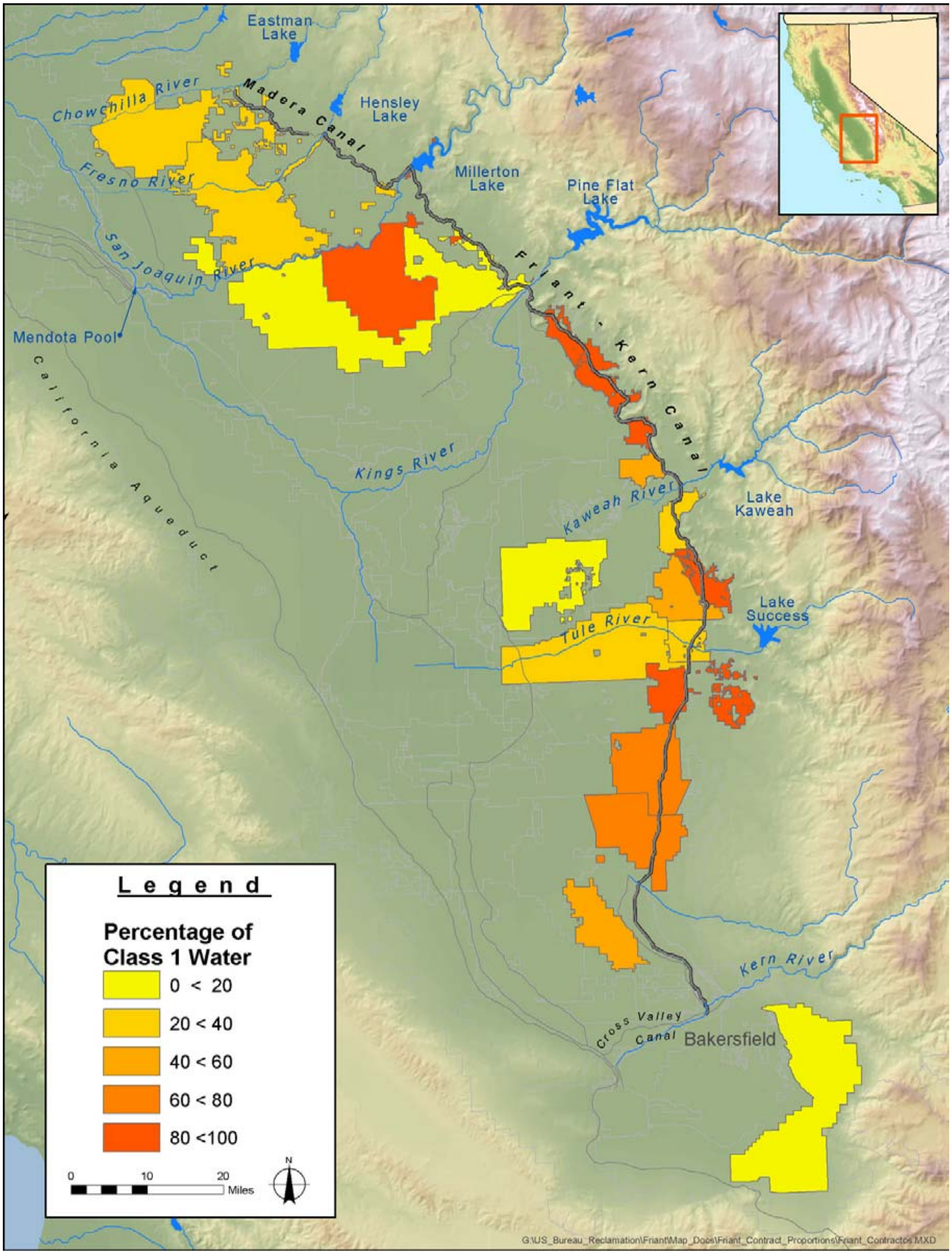


FIGURE 2-4. PERCENT OF CLASS 1 CONTRACT AMOUNTS FOR FRIANT DIVISION CONTRACTORS

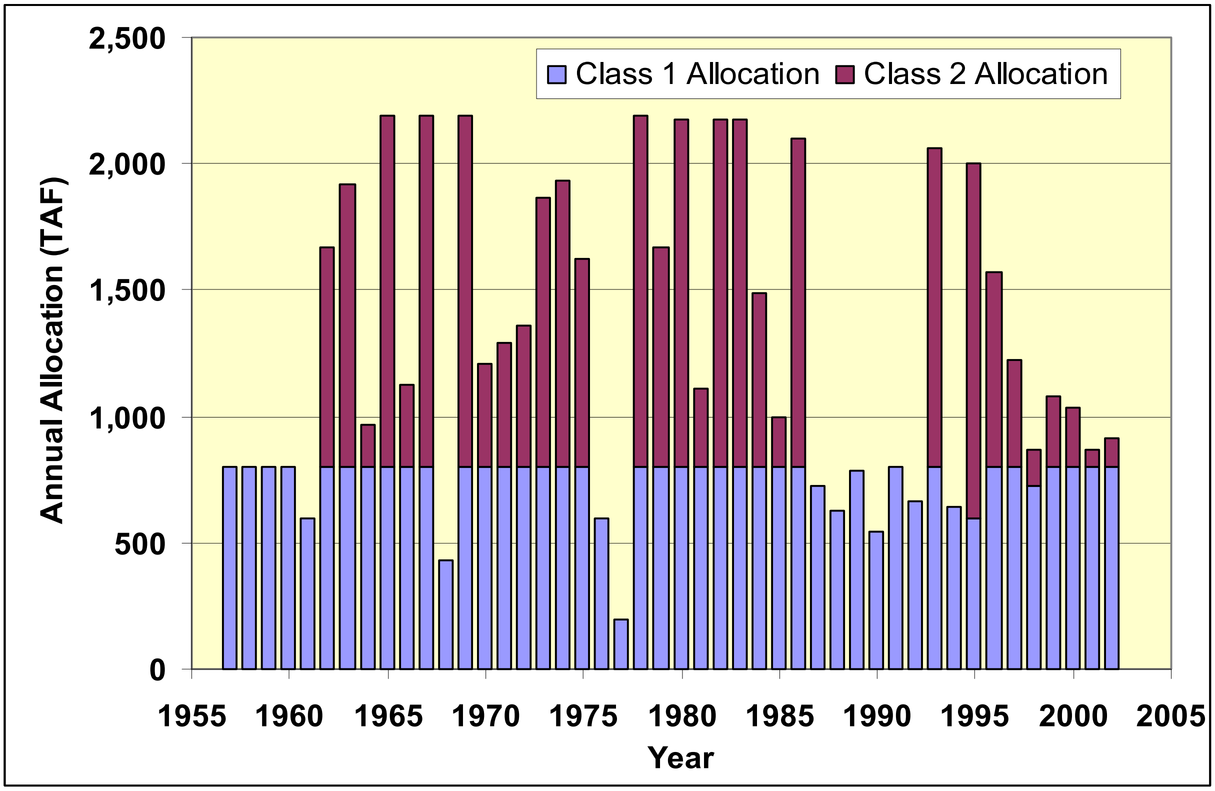


FIGURE 2-5. HISTORICAL ALLOCATION TO FRIANT DIVISION CONTRACTS

During the period from 1957 through 2002, annual allocations of Class 1 water were typically at or above 75 percent of contract amounts, except in three extremely dry years. In this same period, full allocation of Class 2 water supplies occurred in about one-fourth of the years. During the extended drought from 1987 through 1992, no Class 2 water was available and Class 1 allocations were below full contract amounts, except in one year. During this and other historical drought periods, water contractors relied heavily on groundwater to meet water demands.

In addition to the Class 1, Class 2, and conjunctive management aspects of Friant Division operations, a productive program of transfers between districts takes place annually. This program provides opportunities to improve water management within the Friant service area. In wet years, water surplus to one district's need can be transferred to other districts with the ability to recharge groundwater. Conversely, in dry years, water is returned to districts with little or no groundwater supply, thereby providing an ongoing informal groundwater banking program within the Friant Division.

The Cross-Valley Canal, a locally financed facility completed in 1975, enables delivery of water from the California Aqueduct to the east side of the southern San Joaquin Valley near the City of Bakersfield. A complex series of water purchase, transport, and exchange agreements allows the exchange of equivalent amounts of water between Arvin-Edison Water Storage District, near Bakersfield, and eight entities with contracts for CVP water exported from the Delta. When conditions permit, water is delivered to Arvin-Edison from the California Aqueduct in exchange for water that would have been delivered from Millerton Lake.

Hydropower Facilities Upstream of Millerton Lake

The upper San Joaquin River basin is highly developed for hydropower generation. Upstream of Millerton Lake, Pacific Gas & Electric (PG&E) and Southern California Edison (SCE) own several hydropower generation facilities, as shown in Figure 2-6. Both the PG&E and SCE systems consist of a series of diversion reservoirs that provide water through tunnels to downstream powerhouses. Table 2-4 summarizes generation capacity and date of installation for PG&E and SCE power facilities from Millerton Lake upstream to Redinger Lake. This table also summarizes annual reported energy generation from the PG&E and SCE facilities for 1994 through 2002. As indicated by minimum and maximum values, annual energy generation varies widely.

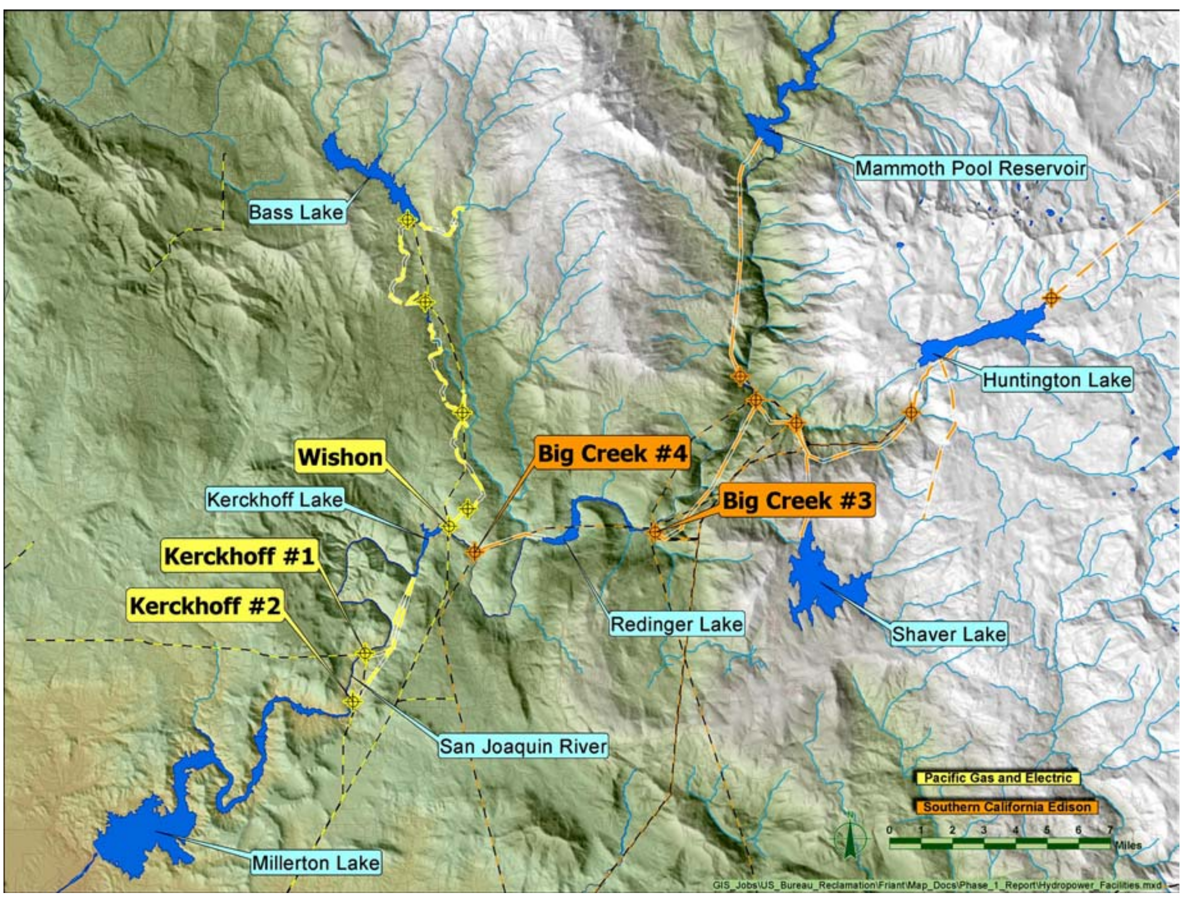


FIGURE 2-6. HYDROPOWER FACILITIES UPSTREAM OF MILLERTON LAKE

TABLE 2-4
HYDROELECTRIC GENERATION ABOVE MILLERTON LAKE

	Pacific Gas & Electric			Southern California Edison	
	Wishon	**Kerckhoff**	**Kerckhoff No. 2**	**Big Creek No.3**	**Big Creek No. 4**
FERC Proj. No.	1354	96	96	120	2017
Number of units	4	3	1	7	2
Capacity (MW)	20	38	155	175	100
Year Commissioned	1919	1920	1983	1923	1952
Reported Annual Generation, Exclusive of Plant Use (GWh)[1]					
1994	28[2]	10[2]	276[2]	567	294[2]
1995	113	116[3]	803[2]	1,196[3]	623[3]
1996	94	52	697	1,050	608
1997	45	72	696	898	590
1998	118[3]	76	73	1,095	613
1999	73	32	411	540[2]	436
2000	74	38	482	838	449
2001	48	11	317	571	301
2002	55	20	368	717	353
Avg. 1994-2002	**72**	**47**	**532**	**830**	**474**

Key:
FERC – Federal Energy Regulatory Commission; GWh – gigawatt-hour; MW – megawatt
Notes:
1. Data sources - annual FERC Licensee reports.
2. Minimum during period of record.
3. Maximum during period of record.

Groundwater Resources

The San Joaquin Valley Groundwater Basin is a structural trough up to 200 miles long and 70 miles wide filled with up to 32,000 feet of marine and continental sediments deposited during periodic inundation by the Pacific Ocean and erosion of surrounding mountains. Continental deposits form an alluvial wedge that thickens from the valley margins toward the axis of the structural trough, which is generally oriented along a north-south alignment (DWR, 2003).

Groundwater is a major source of agricultural and urban water supplies in the study area. Figure 2-7 shows the locations of groundwater basins underlying the San Joaquin Valley within the study area. Typical groundwater production conditions for each sub-basin are listed in Table 2-5, based on information from DWR Bulletin 160-98. At a 1995 level of development, annual average groundwater overdraft is estimated at about 240,000 acre-feet per year in the San Joaquin River hydrologic region and at about 820,000 acre-feet per year in the Tulare Lake hydrologic region (Bulletin 160-98).

TABLE 2-5
PRODUCTION CONDITIONS IN SAN JOAQUIN VALLEY GROUNDWATER SUBBASINS

Basin Number[1]	Basin Name	Extraction (TAF/year)	Well Yields (gpm)	Pumping Lifts (feet)
San Joaquin River Basin				
765	Modesto	230	1,000 – 2,000	90
776	Delta-Mendota	510	800 – 2,000	35 – 150
778	Turlock	450	1,000 – 2,000	90
784	Merced	560	1,500 – 1,900	110
795	Madera	570	750 – 2,000	160
796	Chowchilla	260	1,500 – 1,900	110
Tulare Lake Basin				
821	Kings	1,790	500 – 1,500	150
831	Westside	210	800 – 1,500	200 - 800
849	Kaweah	760	1,000 – 2,000	125 - 250
861	Tulare Lake	670	300 – 1,000	270
898	Tule	660	n/a	150 - 200
891	Pleasant Valley	100	n/a	350
1058	Kern	1,400	1,500 – 2,500	200 - 250

Source: California Department of Water Resources Bulletin 160-98.
Key:
gpm – gallons per minute; n/a – data not available; TAF – thousand acre-feet
Note:
1. Groundwater basin number as shown on Figure 2-7.

FUTURE WITHOUT-PROJECT CONDITIONS

CALFED agencies are developing a consistent set of assumptions regarding future without-project conditions for use in several CALFED studies. As the feasibility study proceeds, the study team will continue to coordinate with the Bay-Delta Authority and other CALFED agencies to define the future without-project condition assumptions. Potential projects and actions that will be considered include conjunctive management actions that would be implemented independently of new storage development, water conveyance improvements, demand management actions, water exchanges and transfers, and other regional actions that would affect demand, allocation, and distribution of water resources.

Local water users and other entities have been considering potential projects and actions that would help address current and potential future water needs, provide water for other purposes (such as restoration of the San Joaquin River), and improve flood protection along the San Joaquin River. Many initiatives under investigation have not been sufficiently developed to assure their completion.

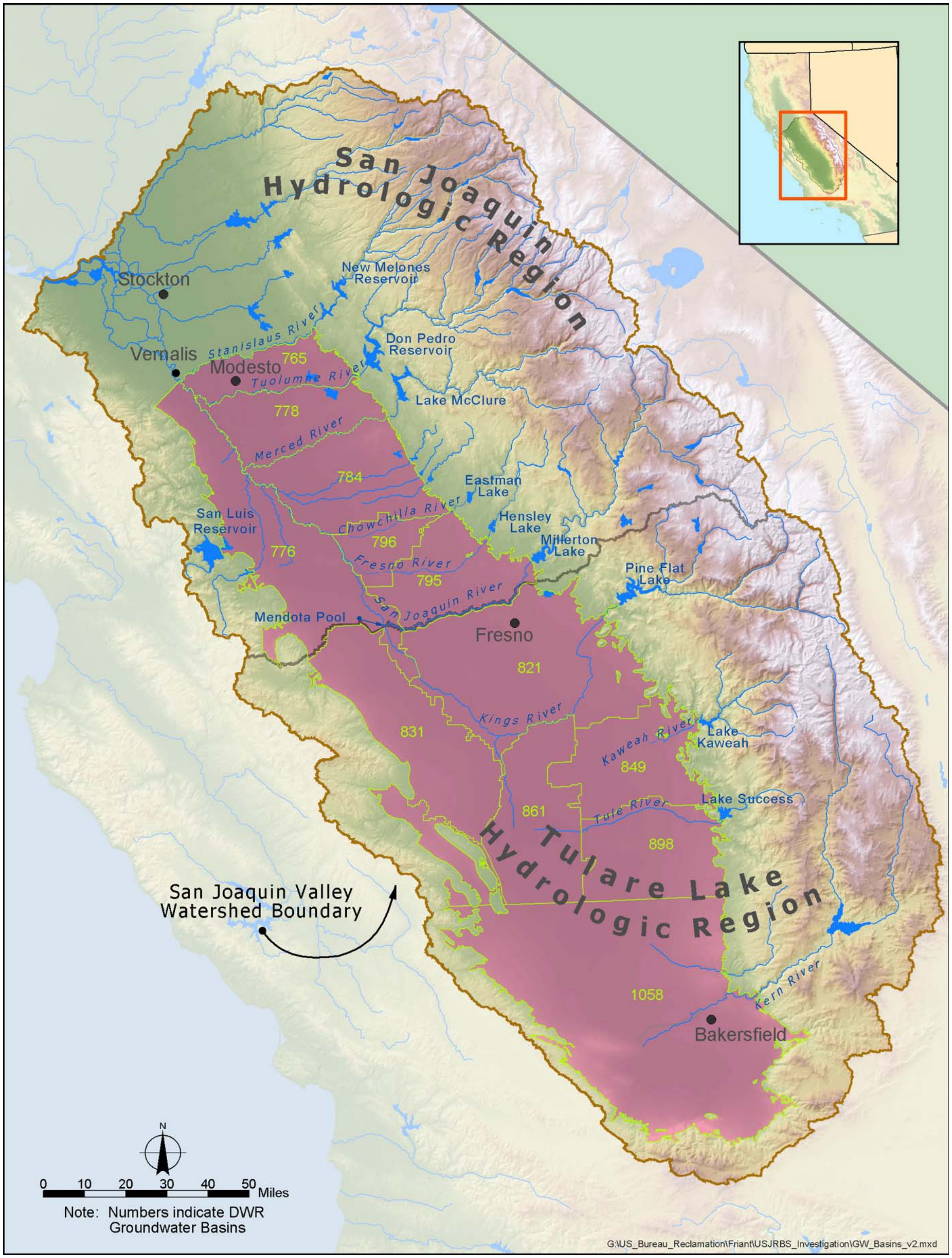


FIGURE 2-7. SAN JOAQUIN VALLEY GROUNDWATER SUBBASINS

CHAPTER 3. PROBLEMS AND OPPORTUNITIES

Water resource problems and opportunities provide a framework for plan formulation and helps establish objectives that a project would attempt to meet. Water resource problems in the San Joaquin Valley are associated with changing water needs, hydrologic variations in water availability, and the capacity of current water storage and conveyance facilities. Problems and opportunities addressed by the Investigation were identified in the CALFED ROD and from stakeholder input.

As stated in Chapter 1, the CALFED ROD identified three primary purposes for developing additional water storage in the upper San Joaquin River basin. These purposes include: contributing to restoration of the San Joaquin River; improving water quality in the San Joaquin River; and facilitating conjunctive water management and water exchanges that improve the quality of water deliveries to urban communities. An initial list of problems to be addressed by the Investigation is based on these purposes.

CALFED documents also indicate that other regional water resources needs should be considered in the evaluation of potential projects. Table 3.1 of the CALFED EIS Implementation Plan states that local participation is desired in the Upper San Joaquin River Basin Storage Investigation to identify how additional storage would improve flood protection and improve conjunctive management utility. The study team interprets this direction to suggest that local needs should be addressed where possible. Local input indicated that additional surface water storage could also address flood damage reduction, power generation, and recreation needs.

Problems

- San Joaquin River ecosystem
- San Joaquin River water quality
- Water supply reliability

Opportunities

- Flood control
- Hydropower generation
- Recreation
- Delta inflow

The three problems of San Joaquin River ecosystem, San Joaquin River water quality, and water supply reliability form the basis for initial plan formulation. Opportunities will be evaluated as additional needs that also could be addressed through developing additional water storage. The following sections describe each problem and opportunity in greater detail.

San Joaquin River Ecosystem

The reach of the San Joaquin River from Friant Dam to the Merced River confluence does not currently support a continuous natural riparian and aquatic ecosystem. Since completion of Friant Dam, most of the water in the river has been diverted for agricultural and M&I uses, with the exceptions of releases to satisfy riparian water rights upstream of Gravelly Ford and flood releases. Consequently, the reach from Gravelly Ford to Mendota Pool is often dry.

Flows from Mendota Pool to Sack Dam contain Delta water for delivery to the San Luis Canal Company and wildlife refuges. Groundwater seepage is the primary source of flow below Sack Dam prior to the confluence with Salt Slough. The reach from Sack Dam to Bear Creek benefits from managed wetland development, whereas marshes have been drained between Bear Creek and the Merced River. Lack of reliable flows and poor water quality in the San Joaquin River result in ecosystem conditions that are generally considered unhealthy.

During the past few decades, societal views towards the ecosystem health of rivers in the Central Valley have changed. Today, many people would prefer a sustainable ecosystem along the upper San Joaquin River. This shift in viewpoint is evident in the numerous programs addressing ecosystem restoration in the Central Valley and along the San Joaquin River as well as ongoing litigation between a coalition of environmental interests represented by the NRDC, and Reclamation and the FWUA *(NRDC v. Rodgers)*.

For several years, NRDC and FWUA have discussed various river restoration ideas that could be used as part of a settlement of *NRDC v. Rodgers*. Resolution of *NRDC v. Rodgers* may include some degree of river restoration, including a flow requirement in the San Joaquin River below Friant Dam. To date, an agreement or a legal decision has not been made regarding flow requirements or restoration objectives for the San Joaquin River downstream of Friant Dam.

The San Joaquin River Resources Management Coalition (RMC), a group of local stakeholders, has recently begun to develop a restoration plan for the San Joaquin River. This effort, funded in part through the United States Environmental Protection Agency, will be developed in several phases. The initial phase, completed in August 2003, included a description of current ecosystem conditions in the San Joaquin River from Friant Dam to the confluence of the Merced River and a process for developing a restoration plan. In the next phase, the RMC restoration plan will identify the types of actions that would be required to attain a future desired ecosystem condition and the types of constraints that may limit the extent to which such actions could be implemented.

A demand on the Friant system for river restoration could be established at some time in the future, although one is not in place today. The Investigation began with the assumption that no specific flow is required, but will consider how additional storage could be used to provide water supplies to support restoration of the San Joaquin River. The Investigation will maintain flexibility so that planning efforts could be adjusted if a river restoration requirement were established during the course of the Investigation.

San Joaquin River Water Quality

Water quality in various segments of the San Joaquin River has been a problem for several decades due to low flow and discharges from agricultural areas, wildlife refuges, and M&I treatment plants. Initial locations of concern for water quality included areas near Stockton and at Vernalis, downstream of the Stanislaus River as the San Joaquin River enters the Delta. Over time, requirements for water quality in the river have become more stringent and the number of locations along the river at which specific water quality objectives are identified has increased.

In 1998, the Central Valley Regional Water Quality Control Board adopted a Water Quality Control Plan for the Sacramento and San Joaquin river basins (Basin Plan) as the regulatory reference for meeting the State and Federal requirements. The Basin Plan lists existing and potential beneficial uses of the lower San Joaquin River, including agricultural uses, M&I uses, recreation, fishery migration and spawning, and wildlife habitat. Specific water quality standards associated with the lower San Joaquin River apply to boron, molybdenum, selenium, dissolved oxygen, pH, pesticides, and salinity. The Basin Plan is undergoing a triennial review for beneficial use and water quality standard updates.

One of the high priority issues of the Basin Plan review is the regulatory guidance for total maximum daily load (TMDL) standards at locations along the San Joaquin River. Section 303(d) of the Federal Clean Water Act (CWA) requires the identification of water bodies that do not meet, or are not expected to meet, water quality standards, or are considered impaired. The current 303(d) list (1998) identifies Mud and Salt sloughs and the San Joaquin River from Mendota Pool downstream to Vernalis as impaired water bodies. The CWA further requires developing a TMDL for each listing. The Basin Plan (including TMDL allocation) is subject to future review and revision. Although it is likely that future versions will address more restrictive water quality objectives than the current version, existing water quality objectives will be used in the Investigation.

Surface Water Supply Reliability

The CALFED Bay-Delta Program identified water supply reliability as a key problem due to a mismatch between Bay-Delta supplies and beneficial uses dependent on the Bay-Delta system. As described in Chapter 2, the Friant Division of the CVP was authorized and is operated to provide surface water supplies to areas with a high use of groundwater. Groundwater basins in the eastern San Joaquin Valley are overdrafted in most years (i.e., more groundwater is pumped out than is replenished either naturally or artificially). Although water deliveries from Friant Dam help reduce groundwater pumping and contribute to groundwater recharge, the continued general downward trends of groundwater levels reveal that significant water supply reliability problems remain.

Future operations of the Friant Division are anticipated to be similar to recent historic operations. Water supply reliability in some areas of the Central Valley will continue to be lower than historical levels and future long-term average water deliveries will likely be less than full contract amounts. Additional storage in the upper San Joaquin River basin could increase the reliability of deliveries to CVP contractors or other water users who could receive water through CVP facilities, resulting in a reduction in groundwater overdraft. This improved supply reliability would provide opportunities for exchanges with urban water users that improve the quality of urban water deliveries.

Flood Control

Flood operations at Friant Dam are based on anticipated precipitation and snowmelt runoff and the operations of upstream reservoirs. During flood operations, releases from Friant Dam are maintained when possible at flow levels that could be safely conveyed through the San Joaquin River and Eastside Bypass. Generally, flood operations target releases at or below 8,000 cubic feet per second (cfs) downstream of Friant Dam. Major storms during the past two decades have demonstrated that Friant Dam, among many other dams in the Central Valley, may not provide the level of flood protection that was intended at the time the flood management system was designed. In January 1997, flood flows from Friant Dam resulted in levee failures and extensive flooding in downstream areas.

Increased water storage capacity in the upper San Joaquin River basin would capture additional flood volume and reduce the frequency and magnitude of damaging flood releases from Friant Dam. The United States Army Corps of Engineers (Corps) recently evaluated changes in flood management operations at Friant Dam and other reservoirs in the Central Valley. Preliminary studies considered individual and combined affects of changes in flood reservoir space and objective flows. These results show that increasing flood storage capacity in Millerton Lake or elsewhere in the upper San Joaquin River basin would have a significant effect on the magnitude and frequency of damaging flood flows downstream of Friant Dam. Although additional study is needed to quantify the economic benefits of additional flood regulation, an opportunity is present for flood damage reduction as part of new surface water storage development in the upper San Joaquin River basin.

Hydropower

Hydropower has long been an important element of power supply in California. Due to its ability to rapidly increase and decrease power generation rates, hydropower often has been used to support peak power loads in addition to base power loads. As reservoir operations have changed during the past two decades to accommodate environmental and changing water demands, the ability to rely on hydropower for meeting peak demands has decreased.

Electricity demands are expected to increase in the future. Although some new power generation capacity will likely come on-line, it is reasonable to expect that new generation capacity will still be required. Although the economic feasibility of hydropower-only projects may be limited, developing new storage for water supply, water quality, ecosystem restoration, and flood damage reduction creates opportunities to add hydropower features.

Recreation

Demands for water-oriented recreational opportunities in the San Joaquin River basin are high. Some of these demands are served by reservoirs on the western slope of the Sierra Nevada Mountains. As population increases in the San Joaquin Valley, recreational demands are expected to increase.

Additional storage in the upper San Joaquin River basin could provide opportunities to increase water-oriented recreation facilities, such as swimming, access points for various types of boating, and trail use. In addition, the release of water from Friant Dam to the San Joaquin River for ecosystem restoration or water quality purposes could also increase recreation opportunities along the river.

Delta Inflows

The primary goals of the CALFED Bay-Delta Program are to improve ecosystem conditions in the Bay-Delta and the reliability of water supplies dependent on the Bay-Delta. Several actions are needed to accomplish these goals, including increasing Delta inflow and reducing Delta export pumping that adversely impacts sensitive species. Additional storage in the upper San Joaquin River basin could change the magnitude, duration, or frequency of inflows to the Delta due to river releases intended to improve the San Joaquin River ecosystem or water quality. The ability of water released from Friant Dam to reach the Delta would depend on water use at Mendota Pool and seepage to groundwater along the San Joaquin River.

Because of the great distance from Friant Dam to the Delta, it is unlikely that new storage in the upper San Joaquin River basin would be operated specifically to meet Delta flow and water quality objectives. However, water released for other purposes, such as water quality or river restoration, could improve the magnitude of Delta inflow at times when additional flow would be beneficial ecological conditions in the Delta.

CHAPTER 4. PLAN FORMULATION

This chapter describes the plan formulation process during Phase 1 of the feasibility study. It includes a description of the planning approach, initial screening of surface storage options, evaluation of surface storage options retained for further study, and an approach for developing conjunctive management options. Plan formulation is an ongoing process that evolves as results of technical studies become available and stakeholder input is received. Throughout Phase 1, the Investigation was supported by input from CALFED agencies and stakeholders. Public outreach included a series of workshops that provided periodic updates to stakeholders on the progress of the Investigation and provided opportunities to receive comments and suggestions on completed and planned work.

The Phase 1 planning approach was designed to identify opportunities for water storage development, estimate the extent to which water resources problems could be addressed with new storage, and identify potential participants for the development of a storage project or program. As shown in Figure 4-1, the Investigation is a multitrack effort that includes the planning process, operations studies, assessment of potential surface storage options, and identification of groundwater storage options.

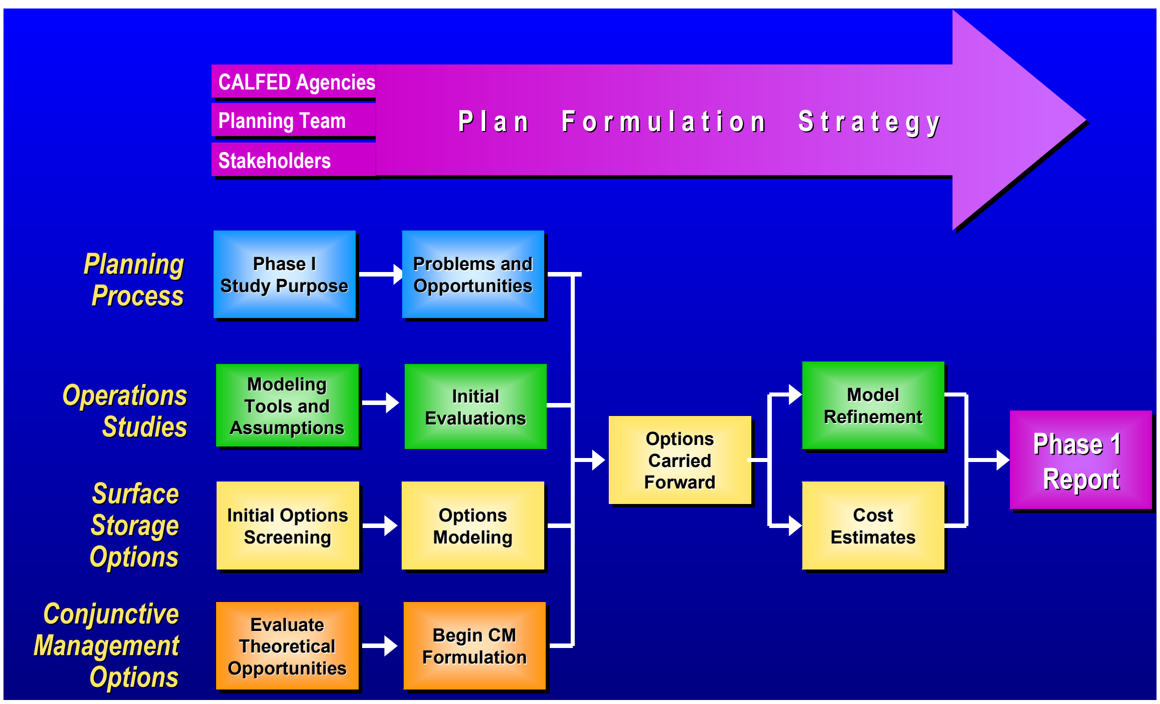


FIGURE 4-1. PHASE 1 INVESTIGATION PLANNING APPROACH

The planning process began with defining the purpose for Phase 1 of the feasibility study. In general, the purpose is to identify and investigate methods that could provide additional storage of San Joaquin River water. From that purpose, a set of goals to be addressed was defined based on the problems described in Chapter 3. The goals are general in nature and provide direction for the Investigation, but do not detail specific desired outputs. Study goals and objectives will continue to be refined as the feasibility study proceeds.

PHASE 1 INVESTIGATION PURPOSE

The CALFED ROD provided guidance for considering initial problems to be addressed by the feasibility study and an initial range of potential storage capacity to be considered. The ROD did not, however, provide quantitative objectives to be achieved or guidance on how to identify a functionally equivalent storage program.

The purpose of Phase 1 was to complete technical studies sufficient to determine whether a potentially viable project exists and to provide focus for more detailed evaluation in the feasibility study. The study was developed to convey relevant information to Reclamation, DWR, CALFED management, and stakeholders who ultimately could be involved in implementing study recommendations. The strategy described below focuses on common information that would likely be needed to support decision-making by all interested parties.

POTENTIAL EFFECTS OF ADDITIONAL WATER SUPPLY AT FRIANT DAM

Many water resource problems to be addressed by the Investigation relate to water supply availability. The overall goal of the Investigation is to develop additional water supplies that could be released from Friant Dam to address these problems. New water supplies could be used specifically for one or more of the primary purposes of the Investigation. Table 4-1 identifies the types of benefits that could be addressed under various operational scenarios.

TABLE 4-1 POTENTIAL EFFECTS OF ADDITIONAL WATER SUPPLY AT FRIANT DAM

Potential Effect	Operational Purpose[1]		
	San Joaquin River Restoration	San Joaquin River Water Quality	Water Supply Reliability
Total Friant Division water deliveries	0	0	+
Class 2 Friant Division water deliveries	+	+	+
Delivery of unstorable water (Section 215)	-	-	-
Reduction in regional groundwater overdraft	+	+	+
Water supply at Mendota Pool	+	+	-
Water quality at Mendota Pool	+	+	-
South-of-Delta supplies and/or Delta inflow	+	+	-
Year-round river releases from Friant Dam	+	+	0
Seasonal river releases from Friant Dam	+	+	0

Key:
+ positive effect
- negative effect
0 no change

Notes:
1. Anticipated effects are based on operations focused on a single purpose. Phase 2 evaluations will include multiple-purpose operational scenarios.

OPPORTUNITIES TO STORE SAN JOAQUIN RIVER WATER

In general terms, San Joaquin River water could be stored either in surface water reservoirs or in groundwater and a variety of approaches are available for either of these two methods. For example, San Joaquin River water could be directly stored in reservoirs on the San Joaquin River, as would be accomplished by raising Friant Dam, in potential off-stream reservoirs in the San Joaquin River basin, or in potential off-canal reservoirs served by the Madera or Friant-Kern canals.

Storage of San Joaquin River water could also be achieved through exchanges with stored water from other watersheds. In this case, water from another watershed could be captured and held so that water from Millerton Lake could be released earlier for delivery to areas otherwise served by other watersheds, thereby lowering storage levels and allowing the capture of more San Joaquin River water. The water captured in the other watersheds would then be used for later delivery.

Groundwater storage could be accomplished by several methods: increasing deliveries to existing water users in the Friant Division in lieu of groundwater pumping; increasing the rate of groundwater recharge; and developing groundwater banks that would accept water during wet years and make it available during dry years.

The following sections describe the approaches used to identify and evaluate surface water storage and groundwater storage options. Surface water storage options were identified and screened based on construction and permitting-related issues. Options retained for further consideration were evaluated to identify potential benefits and costs. To date, specific groundwater storage options that could be evaluated at a similar level of detail have not been identified. Work is continuing to identify specific groundwater storage actions that could be considered in Phase 2.

INITIAL SCREENING OF SURFACE STORAGE OPTIONS

Several surface storage options were considered during Phase 1 of the feasibility study. These options were passed through an initial screening process that was intended to identify options that would be dropped from the study and those to be considered further. This section describes the approach for identifying and selecting potential surface storage sites for consideration.

Surface Storage Options Dropped from Further Consideration

A review of previous regional water resources studies identified 17 potential surface storage options for initial consideration (Figure 4-1). This list included enlarging two existing reservoirs (Lake Kaweah and Lake Success), which were dropped from further consideration because they have already been authorized for construction. The remaining sites include enlarging existing reservoirs and constructing new reservoirs. Some options are located in the upper San Joaquin River basin; others are located in watersheds that are served by the Friant Division or would be operated as off-canal storage. Information considered was obtained from multiple sources, including previous studies, field observations by study team members, and from stakeholders. In some cases, the configuration of a storage option was modified from that project described in previous studies, and information was updated as appropriate.

Initial screening focused on potential construction-related issues that could preclude constructing required facilities, create environmental impacts that could not be mitigated, or create conditions under which permits issued by regulatory agencies or approved by decision-makers would be unlikely. Initial screening did not consider reservoir operations modeling or construction cost estimates.

A Technical Memorandum (TM) was prepared for each surface storage option considered. As indicated in Table 4-2, six surface storage sites were retained for further analysis in Phase 2 of the feasibility study and one option will be further evaluated by others.

Although cost was not a criterion for initial screening, cost information is provided in all of the TMs, which are included as appendices to this report. The following sections describe eight surface storage options that were reviewed and dropped from further consideration.

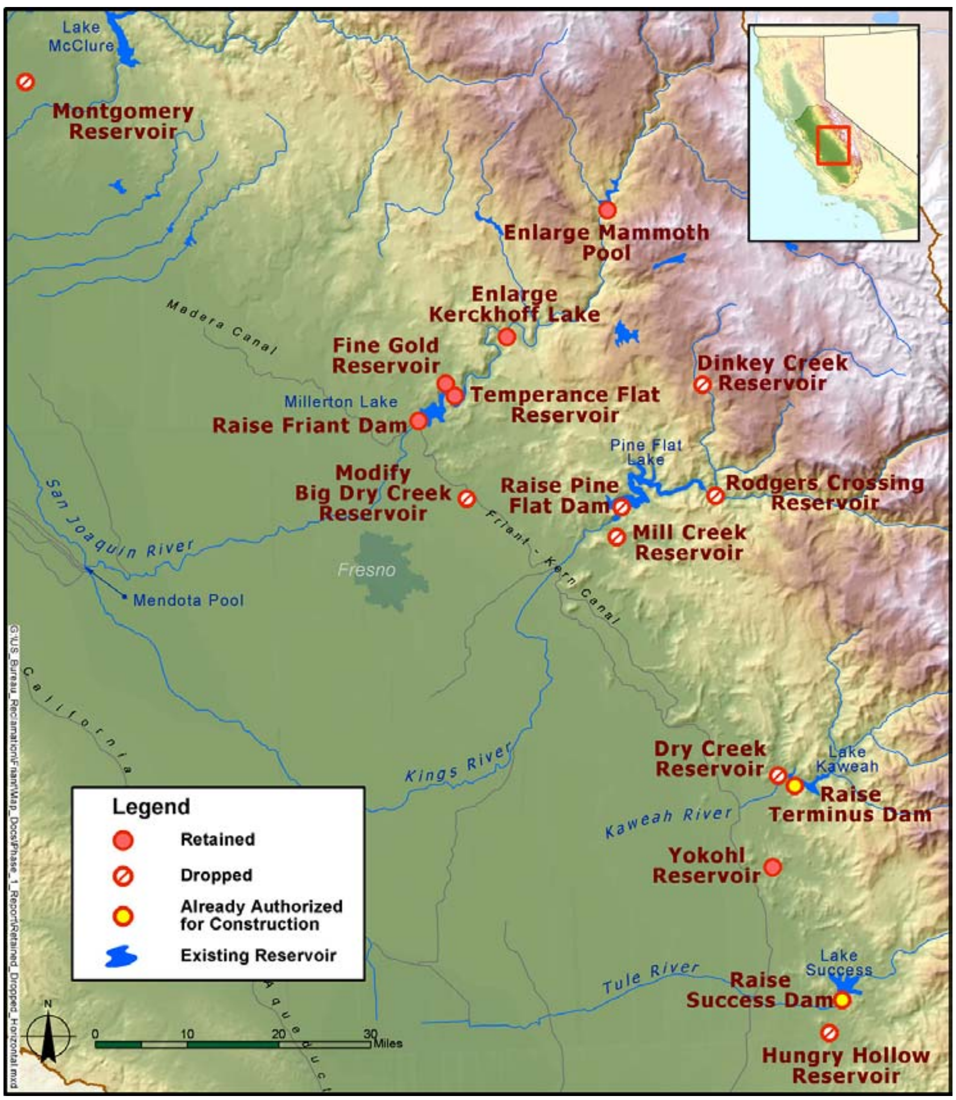


FIGURE 4-2. SURFACE STORAGE OPTIONS CONSIDERED

TABLE 4-2
INITIAL SCREENING OF SURFACE STORAGE OPTIONS

Watershed / Reservoir Site	Max Cap[1] (TAF)	Engineering Issues			Environmental Issues					Result of Initial Screening
		DS	SG	WQ	Bot	WL	AB	Rec	LU	
Merced River Watershed										
Montgomery Reservoir	241									Dropped
San Joaquin River Watershed										
Raise Friant Dam	870									Retained
Fine Gold Creek	800									Retained
Temperance Flat RM 274	2,100									Retained
Temperance Flat RM 279	2,750									Retained
Temperance Flat RM 286 (Enlarge Kerckhoff Lake)	1,400									Retained
Enlarge Mammoth Pool	35									Retained[2]
Big Dry Creek Watershed										
Big Dry Creek Dam	30									Dropped
Kings River Watershed										
Raise Pine Flat Dam	124									Dropped[3]
Mill Creek	200									Dropped
Rodgers Crossing	295									Dropped
Dinkey Creek	90									Dropped
Kaweah River Watershed										
Enlarge Lake Kaweah	n/a									Dropped[4]
Dry Creek	70									Dropped
Yokohl Valley	800									Retained
Tule River Watershed										
Enlarge Lake Success	n/a									Dropped[4]
Hungry Hollow	800									Dropped

Key to Engineering Issues		Key to Assessments	
DS	Safety of existing dam		Unfavorable engineering or operational condition
SG	Soils and geology		Potential environmental effects not determined
WQ	Quality of developed water		Low or no likely adverse environmental effects
			Potential adverse effects; mitigation to be determined
Key to Environmental Issues			Potential unmitigable adverse environmental effects
AB	Aquatic biology & water quality	**Notes**	
Bot	Botany	1.	Maximum new storage capacity (thousand acre-feet).
LU	Land use	2.	Under review by others; will not be considered in Phase 2.
Rec	Recreation	3.	Potential partner not interested in pursuing project.
WL	Wildlife	4.	Authorized for construction by U.S. Army Corps of Engineers.

Merced River Watershed - Montgomery Reservoir

A new reservoir was considered on Dry Creek, a northern tributary to the Merced River. Montgomery Reservoir would be an off-stream reservoir that would store flood flows released or spilled from Lake McClure at New Exchequer Dam and diverted from the Merced River at Merced Falls. Water stored in Montgomery Reservoir would be used to meet water needs in Merced Irrigation District (MID), allowing water stored in Lake McClure to be used in exchange for other purposes.

Montgomery Reservoir would store up to 241 TAF of water. This option would entail construction of a 101-foot-high zoned earthfill dam and eight saddle dams, with a combined crest length of 14,300 feet. Conveyance of water to and from Montgomery Reservoir would require modifications to the North Side Canal.

MID expressed concern regarding the quality of the water that would be developed in Montgomery Reservoir. With a surface area of nearly 8,000 acres, the average reservoir depth would be roughly 30 feet when filled. High water temperature, the likelihood of algal growth, and relatively high evaporative losses would make the developed water undesirable to MID and its customers. This reservoir option was dropped from further consideration.

San Joaquin River Dry Creek Watershed - Big Dry Creek Reservoir

Big Dry Creek Dam is an existing flood control structure in Fresno County, near Clovis, operated by the Fresno Metropolitan Flood Control District. The reservoir area spans Big Dry Creek and associated smaller drainages to the north. The zoned earthfill embankment dam could accommodate a reservoir with approximately 30 TAF of storage. Due to seepage concerns and insufficient inflow, however, the total storage capacity has not been exploited.

The study team considered a turnout from the Friant-Kern Canal, along with an energy dissipation structure, to divert water to Big Dry Creek Reservoir. DWR's Division of Safety of Dams has indicated that no more than 10 TAF can be stored in the existing reservoir, and only if the dam demonstrates satisfactory performance when the reservoir is 50 percent filled. Due to insufficient inflows, the reservoir has yet to be tested at this level of storage. Consequently, uncertainty remains regarding the existing dam's ability to store more than a few thousand acre-feet of water. In addition to these concerns, modifications to enable storage for longer than 90 days may require extensive reconstruction of the dam. Based on these concerns, enlarging the Big Creek Flood Control Basin for long-term water storage was dropped from further consideration.

Kings River Watershed - Raise Pine Flat Dam

Raising the gross pool elevation of Pine Flat Reservoir by 20 feet would result in 124 TAF of additional storage. This would be accomplished by raising the crest of Pine Flat Dam 12 feet and replacing 36-foot-high radial gates with 59-foot-high gates. Additional water stored in the enlarged Pine Flat Reservoir would be exchanged for Friant Division water. Early in the year, water from Millerton Lake could be delivered to Pine Flat water users, thereby creating additional storage space in Millerton Lake to capture San Joaquin River flows. Kings River water that otherwise would have been delivered would be retained in the enlarged Pine Flat Reservoir. Later in the year, water from Pine Flat would be delivered to the Friant-Kern Canal in lieu of releases from Millerton Lake.

Implementation of this option would require collaboration with the Corps and the Kings River Conservation District (KRCD), which represents the users of water stored in Pine Flat Reservoir. KRCD does not support this storage option. KRCD, which had previously studied enlarging Pine Flat Reservoir in coordination with the Corps, recommended that the Investigation not pursue the option further, citing inundation of recreation facilities, aquatic, and terrestrial habitat, and the need to modify PG&E's Kings River Powerhouse upstream of Pine Flat Reservoir. Consequently, this option was dropped from further consideration.

Kings River Watershed - Mill Creek Reservoir

A new dam on Mill Creek, which joins the Kings River approximately 1.7 miles downstream of Pine Flat Dam, was considered. A zoned embankment dam up to 250 feet high would create a reservoir with a storage capacity of up to 200 TAF. Excess flows in the Kings River would be diverted by gravity into Mill Creek Reservoir by means of a 5,000-foot-long, 10-foot-diameter, unlined tunnel. Stored water would be exchanged with Millerton Lake water.

An extensive a sycamore alluvial woodland is located in the lower reaches of Mill Creek near its confluence with the Kings River (Corps, 1994). This is a rare and sensitive habitat type that hosts a diverse assemblage of wildlife, particularly birds. It is anticipated that creation of Mill Creek Reservoir would result in unmitigable negative impacts to the sycamore alluvial woodland habitat. Consequently, this option was dropped from further consideration.

Kings River Watershed - Rodgers Crossing Reservoir

A dam at Rodgers Crossing would be located on the main stem of the Kings River, above Pine Flat Reservoir, and approximately one-half mile upstream of the confluence with the North Fork. Two options had been studied previously, a 400-foot-high concrete arch dam that would create a reservoir capacity of 295 TAF, and a roller-compacted concrete (RCC) gravity dam up to 660 feet high that would create a reservoir capacity of 950 TAF. Stored water would be exchanged with Millerton Lake water.

The Kings River is one of the least disturbed large rivers in California and its wild trout population is considered one of the best in the state. Upstream of Pine Flat Reservoir, the Kings River also supports whitewater recreation. Both options would inundate a portion of the Kings River Special Management Area, and the larger option would inundate a portion of the river that has been Federally designated as a Wild and Scenic River. Inundation of either the Special Management Area or the Wild and Scenic River would violate expressed Congressional intent. A reservoir at Rodgers Crossing would also affect a Wild Trout Fishery, as designated by the California Department of Fish and Game. For these reasons, Rodgers Crossing Reservoir was dropped from further consideration.

Kings River Watershed - Dinkey Creek Reservoir

Dinkey Creek is within the upper watershed of the North Fork of the Kings River. A dam on Dinkey Creek would be located within the Sierra National Forest at an elevation of over 5,400 feet above mean sea level (elevation 5,400). It would be a zoned rockfill dam, approximately 340 feet high and 1,600 feet long, creating a 90 TAF reservoir. Stored water would be exchanged with Millerton Lake water.

Developing a reservoir at Dinky Creek would result in adverse environmental impacts in all categories assessed – botany, wildlife, aquatic biology, recreation, and land use. In particular, a reservoir at Dinkey Creek would fundamentally alter the existing recreation-based community. Dinkey Creek is a popular recreation area and trout fishing destination. A flow reduction could reduce available habitat, particularly during spring and summer when rainbow trout are spawning and rearing. Changes in water temperature below the dam could adversely affect trout and the dam would impede migration. The potentially inundated area includes two organization camps, vacation residences, and roads that provide access on both sides of the stream to numerous recreational resources in the Sierra National Forest. Creation of the reservoir would adversely impact an established community and may be unmitigable. This option was dropped from further consideration.

Kaweah River Watershed - Dry Creek Reservoir

Dry Creek Reservoir would be a new impoundment on Dry Creek, which is a tributary to the Kaweah River, just downstream and northwest of Lake Kaweah at Terminus Dam. The dam would be a 200-foot-high RCC structure with a crest length of approximately 3,210 feet, which would create a 70 TAF reservoir. Water would be diverted from Lake Kaweah through a 7,600-foot-long gravity tunnel, 12 feet in diameter. The new reservoir would also capture natural runoff from Dry Creek. Stored water would be exchanged with Millerton Lake water.

A sycamore alluvial woodland exists near the confluence of Dry Creek and the Kaweah River. As with the Mill Creek Reservoir option, it is anticipated that adverse effects to the sycamore alluvial woodland could not be mitigated. Consequently, this option was dropped from further consideration.

Tule River Watershed - Hungry Hollow Reservoir

Hungry Hollow Dam and Reservoir would be constructed on Deer Creek, a tributary to the Tule River about 3 miles south and downstream of Lake Success and 6 miles east of Porterville. The dam would be a zoned earthfill structure 267 feet in height and 5,200 feet in length that would impound an off-stream reservoir with a storage capacity of up to 800 TAF. Additional features would include two saddle dams, a spillway, outlet works, and relief wells along the downstream toe of the dam. Two conveyance configurations were previously considered. One would divert water from the Friant-Kern Canal via a two-way canal and pump it into the reservoir. A second option involves diverting water from Lake Success and pumping it into Hungry Hollow Reservoir via a 10-foot-diameter tunnel nearly 3 miles in length. For both options, stored water would be exchanged for Millerton Lake water.

Extensive young alluvial deposits, over 300 feet thick, lie beneath the potential dam axis. The deposits are unconsolidated, loose, permeable, and subject to liquefaction during an earthquake. Although no significant faults passing through the site have been identified, the alluvium may not provide an adequate foundation for the dam. In addition, the reservoir would inundate up to 8 miles of Deer Creek, which supports well-developed sycamore alluvial woodland, a rare and regionally important wildlife habitat. It is anticipated that construction of a reservoir on Deer Creek would adversely affect the sycamore alluvial woodland habitat and that the damage could not be mitigated. Consequently, Hungry Hollow Reservoir was dropped from further consideration.

TECHNICAL ANALYSES OF RETAINED SURFACE STORAGE OPTIONS

The remaining surface storage sites retained for further analysis after the initial screening were evaluated to identify potential accomplishments, costs, and environmental effects. Each option was simulated in CALSIM to identify additional water that could be developed; potential power generation and use were estimated; and cost estimates were prepared for major components of each option.

This section describes methodology followed for technical evaluations of retained options. It includes a description of CALSIM model development to establish baseline operation of the Friant Division, methodology applied to estimate hydropower generation and energy use, and assumptions applied for cost estimates. Results of the evaluations are included in the descriptions of retained surface storage options in the next section of this chapter.

CALSIM Model Development and Validation

The CALSIM model simulates the operation of CVP, State Water Project (SWP), and some locally owned facilities throughout California. This model is widely used for water resources studies by Reclamation, DWR, and numerous water agencies in California to identify how potential projects and actions would affect system-wide operations. Prior to the Investigation, CALSIM included a highly generalized representation of the Friant Division that could not simulate changes in project operations in response to changes in demands or facility configurations. As part of this Investigation, the CALSIM model was modified to reflect the decision-making process used to allocate water supplies at Friant Dam. The revised model includes logic that determines the allocation of Class 1 and Class 2 water supplies and the availability of Section 215 water for diversion to the Friant-Kern and Madera canals based on hydrologic conditions.

Historical operations demonstrate that the timing and pattern of demands for Class 1 and Class 2 water depend on the availability of Section 215 water and the total quantity of water allocated on an annual basis. The CALSIM model logic applies water demand patterns for Class 1, Class 2, and Section 215 water supplies based on calculated allocations. Model results were compared to historical operations during validation to assure an accurate representation of Friant Dam operations. A description of CALSIM modifications and a comparison of the results to historical deliveries are presented in the Hydrology and Modeling Technical Appendix. The results from simulated operations compare closely with actual historical operations. The revised CALSIM that includes Friant operations is used as a benchmark for the Investigation

Surface Storage Options Modeling Methodology

Surface storage sites retained for further analysis from the initial screening were evaluated in the CALSIM model to estimate the water supply the option could provide. For each surface storage option, single-purpose evaluations were run for multiple reservoir sizes. Model simulations were done to identify the quantity of water that could be available for each Investigation purpose if the additional water supply created by new storage were operated solely to meet that purpose. The single-purpose analyses did not include any changes to the flood storage rules currently in place.

The single-purpose analyses address the three purposes of the Investigation – river restoration, water quality, and water supply reliability. Each single-purpose evaluation includes a generalized operation of the expanded reservoir to specifically address one project purpose. Operations for one purpose can also contribute to other purposes and address other opportunities. For example, releases to the San Joaquin River for river restoration would also contribute to improved water quality in the river.

Enlarging storage capacity would result in year-to-year changes in water storage conditions; changes would affect Class 1, Class 2, and Section 215 water amounts. A modeling constraint was established to identify how new storage could contribute to Investigation purposes without causing an unaccounted reallocation of existing supplies. The single-purpose evaluations for river restoration and water quality improvement used the iterative approach shown in Figure 4-3 to estimate the annual amount of water that would be available to each purpose without increasing or decreasing deliveries to current water users. Modeling iterations continued until resulting average annual deliveries by water year type were similar to the benchmark simulation. This approach did not result in the same distribution of water deliveries between the different classes of water as for the benchmark simulation, but it furnished information on the total amount of water that additional storage could provide.

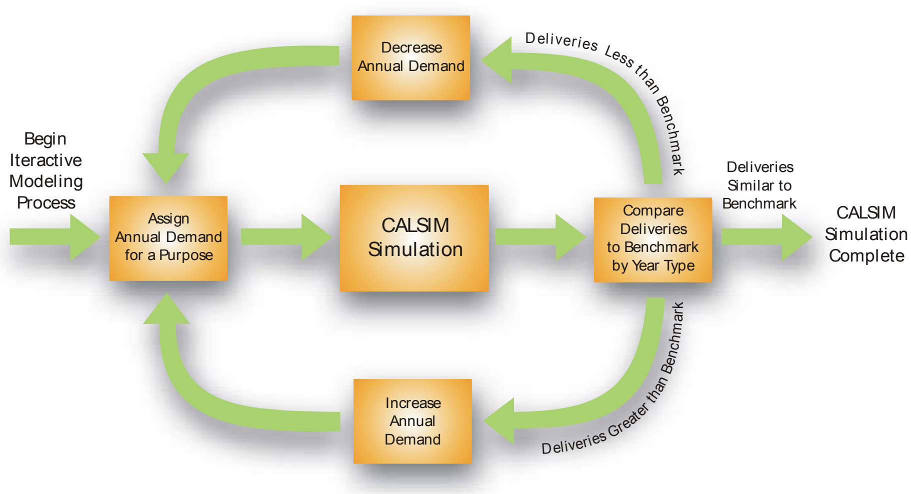


FIGURE 4-3. ITERATIVE MODELING APPROACH FOR SINGLE-PURPOSE RIVER RESTORATION AND WATER QUALITY IMPROVEMENT ANALYSES

Annual restoration and water quality demands for each year type were modified until a set of demands was established that would result in average deliveries for each year type similar to the benchmark. This approach resulted in a wide variation in the annual quantity of water that could be provided for river restoration or water quality improvement. It is important to note that initial modeling scenarios were based on the annual reservoir operations currently applied to Millerton Lake. In calculating annual water supply availability, the model assumes that minimum end-of-year storage would be 130 TAF, or the approximate level of the canal outlets. If the enlarged reservoir were operated with an objective to carry over water supply from one year to the next, the results presented in the following sections would differ. In particular, the wide variation in water quantities between different year types would be reduced and more water would likely be available during critically dry years.

San Joaquin River Restoration Single-Purpose Analysis

As described in Chapter 3, a flow requirement for restoration of the San Joaquin River has not been established. To determine how additional storage could provide water supplies to support restoration of the San Joaquin River, a range of ecosystem demands was placed on Millerton Lake. The model was run in an iterative manner until the constraints of maintaining long-term average annual water supply deliveries, as described above, was satisfied.

The monthly variation of flow (March through the following February) was based on the percentage distribution of monthly flows under an unimpaired condition. The variation of unimpaired flows for all year types was reviewed and found to be similar on a percentage basis. Therefore, the same percent distribution shown was used in all years. The percentage distribution pattern is shown in Figure 4-4.

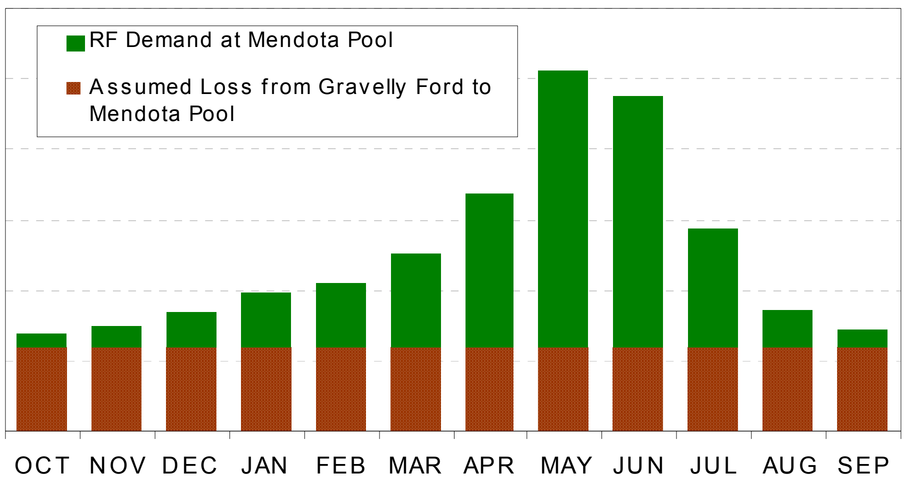


FIGURE 4-4. MONTHLY PERCENTAGE DISTRIBUTION OF RELEASES FOR RIVER RESTORATION FLOW SINGLE-PURPOSE ANALYSIS

Under the river restoration flow single-purpose analysis, the San Joaquin River Exchange Contractors could use Friant water reaching Mendota Pool, and the demand for Delta water at Mendota Pool could be similarly reduced. Provisions could be made to pass water by Mendota Pool and increase downstream flows and Delta inflow. This approach was not evaluated, however, because an assumption of water use at or below Mendota Pool would not have a direct affect on estimating how much new water supply could be available if additional surface water storage were developed. Operational scenarios at Mendota Pool will be evaluated in more detail during Phase 2.

San Joaquin River Water Quality Single-Purpose Analysis

Water quality in the San Joaquin River would improve if water releases from Friant Dam to the San Joaquin River were increased. Water quality improvements would result if released water were delivered to Mendota Pool in lieu of Delta water, or if the released water were allowed to flow downstream of Mendota Pool. In general, water released from Friant Dam is of better quality than water exported from the Delta. An increase in the quantity of better-quality water to Mendota Pool from Friant Dam, and a corresponding decrease of Delta water, would improve the quality of source water to agricultural and refuge areas. This in turn would result in improved quality of discharge to the San Joaquin River.

For the purposes of the Phase 1 studies, quantities of water available for improving San Joaquin River water quality from new storage were estimated on the basis that releases from Friant Dam would be delivered to Mendota Pool. The quantity of water that could be released from Friant Dam for San Joaquin River water quality improvement was estimated in a similar manner to the approach described above for San Joaquin River restoration. The monthly distribution of flows for San Joaquin River water quality improvement, however, differed from that used for river restoration single-purpose analysis. As shown in Figure 4-5, San Joaquin River water quality single-purpose analysis considered simulated releases from Friant Dam during the 3-month period of July through September, when water quality conditions in the San Joaquin River are most severe. Seepage to groundwater is based on an estimate from the San Joaquin River Habitat Restoration Plan of 12 TAF per month for intermittent flow conditions.

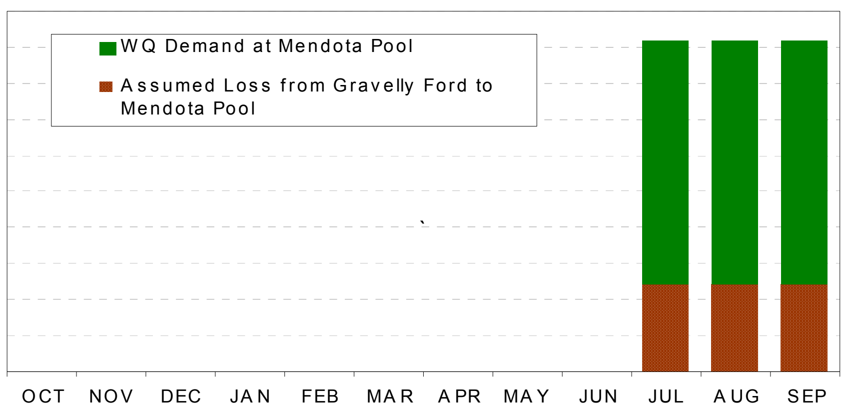


FIGURE 4-5. MONTHLY PERCENTAGE DISTRIBUTION OF RELEASES FOR WATER QUALITY SINGLE-PURPOSE ANALYSIS

For the initial analyses, it was assumed that the San Joaquin River Exchange Contractors would use Friant water reaching Mendota Pool and the demand for Delta water at Mendota Pool would be similarly reduced. Seepage to groundwater would help reduce groundwater overdraft in the area.

It is recognized that water management strategies other than deliveries to Mendota Pool could be developed that would improve San Joaquin River water quality by releasing water from Friant Dam. However, it is expected that other release patterns for water quality purposes in the San Joaquin River would produce generally similar estimates of the amount of water that could be developed from new storage. Operational scenarios at Mendota Pool will be evaluated in more detail during Phase 2.

Water Supply Reliability Single-Purpose Analysis

Single-purposes analyses for water supply reliability used the same logic as the benchmark simulation for diversion to the Madera and Friant-Kern canals based on Class 1, Class 2, and Section 215 demands. The reservoir would be operated as an annual reservoir, with no explicit carryover requirement. In effect, annual deliveries are based on the objective of delivering as much of the annual supply as possible. When annual supplies exceed annual demands, incidental carryover would provide additional water for the following year.

Modeling Retained Surface Storage Options

Storage sites retained for further consideration following the initial review were modeled to identify the extent to which they can contribute to Investigation purposes. Each retained option was represented in CALSIM and operated in combination with existing facilities to identify the amount of new water supply that would be available for the three primary purposes, as described previously. Preliminary results showed that the water supply reliability single-purpose analyses estimated less annual average new water supply than the river restoration or river water quality single-purpose analyses. Therefore, all sizes of the options were simulated using the water supply reliability single-purpose analysis, and some sizes were also evaluated using the river release purposes.

A schematic of CALSIM model modifications that were made to support the evaluation of surface storage options is shown in Figure 4-6. Reservoir nodes were added upstream of Millerton Lake to represent Temperance Flat Reservoir and Kerckhoff Lake. The simulation of Fine Gold Creek Reservoir includes a diversion facility for pump-back storage. Yokhol Valley Reservoir was represented as a generalized pump-back facility off the Friant-Kern Canal. The representation of Yokohl Valley reservoir in CALSIM could also be used to simulate the operation of other off-canal storage sites, including potential groundwater storage options. The capacity of the Friant-Kern Canal decreases south of the Kings River, before reaching Yokohl Valley Reservoir. For initial evaluations, assumed capacity was based on diversion capacity. No attempt was made to reflect reduced canal capacity or canal operating assumptions.

Model Refinement and Sensitivity Analyses

Following initial modeling work, stakeholders provided suggestions on additional model refinements, post-process evaluations, and sensitivity analyses. The additional model developments and application improved understanding of current project operations and will provide information for developing operational assumptions to be considered during Phase 2.

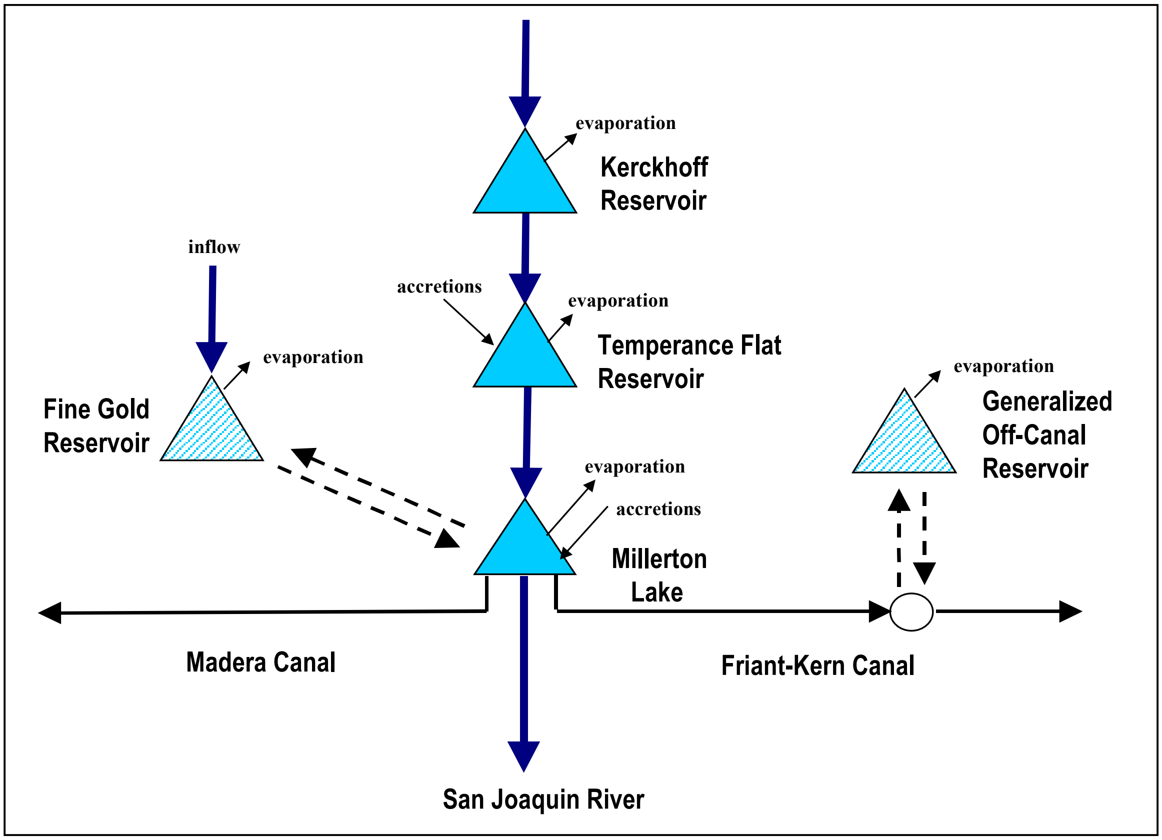


FIGURE 4-6. CALSIM SCHEMATIC FOR SIMULATION OF RETAINED SURFACE STORAGE SITE OPTIONS

Hydropower Generation and Energy Use Analytical Methodology

Preliminary energy estimates were made using a spreadsheet approach based on output from CALSIM. Estimates were made for the single-purpose analyses for restoration and water quality. These simulations were chosen because the restoration flow single-purpose analysis would release water to the San Joaquin River early in the year, whereas the single-purpose analysis for water quality would hold new water in storage until it is released to the San Joaquin River in the late irrigation season. The water supply reliability single-purpose analysis would fall within the range of these operations.

Figure 4-7 shows the relationship between a typical powerhouse configuration at the base of a dam and primary variables that affect energy generation, namely head and flow. These variables are important in determining the energy required to pump water into off-stream or off-canal reservoirs. Energy generation also depends on generating and pumping efficiencies, and equipment operational constraints. Assumptions were made regarding pumping and generating efficiencies, equipment submergence requirements, head and flow ranges within which pumping and generating equipment would operate, and head losses in water passages. Output from CALSIM accounted for flood storage and minimum storage assumptions.

Results are preliminary, due to the assumptions made in this level of study, and therefore give an indication only of possible pumping energy required and energy generation output. A major factor in selecting pump-turbine and motor-generator unit sizes is the relatively large variation in head and flows available for energy generation over the simulation period.

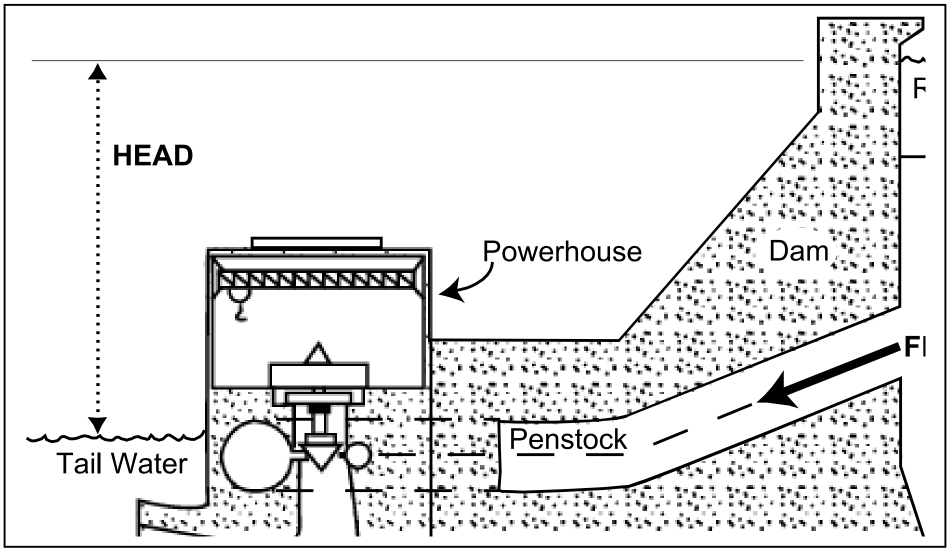


FIGURE 4-7. TYPICAL HYDROELECTRIC ENERGY GENERATION FACILITY

Methodology for Estimating Surface Storage Options Costs

Construction costs were estimated for retained surface storage options. In most cases, previous estimates either did not exist or were considered too old to be confidently updated. Costs were based on prefeasibility-level designs and contain provisions for uncertainties. For most options, costs were estimated for different dam types and reservoir sizes.

Field costs for construction were estimated at 2003 price levels. Field costs represent the estimated costs for identified features, plus allowances for mobilization (5 percent), unlisted items (15 percent), and contingencies (25 percent). Field costs were increased by 25 percent to account for investigations, designs, administration, and construction management to obtain total estimated construction costs.

Costs for road construction, relocations of existing facilities, environmental mitigation, land requirements, reservoir clearing, and finance interest during construction will be prepared during Phase 2.

SURFACE STORAGE OPTIONS RETAINED FOR FURTHER CONSIDERATION

This section describes the six surface storage options identified in Table 4-1 that will be carried forward for further consideration. These include Raise Friant Dam, Fine Gold Creek Reservoir, Temperance Flat Reservoir (three options), and Yokohl Valley Reservoir. The Enlarge Kerckhoff Lake option is represented by one of the three Temperance Flat options and the Enlarge Mammoth Pool option is under study by the FWUA. The Investigation will continue to coordinate with FWUA on the findings of that review.

Raise Friant Dam

Friant Dam is a 319-foot-high concrete gravity dam on the San Joaquin River about 20 miles northeast of Fresno. Potential modifications would include raising the dam up to 140 feet.

Options Considered

Three specific optional dam raise heights were considered, including 25-, 60- and 140-foot raises. Friant Dam would be raised by adding an overlay of RCC on the downstream face, as illustrated in Figure 4-8. In addition to the dam raise, up to three supplemental earthfill dams or dikes would be required. The most extensive would be a dike on the southwest rim of the reservoir (i.e., left side, looking downstream). Two additional, but considerably smaller, saddle dams would be required on the northwest side of Millerton Lake. The availability of materials from local sources does not appear to be a limiting factor.

A 25-foot raise, which would increase storage capacity by about 130 TAF, would involve raising the dam crest and modifying the spillway and spillway chute. It would also require construction of a dike, approximately 3,000 feet long, across a low saddle at the southwest shoreline of the existing reservoir. A 60-foot raise would increase capacity by 340 TAF and entail raising the dam crest, modifying the spillway and spillway chute, and constructing approximately 8,500 feet of new dike. A 140-foot raise would result in approximately 870 TAF of additional capacity, and would require new dikes of approximately 9,500 feet in total length. Figure 4-9 shows the extent of an enlarged Millerton Lake and facilities associated with a 140-foot raise of Friant Dam.

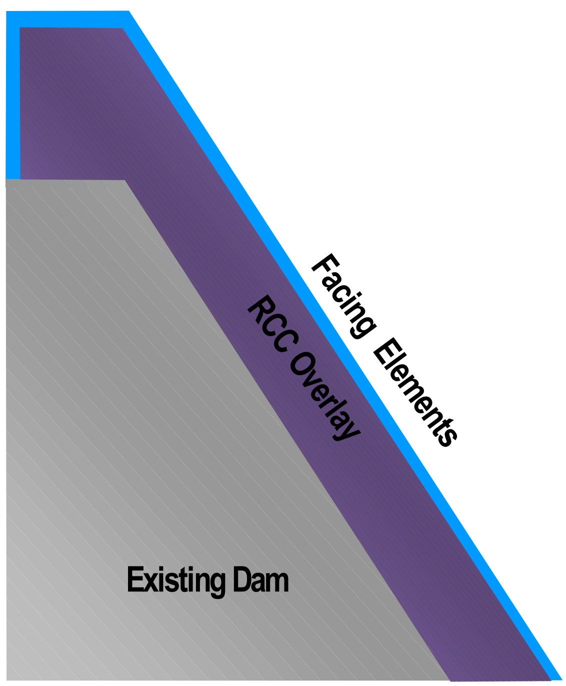


FIGURE 4-8. RAISE FRIANT DAM SIMPLIFIED CROSS SECTION

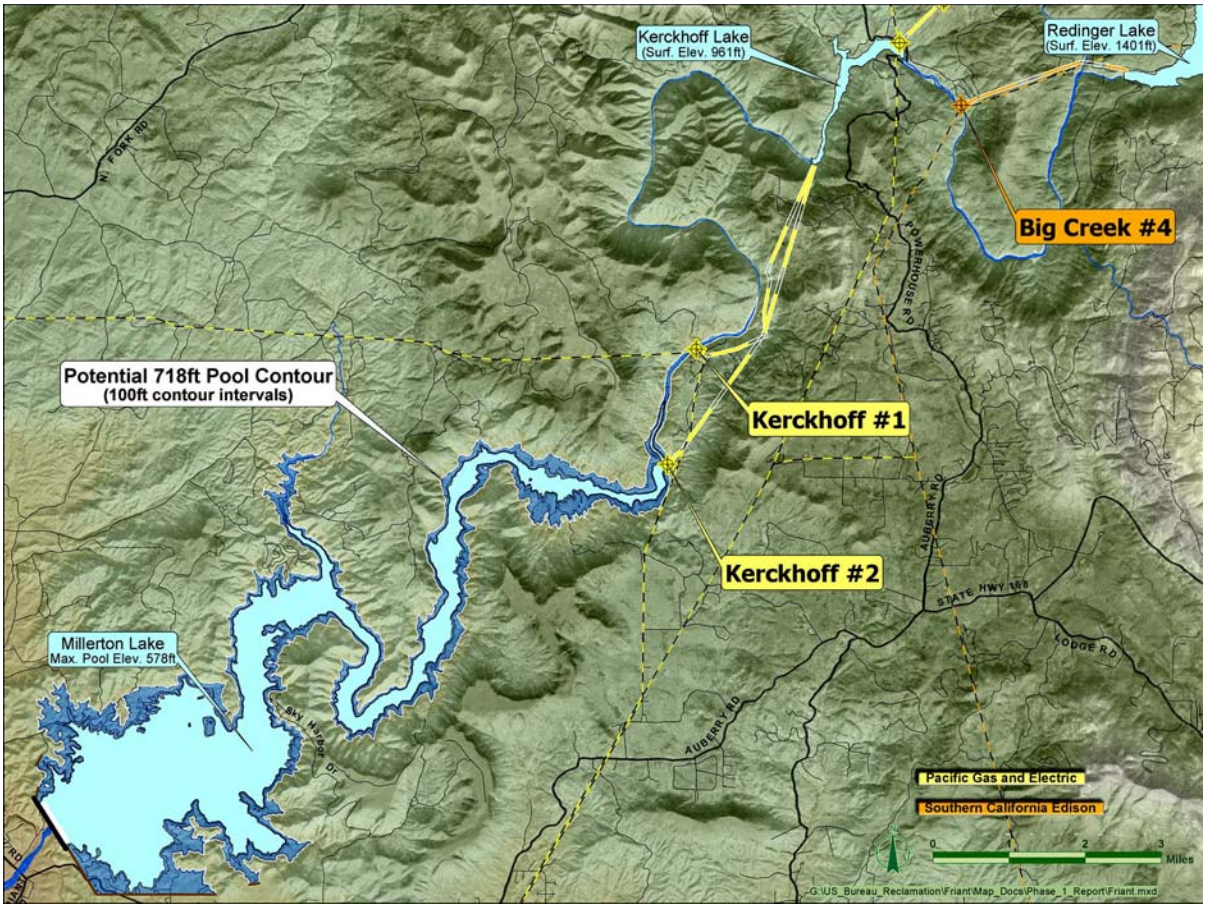


FIGURE 4-9. RAISE FRIANT DAM OPTION

Potential New Water Supply

An enlarged Friant Dam and Millerton Lake would continue to capture flow on the San Joaquin River. Additional storage capacity would provide opportunities to store larger flood volumes than with the current reservoir. Stored water would continue to be diverted to the Friant-Kern Canal, the Madera Canal, and/or released to the San Joaquin River.

CALSIM simulations show that the potential new water supply resulting from raising Friant Dam 140 feet could be as high as 150 TAF/year. The long-term average annual amount associated with each single-purpose analysis for various sizes of Friant Dam are listed in Table 4-3. The table shows that releasing water to the San Joaquin River would provide more water than the water supply reliability single-purpose analysis. This is because water deliveries are limited by contract amounts, whereas simulated releases to the river were maximized to the extent that they would not reduce water deliveries from benchmark levels. The new water supply for the restoration flow single-purpose analysis is higher than that for the water quality analysis because releases would be made earlier in the year, providing more opportunity to capture San Joaquin River inflow during late spring months.

TABLE 4-3
NEW WATER SUPPLY FROM FRIANT DAM RAISE OPTIONS

Friant Dam Raise Height (feet)	Water Surface Elevation (feet, above mean sea level)	Additional Storage Capacity (TAF)	New Water Supply Estimated in Single-Purpose Analysis (average TAF/year)		
			RF	WQ	WS
25	603	125	n/s	n/s	24
45	623	250	n/s	n/s	51
60	638	340	n/s	n/s	68
75	653	450	n/s	n/s	93
111	689	700	152	139	128
140	718	870	n/s	n/s	146

Key:
n/s not simulated
TAF – thousand acre-feet
RF – San Joaquin River restoration flow single-purpose analysis
WQ – San Joaquin River water quality single-purpose analysis
WS – water supply reliability single-purpose analysis

Hydropower Generation and Impacts

The Friant Power Authority owns and operates three power plants at Friant Dam: one each on the Friant-Kern and Madera canals and one at the river outlet, with a combined generation capacity of 2 megawatts (MW). The plants generate energy when flows exceed minimum levels and adequate head is available. Although an analysis of Friant power generation was not completed during Phase 1, additional storage capacity in Millerton Lake would allow more controlled releases through some or all of the power plants. These releases would be associated with higher lake levels and thus would increase energy production.

Raising the level of Millerton Lake would affect energy generation at the Kerckhoff Project. The Kerckhoff No. 2 Powerhouse, which has a capacity of 155 MW, discharges directly into Millerton Lake and would be affected by any increase in the lake level. The Kerckhoff Powerhouse is located at elevation 636 and would also be affected by a raise of Friant Dam of 60 feet or more. As listed in Table 2-4, average energy generation from these plants is about 579 gigawatt-hours per year (GWh/year). It is not likely that additional generation at the Friant power plants resulting from any raise of Friant Dam would replace lost energy generation from the Kerckhoff Project.

Estimated Costs

Cost estimates for raising Friant Dam listed in Table 4-4 include costs for dam modifications, saddle dams, dikes, and land acquisition. Several residential areas around Millerton Lake would be affected by raising the lake level. Based on a review of aerial photography, it is estimated that structures on approximately 165 properties would be within the inundation area associated with a 140-foot raise in lake level.

Preliminary estimates of land acquisition, based on typical costs per acre, are listed in Table 4-3, but are not included in estimated construction costs. Other costs, such as those associated with the Friant and Kerckhoff power plants, relocation of recreation facilities and roads, and reservoir clearing, require additional review.

TABLE 4-4
RAISE FRIANT DAM ESTIMATED CONSTRUCTION COSTS

Dam Raise Height (feet)	Additional Storage Capacity (TAF)	Construction Costs		Estimated Land Acquisition Cost ($Million)
		Field Cost ($Million)	Construction Cost ($Million)	
25	125	100	125	27
60	340	250	310	30
140	870	640	800	40

Key:
TAF – thousand acre-feet

Environmental Considerations

Raising Friant Dam and the level of Millerton Lake would cause environmental impacts to aquatic biology, wildlife, recreation, and land use. Impacts to wildlife and aquatic biology habitats may be difficult to mitigate due to the limited ability to create similar habitat conditions. Raising the level of Millerton Lake, however, would also create an opportunity to increase cold-water and warm-water fish habitat, and recreation opportunities associated with the reservoir.

Raising the level of Millerton Lake would result in relatively low impacts to special habitats and species. Six special status plant species occur in the region, including Hartweg's pseudobahia (a.k.a. San Joaquin adobe sunburst, *Pseudobahia peirsonii*), tree anemone; San Joaquin Valley Orcutt grass, Madera linanthus, succulent owl's-clover, and Bogg's Lake Hedge-hyssop.

Several special status wildlife species exist in the area that would be affected by raising the level of Millerton Lake, including California tiger salamander, and western spadefoot toad. Foothill yellow-legged frogs and tri-colored blackbirds are also likely to occur in the area. Southern bald eagles may use the area for nesting and foraging during winter months.

American shad, an anadromous Atlantic Ocean fish successfully introduced to the Sacramento and San Joaquin rivers, and accidentally planted in Millerton Lake in the mid 1950s, is present in Millerton Lake. This population is the only known landlocked population of the species. Spawning habitat in the upper portion of Millerton Lake and upstream in the San Joaquin River would be affected by raising the level of Millerton Lake. Other impacts to habitat and wildlife would vary relative to the extent of inundation.

Millerton Lake Recreation Area facilities, along the south side of the reservoir, include boat ramps, a marina, camping and day use facilities, and other structures. Any raise of Millerton Lake would affect recreation facilities on the current shoreline. It is anticipated that recreation facilities would be relocated and would remain accessible. Opportunities for additional recreational opportunities would result from higher or longer storage levels in Millerton Lake, which would increase the reservoir surface area during peak recreation months.

Forty-seven archaeological sites, mostly prehistoric, may be within, adjacent to, or outside but close to, the existing pool. Some or all of these sites would be adversely affected by raising the level of Millerton Lake up to 140 feet. In addition, the historic Fresno County Court House, which was relocated to the current shore of Millerton Lake during construction of Friant Dam in the 1940s, would be inundated by raising the lake level more than 20 feet. Inundation damage to archaeological sites can be mitigated with scientific data recovery programs. Reservoir projects also provide an opportunity for public interpretation of the past. Ancillary facilities, such as roads, power lines, or other structures, may provide an opportunity for avoiding impacts to archaeological sites through design or facility placement.

Raising the level of Millerton Lake would affect residential properties around the lake and upstream power generating facilities. A 60-foot raise would also inundate several mines associated with the abandoned Sullivan mine. Impacts to land use, structures, and facilities appear mitigable, but mitigation would likely be at significant cost.

Fine Gold Creek Reservoir

Fine Gold Creek is a tributary to the San Joaquin River that enters Millerton Lake from the north and drains a watershed area of approximately 91 square miles. Fine Gold Creek Reservoir would be designed and operated as a pump-back project. This option would increase water supply by allowing Millerton Lake to be drawn down to a lower level to capture additional San Joaquin River inflow. Water stored in Fine Gold Creek Reservoir water be released to Millerton Lake and then diverted to the Friant-Kern or Madera canals and/or released to the San Joaquin River.

Options Considered

Two potential dam heights and reservoir capacities were considered (Figure 4-10). A low option would include a dam crest at elevation of 900, which corresponds to a 380-foot-high dam and a reservoir with 132 TAF storage capacity. A higher option, at elevation 1,100, would require a 580-foot-high dam and would create a reservoir with 780 TAF storage. For each dam size, two potential dam types were considered; a RCC gravity structure and a concrete-face rockfill (CFRF) dam. The higher dam option would require constructing a saddle dam approximately 100 feet high and 3,200 feet long on the west rim of the reservoir.

Geologic conditions appear suitable for dam construction at this site. Raw materials could be obtained from within the proposed reservoir inundation area. During construction, a temporary coffer dam approximately 80 feet high would be required above the permanent dam site on Fine Gold Creek to divert flows, and a second coffer dam approximately 60 feet high would be required to keep water from Millerton Lake out of the construction zone. One or more diversion tunnels would be required; the number and placement of tunnels depends on the dam type selected.

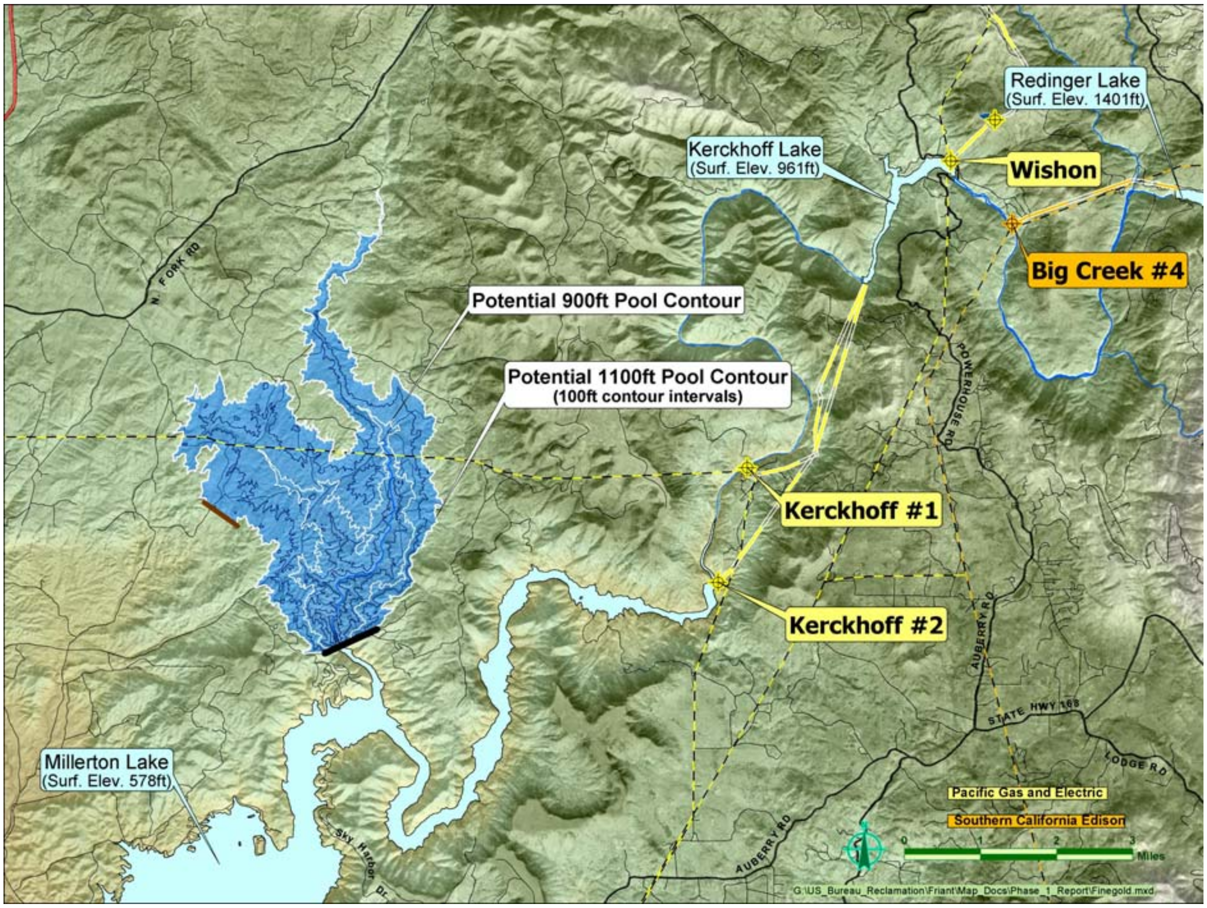


FIGURE 4-10. FINE GOLD CREEK RESERVOIR

Potential New Water Supply

CALSIM modeling results using single-purpose analyses indicate that the larger reservoir option considered at Fine Gold (crest at elevation 1,100) could produce a long-term annual average new water supply of approximately 110 TAF, if operated for water supply reliability. If operated for restoration or water quality purposes, the average new water supply would be slightly higher.

The small dam size considered (crest at elevation 900) with only a fifth of the storage capacity of the larger reservoir option (elevation 1,100), would not be expected to produce more than 20 TAF/year on average. Table 4-5 displays single-purpose analysis results for the storage volumes that were modeled.

TABLE 4-5
NEW WATER SUPPLY FROM FINE GOLD RESERVOIR

Dam Crest Elevation (feet above mean sea level)	Storage Capacity (TAF)	New Water Supply Estimated in Single-Purpose Analysis (average TAF/year)		
		RF	WQ	WS
900	400	n/s	n/s	65
1,100	800	136	124	113

Key:
n/s not simulated
TAF – thousand acre-feet
RF – San Joaquin River restoration flow single-purpose analysis
WQ – San Joaquin River water quality single-purpose analysis
WS – water supply reliability single-purpose analysis

Energy Use and Generation

For the evaluation of energy use and generation, the 800 TAF Fine Gold Creek Reservoir option was considered. CALSIM output included flows to be pumped into Fine Gold Creek Reservoir from Millerton Lake, releases from Fine Gold Creek Reservoir to Millerton Lake (available for generation), evaporation at Fine Gold Creek Reservoir, inflow from Fine Gold Creek and canal, and river releases from Friant Dam. Tables of reservoir areas and volumes relative to reservoir elevations for Fine Gold Creek Reservoir and Millerton Lake were used to estimate water pumping and available power generation heads.

As summarized in Table 4-6, pumping energy requirements for Fine Gold Creek Reservoir would exceed generation potential by nearly 80 percent. An analysis of the potential value of both pumping and generated energy has not yet been completed; thus, it is not possible to determine if the additional pumping energy requirement would also result in a net financial gain or loss. Additional controlled releases through the Friant power plants could increase the energy generation potential. An analysis of the power plants would also be needed to determine if net energy generation is increased or decreased.

New transmission line(s) would be required to serve the Fine Gold Creek pumping and generation plants. They would be connected to one or both of two major power lines, one located about 6 miles to the southeast and the other about 15 miles to the southwest. Additional study is needed to determine if existing lines have adequate capacity, alignments for new lines, and control, protection, interconnections, and protection requirements.

Estimated Costs

Table 4-7 lists estimated construction costs of the Fine Gold Reservoir options considered. Costs are shown for dam and power plant features, including a saddle dam for the elevation 1,100 option. Land acquisition costs are listed separately from construction costs. Additional review during Phase 2 will identify costs that would be associated with reservoir clearing, road construction or relocation, or any needed environmental mitigation.

TABLE 4-6
FINE GOLD ENERGY GENERATION AND USE

Storage Capacity (TAF)	Single-Purpose Analysis	Potential Average Annual Energy Generation (GWh/year)	Potential Average Annual Pumping Energy (GWh/year)
800	WQ	80 – 100	140 – 170
	RF	70 – 90	130 – 160

Key:
GWh/year – gigawatt-hours per year
TAF – thousand acre-feet
RF – San Joaquin River restoration flow single-purpose analysis
WQ – San Joaquin River water quality single-purpose analysis

TABLE 4-7
FINE GOLD RESERVOIR ESTIMATED CONSTRUCTION COSTS

Dam Height (feet)	Capacity (TAF)	RCC Dam		CFRF Dam		Land Cost ($Million)
		Field Cost ($ Million)	Construction Cost ($ Million)	Field Cost ($ Million)	Construction Cost ($ Million)	
380	120	160	200	160	200	3
580	745	430	540	400	500	9

Key:
RCC – roller-compacted concrete
CFRF - concrete-faced rock fill

Environmental Considerations

Creation of Fine Gold Creek Reservoir would result in adverse environmental impacts in a relatively pristine natural area that supports many biological resources. Extensive areas of pine and oak woodland habitat would be affected, as would pockets of riparian and wetland habitats. Vernal pools and special status species of plants, wildlife, and fish may be present in the inundation area. Western pond turtles, a Federally listed endangered species, are known to be present in Fine Gold Creek and its small tributaries. Abandoned mines and mine tailings in the inundation area create the potential for water quality impacts.

Pumped storage operations could affect water temperatures in Millerton Lake and cause fluctuations in water levels in both Millerton Lake and the new Fine Gold Creek reservoir. Lake level fluctuations could negatively affect habitat and spawning conditions for several species of fish, including American shad and largemouth bass.

Eight special status plant species occur in the region, including seven listed species: Hartweg's pseudobahia, tree anemone, San Joaquin Valley Orcutt grass, Madera linanthus, Mariposa pussypaws, succulent owl's-clover, and Bogg's Lake Hedge-hyssop. The greatest mitigation requirements would be associated with impacts to the tree anemone, Hartweg's pseudobahia, and wetland and riparian habitats.

Temperance Flat Reservoir

Temperance Flat is a wide, bowl-shaped area in the upper portion of Millerton Lake approximately 13 miles upstream of Friant Dam. For the purposes of Phase 1 of the feasibility study, all reservoir options between Millerton Lake and Kerckhoff Dam are addressed in this section. Temperance Flat Reservoir would capture the flow of the San Joaquin River downstream of Kerckhoff Lake and before it enters Millerton Lake. Water would be released from Temperance Flat Reservoir to Millerton Lake for canal diversion and/or release to the San Joaquin River. Operating criteria for the two reservoirs could be influenced by ecosystem needs in the reservoirs, recreation opportunities, and hydropower generation.

Options Considered

Initially, four potential Temperance Flat dam sites were identified on the basis of topographic characteristics and previous studies. Three of these sites, at river mile (RM) 274, RM 279, and RM 280, would result in the inundation of the Temperance Flat area. A fourth site, at RM 286, is upstream of the Temperance Flat area and could be considered a downstream enlargement of Kerckhoff Dam.

An initial comparison of site features showed that the RM 279 site is superior to the RM 280 site. These sites are close in proximity and would result in similar environmental effects for a reservoir at a given elevation. Both of these sites have similar geologic conditions, would be accessed in the same manner, would use a portion of the Temperance Flat area as a construction lay-down area, would have similar cofferdam and river diversion requirements, and would obtain dam materials from the same general borrow area.

However, a dam at RM 280 would require more material than a dam at RM 279 to create the same storage capacity at a higher cost. Therefore, RM 280 was dropped from further consideration. The remaining three Temperance Flat dam sites are shown in Figure 4-11, and are described in the following sections.

Foundation conditions at all of the dam sites considered for Temperance Flat options would be sound granitic rock. No special foundation considerations are known at this time, and foundation preparation would be typical for each option. Excavation for the concrete gravity dams was assumed to be 10 feet to remove overburden and weathered bedrock.

RM 274 Site

The RM 274 site is located in Millerton Lake approximately 1 mile upstream of the confluence of Fine Gold Creek and Millerton Lake. It was one of three sites in the original planning studies for Friant Dam in the 1930s, when it was referred to as the Temperance Flat site. From a water storage perspective, it was considered superior to both the Friant Dam site and a site at Fort Miller (just downstream of Fine Gold Creek). The Friant Dam site was selected, however, because construction of a dam at RM 274 would have required canals around the current Millerton Lake area or a diversion dam at Friant.

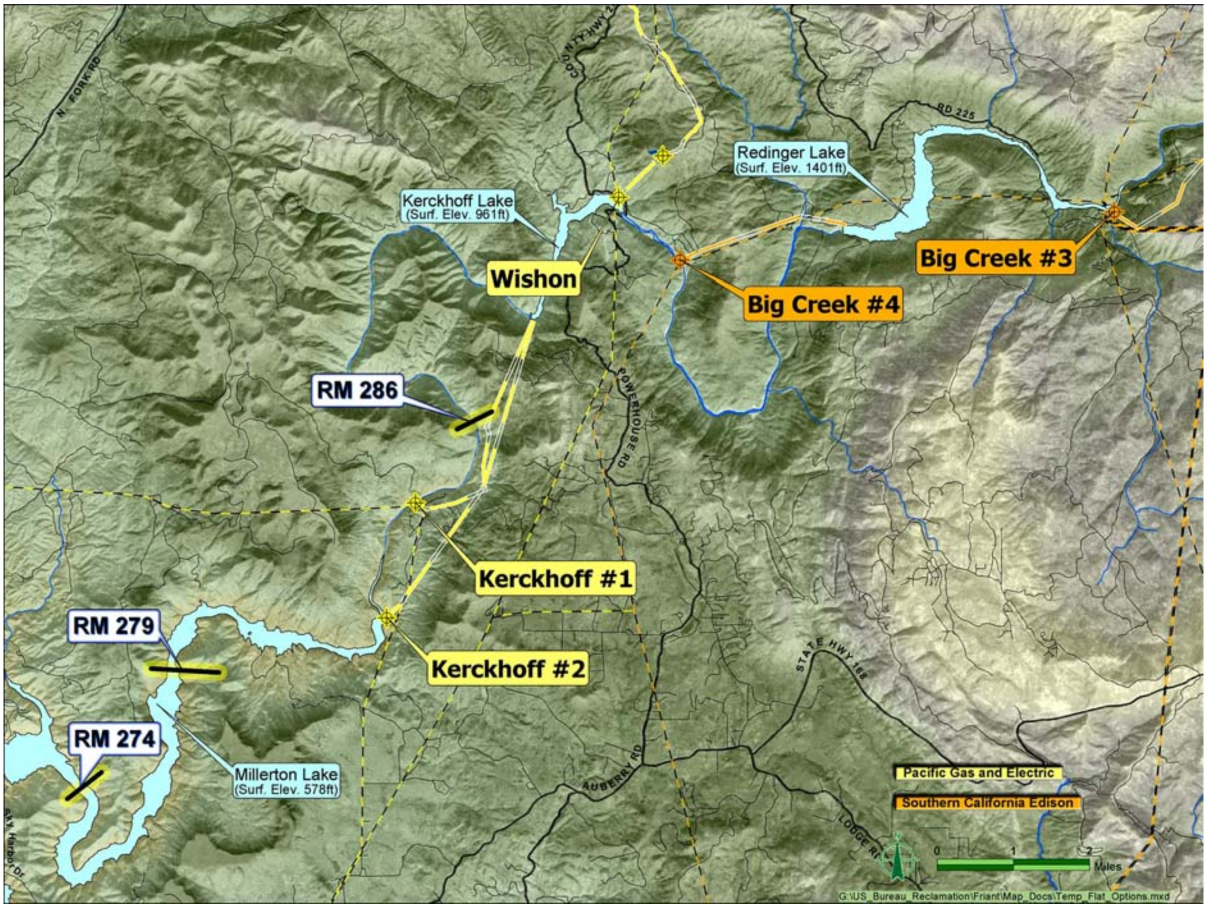


FIGURE 4-11. TEMPERANCE FLAT DAM SITE OPTIONS

The topography of the RM 274 site is fairly uniform on both the left and right abutments. The site rises from elevation 385 in the San Joaquin River channel, about 200 feet below water at the maximum water level. The left abutment rises uniformly to elevation 1,582 at Pincushion Mountain and the right abutment rises uniformly to elevation 1,473 at an unnamed peak. The maximum reservoir level at elevation 1,100 was considered due to a low spot along a ridge making up part of the left abutment adjacent to RM 275. This elevation would correspond to a dam height of about 715 feet and a reservoir capacity of about 2,100 TAF. The potential reservoir for the RM 274 site is shown in Figure 4-12.

The RM 274 site may be appropriate for concrete arch, concrete gravity, and CFRF dams. A concrete arch dam was not considered in the prefeasibility-level review because the relatively flat slopes would result in a wide canyon with potentially large volumes of concrete. However, this option should not be excluded from future consideration since further studies may show that an arch dam is economical. A design for an RCC type dam was not developed in detail for this site but would be similar to the structure considered for the RM 279 site. Preliminary designs and cost estimates were prepared for CFRF dams at two elevations at the RM 274 site, as described in a later section.

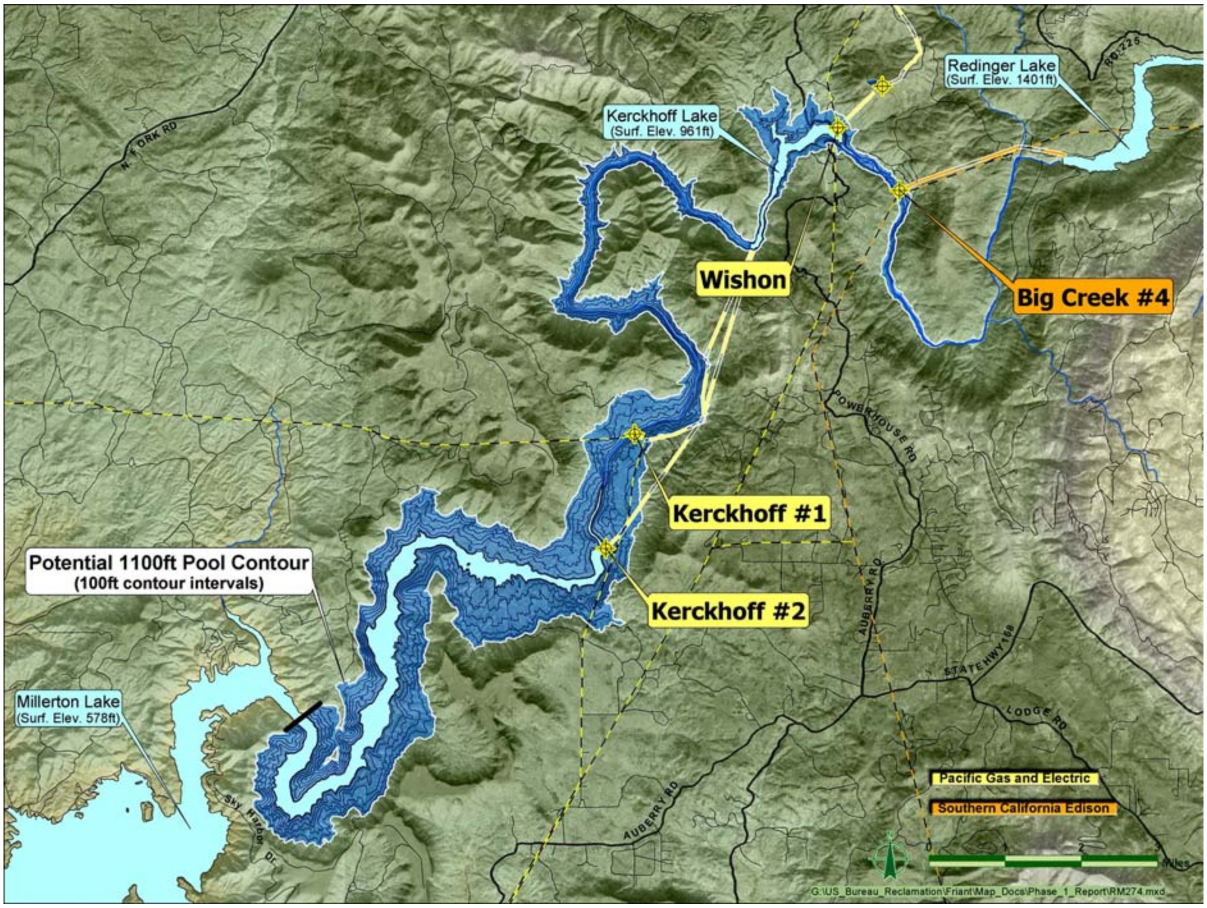


FIGURE 4-12. TEMPERANCE FLAT RM 274 RESERVOIR

Upstream and downstream cofferdams would be required for diverting stream flows during construction and to prevent inundation of the site from Millerton Lake. The cofferdams are sized for the estimated diversion flows, and to allow normal operation of Millerton Lake during construction. The upstream cofferdam would be at elevation 635 to provide sufficient head to pass the diversion flood. The downstream cofferdam would be at elevation 578 for all options, to accommodate normal reservoir operations for Millerton Lake. A significant portion of both cofferdams would be constructed within the existing reservoir pool a maximum depth of 175 feet.

Diversion tunnels through both abutments of the new dam would be required to pass San Joaquin River flows around the construction site. The tunnels would be 30 feet and 40 feet in diameter. One of the diversion tunnels would be used for the outlet works, and the other would be plugged or could be used as part of the spillway depending on the dam height.

RM 279 Site

The RM 279 site is also located in Millerton Lake approximately 2 miles downstream of the Temperance Flat area. The RM 279 site rises uniformly from elevation 460 in the original San Joaquin River channel to elevation 1,080 on the left abutment, and then through a saddle at elevation 1,040 before continuing to elevation 1,416 at an unnamed peak. The right abutment rises uninterrupted to elevation 1,566 at an unnamed peak. A dam crest at elevation 1,300 was considered, which would result in a dam height of 840 feet and a reservoir capacity of over 2,750 TAF. The potential reservoir for the RM 279 site is shown in Figure 4-13.

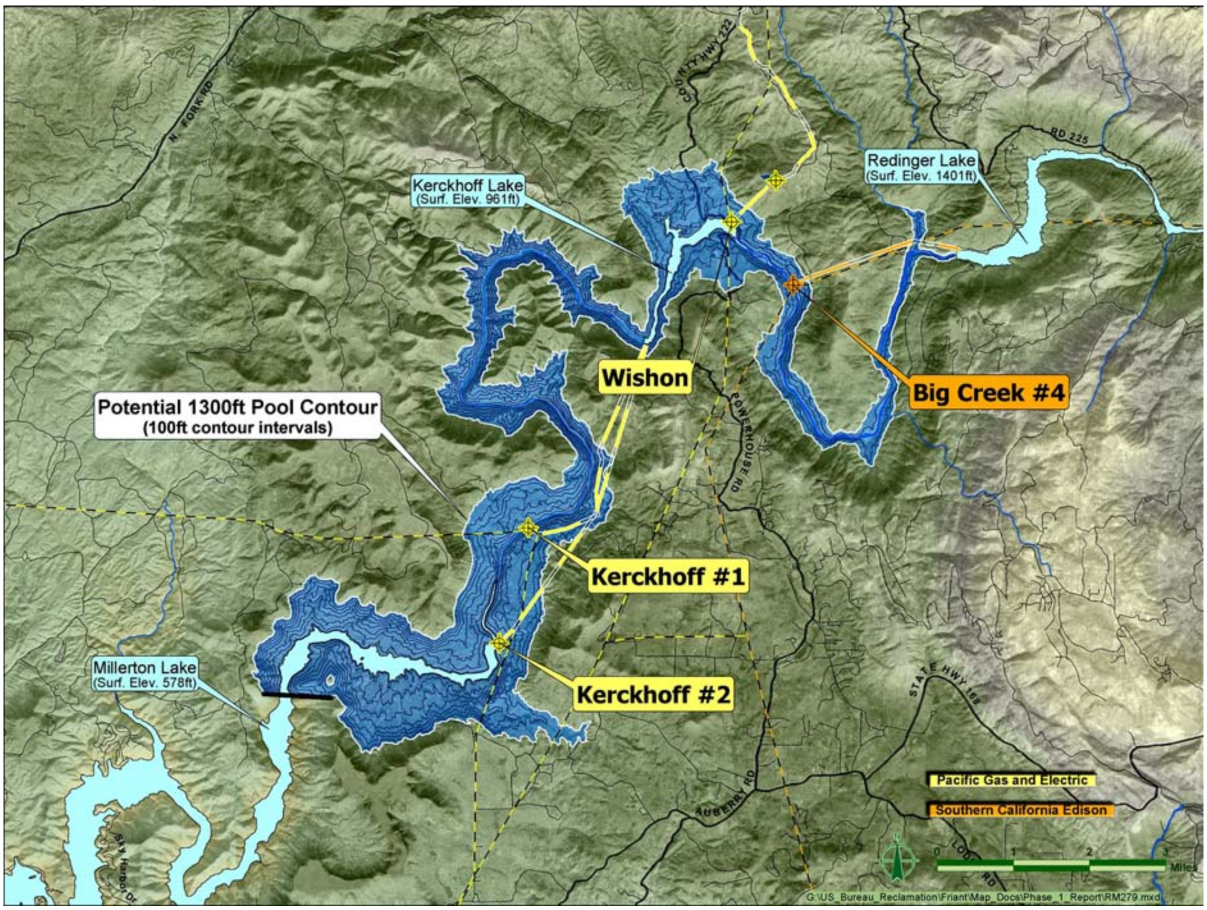


FIGURE 4-13. TEMPERANCE FLAT RM 279 RESERVOIR

The RM 279 site is appropriate for concrete arch, concrete gravity, and CFRF dams. A central-core earth fill dam is not considered economically viable, due to the limited availability of plastic, fine-grained materials for the core. A concrete arch dam was not considered for prefeasibility-level designs because the abutments have relatively flat slopes, which would result in a wide canyon requiring potentially large volumes of concrete. However, this design option was not evaluated sufficiently to exclude it from future consideration.

Upstream and downstream cofferdams would be required for diverting stream flows during construction and to prevent inundation of the site from Millerton Lake. The cofferdams are sized for the estimated diversion flows, and to allow normal operation of Millerton Lake during construction. The upstream cofferdam would have a crest at elevation 635, and a height of approximately 185 feet. The downstream cofferdam would have a crest at about elevation 578, and height of about 125 feet.

Diversion tunnels through both abutments of the new dam would be required to pass San Joaquin River flows around the construction site. The tunnels would be 30 feet and 40 feet in diameter. The smaller diversion tunnel would be converted to the outlet works; thus, a low-level outlet was not considered.

Access to the RM 279 site would require constructing new roads on the Fresno County side of the river. Construction staging and lay-down would be located in the reservoir area. Prefeasibility-level cost estimates were made for RCC and CFRF dams at two elevations.

RM 286 Site

Unlike the RM 274 and RM 279 sites, the RM 286 site is not located in Millerton Lake, but is approximately 6 miles downstream of Kerckhoff Dam, between the dam and the Kerckhoff powerhouses. The RM 286 site rises uniformly from elevation 740 in the San Joaquin River channel to elevation 1,450 on the left abutment, and then through a flatter slope at elevation 1,450 to 1,650 before continuing to elevation 2,100. The right abutment rises uninterrupted and uniformly to beyond elevation 1,850 at an unnamed peak.

A dam crest at elevation 1,400 was considered, which would result in a dam height of 660 feet and a reservoir capacity of 1,400 TAF. A larger reservoir size could be created by constructing a higher dam at the RM 286 site, but it would inundate the Big Creek No. 3 Powerhouse. The cost of power generation loss from Big Creek No. 3 may not be justified by the limited additional new water supply associated with larger sizes. The potential reservoir for the RM 286 site at elevation 1,400 is shown in Figure 4-14.

Upstream and downstream cofferdams would be required for diverting stream flows during construction. The downstream cofferdam would have a crest at about elevation 770, and height of about 30 feet. The upstream cofferdam would have a crest at about elevation 850, and a height of approximately 110 feet.

Diversion tunnels through both abutments of the new dam would be required to pass San Joaquin River flows around the construction site. The tunnels would be 30 feet and 40 feet in diameter. One of the diversion tunnels would be used for the outlet works, and the other would be plugged or could be used as part of the spillway depending on the dam height.

Prefeasibility-level designs and cost estimates were prepared for concrete arch, RCC, and CFRF dam types at two elevations at the RM 286 site, as described in a later section.

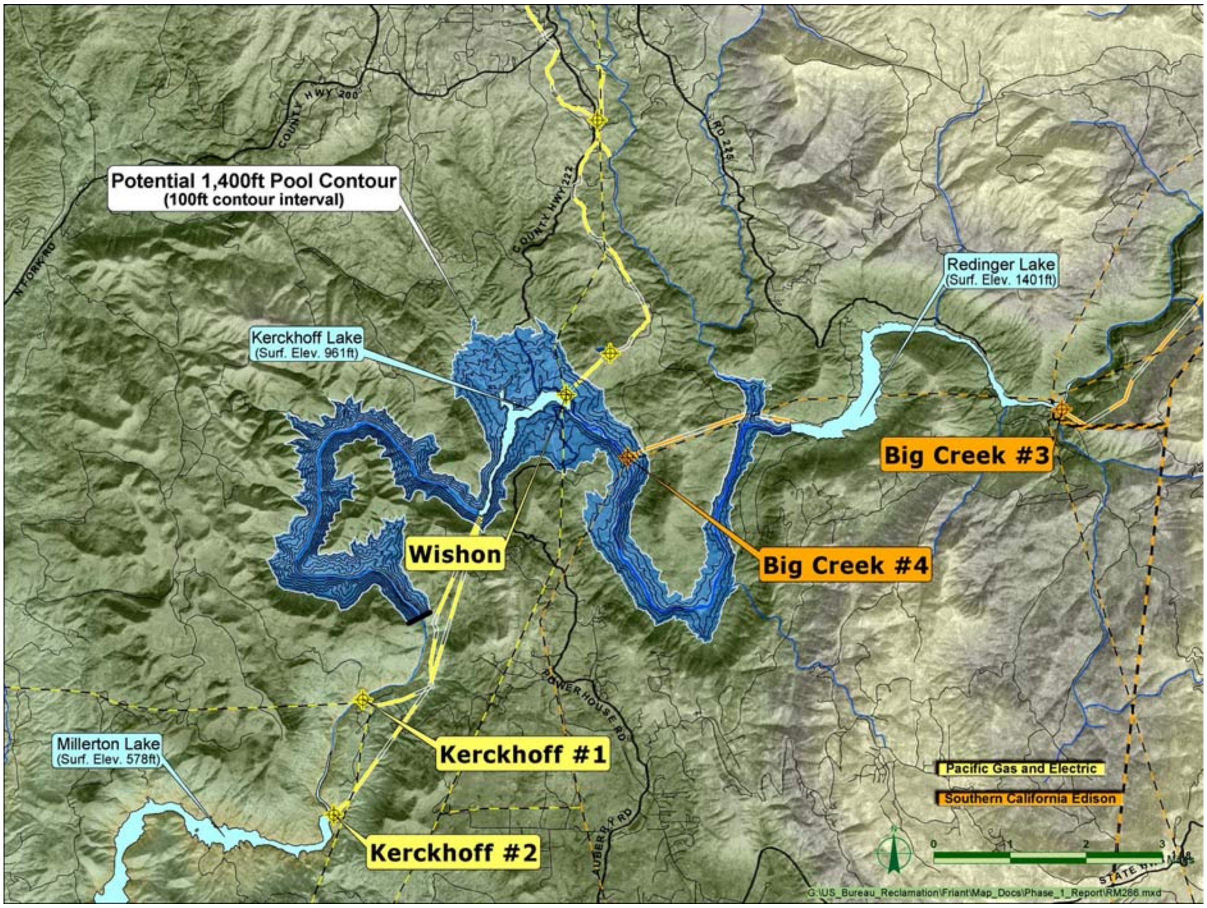


FIGURE 4-14. TEMPERANCE FLAT RM 286 RESERVOIR

Potential New Water Supplies

Constructing a dam at any of the three Temperance Flat locations could create a reservoir of up to 2,000 TAF or greater in storage capacity, depending on the height of the dam. As mentioned previously, the upper limit storage capacity for reservoirs created by the three Temperance Flat dam sites ranges from 1,400 TAF to 2,100 TAF.

Modeling the three options was accomplished using a single representation of Temperance Flat reservoir because the relationship of storage volume to surface area is similar for all three sites. Therefore, estimated losses to evaporation would be similar for all three options.

Results of initial model runs are listed in Table 4-8 and shown graphically in Figure 4-15. As indicated, preliminary results show that the average annual new water supply, measured as additional water available for delivery or controlled releases to the river, would approach 200 TAF/year for a reservoir in excess of 2,000 TAF storage capacity. Figure 4-15 shows a trend of increasing amounts of new water supplies as reservoir size increases. Results from the restoration flow, water quality, and water supply reliability single-purpose analyses are displayed.

TABLE 4-8
NEW WATER SUPPLY FROM TEMPERANCE FLAT OPTIONS

Additional Storage Capacity (TAF)	New Water Supply Estimated in Single-Purpose Analysis (average TAF/year)		
	WS	WQ	RF
725	122	123	146
1,350	168	187	185
2,100	197	n/s	n/s

Key:
n/s not simulated
TAF – thousand acre-feet
RF – San Joaquin River restoration flow single-purpose analysis
WQ – San Joaquin River water quality single-purpose analysis
WS – water supply reliability single-purpose analysis

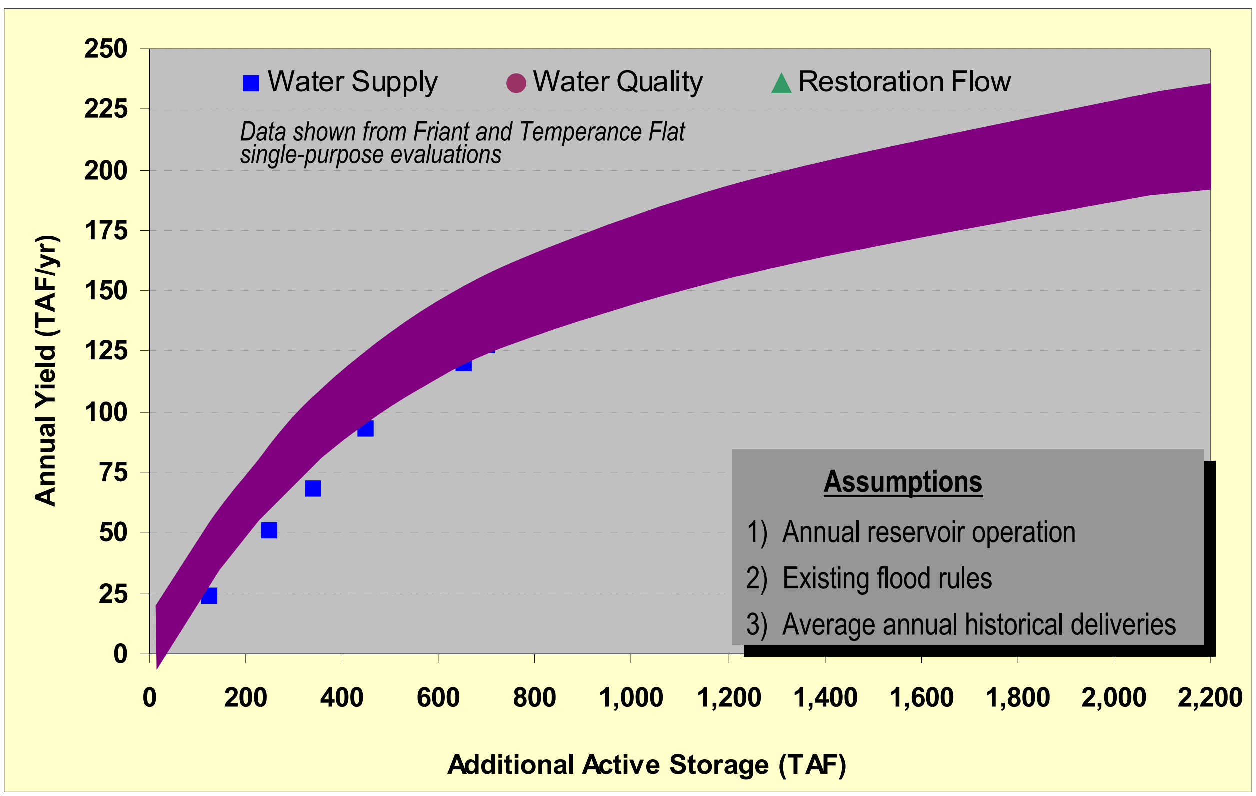


FIGURE 4-15. AVERAGE ANNUAL NEW WATER SUPPLY FOR RAISE FRIANT DAM AND TEMPERANCE FLAT OPTIONS

Hydropower Generation and Impacts

Any of the Temperance Flat options and raising the level of Millerton Lake would affect the operations of existing hydropower project facilities. Depending on the location and height of the dam, Temperance Flat reservoir has the potential to affect up to five powerhouses and two diversion dams upstream of Millerton Lake. The elevations and corresponding storage capacity at which power facilities would be affected are shown in Figure 4-16.

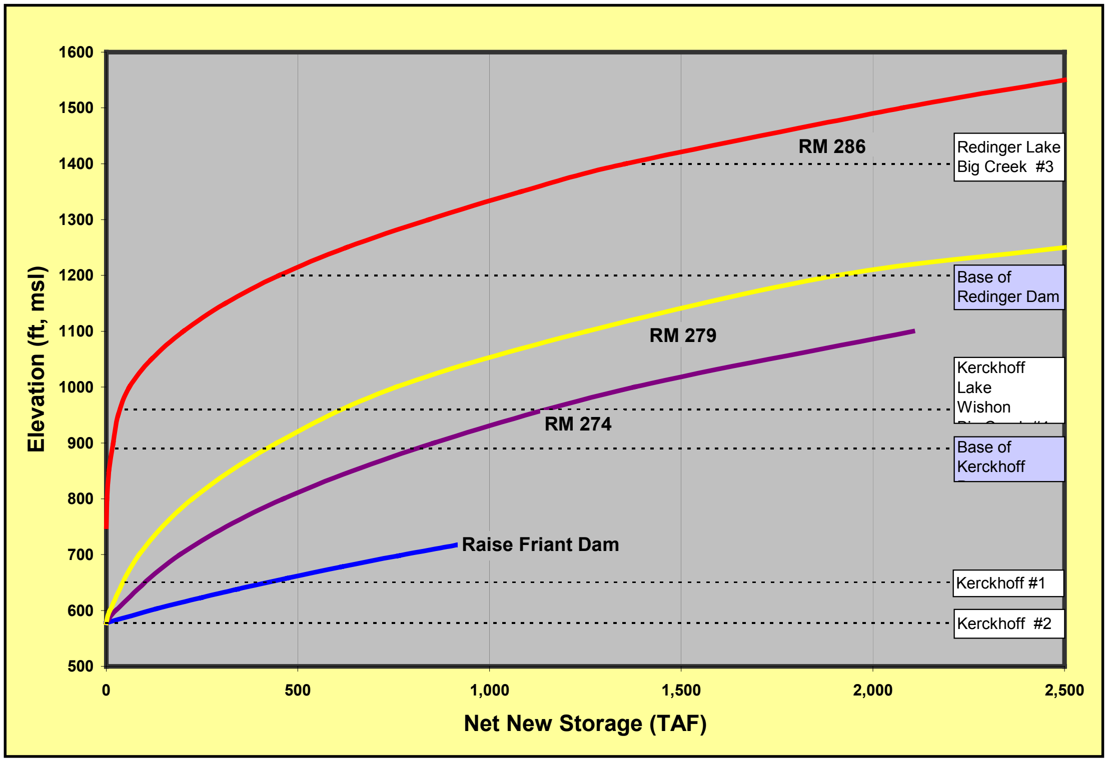


FIGURE 4-16. HYDROPOWER FACILITIES POTENTIALLY AFFECTED BY RAISE FRIANT DAM AND TEMPERANCE FLAT OPTIONS

Each of the potentially affected powerhouses has unique characteristics related to installed generation capacity, head, flow rates, equipment type, equipment age, and efficiency. A summary of generation capacity and recent annual energy generation for each facility is listed in Table 2-4. Figure 4-17 shows the amount of installed generation capacity that would be affected for raising Friant Dam and each Temperance Flat option. As shown, impacts to installed generation capacity increase as storage capacity increases at each site. In all cases, a step increase in generation capacity occurs when additional facilities would be impacted. For the RM 286 site, two curves are shown.

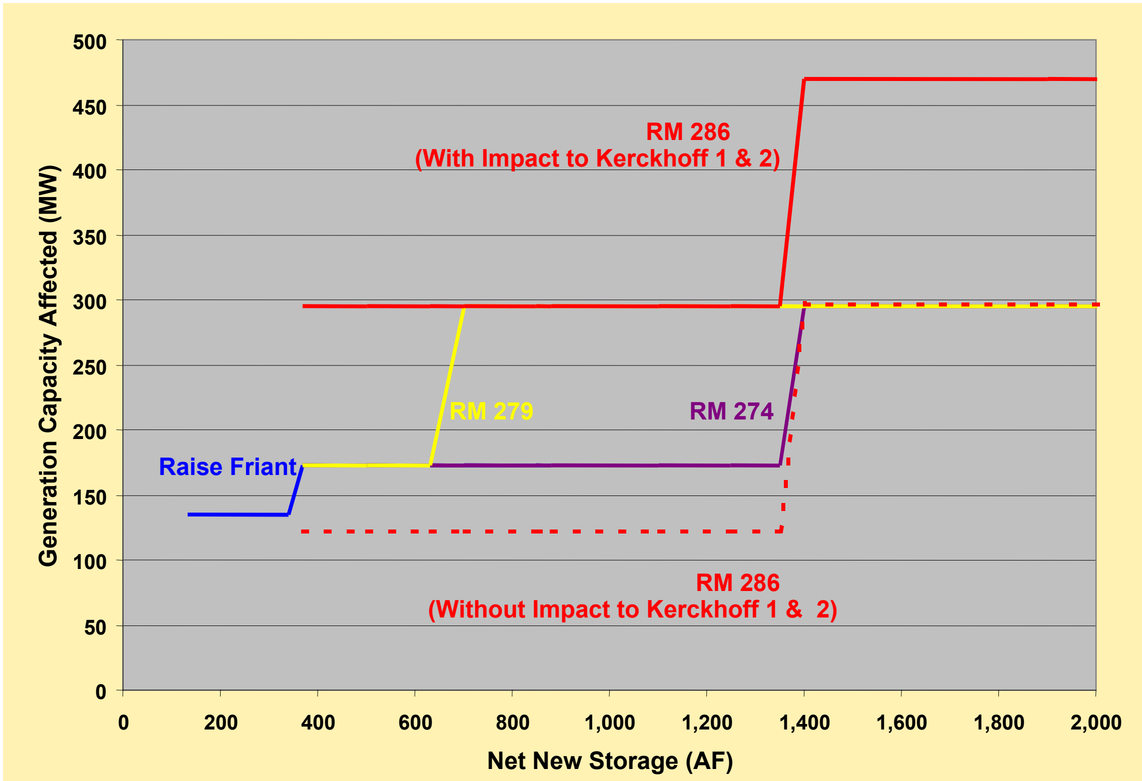


FIGURE 4-17. HYDROPOWER GENERATION CAPACITY POTENTIALLY AFFECTED BY TEMPERANCE FLAT OPTIONS

The RM 286 site is between Kerckhoff Dam and the Kerckhoff Powerhouse. The reservoir would not inundate either Kerckhoff powerhouses, but would affect generation because of the higher head above Kerckhoff Lake. The upper curve would apply if power generation at the Kerckhoff Powerhouse is not possible with a higher reservoir. This would correspond to a minimum of 300 MW installed generation capacity, and as great as 475 MW. If the plants could be operated, however, the impacts on power generation would be less, with 125 MW to about 300 MW of installed capacity affected.

To simplify the analysis, reservoir storage volumes of 725 TAF and 1,350 TAF were considered for each case. These volumes were chosen to generally correspond with storage volumes associated with impacts to power generation facilities. A storage volume of 725 TAF generally corresponds to the volume at which the reservoir at RM 279 would begin to affect generation at the Wishon and Big Creek No. 4 powerhouses. A storage volume of 1,350 TAF approximates the volume at which a reservoir at RM 274 would affect generation at the Wishon and Big Creek No. 4 powerhouses, and a reservoir at RM 286 would affect generation at the Big Creek No. 3 Powerhouse.

CALSIM output included monthly inflows to Temperance Flat Reservoir, water volumes and evaporation at Temperance Flat Reservoir and at Millerton Lake, inflow to Millerton Lake from Fine Gold Creek, and canal and river releases from Friant Dam. Tables of reservoir area and volume in relation to reservoir elevations for Temperance Flat Reservoir and for Millerton Lake were used to calculate head available for power generation.

Assumptions were made regarding turbine and generator efficiencies, minimum and maximum heads and flows for generation, and head losses in water passages. From these data and assumptions, preliminary estimates were made of installed capacity and energy generated on an annual basis.

For either the RM 274 and RM 279 sites, a powerhouse would be located at or near the dam with an installed generation capacity of approximately 100 MW to120 MW. For the 725 TAF option, both Kerckhoff powerhouses would be submerged, although it might be possible to extend the Kerckhoff tunnels to RM 274. The 1,350 TAF option would affect the Kerckhoff and Kerckhoff No. 2 powerhouses, Kerckhoff Dam, Wishon Powerhouse, and the Big Creek No. 4 Powerhouse.

For the RM 286 site, the powerhouse would be located downstream at about RM 283, the location of the Kerckhoff No. 2 Powerhouse. It would be supplied with water from an intake at the dam by means of a tunnel, surge chamber ,and penstocks. For both the 725 TAF and 1,350 TAF options, Kerckhoff Dam would be inundated. The Kerckhoff and Kerckhoff No. 2 powerhouses would not be inundated. It may be possible to use the existing Kerckhoff facilities, with modified gate arrangements, existing tunnels with upgraded or new turbine and generator equipment, and modifications to power station structures. The potential to build new powerhouses at Wishon and Big Creek No. 3 to make use of available, but reduced, head was not evaluated.

Estimates of annual energy generation for all Temperance Flat options are summarized in Table 4-9. In all cases, flow through the powerhouses would be the same, with the primary differences related to available head. More energy generation would be possible from the RM 286 site due to the greater head associated with this reservoir configuration. Estimates also do not include potential generation from pumped storage. It would be possible to construct a pumped storage arrangement at the 274 and 279 sites, because of the close proximity of the Temperance Flat Reservoir to Millerton Lake. The evaluation of a pumped storage project would require additional study of the flow regime and consideration of water supply operation requirements, and was not included in Phase 1 studies. The rather long distance from Millerton Lake to the RM 286 site would likely preclude the use of the RM 286 site for pumped storage purposes. At RM 286, the water conveyance length to available head ratio is considerably greater than 10, which is generally considered an upper limit for economic pumped storage.

TABLE 4-9
TEMPERANCE FLAT POTENTIAL ENERGY GENERATION

Dam Site	Water Storage Capacity (TAF)	Average Annual Energy Generation Potentially Affected[1] (GWh/year)	Potential Average Annual Energy Generation From Temperance Flat[2] (GWh/year)
RM 274	725	579	160 – 210
	1,350	1,125	210 – 270
RM 279	725	1,125	330 – 380
	1,350	1,125	400 – 450
RM 286	725	546 – 1,125[3]	630 – 680
	1,350	546 – 1,125[3]	690 – 740

Key:
GWh/year – gigawatt-hour per year
RM – river mile
TAF – thousand acre-feet
RF – San Joaquin River restoration flow single-purpose analysis
WQ – San Joaquin River water quality single-purpose analysis

Notes:
1. Average annual energy generation as reported in Table 2-4.
2. Range of estimated annual energy generation from restoration flow and water quality single-purpose analyses.
3. Potential impacts to power generation depend on the degree of impact to the Kerckhoff and Kerckhoff No. 2 powerhouses. The lower estimate does not include Kerckhoff power losses; the upper estimate includes the loss of all Kerckhoff power generation.

Due to the proximity of the Temperance Flat sites to existing facilities, it is expected that new power generation facilities would connect to existing transmission systems. Existing transmission line capacity to the Wishon Powerhouse is 70 kilovolts (kV), to the Kerckhoff and Kerckhoff No. 2 powerhouses is 115 kV, and to Big Creek No. 3 and No. 4 powerhouses is 220 kV. Additional study in Phase 2 will consider the adequacy of existing lines to serve new power facilities, and to ascertain the requirements for electrical control and protection.

The control center for the SCE Big Creek Hydroelectric Project is located at the Big Creek No. 3 Powerhouse. This control center would need relocated for any option that included inundation of the Big Creek No. 3 Powerhouse. Costs for relocation have not been estimated but are assumed to be included in the contingency provisions previously described.

Estimated Costs

Table 4-10 lists estimated construction costs for the Temperance Flat Reservoir options considered. As shown, cost estimates have been prepared at each dam site for the range of dam design and elevations that have been identified. Costs include dam and power plant features, including a saddle dam for the 1,300 ft elevation option at RM 279. Additional review is needed to identify costs that would be associated with reservoir clearing, road construction or relocation, and any needed environmental mitigation.

TABLE 4-10
ESTIMATED COSTS OF TEMPERANCE FLAT RESERVOIR OPTIONS

Gross Pool Elevation (feet above mean sea level)	Gross Storage Capacity[1] (TAF)	Net Additional Storage Capacity[2] (TAF)	Dam Type	Construction Costs	
				Field Cost ($Millions)	Construction Cost ($Millions)
RM 274 Dam Site					
800	531	462	CFRF	490	610
1,100	2,187	2,114	CFRF	800	1,000
RM 279 Dam Site					
900	460	444	RCC	410	510
			CFRF	430	540
1,100	1,263	1,243	RCC	750	940
			CFRF	730	910
1,300	2,775	2,736	RCC	1,400	1,750
			CFRF	1,200	1,500
RM 286 Dam Site					
1,200	465	457	Arch	330	410
			RCC	340	430
			CFRF	430	540
1,400	1,403	1,364	Arch	630	790
			RCC	560	700
			CFRF	590	740

Key:
TAF – thousand acre-feet
CFRF – concrete-faced rock fill dam
RCC – roller-compacted concrete dam

Notes:
1. Total storage capacity of new reservoir.
2. Accounts for lost storage capacity in Millerton Lake and Kerckhoff Lake.

Land costs estimates are preliminary and not considered complete.

Environmental Considerations

Developing a reservoir at Temperance Flat would cause adverse environmental effects to aquatic biology, botany, wildlife, and recreation resources, and could affect land uses in the reservoir vicinity. Aquatic species that would be affected by the RM 274 and RM 279 options include Kern brook lamprey, hardhead, American shad, and black bass. These species would be affected because they reside in the upper portion of Millerton Lake, which would be within the reservoir for these options. The RM 286 option would affect reservoir fisheries in the reaches above and below Kerckhoff Lake and in Kerckhoff Lake.

Regional botany is dominated by foothill woodlands of pine and blue oak, with open perennial grasslands. A considerable amount of such habitat would be inundated by a reservoir. Several plant species of special concern are documented as occurring in the project area and could be affected by a Temperance Flat reservoir. Quantitative estimates of potentially affected areas, and the frequency of inundation, will be made in Phase 2. Species for which mitigation may be required include carpenteria, Mariposa pussypaws, and Madera linanthus.

Wildlife species potentially affected by the Temperance Flat options include the southwestern willow flycatcher, the valley elderberry longhorn beetle, the California tiger salamander, and the western pond turtle. Field surveys will be made during Phase 2 to identify the potential presence and extent of habitats that support these species and mitigation approaches will be developed.

The RM 274 and RM 279 options would inundate portions of the Millerton Lake State Recreation Area and portions of the San Joaquin River Gorge Management Area, which is managed by the U.S. Bureau of Land Management (BLM). The larger reservoir option would also inundate Sierra National Forest lands above Kerckhoff Dam. The RM 286 options would not affect the recreation area, but could affect the BLM lands. The Patterson Bend whitewater boating run, a Class V rapid below Kerckhoff Dam, would be completely inundated by any of the Temperance Flat reservoir options considered. Depending on the elevation of the reservoir pool and operations, some or all of the Horseshoe Bend run above Kerckhoff Lake would be inundated by the Temperance Flat options. The RM 274 option would have the smallest effect on this run, whereas the RM 286 option at a storage capacity of about 750 TAF would completely inundate the run.

Prehistoric archaeological sites exist within the potentially inundated area associated with all Temperance Flat options, as do sites where mining occurred historically. Past mining sites have been identified but need to be assessed for their potential historic significance and their potential to affect water quality.

Land use effects associated with Temperance Flat options include impacts to roads, bridges, and trails. The RM 274 and RM 286 options would inundate both the San Joaquin River Trail footbridge at the Kerckhoff Powerhouse and the Road 222 bridge that crosses the San Joaquin River at Kerckhoff Lake. The RM 286 option would not affect the footbridge, but would also inundate the Road 222 bridge. Further evaluation is needed to identify mitigation approaches for these impacts.

Yokohl Valley Reservoir

Yokohl Valley Reservoir would be located approximately 15 miles east of Visalia and 8 miles south of Lake Kaweah. A 260-foot-high earthfill dam, with a crest length of nearly 3,000 feet, would create a 450 TAF reservoir. Two small saddle dams in the hills west of the main dam site would be required.

Options Considered

Yokohl Valley Reservoir would operate as a pump-back storage reservoir served by the Friant-Kern Canal, as shown in Figure 4-18. This is a variation of an option that was described initially in a study of the Mid-Valley Canal by Reclamation. Supplementary flows would come from natural runoff in Yokohl Creek. Stored water would be released to Yokohl Creek and directed to the Friant-Kern Canal to supplement CVP deliveries or to offset releases from Millerton Lake to the San Joaquin River. Only the first option, off-canal storage from the Friant-Kern Canal, is considered in this Investigation.

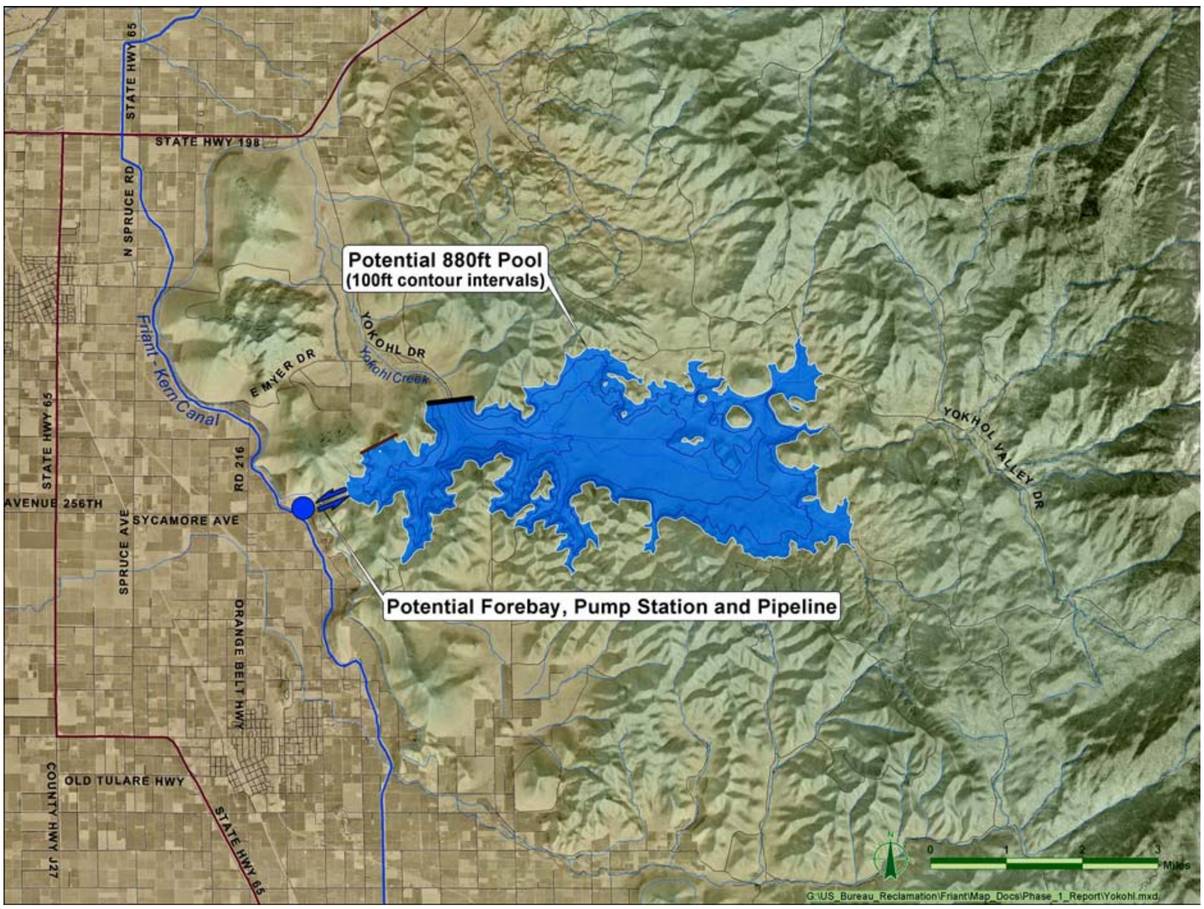


FIGURE 4-18. YOKOHL VALLEY RESERVOIR

Site characteristics at the Yokohl Valley dam site appear to pose no barriers to construction. Underlying rock conditions would be adequate for a dam foundation, sufficient impervious, pervious, and riprap materials exist within 2 miles of the proposed dam site, and potential staging and lay-down areas are located immediately upstream and downstream of the project site. An improved road provides access directly to the dam site and electrical power would likely be available from sources in Exeter or along Highway 198.

Potential New Water Supply

This off-stream and off-basin storage would rely on Friant-Kern Canal diversion as the only water source for the pump-storage operation. In wet months, any water that exceeds demand would be diverted to the Friant-Kern Canal and stored in Yokohl Valley Reservoir to free up Millerton Lake for capture of floodwater. During irrigation season, water released from Yokohl Valley Reservoir can supplement Millerton Lake diversion to satisfy demand along the Friant-Kern Canal. To avoid significant fluctuation in Friant-Kern Canal water levels, pumping and releasing would be through a forebay off the canal. The forebay would be relatively small, compared to surface water storage facilities under consideration, and therefore was not modeled in CALSIM.

Two Yokohl Valley Reservoir sizes were modeled in CALSIM. Two key assumptions were made to address hydrologic and operational issues. First, local inflow to Yokohl Valley Reservoir was not simulated. No river gage has been established to measure Yokohl Creek flow at any location. A synthetic Yokohl Creek inflow, created by regression, suggests a long-term annual average inflow of 9 TAF. This amount was considered minor and within the margin of accuracy of the analysis. Second, the capacity of the Friant-Kern Canal was assumed at 5,000 cfs and all demands were assumed to be located downstream of the forebay. While it is recognized that Friant-Kern Canal capacity downstream of Kings River, upstream of the Yokohl Valley forebay, decreases from approximately 5,000 cfs to about 3,000 cfs, and that demands vary along the canal, the CALSIM model does not include this resolution. It is not known if Friant-Kern Canal capacity between Kings River and the forebay would limit the pump-storage operation; therefore, the results presented below should be considered in the upper range of potential new water supplies. If Friant-Kern Canal capacity would affect pump-back storage operations, the revised estimates would be lower. Pumping capacity to Yokohl Valley Reservoir was assumed at 2,000 cfs.

The new water supply from Yokohl Valley Reservoir would be similar, but generally lower, than similar reservoir sizes at Fine Gold Creek because of conveyance constraints in the Friant-Kern Canal and because the evaporation losses from Yokohl Valley Reservoir are higher. As indicated in Table 4-11, annual average new water supply from the 800 TAF option would approach 100 TAF/year, if Friant-Kern Canal restrictions associated with up-stream demands and conveyance capacity below the Kings River have no additional effect on the simulated operations.

TABLE 4-11
NEW WATER SUPPLY FROM YOKOHL VALLEY RESERVOIR

Storage (TAF)	New Water Supply Estimated in Single-Purpose Analysis (average TAF/year)		
	RF	WQ	WS
400	n/s	n/s	60
800	88	82	97

Key:
n/s not simulated
TAF – thousand acre-feet
RF – San Joaquin River restoration flow single-purpose analysis
WQ – San Joaquin River water quality single-purpose analysis
WS – water supply reliability single-purpose analysis

Energy Use and Generation

Preliminary energy estimates were made using CALSIM output for the restoration flow and water quality single-purpose analyses. In each case, a Yokohl Valley Reservoir with storage volume of 800 TAF was considered. CALSIM output included monthly diversions to the Friant-Kern Canal. For purposes of the energy analysis, Friant-Kern Canal demands downstream of the pump-back plant location were assumed equal to total diversions.

The analysis considered flows to be pumped into Yokohl Valley Reservoir from the Friant-Kern Canal, releases to be made from the Yokohl Valley Reservoir to the Friant-Kern Canal (available for generation), and water volumes and evaporation at the Yokohl Valley Reservoir. The water surface level at the Friant-Kern Canal was assumed to be constant at elevation 410. Water levels in Yokohl Valley Reservoir were calculated and heads required for pumping and those available for power generation were determined.

Assumptions were also made regarding pump-turbine and motor-generator efficiencies, submergence, minimum and maximum heads and flows for pumping and generating, and head losses in water passages. Preliminary estimates of the energy required for pumping and energy generated on an annual basis were made. No existing power generation facilities would be impacted. Energy generation and pumping requirements are summarized in Table 4-12.

New transmission line(s) would be required to serve the Yokohl Valley pumping and generation plants. These transmission lines would be connected to one or both of two major power lines, one located about 3 miles to the west and the other about 5 miles to the east. Additional study during Phase 2 will determine if existing lines have adequate capacity to serve new power facilities, and to ascertain the requirements for electrical control and protection. Additional study is needed to determine if existing lines have adequate capacity, alignments for new lines, and control, protection, interconnections, and protection requirements.

TABLE 4-12
YOKOHL VALLEY RESERVOIR POTENTIALENERGY GENERATION AND USE

Storage (TAF)	Operating Scenario	Potential Average Annual Energy Generation (GWh/year)	Potential Average Annual Pumping Energy (GWh/year)
800	WQ	80– 110	180– 220
	RF	80– 110	180– 220

Key:
GWh/year – gigawatt-hour per year
TAF – thousand acre-feet
RF – San Joaquin River restoration flow single-purpose analysis
WQ – San Joaquin River water quality single-purpose analysis

Estimated Costs

Costs for a 260-foot-high zoned earthfill dam and appurtenant facilities were updated from a study completed in 1975. Total costs were indexed to 2003 price levels, although unit prices were not revised. This approach was considered sufficient for initial review of storage options, but would not be adequate to support detailed comparison with other options under consideration. Following this approach, and applying provisions for mobilization, contingencies, and oversight, total costs are estimated at $350 million. This estimate does not include land acquisition costs or specific costs that would be associated with reservoir clearing, road construction or relocation, or any needed environmental mitigation.

Environmental Considerations

Most of the potentially inundated area in Yokohl Valley would be common grassland. With the exception of botanical and cultural resources, few adverse environmental impacts are anticipated to resources known at the site. Four special status plant species occur in the vicinity of the area, including *Tulare pseudobahia*, a State-listed endangered and Federally listed threatened species, and *Kaweah brodiaea*. Vernal pool spiny-sepaled button-celery grows in Yokohl Creek downstream from the contemplated dam site. The presence of ultrabasic and metagabbro rock makes serpentine-specific plants possible, although none are listed in the CNDDB. Impacts to wildlife would be likely low. No fish were observed in Yokohl Creek during a May 2002 field visit. No recreational resources would be affected.

Numerous cultural resources, including pictographs, native gathering and processing sites, trails, and homesteads, are known to be present and additional sites that have not yet recorded may be present. Inundation of archaeological sites (prehistoric or historic) can result in the loss of important scientific data. Construction of the Yokohl Creek Dam could potentially affect as many as 35 archaeological sites and possibly more. Two Traditional Cultural Places have been identified within the potential reservoir vicinity (“Paint Place” on Rocky Hill, and the steatite quarry near Lindsay Peak), and impacts to these may be of concern to Yokod Yokuts people. Further site investigations and research would be needed to evaluate the significance of environmental impacts and associated mitigation requirements for biological and cultural resources. Land use impacts would be relatively low, and would be associated with relocation of scattered residences.

GROUNDWATER STORAGE OPTIONS

The Friant Division supports conjunctive management of surface water and groundwater supplies in the Eastern San Joaquin Valley. Water deliveries under Class 2 contracts and Section 215 during wetter years reduce groundwater pumping and, in many locations, are used for groundwater recharge. In this manner, the eastern San Joaquin Valley groundwater basins are used for water storage.

During Phase 1, many stakeholders suggested that the potential to develop and operate additional groundwater storage facilities to meet the purposes of the feasibility study be considered. In response, an approach to identify potential groundwater storage and conjunctive management components of the Investigation was developed in coordination with the CALFED Integrated Storage Investigation (ISI) Conjunctive Management Program and with stakeholder input.

The approach began with identifying the theoretical potential for groundwater recharge to determine if groundwater storage was a measure that should be further considered. Analysis focused on estimating the amount of water that could be made available at Friant Dam for groundwater recharge if adequate recharge facilities were in place. The outcome of this evaluation suggested that groundwater storage may be possible to support Investigation purposes, but that specific actions and facilities had not been identified. The following sections describe the theoretical analysis of groundwater recharge potential and a process currently underway to identify projects and actions for consideration in the feasibility study.

Theoretical Analysis of Groundwater Recharge Opportunities

A series of theoretical analyses were conducted using data from the CALSIM benchmark simulation to identify the potential opportunity to recharge San Joaquin River water. Evaluations quantified the amount of water that could be recharged under a variety of assumed operational conditions. No specific facilities were assumed in this analysis.

The theoretical analyses were based on the assumption that flood releases from Millerton Lake in the benchmark simulation could be available for recharge if conveyance and recharge capacity were available. The analyses applied a series of assumptions that addressed varying levels of assumed recharge capacity and the ability of water users to accept additional water during wet periods. The analyses assumed two different approaches for operating Millerton Lake. The first assumed the continued application of existing rules for managing storage in Millerton Lake. A second analysis assumed a reoperation of Millerton Lake that would evacuate storage levels to the minimum canal outlet every year.

Assumed Water Available for Recharge

Water assumed available for recharge in the theoretical analyses was identified as releases to the San Joaquin River in excess of operational requirements (i.e., flood spills). These releases in the CALSIM benchmark model result after maximizing deliveries to Class 1 and Class 2 contracts, and Section 215 water.

Assumed Recharge Capacity

As mentioned previously, no specific new groundwater recharge or extraction facilities that would enable storage of San Joaquin River water have been identified for evaluation in the feasibility study. Therefore, the theoretical analyses considered a range of potentially available additional recharge capacities (expressed as flow rates) that could accept excess water when it is available. Analyses were performed over a wide range of potential instantaneous recharge rates, from zero to 7,000 cfs in increments of 1,000 cfs. It was assumed that recharge could occur through any combination of direct or in-lieu recharge.

Assumed Delivery Constraints

Two constraints related to the delivery of water for recharge were applied in the theoretical analyses. The first constraint relates to the available capacity at the headworks of the Friant-Kern and Madera canals. In the theoretical analysis, capacities of up to 5,000 cfs for the Friant-Kern Canal and 1,250 cfs for the Madera Canal were assumed. In cases where canal capacity constraints were applied, water would be available for recharge to the extent that headworks capacity is available. This constraint does not reflect reductions in canal capacity at locations down-canal from Friant Dam.

A second constraint on deliveries of water for additional recharge relates to the effect of wetness in the Tulare Lake Basin. Review of historical Friant Division operations shows that Friant-Kern Canal deliveries are reduced when water users in the Tulare Lake Basin can take advantage of high flows in the Kings, Kaweah, and Tule rivers. To reflect this condition, a Tulare Basin wetness index constraint was incorporated into the analyses. When this constraint is applied, deliveries for additional recharge would not be accepted when monthly flows in the Tule River exceed 45 TAF.

Assumed Millerton Lake Operations

Analyses were initially conducted assuming that current rules for managing storage in Millerton Lake would apply. Currently, operators seek to achieve minimum storage levels (canal outlets) at the end of September. Inflows from fall and winter rains are captured subject to requirements to maintain available space for flood control storage. In some years, actual end-of-year storage in September is higher than the canal outlet because of changes in inflow patterns or reductions in actual demand.

A second set of analyses was performed assuming a re-operation of Millerton Lake to increase deliveries to potential recharge sites. The reoperation assumed that water could be "predelivered" to recharge facilities in years when a spill would occur. This was accomplished by the use of “perfect foresight” to identify years in which spills would occur in future months. In cases when future spills would occur, the reoperation entailed moving as much water as possible to theoretical recharge facilities. In addition to the conveyance capacity, recharge capacity, and wetness assumptions described previously, two assumptions were made regarding the amount of water that could be diverted in the reoperation. First, the maximum diversion was limited to the amount that would spill in later months. Second, the reoperation was constrained by the amount of water that could be evacuated from active storage in Millerton Lake (above the canal outlets) or at a level that would assure the ability to divert to the canals in subsequent months. These constraints were applied to assure that reoperation did not simply reallocate existing water deliveries.

An alternative approach to reoperation could include "predelivery" of water in any year when storage is above some minimum level. This type of approach would likely result in a need to withdraw banked water to make up for reductions in direct deliveries. The feasibility study will evaluate banking operations that have defined facilities, operational objectives, and implementation guidelines if such options are developed with stakeholder input.

Findings from Theoretical Groundwater Recharge Analyses

Results from several theoretical analyses of groundwater recharge opportunities are displayed in Figure 4-19. The theoretical analyses were made using four combinations of the constraints described above. For each combination of constraints, an analysis was made using current Millerton Lake operational rules and with an assumed reoperation methodology, as describe above. Results show that additional groundwater recharge with the potential development of new groundwater storage facilities and reoperation of Millerton Lake ranges from zero to the available water supply in the San Joaquin River.

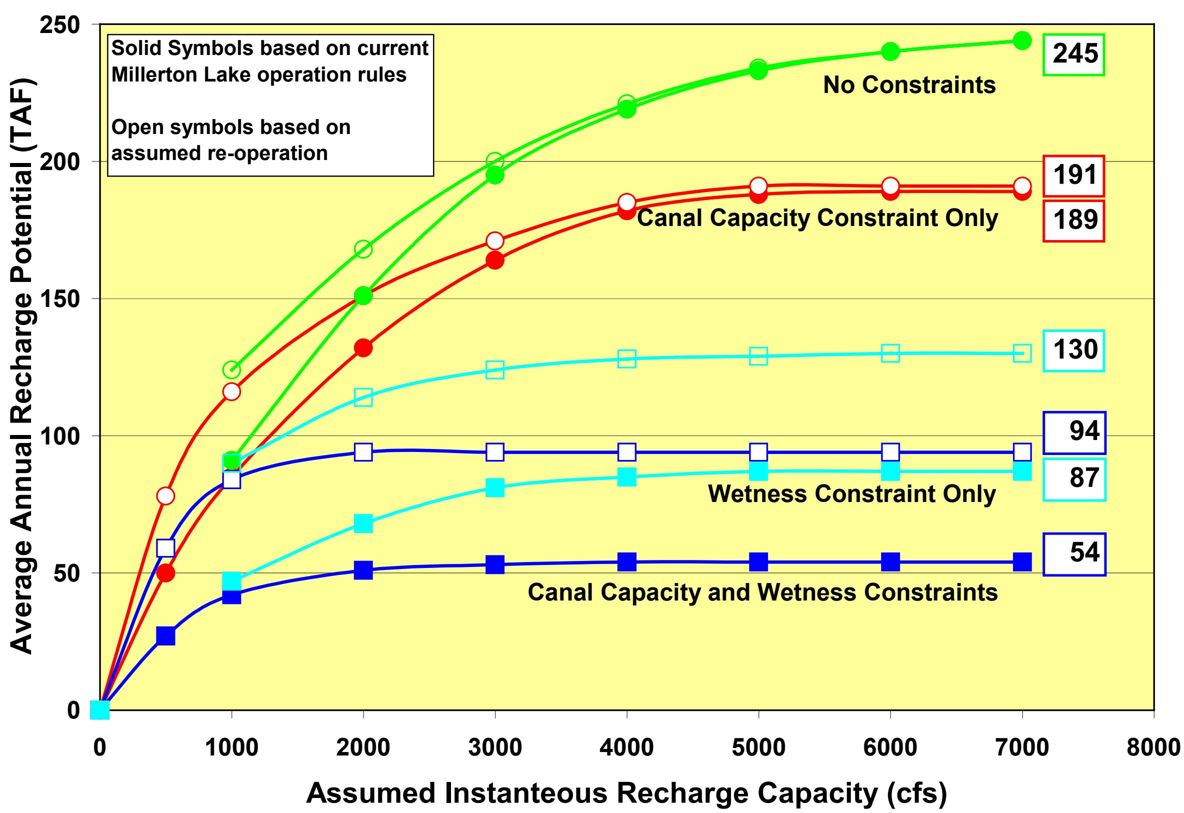


FIGURE 4-19. THEORETICAL GROUNDWATER RECHARGE ANALYSES

Releases or spills to the San Joaquin River at Friant Dam in excess of those required for downstream users vary considerably from year to year. On a long-term basis, the spills average approximately 245 TAF/year. This average amount reflects the maximum amount of additional water that could be developed from the San Joaquin River.

As shown in Figure 4-19, an unconstrained simulation (no limitations on conveyance capacity or wetness effects) suggests that up to 245 TAF/year could be stored in the groundwater basin if an additional recharge capacity of 7,000 cfs were available. When this approach is used with reoperation of Millerton Lake, the upper limit of recharge potential is not affected, but long-term average recharge amounts increase with the same installed recharge capacity.

Applying canal headwork capacity constraints would reduce the maximum potential recharge amount to about 190 TAF/year. Reoperation would produce similar effects, no increase in the upper limit, but higher recharge potential with the same installed recharge capacity. Application of the wetness constraint, without a limitation on canal capacity, results in considerably lower recharge opportunities. With no change in Millerton Lake operations, this analysis suggests a maximum recharge amount of 87 TAF/year with an additional installed recharge capacity of 4,000 cfs. If Millerton Lake were reoperated in this scenario, the total recharge opportunity could rise to about 130 TAF/year with an additional installed recharge capacity of 3,000 cfs. Lastly, an analysis that applies both canal capacity and basin wetness constraints shows that about 54 TAF/year could be recharged with developing 2,000 cfs additional recharge capacity. If Millerton Lake were reoperated in this manner, average annual recharge amounts could rise to 94 TAF/year with the development of about 2,000 cfs additional recharge capacity.

These results suggest that an opportunity to store additional San Joaquin River water may be possible with development of additional conjunctive management and potential reoperation of Millerton Lake. The ability for these approaches to support the purposes of the feasibility study, however, will depend on identifying specific facilities and operational objectives. The following sections describe an approach currently underway that is intended to identify specific locally controlled options that could increase the use of groundwater storage.

Conjunctive Management Options Formation

Similar to the approach used to evaluate surface storage options, conjunctive management options will be incorporated into the feasibility study to the extent that they can contribute to the purposes of the Investigation. Further, the identification and development of groundwater storage options will be consistent with the CALFED policy of supporting voluntary, locally controlled groundwater management projects that are designed to address local water needs first, before considering regional or statewide benefits. The focus will be to identify specific options, including policy actions and facilities that would result in additional conjunctive management of water from Millerton Lake in a manner that would contribute to the purposes of the Investigation.

Conjunctive Management Evaluation Approach

The evaluation approach for conjunctive management began with a review of potential constraints to conveying additional water from Millerton Lake. This evaluation indicated that capacity to transport water to groundwater storage locations along the Friant-Kern and Madera canals, and in the San Joaquin River downstream of Friant Dam, did not appear to be a significant limiting factor. Through coordination with the ISI Conjunctive Management Program, the study team identified stakeholders interested in expanding their conjunctive management operations. Various agencies were contacted to determine their interest in regional conjunctive management actions that could contribute to the purposes of the Investigation in a manner equivalent to adding surface storage at Friant. The agencies included CVP and non-CVP contractors that reflect a wide range of agricultural and M&I demands, accessibility to alternative surface water supplies, and underlying groundwater conditions.

As conjunctive management options are identified, they will be subject to screening criteria that recognize hydrologic, physical, institutional, and legal constraints. Institutional impediments will be identified that would need to be removed to allow the implementation of certain options. Operational assumptions, including the potential reoperation of Millerton Lake, will be identified with specific options.

The Friant Division of the CVP covers an area that can receive water from seven rivers, numerous local streams, and Delta exports from CVP and SWP facilities. Water supplies from sources other than the San Joaquin River could contribute to the same purposes as this Investigation, but would not be considered in the Investigation unless operated in a manner functionally equivalent to enlarging Millerton Lake. This approach is consistent with the approach used to identify potential surface storage options in other watersheds.

The following steps describe the identification and preliminary evaluation of conjunctive management options.

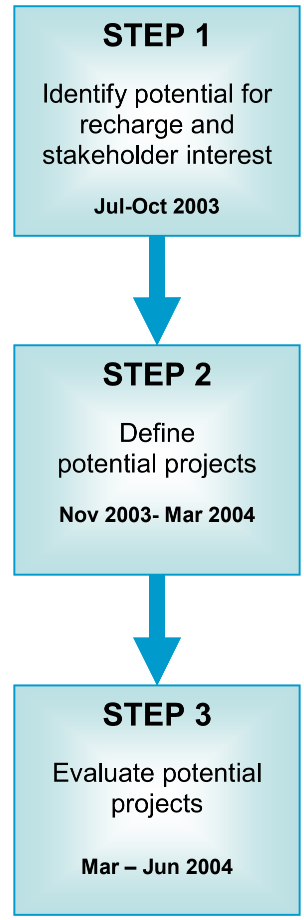
Step 1: Identify Potential Significance of, and Stakeholder Interest in, Regional Conjunctive Management Options.

This step is essentially complete. As described above, a potential for additional groundwater storage was identified through a series of theoretical analyses. On the basis on these results, conjunctive management as a measure to store San Joaquin River water was retained for further definition and consideration. In addition to the theoretical analyses, a set of stakeholders that would likely be involved in implementing conjunctive management actions was contacted to identify their degree of interest. The stakeholders were identified based on previous implementation of groundwater storage projects and an expressed interest in conjunctive management as identified by the CALFED ISI Conjunctive Management Program. The stakeholders indicated a high degree of interest in regional, cooperative opportunities for groundwater storage and banking. Through these interviews, however, no specific projects were identified that could be considered in the feasibility study and significant physical and legal constraints were identified that could limit opportunities.

Step 2: Define Potential Conjunctive Management Options.

Inclusion of conjunctive management options cannot be limited to a theoretical evaluation. Step 1 of the process revealed an interest by stakeholders to participate in formulating conjunctive management options, but did not result in identifying specific actions that could be evaluated. To consider a conjunctive management option in the feasibility study, its components need to be described at a level of detail that enables comparison with other storage options. Consistent with the CALFED ROD, potential conjunctive management options will be locally initiated and managed. Because local project proponents must support any conjunctive management option, these details will be developed through a stakeholder coordination process.

Water agencies and organizations that have shown an interest in participating, and have the ability to implement conjunctive management actions, will assist in formulating conjunctive management options. This group will be tasked with identifying specific components, including water sources, operational assumptions, and conveyance, recharge, extraction, and distribution facilities. The group will also help identify institutional and legal constraints associated with developing and operating specific conjunctive management options.



Conjunctive Management Evaluation Approach

Step 3: Evaluate Potential Conjunctive Management Options.

Potential options identified through stakeholder coordination will be evaluated in relation to hydrologic, physical, institutional, and legal criteria to identify those options that could contribute to the purposes of the Investigation, with or without additional surface water storage capacity. Four criteria will be considered, as described below.

- ***Sources of Water***

Some conjunctive management options may be based on multiple water supplies, including Millerton Lake. The evaluation will consider portions of the options that would make water available at Millerton Lake to contribute to the purposes of the Investigation. The coincidence of water supplies from multiple sources, the ability of new facilities to accept delivery of Millerton floodwater during wet periods, and exchanges of Millerton water with other waters may be considered.

- ***Project Facilities***

The location of lands, recharge facilities, conveyance facilities, and extraction facilities will be defined, including hydrologic and geophysical groundwater basin characteristics. The level of detail will be consistent with estimates of surface storage facilities to enable meaningful comparison of options.

- ***Institutional Issues***

County ordinances, the need for new contracts with the Federal government, or the need to modify the terms of existing contracts for delivery of Class 1 and Class 2 water will be identified. Assumptions regarding the maintenance of long-term historical water deliveries will be clearly identified.

- ***Operational Assumptions***

Operational requirements will be described, including assumptions regarding seasonal or multiyear storage and withdrawal operations. Opportunities for predelivery of contract supplies and exchanges that can provide water to contribute to the purposes of the Investigation will be identified.

Specific operational criteria for each option will define the physical characteristics, operational assumptions, and quantity of water that could be stored in underground aquifers to contribute to the purposes of the Investigation. Options that can be implemented without developing additional surface water storage, and are not already included in the without-project future condition, will provide the basis for an alternative to new surface storage. Options that would rely on additional surface water storage capacity before a local entity is able to begin implementation will be included in surface storage alternatives.

THIS PAGE LEFT BLANK INTENTIONALLY

CHAPTER 5. PUBLIC INVOLVEMENT DURING PHASE 1

The Phase 1 Investigation addressed issues of interest and concern to stakeholders engaged in local and regional water resource planning. To provide meaningful opportunities for these stakeholders to participate and to become informed regarding Phase 1 activities, the Investigation included an extensive public involvement program featuring both interactive and outreach components:

- Structured series of interactive public workshops
- Briefings for governmental and nongovernmental agencies and coalitions
- Briefings for tribal representatives
- Coordination with local water resources planning and management groups
- Coordination with agencies
- Interviews with water management agency representatives
- Tours of Millerton Lake and portions of the upper San Joaquin River
- Distribution of informative brochures, fact sheets, and documents that provided background and updates on the Investigation's progress
- Distribution of Investigation documents via a Web site

The interactive components of the public involvement program focused on involving those with a stake in the outcome of the Investigation. Stakeholders in the Investigation study area brought a high level of experience and local knowledge to the process, and provided a variety of recommendations, responses, and reviews that likewise informed the plan formulation process. Outreach components were designed to provide information and materials to a broad group of interested parties. These outreach efforts disseminated information widely, brought additional stakeholders to the process, and enhanced coordination with related water resources planning and management groups.

PUBLIC WORKSHOPS

The interactive component of the public involvement program included a structured series of workshops and meetings at which participants had opportunities to hear presentations by the study team, take part in discussions regarding plan formulation, and provide input about the planning process, analyses, and project documents. This process included six general workshops and one topic-oriented working session. Figure 5-1 depicts the workshop series, which was designed to provide opportunities for involvement at key milestones in the planning process.

WORKSHOP TOPICS

WORKSHOP #1 "Introduction" May 29, 2002	WORKSHOP #2 "Approach and Options" July 21, 2002	"Ecosystem Restoration Flows" September 4, 2002	WORKSHOP #3 "Options" October 18, 2002	WORKSHOP #4 "Initial Results" February 11, 2003	WORKSHOP #5 "Appraisal Phase" April 30, 2003	WORKSHOP#6 "Alternatives" August 27, 2003
• Investigation Overview • Principles of Participation • Phase I Approach • Technical Activities to be Conducted - Modeling - Engineering - Environmental	• Phase I Purpose and Goals • Problems and Opportunities • Initial Analysis Approach and Assumptions • Storage Options	• Initial Phase I Modeling Approach • Initial Modeling Assumptions for Restoration	• Surface Storage Option Screening • Conjunctive Management • Model Modifications and Preliminary Results	• Functional Equivalence • Preliminary Single Purpose Analysis Results • Continuation Criteria	• Preliminary Alternatives • Draft Analysis Results	• Analysis Results • Alternatives • Phase 2 Feasibility Study and EIS/EIR

FIGURE 5-1. PHASE 1 STAKEHOLDER WORKSHOP PROCESS

Workshop participants included representatives of water agencies, counties, State and Federal agencies, water districts, environmental interest groups, and others with an interest in the Investigation. The workshops, which were held in a variety of locations within the study area, and were announced via E-mail, mailed postcards, and the project Web site, were well-attended. Each workshop included multiple interactive segments during which participants expressed their concerns, asked questions, and discussed issues central to the Investigation. Detailed summaries of the workshops were prepared, distributed to participants, and posted on the project Web site. The workshops are summarized briefly below.

Workshop 1 – Introduction

The first workshop, held in Fresno on May 29, 2002, initiated stakeholder participation in the Investigation. The workshop included presentations and discussions on Investigation purposes and a review of the origins and authorities for the study. The study team presented the Phase I approach and explained the types of water resources problems the Investigation would focus on during analyses. During a brainstorming session, participants described problems they wanted the study to address and noted special considerations for the planning process. The plan for technical activities was also presented.

Workshop 2 – Approach and Options

Workshop 2, held on July 31, 2002, in Modesto, provided an overview of the study approach and clarified the goals of the Investigation. Prior to the workshop, participants were provided a description of water resources problems and opportunities as they relate to the Investigation. Presentations and discussions centered on this information. Participants commented on the approach for addressing water quality, ecosystem, and water supply reliability problems and discussed the initial analysis concept. The study team presented a preliminary list of storage options identified in the Investigation. Additional presentations introduced the hydrologic models and modeling assumptions that would be used for Investigation analyses. During this workshop, participants identified a need for a separate discussion of Friant Dam release patterns to use in the initial evaluation of ecosystem restoration opportunities. This follow-up discussion was held at an Ecosystem Restoration Flows workshop, described below.

Working Session – Ecosystem Restoration Flows

A working session focused on Ecosystem Restoration Flows was held on September 4, 2002, in Madera. Because many participants in this meeting had not attended previous Investigation workshops, this meeting included a review of Investigation purposes and planning approach. Presentations covered the hydrologic model to be used, assumptions and constraints in the model, and information needs. Participants provided recommendations and information in identifying appropriate Friant Dam release patterns for inclusion in Investigation analyses of water supplies that would be available for restoration flows. Participants suggested modeling a river flow release that was patterned after the unimpaired San Joaquin River hydrograph – an approach that was used in the Investigation.

Workshop 3 – Options

Workshop 3, held in Los Banos on October 18, 2002, updated participants on Investigation progress and presented preliminary results of option screening and model simulations. Presentations covered the context of the Investigation within the CALFED Bay-Delta Program and explained the formal review process to be used for Investigation documents. Participants were provided draft results of the initial surface storage option screening. A presentation and accompanying facilitated discussion centered on the ISI Conjunctive Water Management Program and integration of conjunctive management in the Investigation. Also discussed were modifications to the hydrologic model sample results.

Workshop 4 – Initial Results

The fourth workshop, held in Fresno on February 11, 2003, reviewed the overall Investigation approach and presented components and working status of the In-Progress Phase I Investigation Report. A draft version of the Phase 1 Investigation Report was released for public review following this workshop. The report contained 1) water resources problems and opportunities; 2) study planning approach; 3) initial screening of potential surface storage options; and 4) modeling approach and initial evaluations. A presentation covered a preliminary framework for comparing storage options, and discussions revisited the potential inclusion of conjunctive management options. Assumptions used for the model were presented along with preliminary results of the single-purpose analyses.

Workshop 5 – Appraisal Phase

At Workshop 5, held in Fresno on April 30, 2003, participants were informed that Congress had authorized Reclamation to prepare a feasibility study for new storage in the upper San Joaquin River basin. A presentation summarized participants' comments on the Phase I In-Progress Report. Discussion continued on the proposed approach for incorporating conjunctive management options. Screening results for initial surface storage options were reviewed and first cost estimates for retained sites were provided. Presentations covered modeling results, including sensitivity analyses, and previewed upcoming evaluations. Participant recommendations included requests for analyses of potential impacts to Millerton Lake residences and upstream hydropower projects.

Workshop 6 – Alternatives

Workshop 6, held in Modesto August 27, 2003, reviewed the range of storage options examined by the Investigation and presented details of the analyses that have been conducted on the surface storage options carried forward for further study. A status overview recounted Investigation purposes, described the range of surface storage options that have been appraised, and reviewed screening of the surface storage options. The study team summarized the analyses of retained surface storage options, including potential hydrologic accomplishments; engineering and geology aspects; environmental resources; impacts to existing hydropower facilities; and the potential for new or replacement hydroelectric generation. An update was provided on the formulation of potential groundwater storage options to be led by DWR. This subject generated discussion and questions from several stakeholders. Participants were also provided an overview of the feasibility study schedule and activities and encouraged to remain involved actively as the feasibility study continues.

COORDINATION WITH WATER RESOURCES PLANNING AND MANAGEMENT AGENCIES AND GROUPS

The context in which the Investigation is being conducted includes a complex set of Federal, State, and local regulations. Local and regional planning is being conducted with involvement from a wide variety of organizations at all political levels and with varying mandates and policies. Many of the organizations responsible for planning, enforcing regulations, and developing and implementing policy are involved in several related programs and ongoing efforts that affect the water system facilities being studied in this Investigation.

In addition to public workshops, a variety of communication tools are in place to provide timely information and comment opportunities to the public through completion of the feasibility study and environmental review. The Phase 1 public involvement program featured both interactive and outreach components that included the following:

- Coordination with governmental agencies and nongovernmental organizations
- Briefings for tribal representatives
- Briefings for elected officials
- Coordination with local water resources planning and management groups
- Interviews with water management agency representatives
- Tours of Millerton Lake and portions of the upper San Joaquin River
- Informative brochures, fact sheets, and documents that provided Investigation background and progress updates
- Distribution of Investigation documents via a Web site

INTERVIEWS WITH LOCAL STAKEHOLDERS

As part of the approach to identify and evaluate conjunctive management opportunities that have the potential to support Investigation purposes, Investigation staff conducted one-on-one interviews with local stakeholders regarding regional, cooperative opportunities for groundwater storage and banking. These interviews identified a high level of interest among the stakeholders. During the interviews, no specific projects were identified that could be incorporated into the Investigation, and stakeholders made note of significant physical and legal constraints that could affect implementation of conjunctive management options.

TOURS

Investigation staff conducted two tours of Millerton Lake and the upper San Joaquin River during 2003, and provided presentations on several similar tours conducted by other organizations. These half-day tours provided interested parties a firsthand view of several of the surface storage sites under consideration. Tour participants viewed portions of the Raise Friant Dam, Fine Gold, and Temperance Flat option sites, and presenters provided information regarding environmental resources, hydropower facilities, and construction issues. Investigation staff also supplied briefing materials for a special air tour of the surface storage option sites.

INFORMATIONAL MATERIALS AND DOCUMENT ACCESS

Throughout Phase 1, the study team prepared and distributed a variety of informational materials. Among these materials were the following:

- *Related Authorities, Regulation, Programs, and Groups*: This document, provided at the first workshop, is a guidance tool that identifies and describes legal, regulatory, and institutional constraints associated with the Investigation. This memorandum explains how the constraints interrelate and provides descriptions of 40 authorities, regulations, programs, agreements, and groups related to water issues in the upper San Joaquin River basin.
- Investigation Brochures: Four-page brochures, covering the Investigation approach, schedule, technical analyses, study results, and public involvement, were prepared and distributed widely during Phase 1.
- Fact Sheets: A variety of fact sheets distributed during Phase I summarized topics such as the planning process and workshop series, surface storage options, and the approach for identifying and incorporating conjunctive management options.

The Investigation Web site, hosted by Reclamation at http://www.usbr.gov/mp/sccao/storage/ contains the above materials and project reports, technical memoranda, all presentations and handouts used at public workshops, contact information for the study team, and an E-mail gateway for contacting the study team. The Web site has been a key feature in outreach efforts. Throughout Phase 1, a mailing list of interested parties was used to distribute postcard notifications of workshops and document releases. The Phase 1 mailing list will form the basis for an extended Phase 2 mailing list.

THIS PAGE LEFT BLANK INTENTIONALLY

CHAPTER 6. NEXT STEPS

The Phase 1 Investigation Report represents an early milestone in developing the Upper San Joaquin River Basin Storage Investigation Feasibility Study. As described earlier, the objectives of the Phase 1 Investigation Report are to describe the problems and opportunities that are being addressed in the feasibility study, identify options for consideration, and present the results of technical studies that support initial screening of storage options. As presented in this report, a total of 17 surface water storage options was initially identified and considered. Through the initial screening process, six options were retained for further consideration in the feasibility study. The report described potential accomplishments, costs, and environmental effects of the retained surface storage options. The report also described the approach underway to identify potential conjunctive management options that could support Investigation purposes.

The surface water storage options that were retained for consideration will undergo additional study in the coming months. Technical studies will be tailored to allow definition of initial alternatives and identification of alternatives that will be evaluated throughout the remainder of the feasibility study. Several additional important milestones will be needed before a final document can be prepared for consideration by Federal, State, and local decision-makers. The following sections describe future planned milestones in the development of the Feasibility Report. During the fall of 2003, detailed work plans will be developed to address the planning, technical, and administrative activities to support the remainder of the Feasibility Study. A schedule of Phase 2 milestones is shown in Figure 6-1.

NOTICE OF INTENT / NOTICE OF PREPARATION

Phase 1 planning activities were completed in advance of National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA) activities. A very active stakeholder involvement process was implemented to obtain input and feedback on planning activities and findings as initial studies were completed. With the completion of initial screening, Reclamation and DWR will formally initiate Federal and State of California environmental review processes in accordance with NEPA and CEQA, respectively. A Notice of Intent (NOI) to prepare an EIS and a Notice of Preparation (NOP) of an EIR will be issued in early 2004. The NOI/NOP will describe the purposes of the feasibility study and indicate the type of decision that will be made based on the final documents.

ALTERNATIVES REPORT

The surface storage options retained for further study will be compared in terms of accomplishment, cost, environmental impacts, and implementation issues to identify options that will form the basis of the initial alternatives. Alternatives will be formulated as a combination of options and operational objectives. The costs and benefits of initial alternatives will be compared and a set of final alternatives to be evaluated in the EIS will be identified. The Alternatives Report is planned for release in June 2004.

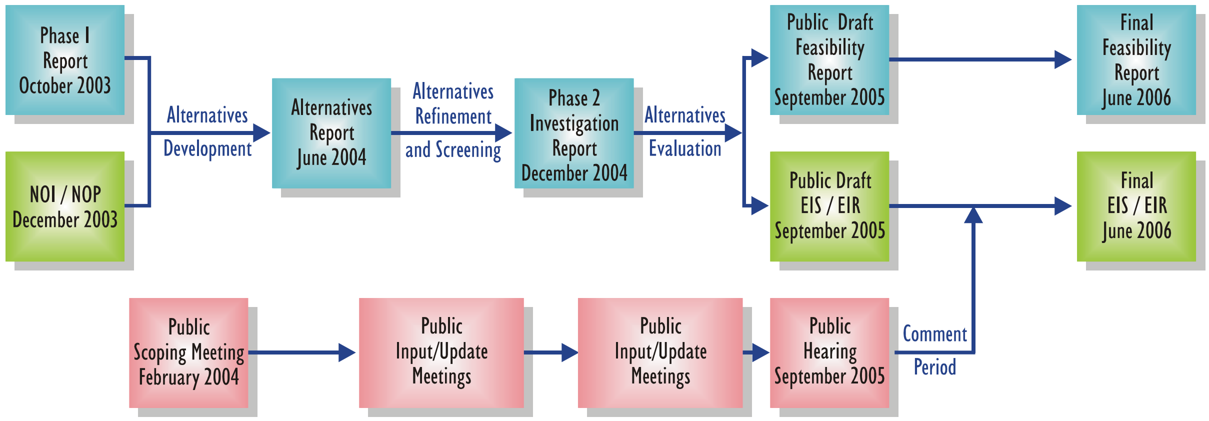


FIGURE 6-1. PHASE 2 MILESTONES

PHASE 2 INVESTIGATION REPORT

Preliminary analysis of costs, accomplishments, and environmental impacts of the final set of alternatives will be presented in the Phase 2 Investigation Report. This document will precede the Feasibility Report and EIS/EIR and will provide information on environmental effects of the alternatives. Recommended mitigation may be included, although this information may still be under development. It is expected that the Phase 2 Information Report will be issued in December 2004.

DRAFT FEASIBILITY REPORT AND EIS/EIR

The Draft Feasibility Report will fully describe and evaluate the final alternatives, including costs and benefits, and the preferred alternative will be identified. The EIS/EIR will disclose the environmental consequences, both beneficial and adverse, of the alternatives and will describe proposed mitigation for the preferred alternative. The Draft EIS/EIR will be circulated for formal public review and comment in accordance with NEPA and CEQA requirements. The Draft Feasibility Report and EIS/EIR are scheduled for June 2005.

FINAL FEASIBILITY REPORT AND EIS/EIR

Following receipt of public comments on the Draft Feasibility Report and EIS/EIR, the study team will prepare responses to comments and incorporate necessary revisions and clarifications into the documents. The Final Feasibility Report will include an implementation plan that describes the involvement of Federal, State, and local agencies in implementing the preferred alternative, if it is different from the no-action alternative. The Final EIS/EIR will include responses to comments and will form the basis for developing a ROD, which will be prepared immediately following issue of the Final EIS/EIR. The Final Feasibility Report and EIS/EIR are scheduled for June 2006.

CHAPTER 7. LIST OF PREPARERS

NAME	AFFILIATION	ROLE
Jason Phillips	Reclamation	Project Manager
Chuck Howard	Reclamation	Regional Geologist (retired)
Joel Sturm	Reclamation	Regional Geologist
Alan Stroppini	Reclamation	Lead Engineer
Clarence Duster	Reclamation	Geotechnical Engineer
Mark Pabst	Reclamation	Geotechnical Engineer
Steve Higinbotham	Reclamation	Civil Engineer
Claire Hsu	Reclamation	CALSIM Modeling
Marian Echeverria	Reclamation	Public Involvement
Waiman Yip	DWR	Project Manager
Richard Hayes	DWR	Civil Engineer, Hydrologist
Jeremiah McNeil	DWR	Engineer
Nate Wales	DWR	Engineer
Eric Hong	DWR	Conjunctive Management
William Swanson	MWH	Project Manager
Stephen Osgood	MWH	Planner
Yung-Hsin Sun	MWH	Hydrologic Modeling
Anna Fock	MWH	Hydrologic Modeling
David Rogers	MWH	Engineering Team Leader
James Herbert	MWH	Engineering Geologist
Foster Pelton	MWH	Hydropower
Jill Miller	MWH	Hydropower
Irina Torrey	MWH	Environmental Team Leader
Sara Hamm	MWH	Environmental Coordination
Philip Unger	MWH	Aquatic Biology
David Stevens	MWH	Wildlife Biology
Stephanie Murphy	MWH	Wildlife Biology
Barry Anderson	MWH	Botany
Sandra Perry	MWH	Recreational Resources
David White	MWH	Cultural Resources
James Darke	MWH	GIS Analyst
Steve Irving	MWH	GIS Technician
Emily McAllister	MWH	Technical Editor
Michelle Irwin	MWH	Document Coordinator
Coral Cavanagh	CDM	Public Involvement
Carrie Metzger	CDM	Public Involvement
Charles Gardiner	Public Affairs Management	Public Involvement
Walter Bourez	MBK	CALSIM Model Development
Russ Grimes	SKS	Conjunctive Management
Dan Steiner	Consultant	CALSIM Model Development

THIS PAGE LEFT BLANK INTENTIONALLY

CHAPTER 8. REFERENCES

GENERAL REFERENCES USED FOR THE INVESTIGATION

CALFED. 2000a. Bay-Delta Program Record of Decision. August.

CALFED. 2000b. CALFED Initial Surface Water Storage Screening. August.

California Division of Mines and Geology (CDMG). 1966a. Geologic Map of California – Fresno Sheet, 1:250,000. Fourth printing, 1991.

CDMG. 1966b. Geologic Map of California – San Jose Sheet, 1:250,000. Fourth printing, 1981.

CDMG. 1967. Geologic Map of California – Mariposa Sheet, 1:250,000. Fourth printing, 1991.

CDMG. 1994. Fault Activity Map of California and Adjacent Areas with Locations and Ages of Volcanic Eruptions, 1:750,000. Compiled by Charles W. Jennings.

Carson, James D. 1989. USFWS letter to U.S. Army Corps of Engineers regarding Tule River and Kaweah River Basin Investigations. January 23.

Corps of Engineers (Corps). 1957. General Design Memorandum, Design Memorandum No. 5, Terminus Project, Kaweah River California. United States Department of the Army, Sacramento District. December 15.

Corps. 1958. General Design Memorandum (revised), Design Memorandum No. 6, Success Project, Tule River California. United States Department of the Army, Sacramento District. December 1.

Corps. 1966. Terminus Reservoir, Geology, Paleontology, Flora and Fauna, Archeology, History. United States Department of the Army, Sacramento District. August.

Corps. 1986. Kaweah and Tule River Reconnaissance Study, California, Hydrology. United States Department of the Army, South Pacific Division, Sacramento District. September.

Corps. 1987. Tule River Basin Investigation, California, Reconnaissance Report. United States Department of the Army, South Pacific Division, Sacramento District. July.

Corps. 1989a. Kings River Basin Investigation, California. United States Department of the Army, Sacramento District. March.

Corps. 1989b. Tule River Basin Investigation, California, Office Report, Feasibility Level, Basis of Design and Cost Estimate. United States Department of the Army, South Pacific Division, Sacramento District. August.

Corps. 1990a. Kaweah River Basin Investigation, California, Basis of Design and Cost Estimates, Office Report, Feasibility Level. United States Department of the Army, South Pacific Division, Sacramento District. January.

Corps. 1990b. Kaweah River Basin, California, Hydrology, Office Report, Feasibility Level. United States Department of the Army, South Pacific Division, Sacramento District. August.

Corps. 1990c. Tule River Basin, California, Office Report, Hydrology. United States Department of the Army, South Pacific Division, Sacramento District. August.

Corps. 1992a. Tule River Basin Investigation, California, Interim Report. United States Department of the Army, South Pacific Division, Sacramento District. March.

Corps. 1992b. Tule River Basin Investigation, California, Interim Report. United States Department of the Army, South Pacific Division, Sacramento District. March.

Corps. 1993. Success Dam, Success Lake, Tule River, California, Dam Safety Assurance Program Reconnaissance Report, Seismic Evaluation. United States Department of the Army, South Pacific Division, Sacramento District. August.

Corps. 1994. Pine Flat Dam Fish and Wildlife Habitat Restoration Investigation, California, Reconnaissance Report, Appendix C. United States Department of the Army, South Pacific Division, Sacramento District. April.

Corps. 1996. Kaweah River Investigation, California, Draft Feasibility Report. United States Department of the Army, South Pacific Division, Sacramento District. June.

Corps. 1999a. Sacramento and San Joaquin River Basins, California, Post-Flood Assessment. United States Department of the Army, South Pacific Division, Sacramento District. March 29.

Corps. 1999b. Tule River Basin Investigation, California, Draft Feasibility Report. United States Department of the Army, South Pacific Division, Sacramento District. April.

Department of Water Resources (DWR). 1998. DWR Bulletin 160-98, California Water Plan Update. November.

DWR. 2002. Personal communication with Karen Enstrom. December.

DWR. 2003. California's Groundwater – Bulletin 118. Public Review Draft. April.

International Engineering Company, Inc. (IECO). 1974. Master Plan for Kings River Service Area. For Kings River Conservation District (KRCD). December.

Lendenmann, E.C. 1975. Draft Geologic Report, 2nd Draft. For United States Department of the Interior, Bureau of Reclamation.

Marchand, D. 1980. Preliminary Geologic Maps Showing Cenozoic Deposits of the Snelling and Merced Falls Quadrangles, Merced and Stanislaus Counties, California. Open-File Report 81-107. United States Geological Survey.

Reclamation. 1961a. Feasibility Design Estimate Drawings, Volume II. United States Department of the Interior, East Side Division CVP.

Reclamation. 1961b. Cost Estimate-Project DC-1, Appendix, Volume III. United States Department of the Interior, East Side Division CVP.

Reclamation. 1966. Feasibility of Water Supply Development. June.

Reclamation. 1968. A Re-evaluation of the Report on the Feasibility of Water Supply Development. United States Department of the Interior, East Side Division CVP. September.

Reclamation. 1971. Ground-Water Geology and Resources Appendix.

Reclamation. 1974. Topographic Map, Sheets 1 through 6. United States Department of the Interior, East Side Division CVP, Mid-Valley Canal.

Reclamation. 2002. Appraisal-Level Probabilistic Ground Motion Evaluation, Technical Memorandum No. D-8330-2002-10. Prepared for the Upper San Joaquin River Basin Investigation, Central Valley Project, California. United States Department of the Interior, Bureau of Reclamation, Technical Service Center, Seismotectonics and Geophysics Group. August.

Saleeby, Jason. 1974. Notes on mafic, ultramafic and associated metasedimentary rocks of the southwestern Sierra Nevada Foothills. November.

United States Fish and Wildlife Service (USFWS). 1995. Environmental Effects of Yield Increase Options. Report to Congress. September.

USFWS. 2002. Letter from Caroline Prose to the United States Army Corps of Engineers. February 7.

URS. 2000. Technical Memorandum 4, Draft Long List of Alternatives, Development of Water Supply Alternatives for Use in Habitat Restoration for the San Joaquin River. For Friant Water Users Authority and Natural Resources Defense Council Coalition. November 22.

URS. 2001. Technical Memorandum 5, Analysis of Long List of Alternatives, Development of Water Supply Alternatives for Use in Habitat Restoration for the San Joaquin River. For Friant Water Users Authority and Natural Resources Defense Council Coalition. May 24.

ADDITIONAL REFERENCES USED FOR DINKEY CREEK RESERVOIR

Kistler, R.W., and P.C. Bateman. 1966. Stratigraphy and Structure of the Dinkey Creek Roof Pendant in the Central Sierra Nevada, California. Geological Survey Professional Paper 524-B. For United States Department of the Interior, United States Geological Survey.

ADDITIONAL REFERENCES USED FOR FINE GOLD RESERVOIR

Department of Water Resources (DWR). 2002. Draft - Reconnaissance Survey of Fine Gold Creek Reservoir. State of California, Department of Public Works. January.

WAVE Engineers, Inc. (WAVE). 1991. Initial Operation Study, Fine Gold Water Conservation Project. For Madera Irrigation District. February.

ADDITIONAL REFERENCES USED FOR FRIANT DAM RAISE

Friant Water Users Authority. n.d. Information Report on Friant Division Water Deliveries.

Hill, L.K. 1952. Additional water supply and economic analysis of possible raising of Friant Dam 60 feet in height. Case of Rank v. Krug, Civil No. 685-ND. For United States Department of the Interior, Bureau of Reclamation, Office of the Regional Counsel. July 21.

Lendenmann, Ernest C. 1989. Geologic Data for Safety of Dams Modification Decision Analysis – Construction Geologic Data and General Summary of Construction Concrete Data, for Friant Division - Central Valley Project. United States Department of the Interior, Mid-Pacific Region, Bureau of Reclamation, Regional Geology Section. May.

Murphy, F.M. 1937. Geological Report on the Friant Damsite – Central Valley Project, For United States Department of the Interior, Bureau of Reclamation, Friant Division. January 15.

Reclamation. 1952. Friant Dam Raising, Earth Dikes, Crest El. 646. United States Department of the Interior. April.

Reclamation. 1982. Friant Dam, Reconnaissance Estimate. United States Department of the Interior, Region 2. July.

Reeves, Christopher R. n.d. Geologic Data for Modification Decision Analysis, Safety of Dams Studies, Friant Dam, Saddle Dams (Dikes) and Friant-Kern Canal, Station 145 to Station 155. For United States Department of the Interior, Mid-Pacific Region, Bureau of Reclamation, Regional Geology Section, Central Valley Project – Friant Division.

ADDITIONAL REFERENCES USED FOR HUNGRY HOLLOW RESERVOIR

Binkley, Margaret D. 1961. Deer Creek Pump Connection and Hungry Hollow Pumping Plant Intake Channel Engineering Geology for Feasibility Cost Estimates. For United States Department of the Interior, Bureau of Reclamation, Conveyance Unit, East Side Division CVP. January 12.

Reclamation. 1960. Hungry Hollow Dam, Basic Estimate DC-1, Reconnaissance Estimate. United States Department of the Interior, Conveyance Unit, East Side Division CVP, Mid-Valley Canal. July.

Reclamation. 1961. Hungry Hollow Dam, Reconnaissance Design Drawing. United States Department of the Interior. East Side Division CVP. March 10.

ADDITIONAL REFERENCES USED FOR MONTGOMERY RESERVOIR

CALFED. 1997. Facilities Descriptions and Updated Cost Estimates for Montgomery Reservoir. Storage and Conveyance Refinement Team.

Department of Water Resources (DWR). 2000. Draft - Reconnaissance Survey of Montgomery Reservoir. State of California, Department of Public Works. December.

Reclamation. 1959. Montgomery Dam and Reservoir Site, Preliminary Geology. United States Department of the Interior, East Side Division CVP. February 5.

San Joaquin River Management Program Wildlife Committee (SJRMPWC). 1993. Montgomery Offstream Storage Reservoir Proposal Memorandum. June.

United States Fish and Wildlife Service (USFWS). 1992. Planning Aid Report – San Joaquin River Basin Resource Initiative – Montgomery Offstream Storage Reservoir. December.

ADDITIONAL REFERENCES USED FOR PINE FLAT DAM RAISE

Barnes, S.M., Henry Karrer, Wm. H. McGlasson, J.F. Sorenson, and Robert E Leake, Jr. 1965. Progress Report of Engineering Committee on Kings River Water Utilization Projects Upstream from Pine Flat Reservoir. For Kings River Water Association. November 16.

Corps of Engineers (Corps). 1976. Pine Flat Lake, Kings River, California, Master Plan, Design Memorandum No. 7. United States Department of the Army, Sacramento District. October.

Corps. 1989a. Environmental Assessment Reconnaissance Study for Flood Control for Pine Flat Dam, Kings River. United States Department of the Army, Sacramento District. August.

Corps. 1989. Pine Flat Dam, Kings River, California, Reconnaissance Report. United States Department of the Army, Sacramento District. September.

Reclamation. 1930. Pine Flat Dam, California Water Resources Investigations, Preliminary Estimate. United States Department of the Interior. November 15.

ADDITIONAL REFERENCES USED FOR TEMPERANCE FLAT RESERVOIR

Forbes, Hyde. 1930. Geological Report on Friant, Fort Miller, and Temperance Flat Damsites on San Joaquin River. For State of California Department of Public Works, Division of Water Resources. March.

ADDITIONAL REFERENCES USED FOR YOKOHL VALLEY RESERVOIR

Hall, Charles E. 1958. Memorandum for Geology Files, Geologic Reconnaissance – Yokohl, Owens Mountain, Windy Gap, Buchanan, Hidden and Bailey Flat Dam Sites – East Side Investigations for the Fresno-Chowchilla Project. For United States Department of the Interior, East Side Division CVP, Bureau of Reclamation. July 28.

Kohl, W.P. 1958. Field inspection of the proposed Yokohl and Upper Owens Mountain dam sites for the East Side Investigation and Windy Gap, Bailey Flats, Hidden and

Buchanan sites for the Fresno-Chowchilla Project. For United States Department of the Interior, East Side Division CVP, Bureau of Reclamation. May.

Lendenmann, E.C. 1975. Yokohl Damsite, Mid-Valley Canal, Geologic Log of Boring, DH-1. For United States Department of the Interior, Bureau of Reclamation. February 12.

Reclamation. n.d. Geologic Map Showing Yokohl Damsite and Dike Sites. United States, Department of the Interior, East Side Division CVP, Mid-Valley Canal.

Reclamation. 1972a. Yokohl Dam and Reservoir, Reconnaissance Flood Hydrology, Cross Valley Investigation. United States Department of the Interior, Dams Unit, East Side Division CVP, Mid-Valley Canal. March 24.

Reclamation. 1972b. Reconnaissance Cost Estimates for Yokohl Creek Reservoir Pumping Plant, Pump Line and Other Features, Cross Valley Canal Studies - East Side Division - Central Valley Project. United States Department of the Interior, Dams Unit, East Side Division CVP, Mid-Valley Canal. March 22.

Reclamation. 1972c. Yokohl Dam and Reservoir, Cross Valley Investigation Central Valley Project. United States Department of the Interior, Dams Unit, East Side Division CVP, Mid-Valley Canal. March 23.

Reclamation. 1975. Reconnaissance Cost Estimates for Yokohl Dam and Reservoir. United States Department of the Interior. December 1974 through April 7.

Water and Power Resources Service. 1980a. Yokohl Reservoir and Tunnel Alignment. United States Department of the Interior, East Side Division CVP, Surface Geology. June 20.

Water and Power Resources Service. 1980b. Proposed Borrow Areas, Yokohl Dam and Reservoir. United States Department of the Interior, East Side Division CVP. June 25.

CHAPTER 9. GLOSSARY

A

Acre-foot—The volume of water necessary to cover 1 acre to a depth of 1 foot. Equal to 43,560 cubic feet, 325,851 gallons, or 1,233 cubic meters. Depending on location and lot size, an acre-foot is generally considered enough water to meet the needs of up to two California single-family households.

Affected environment—Existing biological, physical, social, and economic conditions of an area subject to change, both directly and indirectly, as a result of a proposed human action.

Afterbay – A pool of water at the base of a dam, specifically, water after it has passed through a turbine.

Air quality—Measure of the health-related and visual characteristics of the air, often derived from quantitative measurements of the concentrations of specific injurious or contaminating substances.

Alluvium—Soil particles transported and deposited by water.

Anthropogenic—Human-created.

Anadromous—In general, this term refers to fish such as salmon or steelhead trout that hatch in fresh water, migrate to and mature in the ocean, and return to freshwater as adults to spawn. Section 3403(a) of the CVPIA defines anadromous as "those stocks of salmon (including steelhead), striped bass, sturgeon, and American shad that ascend the Sacramento and San Joaquin rivers and their tributaries and the Sacramento-San Joaquin Delta to reproduce after maturing in San Francisco Bay or the Pacific Ocean."

Anadromous Fish Restoration Program (AFRP)—A program authorized by the CVPIA to address anadromous fish resource issues in Central Valley streams that are tributary to the Delta. This program is led by the United States Fish and Wildlife Service.

Applied Water (AW)—The quantity of water delivered to the intake of a city's water system or a farm headgate, the amount of water supplied to a marsh or other wetland, either directly or by incidental drainage flows.

Appropriative water rights—Water rights based upon the principle of prior appropriations, or "first in time, first in right."

Aquatic—Living or growing in or on the water.

Aquifer—A geological formation capable of producing and storing water.

Authorization—An act by the Congress of the United States which authorizes use of public funds to carry out a prescribed action.

B

Baseload—Most commonly referred to as baseload demand, this is the minimum amount of power that a utility or distribution company must make available to its customers, or the amount of power required to meet minimum demands based on reasonable expectations of customer requirements. Baseload values typically vary from hour to hour in most commercial and industrial areas.

Basin Irrigation Efficiency—Evapotranspiration of applied water divided by the net diversion.

Bay-Delta Plan Accord—In December 1994, representatives of the State and Federal governments and urban, agricultural, and environmental interests agreed to the implementation of a Bay-Delta protection plan through the SWRCB, to provide ecosystem protection for the Bay-Delta Estuary. The Draft Bay-Delta Water Control Plan, released in May 1995, superseded D-1485.

Beneficial use—Those uses of water as defined in the State of California Water Code (Chapter 10 of Part 2 of Division 2), including but not limited to agricultural, domestic, municipal, industrial, power generation, fish and wildlife, recreation, and mining.

Benthic—Bottom of rivers, lakes, or oceans; organisms that live on the bottom of water bodies.

Biological assessment—An evaluation, in accordance with Section 7 of the Endangered Species Act, to determine the potential presence of threatened or endangered species and the potential for a proposed action to affect its habitat.

Biological opinion—Document issued under the authority of the Endangered Species Act stating the United States Fish and Wildlife Service and/or the National Marine Fisheries Service finding as to whether a Federal action is likely to jeopardize the continued existence of a threatened or endangered species or result in the destruction or adverse modification of critical habitat. This document may include:

Critical habitat—A description of the specific areas with physical or biological features essential to the conservation of a listed species and which may require special management considerations or protection. These areas have been legally designated via Federal Register notices.

Jeopardy opinion—The United States Fish and Wildlife Service or National Marine Fisheries Service opinion that an action is likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat. The finding includes reasonable and prudent alternatives, if any.

No jeopardy opinion—United States Fish and Wildlife Service or NMFS finding that an action is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat.

C

CALFED—Joint Federal and State program to address water-related issues in the Delta of the Sacramento-San Joaquin rivers.

Candidate species—Plant or animal species not yet officially listed as threatened or endangered, but which is undergoing status review by the United States Fish and Wildlife Service or the National Marine Fisheries Service.

Carryover storage—Water remaining in storage at the end of the water year.

Catch—At a recreational fishery, refers to the number of fish captured.

Central Valley Habitat Joint Venture—As defined by Section 3403(c) of the CVPIA, "the association of Federal and State agencies and private parties established for the purpose of developing and implementing the North American Waterfowl Management Plan as it pertains to the Central Valley of California."

Central Valley Project (CVP)—As defined by Section 3403(d) of the CVPIA, "all Federal reclamation projects located within or diverting water from or to the watershed of the Sacramento and San Joaquin rivers and their tributaries as authorized by the Act of August 26, 1937 (50 Stat. 850) and all Acts amendatory or supplemental thereto ...."

Central Valley Project service area—As defined by Section 3403(e) of the CVPIA, "that area of the Central Valley and San Francisco Bay Area where water service has been expressly authorized pursuant to the various feasibility studies and consequent congressional authorizations for the Central Valley Project."

Central Valley Project water—As defined by Section 3403(f) of the CVPIA, "all water that is developed, diverted, stored, or delivered by the Secretary in accordance with the statutes authorizing the Central Valley Project in accordance with the terms and conditions of water rights acquired pursuant to California law."

Central Valley Project Water Service Contractor—Water users that have contracted with the United States Bureau of Reclamation for water developed by and conveyed through CVP facilities.

Channel—Natural or artificial watercourse, with a definite bed and banks to confine and conduct continuously or periodically flowing water.

Confined aquifer—An aquifer bounded above and below by confining layers of distinctly lower permeability than the aquifer itself.

Confluence—The flowing together of two or more streams; the place of meeting of two streams.

Conjunctive water management—The planned and managed operation of a groundwater basin and a surface storage system combined through a coordinated conveyance infrastructure to maximize the efficient use of surface and groundwater resources.

Conserved water—That water resulting from the contractor operations and practices that results in less use of the allocated supply.

Conveyance capacity—The rate at which water can be transported by a canal, aqueduct, or ditch. In this document, conveyance capacity is generally measured in cubic feet per second.

Conveyance losses—Evaporation, evapotranspiration, and seepage losses in major conveyance canals.

Cooperating agency—An agency that meets the following criteria: (1) is included in 40 CFR Chapter V, Council on Environmental Quality (CEQ) Rules and Regulations, Appendix 1 - Federal and Federal-State agency National Environmental Policy Act (NEPA) contacts; and/or (2) has study area-wide jurisdiction by law or special expertise on environmental quality issues; (3) has been invited by the lead agency to participate as a cooperating agency; and (4) has made a commitment of resources (staff and/or funds) for regular attendance at meetings, participation in workgroups, in actual preparation of portions of the programmatic environmental impact statement (PEIS), and in providing review and comment on activities associated with the PEIS as it progresses. The role of the cooperating agency is documented in a formal memorandum of agreement with the lead agency.

Cost-of-service water rates—The water rate charged to recover all operating and capital costs, and individual contractor operating deficits, associated with the providing of water service. Components of operation and maintenance (O&M) and capital cost vary by contractor depending on services required for water delivery. Differs from full cost in that no charge for interest on capital is included.

Cubic feet per second—A measure of water flow. As a rate of streamflow, a cubic foot of water passing a reference section in 1 second of time. One cubic foot per second equals 0.0283 m^3/s (7.48 gallons per minute). One cubic foot per second flowing for 24 hours produces approximately 2 acre-feet of water.

D

Decision -1641 (D-1641)—The SWRCB decision specifying water quality standards for the Sacramento-San Joaquin Delta and Suisun Marsh.

Dedicated Water—Refers to the 800,000 acre feet of CVP yield identified in Section 3406(b)(2) of the CVPIA that the Secretary must dedicate and manage for the primary purpose of implementing the fish and wildlife purposes and measures of the act, to help California protect the Bay-Delta estuary, and to help meet legal obligations imposed on the CVP under State and Federal law, including the Federal Endangered Species Act (ESA).

Deep Percolation—Percolation of applied water and precipitation below the root zone of plants.

Deficiencies—Reductions in deliveries of contracted water. The amount of the reduction is expressed as the percent of full annual contract amount.

Delta—A low, nearly flat alluvial tract of land formed by deposits at or near the mouth of a river. In this report, delta usually refers to the delta formed by the Sacramento and San Joaquin rivers.

Density—The mass of a substance per unit of volume of that substance.

Depletion—Represents water consumed in a service area or no longer available as a source of supply.

Depletion study area—An analysis unit defined by the California Department of Water Resources for water resources planning investigations. Defined as the division of large drainage areas into smaller drainage and service areas from which water supplies and demands can be evaluated.

Dissolved oxygen (DO)—The concentration of free (not chemically combined) molecular oxygen (a gas) dissolved in water, usually expressed in milligrams per liter, parts per million, or percent of saturation. DO levels are considered the most important and commonly employed measurement of water quality and indicator of a water body's ability to support desirable aquatic life.

Dry-farmed—Crop production without the use of irrigation.

E

Endangered species—Any species or subspecies of bird, mammal, fish, amphibian, reptile, or plant which is in serious danger of becoming extinct throughout all, or a significant portion of its range. Federally endangered species are officially designated by the United States Fish and Wildlife Service or the National Marine Fisheries Service and published in the Federal Register.

Endemism—Native or limited to a certain region (endemic).

Enhancement—Measures which develop or improve the quality or quantity of existing conditions or resources beyond a condition or level that would have occurred without an action (i.e., beyond compensation).

Entrainment—The drawing of fish and other aquatic organisms into water diversions.

Environmental consequences—The impacts to the affected environment that are expected from implementation of a given alternative.

Environmental Impact Statement (EIS)—An analysis required by the National Environmental Policy Act (NEPA) for all major Federal actions, which evaluates the environmental effects of alternative actions.

Ephemeral stream—Intermittent or seasonal flow.

Epilimnion—The upper, wind-mixed layer of a thermally stratified lake. This water is turbulently mixed throughout at least some portion of the day and because of its exposure, can freely exchange dissolved gases (such as O_2 and CO_2) with the atmosphere.

Escapement—Number of salmon that actually return to a stream to spawn.

Estuary—A water passage where the tide meets a river current; an arm of the sea at the lower end of a river.

Evaporation—The change of a substance from the solid or liquid phase to the gaseous (vapor) phase.

Evapotranspiration (ET)—Water evaporated from plant surfaces or transpired by plant tissues.

Evapotranspiration of Applied Water (ETAW)—Portion of the evapotranspiration provided by the applied water.

Exotic species—Any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem, and whose introduction does or is likely to cause economic or environmental harm or harm to human health.

Extirpated species—A species that has become extinct in a given area.

F

Fallowed land—Cultivated land that lies idle during a growing season.

Field irrigation efficiency—The efficiency of water application. Computed by dividing the evapotranspiration of applied water by applied water and converting the result to a percentage. Efficiency may be computed at three levels: farm, district, or basin.

Fill—A man-made deposit of soil or other materials.

Firm water supplies—Non-interruptible water supplies guaranteed by the supplier to be available at all times except for reasons of uncontrollable forces or continuity of service provisions.

Fish ladders—A series of ascending pools constructed to enable salmon or other fish to swim upstream around or over a dam.

Fish passage facilities—Features of a dam that enable fish to move around, through, or over without harm. Generally an upstream fish ladder or a downstream bypass system.

Flow—The volume of water passing a given point per unit of time.

Instream flow requirements—Amount of water flowing through a stream course needed to sustain instream values.

Minimum flow—Lowest flow in a specified period of time.

Peak flow—Maximum instantaneous flow in a specified period of time.

Return flow—Portion of water previously diverted from a stream and subsequently returned to that stream or to another body of water.

Forebay—Water stored behind a dam, specifically, water intended to go through a turbine.

Fry—Life stage of fish between the egg and fingerling stages.

G

Geographic Information System (GIS)—A computer system which allows for input and manipulation of geographic data to allow researchers to manipulate, analyze and display the information in a map format.

Groundwater—Water stored below the ground surface.

Groundwater banking – Storage of water in the groundwater basin for later and planned use by intentionally recharging the basin.

Groundwater level—Refers to the water level in a well, and is defined as a measure of the hydraulic head in the aquifer system.

Groundwater management—The planned and coordinated management of a groundwater basin or portion of a groundwater basin with a long-term sustainability of the resource.

Groundwater overdraft—A condition of a groundwater basin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years.

Groundwater pumping—Quantity of water extracted from groundwater storage.

Groundwater recharge—The natural or intentional infiltration of surface water into the zone of saturation.

Groundwater storage—The quantity of water in the zone of saturation.

Groundwater table—The upper surface of groundwater.

H

Habitat—Area where a plant or animal lives.

Hypolimnion—The bottom, and most dense layer of a stratified lake. It is typically the coldest layer in the summer and warmest in the winter. It is isolated from wind mixing and typically too dark for much plant photosynthesis to occur.

I

Indicator species—Organism, species, or community that indicates presence of certain environmental conditions.

Interest group—An agency or other entity that has expressed an interest, verbally or in writing, in becoming more involved in the development of a planned project.

Intermittent or seasonal stream—Stream on or in contact with the groundwater table that flows only at certain times of the year when the groundwater table is high.

Irrigation water—Water made available from the project that is used primarily in the production of agricultural crops or livestock, including domestic use incidental thereto, and the watering of livestock. Irrigation water does not include water used for domestic uses such as the watering of landscaping or pasture for animals (e.g., horses) which are kept for personal enjoyment. It generally does not include water delivered to landholdings operated in units of fewer than 2 acres, unless the contractor establishes to the satisfaction of the contracting officer that the use of the water delivered to any such landholding is a use within this definition.

J

Juvenile—Young fish older than 1 year but not having reached reproductive age.

L

Land classification—An economic classification of variations in land reflecting its ability to sustain long-term agricultural production.

Land retirement—Permanent or long-term removal of land from agricultural production.

Level 2—A term used to refer to refuge water supply deliveries. The 1989 and 1992 Refuge Water Supply Studies define Level 2 refuge water supplies as the average amount of water the refuges received between 1974 and 1983.

Level 4—A term used to refer to refuge water supply deliveries. Level 4 refuge water supplies are defined in the 1989 and 1992 Refuge Water Supply Studies as the amount of water for full development of the refuges based on management goals developed in the 1980s. The CVPIA authorized purchase of the Level 4 increment, the difference between Level 2 and Level 4 amounts.

Limnology—Scientific study of the physical characteristics and biology of lakes, streams, and ponds.

Long-term contract—Contracts with terms of more than 10 years.

M

Main stem—The main course of a stream.

Mitigation—One or all of the following: (1) Avoiding an impact altogether by not taking a certain action or parts of an action; (2) minimizing impacts by limiting the degree or magnitude of an action and its implementation; (3) rectifying an impact by repairing, rehabilitating, or restoring the affected environment; (4) reducing or eliminating an impact over time by preservation and maintenance operations during the life of an action; and (5) compensating for an impact by replacing or providing substitute resources or environments.

Model—A tool used to mathematically represent a process that could be based on empirical or mathematical functions. Mathematical models can be computer programs, spreadsheets, or statistical analyses.

N

Natural production—As defined by Section 3403(h) of the CVPIA, "fish produced to adulthood without direct human intervention in the spawning, rearing, or migration processes."

Nonconsumptive water use—Water uses, including swimming, boating, water skiing, fishing, maintenance of stream-related fish and wildlife habitat, hydropower generation, and other uses that do not substantially deplete water supplies.

Nonrecoverable loss—Losses to salt sinks, or evaporation and evapotranspiration in conveyance and drainage canals. Expressed as a percentage of evapotranspiration of applied water.

O

Operating non-Federal entity—A non-Federal entity, such as a water district, that operates and maintains Federal facilities pursuant to an agreement with the United States.

P

Percolation—The downward movement of water through the soil to the groundwater table.

Perennial stream—Flows continuously throughout the year.

Place of use—The geographic area specified in a water right permit or license issued by the California State Water Resources Control Board, wherein the water may be used.

Point of diversion—The point along a river or stream that a water right permit or license specifies water may be diverted to areas away from the river.

Programmatic environmental impact statement—EIS prepared prior to a Federal agency's decision regarding a major program, plan, or policy. It is usually broad in scope and followed by subsequent more narrowly focused NEPA compliance documents such as site-specific environmental assessments and environmental impact statements.

Project repayment—The return to the Treasury of the reimbursable funds expended to construct, operate, maintain, and replace project facilities under the terms and conditions authorized by Congress plus other costs assigned by Congress.

Proposed action—Plan that a Federal agency intends to implement or undertake and which is the subject of an environmental analysis. Usually, but not always, the proposed action is the agency's preferred alternative for a project.

Public involvement—Process of obtaining citizen input into each stage of the development of planning documents. Required as a major input into any EIS.

R

Range—Geographic region in which a given plant or animal normally lives or grows.

Reasonableness criteria—Parameters established by the AFRP for determining the "reasonableness" of restoration actions. These parameters include consideration of potential adverse economic and social impacts, public sentiment, the magnitude of benefits, the certainty that an action will achieve projected benefits, and the authority established by existing laws and regulations.

Recharge—The processes of water reentering the voids in an aquifer, which causes the water table to rise in elevation.

Reclamation laws—As defined by Section 3403(I) of the CVPIA, "the Act of June 17, 1902 (82 Stat. 388) and all Acts amendatory thereof or supplemental thereto."

Reclamation Reform Act—The Reclamation Reform Act of 1982 (Public Law 97-293, 96 Stat. 1263) was signed by the President on October 12, 1982. While retaining the basic principle of limiting the amount of owned land that may receive irrigation water deliveries from Reclamation projects, the Act introduced the concept of full-cost pricing (including interest on the unpaid plant investment) for certain irrigation water deliveries to leased lands.

Record of Decision (ROD)—Concise, public, legal document that identifies and publicly and officially discloses the responsible official's decision on the alternative selected for implementation. It is prepared following completion of an EIS.

Redd—Depression in river or lake bed dug by fish for the deposition of eggs.

Refuge Water Supply Report—As defined by Section 3403(j) of the CVPIA, "the report issued by the Mid-Pacific Region of the Bureau of Reclamation of the United States Department of the Interior entitled Report on Refuge Water Supply Investigations, Central Valley Hydrologic Basin, California (March 1989)."

Repayment contract—As defined by Section 3403(k) of the CVPIA, "the same meaning as provided in sections 9(d) and 9(e) of the Reclamation Project Act of 1939 (53 Stat. 1187, 1195), as amended." See water service contract.

Reservoir—Artificially impounded body of water.

Reservoir storage capacity—Reservoir capacity normally usable for storage and regulation of reservoir inflows to meet established reservoir operating requirements.

Flood control storage capacity—Reservoir capacity reserved for the purpose of regulating flood inflows to reduce flood damage downstream.

Restoration Fund—As defined in Section 3403(l) of the CVPIA, "the Central Valley Project Restoration Fund established by this title."

Return flows—Water returned to the natural surface water system after use by the water user.

Riparian—Areas along or adjacent to a river or stream bank the waters of which provide soil moisture significantly in excess of that otherwise available through local precipitation.

Riparian water rights—Exists for lands which abut a waterway, or which overly an underground stream.

S

Sacramento River Settlement Contractors—Various irrigation districts, mutual water companies and other water users that hold Sacramento River Water Rights Settlement Contracts with the United States. The Settlement Contracts provide for the recognition of the contractors' underlying water rights to divert the natural flow of the Sacramento River, while also providing for a supplemental supply of Central Valley Project (CVP) project water during the summer months. Approximately 2.2 million acre-feet of water are diverted under the Settlement Contracts, serving approximately 440,000 acres between Redding and Sacramento.

Salmonids—Fish of the family *Salmonidae*, such as salmon, trout (including steelhead), and whitefish.

Scoping—The process of defining the scope of a study, primarily with respect to the issues, geographic area, and alternatives to be considered. The term is typically used in association with environmental documents prepared under the National Environmental Policy Act.

Secretary—The Secretary of the Interior.

Section 215 Water—Water defined under Section 215 of the Reclamation Reform Act of 1982 (RRA), as unstorable irrigation water to be released due to flood control criteria or unmanaged flood flows.

Seepage—Water that passes through canal lining, stream banks, or other holding or conveyance systems. Groundwater flow is a type of seepage.

Shasta Criteria—Establishes when a water year is considered critical, based on inflow to Shasta Lake. When inflows to Shasta Lake fall below the defined thresholds, the water year is defined as critical, and water deliveries to Sacramento River Water Rights and San Joaquin River Exchange Contractors may be reduced up to 25 percent. A year is critical when the full natural inflow to Shasta Lake for the current water year (October 1 of the preceding calendar year through September 30 of the current calendar year) is equal to or less than 3.2 million acre-feet. This is considered a single-deficit. A year is also critical when the accumulated difference (deficiency) between 4 million acre-feet and the full natural inflow to Shasta Lake for successive previous years, plus the forecasted deficiency for the current water year, exceeds 800,000 acre-feet.

Short-term contract—Contracts with a term of more than 5 years but less than 10 years.

Semiconfined aquifer—A condition where the movement of groundwater is restricted sufficiently to cause differences in head between different depth zones of the aquifer during periods of heavy pumping, but during periods of little draft the water levels recover to a level coincident with the water table.

Smolt—A juvenile salmon or steelhead migrating to the ocean and undergoing physiological changes to adapt its body from a freshwater to a saltwater environment.

Spawning—The releasing and fertilizing of eggs by fish.

Spill—Water released from reservoirs to comply with flood control criteria.

Spillway—Overflow structure of a dam.

Stream—Natural water course.

Subsidence—A local ground movement that involves principally the gradual downward settling or sinking of the earth's surface with little or no horizontal motion.

Surface water diversion—Total quantity of water removed from a stream.

Surface Water Return Flow—Percent of water that directly returns by surface to the stream.

T

Tailwater—Water immediately downstream of a dam.

Target Flows—Flow goals used in development of the Draft PEIS alternatives. The goals were based upon preliminary information developed for the AFRP Restoration Plan.

Temporary contract—Contract with a term of less than 5 years.

Threatened species—Legal status afforded to plant or animals species that are likely to become endangered within the foreseeable future throughout all or a significant portion of their range, as determined by the United States Fish and Wildlife Service or the National Marine Fisheries Service.

Tiering—Procedure which allows an agency to avoid duplication of paperwork through incorporation by reference of the general discussions and relevant specific discussions from an environmental compliance document of broader scope into a subsequent document of narrower scope.

Total supply—Total water supply available to area (surface water plus groundwater).

Transfers, sales, and exchanges—A transfer or sale is a one-way transaction to another contractor usually on an annual basis, but could be on a permanent basis. An exchange is a two-way transaction wherein a contractor transfers water to another contractor to be returned at a later date.

Tributary—A stream feeding into a larger stream or a lake.

Turnout—Structure along main canal system for distribution of water.

W

Warren Act—The Warren Act of February 1, 1911, provides authority to convey and store nonproject water within project facilities. Both nonproject M&I and irrigation water can be stored or conveyed in project facilities. Section 1 of the Warren Act requires Reclamation to charge water contractors for the cost of conveying nonproject water through project facilities. Unlike virtually all other CVP rates, Warren Act rate revenues are not creditable to project repayment and are returned directly to the United States Treasury.

Water acquisition—The purchase of water from willing sellers.

Watershed—A region or area bounded peripherally by a water parting and draining ultimately to a particular watercourse or body of water.

Water year—Usually when related to hydrology, the period of time beginning October 1 of one year and ending September 30 of the following year and designated by the calendar year in which it ends.

Wetland—A zone periodically or continuously submerged or having high soil moisture, and which has aquatic and/or riparian vegetation components, and is maintained by water supplies significantly in excess of those otherwise available through local precipitation.

Wildlife habitat—An area that provides a water supply and vegetative habitat for wildlife.

Willing sellers—A term used to describe individuals who would be interested in selling water supplies under transfer guidelines established by SWRCB and other regulatory agencies.

X

X2—Salinty criteria of two parts per thousand (2 ppt), which must be maintained in Suisun Bay during the spring runoff period (February through June).

THIS PAGE LEFT BLANK INTENTIONALLY