F I N A L

WATER SUPPLY STUDY

DEVELOPMENT OF WATER SUPPLY ALTERNATIVES FOR USE IN HABITAT RESTORATION FOR THE SAN JOAQUIN RIVER

Prepared for
Friant Water Users Authority
Lindsay, California

and

Natural Resources Defense Council Coalition
San Francisco, California

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URS Corporation
500 12th Street, Suite 200
Oakland, CA 94607

26812392.00600

PREFACE

This report has been prepared to assist the parties with time-sensitive settlement negotiations in NRDC v. Rodgers and to develop a consensus-based restoration plan for the San Joaquin river. This report is solely the work product of the authors, not the parties to NRDC v. Rodgers. There should be no inference that the analysis and conclusions contained in this report have been endorsed by any of the litigants. This report is intended to identify various alternatives, actions, opportunities, constraints and uncertainties, but is not intended to be a final water supply plan. Further study will be required prior to implementation of certain actions described in this report.

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Acronyms

AEWSD	Arwin-Edison Water Storage District
APE	area of potential effect
CDFG	California Department of Fish and Game
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CRHR	California Register of Historic Resources
CVC	Cross Valley Canal
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
Delta	Sacramento/San Joaquin Delta
DMC	Delta-Mendota Canal
DWR	California Department of Water Resources
ESA	Endangered Species Act
EWA	Environmental Water Account
FWUA	Friant Water Users Authority
IID	Imperial Irrigation District
MWD	Metropolitan Water District of Southern California
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NRDC	Natural Resources Defense Council
NRHP	National Register of Historic Places
NEA	Northwest Economic Associates
O&M	operation and maintenance
PG&E	Pacific Gas and Electric Company
Plan	Water Supply Plan
ppm	parts per million
PVID	Palo Verde Irrigation District
PVWMA	Pajaro Valley Water Management Agency
Reclamation	U.S. Bureau of Reclamation
RM	River Mile

RWQCB	Regional Water Quality Control Board
SCE	Southern California Edison
SCVWD	Santa Clara Valley Water District
SRF	State Revolving Fund
SWP	State Water Project
SWRCB	State Water Resources Control Board
TDS	total dissolved solids
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
VAMP	Vernalis Adaptive Management Plan
WSOT	Water Supply Oversight Team
WWD	Westlands Water District

Glossary

Bundle (Bundle Configuration). A bundle is a combination of water supply components (selected from one or more themes) that represents a complete, stand-alone water supply alternative.

Category 1 Water. A modeling assumption (purchase) that represents the direct offset of Friant water user demands. It is utilized every year on a constant monthly delivery pattern.

Category 2 Water. A modeling assumption (purchase) that also represents a potential offset of Friant water user demands. When applied as an Eastside source, it directly offsets Friant water user demands on a year-type basis and on an irrigation requirement pattern. When applied as a Westside source, it becomes a recirculation supply.

Category 3 Water. A modeling assumption (purchase) that satisfies water supply shortages after all other bundle elements have been utilized. It is fashioned to represent the consumptive pattern of several area crops and serves shortages that occur during the irrigation season.

Class 1 Water. A Friant Division annual water supply amounting to the first 800,000 acre-feet of yield from the San Joaquin River and Millerton Lake.

Class 2 Water. Contracted water amounting to 1,401,475 acre-feet of yield from the San Joaquin River that is met only after satisfying Class 1 obligations.

Common Elements. A set of components generally relying on existing facilities, including the reoperation of Friant Dam/Millerton Lake and related facilities, recovery and recirculation, water market purchases, reclamation, conjunctive use, and conservation. These components are common to all bundles.

Component. A component is a water supply infrastructure or management action (such as a new dam and reservoir or reoperation of an existing reservoir) that may or may not be complete in terms of its ability to satisfy water supply needs in and of itself.

Conservation Storage. The amount of reservoir storage utilized to manage inflow to a subsequent period for an intended use.

Eastside. The Eastside consists of land along the eastern side of the San Joaquin Valley. In the context of this analysis, the Eastside refers to the areas directly affected by the delivery of water from the Friant Division. This delivery area stretches from approximately the community of Chowchilla in the north to the Tehachapi Mountains in Kern County to the south.

Eastside Tributaries (San Joaquin River Basin). Eastside tributaries to the San Joaquin River include the Merced, Tuolumne, and Stanislaus Rivers. The Fresno and Chowchilla Rivers and overflow from the Kings River system also occasionally contribute to flows in the San Joaquin River.

Eastside Tributaries (Tulare Lake Basin). In the context of this analysis, the Eastside tributaries refer to the Kings, Kaweah, and Tule Rivers as they provide opportunities for water supplies.

Friant Dam. Friant Dam is a 319-foot-high concrete gravity structure completed by the USBR in 1942. The dam forms Millerton Lake, which is a reservoir with a storage capacity of 520,500 acre-feet. The dam and associated reservoir provide flood control and conservation storage and are used to divert water to the Madera and Friant-Kern Canals for irrigation of crops and to provide water to cities. The reservoir also serves as a recreation area, providing boating, fishing, picnicking, and swimming opportunities for the public.

Friant Division. The Friant Division, a unit of the United States Bureau of Reclamation's Central Valley Project (CVP), delivers water to over 1,000,000 acres of land along the Eastside of the San Joaquin Valley. This delivery area stretches from approximately the community of Chowchilla in the north to the Tehachapi Mountains in Kern County to the south.

Friant-Kern Canal. The Friant-Kern Canal conveys water southerly from Millerton Lake to areas in Fresno, Tulare, and Kern Counties. The canal has an initial capacity of 5,300 cubic feet per second (cfs) at its head works that decreases along its course to 2,500 cfs at its terminus at the Kern River.

Friant Service Area. The combined areas served by the Friant-Kern Canal and Madera Canal.

Groundwater Banking. Ground water banking is an important method for the conjunctive management of surface and groundwater. It consists of recharging stream flow into permeable aquifers during years of normal and surplus runoff and extracting it during dry years for beneficial use.

Madera Canal. The Madera Canal conveys water northerly from Millerton Lake to lands in Madera County. The canal has an initial capacity of 1,275 cfs at its head works that decreases to 750 cfs at its terminus at the Chowchilla River.

Mendota Pool. The Mendota Pool is created by the impoundment of Mendota Dam. Mendota Pool serves as the diversion point for several San Joaquin River prior-right holders and CVP contractors. Water is released from Mendota Dam to serve additional entities that divert at Sack Dam. Water can flow to the Mendota Pool from the San Joaquin River or from the Tulare Lake Basin (by way of Fresno Slough and the James Bypass). Mendota Pool is also the terminus of the Delta-Mendota Canal. During flood operations, Mendota Pool also receives inflow from the Kings and San Joaquin Rivers.

Residual Purchases. A modeling assumption (purchase) that satisfies all other water supply shortages that are caused by modeling limitations and anomalistic hydrology. Please see Section 6.1.6.3 for a more detailed description of residual purchases.

Residual Storage. A modeling result that depicts the amount of water that is developed by a bundle but remains unused within the study period. Residual storage occurs due to modeling limitations or because the storage of surplus flows occurs in a location that is not accessible to the entire Friant Division.

Sacramento–San Joaquin River Delta. The Delta encompasses the confluence of the Sacramento and San Joaquin Rivers. The Delta is about 1,150 square miles in area with over 700 miles of channels and sloughs. An annual average of 21 million acre-feet of water reach

the Delta, and a significant amount (an annual average of 5.4 million acre-feet) of this water is transported through the Delta for export at the SWP's Banks Pumping Plant and the CVP's Tracy Pumping Plant. Other water diversions from the Delta occur for in-Delta uses, the SWP North Bay Aqueduct, and the Contra Costa Canal.

San Joaquin River Hydrologic Region (DWR Bulletin 160-98 designation). The San Joaquin River Hydrologic Basin consists of basins draining into the San Joaquin River system from the Cosumnes River Basin in the north through the southern boundary of the San Joaquin River watershed.

Synthetic Hydrology. Hydrologic data that have been developed from other than direct measurement. At times hydrologic records for a particular parameter are missing or were not measured. Mathematical, statistical, or empirical relationships with another parameter may provide a way to synthesize the missing record.

Theme. The large number of components led to a strategy for packaging components according to a theme. A theme is a way of combining components to achieve a particular emphasis or objective. Themes were selected based on geography and functional operation. For example, one of the themes focused on reoperation of existing facilities to provide additional water supplies.

Tulare Lakebed. The Tulare Lakebed is a natural depression of land in the southern portion of the San Joaquin Valley that receives runoff from the Kings, Kaweah, Tule, and Kern Rivers during high-runoff years. The former lake bottom covered nearly 700 square miles. The lakebed is closed to the San Joaquin River to the north except for an outlet from the Kings River via the James Bypass and Fresno Slough. The lakebed also receives runoff from the Coast Range Mountains and areas to the west during large rain events. Tulare Lakebed is normally used for agricultural production. During flooding, inflows are contained in levee storage compartments to limit the amount of cropland that is inundated. Stored floodwaters are subsequently routed to adjacent lands for irrigation or are depleted by seepage and evaporation. The area considered in Bundle C is approximately 39 square miles.

Tulare Lake Basin. The Tulare Lake Basin is bounded on the south by the Kings-Kern County line, on the west by the California Aqueduct and the eastern boundary of Westlands Water District, on the north by the southern boundary of the Kings Basin, and on the east by the westerly boundaries of the Kaweah and Tule basins. The southern half of the Tulare Lake Basin consists of lands in the old Tulare Lakebed in Kings County.

Tulare Lake Hydrologic Region (DWR Bulletin 160-98 designation). The Tulare Lake Hydrologic Region is the closed drainage basin at the south end of the San Joaquin Valley, south of the San Joaquin River watershed, encompassing basins draining to the Kern, Tulare, and Buena Vista Lakebeds.

Urban Conservation. Urban conservation refers to those measures and practices that reduce the total water used by the urban community. Conservation can at times change the timing of water use or it can reduce the consumptive use of water.

Westside. In the context of this analysis, the Westside refers to the area and facilities affected by the SWP/CVP operation and thus potentially affected by restoration project use of recirculation.

1.1 INTRODUCTION

This Water Supply Study (Study) provides a pre-reconnaissance performance analysis of alternatives for supplying sufficient water to support restoration of San Joaquin River habitat and fisheries while not adversely impacting Friant Division water supplies. The prototypical water supply approaches presented in this Study are made up of combinations or "bundles" of alternative water supply projects (termed herein as project "components") that are designed to meet the overall hypothetical restoration requirements and water supply needs. One of the objectives of the Study is to identify water supplies available to the Study area and to identify ways to manage those supplies to accomplish the mutual goals of the Friant Water Users Authority (FWUA) and the Natural Resources Defense Council (NRDC) Coalition. The analysis was undertaken to establish a firm technical basis for estimating the comparative ability of the alternative approaches to achieve those goals and to identify potential impacts. These alternatives may be reconfigured and modified as a result of further evaluation and negotiation between the parties. It is understood that some or all alternatives may have impacts on the regional economy, the environment, or other parties that may require mitigation or reconfiguration. It is also understood that the impacts of any or all of the alternatives cannot be adequately evaluated without also evaluating other impacts, including but not limited to flood control, recreation, and restoration of flows and environmental values to the San Joaquin River below Friant Dam.

The Study has been prepared by URS Corporation and its subconsultants, herein referred to as the Consultant Team, with input and direction from the Water Supply Oversight Team (WSOT) (see Section 10, "Preparers of Study"). The WSOT consists of members representing the FWUA, the NRDC Coalition, the San Joaquin River Exchange Contractors Water Authority, the Natural Heritage Institute, and the U.S. Bureau of Reclamation (USBR). Neither the FWUA nor the NRDC Coalition, nor any other reviewer, has approved or endorsed any of the findings of this Study.

The purpose of this Study is to provide FWUA, the NRDC Coalition, and other interested parties with information to help guide future planning efforts. This document does not attempt, and should not be interpreted as attempting, to propose any specific water supply alternative as a final, preferred alternative.

1.1.1 PROJECT HISTORY

The San Joaquin River is one of California's largest rivers with a drainage area of over 11,400 square miles at Vernalis and includes the Stanislaus, Tuolumne, and Merced rivers as major tributaries. In the 1940s, the USBR built Friant Dam just northeast of Fresno. Friant Dam diverts most of the flow of the upper river (drainage area 1,632 square miles) to support thousands of farms and several municipalities on the east side of the San Joaquin Valley.

In 1988, NRDC and 14 other conservation and fishing organizations filed a lawsuit, *NRDC v. Patterson*, Civ. No. S-88-1658 LKK (E.D. Cal.) (Friant Litigation), challenging the renewal of USBR water contracts and the lack of sufficient fishery flows below Friant Dam. The Plaintiffs seek to restore riparian habitat and salmon runs to the main stem of the San Joaquin River below Friant Dam.

On or about October 12, 1999, NRDC, FWUA, and the other parties to the Friant Litigation requested that the United States District Court for the Eastern District of California issue an interim stay in the Friant Litigation for the purpose of implementing the Restoration Work Plan agreed upon by the parties on or about October 7, 1999. The temporary stay in the eleven-year legal battle was subsequently entered by the U.S. District Court. The development of this Water Supply Study has proceeded as a consensus process consistent with the following steps outlined in the October 1999 Restoration Work Plan:

- Ongoing Public Outreach
- **Develop Historical and Existing Conditions**
- Scope Restoration Elements for San Joaquin River
- Develop San Joaquin River Restoration Plans
- Refine Restoration Plans
- **Scope San Joaquin River Water Supply Options**
- **Develop a Long List of Potential Water Supply Options**
- **Develop Short List of San Joaquin River Water Supply Plans**
- **Analyze the Short List of Water Supply Options**
- Integrate the Restoration Plans with the Short List of Water Supply Options
- Prepare a draft Settlement Plan

The steps included in this Study are shown in boldface. Consistent with these steps, technical memoranda were prepared to report on the preliminary results and to obtain input from the WSOT, leading to the development of the Study. Key memoranda used for this Study are:

- *Preliminary Water Supply Screening Criteria: Technical Memorandum 6 for the Development of Water Supply Alternatives for Use in Habitat Restoration for the San Joaquin River.* October 19. URS. 2000a.
- *Preliminary Long List of Alternatives: Technical Memorandum 3 for the Development of Water Supply Alternatives for Use in Habitat Restoration for the San Joaquin River.* October 20. URS. 2000b.
- *Technical Memorandum 7: Revised Screening Criteria and Value Scales Methodology, Development of Water Supply Alternatives for Use in Habitat Restoration for the San Joaquin River.* November 20. URS. 2000c.
- *Technical Memorandum 4: Draft Long List of Alternatives, Development of Water Supply Alternatives for Use in Habitat Restoration for the San Joaquin River.* November 22. URS. 2000d.
- *Technical Memorandum 5: Analysis of Long List Alternatives, Development of Water Supply Alternatives for Use in Habitat Restoration for the San Joaquin River.* May 24. URS. 2001a.
- *Technical Memorandum 8: Approved Short List Alternatives, Development of Water Supply Alternative for Use in Habitat Restoration for the San Joaquin River.* June 11. URS. 2001b.

The application of these materials to the alternatives development process is explained in Section 5. Additional technical memoranda were prepared to support the development of the work products cited above, including an initial literature review and agency survey.

This Study documents the key conclusions for each of the Work Plan steps in boldface in the main text with additional information provided in the appendices.

1.1.2 PROJECT AREA

The geographic scope for the restoration planning effort of the San Joaquin River extends from Friant Dam to the Sacramento/San Joaquin Delta. The focus for habitat restoration analysis and planning is the San Joaquin River from Friant Dam to the river's confluence with the Merced River. These areas are shown in Figure 1-1.

Development of water resources in the San Joaquin River basin started about 130 years ago. Friant Dam is a 319-foot-high concrete gravity structure completed by the USBR in 1942. The dam forms Millerton Lake, which is a reservoir with a storage capacity of 520,000 acre-feet. The dam and its associated reservoir provide flood control and conservation storage and are used to divert water to the Madera and Friant-Kern Canals. The reservoir also serves as a recreation area, providing boating, fishing, picnicking, and swimming opportunities for the public (FWUA 1999).

Upstream reservoirs and Friant Dam/Millerton Lake have significantly altered the downstream peak flows and flow durations since construction, resulting in substantial changes to the original riparian habitat and fishery. Since development of the Friant project, portions of several reaches of the San Joaquin River below Gravelly Ford are currently dry in all but the wettest years. Following construction of Friant Dam and the initiation of Friant Division operations, the remaining salmon on the main stem of the San Joaquin River ceased to exist.

Figure 1-1 presents the San Joaquin River system, including the service area of the Friant Division of the Central Valley Project. The Friant Water Users Authority represents the majority of the water users within the Friant Division.

1.1.3 IMPORTANT LIMITATIONS AND ASSUMPTIONS

There are important limitations and assumptions for the analyses and conclusions contained in this Study. These focus on the following:

- Assumptions regarding restoration water needs

The San Joaquin River supplemental release schedules referenced as "restoration demand" in this Study were used as the basis for developing and analyzing the various bundles. The supplemental release schedules are preliminary and hypothetical and are used for modeling purposes only. The schedules are not based on an accepted study of actual restoration water needs and as such are not intended to mandate a supplemental release. The supplemental releases are provided to represent release schedules that vary seasonally and with the annual availability of water.

- Water rights

This Study includes a number of components that are dependent upon securing water from sources both inside and outside the Friant Division. The general assumption in the Study is that all acquisitions of water from the holders of water rights on any river that are the subject of this Study will be cooperative and voluntary, and that no water rights holders will be harmed by the alternatives. There is no intention to endorse involuntary transfers, exchanges, or acquisition of water to benefit the San Joaquin River restoration effort. Place of use and water rights are assumed to be resolvable when specific projects are studied. These projects are intended to be achieved through mutually beneficial programs with local entities.

- Modeling assumptions

The gaming model used in the development of the Study was a precursor to the long-term operational model. The focal point of the analysis is the understanding of expected costs and benefits of the bundles through long-term monthly operational modeling. The analyses were performed using a spreadsheet model that depicts different physical and operational systems. The basic operational requirement of the long-term modeling is to meet the demands for both restoration of the river and Friant-related water deliveries to Friant water users. See Section 6.1 and Appendix C. Meeting the water demands is accomplished through additional management of flows with facilities and the purchase of water.

- Engineering limitations

Only the most basic conceptual engineering has been performed to date on the components necessary to implement the various bundles considered in this Plan. See Section 2.4.3.

- Environmental limitations

Only limited research has been performed regarding the potential environmental impacts of the components of the various bundles. No site-specific investigations have been performed. Investigations of special-status species and cultural resources at possible new storage facilities were based on literature searches. Water quality and land use concerns are identified based on readily available information. Detailed analyses of effects on water quality, flood control, recreation, and other resources have not been conducted at this stage in the planning process.

- Economic limitations

Only limited analysis has been performed regarding the potential costs of the components of the various bundles. No evaluation of the overall economic impacts of implementing the water supply bundles, in conjunction with restoring flows and environmental values to the San Joaquin River below Friant Dam, has been performed.

- Institutional limitations

Investigation of the institutional barriers to development of the components necessary to implement the various bundles has been limited to preliminary contacts with a select group of potential stakeholders.

- Power limitations

For modeling purposes, power generation through certain existing and potential new facilities was evaluated. Impacts to existing individual power facilities—those owned by Friant Power Authority (FPA) and others—were minimally analyzed. Potential impacts and mitigation

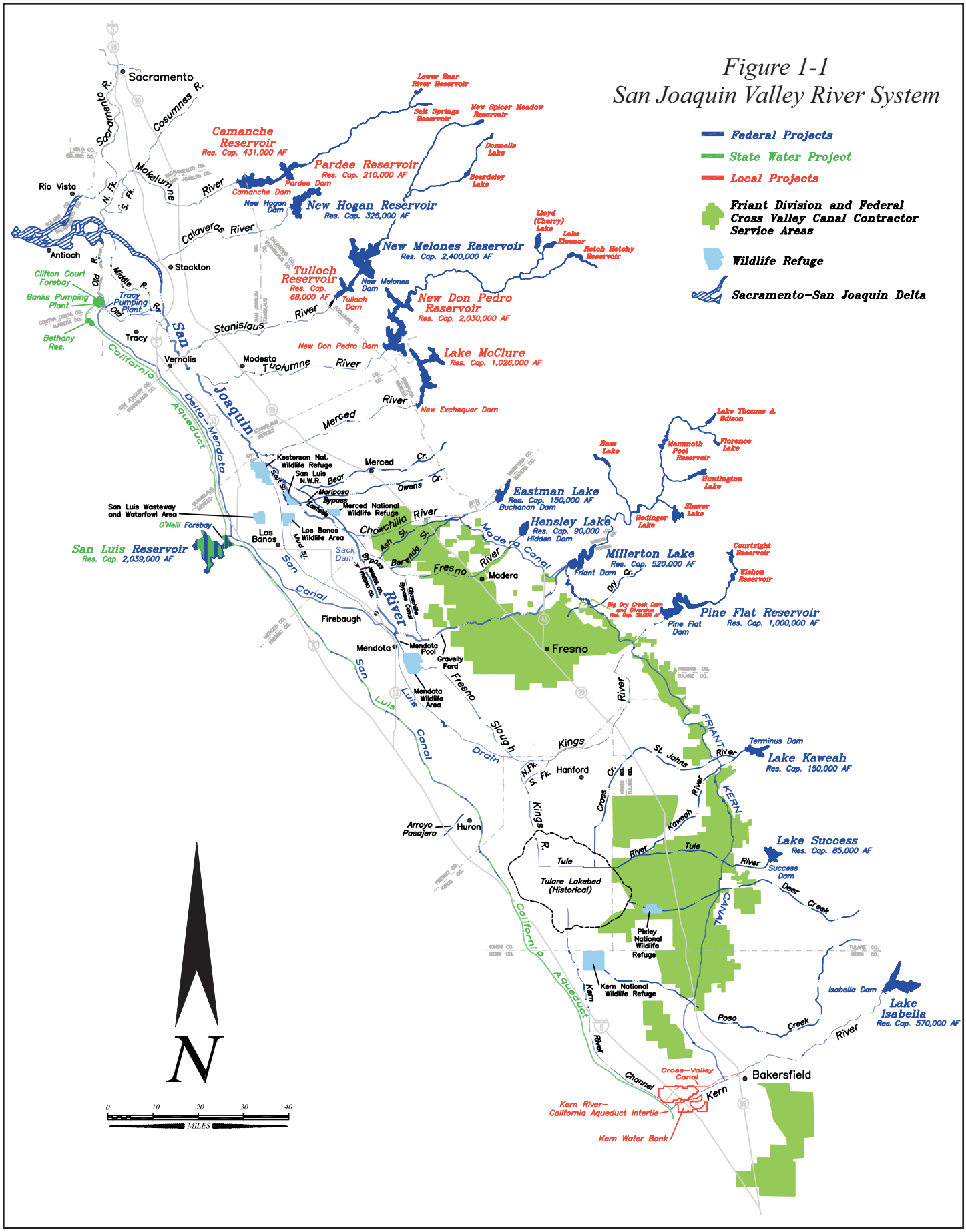
Figure 1-1
San Joaquin Valley River System
Federal Projects
State Water Project
Local Projects
Friant Division and Federal Cross Valley Canal Contractor Service Areas
Wildlife Refuge
Sacramento–San Joaquin Delta
Sacramento
Sacramento R.
Cosumnes R.
Mokelumne River
N. Fk.
S. Fk.
Rio Vista
Antioch
Stockton
Clifton Court Forebay
Banks Pumping Plant
Tracy Pumping Plant
Old R.
Middle R.
Bethany Res.
Tracy
Vernalis
Modesto
Merced
San Joaquin River
Stanislaus River
Tuolumne River
Merced River
Calaveras River
Camanche Reservoir
Res. Cap. 431,000 AF
Camanche Dam
Pardee Reservoir
Res. Cap. 210,000 AF
Pardee Dam
New Hogan Dam
New Hogan Reservoir
Res. Cap. 325,000 AF
Lower Bear River Reservoir
Salt Springs Reservoir
New Spicer Meadow Reservoir
Donnells Lake
Beardsley Lake
Lloyd (Cherry) Lake
Lake Eleanor
Hetch Hetchy Reservoir
New Melones Reservoir
Res. Cap. 2,400,000 AF
Tulloch Reservoir
Res. Cap. 68,000 AF
New Melones Dam
Tulloch Dam
New Don Pedro Reservoir
Res. Cap. 2,030,000 AF
New Don Pedro Dam
Lake McClure
Res. Cap. 1,026,000 AF
New Exchequer Dam
California Aqueduct
Delta-Mendota Canal
Kesterson Nat. Wildlife Refuge
San Luis N.W.R.
Bear Cr.
Mariposa Bypass
Merced National Wildlife Refuge
Owens Cr.
San Luis Wasteway and Waterfowl Area
O'Neill Forebay
San Luis Reservoir
Res. Cap. 2,039,000 AF
Los Banos
Los Banos Wildlife Area
Mud Slough
Sack Dam
Chowchilla River
Ash Slough
Berenda Slough
Fresno River
Madera
Madera Canal
Eastman Lake
Res. Cap. 150,000 AF
Buchanan Dam
Hensley Lake
Res. Cap. 90,000
Hidden Dam
Millerton Lake
Res. Cap. 520,000 AF
Friant Dam
Dry Cr.
Bass Lake
Lake Thomas A. Edison
Mammoth Pool Reservoir
Florence Lake
Huntington Lake
Shaver Lake
Redinger Lake
Courtright Reservoir
Wishon Reservoir
Big Dry Creek Dam and Diversion
Pine Flat Reservoir
Res. Cap. 1,000,000 AF
Pine Flat Dam
Fresno
Firebaugh
Mendota
Mendota Pool
Gravelly Ford
Mendota Wildlife Area
San Luis Canal
Fresno Slough
Kings River
Hanford
N. Fk.
S. Fk.
Kings R.
Cross Cr.
St. Johns River
Terminus Dam
Lake Kaweah
Res. Cap. 150,000 AF
Friant-Kern Canal
Kaweah River
Tule River
Lake Success
Res. Cap. 85,000 AF
Success Dam
Deer Creek
Tulare Lakebed (Historical)
Arroyo Pasajero
Huron
Pixley National Wildlife Refuge
Kern National Wildlife Refuge
Kern River
Poso Creek
Isabella Dam
Lake Isabella
Res. Cap. 570,000 AF
Bakersfield
Cross-Valley Canal
Kern River Channel
Kern River–California Aqueduct Intertie
Kern Water Bank
N
0 10 20 30 40
MILES

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measures for changed power operations should be fully evaluated before any water supply alternative is finalized and implemented.

The power required to deliver water is fully incorporated into the analyses. However, the assumed cost of providing that power is subject to the volatility of the power market. The costs associated with the energy consumption of a bundle should be viewed only as a benchmark for comparison between bundles.

- Other limitations

The conclusions presented in this Study represent the judgment of the Consultant Team with input from the WSOT and are not necessarily the same conclusions that would be reached by any individual members of the WSOT, any of the parties involved in negotiating the final plan, or other reviewers. The Draft Study was reviewed by the agencies and organizations involved in negotiating the plan, and numerous comments have been addressed in this and subsequent sections.

1.2 GOALS AND OBJECTIVES

The NRDC Coalition and the Central Valley Project (CVP) Friant Water Users Authority developed the following mutual goals statement to govern the settlement process:

> "The mutual goal of the parties is to expeditiously evaluate and implement, on a mutually acceptable basis, instream and related measures that will restore natural ecological functions and hydrologic and geomorphologic processes of the San Joaquin River below Friant Dam to a level that restores and maintains fish populations in good condition, including but not limited to naturally-reproducing, self-sustaining populations of chinook salmon. It is further the mutual goal of the parties to accomplish these restoration goals while not adversely impacting the overall sufficiency, reliability and cost of water supplies to Central Valley Project Friant Division water users.
>
> "In adopting this statement of mutual goals, the parties accept for purposes of this settlement only:
>
> 1. The goal of restoring and maintaining in good condition naturally-reproducing, self-sustaining chinook salmon in the San Joaquin River below Friant Dam may not be achievable;
> 2. The goal of not adversely impacting the overall sufficiency, reliability and cost of water supplies to the CVP Friant Division water users may not be achievable; and
> 3. The mutual goals may prove after study and investigation not to be fully compatible."

Study objectives indicate how these mutual goals are to be accomplished (independent of pilot projects or other experimental studies beyond the scope of this document). These objectives are:

- Identify and investigate a wide variety of water supply alternatives (i.e., a "long list" of alternatives), including management measures, that can directly or indirectly produce water for river restoration

- Develop a "short list" of water supply alternatives that can meet a hypothetical restoration hydrograph, provided to the water supply Consultant Team by the Restoration Oversight Team
- Evaluate these water supply alternatives for overall sufficiency, reliability, and cost impacts to CVP Friant Division water users
- Evaluate these water supply alternatives at a planning level for other potential environmental, engineering, and implementation concerns

1.3 HYDROLOGIC SETTING

Annual average precipitation within the San Joaquin River watershed varies from approximately 10 inches in the lower elevations to over 60 inches at higher elevations. November through March runoff is typically rain-driven while April through July runoff is typically from snowmelt. On average, 70 percent of the natural flow at Friant Dam occurs during the April through July snowmelt period. There is little natural local runoff between Friant Dam and the confluence with the Merced River between April and November in a typical year.

Natural runoff at Friant Dam averages approximately 1,780,000 acre-feet per year. Unimpaired runoff varies significantly from year to year, with over 4,600,000 acre-feet in 1983 and only 362,000 acre-feet in 1977 (water year 1909 through 2000). In addition to Millerton Lake (total storage capacity of 520,000 acre-feet), with a usable capacity of about 380,000 acre-feet, Southern California Edison and Pacific Gas and Electric Company operate reservoirs totaling over 600,000 acre-feet of storage upstream from Friant Dam. Millerton Reservoir is operated on an annual basis. It is not intended to carry over large volumes of water from year to year. The Friant Project is operated in conjunction with transfers, exchanges, and groundwater programs to provide a reliable water supply for irrigation and municipal use.

The Friant Unit employs a two-class system of water allocation. Class 1 water is the firm supply amounting to the first 800,000 acre-feet of yield from the San Joaquin River and Millerton Lake. Class 2 water develops only after the Class 1 allotment is fully met and provides up to 1,401,475 acre-feet of supply. During periods of excess supply, additional Friant water is made available to both long-term contractors and temporary contract users, and at times water is also diverted to the canals to minimize flooding along portions of the San Joaquin River. Water available in wet years is used to directly serve consumptive needs, is stored in the ground, or is used to offset groundwater pumping. In dry years, the groundwater basin is drawn on to meet water supply needs.

On an average basis, of the 1,780,000 acre-feet inflow to Millerton Lake, approximately 117,000 acre-feet are released to the river to satisfy downstream prior-right riparian water user and contractor demands between Friant Dam and Gravelly Ford, and 1,378,000 acre-feet are diverted to the Friant-Kern and Madera Canals. (The deliveries to the canals include water in excess of contracted Class 1 and Class 2 water during wet years.) The remaining 285,000 acre-feet are flood control releases that occur in approximately 40 percent of the years when water is released to the river in excess of minimum requirements due to Millerton Lake's limited capacity to manage all inflows.

The amount of irrigated Friant Division land varies depending on water availability. The amount of land irrigated in any given year varies only slightly due primarily to the conjunctive use of groundwater and surface water. Currently, up to 1,000,000 acres are planted, depending on water year type. This is down from the late 1970s and early 1980s, when 1,100,000 acres were planted in years with a good water supply.

Between 1949 and 1964 it is estimated that the groundwater storage under lands served by Friant contractors dropped by approximately 450,000 acre-feet. Since then, the groundwater storage is estimated to have been roughly in balance on an overall basis, although some Friant contractors have failed to recover from the drawdown of the water table during the 1987-1992 drought.

Releases to the San Joaquin River below Friant Dam are currently limited to that flow necessary to meet downstream contractor and riparian requirements, or flood control releases. The hypothetical restoration flow used for modeling purposes would result in an additional average annual release to the river of 349,000 acre-feet in a modified downstream river channel configuration and 445,000 acre-feet for the existing San Joaquin River channel (not including the existing 117,000 acre-feet of riparian and contractor demands). In the wettest 20 percent of years, the river can generally satisfy both the restoration flow and water users' demands. In the remaining years, the supply deficit to meet both demands averages between 200,000 and 300,000 acre-feet per year.

This Study evaluates alternatives for meeting the portion of the total demand that cannot be incidentally met by spills. Sources of supply include the capture and reuse of restoration flows for irrigation; the development of additional groundwater and surface storage to make use of occasional surplus flows at Friant Dam; the use of occasional surplus flows from the Kings, Kaweah, and Tule Rivers in the Tulare Lake Basin south of Friant Dam; the use of occasional surplus and Vernalis Adaptive Management Plan (VAMP) flows (provided for in the San Joaquin River Agreement) from the Merced River system north of Friant Dam; and water purchases. The purchases include urban conservation, agricultural conservation, and oil field water, long-term purchases (such as dry year options and contract entitlement purchases) and short-term purchases.

1.4 DEVELOPMENT OF ALTERNATIVES

In September 2000 the Consultant Team began development of a long list of alternatives. This list was subsequently screened to produce the short list of alternatives, and is described herein as part of the Study.

The process for development of the bundles contained in the Study included the following steps:

- Creation of a long list of 73 components
- Preliminary sorting of components into a series of 8 categories of alternatives by type of component
- Organization of the components into 16 packages based on a theme
- Refinement and review of the component packages
- Combination of component packages into 9 alternative water supply bundles
- Selection of a short list of five alternative water supply bundles (Bundles A, B, C, D, and E)

- Bundle refinement
- Analysis of the bundles

Each of the five bundles consists of a combination of water supply components that together represent a complete, stand-alone water supply alternative. Table 1-1 lists the five bundle configurations and components. The bundles evaluated in the short list are made up of combinations of the 19 components listed below. The bundles began with the concept of relying on existing facilities, including reoperation, recirculation, conservation, reclamation, and water purchases. This concept was expanded to include other components as necessary to meet restoration demand. Components listed in ***bold italics*** are the ones now common to all of the bundles considered.

- Facilities to store surplus water including ***(1) additional groundwater storage and extraction;*** (2) use of minimum or "dead" pool storage at Millerton; (3) development of storage at the Tulare Lakebed; (4) enlargement of Millerton and Mammoth Pool Reservoirs; and (5) construction of a new reservoir on Fine Gold Creek.
- Components to facilitate the capture, recirculation, and reuse of restoration flows and movement of surplus and purchased flows, including ***(6) use of existing Mendota Pool; (7) use of existing SWP and CVP conveyance and San Luis Reservoir; (8) use of existing Cross Valley conveyance facilities; (9) construction of pumping facilities to move water upstream in the Kern County portion of the Friant-Kern Canal; (10) construction of an intertie between the Friant-Kern Canal and Cross Valley Canal; (11) assumption of a storage account in the SWP/CVP projects (or with their contractors) to temporarily store the water developed by a bundle that is not otherwise useable;*** (12) use of existing SWP and CVP Delta pumping facilities; (13) construction of a new pumping plant from the San Joaquin River to the Delta-Mendota Canal near Patterson; and (14) expansion of the capacity of the Cross Valley Canal.
- Facilities to provide water to the system, including ***(15) water purchases (both short- and long-term); (16) reclamation of oil field water; (17) urban conservation; (18) improved on-farm conservation and irrigation efficiency (although recognized as a source of new water, it was not explicitly included in the modeling analysis as a separate category); (19) pump-in facilities at the Kings, Kaweah, and Tule Rivers;*** and (20) diversion and conveyance of Merced River water to areas served by the Madera Canal.

1.5 ANALYSIS OF ALTERNATIVES

A long-term hydrological model was used to analyze the ability of the various bundles to meet the river restoration and Friant Division water supply requirements and to estimate associated costs. The bundles were analyzed for two different river restoration requirements and two different assumptions about baseline Friant Division water supply requirements. The resulting four scenarios are titled Modified Channel/Base X Demands, Existing Channel/Base X Demands, Modified Channel/Base Y Demands, and Existing Channel/Base Y Demands. These four scenarios were used to cover the range of possible demands and constructed configurations of the San Joaquin River.

Table 1-1
Bundle Configurations

		COMPONENTS												
		Groundwater Storage and Extraction Programs	Mendota Pool Recirculation	Conveyance in CA and DMC/San Luis Storage	East and West Conveyance at Kern	Friant-Kern Canal Reverse Pumping	Eastside Tributary Pump-in	California Aqueduct Account	Water Purchases, Reclamation, and Water Conservation	Delta Recirculation	Millerton Minimum Pool Storage	Tulare Lakebed Storage and Conveyance	Millerton Enlargement/Mammoth Modifications	Fine Gold Reservoir
Bundle A:	Existing Facilities	■	■	■	■	■	■	■	■					
Bundle B:	Expanded Recirculation plus Millerton Minimum Pool	■	■	■	■	■	■	■	■	■	■			
Bundle C:	Tulare Lakebed Storage	■	■	■	■	■	■	■	■	■		■		
Bundle D:	Millerton Enlargement/Mammoth Pool	■	■	■	■	■	■	■	■	■			■	
Bundle E:	Millerton/Mammoth and Fine Gold	■	■	■	■	■	■	■	■	■			■	■
		COMMON ELEMENTS												

Figure 1-2 shows the sources of water used to meet the total river requirements below Friant Dam. The total river requirements are either an annual average of 466,000 or 562,000 acre-feet, depending on channel configuration. These flows include the 117,000 acre-feet of release required for current downstream riparian and contractor needs. Flow to meet the total river requirements include: (1) the release for current downstream riparian and contractor needs, (2) the conversion of spills into a controlled release, (3) recirculation to the Friant Division (reported as flow through the Cross Valley Canal), (4) purchases, and (5) water utilized from the Eastside tributary streams within the Friant Division. The development of water in excess of the total river requirement (a composite amount from all of the sources) manifests within the analysis as residual groundwater storage. This residual amount of storage corresponds to the volumes of water shown in Figure 1-2 that exceed the noted total river release requirement. Additional water developed by each bundle that becomes residual storage in SWP/CVP Westside facilities is not shown on Figure 1-2. Figure 1-3 depicts the average annual net costs of each bundle under the four different combinations of channel and demand scenarios. Please note that Figures 1-2 and 1-3 cannot be compared directly because they are based on fundamentally different assumptions about the operation of Friant Dam.

1.5.1 Bundle A

Bundle A consists of groundwater programs, capture of surplus water from the Kings, Kaweah, and Tule Rivers, recirculation of restoration flows utilizing Mendota Pool, use of SWP and CVP facilities, the Cross Valley Canal and upgrades to the Friant-Kern Canal, use of urban conservation water, agricultural conservation water, and water purchases (representing water efficiency programs and water purchases from a variety of sources) to meet the full restoration and water supply demands. As shown in Figure 1-2, this bundle relies to a greater extent on water purchases and to a lesser extent on recirculation for development of water supplies. These additional purchases are costly compared to capture and recirculation of restoration flows (Figure 1-3). This bundle has a consistently higher estimated cost than Bundles B, C, and D.

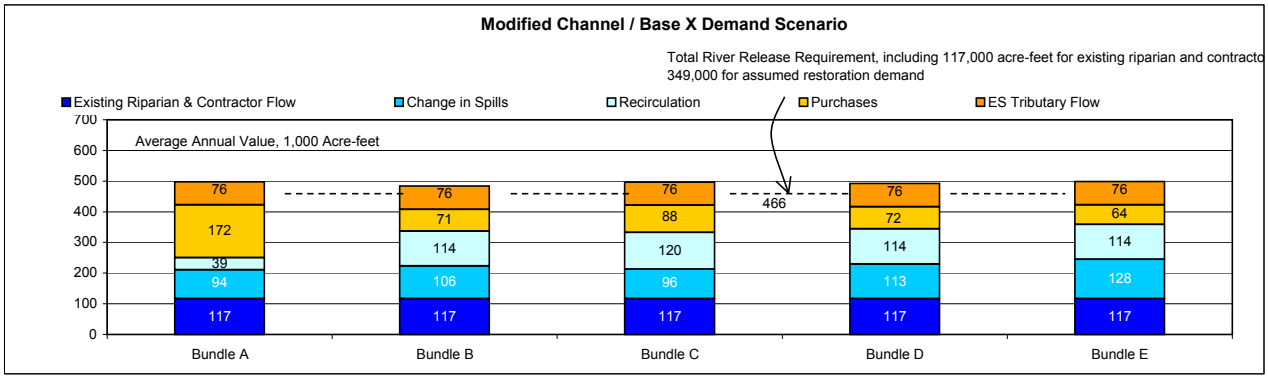
Primary implementation issues for Bundle A include the need for long-term multi-party agreements for recirculation; acquisition of surplus water from the Kings, Tule, and Kaweah Rivers; and negative effects on recreation that could result from consistently operating Millerton Lake at a lower average elevation.

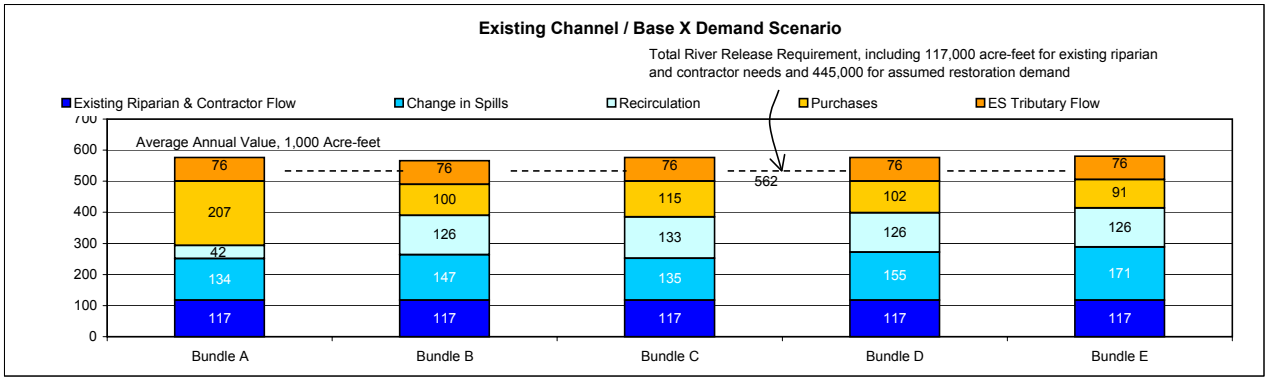
Bundle A is less reliable than the remaining bundles because of its greater reliance on water purchases. Water may not always be available at an acceptable price at a location suitable for transfer and use within the Friant Division service area. Alternative forms of purchases, such as long-term options and permanent acquisitions (such as those modeled) would have an effect on reliability.

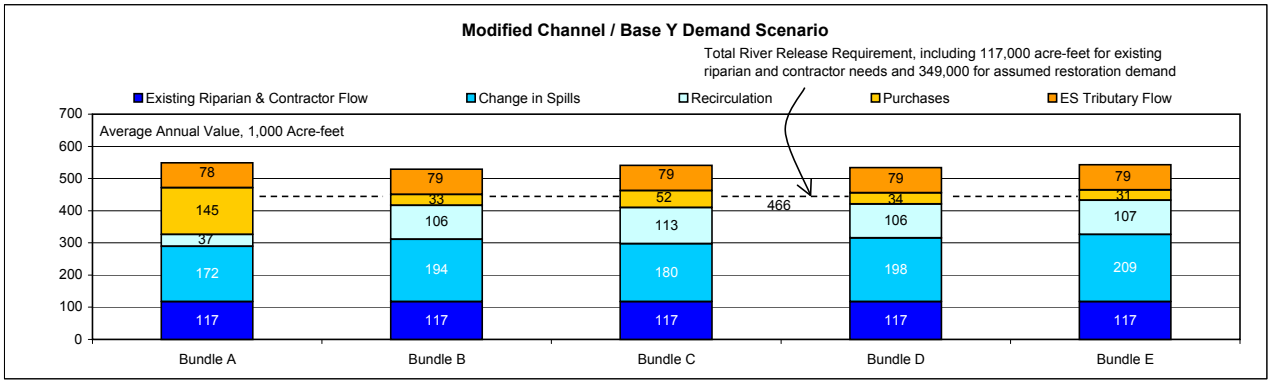
1.5.2 Bundle B

Bundle B adds components utilizing SWP and CVP Delta pumping facilities and 100,000 acre-feet of minimum pool storage within Millerton Lake to the base components included in Bundle A. The results show a significant reduction in the need for water purchases as more water is recirculated and additional water is conserved at Millerton. As shown in Figure 1-3, the estimated cost of this bundle is significantly lower than the cost of bundles A and E and slightly, but consistently, lower than the cost associated with Bundles C and D.

Figure 1-2 Sources of Water to Meet River Flow Requirements







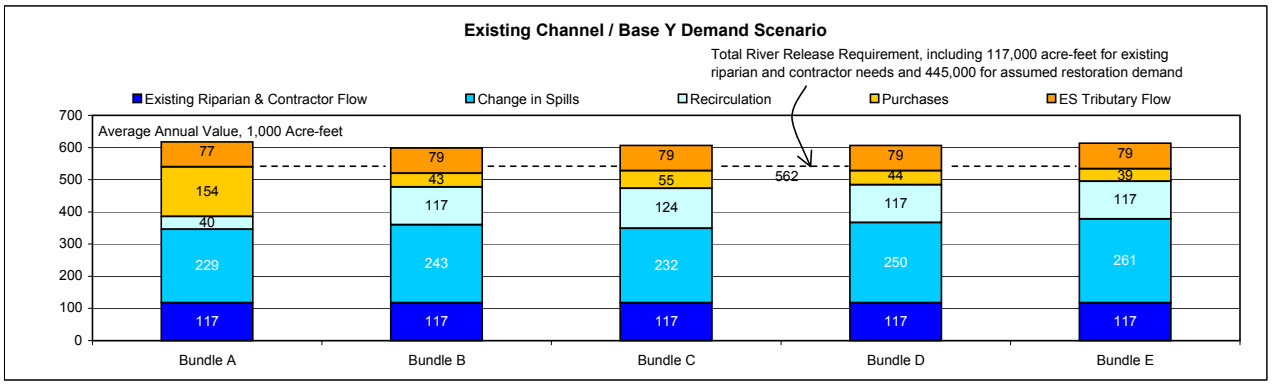


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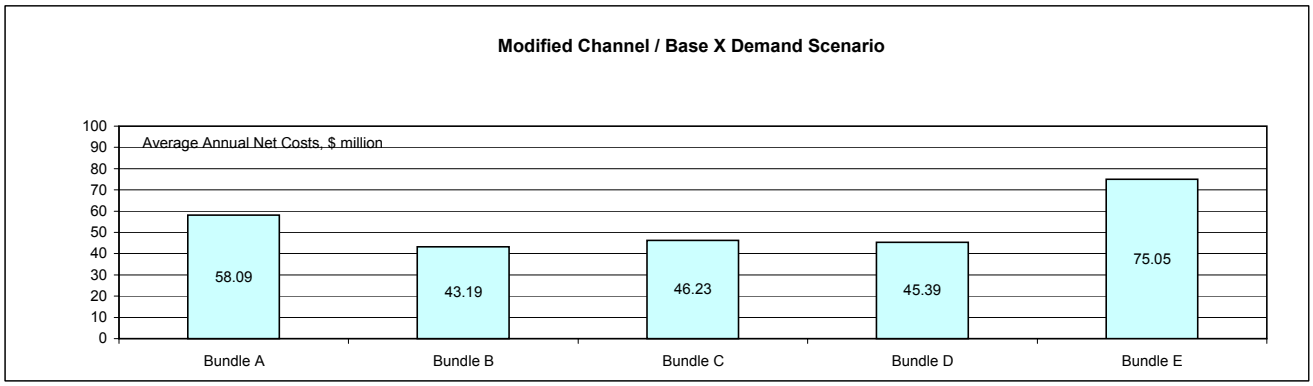
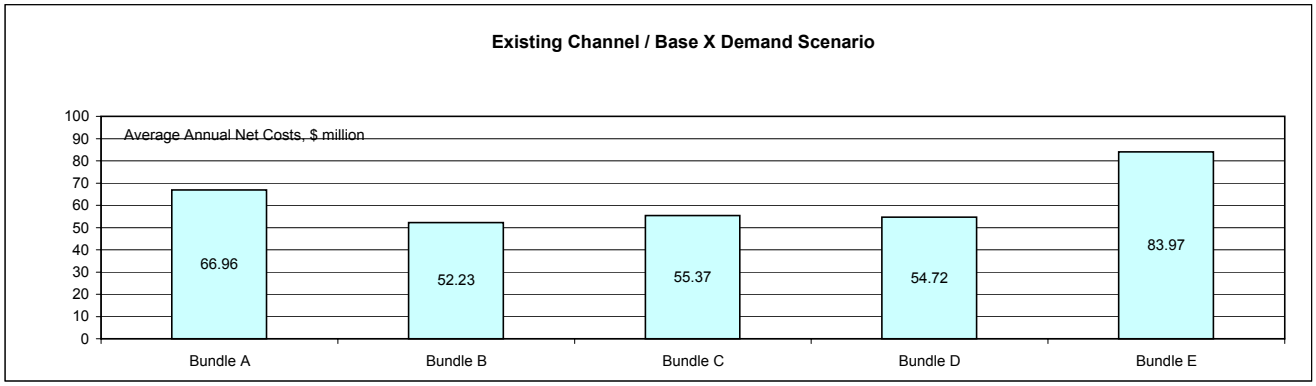
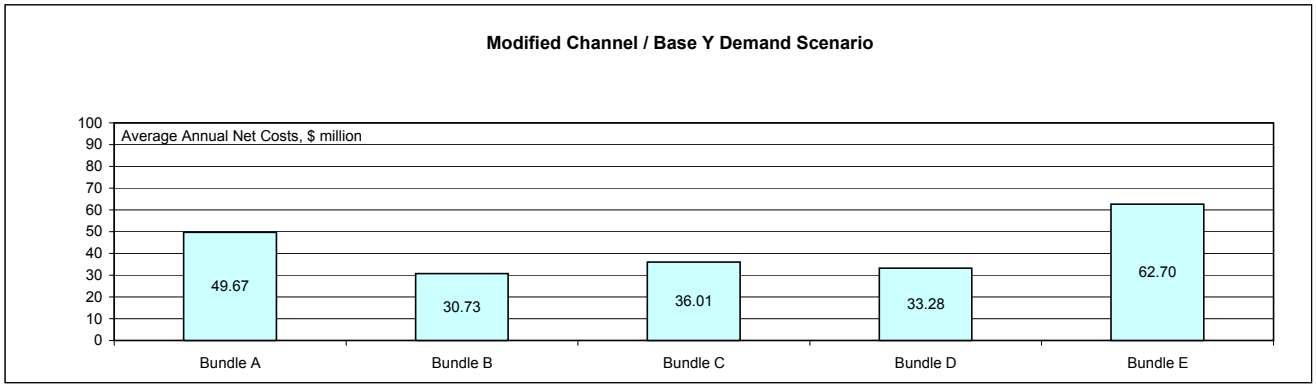
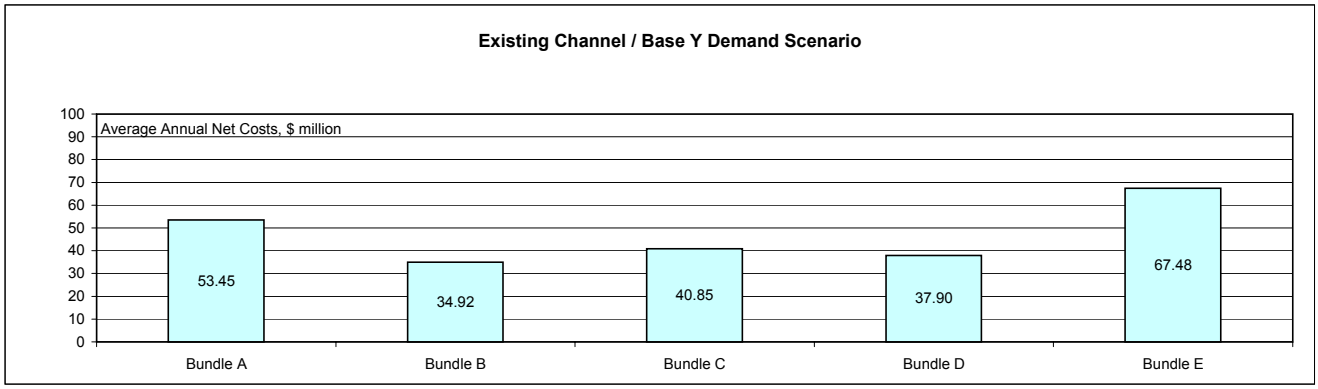
Figure 1-3 Average Annual Net Costs









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Bundle B shares the same implementation issues associated with Bundle A. Moreover, the potential negative recreation impacts are even more significant with Bundle B because Millerton Lake would be operated at an even lower elevation. In addition, there are significant engineering challenges associated with installing the pumping system necessary to effectively utilize minimum pool storage.

1.5.3 Bundle C

Bundle C adds components utilizing SWP and CVP Delta pumping facilities and 100,000 acre-feet of storage within the Tulare Lakebed to the base components included in Bundle A. As in Bundle B, the results show a significant reduction in the need for water purchases as more water is recirculated and additional water is conserved at the Tulare Lakebed. As shown in Figure 1-3, the estimated cost of this bundle is significantly lower than the costs of bundles A and E and slightly, but consistently, higher than the costs associated with Bundles B and D.

Bundle C shares the same implementation issues associated with Bundle A. Acquisition of a site within the Tulare Lakebed is the primary additional implementation issue associated with this bundle.

1.5.4 Bundle D

Bundle D adds components utilizing SWP and CVP Delta pumping facilities, 105,000 acre-feet of new storage from a raised Friant Dam, and 30,000 acre-feet of new storage from a raised water surface at Southern California Edison's Mammoth Pool to the base components included in Bundle A. As in Bundles B and C, the results show a significant reduction in the need for water purchases as more water is recirculated and additional water is conserved at Millerton and Mammoth Reservoirs. As shown in Figure 1-3, the estimated cost of this bundle is significantly lower than the cost of Bundles A and E and slightly, but consistently, lower than the cost associated with Bundle C, and higher than the cost associated with Bundle B.

Except for the recreation issues at Millerton Lake, Bundle D shares the same implementation issues associated with Bundle A. The recreation impacts are somewhat different because the larger reservoir results in an average water surface similar to existing operations. However, the raised water surface would flood many of the existing recreational facilities surrounding the lake. In addition, there are likely engineering, environmental, and institutional issues associated with raising the maximum water surface at these two existing reservoirs.

1.5.5 Bundle E

Bundle E adds a 400,000 acre-foot new reservoir at the confluence of Fine Gold Creek with Millerton Lake to Bundle D. As with Bundles B, C, and D, the results show a significant reduction in the need for water purchases as more water is recirculated and additional water is conserved at Millerton, Mammoth, and Fine Gold Reservoirs. As shown in Figure 1-3, the estimated cost of this bundle is significantly higher than the costs of the other bundles. This is because of the high capital cost associated with development of a major new storage facility compared to its incremental benefit of slightly reduced water purchases (in comparison to the other storage options).

Bundle E shares the same implementation issues associated with Bundle D. In addition, there are likely significant environmental and institutional issues associated with the construction of a major new dam.

1.5.6 Bundle Sensitivities

In addition to the five basic bundles, configuration sensitivity analyses show the effects of adding or subtracting components to the bundles. Incremental recirculation components are added to each bundle. Bundle A is tested for its sensitivity to Delta and Patterson recirculation, separately and combined. The other bundles are tested for their sensitivity to the addition of Patterson recirculation. The influence of not using Eastside Tributary surplus flow on the results is also determined for each bundle. Bundle B is tested for the effect of exercising an intertie with the Merced River system. Adding components of recirculation (either Delta alone, Patterson alone, or Delta and Patterson combined) to Bundle A decreases costs. However, this circumstance is primarily a comparison between the assumed cost and form of purchases and the costs of recirculation components. When added to the other bundles, incremental Patterson recirculation increases the costs of each bundle.

1.6 ECONOMIC ANALYSIS FRAMEWORK

Section 7 describes a conceptual basis for the future analysis of economic impacts and provides an analytical and methodological approach for the quantification of the impacts of the bundles. This section also identifies approaches and methodologies that may be used in a quantitative analysis at both the programmatic and the site-specific levels.

The conceptual framework presented focuses on those resource areas that are likely to be affected by the bundles. The assumed goal of the economic analysis is to provide a set of economic measures that can be used to compare the bundles. The bundles include a combination of construction, machinery and equipment installation, reservoir and facility operation, water acquisitions, and the resultant changes in water supplies. The primary resource areas likely to be affected include agricultural economics, surface water supplies and facilities, groundwater, fisheries, vegetation, recreation, regional economics, and the Sacramento/San Joaquin Delta.

- Agricultural economic impacts are likely to include changes in water use, cropping patterns, employment, and farm income. These impacts are expected to occur over both the short run and the long run, and they are likely to vary by type of water year. It is possible that agricultural water use changes will occur both inside and outside the study area.
- Changes in reservoir operation and river flows may have effects on recreation supply and demand. Recreation supply may change because access to reservoir and river recreation locations may change. Use of the recreation sites may be affected by those changes as well as availability and access to other sites, congestion, and quality and attractiveness.
- The regional economic impacts of the bundles (or components of various bundles) depend on the specific activities and their respective direct, indirect, and induced effects. The relative magnitudes of the three types of impacts are likely to vary depending on the specific sectors impacted (e.g., suppliers of purchased agricultural inputs, pumps and related hardware, and concrete and other construction materials).

The methodological approach recommended for the economic impact analysis includes different models and measurements.

- It is suggested that direct agricultural economic impacts be measured using a regional agricultural production model such as the Central Valley Production Model (CVPM). The economic impact estimates produced by a model should include changes in gross and net revenues, cropping mix, water use, and other farm-level variables. It is also suggested that focus groups be used to collect district- and farm-level primary data on responses to the bundles to improve the quality of the input data, to validate the model outputs, and to help define the sensitivity analyses to be run with the model.
- The approach to measure energy impacts may include models to assess power production in response to changes in reservoir operation or capacity. The construction and use of such models are outside the domain of economic impact analysis, although the outputs of those models will be critical to the analysis by reflecting the competing uses for water.
- The recreation impacts of the bundles may be important, and a detailed assessment of those impacts may require the consideration of both use and non-use values of recreationists. Changes in reservoir operation and capacity will likely influence the recreation "capacity" of the area as well as the relative attractiveness of the area to recreationists. Statistical relationships linking reservoir levels and population may be used to estimate recreation demand at reservoirs. A similar approach may be used to estimate riverine recreation demand. Other techniques may be required to estimate the non-use values associated with recreational sites.
- Measurement of regional economic impacts should include both the direct and the indirect impacts on each of the other resource areas. Applicable approaches for regional impact estimation include input-output analysis, multiplier analysis, and computable general equilibrium models.

1.7 IMPLEMENTATION

Implementation of the water supply measures identified in this Study or in future evaluations will require the necessary stakeholder support and a proactive approach to addressing the concerns of the affected parties. The issues that need to be addressed fall into four basic categories: environmental, institutional, engineering, and financial.

- **Environmental.** All of the proposed bundles include components having potential environmental issues that must be addressed through the CEQA-NEPA process. Environmental impacts are likely to be more significant for those components that involve major new construction or substantial changes to previous operations.
- **Institutional.** Institutional issues include resolution of water rights and water use concerns and negotiation of agreements for the use of facilities owned by others or obtaining approvals from other entities impacted by the construction or operation of the projects associated with a future water supply plan. For example, all bundles assume the use of "excess" capacity in facilities owned and operated as part of the State Water Project (SWP) and the Central Valley Project (CVP), including the California Aqueduct and San Luis Reservoir. Cooperation from

a number of entities is essential to successful implementation of any of the bundles considered.

- **Engineering.** Engineering issues relate primarily to the technical feasibility of a component and whether it can physically be constructed or operated as planned while meeting the required factors of safety for a facility of its type. At this point, many assumptions have been made based on general and/or incomplete data on foundation and site conditions, hydraulic performance, existing stability, and other engineering aspects. These issues must be addressed in greater detail for any bundle chosen for additional investigation.
- **Financial.** Financial issues relate to the economic feasibility of the proposed bundles and assignment of the costs of the bundles. Specifically, the issues to be addressed include how and by whom the various aspects of the project are to be funded, acceptable levels of financial risk, contingencies, and other financial issues.

Factors that need to be taken into account in implementing each of the proposed bundles identified in this Study include the following:

- **Water purchase arrangements.** Agreements for the purchase, transfer, or exchange of water supply can take any number of forms, as evidenced by the variety and creativity of historical agreements. These agreements vary in their duration, their price and payment terms, the frequency and timing of the actual transfers, and the allocation of financial and water supply risk between buyer and seller.
- **Capital improvements.** All of the bundles include capital improvement components. Although no "fatal flaws" have been detected for any of the components included in the bundles to date, risk is always associated with the implementation of any component. Such risks may be environmental, institutional, or engineering in nature.
- **Funding sources.** Whichever water supply alternative is ultimately selected, funding for the water supply will consist of three components: funds for water purchases, capital improvement funds, and operation and maintenance funds (including plan management).
- **Institutional arrangements.** Successful implementation of a plan for river restoration may require the establishment of a single entity with the responsibility and authority to carry out the plan. In addition to having the responsibility and the authority, this entity must be fully accountable for implementation. In any event, the implementation entity or entities (whether new or existing) would need to have the authority to:
  - Enter into contracts
  - Purchase and sell water
  - Lease, construct, operate, and maintain facilities
  - Manage funding, including obtaining state and federal funds, charging fees, and issuing and paying bonds
  - Perform additional studies

  The entity's responsibility would be to implement the plan. This includes implementing specific measures, priority setting based on available funds, monitoring and assessment of

success or failure, adaptive management, developing additional sources of funds, and reviewing plan performance on a periodic basis, such as annually.

- **Timing.** Components differ significantly in the time required for implementation. Short-term water purchases, and potentially other water purchases, can be implemented quickly, within 0-5 years. Other components, especially the construction of new surface storage facilities may take 5-10 years. These considerations indicate that a plan that can be adjusted over time may be necessary.

1.8 PRIORITIZATION OF ALTERNATIVES

This Study recommended steps for prioritizing the bundles for later studies and outlined a decision analysis screening methodology. This methodology consists of six steps explained herein. The objective is to see how the five bundles (i.e., short list of alternatives) described in Section 6 rank relative to each other according to several criteria, subcriteria, value scales, and the relative weights of the criteria/subcriteria. In summary, implementing the process for prioritization of the short list of alternatives involved developing the screening criteria (including agreement on project goals and objectives), developing the subcriteria, developing the values scales and weighting of criteria and subcriteria, and finally using this information to prioritize the bundles included in this Study.

The complete decision analysis process for the prioritization of alternatives consists of the following steps:

1. Define evaluation criteria/subcriteria and their scales
2. Develop a short list of bundles
3. Assess value scales for individual subcriteria
4. Assess the relative weights of criteria and subcriteria
5. Develop raw impact data for each bundle
6. Evaluate bundles and assist in prioritization of the bundles

Guidance for Step 6 is included in this Study to enable the WSOT to prioritize these or other bundle configurations as needed.

1.9 FUTURE PLANNING

The information contained in this Water Supply Study, along with the results of the parallel restoration study, may be used by FWUA and the NRDC Coalition to support the development of a comprehensive plan to restore flows and environmental values to the San Joaquin River below Friant Dam while not adversely affecting CVP Friant Division water users. The alternatives evaluated in this Study may be reconfigured and modified during the plan's development to constitute different alternatives for implementation. Furthermore, individual components of bundles may be evaluated and implemented separately.

1.10 CONSULTANT TEAM CONCLUSIONS

The following conclusions have been developed by the Consultant Team. Satisfaction of the assumed restoration flows and Friant water user demands requires the development of significant amounts of water. Conclusions regarding the relative viability of one bundle compared to another may change if significant changes in the demands occur.

- The model shows how total demand could be met with supply from the components in each bundle. Also, different amounts of long-term, fixed purchases are assumed in each bundle. The model uses short-term purchases to meet the demand after supply from all other sources is utilized. The analysis is then a matter of determining what facilities, programs, and arrangements are needed to implement a specific alternative and finding a viable means to fund the alternative.
- Additional conservation of currently surplus flows of the upper San Joaquin River and Tulare Lake Basin is a significant component of a supplemental supply. The conservation of these flows occurs primarily through increased groundwater storage programs. To develop the water determined in this analysis, the programs will need to be capable of storing 200,000 to 400,000 acre-feet annually when opportunities occur and withdrawing approximately 150,000 acre-feet per year for several sequential years. The required amount of storage capacity for a bundle can vary depending on the assumption for other bundle components, particularly water purchases. If water purchases are not assumed, total groundwater storage ranging between 2,800,000 and 3,800,000 acre-feet would be necessary to bridge the lengthy drought of 1924 through 1936, depending on the facilities included in a bundle. Long-term operation of the groundwater basin within the various bundle scenarios (and during the assumed hydrologic sequence) could lead to a positive balance ranging between 1,000,000 and 6,000,000 acre-feet.
- Surface water storage is effective in capturing surplus flows. However, the amount of water developed with surface storage is limited by the amount of water (spills) that can be captured in a year, or series of years, and carried forward into non-spill periods. Significant quantities of flow during long-duration periods of surplus flows remain uncaptured due to limitations in available space to capture the flows.
- Development of the Eastside tributary surplus flows contributes to the development of supplemental water; however, current surplus water at Friant nearly equals that potential. Modeling indicates that development of Eastside tributary surplus flows will functionally contribute to spills to the San Joaquin River. Development of the Eastside tributary surplus flows appears to be an opportunity within the bundles, but not a necessity.
- Capture and reuse of the restoration flows is also a significant contributor to developing supplemental water. Each additional component of capture opportunity (e.g., Mendota Pool, Delta, and Patterson) increases the reuse of restoration flows and thereby offsets potential water supply impacts. However, the recirculation component requires the institutional cooperation of several agencies and the physical availability of their facilities or construction of new facilities.
- Seasonal, temporary storage is needed to regulate recirculated water. Although modeling indicates that use of available space in San Luis Reservoir is most efficient, the availability of

alternative storage space (e.g., Tulare Lakebed) complements the component and would provide a backup opportunity should San Luis Reservoir storage not be available.

- The reoperation of Millerton Lake for the restoration demands will change the flow regime (both seasonal increases and decreases) of the San Joaquin River below Friant Dam, including the timing and availability of flow that otherwise may have been used at Mendota Pool or in the Delta as SWP and CVP supplies.
- There are significant long-term costs associated with implementation of a hypothetical restoration demand averaging between 349,000 and 445,000 acre-feet per year (which is in addition to the 117,000 acre-feet of release for existing downstream riparian and contractor needs). The three bundles that appear most cost-effective are Bundle B (Delta Recirculation and Millerton Minimum Pool Storage), Bundle C (Tulare Lakebed Storage), and Bundle D (Millerton Enlargement and Mammoth Pool Modifications).
- Review of the modeling results shows that a fourth cost effective bundle would likely consist of the Delta recirculation component added to Bundle A.
- Although the costs associated with an intertie with the Merced River system to Bundle B incrementally add to the cost of the bundle, the difference is well within the margin of error of the cost estimate. This component, when included on its own or as a substitute for another component included among the common elements, may reduce the overall cost of many or all of the bundles considered.
- Although the costs associated with adding Patterson recirculation to Bundles B through E incrementally add to the cost of the bundle, this component may be more cost-effective than the other components included among the common elements.

2.1 GENERAL

This Water Supply Study (Study) evaluates alternatives for providing sufficient water to support both San Joaquin River habitat and fisheries while not adversely impacting Friant Division water supplies. The alternatives presented in this Study are made up of combinations or "bundles" of alternative water supply projects or "components" that collectively meet the overall hypothetical restoration requirements and water supply needs. Hypothetical restoration requirements were established independently from the water supply investigations, and models were constructed to meet these restoration flows.

The Study has been prepared by URS Corporation and its subconsultants, herein referred to collectively as the "Consultant Team," with input and direction from the Water Supply Oversight Team (WSOT). The WSOT consists of members representing the Friant Water Users Authority (FWUA), the Natural Resources Defense Council (NRDC) Coalition, the San Joaquin River Exchange Contractors Water Authority, the Natural Heritage Institute, and the U.S. Bureau of Reclamation (USBR).

2.2 PROJECT HISTORY

The San Joaquin River is one of California's largest rivers, extending 267.5 miles from Friant Dam to the confluence with the Sacramento River in the Sacramento–San Joaquin River Delta. In the 1940s, the U.S. Bureau of Reclamation built Friant Dam just northeast of Fresno. The dam diverts most of the flow of the river to support thousands of farms and several municipalities on the east side of the San Joaquin Valley.

In 1988, the NRDC Coalition and 14 other conservation and fishing organizations filed a lawsuit, *NRDC v. Patterson,* Civ. No. S-88-1658 LKK (E.D. Cal.) (Friant Litigation), challenging the renewal of USBR water contracts and the lack of sufficient fishery flows below Friant Dam. The Plaintiffs seek to restore riparian habitat and salmon runs to the main stem of the San Joaquin River below Friant Dam. The other plaintiffs in the case are Trout Unlimited of California, the Bay Institute of San Francisco, California Natural Resources Federation, California Sportfishing Protection Alliance, California Trout, Friends of the River, Northern California Guides Associations, Pacific Coast Federation of Fishermen's Associations, San Joaquin Raptor Rescue Center, Sierra Club, Stanislaus Audubon Society, United Anglers of California, California Striped Bass Association, and National Audubon Society. The Friant Water Users Authority, the U.S. Department of the Interior, and the USBR, defendants in the case, were joined by 18 Friant Division irrigation districts as defendants/intervenors:

- Orange Cove Irrigation District
- Lindmore Irrigation District
- Lindsay-Strathmore Irrigation District
- Terra Bella Irrigation District
- Exeter Irrigation District
- Ivanhoe Irrigation District

- Tulare Irrigation District
- Lower Tule River Irrigation District
- Saucelito Irrigation District
- Delano-Earlimart Irrigation District
- Tea Pot Dome Water District
- Arvin-Edison Water Storage District
- Southern San Joaquin Municipal Utility District
- Shafter-Wasco Irrigation District
- Porterville Irrigation District
- Stone Corral Irrigation District
- Madera Irrigation District
- Chowchilla Water District

On or about October 12, 1999, NRDC, FWUA, and the other parties to the Friant Litigation requested that the U.S. District Court for the Eastern District of California issue an interim stay in the Friant Litigation for the purpose of implementing the Restoration Work Plan agreed upon by the parties on or about October 7, 1999. The temporary stay in the 11-year legal battle was subsequently entered by the U.S. District Court. The development of this Water Supply Study has proceeded as a consensus restoration process consistent with the steps outlined in the October 1999 Restoration Work Plan. Between October 1999 and September 2000, the FWUA and NRDC prepared and distributed a Request for Proposal and selected URS (prime contractor) to prepare a Water Supply Study.

Development of specific water supply alternatives began in September 2000 with the identification of a preliminary long list of 64 alternatives representing potential or existing projects, including surface and groundwater storage; reservoir reoperation; conveyance; watershed yield enhancement; and water acquisitions, transfers, exchanges, and management. The alternative projects and facilities (the components of the alternatives) were initially presented to the WSOT in October 2000 (URS 2000b).

On review of the preliminary long list by the WSOT, nine additional components were added to the list. The 73 components were then evaluated (URS 2000d) on the basis of cost, water yield, and opportunities and constraints to development and use.

The large number of components led to a strategy for packaging components according to a series of eight "themes." A theme is a way of combining components to achieve a particular emphasis or objective. For example, one of the themes focused on obtaining additional water supply solely from reoperation of the Friant Dam and reservoir. Themes were selected based on geography and functional operation. Substantial discussion of the themes and their associated options took place among the members of the WSOT from December 2000 through April 2001. The various themes considered were described in a technical memorandum for review by the WSOT in May 2001 (URS 2001a). In that document the Consultant Team analyzed the themes

for potential yield, costs, and implementation concerns. This analysis served as the basis for development of a short list of alternatives to be carried forward for further analysis.

The next step in developing and analyzing alternatives involved a process of combining the water supply components into a series of "bundles" of alternatives, each of which were developed to provide a target water supply. The bundling process consisted of combining the components into a short list of viable alternatives that meet the water supply objectives. As an initial step in the bundling process, members of the Consultant Team, the WSOT, and several stakeholder guests participated in interactive "gaming" exercises, which took place during two sessions (September 10–11 and October 1, 2001). The purpose of the gaming exercises was to identify and evaluate alternative means of developing water supply; to educate the participants in the many constraints on water conveyance and storage; to elicit and share information on opportunities for water exchanges and constraints on operations; and to identify protocols for exercising various water supply opportunities.

As a result of the gaming process and subsequent review by the WSOT, five bundles of alternatives were short-listed and evaluated using a long-term hydrological model with post-processing that includes estimated project costs to assess the long-term performance of each bundle. The results of this evaluation provide the basis for the development of this Study. An overview of the contents of this Study is presented in Section 2.5.

The final step in developing and analyzing alternatives was the evaluation of the short list alternatives with additional data collection and analysis presented in the Draft Study (URS 2002). The short list alternatives may be subjected to a prioritization process using detailed screening criteria and a weighting/ranking procedure developed and explained in two technical memoranda submitted to the WSOT (URS 2000c, 2000d) and in Section 9 of this document. The Study is scheduled for completion on October 10, 2002.

The Study will be evaluated together with the San Joaquin River Restoration Study to produce an integrated San Joaquin River restoration/water supply plan. The San Joaquin River Restoration Study is being produced by Jones & Stokes Associates, Inc., and Stillwater Sciences with guidance from a Restoration Oversight Team simultaneously with the Water Supply Study.

2.3 PROJECT AREA

The geographic scope for the restoration planning effort of the San Joaquin River extends from Friant Dam to the Sacramento/San Joaquin Delta (Delta). The focus for habitat restoration analysis and planning is the San Joaquin River from Friant Dam to the river's confluence with the Merced River. These areas are shown in Figure 2-1, prepared by FWUA.

Development of the water resources in the San Joaquin River basin started about 130 years ago. Friant Dam is a 319-foot-high concrete gravity structure completed by the USBR in 1942. The dam forms Millerton Lake, which is a reservoir with a storage capacity of 520,500 acre-feet. The dam and associated reservoir provide flood control and conservation storage and are used to divert water to the Madera and Friant-Kern Canals for irrigation of crops and to provide water to cities. The reservoir also serves as a recreation area, providing boating, fishing, picnicking, and swimming opportunities for the public (FWUA 1999).

Upstream reservoirs and Friant Dam/Millerton Lake have significantly altered the downstream peak flows and flow durations since construction. Since development of the Friant project, portions of several reaches of the San Joaquin River below Gravelly Ford are currently dry in all but the wettest years. Since 1999 this normal pattern has been changed by the implementation of small-scale pilot projects involving water releases and bypasses to support habitat restoration and water management studies. The Delta-Mendota Canal has been in operation since the mid-1950s. It maintains a perennial flow of imported Delta water in the reach of the river between Mendota Pool and Sack Dam during times of minimal Friant Dam release and minimal local San Joaquin River inflow.

The U.S. Army Corps of Engineers (USACE) and the USBR have constructed other dams, reservoirs, and canals on major streams flowing into the San Joaquin Valley from the east since the late 1940s, as authorized by Congress. Local and state levees and flood control projects have also been constructed. The result is a complex infrastructure that significantly alters the original river system. Congress acted to benefit the entire population of the San Joaquin Valley, and the nation as a whole, by securing storage areas for water supply to stimulate the economic growth of agriculture, to provide food and fiber, and to provide security from property damage and loss of life from periodic floods. However, the complex infrastructure also resulted in significant changes in riparian habitat and removal of salmon from the reaches of the river above its confluence with the Merced River.

Figure 2-2 is a schematic of the existing hydrology and infrastructure of the San Joaquin River and Tulare Lake Basin system with an emphasis on major existing facilities that are frequently referenced in subsequent sections of this Study.

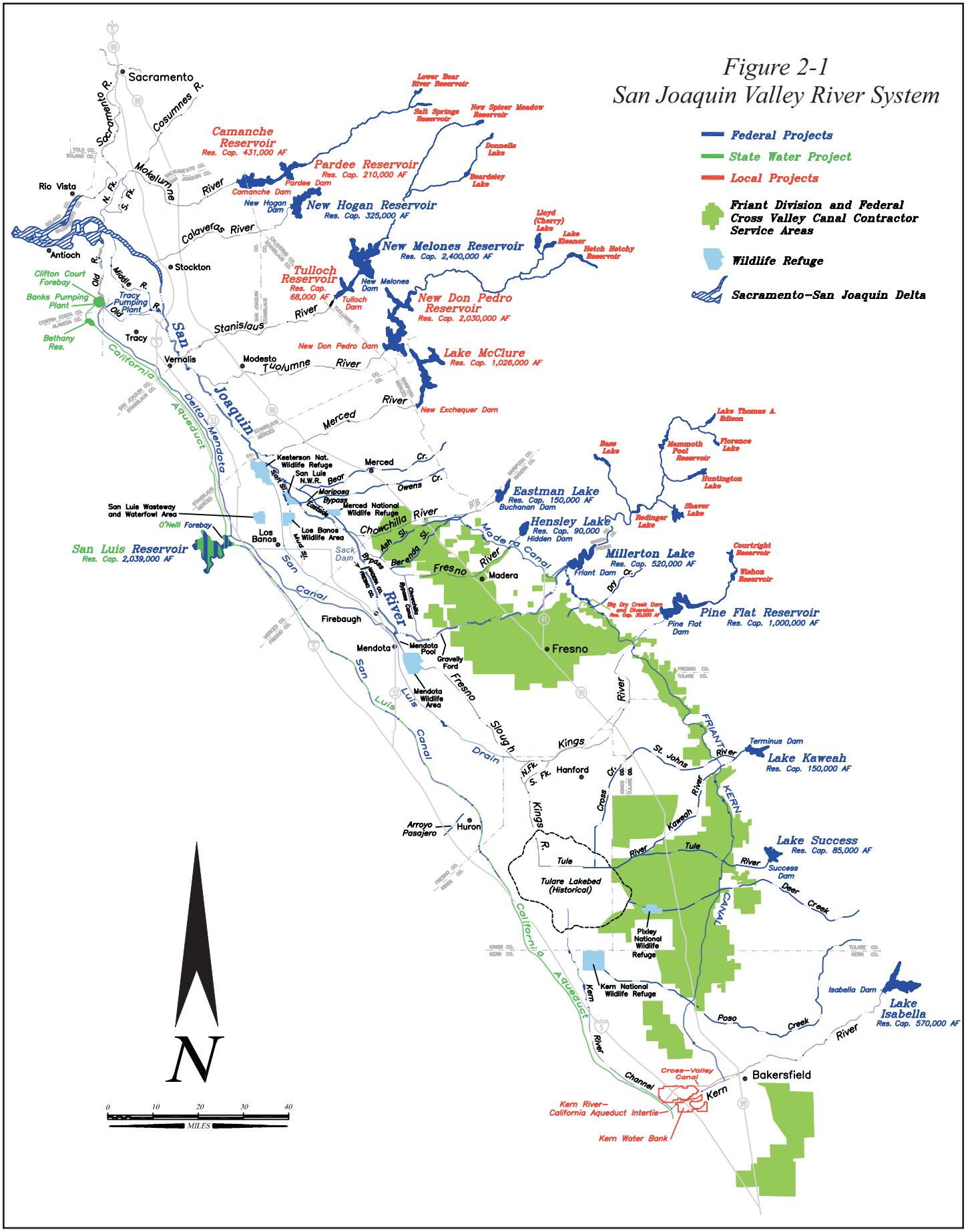
2.4 IMPORTANT ASSUMPTIONS AND LIMITATIONS

2.4.1 Assumptions Regarding Restoration Water Needs

The San Joaquin River supplemental release schedules referenced as “restoration demand” in this Study were used as the basis for developing and analyzing the various bundles. The supplemental release schedules are preliminary and hypothetical and are used for modeling purposes only. The schedules are not based on an accepted study of actual restoration water needs and as such are not intended to mandate a supplemental release. The supplemental releases are provided to represent release schedules that vary seasonally and with the annual availability of water. The release requirements used in this Study are described in Section 6.1.4.

2.4.2 Water Rights

This Study includes a number of components that are dependent upon securing water from sources both inside and outside the Friant Division. The general assumption in the Study is that all acquisitions of water from the holders of water rights on any river that becomes the subject of this Study will be cooperative and voluntary, and that no water rights holders will be harmed by the alternatives. There is no intention to endorse the study of involuntary transfers, exchanges, or acquisition of water to benefit the San Joaquin River Restoration Project. Place of use and water rights are assumed to be resolvable when specific projects are studied. These projects are intended to be achieved through mutually beneficial programs with local entities.



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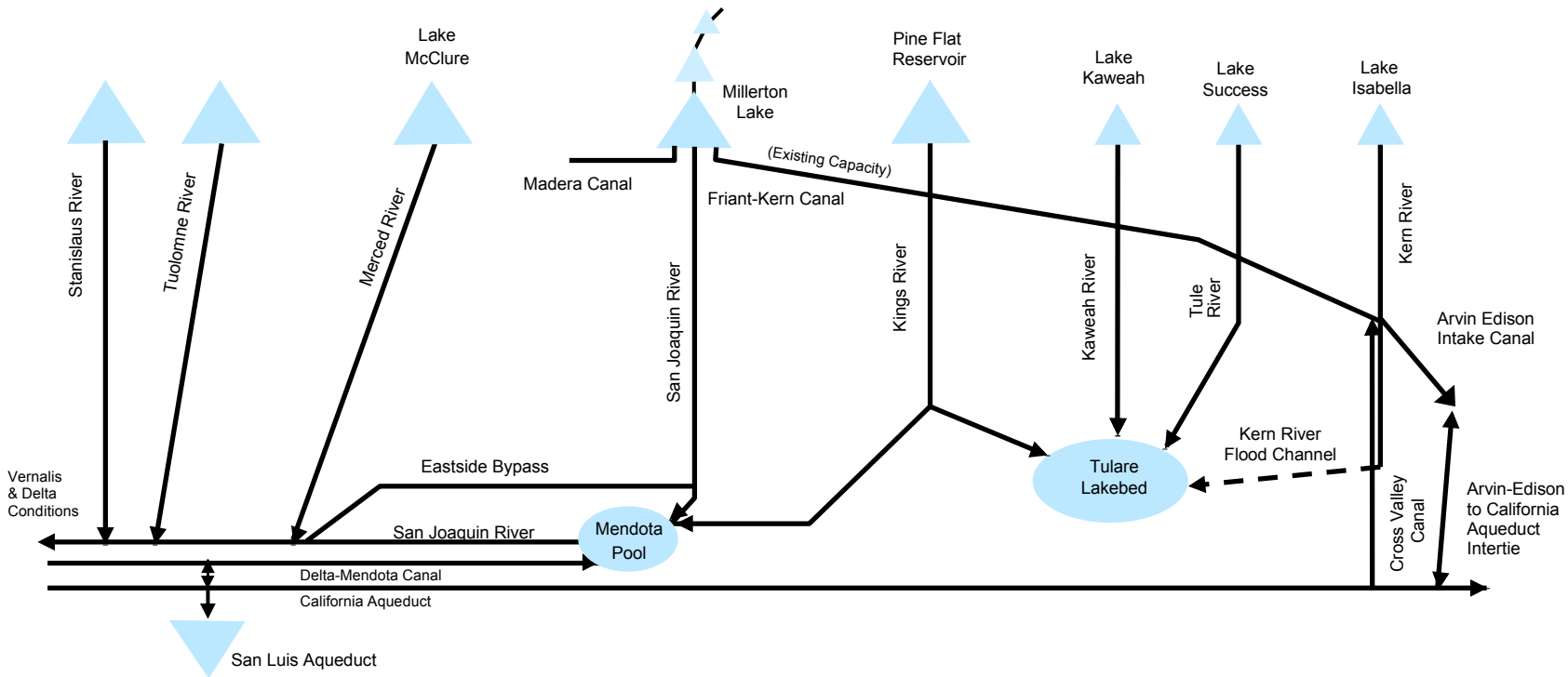

Figure 2-2
San Joaquin River and Tulare Lake Basin
Hydrology and Infrastructure

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2.4.3 Model Assumptions

The gaming model (Appendix B) used in the development of the Study was a precursor to the long-term operational model (Appendix C). The focal point of the analysis is the understanding of expected costs and benefits of the bundles through long-term operational modeling. The analyses were performed using a spreadsheet model that depicts different physical and operational systems. The basic operational requirement of the long-term modeling is to meet the demands for both restoration of the river and Friant-related water deliveries to Friant water users. See Section 6.1 and Appendix C for discussion of assumptions related to baseline canal diversions and Friant Division operations, restoration flow, costs, and water purchases and sales. Meeting the water demands is accomplished through additional management of flows with facilities and the purchase of water.

2.4.4 Engineering Limitations

Only the most basic conceptual engineering has been performed to date on the components necessary to implement the various bundles considered in this Study. The sizes and costs of new and upgraded facilities have been estimated based on preliminary layout sketches and unit costs for similar facilities. Although significant allowances for unidentified items and contingencies have been included, no site-specific investigations have been performed. In particular, no structural analyses have been completed on the overall stability of existing structures (i.e., existing dams and canals that might be impacted by an increase in water surface elevation), no geotechnical investigations have been performed at proposed sites for new facilities, and no detailed routing studies have been completed to define pipelines and canal alignments. See Section 2.4.3.

2.4.5 Environmental Limitations

Only limited research has been performed regarding the potential environmental impacts of the components of the various bundles. No site-specific investigations have been performed. Investigations of special-status species and cultural resources at possible new storage facilities were based on literature searches. Water quality and land use concerns are identified based on readily available information. Detailed analyses of effects on water quality, flood control, recreation, and other resources have not been conducted at this stage in the planning process.

2.4.6 Economic Limitations

Only limited analysis has been performed regarding the potential costs of the components of the various bundles. No evaluation of the overall economic impacts of implementing the water supply bundles, in conjunction with restoring flows and environmental values to the San Joaquin River below Friant Dam, has been performed.

2.4.7 Institutional Limitations

Investigation of the institutional barriers to development of the components necessary to implement the various bundles has been limited to preliminary contacts with a select group of potential stakeholders.

2.4.8 Power Limitations

For modeling purposes, total power generation through existing and potential new facilities was evaluated. Impacts to individual power facilities, those owned by Friant Power Authority (FPA) and others, were minimally analyzed. Potential impacts and mitigation measures for changed power operations should be fully evaluated before any water supply alternative is finalized and implemented.

The power required to deliver water is fully incorporated into the analyses. However, the assumed cost of providing that power is subject to the volatility of the power market. The costs associated with the energy consumption of a bundle should be viewed only as a benchmark for comparison between bundles.

2.4.9 Conclusions

The conclusions presented in this Study represent the judgment of the Consultant Team with input from the WSOT and are not necessarily the same conclusions that would be reached by any individual members of the WSOT, any of the parties involved in negotiating the final plan, or other additional reviewers. The Draft Study was reviewed by the agencies and organizations involved in negotiating the preferred alternative, and numerous comments have been addressed in this and subsequent sections.

2.5 SCOPE OF STUDY

This Study summarizes the information pertaining to development of the five alternative water supply bundles. The Study is based on the work presented in technical memoranda and combines the most promising of the long-list components (identified in the theme and gaming investigations) into a short list of bundles for more detailed investigation.

The remainder of this document is organized as follows:

- Section 3 presents a summary of the FWUA/NRDC Coalition goals for the project and a preliminary project “Purpose and Need” statement.
- Section 4 presents the project hydrology. This section reviews both the overall hydrology of the San Joaquin Basin and the specific hydrology associated with the San Joaquin River below Friant Dam and the areas served by the FWUA. This section also presents baseline conditions for the historical period 1922 through 1999 and shows how existing facilities might have been operated through this period if all present day facilities, demands, and requirements had been in place. In addition, this section reviews opportunities for making additional water available for river restoration.

- Section 5 describes the process used in developing the alternatives for meeting both river restoration needs and existing water supply requirements. This section also describes the selected bundles and the various components making up these bundles.
- Section 6 describes the gaming process and long-term hydrologic model that were used to winnow the many alternative project components comprising the themes down to a manageable number of preliminary bundles. Section 6 also presents the estimated costs to implement, operate, and maintain the various components considered in the bundles. In addition, this section presents the results of the analyses for each of the bundles investigated.
- Section 7 describes a conceptual basis for the future analysis of economic impacts and provides an analytical and methodological approach for the quantification of the impacts of the bundles. This section also identifies approaches and methodologies that may be used in a quantitative analysis at both the programmatic and the site-specific levels.
- Section 8 discusses issues associated with bundle implementation, including environmental, institutional, engineering, and financial issues. Section 8 also addresses water purchases, capital improvement programs, and preliminary arrangements for the establishment of an entity to implement the selected project.
- Section 9 describes the work remaining in the initial process that may need to be completed to obtain a preferred alternative.

This section discusses the overall goal of the Water Supply Study for the San Joaquin River and the related objectives that have guided the development of alternatives for this water supply planning project.

3.1 MUTUAL GOALS

The NRDC Coalition and the Central Valley Project (CVP) FWUA developed the following mutual goals statement to govern the settlement process:

> "The mutual goal of the parties is to expeditiously evaluate and implement, on a mutually acceptable basis, instream and related measures that will restore natural ecological functions and hydrologic and geomorphologic processes of the San Joaquin River below Friant Dam to a level that restores and maintains fish populations in good condition, including but not limited to naturally-reproducing, self-sustaining populations of chinook salmon. It is further the mutual goal of the parties to accomplish these restoration goals while not adversely impacting the overall sufficiency, reliability and cost of water supplies to Central Valley Project Friant Division water users.
>
> "In adopting this statement of mutual goals, the parties accept for purposes of this settlement only:
>
> 1) The goal of restoring and maintaining in good condition naturally-reproducing, self-sustaining chinook salmon in the San Joaquin River below Friant Dam may not be achievable;
>
> 2) The goal of not adversely impacting the overall sufficiency, reliability and cost of water supplies to the CVP Friant Division water users may not be achievable; and
>
> 3) The mutual goals may prove after study and investigation not to be fully compatible.
>
> "Nevertheless, the parties intend to further these mutual goals through the development of more specific objectives, a joint work plan, and mutually agreeable pilot projects beginning in the current year."

3.2 WATER SUPPLY PLANNING PROCESS

The water supply planning process initiated by the NRDC Coalition and the FWUA poses the following objectives to meet the mutual goals:

- Identify and investigate a wide variety of water supply alternatives (i.e., a "long list" of alternatives), including management measures, that can directly or indirectly produce water for river restoration
- Develop a "short list" of water supply alternatives that can meet a hypothetical restoration hydrograph, provided to the water supply Consultant Team by the Restoration Oversight Team
- Evaluate these water supply alternatives for overall sufficiency, reliability, and cost impacts to CVP Friant Division water users

- Evaluate these water supply alternatives at a planning level for other potential environmental, engineering, and implementation concerns

3.3 PROJECT PURPOSE AND NEED

The **purpose** of the water supply planning project is to:

- Identify sources of water to augment San Joaquin River flows below Friant Dam, and
- Identify methods of delivering or conveying that water to the San Joaquin River below Friant Dam, or to Friant Division water users in lieu of water released from Friant Dam

The **project is needed** to:

- Support restoration of ecological processes and fish populations on the San Joaquin River below Friant Dam
- Avoid adverse impacts to the overall sufficiency, reliability, and cost of water to Friant Division water users
- Involve interested public/stakeholders in understanding key issues and potential mechanisms for providing restoration flows

The development of water supply quantities and flow schedules is being conducted independent of a parallel planning process that is being carried out by the Restoration Oversight Team to produce the San Joaquin River Restoration Study. The Water Supply Study will be evaluated together with the San Joaquin River Restoration Study to produce an integrated San Joaquin River restoration/water supply plan. Currently under preparation, the Restoration Study focuses on identifying what needs to be done to restore the river and initially is not subject to water supply constraints. The hypothetical restoration flows were provided to the Consultant Team solely for the purposes of water supply modeling and are not intended to be a restoration flow recommendation. The hydrologic model that was used to analyze the alternative water supply bundles was constructed to meet a total demand consisting of given restoration flows and Friant Division water deliveries.

The objectives of this Study are to identify the water supplies available to the study area and to identify ways to manage those supplies to accomplish the mutual goals of the FWUA/NRDC Coalition. The analysis was done to establish a firm technical basis for estimating the comparative ability of the alternative approaches to achieve those goals and to identify potential impacts. These alternatives may be reconfigured and modified as a result of further evaluation and negotiation between the parties. It is understood that some or all alternatives may have impacts on the regional economy, the environment, or on water users that may require mitigation or reconfiguration.

The San Joaquin River Restoration Project is most commonly focused on the restoration of the reach of the San Joaquin River that stretches from immediately below Friant Dam to the confluence of the San Joaquin with the Merced River. Some of the restoration releases may provide biological benefits in the Lower San Joaquin River and the Sacramento–San Joaquin Delta. The restoration flows will affect the hydrology and water management of the entire San Joaquin River and Tulare Lake Basins and the portions of the state's water resources that are linked to the Sacramento–San Joaquin Delta. Given the increasing control of the water that enters and leaves the Delta, changes in releases from Friant Dam that alter these flows would affect other portions of the state's water system. In addition to the hydrologic effect that the project's releases would have on other entities in the Delta, the water supply alternatives evaluated in this Study rely on new facilities and the facilities of other entities to effectively accomplish the mutual goals of developing restoration flows while maintaining the water supply of Friant Division water users.

4.1 GEOGRAPHICAL SCOPE

The major focus of the Study is to demonstrate water supply alternatives ("bundles" of components that develop water) that provide restoration flows while maintaining the water supply of Friant Division water users. The components within a bundle include actions such as reuse of restoration flows for direct use or exchange; water purchases from entities local to the Friant Division service area; and the use or purchase of water supplies available from the Westside of the San Joaquin Valley that originate from the Delta. Other components use existing conveyance and storage facilities that are either local to the Friant Division or potentially hydraulically connected to the Friant Division. The following discussion illustrates the breadth of the areas and projects potentially affected by elements included in the Study.

4.1.1 Friant Division

The Friant Division, a unit of the United States Bureau of Reclamation's CVP, delivers water to over 1,000,000 acres of land along the Eastside of the San Joaquin Valley. This delivery area stretches from approximately the community of Chowchilla to the north to the Tehachapi Mountains in Kern County to the south. Friant Dam, located on the San Joaquin River about 25 miles northeast of Fresno, impounds water in Millerton Lake for water supply, flood control, and recreational purposes. The lake has a total storage capacity of 520,500 acre-feet. Releases from the dam include diversions to the Friant-Kern and Madera Canals and releases to the lower San Joaquin River. The San Joaquin River near Friant Dam has a long-term average annual (1909–2001) unimpaired runoff of about 1,774,000 acre-feet. Significant upstream development by power companies regulates the inflow to Millerton Lake. Figure 2-1 (Section 2.3) illustrates the general locations of Friant Division facilities and water users.

The Friant-Kern Canal conveys water southerly from Millerton Lake to areas in Fresno, Tulare, and Kern Counties. The canal has an initial capacity of 5,300 cubic feet per second (cfs) at its head works that decreases along its course to 2,500 cfs at its terminus at the Kern River. The Madera Canal conveys water northerly from Millerton Lake to lands in Madera County. The canal has an initial capacity of 1,275 cfs at its head works that decreases to 750 cfs at its terminus at the Chowchilla River.

Construction was completed on the major Friant Division facilities between 1939 and 1949. This construction facilitated the start of a major conjunctive surface water/groundwater operation within the Friant Division service area. Water diversions to the Madera Canal began in 1945. Friant-Kern Canal diversions began in 1949, making initial deliveries in its upper reaches. Additional entities were served as construction proceeded downstream. The water supply of the Friant Division is generally described by two classes of water allocation. Class 1 water is the firm supply amounting to the first 800,000 acre-feet of yield from the San Joaquin River and Millerton Lake. Class 2 water develops only after the Class 1 allotment has been fully met and provides up to 1,401,475 acre-feet of supply. Class 2 water is generally under contract with districts that have access to groundwater and can accept a wide variation in year-to-year supplies from the Friant Division. During periods of high inflow, additional water is made available to both Friant and non-Friant contractors, and at times water is also diverted to the canals to minimize flooding along portions of the San Joaquin River. Due to the limited capacity of Millerton Lake to allow carry-over storage, the Friant Division essentially operates as an annual water supply. Water supplies available in wet years directly serve consumptive needs, are stored in the groundwater aquifer, or are used to offset groundwater pumping (in lieu recharge of the groundwater basin). During dry years, the groundwater basin is more heavily drawn from to meet consumptive use needs.

Flood control is a key component of Friant Division operations. The flood control objective of the U.S. Army Corps of Engineers for Friant Dam operations is to limit flows below the dam to Gravelly Ford to 8,000 cfs. Millerton Lake storage of 170,000 acre-feet is reserved for flood control during the rain flood season, and conditionally up to 390,000 acre-feet of storage is reserved for spring snowmelt runoff. This latter water reservation depends on forecasted runoff, available upstream storage space, and projected irrigation demands.

Friant Dam must also release water to the lower San Joaquin River to satisfy downstream riparian water demands between Friant Dam and Gravelly Ford. The amount of water varies somewhat annually, but is approximately 117,000 acre-feet. No explicit flow releases below the dam are currently required for in-stream fishery or other environmental purposes. The San Joaquin Fish Hatchery, immediately below the dam, receives a continuous 35 cfs from the dam. The water, after being used by the hatchery, is returned to the river.

The Friant Division is a component of the CVP and is intrinsically linked to the operation of the CVP. The waters now used by the Friant Division once flowed to downstream water users, particularly to a group of water users located adjacent to the San Joaquin River at the Mendota Pool. Operation of the Friant Division diverts this water to the Friant Division service area, and thus a substitute water supply is necessary for the prior-right holders along the river. The substitution of supply for these prior-right holders is a primary purpose of CVP facilities, from Shasta Reservoir in Northern California to the Delta-Mendota Canal in the Central Valley.

4.1.1.1 Friant Water Users

Currently, there are 28 entities with long-term water service contracts for Friant Division water supply. The contracts sum to a total Class 1 supply of 800,000 acre-feet per year and a total Class 2 supply of 1,401,475 acre-feet per year. Table 4-1 lists the long-term contractors for the Friant Division.

Table 4-1
Long-Term Friant Division Water Contractors and Cross Valley Canal Exchange Contractors

Contract Type/Contractor	Contract Amount (acre-feet)	
	Class 1	Class 2
Friant-Kern Canal Service Area Agriculture Water Contracts		
Arvin-Edison WSD	40,000	311,675
Delano-Earlimart ID	108,800	74,500
Exeter ID	11,500	19,000
Fresno ID		75,000
Garfield WD	3,500	
International WD	1,200	
Ivanhoe WD	7,700	7,900
Lewis Creek WD	1,450	
Lindmore ID	33,000	22,000
Lindsay-Strathmore ID	27,500	
Lower Tule River ID	61,200	238,000
Orange Cove ID	39,200	
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	
Tea Pot Dome WD	7,500	
Terra Bella ID	29,000	
Tulare ID	30,000	141,000
Sub-total	595,750	1,041,475
Madera Canal Service Area Agriculture Water Contracts		
Chowchilla WD	55,000	160,000
Madera ID	85,000	186,000
Sub-total	140,000	346,000
Downstream San Joaquin River Service Area Water Contract		
Gravelly Ford WD		14,000
Total Friant Division Agriculture Water Contracts	735,750	1,401,475
Friant Division Municipal Water Supply Contracts		
City of Fresno	60,000	
City of Orange Cove	1,400	
City Lindsay	2,500	
Fresno County Water Works District No. 18	150	
Madera County	200	
Total Friant Division Municipal Water Supply Contracts	64,250	
Total Friant Division Contract Supply	800,000	1,401,475

Table 4-1 (Continued)
Long-Term Friant Division Water Contractors and
Cross Valley Canal Exchange Contractors

Contract Type/Contractor	Contract Amount (acre-feet)
Cross Valley Canal Exchange Contracts	
County of Fresno	3,000
County of Tulare	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 Contracts	128,300

In addition to the Friant Division long-term contracts, 128,300 acre-feet of water can be conveyed into the Friant Division through the Cross Valley Canal Contracts. The Cross Valley Canal Contracts provide Westside CVP water from the Delta to eight Cross Valley Contractors (see Table 4-1), who have historically exchanged some of their Westside CVP water for roughly equivalent amounts of Friant Division water that would otherwise be delivered to the Arvin-Edison Water Storage District (AEWSD). The locally financed Cross Valley Canal, located in Kern County, connects the California Aqueduct with facilities of AEWSD and others. Through a long-standing water exchange agreement, the Cross Valley Contractors exchange their Cross Valley Canal Contract water supplies with the AEWSD for equivalent amounts of Friant Division water that would otherwise be delivered to AEWSD. In addition, Kern-Tulare Water District and Rag Gulch Water District can directly deliver water from the Cross Valley Canal to the Friant-Kern Canal through privately owned siphons. Figure 2-1 (Section 2.3) illustrates the location of the long-term Friant Division contractors and the Cross Valley Canal Contractors. When flood control releases are being made or are anticipated to be made from Friant Dam, water can also be delivered to short-term or temporary contract users in Fresno, Kings, Tulare, and Kern Counties. These temporary users may be one or more of the following:

- Buena Vista Water Storage District
- Cawelo Water District
- Consolidated Irrigation District
- Corcoran Irrigation District
- Deer Creek & Tule River Authority
- Kaweah Delta Water Conservation District
- Kern County Water Agency
- Kern Delta Water District
- Kern Water Bank
- Kings County Water District

- Kings River Conservation District
- Lakeside Irrigation Water District
- Liberty Water District
- North Kern Water Storage District
- Rosedale-Rio Bravo Water Storage District
- Semitropic Water Storage District
- Tulare Lake Basin Water Storage District

4.1.1.2 San Joaquin River below Friant Dam

The San Joaquin River reach from Friant Dam (River Mile [RM] 267.5) to the confluence of the Merced River at Hills Ferry (RM 118.0) is approximately 150 miles in length. For consistency with other restoration studies, this 150 miles of the San Joaquin River has been divided into five standard reaches as shown on the Figure 4-1. Geographic features of primary influence include the San Joaquin River flood control and bypass system (Chowchilla, Eastside, and Mariposa Bypasses and associated weirs) and the natural flood basins and sloughs (e.g., Mariposa, Mud, and Salt Sloughs) that historically received flows exceeding the natural capacity of the San Joaquin River channel. Other key points along the channel include Gravelly Ford (RM 229.0), Mendota Dam (RM 204.8), and Sack Dam (RM 182.0) (J&S 1998).

The vast majority of the basin runoff occurs from the Eastside tributaries to the San Joaquin River. These tributaries extend from the Fresno River in the south to the Consumnes River in the north. Several small tributaries enter the river between Friant Dam and Gravelly Ford, the largest of which is Little Dry Creek. Between Gravelly Ford and the Merced River, flood flows enter the San Joaquin River flood control system from the Fresno and Chowchilla Rivers; the Fresno, Ash, and Berenda Sloughs; and Bear Creek and several other small streams via the Eastside and Chowchilla Bypasses. During periods of high runoff in the Kings River Basin to the south, water is discharged to the San Joaquin River from the Kings River via Fresno Slough and the James Bypass (J&S 1998).

4.1.2 Central Valley Project

The CVP is the largest water control and delivery system in the state of California. Features of the CVP include Shasta, Trinity, Folsom, and New Melones Reservoirs, the Tracy Pumping Plant, and the Delta-Mendota and Contra Costa Canals. The CVP also includes San Luis Reservoir and San Luis Canal, which are jointly owned with the State of California. The Friant Division is a unit of the CVP. Although only occasionally connected hydrologically to the CVP, the Friant Division's diversion of San Joaquin River is a key component of the CVP's system for Northern California storage and the Delta-Mendota Canal. San Joaquin River prior-right holders near the Mendota Pool receive substitute water from the CVP via the Delta-Mendota Canal.

The CVP was developed primarily for irrigation, but also serves other purposes such as providing flood control, improving navigation on the Sacramento River, supplying municipal water, generating electrical power, conserving fish and wildlife, creating recreational opportunities, and enhancing water quality. CVP water supply contracts amount to over 9 million

acre-feet, inclusive of Friant Division supplies and prior-right settlements. Contract supplies are provided for agriculture, municipal uses, and fishery and wildlife habitat. More than 250 long-term water contractors in the Central Valley, the Santa Clara Valley, and the San Francisco Bay Area receive CVP water.

4.1.3 State Water Project

Like the CVP, the State Water Project (SWP) spans much of the state. SWP facilities regulate water on the Feather River. Combined with other waters of the Delta watershed, the SWP delivers water to areas in the Feather River Basin, the San Francisco Bay Area, the San Joaquin Valley, the Tulare Lake Basin, and Southern California. Oroville Dam is the Northern California storage component of the SWP, and the Banks Pumping Plant and the California Aqueduct are SWP conveyance devices within the San Joaquin Valley. San Luis Reservoir provides storage (jointly with the CVP) for the SWP in the San Joaquin Valley, with additional facilities extending south over the Tehachapi Mountains to Southern California.

4.1.4 Sacramento–San Joaquin River Delta

The Delta encompasses the confluence of the Sacramento and San Joaquin Rivers. The Delta is about 1,150 square miles in area with over 700 miles of channels and sloughs. An annual average of 21 million acre-feet of water reach the Delta, and a significant amount (an annual average of 5.4 million acre-feet) of this water is transported through the Delta for export at the SWP's Banks Pumping Plant and the CVP's Tracy Pumping Plant. Other water diversions from the Delta occur for in-Delta uses, the SWP North Bay Aqueduct, and the Contra Costa Canal.

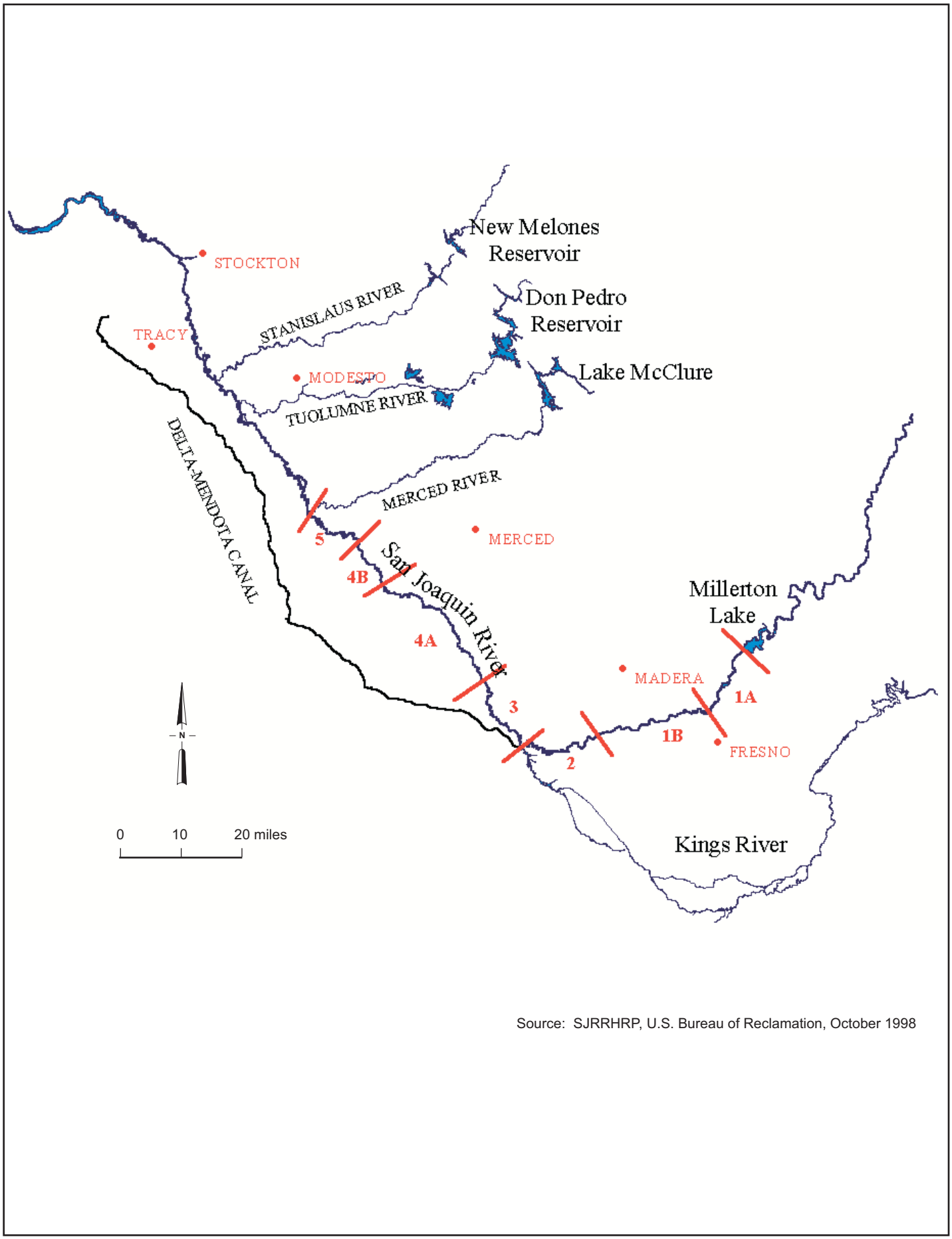
Concerns for the Bay, the Delta, and riverine ecosystems are currently being addressed by several programs and regulations. The Delta is the hub for both CVP and SWP export operations. Thus, the responsibility for meeting supply requirements in the Delta is cooperatively shared by the two projects through a Coordinated Operations Agreement. Water quality and flow objectives in the Delta are established by the State Water Resources Control Board (SWRCB) and are currently identified in Water Right Decision 1641 (SWRCB 1999). Other legislation, programs, and regulations affecting the Bay-Delta and riverine systems include the Central Valley Project Improvement Act, federal and state Endangered Species Acts, and the CALFED Bay-Delta Program.

4.1.5 Eastside Tributaries to Friant-Kern Canal

The Friant-Kern Canal traverses approximately 151 miles on the eastern side of the San Joaquin Valley from Friant Dam to a terminus point at the Kern River. Along its course it crosses or siphons under several rivers and streams. The most substantial of these watercourses are the Kings, Kaweah, and Tule Rivers. USACE and locally sponsored projects provide flood control and water supply on these systems. Occasionally, an abundance of runoff causes flooding to downstream areas or, in the instance of the Kings River, with flows into the San Joaquin River via the James Bypass and Fresno Slough.

4.1.6 Tulare Lakebed

The Tulare Lakebed is a natural depression of land in the southern portion of the San Joaquin Valley that receives runoff from the Kings, Kaweah, Tule, and Kern Rivers during high-runoff



Source: SJRRHRP, U.S. Bureau of Reclamation, October 1998

Figure 4-1. San Joaquin River System Reaches

years. The lakebed is closed to the San Joaquin River to the north except for an outlet from the Kings River via the James Bypass and Fresno Slough. The lakebed also receives runoff from the Coast Range Mountains and areas to the west during large rain events. The lakebed is normally used for agricultural production. During flooding, inflows are contained in levee storage compartments to limit the amount of cropland that is inundated. Stored floodwaters are subsequently routed to adjacent lands for irrigation or are depleted by seepage and evaporation. In the past, local Tulare Lakebed interests have pumped from the tributaries into the Friant-Kern Canal during flood events to reduce the amount of flooding that would otherwise occur.

4.1.7 Mendota Pool

Mendota Pool is created by the impoundment of Mendota Dam. Mendota Pool serves as the diversion point for several San Joaquin River prior-right holders and CVP contractors. Water is released from Mendota Dam to serve additional entities who divert at Sack Dam. Water can flow to the Mendota Pool from the San Joaquin River or from the Tulare Lake Basin (by way of Fresno Slough and the James Bypass). Mendota Pool is also the terminus of the Delta-Mendota Canal. Nearly 1,000,000 acre-feet of water a year normally flow through this complex. During San Joaquin River or Tulare Lake Basin flood periods, additional water flows through the complex or is used by the area entities in lieu of Delta-Mendota Canal deliveries.

4.1.8 San Joaquin River Eastside Tributaries

Eastside tributaries to the San Joaquin River include the Merced, Tuolumne, and Stanislaus Rivers. The Fresno and Chowchilla Rivers and overflow from the Kings River system also occasionally contribute to flows in the San Joaquin River. The San Joaquin River immediately below Sack Dam is typically dry. Drainage and operational spills from adjacent lands produce most of the flow in the San Joaquin River upstream of the confluence with the Merced River. Thereafter, the three major tributaries contribute to the flow that reaches Vernalis (an established point of measurement that is used as a reference for San Joaquin River flow entering the Delta). Other than during a 31-day period in April and May, no tributary other than the Stanislaus River has a responsibility for flow in the San Joaquin River. During the April-May period, the USBR and several of the major water rights holders within the Stanislaus, Tuolumne, and Merced River Basins, and the San Joaquin River Exchange Contractors Water Authority at Mendota Pool jointly operate their systems to provide experimental and protective flow conditions at Vernalis. The protocol for the conditions are part of the San Joaquin River Agreement and are recognized in SWRCB Water Right Decision 1641 (SWRCB 1999). During other times of the year, the Merced and Tuolumne Rivers are operated for local concerns with flows incidentally discharging into the San Joaquin.

The USBR has a responsibility to the San Joaquin River through its operation of New Melones Reservoir. SWRCB Water Right Decision 1641 assigns responsibility to USBR for certain water quality and flow conditions at Vernalis. USBR integrates the San Joaquin River flow that originates upstream of the confluence with the Stanislaus River in its operation of New Melones Reservoir. Changes to upstream conditions can at times affect USBR's operations.

4.1.9 Kern River

The Kern River is the southern-most river in the Tulare Lake Basin. The majority of its watershed lies behind the front range of the Sierra Nevada, which drains to the Kaweah and Tule

River drainages. Runoff from the watershed is regulated by Isabella Lake. Downstream, the area is highly developed and uses most of the river's runoff for direct irrigation or recharge to groundwater. During exceptionally large flood events, water can flow to the Tulare Lakebed; however, a portion or all flood flows can be diverted to the California Aqueduct via the Kern River Intertie. The area is currently host to numerous large-scale conjunctive use/banking programs, including significant programs developed by the Kern County Water Agency and the Semitropic Water Storage District.

4.2 WATER DEMAND AND HYDROLOGY

The Friant Division service area consists of a variety of water users, including agricultural, municipal, and industrial users. Although Millerton Lake is the largest source of surface water within the Friant Division, some water users can draw other sources within the Division, including groundwater and local supplies.

4.2.1 Agricultural Water Demand

The total irrigated acres within the Friant Division are approximately 1,000,000 acres. The amount of land irrigated in any given year varies only slightly due primarily to the conjunctive use of groundwater and surface water. Groundwater use is substituted for surface water use in drier years so that the cropped acreage remains fairly constant with the exception that some double cropping may be curtailed. Table 4-2 shows the cropped acreage by district as reported by the districts to the Bureau of Reclamation in the water needs analysis prepared for water supply contract renewals. This is the acreage of crops irrigated with CVP water. The table shows cropped acres for 1995 and for projected conditions in 2025. Most districts used 1996 as a representative year rather than 1995; however, several districts did not report crop water use information in 1996 due to limited irrigation acreage. Therefore, 1995 provides a more complete inventory. The table also shows the total land acreage in agriculture for each district. The total irrigated acreage can exceed the acreage of agricultural land due to multiple cropping over a year. The projected irrigated acreage for 2025 generally exceeds the average acreage irrigated from 1979 to 1997 and exceeds the maximum irrigated acreage during that period for about half of the districts. If the actual irrigated acreage in 2025 is greater than in the past, there may or may not be sufficient CVP water to satisfy the increased demand.

A wide variety of crops are grown in the Friant Division service area (close to 50 different varieties during some years). Table 4-3 shows the top five crops grown in each district from 1979 to 1997. For the Friant Division as a whole, vineyards, cotton, subtropical orchard, alfalfa, and almonds accounted for over 70 percent of the total irrigated acres from 1979 to 1997, as well as in 1995. Citrus fruits make up the main portion of the crops included in the subtropical orchard category. This is similar to the leading crops reported in the Long Term Contract Renewal Environmental Assessment, which reported vineyards, subtropical orchard, cotton, almonds, and alfalfa as the leading crops for 1996. The California Department of Water Resources Bulletin 160-98 does not report leading crops for the Friant Division but reports that the dominant crop is cotton, followed by permanent orchards (mostly almonds and pistachios) and vineyards in the Tulare Lake Hydrologic Unit (DWR 1998a).

The gross irrigation requirement, defined as the crop water demand at the point of diversion and includes losses and deep percolation, for the Friant Division, based on the cropping patterns

Table 4-2
Irrigated Acreage in the Friant Division

District	Average 1995	Projected 2025	District Acreage in Agriculture[a]
Friant-Kern Canal Service Area			
Arvin-Edison WSD	129,340	129,340	116,116
Delano-Earlimart ID	49,826	50,972	53,779
Exeter ID	11,288	12,670	11,938
Fresno ID	159,547	168,039	156,954
Garfield WD	1,415	no data	1,357
International WD	627	no data	677
Ivanhoe ID	10,526	10,514	10,634
Lewis Creek WD	631	no data	195
Lindmore ID	23,752	25,581	25,753
Lindsay-Strathmore ID	11,852	12,545	13,200
Lower Tule River ID	98,824	110,874	93,502
Orange Cove ID	26,500	24,955	27,531
Porterville ID	13,291	13,212	14,651
Saucelito ID	19,217	17,702	19,342
Shafter-Wasco ID	29,233	32,504	34,728
Southern San Joaquin MUD	46,052	49,045	51,735
Stone Corral ID	5,297	5,163	6,321
Tea Pot Dome WD	2,948	3,482	3,365
Terra Bella ID	12,094	12,140	11,277
Tulare ID	67,315	73,573	65,780
Subtotal	719,575	752,311	718,835
Madera Canal Service Area			
Chowchilla WD	56,133	72,576	59,721
Madera ID	99,837	107,658	114,672
Subtotal	155,970	180,234	174,393
Gravelly Ford WD	8,442	8,468	7,920
Cross Valley Canal Service Area			
Alpaugh ID	5,381	8,000	7,243
Atwell Island WD	4,205	4,482	4,450
Hills Valley ID	2,317	3,353	2,323
Kern-Tulare WD	12,703	16,504	16,321
Pixley ID	61,419	67,419	60,629
Rag Gulch WD	4,908	5,805	36,431
Tri-Valley WD	836	871	1,863
Subtotal	91,769	106,434	129,260
Total Friant Division	975,756	1,047,447	1,030,408

[a] Includes irrigated and non-irrigated lands from 1990 Kern County data, 1993 Tulare County data, 1994 Fresno County data, and 1995 Madera County data.
Sources: USBR 2000b; USBR 2000c.
Data was obtained from USBR because Bulletin 160-98 does not present projections by district, only by hydrologic region.

Table 4-3
Main Crops Grown in Friant Unit Between 1979 and 1997 (Ranked by Acreage)

District	Crop #1	Crop #2	Crop #3	Crop #4	Crop #5
Friant-Kern Canal Service Area					
Arvin-Edison WSD	Vineyard	Potatoes	Cotton	Subtropical Orchard	Misc. Truck/Field (Med)
Delano-Earlimart ID	Vineyard	Almonds	Cotton	Deciduous Orchard	Alfalfa
Exeter ID	Subtropical Orchard	Vineyard	Deciduous Orchard	Pasture (Improved)	Grains
Fresno ID	Vineyard	Subtropical Orchard	Pasture (Improved)	Cotton	Almonds
Garfield WD	Almonds	Deciduous Orchard	Subtropical Orchard	Pasture (Improved)	Vineyard
International WD	Subtropical Orchard	Wheat	Barley	Grains	NA
Ivanhoe ID	Subtropical Orchard	Vineyard	Deciduous Orchard	Pasture (Improved)	Alfalfa
Lewis Creek WD	Subtropical Orchard	Cotton	Vineyard	Beans (Dry)	Barley
Lindmore ID	Subtropical Orchard	Cotton	Vineyard	Alfalfa	Deciduous Orchard
Lindsay-Strathmore ID	Subtropical Orchard	Deciduous Orchard	Grains	Corn (Field)	Pasture (Improved)
Lower Tule River ID	Cotton	Alfalfa	Corn (Field)	Wheat	Barley
Orange Cove ID	Subtropical Orchard	Wheat	Deciduous Orchard	Cotton	Almonds
Porterville ID	Deciduous Orchard	Cotton	Subtropical Orchard	Vineyard	Alfalfa
Saucelito ID	Vineyard	Cotton	Wheat	Subtropical Orchard	Deciduous Orchard
Shafter-Wasco ID	Cotton	Almonds	Alfalfa	Nursery/Lettuce	Vineyard
Southern San Joaquin MUD	Cotton	Almonds	Vineyard	Alfalfa	Subtropical Orchard
Stone Corral ID	Subtropical Orchard	Deciduous Orchard	Cotton	Pasture (Improved)	Vineyard
Tea Pot Dome WD	Subtropical Orchard	Vineyard	Deciduous Orchard	Wheat	Pasture (Improved)
Terra Bella ID	Subtropical Orchard	Deciduous Orchard	Grains	Wheat	Cotton
Tulare ID	Cotton	Alfalfa	Corn (Field)	Wheat	Barley
Madera Canal Service Area					
Chowchilla WD	Cotton	Almonds	Alfalfa	Corn (Field)	Wheat
Madera ID	Vineyard	Almonds	Cotton	Subtropical Orchard	Corn (Field)
Downstream San Joaquin River Service Area					
Gravelly Ford WD	Vineyard	Almonds	Cotton	Pasture (Improved)	Wheat
Cross Valley Canal Service Area					
Alpaugh ID	Cotton	Alfalfa	Barley	Wheat	Grains
Atwell Island WD	Cotton	Alfalfa	Barley	Wheat	Grains
Hills Valley ID	Subtropical Orchard	Vineyard	Deciduous Orchard	Pasture (Improved)	Almonds
Kern-Tulare WD	Subtropical Orchard	Almonds	Vineyard	Wheat	Deciduous Orchard
Pixley ID	Cotton	Wheat	Alfalfa	Corn (Field)	Vineyard
Rag Gulch WD	Vineyard	Subtropical Orchard	Almonds	Wheat	Cotton
Tri-Valley WD	Subtropical Orchard	Deciduous Orchard	Almonds	NA	NA
Friant Division (all above districts combined):	Vineyard	Cotton	Subtropical Orchard	Alfalfa	Almonds

Deciduous Orchard: walnuts, pecans, other nuts, cherries, apples, apricots, and other fruits.
Subtropical Orchard: olives, oranges, tangerines, lemons, limes, grapefruit, peaches, prunes, plums, and pears.
Source: USBR 2000b.

shown in Appendix A, Section 5, is shown in Table 4-4. The total current demand is estimated to be about 2.9 million acre-feet. This includes areas that are double cropped if both crops are irrigated. Therefore, the total irrigated acres can exceed the total agricultural area of a district.

Table 4-4
Agricultural Water Requirements

District	Gross Irrigation Requirement (acre-ft/acre) 1995	Gross Irrigation Requirement (acre-ft/acre) 2025	Gross Irrigation Requirement (acre-feet) 1995	Gross Irrigation Requirement (acre-feet) 2025
Friant-Kern Canal Service Area				
Arvin-Edison WSD	3.0	3.0	390,059	390,059
Delano-Earlimart ID	3.0	3.1	147,497	156,441
Exeter ID	3.1	3.4	35,281	37,412
Fresno ID	3.0	3.1	482,450	515,234
Garfield WD	3.1	ND	4,419	ND
International WD	3.0	ND	1,905	ND
Ivanhoe ID	3.1	3.1	32,380	32,430
Lewis Creek WD	3.0	ND	1,892	ND
Lindmore ID	3.0	2.8	71,036	72,898
Lindsay-Strathmore ID	2.9	3.4	34,682	42,381
Lower Tule River ID	3.0	2.9	297,263	322,476
Orange Cove ID	3.2	3.6	84,872	90,565
Porterville ID	3.0	3.5	39,269	45,702
Saucelito ID	2.7	2.9	51,842	50,728
Shafter-Wasco ID	3.2	3.0	93,759	97,894
Southern San Joaquin MUD	3.1	3.4	143,955	165,427
Stone Corral ID	3.0	3.1	16,072	15,904
Tea Pot Dome WD	3.5	4.0	10,464	14,072
Terra Bella ID	3.6	3.9	43,108	47,552
Tulare ID	3.0	2.9	199,047	212,081
Madera Canal Service Area				
Chowchilla WD	3.3	3.3	187,368	235,931
Madera ID	2.8	3.1	282,625	333,389
Downstream San Joaquin River Service Area				
Gravelly Ford WD	3.1	3.0	26,400	25,296
Cross Valley Canal Service Area				
Alpaugh ID	3.7	4.1	19,819	32,799
Atwell Island WD	3.7	3.3	15,422	15,003
Hills Valley ID	3.1	3.0	7,153	10,174
Kern-Tulare WD	3.1	2.9	38,905	47,790
Pixley ID	3.5	3.1	213,124	206,007
Rag Gulch WD	2.8	3.0	13,657	17,248
Tri-Valley WD	3.2	3.5	2,651	3,065
Friant Division (average or total for above districts):	3.1	3.2	2,988,377	3,235,956

Source: USBR, 2000 and WSOT, detailed comments, July 31, 2002
ND = no data on crop acreage

This demand is projected to increase to 3.1 million acre-feet in 2025 assuming an increase in irrigated acreage (see Table 4-2 for the projected 2025 acreage reported to USBR by the districts) and a slightly different crop mix. No water conservation measures were assumed. This

increase in demand could be reduced through water conservation measures. The increase in water demand and irrigated acres is contrary to the results in Bulletin 160-98, which predicts a decrease in irrigated acres in the Tulare Lake Hydrologic Region from about 3 million acres to 2.9 million acres. Bulletin 160-98 also predicts a change in crop mix from grain and field crops to more truck crops and permanent crops. For the Tulare Lake Region this translates to a decrease in cotton, grain, and alfalfa and an increase in tomatoes, truck crops, and orchards. The net result predicted in Bulletin 160-98 is no significant change in agricultural water demand. The conclusion from comparing these two sets of results is that there should be no significant change in agricultural water demand in the Friant Division between the present and 2025.

To estimate the current water demand, it was assumed that the total quantity and variety of crops would be the same as reported for 1995, which was a wet year with a corresponding planted acreage of approximately 930,000 acres. Crop coefficients and other data used in the analysis are shown in Appendix A, Section 5. For the projection of future water requirements (2025), the estimated acreage and crop mix were based on estimates provided by the U.S. Bureau of Reclamation for the year 2025 (USBR 2000c). Total planted acreage was approximately 1,047,000 acres.

4.2.2 Urban Water Demand

The Friant Division municipal water contractors are listed in Table 4-1. The contracts total 64,250 acre-feet of Class I water, with the City of Fresno accounting for over 90 percent of the total. The City of Fresno currently distributes groundwater. Rainfall and stream flow replenish about half of the pumped water, and the Class I water from Friant, along with Fresno's entitlement to 21 percent of the Class II supply from Fresno Irrigation District (FID), is used to replenish the rest. The amount of Class II water available to the FID is dependent on seasonal rainfall.

Municipalities in the Tulare and San Joaquin basins that don't receive CVP water may fulfill their water demand through groundwater pumping, deliveries from the SWP, local surface water supplies, or some combination of the three. For example, the City of Bakersfield meets its water demand through SWP deliveries, groundwater pumping, and deliveries from the Kern River.

In the year 2000, the City of Fresno (population of 460,400) used approximately 156,440 acre-feet (50,976 million gallons) of water (City of Fresno 2002). Assuming the current per capita water demand remains the same in the future and a population growth rate of 1.9 percent (City of Fresno 2002), the annual water demand in 2025 could increase to approximately 250,000 acre-feet (82,000 million gallons). Based on the model study results in *The California Water Plan Update* (DWR 1998) the per capita water demand is estimated to decrease in the future due to conservation efforts. Under certain future circumstances the demand associated with an increasing population may be offset by a reduced per capita demand. However, the current urban water demand alone suggests that the City of Fresno will use all of its surface water entitlements, if not an increased share of available water.

Bulletin 160-98 (DWR 1998a) provides an estimate of the growth in urban water use by region. A major factor in the potential for increased urban water use is the projected growth in population in the Friant Division geographic area. The City of Fresno's projected annual population growth rate of 1.9 percent can be applied throughout the county. Bulletin 160-98 projects that Fresno County will grow by 80 to 100 percent, Tulare County by 60 to 80 percent,

and Kern County by over 100 percent. With no conservation measures in place these growth rates would result in a corresponding increase in urban water demand. However, per capita consumption is declining due to conservation measures already in place (e.g., mandated low-flow toilets and showerheads). Also, CALFED includes water use efficiency in all its Delta alternatives and is looking at methods (such as those discussed with the SWRCB) to better discourage unreasonable water use.

CALFED estimates that urban water conservation measures would apply to residential water use; urban landscape use; commercial, industrial, and institutional use; and water distribution system loss and leakage.

Outdoor water conservation measures include the reduction of evapotranspiration and percolation of water to irrecoverable sinks. CALFED estimates that 9,000 to 18,000 acre-feet are potentially available through outdoor conservation of irrecoverable losses on the Eastside.

The potential reduction in water use for commercial and industrial uses may average 22.2 percent across the state. CALFED projects continued decline in commercial and industrial water use, increasing environmental constraints on wastewater discharge and recycling practices, more water-efficient industrial practices, a shift away from a manufacturing economy, and movement of some industries out of the state. CALFED estimates that the implementation of the current best management practices would reduce current commercial and industrial water use by 15 percent.

The Central Valley Project Improvement Act (CVPIA), passed by Congress in 1992, requires water metering for new or renewed water supply contracts. The metering of all water service connections also promotes conservation by enabling billing based on use. This action should result in a decrease in per capita demand. Bulletin 160-98 predicts a decrease in demand due to conservation measures of 36 gallons per capita per day in the San Joaquin River Basin and 30 gallons per capita per day in the Tulare Lake Basin.

Urban growth in largely agricultural areas often results in the conversion of agricultural land to urban areas. This conversion can result in either an increase or decrease in water demand depending on the type of agriculture being replaced and the type of urban development. Table 4-5, from Bulletin 160-98, compares typical water demand for urban and the major agricultural products grown in the Fresno area.

In general, water use is similar for low housing densities (4 to 5 units per acre) and agriculture. However, higher density development of single-family dwellings (six units or more per acre) tend to have greater applied water requirements than many crops (DWR 1998a).

Table 4-5
Typical Water Demand

Type of Use	Applied Water Use (af/acre)
Urban (average for Fresno Area)	3.2
Agricultural	
Grapevines	2.9
Deciduous orchard	3.5
Alfalfa	4.7
Pasture (improved)	4.5
Cotton	3.2

Source: DWR 1998a

4.2.3 Upper San Joaquin River Hydrology

Flow in the San Joaquin River both upstream and downstream of Friant Dam has radically changed due to development of upstream hydroelectric projects and the Friant Division. Construction by Southern California Edison (SCE) for the dams and tunnels of its Big Creek Project began in 1912 and continued for decades. Pacific Gas and Electric Company (PG&E) also developed portions of the upper San Joaquin River basin for hydroelectric generation. Work began on Friant Dam in 1939 with some regulation provided in 1942. The project began full operation during 1949.

4.2.3.1 Watershed Description

The watershed upstream of Friant Dam encompasses an area of 1,632 square miles of the western slope of the Sierra Nevada Mountain Range. Bounded by the watersheds of the Merced and Fresno Rivers to the north and the Kings River watershed to the south, elevations in the watershed upstream of Friant Dam range from 10,000 to 13,000 feet at the crest of the Sierra to the east to about 350 feet at Friant Dam. The three main branches, the north, middle, and south forks join to form the main stem of the upper San Joaquin River above Mammoth Pool Reservoir. Big Creek, Stevenson Creek, and Willow Creek join with the San Joaquin River below Mammoth Pool Reservoir.

Annual average precipitation in the watershed varies from a little over 10 inches at the toe of the foothills to over 60 inches at higher elevations. Rain typically occurs below elevation 4,000 feet; snow occurs at higher elevations.

4.2.3.2 Unimpaired Runoff and Millerton Lake Inflow

The average annual unimpaired runoff at Friant Dam is about 1,774,000 acre-feet. During the 1909 through 2001 period of record, the annual runoff on a water year basis (October 1 to September 30) has varied from a high of 4,642,000 acre-feet (1983) to a low of 362,000 acre-feet (1977). The monthly distribution of the unimpaired runoff can vary significantly and is typical of Sierra Nevada watersheds. November through March runoff is typically the result of rain-fed runoff, whereas April through July runoff is typically the melting of accumulated snow. Some 70 percent of the annual runoff occurs during the April through July snowmelt period. However, significant runoff can occur during the winter if precipitation in the form of rain occurs at higher elevations, and the accumulated snow melts. Figure 4-2 illustrates the annual record of unimpaired runoff at Friant Dam.

Runoff is significantly affected by major diversion and storage projects owned and operated by SCE and PG&E. Upstream of Friant Dam these two power companies operate seven major reservoirs and numerous power plants, conduits, and tunnels. The use of over 600,000 acre-feet of gross reservoir storage can significantly affect runoff. Table 4-6 lists the major storage facilities upstream of Friant Dam.

An agreement between USBR and SCE (*Operating Contract Related to Southern California Edison Company's Mammoth Pool and Existing Projects on the San Joaquin River*) provides for specific allowable storage within the SCE reservoirs at the end of the water year based on several runoff and storage parameters. Within the water year, significant flexibility exists for SCE and PG&E to optimize their hydroelectric operations. These operations typically reduce upstream

Table 4-6
Major Storage Facilities Upstream of Friant Dam

Lake	Dam	Owner	Capacity (acre-feet)	Year Completed
T.A. Edison	Vermilion Valley	SCE	125,000	1954
Florence	Florence Lake	SCE	64,400	1926
Huntington	Huntington Lake	SCE	88,000	1917
Shaver	Shaver Lake	SCE	135,300	1927
Mammoth Pool	Mammoth Pool	SCE	123,000	1960
Redinger	Big Creek No. 7	SCE	35,000	1951
Bass	Crane Valley	PG&E	45,400	1910
TOTAL			616,100	

reservoir storage (providing hydrogeneration) during the summer and fall and thus supplement natural runoff. During winter, runoff to these upstream reservoirs is released as generation, and the reservoirs are filled during the spring when runoff exceeds generation capacity. Table 4-7 reports the calculated inflow to Millerton Lake since 1944. The effects of upstream operations on monthly runoff are shown in Figure 4-3.

The long-term average inflow to Millerton Lake (1944–2001) is 1,783,000 acre-feet, and the unimpaired runoff during the same period is 1,785,000 acre-feet.

4.2.3.3 Diversions and Deliveries within the Friant Division

Diversions to the Madera Canal and the Friant-Kern Canal have occurred since 1944 and 1949, respectively. Diversions vary from year to year based on water availability and the ability of Friant water users to accept deliveries. The Friant Division water supply is essentially an annual water supply with little carry-over capability. Table 4-8 illustrates the historical diversion of water to the Friant-Kern Canal. Table 4-9 illustrates the historical diversion of water to the Madera Canal. The values indicated in these two tables for “contract year” represent annual deliveries for March through the following February. The monthly and total average values in these two tables are provided for the entire period of record (1949 to 2001). Although Friant Division water demand is still evolving, the latter record since 1961 is essentially indicative of full project delivery build-up as limited by the supply available each year.

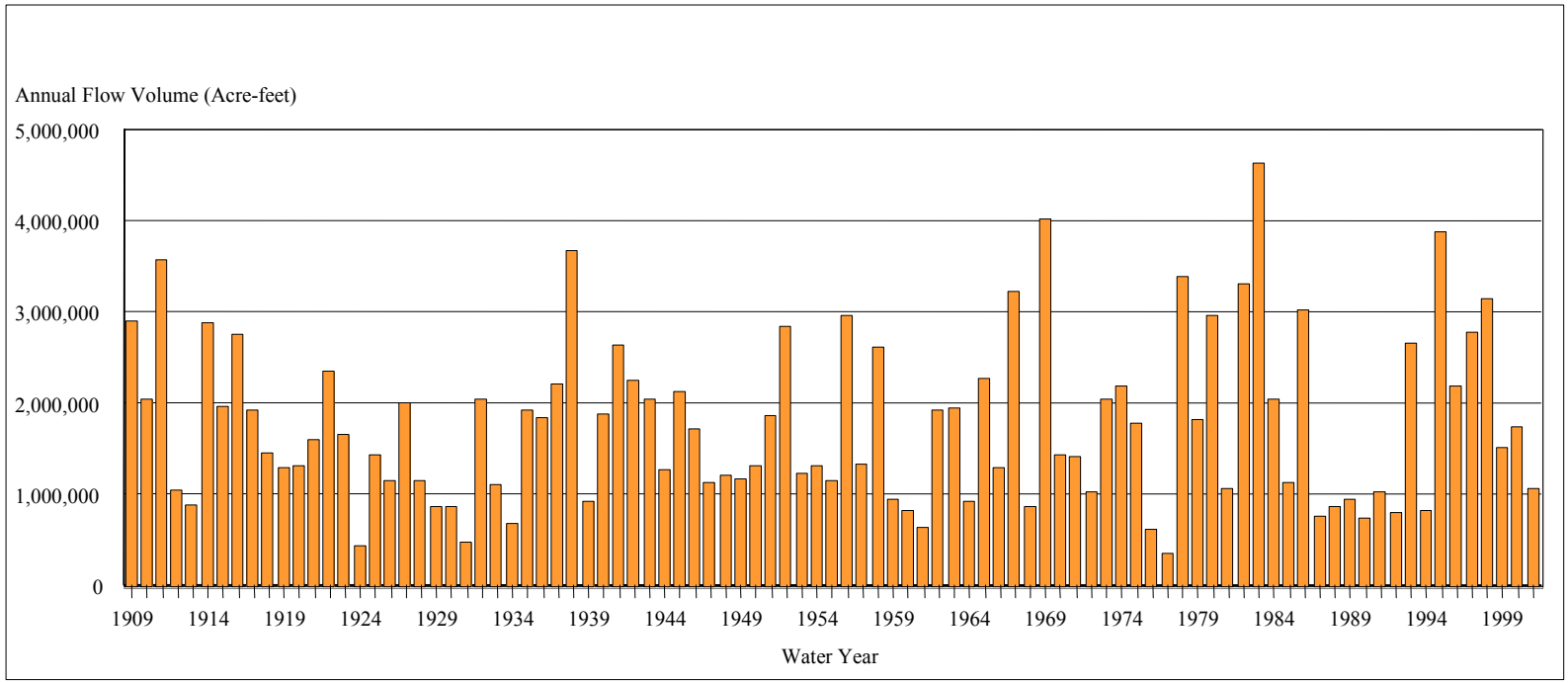


Figure 4-2
Historical Unimpaired Runoff to Millerton Lake

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Table 4-7
Computed Inflow to Millerton Lake (1,000 Acre-feet)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Apr-Jul	Total
1944	59	49	43	46	54	115	128	269	200	141	85	76	738	1,265
1945	60	83	93	76	221	163	259	371	367	223	108	86	1,219	2,109
1946	99	104	146	110	75	116	259	327	220	127	84	73	933	1,740
1947	62	87	116	83	81	112	135	218	97	72	61	55	521	1,178
1948	55	38	38	31	32	43	123	268	273	105	69	65	769	1,140
1949	54	44	35	36	44	103	203	278	200	87	75	51	768	1,209
1950	35	24	44	58	106	112	222	272	196	97	80	70	786	1,315
1951	61	205	274	139	128	131	173	215	210	133	90	58	732	1,818
1952	49	45	105	154	121	200	353	666	569	313	131	85	1,901	2,790
1953	75	53	82	112	58	73	150	137	230	155	90	61	671	1,276
1954	53	43	46	45	73	129	233	292	172	91	71	52	787	1,300
1955	39	48	70	66	60	83	118	215	217	106	73	55	654	1,148
1956	36	35	401	308	205	188	266	443	434	298	124	99	1,440	2,834
1957	91	67	73	46	70	101	133	220	287	133	85	66	773	1,372
1958	58	60	82	80	132	211	370	594	488	261	134	100	1,713	2,568
1959	85	78	67	59	102	128	151	160	133	66	44	60	509	1,132
1960	35	22	16	26	83	79	103	106	103	100	107	82	412	863
1961	33	29	43	27	35	49	98	105	95	40	49	47	337	647
1962	19	19	34	29	187	157	214	288	333	181	146	118	1,015	1,725
1963	76	56	35	57	217	115	223	261	335	251	163	156	1,070	1,945
1964	62	102	96	52	52	74	98	114	143	108	119	102	463	1,121
1965	26	43	108	204	173	188	212	211	321	219	167	156	964	2,029
1966	91	110	144	119	95	122	157	168	133	101	79	53	558	1,371
1967	49	52	135	139	196	247	319	467	632	521	194	177	1,940	3,129
1968	95	87	96	73	95	84	105	93	105	111	106	84	414	1,135
1969	27	44	58	280	326	299	330	885	772	417	186	174	2,404	3,798
1970	67	84	93	169	137	156	132	168	157	146	117	90	602	1,515
1971	44	58	111	113	109	115	145	154	156	154	140	118	610	1,417
1972	59	49	91	75	79	119	99	104	129	96	93	52	428	1,043
1973	74	61	76	96	171	193	211	388	353	161	124	96	1,112	2,003
1974	73	91	128	184	126	219	253	338	337	175	161	114	1,103	2,200
1975	66	67	70	48	93	136	214	296	415	147	123	125	1,071	1,798
1976	78	93	70	44	52	81	65	46	67	60	78	94	238	828
1977	28	23	17	15	16	9	10	10	67	75	61	45	163	378
1978	8	13	53	152	240	343	320	480	647	409	201	175	1,856	3,042
1979	106	100	84	129	149	214	232	327	260	142	139	94	961	1,976
1980	74	29	60	260	287	280	284	428	490	406	193	136	1,609	2,926
1981	74	66	58	62	94	97	149	151	114	101	97	79	514	1,140
1982	55	58	115	156	188	266	476	584	499	349	209	185	1,908	3,140
1983	102	163	244	282	347	467	336	600	1,032	620	298	212	2,588	4,704
1984	109	163	222	228	166	207	188	190	195	163	147	116	736	2,091
1985	82	56	61	89	95	106	192	172	107	78	82	96	549	1,215
1986	77	80	94	103	356	424	329	450	520	254	136	102	1,552	2,923
1987	90	56	41	40	58	88	117	140	100	105	113	54	462	1,000
1988	36	37	41	70	54	93	97	103	98	101	70	53	399	853
1989	32	32	30	36	42	109	140	123	114	106	112	52	483	927
1990	47	37	25	27	40	86	103	99	61	121	72	49	384	766
1991	24	20	19	26	18	112	107	129	164	157	92	58	558	925
1992	56	34	25	41	70	114	117	109	64	106	92	63	396	891
1993	49	5	27	180	172	242	271	463	471	307	131	138	1,511	2,456
1994	92	61	61	46	49	84	102	124	113	105	104	78	445	1,020
1995	51	14	27	196	174	424	349	572	696	706	256	118	2,324	3,584
1996	112	71	79	94	188	288	267	414	359	207	137	120	1,247	2,337
1997	46	96	236	646	187	246	248	395	314	150	129	139	1,107	2,832
1998	83	67	69	119	244	250	270	298	702	608	189	175	1,878	3,072
1999	81	97	114	94	118	120	159	209	254	129	143	120	751	1,637
2000	66	38	47	51	121	219	217	312	288	152	117	79	969	1,708
2001	82	75	31	37	34	94	139	221	142	79	102	85	581	1,121
Avg	62	62	86	110	126	162	198	280	289	192	120	96	958	1,783
Min	8	5	16	15	16	9	10	10	61	40	44	45	163	378
Max	112	205	401	646	356	467	476	885	1,032	706	298	212	2,588	4,704

Table 4-8
Diversions to the Friant-Kern Canal (1,000 Acre-feet)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Contract Year
1949	0	0	0	0	0	1	1	0	0	16	24	0	43	43
1950	0	0	0	0	0	15	22	18	53	46	42	0	195	195
1951	0	0	0	0	0	24	37	12	66	108	86	36	368	396
1952	14	9	0	0	5	3	12	29	56	126	138	70	462	526
1953	73	17	0	0	1	56	54	40	99	164	160	75	741	691
1954	23	7	0	0	12	53	58	124	153	172	146	63	811	813
1955	25	6	0	0	12	87	77	64	135	167	157	74	805	950
1956	27	10	0	0	151	155	121	108	182	201	222	142	1,320	1,235
1957	50	31	0	1	22	92	78	63	211	181	152	108	990	1,012
1958	28	4	0	5	89	67	34	89	170	256	260	143	1,145	1,143
1959	63	18	0	0	43	149	71	57	143	133	97	35	810	769
1960	58	10	0	0	15	70	38	32	115	111	87	46	582	565
1961	23	3	1	0	40	51	26	23	75	80	81	38	442	428
1962	24	9	0	0	19	165	266	150	190	217	216	113	1,370	1,456
1963	54	22	0	1	61	74	164	221	244	238	260	173	1,513	1,593
1964	95	17	0	7	100	76	31	37	113	158	152	52	838	981
1965	29	0	0	82	250	218	77	187	207	214	207	159	1,631	1,555
1966	72	36	14	83	81	152	72	68	148	156	124	60	1,066	997
1967	36	12	0	16	153	148	101	59	139	242	267	240	1,413	1,599
1968	132	52	27	51	141	61	51	70	111	110	100	61	967	610
1969	18	2	3	1	22	14	53	123	160	237	260	190	1,082	1,351
1970	59	51	39	32	134	73	94	96	158	189	208	82	1,214	1,089
1971	35	15	0	12	126	107	72	52	123	234	218	98	1,092	1,055
1972	48	24	19	6	54	106	51	84	128	149	92	51	812	789
1973	21	1	0	0	106	103	158	222	215	211	203	130	1,371	1,497
1974	48	26	0	43	137	137	218	231	242	241	243	103	1,668	1,578
1975	49	16	0	9	90	81	153	243	226	232	174	119	1,392	1,365
1976	52	14	0	5	67	54	34	48	77	95	79	47	571	494
1977	17	12	0	3	28	10	8	5	36	55	60	29	264	286
1978	20	4	0	0	59	16	19	115	207	242	237	147	1,067	1,413
1979	190	81	0	0	157	144	202	188	231	222	182	84	1,681	1,369
1980	42	20	0	0	54	65	159	136	222	241	261	156	1,357	1,532
1981	117	44	22	25	84	45	52	81	133	205	117	57	981	990
1982	29	11	2	69	190	116	104	217	262	275	258	145	1,678	1,570
1983	106	40	10	20	17	2	35	55	170	236	177	128	996	1,102
1984	72	51	0	0	175	111	84	129	218	234	167	104	1,344	1,262
1985	80	23	0	0	112	80	81	105	150	141	90	58	919	851
1986	52	10	1	11	73	56	122	202	255	251	209	166	1,407	1,490
1987	79	37	25	18	70	30	67	54	90	116	90	58	734	670
1988	46	4	3	11	102	47	24	52	106	139	76	43	653	547
1989	29	6	0	0	25	36	74	62	126	182	94	45	679	700
1990	37	22	5	2	14	33	36	40	57	96	95	51	489	474
1991	36	10	0	0	19	0	18	69	128	182	124	64	651	667
1992	52	12	0	5	12	12	41	77	156	108	104	50	627	660
1993	34	4	0	12	64	179	232	261	270	302	244	104	1,705	1,726
1994	70	24	8	15	17	27	39	40	133	149	111	55	690	709
1995	24	6	0	7	116	119	84	138	251	276	265	162	1,449	1,601
1996	113	71	34	27	61	100	206	221	269	266	185	92	1,645	1,477
1997	64	10	1	61	1	108	162	138	224	234	155	109	1,268	1,330
1998	109	37	20	10	24	9	2	28	94	224	200	126	882	997
1999	96	21	57	33	108	61	69	146	202	224	165	73	1,254	1,034
2000	62	15	0	12	6	116	117	259	214	210	166	96	1,272	1,277
2001	44	16	15	12	11	18	36	126	187	164	101	59	790	0
Avg (All)	**52**	**19**	**6**	**13**	**67**	**74**	**81**	**104**	**157**	**182**	**158**	**90**	**1,004**	**991**
Avg (1961 on)	**59**	**22**	**7**	**17**	**78**	**77**	**90**	**119**	**169**	**195**	**166**	**97**	**1,096**	**1,077**

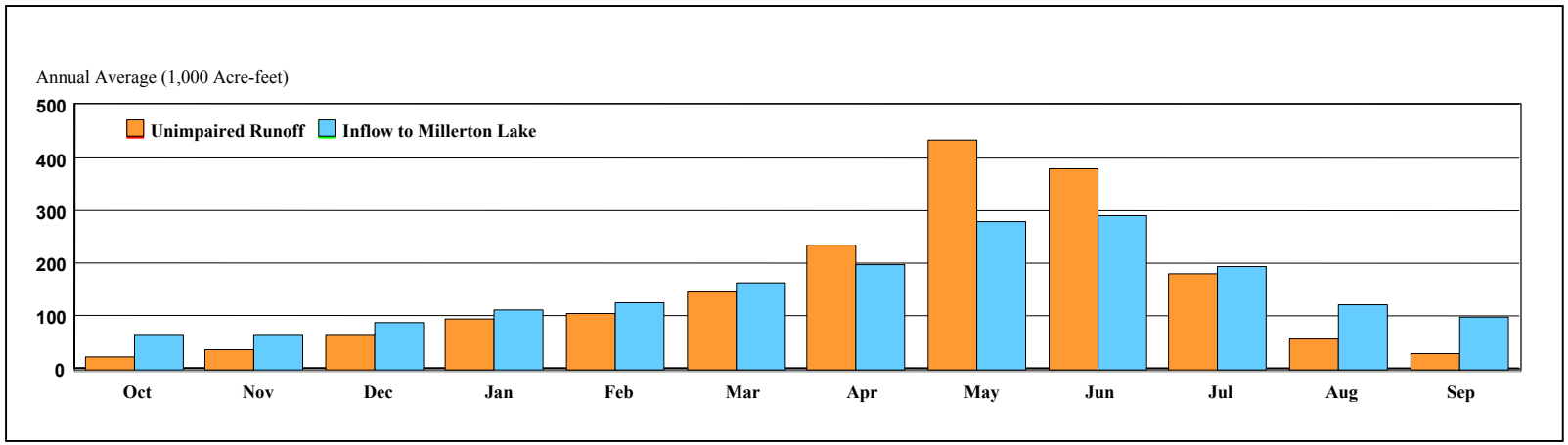

Figure 4-3
Unimpaired Runoff and Inflow to Millerton Lake

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Table 4-9
Diversions to the Madera Canal (1,000 Acre-feet)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Contract Year
1949	0	0	0	0	0	1	10	12	25	41	40	21	152	152
1950	0	0	0	0	0	0	3	12	24	37	25	17	118	118
1951	0	0	0	0	0	2	11	9	23	46	41	11	142	142
1952	0	0	0	0	0	0	1	14	34	47	54	29	179	181
1953	2	0	0	0	0	11	12	11	28	52	49	29	193	192
1954	1	0	0	0	0	4	18	24	41	54	51	20	212	211
1955	0	0	0	0	1	19	10	12	37	53	52	34	219	221
1956	0	0	0	0	3	10	15	15	45	60	57	33	239	236
1957	0	0	0	0	0	12	20	9	46	62	58	34	241	243
1958	2	0	0	0	0	4	6	28	52	64	59	29	244	250
1959	5	0	0	0	3	31	15	24	44	62	24	0	208	200
1960	0	0	0	0	0	19	6	0	42	58	17	0	144	144
1961	0	0	0	0	0	11	2	0	17	58	14	0	103	103
1962	0	0	0	0	0	8	30	30	53	67	63	26	277	278
1963	0	0	0	0	1	7	13	31	54	66	65	33	271	280
1964	10	0	0	0	1	29	0	6	50	76	50	6	228	223
1965	0	0	0	1	5	33	14	38	58	74	64	37	324	338
1966	12	0	0	0	8	31	16	8	48	72	29	0	224	229
1967	0	0	0	9	16	13	16	73	64	78	76	44	389	411
1968	24	7	0	0	15	9	0	8	43	38	22	2	170	145
1969	5	0	0	0	16	27	25	53	69	78	75	56	404	449
1970	21	6	3	7	30	17	38	41	55	57	24	1	298	258
1971	15	1	0	0	10	30	10	13	48	70	66	18	281	262
1972	1	0	0	0	6	39	0	2	40	49	17	0	153	149
1973	0	1	0	0	2	13	42	55	69	80	67	20	347	383
1974	0	0	0	29	9	21	38	59	72	79	71	16	395	367
1975	0	0	0	0	10	16	26	58	74	76	50	10	320	310
1976	0	0	0	0	0	0	0	0	13	48	33	0	94	94
1977	0	0	0	0	0	0	0	0	1	26	5	0	32	53
1978	0	0	0	0	21	50	63	75	76	78	51	22	437	457
1979	32	7	0	0	3	10	56	70	70	69	59	19	395	360
1980	1	0	0	0	5	67	75	77	75	72	71	40	484	510
1981	33	0	0	0	0	3	21	43	33	22	19	27	200	206
1982	0	0	0	11	27	26	53	78	75	76	68	42	456	472
1983	29	2	0	0	24	55	70	75	75	77	57	69	533	522
1984	37	0	0	0	8	47	34	32	31	63	51	38	340	318
1985	5	0	0	0	17	43	2	5	26	45	41	22	205	225
1986	5	0	0	0	37	60	71	76	76	79	67	42	513	506
1987	23	9	0	0	3	8	0	0	41	52	33	3	173	138
1988	0	0	0	0	0	0	0	8	43	60	10	0	122	122
1989	0	0	0	0	0	0	0	23	44	54	27	0	148	148
1990	0	0	0	0	0	0	0	0	22	56	31	1	112	112
1991	0	0	0	0	0	0	0	18	28	61	44	4	156	156
1992	0	0	0	0	0	0	0	23	50	47	6	0	127	127
1993	0	0	0	0	0	33	52	65	63	74	58	45	390	427
1994	32	5	0	0	0	0	0	15	35	44	44	8	182	148
1995	0	0	0	0	3	38	51	64	61	72	61	39	389	422
1996	27	6	0	0	3	40	41	61	61	55	43	27	363	387
1997	8	0	2	32	17	51	44	50	59	57	37	34	392	350
1998	18	0	0	0	0	33	52	58	62	69	34	29	355	404
1999	16	16	22	3	10	23	28	42	37	54	45	27	323	266
2000	9	0	0	0	0	9	36	47	52	55	38	22	269	273
2001	13	0	0	0	0	0	20	28	47	46	33	11	199	
Avg (All)	**7**	**1**	**1**	**2**	**6**	**19**	**22**	**32**	**47**	**60**	**44**	**21**	**262**	**263**
Avg (1961 on)	**9**	**1**	**1**	**2**	**8**	**22**	**25**	**37**	**51**	**62**	**44**	**21**	**282**	**285**

ensure that allocations can be met. Table 4-10 illustrates the historical allocation of Class 1 and Class 2 supplies. The purpose of Table 4-10 is to illustrate the annual variability of water supply to Friant Division water users. The actual delivery of water to Friant Division water users may differ from the allocations (e.g., water may be declared but undelivered or the record may not reflect a consistent institutional designation of water deliveries). Further, the table does not reflect deliveries not designated as Class 1 or Class 2 supplies. Appendix A includes several records of deliveries, some disaggregated by water delivery classification. At times the records do not correspond with each other on a water delivery classification basis. Specific absolute values for water deliveries, by classification, within this report are not provided, and the use of the data included in Appendix A should be approached with caution until a reconciliation of the differences is made. Water, in addition to Class 1 and 2 water, is made available in periods of high runoff when flood control releases are being made from Friant Dam or are anticipated to be made. This "surplus" or "other" water (see Section 6.3) is made available to both long-term and short-term contractors and can be delivered to lands that are not in compliance with the acreage limitations of USBR law (water delivered to these lands is sometimes called section 215 water).

Tables 4-8 and 4-9 include both the Class 1 and Class 2 deliveries as well as "surplus" water deliveries. See also Appendix A, Section 2.

4.2.3.4 River Flow Characteristics

Currently, releases to the San Joaquin River below Friant Dam are limited to that flow necessary to meet downstream contractor and riparian requirements, or flood control releases. The general rule for satisfying downstream water supply requirements is to maintain stream flow past each entity, including the last riparian land holding at Gravelly Ford. The annual amount of flow required varies from year to year, but is currently about 117,000 acre-feet. This amount has increased during the last decade and could continue to increase in the future.

Table 4-11 illustrates the monthly volume of release to the San Joaquin River from Friant Dam for the last 25 years. The trend of riparian release requirements can be estimated from this record. This record also provides insight regarding the frequency with which flood control releases occur.

The current objective of flood control operation of Friant Dam is to restrict releases from Millerton Lake to limit downstream flows in the San Joaquin River to 8,000 cfs (inclusive of flow from Cottonwood Creek and Little Dry Creek) or to a flow of 6,500 cfs at the "near Mendota" gauge below Mendota Dam. Based on USACE information, with the currently allocated flood control space in Millerton Lake this objective for downstream flows has an annual 4 percent chance of exceedance (exceeded about once in 25 years). The target flood control release has been exceeded 4 times in a 29-year period (1969, 1983, 1986, and 1997).

Table 4-10
Friant Division Water Declarations

Contract Year Mar-Feb	Class 1	Class 2*	Contract Year Mar-Feb	Class 1	Class 2
2000-01	100	17	1978-79	100	100
1999-00	100	20	1977-78	25	0
1998-99	100	10	1976-77	75	0
1997-98	100	60	1975-76	100	60
1996-97	100	58	1974-75	100	82
1995-96	100	100	1973-74	100	77
1994-95	80	0	1972-73	100	4
1993-94	100	90	1971-72	100	35
1992-93	83	0	1970-71	100	29
1991-92	100	0	1969-70	100	100
1990-91	68	0	1968-69	92	0
1989-90	98	0	1967-68	100	100
1988-89	78	0	1966-67	100	23
1987-88	91	0	1965-66	100	100
1986-87	100	100	1964-65	100	12
1985-86	100	14	1963-64	100	80
1984-85	100	50	1962-63	100	62
1983-84	100	100	1961-62	75	0
1982-83	100	100	1960-61	100	0
1981-82	100	6	1959-60	100	0
1980-81	100	100	1958-59	100	0
1979-80	100	63	1957-58	100	0

Friant-Kern Canal Service Area	Madera Canal Service Area	Millerton Lake Service Area
100 Percent Allocations	100 Percent Allocations	100 Percent Allocations
Class 1 - 659,650 acre-feet	Class 1 - 140,000 acre-feet	Class 1 - 350 acre-feet
Class 2 - 1,041,475 acre-feet	Class 2 - 346,000 acre-feet	Class 2 - 14,000 acre-feet

Total Friant Division Service Area
100 Percent Allocations
Class 1 - 800,000 acre-feet
Class 2 - 1,401,475 acre-feet

* Class 2 declarations subsequent to 1995 may not reflect all Class 2 water delivered during uncontrolled periods.

Table 4-11
Friant Dam Releases to San Joaquin River (1,000 Acre-feet)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1976	5	4	3	4	3	7	6	11	10	10	10	8	81
1977	6	5	6	4	5	7	9	8	10	12	12	9	93
1978	8	7	5	2	98	290	419	332	156	8	6	6	1,338
1979	6	3	4	17	15	6	6	11	7	7	7	6	96
1980	6	5	4	122	199	237	103	138	23	89	10	8	944
1981	5	4	2	3	3	3	5	6	8	11	8	7	65
1982	6	6	3	3	2	9	409	231	89	22	6	5	790
1983	4	92	228	223	281	437	466	380	527	311	81	119	3,150
1984	73	76	133	241	22	5	13	6	8	9	8	7	601
1985	6	3	2	2	2	3	7	8	9	10	9	8	67
1986	7	4	3	3	201	416	288	17	32	10	8	7	997
1987	4	5	2	2	3	2	8	8	9	10	9	8	70
1988	7	4	4	3	4	7	6	8	9	12	11	9	84
1989	8	6	3	2	4	6	8	9	10	13	13	9	92
1990	8	7	6	3	5	7	10	12	12	14	14	11	107
1991	10	8	7	7	8	5	7	11	12	14	13	11	111
1992	10	8	7	5	5	7	9	13	16	17	18	15	130
1993	13	8	7	3	2	26	72	57	64	42	18	15	327
1994	10	7	6	7	7	10	10	11	13	17	16	15	128
1995	11	8	7	3	21	228	341	452	157	324	29	12	1,592
1996	10	8	5	5	35	97	68	100	20	15	14	12	390
1997	11	7	63	545	353	80	14	17	17	19	21	18	1,165
1998	16	12	11	6	174	146	273	252	393	270	25	26	1,603
1999	24	24	35	17	28	5	6	9	25	35	20	14	242
2000	10	6	5	5	3	54	8	8	28	14	15	14	170
2001	13	11	11	8	5	5	7	9	16	14	16	20	137

Since 1999, supplemental flows have been released to the San Joaquin River for experimental and data-gathering purposes. These pilot program flows are included in Table 4-11 and the quantities are shown in Table 4-12.

Table 4-12
Restoration Pilot Program Releases from Friant Dam (Acre-feet)

	May	June	July	August	September	Total
1999	0	0	23,040	7,349	1,887	32,276
2000	0	0	413	2,577	2,559	5,549
2001	50	4,304	0	0	4,836	9,190

Flow in the San Joaquin River typically does not continue past Gravelly Ford. When flows do occur (usually as a result of flood control releases) they are normally diverted to the Chowchilla Bypass above Mendota Pool. However, if water user demands exist at Mendota Pool that are not being met with overflows from the Kings River, San Joaquin River flow is routed to the Mendota Pool to offset delivery requirements from the Delta-Mendota Canal. Such offsets typically increase the water supply to Westside CVP contractors.

4.2.3.5 Water Supply Availability

The Friant Division (Millerton Lake) water supply is essentially operated on an annual basis. The objective of operations is to optimize reservoir storage during the snowmelt season to carry as much stored runoff as possible into the summer irrigation season. Water delivery allocations are declared on the basis of emptying the reservoir by the end of September. Typically, not all of the allocated water is delivered by the end of September and thus Millerton Lake storage is greater than minimum at that time. The Friant Division water users have until the new contract year (the following March) to use their allocations. The annual nature of the water supply is depicted in Figure 4-4. As seen in the figure, on an annual basis all water entering Millerton Lake is essentially released to the river or diverted to the canals.

To illustrate the challenge involved in meeting both restoration flows and historical levels of Friant water user deliveries, Figure 4-5 shows a comparison of Millerton Lake inflow and the projected demands incorporated into the Study.

The information shown in Figure 4-5 is derived from the modeling of operations. The information is arranged in order of Millerton Lake inflow, from the largest year of modeled inflow to the smallest year of modeled inflow. Each bar depicts the annual water demands corresponding to a year of inflow. The water demands have been disaggregated between the two levels of restoration flow requirements (the requirements for a modified channel and the additional increment needed if the channel is not modified) and the two levels of baseline canal diversions (Case Y and the additional increment needed to meet the Case X Demands). Section 6 discusses the derivation of both the restoration flow requirement and the baseline canal demands (Sections 6.1.4 and 6.1.3, respectively).

The imbalance between inflow and demands is shown by the portion of the demand bar that exceeds inflow. The deficit between inflow and demands at times understates the imbalance since inflow at times is so large that it cannot be stored for later use. However, the figure illustrates that demands exceed the supply from inflow by an average of 200,000 acre-feet during years other than the wettest 20 percent of the Modified Channel/Baseline Demands. With the hypothetical restoration flow requirements for the Existing Channel, the average deficit is about 200,000 acre-feet for dry years, 250,000 acre-feet for normal-dry years, and 300,000 acre-feet for normal-wet years. The elimination of these deficits is the purpose of the Study components.

4.2.3.6 Sources Available to Friant Water Users

Several Friant water contractors rely primarily, if not entirely, on Friant Division water supplies. Other Friant Division contractors may have access to groundwater, locally developed surface supplies, or imported supplies via the CVP from the Sacramento–San Joaquin Delta. Locally developed surface supplies include storage projects on the Chowchilla, Fresno, Kings, Kaweah, Tule, and Kern Rivers. In wet years, Friant water users that have access to local surface supplies use that water before they use water from the Friant Division. Table 4-13 shows Friant Division water contractors and their sources of water.

4.2.3.7 Groundwater Conditions

Groundwater is a key component of the water supply for Friant Division water users. The structure of water allocation from the Friant Division is itself a recognition of the integration of groundwater and surface water supplies. During times of plentiful surface water supplies, Friant

Table 4-13
Water Sources of Friant Water Contractors and Cross Valley Contractors[1]

Contractor	Friant Division Facility	Non-Friant Source	Groundwater Facilities
Arvin-Edison WSD	Friant-Kern Canal		Pumping, Recharge
Chowchilla WD	Madera Canal	Chowchilla River	Pumping, Recharge
Delano-Earlimart ID	Friant-Kern Canal		Pumping, Recharge
Exeter ID	Friant-Kern Canal		Pumping
Fresno Co. WWD No. 18			
Fresno County	Cross Valley Canal		
Fresno ID	Friant-Kern Canal	Kings River	Pumping, Recharge
City of Fresno			Pumping, Recharge
Garfield WD	Friant-Kern Canal		
Gravelly Ford WD	San Joaquin River	Cottonwood Creek	Pumping, Recharge
Hills Valley ID	Cross Valley Canal		Pumping
International ID	Friant-Kern Canal		
Ivanhoe ID	Friant-Kern Canal	Wutchumna	Pumping
Kern-Tulare WD	Cross Valley Canal	Kern River	Pumping
Lewis Creek WD	Friant-Kern Canal		
Lindmore ID	Friant-Kern Canal		Pumping, Recharge
City of Lindsay	Friant-Kern Canal		
Lindsay-Strathmore ID	Friant-Kern Canal	Wutchumna	Pumping
Lower Tule River ID (also a Cross Valley Canal contractor)	Friant-Kern Canal	Tule River, Cross Valley	Pumping, Recharge
Madera County			
Madera ID	Madera Canal	Fresno River	Pumping, Recharge
Orange Cove ID	Friant-Kern Canal		Pumping
City of Orange Cove	Friant-Kern Canal		
Pixley ID	Cross Valley Canal	Deer Creek	Pumping, Recharge
Porterville ID	Friant-Kern Canal	Tule River	Pumping, Recharge
Rag Gulch WD	Cross Valley Canal	Kern River	Pumping
Saucelito ID	Friant-Kern Canal		Pumping, Recharge
Shafter-Wasco ID	Friant-Kern Canal		Pumping
So. San Joaquin MUD	Friant-Kern Canal		Pumping, Recharge
Stone Corral ID	Friant-Kern Canal		Pumping
Tea Pot Dome WD	Friant-Kern Canal		
Terra Bella ID	Friant-Kern Canal		Pumping
Tri-Valley WD	Cross Valley Canal		
Tulare County	Cross Valley Canal		
Tulare ID	Friant-Kern Canal	Kaweah River	Pumping, Recharge

Source: Leu 2001.
[1]Information on the use of district wells or private wells by district is not readily available.

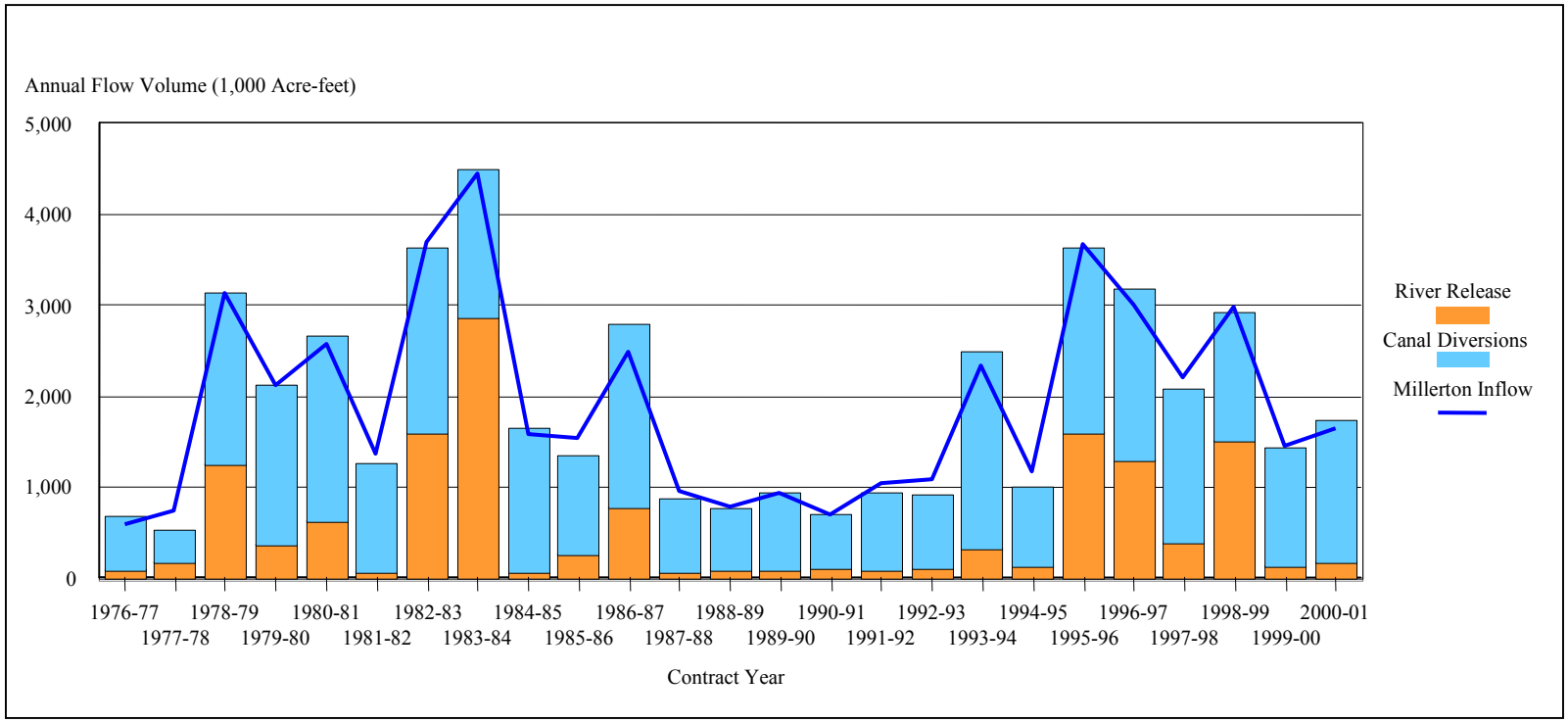

Figure 4-4
Historical Millerton Lake Inflow and Releases

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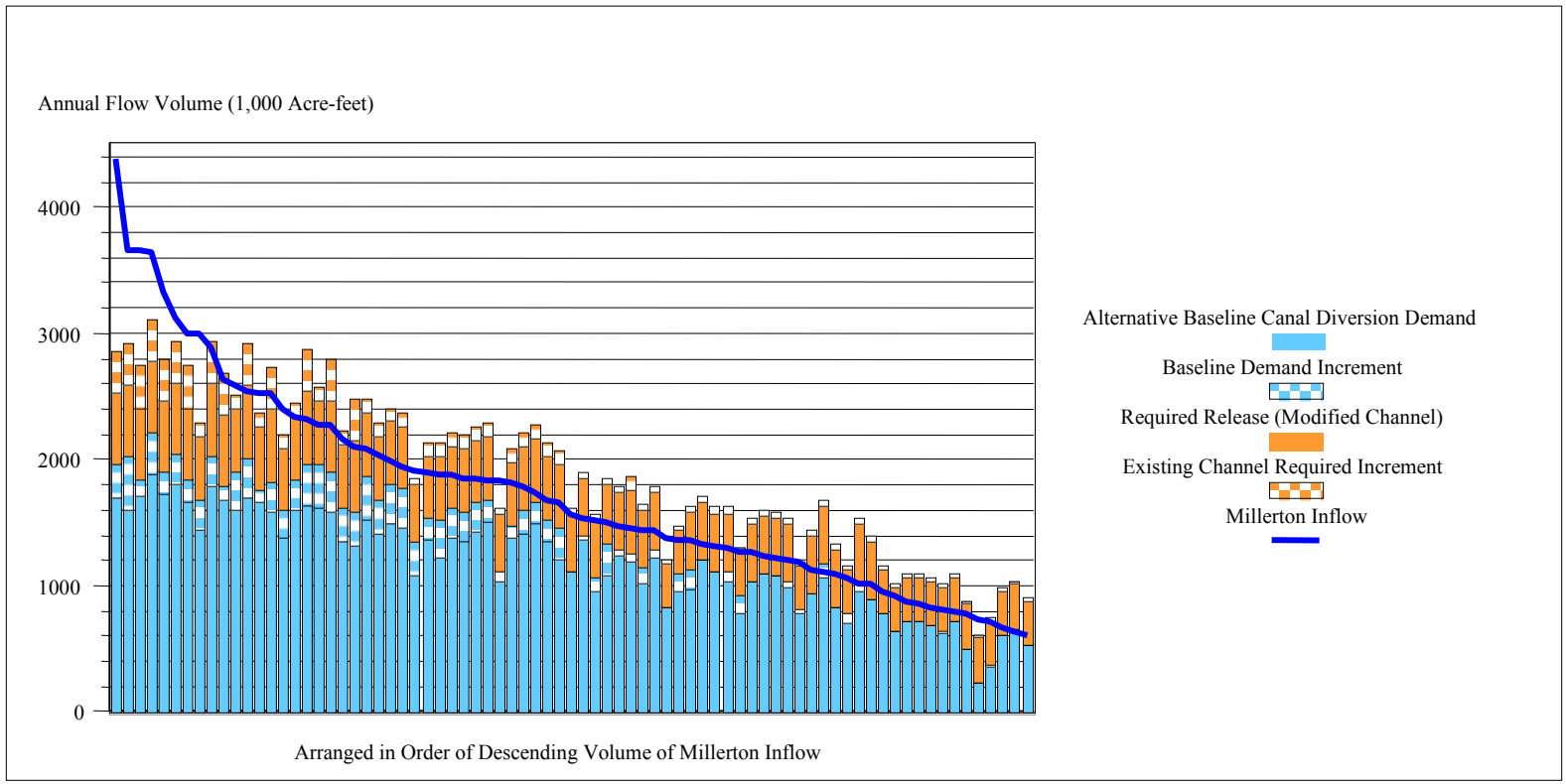

Figure 4-5
Modeled Millerton Lake Inflow and Demands

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water users receive Class 2 and other forms of water from the Friant Division. These deliveries reduce their pumping of groundwater. At some times and in certain districts, artificial recharge is used to store surface water for future use. During drier years, when surface water supplies are reduced, Friant water users return to groundwater pumping to satisfy their demands.

Information on regional groundwater conditions within the Friant Division is detailed in a number of reports by the U.S. Geological Survey. Mendenhall (1916), Davis, Lofgren, and Mark (1964), Croft and Gordon (1968), Hilton (1963), and Lofgren and Klausing (1969), as well as the California Department of Water Resources (1959), have performed studies that describe the occurrence and use of groundwater resources in the area. In addition to these studies, USBR prepared factual reports when developing the Friant project wherein evaluations were made as to the availability of groundwater resources. Mendenhall's work was prior to extensive exploitation and gives a good accounting of the availability of supplies around the turn of the century. The more recent studies were prepared in the reaction to rapidly dropping groundwater levels and significant land subsidence due to groundwater withdrawals.

Generally, the boom of irrigation development in the Valley occurred after the end of World War I and was almost entirely dependent on the development of groundwater resources. The areas impacted most severely were those areas that were not naturally replenished (Eastern Madera County, Southern Tulare County, and Northern Kern County). In some cases the drop in levels was documented to be more than 150 feet in 30 years. The importation of surface supplies is said to have stabilized the long-term trend of groundwater depletion; however, water levels have not recovered in many places to pre-project conditions.

The general state of balance between groundwater, surface water supplies, and demands can be seen in Figure 4-6. This figure shows the cumulative groundwater storage change within the Friant Division service area for the period 1965 through 1999. The data are based on a calculation of the annual change in groundwater elevation, specific yield, and area within Friant Division water districts. The methodology was developed by USBR for reporting in its annual Water Supply Report (discontinued in 1992) and has since been used by FWUA for the purposes of this report (FWUA 2002).

The main groundwater supply for the Friant Division service area (and for the entire San Joaquin Valley) comes from direct recharge from infiltrating stream flow and precipitation, artificial recharge, and application of irrigation water. The demands on the groundwater supply are primarily agricultural and urban. The long-term annual trend shown in Figure 4-6 is indicative of the dependence of the service area on the conjunctive use of groundwater and surface water supplies. The long-term trend mirrors the accumulation of precipitation. The changes in year-to-year volumes are directly related to the availability of surface water supplies, and surface water supplies are directly related to runoff due to precipitation. (Percolation of precipitation and stream flow infiltration during wet years also influences the accumulated volume.)

Review of the results shows that during dry sequences of years (e.g., 1976 to 1977 and 1987 to 1992), significant reliance on groundwater occurs within the Friant Division service area, and this reliance leads to significant cumulative deficits to the groundwater basin. Conversely, during the relatively wet years of the early 1980s and the post-1992 years, the basin as a whole has recovered. The analysis for the 1965 to 1999 period indicates that there has been a great fluctuation in volume during the period and in general no net gain or loss to the basin as a whole.

Information from the USBR Water Supply Reports indicates that from the beginning of Friant Division operation (1944 for the Madera Canal and 1949 for the Friant-Kern Canal) through 1964 (the beginning of the period illustrated in Figure 4-6), the Friant Division service area experienced a cumulative reduction in groundwater storage of 450,000 acre-feet (FWUA 2002). This antecedent condition is not illustrated in the figure, and the trend of groundwater depletion is not evident before Friant Division development and operation.

Although the results indicate that the use and recovery of groundwater storage has generally "balanced" for the Friant Division service area as a whole during recent wet and dry cycles, certain areas within the service area do not individually show a balance. Appendix A, Section 1 illustrates the results of the analysis for the period 1990 through 1999. The districts within the Madera Canal service area (Chowchilla WD and Madera ID) show groundwater trends that are exceptions to the general trend of balancing. The results show that since the end of the 1987 to 1992 drought, these two areas have been slow to recover (Chowchilla WD) or have experienced a worsening of cumulative storage (Madera ID). Within the Friant-Kern Canal service area, most district areas show a trend toward recovery, particularly the Arvin-Edison Water Storage District, which, though still in overdraft, has significant capacity to operate in lieu and artificial recharge programs. The exceptions reflect areas that are not conducive to rapid recharge.

4.3 SOURCES AND FACILITIES FOR RESTORATION WATER SUPPLY

The Study identifies various means to develop water to meet the objective of providing hypothetical restorations flows and maintaining Friant Division water user deliveries. Facilities and sources of water supplies are necessary to develop the water.

4.3.1 Surplus Flows at Friant Dam

One source of water that can be further developed is the water that already occurs at Friant Dam. During about 40 percent of the years evaluated within the baseline operation, inflow is greater than Millerton Lake's ability to control all inflow through storage, canal diversions, and minimum releases downstream. This circumstance results in "spills" to the San Joaquin River. Through use of additional storage, water that would otherwise be spilled from Friant Dam could be conserved for later use. The Study investigates the storage of this water in surface water reservoirs (e.g., "enlarged Millerton" and a new Fine Gold Reservoir) and groundwater storage.

Table 4-11 (Section 4.2.3.4) shows the occurrence of Millerton Lake spills during recent history. Figure 4-7 illustrates a long-term simulation of annual spills from Millerton Lake for the period 1922 through 1999. This simulation is representative of operations for diversions and downstream requirements that mimic recent history (described in Section 6, Case X Demand scenario).

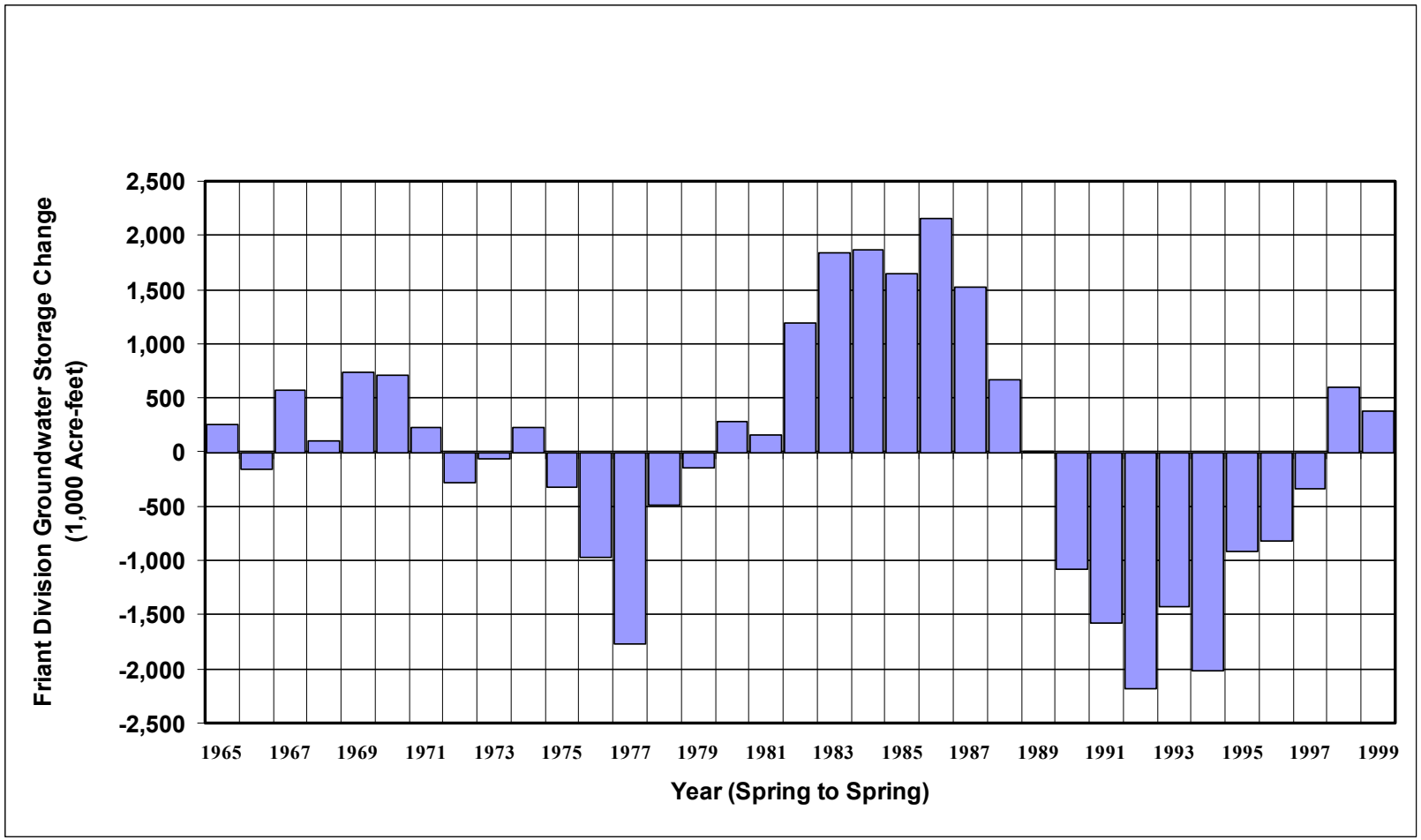

Figure 4-6
Friant Division Cumulative Groundwater Storage Change

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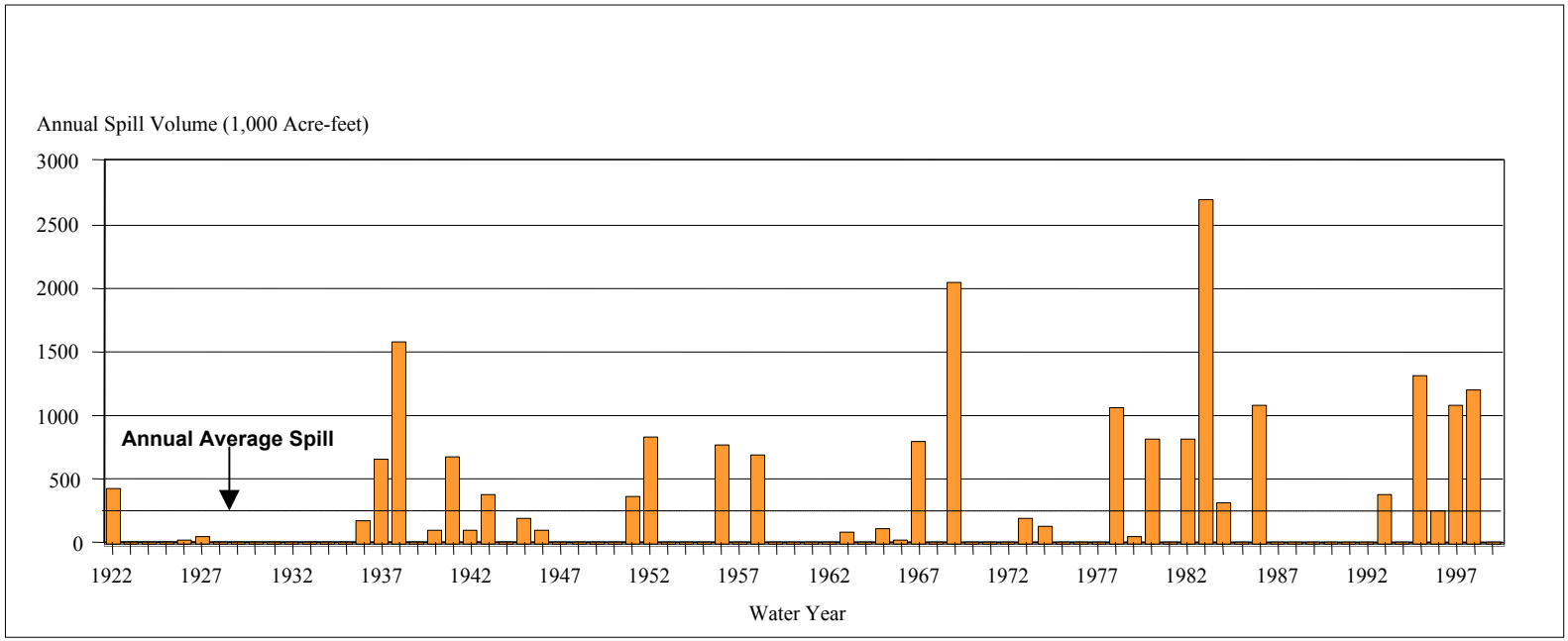

Figure 4-7
Simulated Millerton Lake Spills
Case X Demand

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Simulated spills range from negligible to over 2,500,000 acre-feet in a year, with an annual average of 276,000 acre-feet. Although spills may occur during any month of the year, spills most frequently occur between January and June.

Some of the spills depicted in Figure 4-7 diminish when restoration flow requirements are included in simulated operations. A portion of the spilled water becomes a portion of required restoration flows. Also, the annual restoration flow requirement draws more heavily on Millerton

Lake storage, which creates additional available storage for subsequent runoff that would otherwise be spilled.

4.3.2 Eastside Tributary Surplus Flows

Several major rivers contribute to the hydrology of the Tulare Lake Basin and directly or indirectly affect the operation of the Friant Division. The Kings, Kaweah, Tule, and Kern Rivers are currently contributing to the water supply of certain Friant Division contractors. Each of these rivers has been developed for water supply and flood control purposes. Table 4-14 provides data concerning the streams and their control facility.

Table 4-14
Eastside Tributary Streams

Stream	Average Annual Runoff (Acre-feet)	Control Facility	Storage Capacity (Acre-feet)
Kings River	1,660,000	Pine Flat Dam	1,000,000
Kaweah River	427,000	Terminus Dam	150,000
Tule River	149,000	Success Dam	82,300
Kern River	707,000	Isabella Dam	570,000

The Fresno River and Chowchilla River systems also have the potential to affect Friant Division operations and provide an additional source of water to Madera Canal contractors. Each of these systems has an annual average runoff of approximately 80,000 acre-feet. Hidden Dam (Hensley Lake, 90,000 acre-feet) regulates the Fresno River and Buchanan Dam (Eastman Lake, 150,000 acre-feet) regulates the Chowchilla River. Flows from these rivers are tributary to the San Joaquin River via the Eastside Bypass downstream of Friant Dam.

At times flows from the Eastside tributaries exceed the capacity for beneficial use. For the Kings River system, flood flows are often routed to the San Joaquin River via the James Bypass. Kings River flood flows are also routed to the Tulare Lakebed and impounded for later use. Flood flows from the Kaweah, Tule, and Kern River systems are similarly routed to the Tulare Lakebed during flood events. This Study contemplates greater conservation of Eastside tributary flow. Common to the configurations (bundles) is the diversion of Eastside tributary surplus flows to Study components. Most commonly exercised is the interception of flood flows at the Friant-Kern Canal, where the canal crosses the Kings, Kaweah, and Tule Rivers. The surplus flow is diverted to the Friant-Kern Canal to directly meet Friant water user demands and/or is banked in groundwater for future use. Also, percolation of flood flows with high suspended solids into recharge ponds is detrimental to the ponds (the sealing of the ponds by the suspended fines has been a common experience).

Figure 4-8 illustrates the annual frequency of surplus flows from the Eastside tributary streams. The assumed occurrence of surplus flows used in this analysis is based on a combination of recorded flows, reported flooding of Tulare Lakebed, and estimated hydrology. For periods when comprehensive records of flooding were not available and for periods prior to the existence of the current facilities, relationships between basin hydrologic parameters and flows were developed. These relationships are included in the analysis supporting results reported in Appendix A. On the assumption that current and local programs under development will minimize the occurrence of Kern River flood flows to the Tulare Lakebed, potential surplus flows from the Kern River system were not used in this analysis.

4.3.3 San Joaquin River Tributaries

The major San Joaquin River tributaries include the Merced, Tuolumne, and Stanislaus Rivers. Each of these systems contributes to the hydrology of the San Joaquin River and the Sacramento–San Joaquin Delta. This Study emphasizes the Merced River system. Two facets of potential water supply from the Merced River are evaluated: (1) the flows contributed to the San Joaquin River for San Joaquin River Agreement VAMP purposes and (2) the surplus flows of the system.

The premise of the VAMP exchange is that restoration flows released from Friant Dam contribute to flow in the San Joaquin River during the VAMP flow period. In exchange for these releases it is assumed that VAMP flow that otherwise would be contributed to the San Joaquin River from the Merced River may instead be conveyed to the Madera Canal service area and used to offset diversion requirements from Millerton Lake. The second component of water supply from the Merced River is the conveyance of flood flows from the Merced River to the Madera Canal service area.

Due to the lack of information concerning the occurrence and operation of flood flows from the Fresno and Chowchilla River systems, they are not included as potential water supplies in this Study. As additional information is acquired regarding these systems, these flows could be incorporated into future analyses.

4.3.4 Delta Supplies

The Study assumes the use of the existing pumping and conveyance facilities for the SWP/CVP. In general, pumping from the Delta in the Study has been limited to recapture of the amount of incremental water that reaches the Delta from Friant Dam restoration releases. On occasion, the Study includes the pumping of additional water that is assumed to be surplus to the San Joaquin River. The Study does not assume the development of additional supply from surplus Delta flows. Also, water purchases conveyed through the Delta have not been explicitly modeled in the Study.

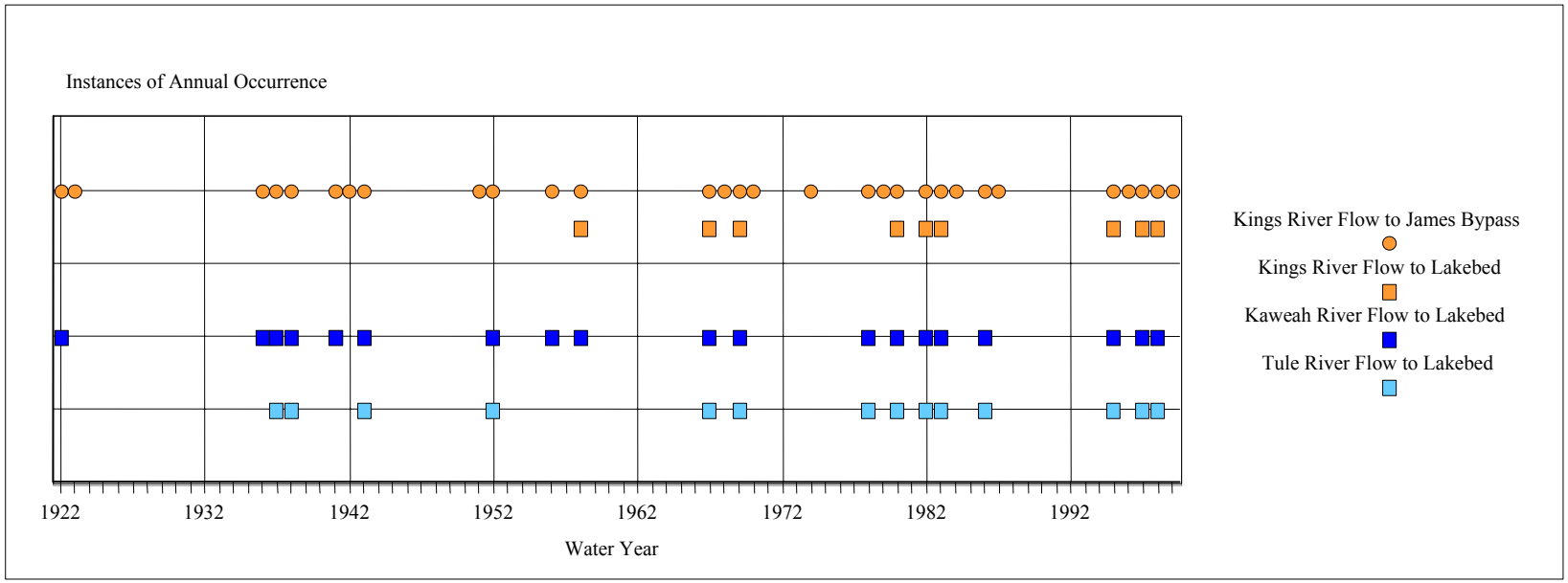

Figure 4-8
Simulated or Recorded Eastside Tributary Surplus Flow

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5.1 OVERVIEW OF PROCESS

This section reviews the process used for development and evaluation of alternatives for producing a water supply that supports habitat restoration on the San Joaquin River. The process was initiated in September 2000 and began with the development of a "long list" of alternatives, which was subsequently screened to produce the "short list" of alternatives described herein as part of this initial Study. It is anticipated that additional evaluations will be used to modify, reconfigure, and improve this short list; assist in selecting measures for implementation; and develop a comprehensive plan to restore flows and environmental values to the San Joaquin River below Friant Dam. "Alternative" is a general term that applies to all water supply components and the assembly of these components into appropriate bundles that represent the short list alternatives. To avoid confusion, the specific terms associated with the development of the short list alternatives and used in subsequent sections of this Study are described below:

- **Component.** A component is a water supply alternative (such as a new dam and reservoir or reoperation of an existing reservoir) that may or may not be complete in terms of its ability to satisfy the water supply needs in and of itself. A total of 73 individual components were initially identified. Many of these are components of possible alternative bundles, and most of these must be combined with other components to form complete, stand-alone water supply bundles. All of the components identified were subject to preliminary screening for fatal flaws.
- **Theme.** The large number of components led to a strategy for packaging components according to a theme. A theme is a way of combining components to achieve a particular emphasis or objective. Themes were selected based on geography and functional operation. For example, one of the themes focused on reoperation of existing facilities to provide additional water supplies. A total of eight themes were identified and used as a basis for combining the components into a series of packages that were then screened for potential yield, cost, and implementability and used to develop the short list of alternative water supply bundles.
- **Bundle.** A bundle is a combination of water supply components (selected from one or more themes) that represents a complete, stand-alone water supply alternative. Several bundles have been identified as part of our evaluations and represent the short list of alternatives that have been carried forward for the detailed analyses described herein.
- **Common Elements.** Common elements are a set of components that rely on existing facilities. Common elements include reoperation of Friant Dam/Millerton Lake and related facilities, recovery and recirculation, water market purchases, reclamation, and conservation. These common elements were used in each preliminary bundle. In addition to these common elements, the final bundles also include groundwater storage and extraction programs, Friant-Kern Canal reverse pumping, and Eastside tributary pump-in as additional common elements. Refer to Table 5-1.

Table 5-1
Bundle Configurations

	COMPONENTS												
	Groundwater Storage and Extraction Programs	Mendota Pool Recirculation	Conveyance in CA and DMC/San Luis Storage	East and West Conveyance at Kern	Friant-Kern Canal Reverse Pumping	Eastside Tributary Pump-in	California Aqueduct Account	Water Purchases, Reclamation, and Water Conservation	Delta Recirculation	Millerton Minimum Pool Storage	Tulare Lakebed Storage and Conveyance	Millerton Enlargement/Mammoth Modifications	Fine Gold Reservoir
Bundle A: Existing Facilities	■	■	■	■	■	■	■	■					
Bundle B: Expanded Recirculation plus Millerton Minimum Pool	■	■	■	■	■	■	■	■	■	■			
Bundle C: Tulare Lakebed Storage	■	■	■	■	■	■	■	■	■		■		
Bundle D: Millerton Enlargement/Mammoth Pool	■	■	■	■	■	■	■	■	■			■	
Bundle E: Millerton/Mammoth and Fine Gold	■	■	■	■	■	■	■	■	■			■	■
	COMMON ELEMENTS												

The process for development of the bundles contained in this Study includes the following steps:

- Creation of a long list of components
- Preliminary sorting of components into a series of eight categories of alternatives by type of component
- Organization of the components into themes
- Refinement and review of the themes
- Combination of theme components into a series of water supply alternative bundles
- Selection of a short list of bundles
- Bundle refinement
- Analysis of the bundles

Figure 5-1 provides an overview of the process used for developing and refining the water supply alternatives.

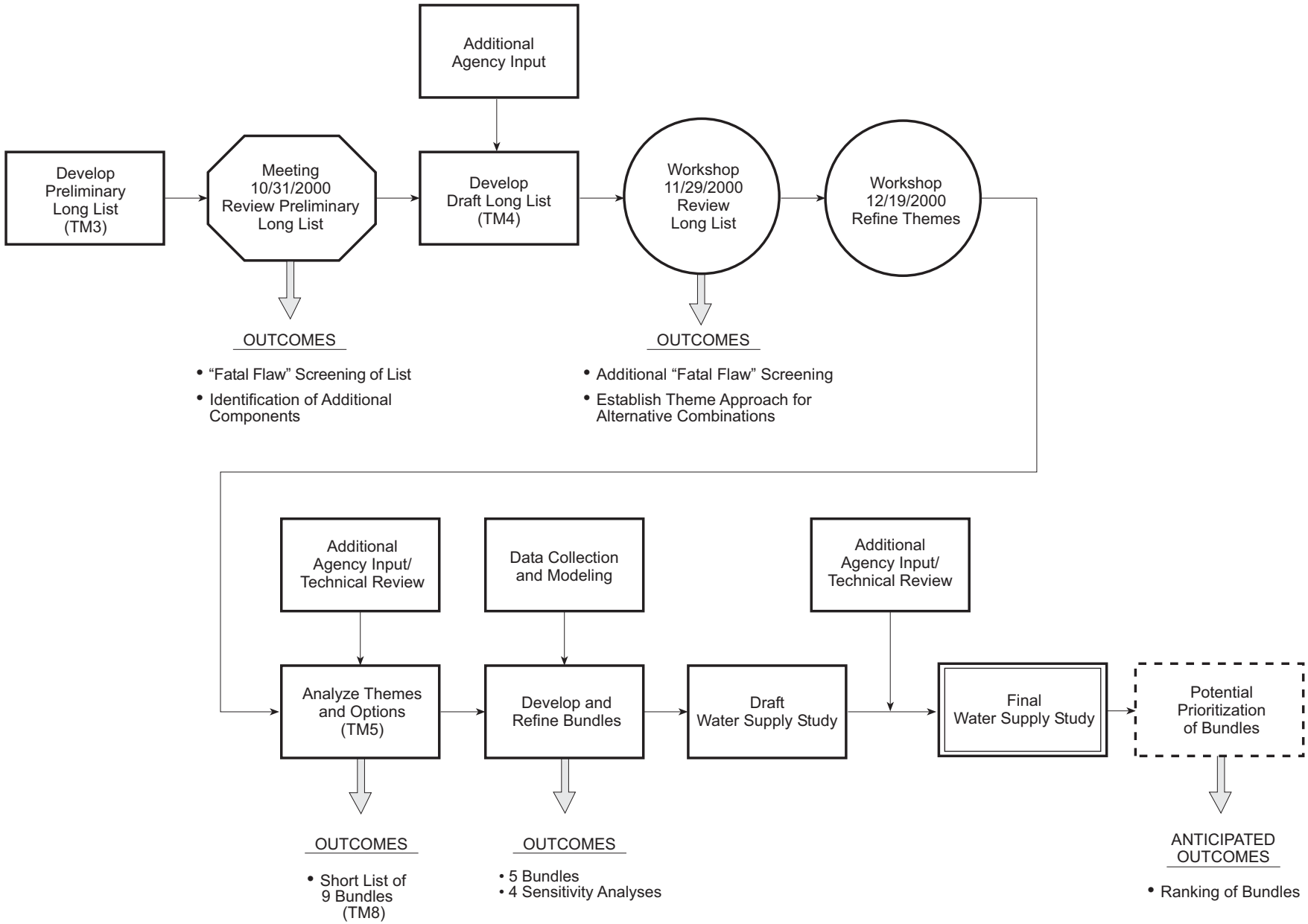
5.1.1 Development and Expansion of Long List

A preliminary listing and description of 64 candidate water supply alternatives (i.e., components) for providing water to the San Joaquin River was presented in Technical Memorandum 3 (URS 2000b). This "Preliminary Long List" of components (which was subsequently expanded to 73 components) was initially developed considering the list of 15 alternatives contained in Appendix C of the Request for Proposals and subsequently expanded using information obtained from the URS Consultant Team and from a literature review and agency survey efforts. Much of the preliminary information was developed from discussions with representatives from water supply agencies, irrigation districts, and state and federal agencies.

For presentation and ease of comparison, the preliminary long list of components was organized into a series of eight categories of alternatives as indicated below. In those instances where an alternative consists of a combination of two or more components, the alternative was categorized according to the primary focus of the alternative.

- Category 1: Groundwater/Conjunctive Use Alternatives
- Category 2: Reservoir Reoperation Alternatives
- Category 3: Watershed Yield Enhancement Alternatives
- Category 4: New/Expanded Surface Storage Alternatives
- Category 5: Westside Alternatives
- Category 6: New/Expanded Conveyance System Alternatives
- Category 7: Water Transfers, Exchanges, and Management Alternatives
- Category 8: Environmental Water Account/Acquisition Alternatives

The 64 preliminary alternatives described in Technical Memorandum 3 (URS 2000b) were reviewed on October 31, 2000, with the WSOT, at which time 9 additional components were



URS	Project No. 26812392 San Joaquin River Water Supply Study	PROCESS FOR DEVELOPING WATER SUPPLY ALTERNATIVES	Figure 5-1

26812392.00600/100702/gos

added, for a total of 73 components. This draft long list was subjected to further data collection and analysis in Technical Memorandum 4, including estimates of yield and cost along with environmental concerns and other factors that could affect implementation (URS 2000d). The components considered are listed below in Table 5-2.

The draft long list of alternatives was reviewed with the WSOT during a workshop on November 29, 2000. At that time only a few components were removed from the list and it was determined that additional cost information was needed for some of the new storage components. Also, at that workshop the theme approach to combining components into workable alternative packages was introduced. The theme approach was selected as the basis for winnowing out many of the components and for combining the remaining components into alternative packages, which were the precursors to the complete stand-alone bundles.

5.1.2 Description of Themes Approach

The original eight categories listed in Section 5.1.1 are types of projects or facilities. The large number of components associated with these categories led to the development of a **strategy** for sorting and combining individual components according to a theme. As described above, a theme is a way of combining components to achieve a particular management or operational emphasis or objective. Rather than evaluate site-specific projects, the approach was taken to identify and define different strategies and approaches and to evaluate how well they performed in different configurations. The themes that were selected in December 2000 are based on geography and functional operation. Some themes are broken down into multiple subthemes or options that represent variations in approach to the theme, while maintaining the overall objective of the theme. The themes and their associated alternatives were discussed among the members of the WSOT in meetings and teleconferences from December 2000 through April 2001 and ultimately resulted in the themes and alternatives contained in *Technical Memorandum 5: Analysis of Long List Alternatives* (URS 2001a). In this document, the URS Consultant Team analyzed the alternatives associated with each of the following themes for potential yield, costs, and implementation concerns.

- Theme 1: Friant/San Joaquin River Basin Reoperation
  - Option 1A: Modified Friant Minimum Pool (Less Than 140,000 Acre-Feet)
  - Option 1B: Modified Friant Operations to Maximize Yield
- Theme 2: Friant Release Recapture
  - Option 2A: Friant Release Recapture Utilizing Existing Conveyance Facilities
  - Option 2B: Friant Release Recapture With New Patterson Pumping Facility
  - Option 2C: Friant Release Recapture With a Mid-Valley Canal
- Theme 3: San Joaquin River New Storage
- Theme 4: Friant Eastside Capture (South of Millerton Lake)
  - Option 4A: New Surface Storage East of Friant-Kern Canal
  - Option 4B: New Surface Storage In Tulare Lake Bed

Table 5-2
Components of the Alternatives Considered in Water Supply Study

1. Groundwater/Conjunctive Use Alternatives

   Arvin-Edison Water Storage District
   Semitropic Water Storage District
   Fresno Irrigation District
   Aquifer Storage and Recovery Project through surface water treatment plants
   Madera Ranch
   Poso Creek
   Central Fresno County/Raisin City Water District
   Kern County Groundwater Banking Program
   Pleasant Valley Area (West Side)
   Gravelly Ford Water Bank
   Lake Madera
   Deer Creek
   Merced River Watershed
   Kings River
   Southern Tulare/North Kern Joint Powers Authority
   West of California Aqueduct in Westlands Water District
   Kaweah Delta Water Conservation District (KDWCD)
   Mendota Pool area
   Recharge well field on Kaweah River
   White River
   Kern County Water Agency

2. Reservoir Reoperation Alternatives

   Reoperation of Millerton Lake for peak spring releases
   Reoperation of Millerton Lake to reduce rain season flood control releases
   Reoperation of Millerton Lake to use the pool below canal intakes
   Reoperation of Millerton Lake to supply water to San Luis Canal
   Reoperation of power reservoirs above Millerton Lake
   Coordinate Millerton Lake operation with facilities on Kaweah River
   Coordinate Millerton Lake operation with space in Pine Flat Reservoir
   Coordinate Millerton Lake operation with facilities on Eastside
   Coordinate Millerton Lake operation with Tulare Lake operation

3. Watershed Yield Enhancement Alternatives

   Cloud-seeding for runoff management
   Water augmentation through land use practices

4. New/Expanded Surface Storage Alternatives

   San Joaquin River Watershed:
   Friant Dam raise
   New Temperance Flat Dam
   Mammoth Pool expansion
   New Fine Gold Creek Dam
   Big Dry Creek Reservoir
   Kings River Watershed:
   Pine Flat Dam raise
   New Rogers Crossing Dam
   New Mill Creek Dam

New Dinkey Creek Dam
Kaweah River Watershed:
Terminus Dam raise
New Yokohl Creek Dam
New Dry Creek Dam
Tule River Watershed:
Success Dam raise
New Hungry Hollow Dam
West Side Watershed:
New Los Banos Grande Dam
New Panoche Creek Dam
New Arroyo Pasajero
New storage – Tulare Lake Basin
N. San Joaquin River Watershed:
Montgomery Reservoir

5. New/Expanded Conveyance System Alternatives

Cross Valley Canal improvements
Tulare Lake Basin connection to Friant-Kern Canal
Tulare Lake Bed connection to California Aqueduct
Mid Valley Canal
East Side Rivers Interconnection
San Joaquin Pipeline connection to California Aqueduct
Mendota Pool/Outside Canal to Delta-Mendota Canal
San Joaquin River to Delta-Mendota Canal Interconnection
Delta-Mendota Canal to California Aqueduct Intertie
Shafter-Wasco Pipeline
Arvin-Edison to California Aqueduct Intertie
Kern Water Bank Canal

6. Water Transfers, Exchanges, and Management Alternatives

Transfers from Water Conservation Measures
Water Management
- Recirculation
- Tailwater recovery
- Drainwater reuse
- Spill management
- Reuse of municipal and industrial effluent
- Oil field water reclamation

7. Environmental Water Account/Acquisition Alternatives

CALFED Environmental Water Account
General Environmental Water Account to be applied to the San Joaquin River Basin

- Theme 5: Friant Eastside Capture (North of Millerton Lake)
  - Option 5A: Friant-North Eastside Capture, No Surface Storage – Madera Canal Service Area
  - Option 5B: Friant-North Eastside Capture, With Surface Storage at Montgomery Reservoir – Madera Canal Service Area
  - Option 5C: Friant-North Eastside Capture, With Storage at Montgomery Reservoir – Madera Canal Service Area and San Joaquin River
- Theme 6: Eastside-Friant Canal
- Theme 7: Western Supply
  - Option 7A: Outside Canal to Delta-Mendota Canal
- Theme 8: Water Purchases and Management
  - Option 8A: Water Acquisitions
  - Option 8B: Water Reclamation
  - Option 8C: Environmental Water Account

5.2 DEVELOPMENT OF PRELIMINARY BUNDLES

The next step in the development of alternatives (and the associated analysis process) involved combining the most promising water supply options from the theme approach as identified in Technical Memorandum 5 (URS 2001a) (and supplemented as needed with components contained in Technical Memorandum 4 [URS 2000d]) into a series of "bundles." A bundle is a combination of options/components from the themes that represents a complete, stand-alone alternative. The bundling of alternatives was based on a process that evaluated the components by focusing on a few key criteria, namely yield, cost, and implementation factors, including the timing of supply and reliability. The goal of this step was to develop three to five bundles that would serve as the short list of alternatives for further analysis and the development of this Water Supply Study.

The bundles began with the concept of relying on existing facilities, including reoperation, recirculation, conservation, reclamation, and water purchases. Together these components are called "common elements" because they are included in all of the bundles (i.e., are common to all). This concept was expanded to include other components as necessary to meet the preliminary restoration demand. Nine alternative bundles were described in *Technical Memorandum 8: Approved Short List Alternatives* (URS 2001b). The bundles approved by the WSOT for further investigation with the hydrologic modeling are described below.

5.2.1 Preliminary Bundle A: Common Elements Maximized

The elements that constitute this bundle include water market purchases, reclamation and conservation, reoperation of Friant Dam/Millerton Lake and related facilities, and recovery and recirculation of restoration flows utilizing existing facilities. These elements are described in Sections 6.1.6 and 6.3.

5.2.2 Preliminary Bundle B: Common Elements Plus Improved Recirculation

This bundle consists of Bundle A elements, as needed, to meet part of the restoration demand and a modified recirculation element with new facilities, including a pump station near the community of Patterson and increased capacity to the Cross Valley Canal. The Patterson facility would pump restoration flow from the San Joaquin River to the Delta-Mendota Canal for delivery back to Friant Division water users via the Cross Valley Canal.

5.2.3 Preliminary Bundle C: Common Elements Plus Storage

Bundle C consists of new surface and groundwater storage in addition to the Bundle A elements. Seven options/suboptions were considered.

- Bundle C1: Groundwater Storage
- Bundle C2: Groundwater Storage Plus Friant Minimum Pool and Reoperation
- Bundle C3: Groundwater Storage Plus Tulare Lakebed Storage
- Bundle C4: Groundwater Storage Plus Friant Minimum Pool and Existing Reservoirs
- Bundle C5: Groundwater Storage Plus New Eastside Storage
  - Bundle C5.1: Raise Friant Dam for up to 105 TAF
  - Bundle C5.2: Fine Gold Creek off-stream storage for up to 200-400 TAF
  - Bundle C5.3: Yokohl Creek on-stream storage for up to 200-400 TAF

5.3 BUNDLE REFINEMENT AND ANALYSIS

The next step involved the refinement of the short-list alternatives (preliminary bundles) with additional data collection and analysis, including hydrologic modeling and costing, over the period July 2001 through January 2002. With the completion of Technical Memorandum 8 (URS 2001b), additional analyses were completed to reduce the number of bundles to be evaluated in this Study. For the options under Bundle C5, additional cost, biological sensitivities, and cultural resources concerns were developed. Bundle C5.3 was eliminated from further evaluation after the WSOT reviewed this additional information and previous information presented in Technical Memoranda 4 and 5 (URS 2000d and URS 2001a respectively). The next steps in the refinement and analysis process were interactive modeling/gaming of the system followed by long-term hydrologic modeling, including sensitivity analyses. The details of the hydrologic modeling and costing are included in Section 6.1. The refined bundles are presented below.

5.3.1 Final Bundles

Five distinctly different bundles, Bundles A, B, C, D, and E, were developed through the bundle refinement process. The components associated with one or more of the bundles are illustrated in Figure 5-2. These components range from water purchases to surface water storage facilities and can include the use of storage and conveyance facilities of various entities. The components in blue already exist, whereas the components in red are new facilities.

Table 5-1 describes the various components included in each bundle.

- Bundle A generally represents the use of existing storage and conveyance systems along with a major groundwater storage and extraction system and high reliance on water purchases to meet deliveries and restoration flows. Bundle A components are common to all of the other bundles, but their relative utilization varies as other supply and conveyance components are added in each of the other bundles.
- Bundle B builds on the configuration of Bundle A with a component of additional recirculation (the ability to capture restoration flows downstream at the Delta for re-use). This bundle also includes a component to develop additional storage at Millerton Lake through operating the reservoir down to a minimum pool of 40,000 acre-feet and thereby gaining approximately 100,000 acre-feet of presently unexercised reservoir operating capacity.
- Bundle C includes development of a new storage reservoir (100,000 acre-feet) in the Tulare Lakebed for both regulation of recirculated flows and for capture of flood flows.
- Bundle D includes development of additional storage at Millerton Lake through an assumed enlargement of the reservoir (105,000 acre-feet) and through modifications to Mammoth Pool facilities (30,000 acre-feet).
- Bundle E includes the components associated with Bundle D and an additional storage component developed at the proposed Fine Gold Reservoir site (400,000 acre-feet).

5.3.2 Configuration Sensitivity Analyses

In addition to these five primary bundle configurations, several configuration sensitivity analyses are included. Various components of recirculation were added to Bundle A to evaluate the individual and combined effectiveness of recirculation. Added to Bundle B is a 100 cfs capacity intertie with the Merced River Basin system. Added to Bundles B, C, D and E is additional recirculation from the San Joaquin River (including a 500 cfs capacity Patterson Pump Station) to permit capture of river flow not necessary for downstream river restoration. Sensitivity analysis on these bundles also includes a component to increase west to east capacity on the Cross Valley Canal by 337 cfs. The effect of eliminating Eastside Tributary surplus from each bundle is also evaluated.

This configuration sensitivity evaluation of the bundles is described in Section 6.8.

5.4 BUNDLE COMPONENTS

All of the bundles representing the short list alternatives consist of a variety of component facilities, including existing facilities, proposed upgrades to existing facilities, and proposed new facilities. All of the facilities considered are described in Technical Memorandum 5 (with addenda) (URS 2001a). The components chosen for inclusion in one or more of the bundles are described briefly below.

There are institutional, recreational, environmental, or other concerns associated with all of the bundle components. These concerns are briefly described in Section 6 under the analysis of each bundle.

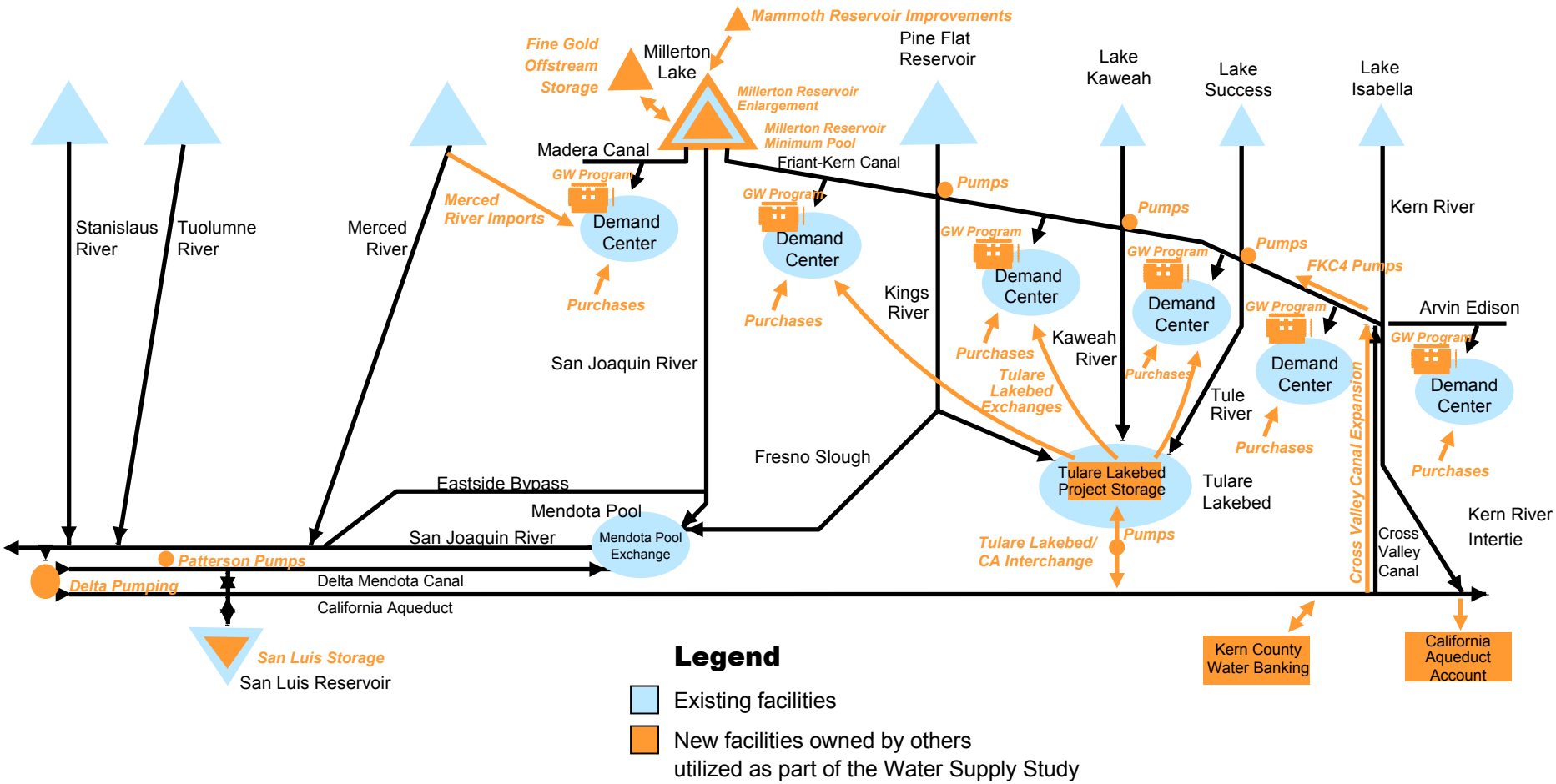


Figure 5-2
All Components in Bundle Configurations

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Some bundle components can be viewed as surrogates for other similar facilities in order to maintain a high degree of flexibility at this stage of the planning process. For example, improving the capacity of the existing Cross Valley Canal by 500 cfs could be viewed as a surrogate for other conveyance changes. Costs may change, but the functionality of 500 cfs of additional conveyance capacity would remain similar. In much the same way, enlarging Millerton Lake can be viewed as a surrogate for other San Joaquin River on-stream surface storage options.

5.4.1 Groundwater Storage and Extraction Programs

Each of the short list bundles includes groundwater banking and extraction as a basic building block of the bundle. The groundwater banking and extraction programs are treated in the economic analysis as contractual arrangements and costed with a "put charge" for any water banked. The water is also assigned a power cost to account for the cost of pumping during extraction, which varies depending on the assumed location of the groundwater bank (see Section 6.1).

All of the banks include the facilities necessary to develop their assumed banking and extraction capabilities. Although conceived as contractual arrangements with the physical mechanisms of the programs to be established by the banker and purchaser (e.g., in lieu or direct recharge), certain constraints are assumed for each of the banks. It should be noted that recharge could be implemented with expanded in lieu programs, but for modeling purposes an active recharge program was assumed.

The groundwater storage and extraction program assumes use of a number of existing or newly developed groundwater banks within or adjacent to Friant Water Users' demand centers. In addition, a Westside bank is included to provide storage for recovered and recirculated flows that could not be conveyed and/or utilized directly because of conveyance limitations and/or limited demand during a particular time period. Direct San Joaquin River recharge was not evaluated for this study.

Specifically, a total of six Eastside banks (or aggregations of banks) have been modeled to service Friant Division demand centers (see Figure 5-2):

- Madera Canal
- Between San Joaquin and Kings Rivers
- Between Kings and Kaweah Rivers
- Between Kaweah and Tule Rivers
- Between Tule and Kern Rivers
- South of Kern River

Each of these Eastside demand centers is assumed to have an aggregate banking capability equal to 8,000 acre-feet per month (132 cfs) and an extraction capability of 5,000 acre-feet per month (83 cfs). The banking value is a surrogate of a program that utilizes approximately 800 acres of active recharge area at each of these demand centers. The assumed Westside (Kern County area) program is modeled to have a banking capability of 10,000 acre-feet per month (1,000 acres of active recharge area, 166 cfs) and an extraction capability of 8,000 acre-feet per month (132 cfs).

The banking capacity is based on an average recharge rate of 4 inches per day. Extraction at the assumed rates is based on a combination of existing and new wells developed by the various entities managing the banks.

5.4.2 Mendota Pool Recirculation

Capture and re-use of restoration flows utilizing the existing Mendota Pool is another important component of all the bundles. Flow that reaches the Mendota Pool can be used to offset the Mendota Pool water user demand for Delta-Mendota Canal deliveries. This offset can then be credited to the Westside operation of the SWP and CVP, which can then provide water to Friant districts using the existing facilities and exchanges described below. The degree of recirculation at Mendota Pool that can be achieved is constrained by water demands at the Mendota Pool, the amount of water arriving at the site, and assumed flow bypass requirements to maintain restoration flows in the river downstream of the site.

This component involves the use of existing facilities to re-use restoration flows. No new facilities are involved.

5.4.3 Conveyance in the California Aqueduct and Delta-Mendota Canal and Storage in San Luis Reservoir

Conveyance in the California Aqueduct and Delta-Mendota Canal is necessary for the recirculation component. Flows captured at the Mendota Pool or obtained elsewhere west of the Friant service area require a path to return the flows to areas that can offset Friant Division water user demands on Millerton Lake storage. Also, San Luis Reservoir is needed at times to temporarily store such flows to match demand and to stay within conveyance capacities.

Cursory review of the operation of the SWP and CVP facilities indicates that conveyance capacity within their canal facilities will not be a constraint, and preliminary results from ongoing CALSIM II modeling (extracted from the December 14, 2001, joint USBR/DWR release of CALSIM II) indicate that space is seasonally available in San Luis Reservoir. During this preliminary review of alternatives, contractual arrangements necessary to utilize these facilities have not been investigated with the DWR and the USBR. However, SWP districts may wheel other water through their space in the California Aqueduct. For this reason, a large agency, such as MWD or KCWA, could be a valuable partner. Although a specific arrangement would need to be negotiated, an assumed wheeling charge has been included to account for the costs to convey water from and to any location, ranging from the Delta to the Cross Valley Canal turnout (see Section 6.1). The energy required for this wheeling (e.g., O'Neill, San Luis, and Dos Amigos) is also included, as described in Section 6.1.

This component consists of use of existing facilities to re-use restoration flows. No new facilities are involved.

5.4.4 East and West Conveyance in Southern San Joaquin Valley

Several possible means for conveying water from the California Aqueduct to demand centers served from the Friant-Kern Canal were reviewed on a preliminary basis in Technical Memorandum 4 (URS 2000d). These consisted of the Cross Valley Canal and improvements

thereto, the Shafter-Wasco Pipeline, the Arvin-Edison California Aqueduct Intertie, and the Kern Water Bank Canal and Tulare Lake Basin connections to both the Friant-Kern Canal and the California Aqueduct. Although all of these conveyances have some capacity to serve Friant Division members (either directly or through exchanges), for modeling purposes it is assumed that the Cross Valley Canal (CVC), exchanges through the Tulare Lake Basin, and the Kern River channel provide the necessary linkage between Eastside and Westside supplies and demands. West-to-east capacity is assumed to be seasonally available in the CVC, as explained in Appendix A, Section 4. Such capacity is based on review of unused capacity by water year type for recent years. This estimated available capacity in the CVC is likely to change due to the many programs that are being developed and implemented in Kern County. In addition, a limited amount of west-to-east capacity is assumed available through the Tulare Lake. Through exchanges, water from the lakebed has been modeled to meet Friant Division needs in portions of Kings and Tulare Counties.

For east-to-west conveyance of flows (e.g., for storage of Millerton Lake or Eastside tributary surplus flows) on the Westside, it is assumed that 1,000 cfs of conveyance capacity is available through a combination of the CVC, Kern River channel, and other interconnection facilities. If the available capacity is overestimated, the water aspects of this analysis will not necessarily change; however, the economic results will require adjustment to reflect the cost to construct canal improvements to provide additional capacity.

In general this component consists of use of existing facilities to re-use restoration flows. However, the bundle configuration sensitivity analyses that include the Patterson Recirculation Component indicate the need for improved west-to-east capacity in the CVC. To fully utilize all the water potentially available for recirculation, there may be a need for additional capacity. Additional capacity could be made available in the CVC by construction of alternative new facilities in Kern County. The improvements are assumed to provide a minimum firm capacity of 500 cfs by increasing the overall canal capacity by 337 cfs. The improvements include upgrading the pumps at each of six existing lift stations on the canal, installing larger (or additional siphons) at some roadway crossings, and raising the canal liner.

5.4.5 Friant-Kern Canal Reverse Pumping

The effectiveness of the recirculation operation is limited by the demand within the FWUA service area that can use either Millerton Lake water or recirculated water. At present, west-to-east exchanges are constrained because Arvin-Edison Water Storage District is the only Friant Division long-term contractor directly served by CVC facilities. To offset this limitation, it is assumed that the lower reach of the Friant-Kern Canal will be modified to accommodate pumping up-reach to meet half the demand of Friant Division contractors between the Tule and Kern Rivers.

This component involves improving the intertie between the Cross Valley and Friant-Kern Canals and constructing lift stations to move 500 cfs up the Friant-Kern Canal. The improvements and lift stations would be capable of delivering water from the Friant-Kern Canal terminus at the Kern River upstream to an equalizing reservoir between Deer and Poso Creeks. There is a net difference in water surface elevation of approximately 12 feet over the 30 miles length between the Friant-Kern terminus and the equalizing reservoir.

5.4.6 Eastside Tributary Pump-in

Surplus flows intermittently occur on the Kings, Kaweah, and Tule River systems. For purposes of this analysis, surplus conditions are defined as periods of time when flood flows were recorded/estimated to pond and cause flood damage in the Tulare Lakebed and, in the case of the Kings River, periods when flood flows were diverted via the James Bypass to the San Joaquin River. The estimated values for Eastside Tributary surplus flows are included in Appendix A.1

This component involves construction of pump-in facilities similar to temporary facilities used in the past, with an assumed capacity of 1,000 cfs at the Friant-Kern Canal crossings of each of these tributaries.

5.4.7 California Aqueduct Account

This component is a catch-all account for water developed by various mechanisms that is unused for demand offset and not explicitly stored by the end of simulation due to limitations in the ability to convey it to demand centers using existing or planned conveyance facilities and modeling protocols. Water that accumulates in this account includes recirculation water that is evacuated from San Luis Reservoir because of the combination of lack of available storage space, conveyance capacity, or Friant water user demand. This account also includes surplus flows from Millerton Lake and the Eastside tributaries that exceed the capability of direct-use and the assumed groundwater banking system. Although not modeled, this account could use SWP or MWD storage facilities in Southern California and develop yield through sale or exchange. The monetary implications of this water on the analyses are described in Section 6.1.6.5.

5.4.8 Water Purchases

The water purchase component includes both long-term and short-term supplies. Long-term purchases are included in the first tier of water called on to meet water supply needs. The short-term supply is used to make up the difference between other supplies and overall demand for water. The various categories of water purchases are described in Section 6.1.

5.4.9 Delta Recirculation

In all but Bundle A it is assumed that the Delta pumping facilities of the SWP and CVP will be available to capture restoration releases and other surplus San Joaquin River flows for the Study. The pumping and conveyance systems of the SWP/CVP are simplistically treated together for the purposes of this analysis. Available pumping capacity from the Delta is derived from the same CALSIM II preliminary analysis (extracted from the August 2002 joint USBR/DWR release of CALSIM II) described in Section 5.4.3 and includes consideration of SWRCB Decision 1641 (SWRCB 1999), Endangered Species Act (ESA), EWA, and CVPIA Delta constraints and operations. Output from the CALSIM model provides information that indicates windows of time (seasons) when incremental pumping at the Delta is allowed or precluded.

5.4.10 Millerton Minimum Pool Storage

Bundle B includes the use of existing storage in Millerton Lake that currently is not normally utilized in operations. The original storage elevation curve indicated that approximately 140,000 acre-feet of storage are located below elevation 471. (Sedimentation has reduced this capacity by an unquantified amount.) Releases to the Friant-Kern Canal are significantly impaired below this elevation. Releases to the Madera Canal are similarly impaired below elevation 446.

This component allows Millerton Lake to be drawn down to 40,000 acre-feet (approximate elevation 404 based on the original storage elevation curve), an increment of 100,000 acre-feet of additional available storage. The option to use storage below elevation 471 is contingent on the construction of facilities to make deliveries to the two canals. These facilities are assumed to include pumping plants and piping to lift water up to the head works of the two canals.

One option for implementing this component includes placing a number of floating barges on the reservoir. Fifty-two 500-horsepower pumps mounted on 26 barges connecting to two manifolds could deliver 2,000 cfs to the Friant-Kern Canal. An additional 8 barges with sixteen 500-horsepower pumps could deliver 800 cfs to a manifold connecting to the Madera Canal. Alternatively, the existing outlets discharging to the San Joaquin River could be tapped and new pump stations and pipelines constructed to lift water from the low level outlets back up to the two canals.

5.4.11 Tulare Lakebed Storage and Conveyance

Bundle C assumes the development of reservoir storage in the Tulare Lakebed to store Eastside and Westside flood flows as well as provide temporary storage for recirculated supplies when other storage is not available. Bundle C also includes construction of facilities to convey water between the Tulare Lakebed and the California Aqueduct.

Bundle C includes land acquisition, levee and dike enhancements for the intermittent impoundment of water, and piping and pumping facilities to convey and lift stored flow to the California Aqueduct for delivery to Friant Division water users. Sizes of 500 cfs for conveyance and 100,000 acre-feet for impoundment are assumed in the analyses. For those assumed sizes, approximately 25,000 acres of land would be needed based on a water storage depth of 8 to 10 feet at the low point of the basin. It is assumed that the land could continue to be used for agriculture during periods when it is not needed to store water. There is also some ability to use the facility to provide wetland and bird habitat, to promote exchanges, and to temporarily store high-turbidity flows from the California Aqueduct. Similar facilities are being proposed by local districts, DWR, and Kings River interests.

Two pump stations would be necessary. One station would pump water out of the reservoir to existing canals. A second station would be needed to pump water from one of these canals approximately two miles to the California Aqueduct utilizing a combination of new and upgraded existing conveyance.

5.4.12 Millerton Enlargement and Mammoth Modifications

Bundle D incorporates two elements of storage that are assumed to be functionally equivalent to increasing existing Millerton Lake storage. Bundle D includes raising Friant Dam to gain

105,000 acre-feet of storage. It also includes modifying the dam at Mammoth Pool (upstream of Millerton Lake) to gain 30,000 acre-feet of additional impoundment. Both of these potential increases are treated within the modeling as increased storage capacity in Millerton Lake.

The Friant raise would involve raising the existing concrete dam by an additional 20 feet, constructing a new 3,000-foot-long embankment saddle dam, modifying the existing spillway to accommodate the increased dam height, and relocating roads and recreation areas that would be flooded by the higher water surface.

The Mammoth Pool raise would involve modifying the spillway to accept 27-foot-high gates, increasing the height of the existing embankment dam to provide adequate freeboard, and relocating roads and recreation areas that would be flooded by the higher water surface.

5.4.13 Fine Gold Reservoir

Bundle E adds an additional element of reservoir storage to the Bundle D configuration. This storage consists of an off-stream reservoir on Fine Gold Creek, a minor stream tributary to Millerton Lake. The maximum storage of this facility has been set as 400,000 acre-feet, including a minimum pool of 30,000 acre-feet.

This component consists of a new 440-foot-high dam on Fine Gold Creek at its confluence with Millerton Lake. The contributing drainage area of the creek at this point is approximately 91 square miles. Average net annual runoff (including evaporation losses) is estimated to be approximately 28,000 acre-feet. Because of this limited local runoff, it would be operated as an off-stream facility, with most of the water pumped from Millerton Lake to fill it in times of available supply. A gravity feed was also considered, but because of the maximum storage elevation in the proposed reservoir (elevation 1,016 feet) a tap from the San Joaquin River would need to be located a number of miles upstream near Redinger Lake and would require almost 12 miles of tunnel.

It is assumed that the Millerton/Fine Gold system would be operated as a pump-storage facility. Large pumps are necessary to take advantage of high inflow during limited periods when water is available. A pump-turbine (pump storage) system allows the recovery of most of the energy required to lift the water to the higher elevation in Fine Gold Reservoir on its return to Millerton Lake. There can be economic advantages with daily operation of such a pump storage system; water is pumped up during hours of low-value energy and returned during hours of high-value energy. Such a system was previously proposed in conjunction with a reservoir at Fine Gold (Parsons, Brinkerhoff, Quade, and Douglas, Inc. 1988). Pumping up to 50,000 acre-feet during a month has been assumed in the model to enable filling Fine Gold Reservoir. A detailed economic study would be necessary to determine the optimal capacity for pump storage use. (In the 1988 study, a flow capacity of 8,000 cfs was assumed.)

5.4.14 Patterson Recirculation

A third component of recirculation, a pumping and conveyance facility to lift water from the San Joaquin River to the Westside conveyance facilities of the SWP/CVP, is included in the sensitivity analyses. Although an exact location has not been evaluated, the San Joaquin River and the Delta-Mendota Canal are approximately four miles apart in the stretch of the river in or near the communities of Patterson and Wesley. A potential alignment would be adjacent to an

existing wasteway from the canal to the river. A fish screen facility for the intake at the San Joaquin River is included in addition to the pump station and pipeline to convey recirculated water to the Delta-Mendota Canal. The facility is sized for a capacity of 500 cfs based on preliminary review of the quantity of water that might be available with the assumed restoration flows. This value will need to be refined and optimized once actual restoration flows are determined.

5.4.15 Merced River Basin Intertie

An additional component of configuration sensitivity is an intertie between the Madera Canal service area and the Merced River Basin. Included in this component are canal improvements and new canal, pumping, and pipeline facilities to convey surplus Merced River flows and Vernalis Adaptive Management Plan (VAMP) flows into the Madera Canal service area. A feasibility study on this intertie was recently completed by others for the Bureau of Reclamation (Tolladay, Fremming, & Parson 2000). The study examined options for delivery to several different locations. In the study delivery was assumed as far as Berenda Reservoir. (Delivery to this location would serve approximately 43 percent of the total Madera Canal service area. The assumed size of this intertie is 100 cfs. The associated reduction in Madera Canal demands makes additional water available at Millerton Lake. When available supply exceeds demands within this portion of the service area, the water is stored in the Madera Canal area groundwater basin. The assumption regarding use of potentially reduced VAMP flows will require coordination with the San Joaquin River Group Authority and favorable interpretation of provisions of the San Joaquin River Agreement.

5.4.16 Friant Dam River Release Generator

All of the bundles include increased electrical generating capacity for releases made to the San Joaquin River. In the model, a second turbine generator unit with a capacity of 450 cfs is added to the existing capacity of approximately 150 cfs. The optimal increase in size will vary depending on the restoration flow requirements. Electrical energy generated by this 450 cfs (approximately 6 MW depending on reservoir elevation) of new capacity is credited toward project demand in the Study, although it is recognized that any resulting impacts to existing generators would require mitigation or reconfiguration of the alternative. For modeling purposes, total power generation through potential new facilities was evaluated. Impacts to individual existing power facilities, including Friant Power Authority (FPA) and others, were minimally analyzed. Potential impacts and mitigation measures for changed power operations should be fully evaluated before any water supply alternative is finalized and implemented.

At the core of this Water Supply Study (Study) are the many alternative programs and facilities constituting the water supply bundle configurations that can potentially provide water for restoration of the river. These alternatives were evaluated through a series of progressively refined analyses that provide additional insight to the effectiveness of each bundle or component of an alternative. Critical to evaluating the effectiveness of an alternative and its components is hydrologic modeling and costing. The hydrologic modeling provides an estimate to the question of how much water an alternative can develop, and the costing provides the corresponding price at which the water is developed.

At the early stage of Study formulation, the analyses use relatively coarse methods to evaluate the hydrologic performance of individual alternatives and components. The evaluation process becomes more refined as the less promising components are set aside and the linkages and dependencies between components become evident. The most recent series of analyses involved a two-step process of interactive operational modeling ("gaming") followed by long-term operational modeling for the evaluation of alternatives.

The purpose of this section is to present the results of a detailed analysis of the chosen alternatives. Section 6.1, "Models and Assumptions," discusses the gaming process used to assist in the identification of issues to be addressed in the development of assumptions for implementing long-term operational modeling. This section also describes the long-term operational modeling that is used to analyze the expected costs and benefits of the alternatives. Section 6.2, "Analysis of Bundles," describes in general terms the bundle analysis process and the operational protocols common to the selected bundles. Each bundle is then described in detail, beginning in Section 6.3 and continuing through Section 6.7. The descriptions are divided into several sections: (1) a general description of bundle components and a tabular summary of hydrologic and cost results for each configuration scenario of a bundle, (2) operation and hydrologic findings for the Modified Channel/Case X demand scenario and the Existing Channel/Case Y demand scenario, (3) technical concerns, (4) institutional challenges, and (5) environmental concerns. Section 6.8, "Bundle Configuration Modification and Sensitivity," presents the results when the basic bundles are modified to include or remove certain components. Finally, Section 6.9, "Summary of Results and Other Considerations," provides a summary and comparison of the bundles and sensitivities.

6.1 MODELS AND ASSUMPTIONS

The results described in this section derive from a set of assumptions and modeling protocols regarding canal demand, river releases, surface water/groundwater reservoir coordination, and the order in which water is brought in. Different modeling protocols and assumptions would produce different results.

6.1.1 Gaming

The five alternative bundle configurations described in Section 5 are the result of screening and refinement of many components and groupings of components. The winnowing process was aided using a "gaming" approach that allowed interested individuals to participate in developing knowledge of the hydrology of the San Joaquin Valley, operations of the San Joaquin River and

Bay-Delta, and the water systems potentially affected by the bundles. Gaming was also used to establish an understanding of how participants prioritize options for operating the overall system.

Through the gaming process, a "feel" for the system is acquired. Participants were required to make operational decisions for the facilities included in the "game," with only the water supply and demand knowledge that would be known at the time of the decision. Because the bundles venture into diverse geographical and institutional areas, the gaming assists with the identification of issues to be addressed and the development of assumptions for implementing long-term operational modeling.

The gaming model used in the development of the bundles was a precursor to the long-term operational model. The gaming model is described in Appendix B along with documentation of the gaming sessions. The most salient information gained from the gaming process related to the constraints associated with the capture and re-use of restoration flows downstream of the lower river, the need for storage to regulate the re-use of restoration flows, and the need for storage to better use existing surplus flows. The gaming process also provided general rules for operating various facilities contemplated for the bundles.

6.1.2 Long-Term Operational Modeling

The focal point of the alternatives analysis is understanding expected costs and benefits through long-term operational modeling. The performance of each bundle is evaluated in terms of its ability to provide water for the restoration of the river and by the fixed and variable costs associated with the bundle. The analyses are performed using a spreadsheet model that depicts the physical and operational system envisioned by the bundle. Bundle facilities and operations are modeled over a relatively long sequence of years, thereby depicting system performance through floods, droughts, and other combinations of years. The model is described in Appendix C. Figure 5-2 in Section 5.3.1 provides a schematic of the physical components depicted in the long-term model.

The model simulates operation of a bundle over 78 consecutive years of historically based monthly hydrology. Operational closure in the model occurs at Millerton Lake. That is, the water balance between water demands (such as canal diversions and river releases) and water supply (such as reservoir inflow, capture and re-use supplies, and other components satisfying water demands) occurs at Millerton Lake. If the demands exceed the supply, the reservoir loses storage. If the supply exceeds demands, the reservoir gains storage. Interacting with the balance are the various components of the bundle. Underlying the simulation is hydrology developed through several analyses carried in working forums outside the scope of this Study, including recent CALSIM II, SANJASM, and STANMOD results (USBR and SJRGA 2001; USBR and DWR 2001). The hydrology is described in Appendix A.

6.1.3 Baseline Canal Diversions and Friant Division Operation

The operational requirement of the long-term modeling is to meet the demands for both restoration of the river and Friant-related water deliveries to Friant water users. Irrigation deliveries vary from year to year based on an annually variable water supply. The task of synthesizing a long-term depiction of water deliveries requires the development of a baseline

operation model for the Friant Division that combines current operational objectives for water supply and flood control with water demands from the Friant water users. These demands have been developed for the hydrologic period 1922 through 1999. The long-term model includes delivery of water to Friant water users as a demand to be met with either Millerton Lake water supply or other mechanisms.

The baseline operation model used to simulate the current operation of the Friant Division is a spreadsheet tool. Input to the model for operations upstream of Millerton Lake is consistent with the "Base Plan" results described in *Evaluation of Potential Increases in Millerton Lake Water Supply Resulting from Changes in Upper San Joaquin River Basin Projects Operation, Phase 2* (USBR 2000d). Flood control operations for Millerton Lake and the lower San Joaquin River are based on the rainflood space reservation requirements specified by the U.S. Army Corps of Engineers (USACE). The flood control operation during the snowmelt runoff period recognizes the competing objectives of water supply and flood control. The operation attempts to maximize water supply carry-over storage while recognizing the potential for downstream flooding. Forecasted flood releases are managed throughout the flood control season. Minimum required releases below Friant Dam for riparian and prior-right users are modeled as a constant annual requirement of 116,700 acre-feet distributed in a monthly pattern typical of historical operations.

The best representation of water demands on Millerton Lake would result from a comprehensive analysis that considered the consumptive use requirements of the Friant water users together with all of their available water resources. Deliveries from Millerton Lake represent a supply supplemental to other sources and do not meet total consumptive demand for Friant districts. However, that form of comprehensive analysis is beyond the scope of this study. Instead, the water deliveries considered in the study mimic historical operations.

A review of the historical record of water deliveries from the Friant Division was conducted. The record of those deliveries is contained in a database maintained by Reclamation. The protocol of the database attempts to categorize the different classifications of water deliveries made through the Friant Division. Refer to Appendix A, Section 2, for a description of the various classes of water and historical deliveries. The review found several anomalies within the data, some of which could be explained by changing practices of classification (or institutional changes in classifications) and others that were apparently data entry errors. Although questionable or possibly misinterpreted data were a problem, the review provided significant insight regarding the relationship between water supply availability and water delivery patterns for the Friant Division.

Most salient to this analysis are the data concerning monthly deliveries from the Friant-Kern Canal and the Madera Canal as water supply availability changes during a year. The data and analysis allowed development of a water delivery function based on water supply availability at Millerton Lake that is responsive to both flood control requirements and other considerations within the basin that affect the delivery of water from the Friant Division (such as water availability from tributaries within the Tulare Lake Basin). Analysis also provided a coarse division of water deliveries between Class 1, Class 2, and other water classifications. Added to the synthesized water deliveries are canal losses that were developed through a comparison of historical water deliveries and canal diversions.

The baseline operation model was calibrated to match historical water deliveries. Operation rules were developed to synthetically mimic recorded diversions for the period after 1961. (Prior to 1961, Friant Water Users facilities were not completely built out, and many of the facilities in the Tulare Lake Basin were incomplete.) Historical canal diversions for the Friant Division are shown in Figure 6.1-1. Within the historical record are deliveries that include Class 1 and 2 deliveries, "surplus," and "other" deliveries. These "surplus" and "other" deliveries include a combination of flood flows to ineligible lands (per Reclamation Reform Act) and other delivery exceptions.

FWUA and the NRDC Coalition have not reached agreement over what constitutes the proper baseline of deliveries for assessing water supply impacts. Therefore, two levels of baseline demand are used in the analysis. In addition to the historical record, Figure 6.1-1 illustrates Case X, a synthetic baseline operation designed to match the total historical canal diversions. In addition to historical and Case X, Figure 6.1-2 also illustrates Case Y, a baseline synthetic operation designed to match historical deliveries less "surplus" and "other" deliveries.

The difference between the two levels of demands is the simulation of deliveries during times of flood operations at Millerton Lake. In the Case X synthesis, when Millerton Lake is releasing to the river in excess of minimum requirements, additional water representing the availability of flood flows for delivery is included. In the Case Y synthesis, this additional water is not included.

Use of the Case Y diversion scenario has an implied impact on the overall historical water balance within the Tulare Lake Basin, as discussed in Section 6.9.

In addition to the synthetic canal diversions, other baseline hydrologic parameters are required for the long-term model. The two baseline demands result in two different operations for the lower San Joaquin River. These two operations differ in terms of frequency and magnitude of simulated flows that at times reach the San Joaquin River–Chowchilla Bypass bifurcation. The changes in Millerton Lake operation affect the results used from other studies depicting San Joaquin River and Delta operations. Therefore, adjustments to the CALSIM II, SANJASM, and STANMOD hydrology were incorporated into the long-term model.

6.1.4 Restoration Flow Assumptions

Preliminary hydrographs concerning flows necessary for the restoration of the river were provided for this study. At the time the hydrographs were provided (August 2001), the estimates were explicitly qualified as being only hypothetical for use in this modeling process. The definition of the restoration hydrograph is pending completion of additional analyses by the separate restoration study. The restoration hydrographs were provided in a format that allowed the development of average monthly flow requirements for various reaches of the lower river. Two different sets of hydrographs were prepared:

- One set was based on flow requirements for a channel that represents no modification of existing habitat conditions other than by flow (**existing** channel). Refer to Appendix C, Section 2, Attachment A, Page 4, Assumption 7.

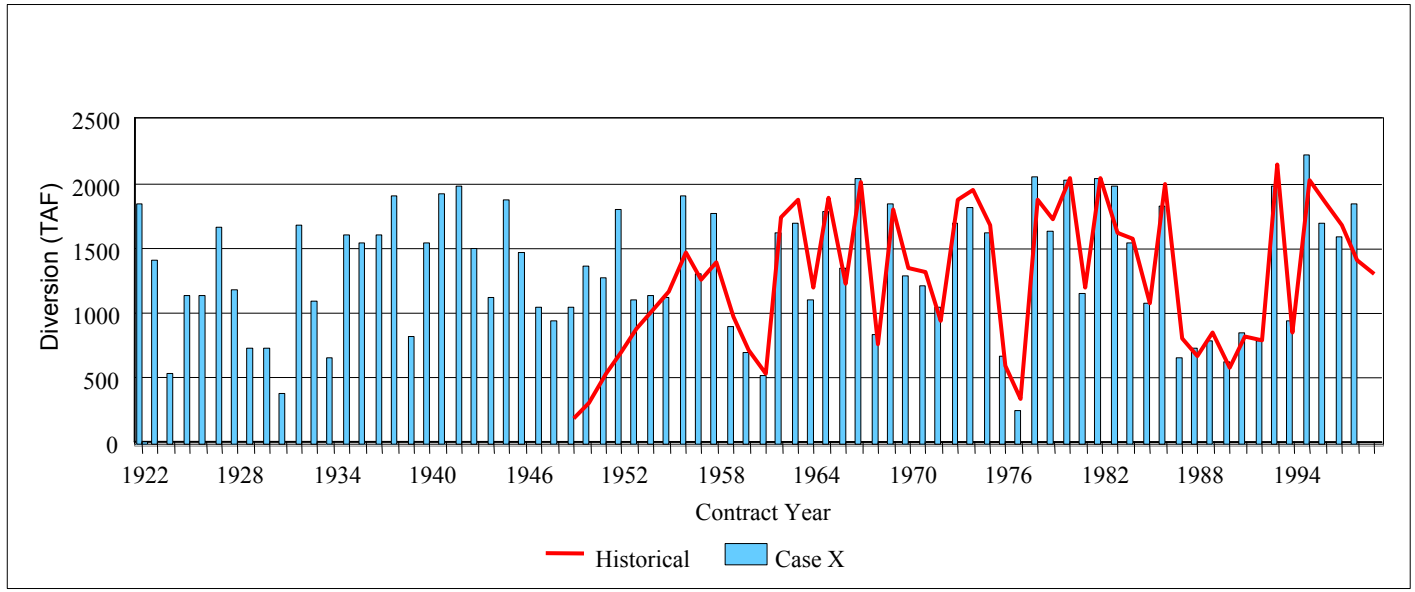

Figure 6.1-1: Total Friant Division Canal Diversions: Historical and Case X Baseline Demands

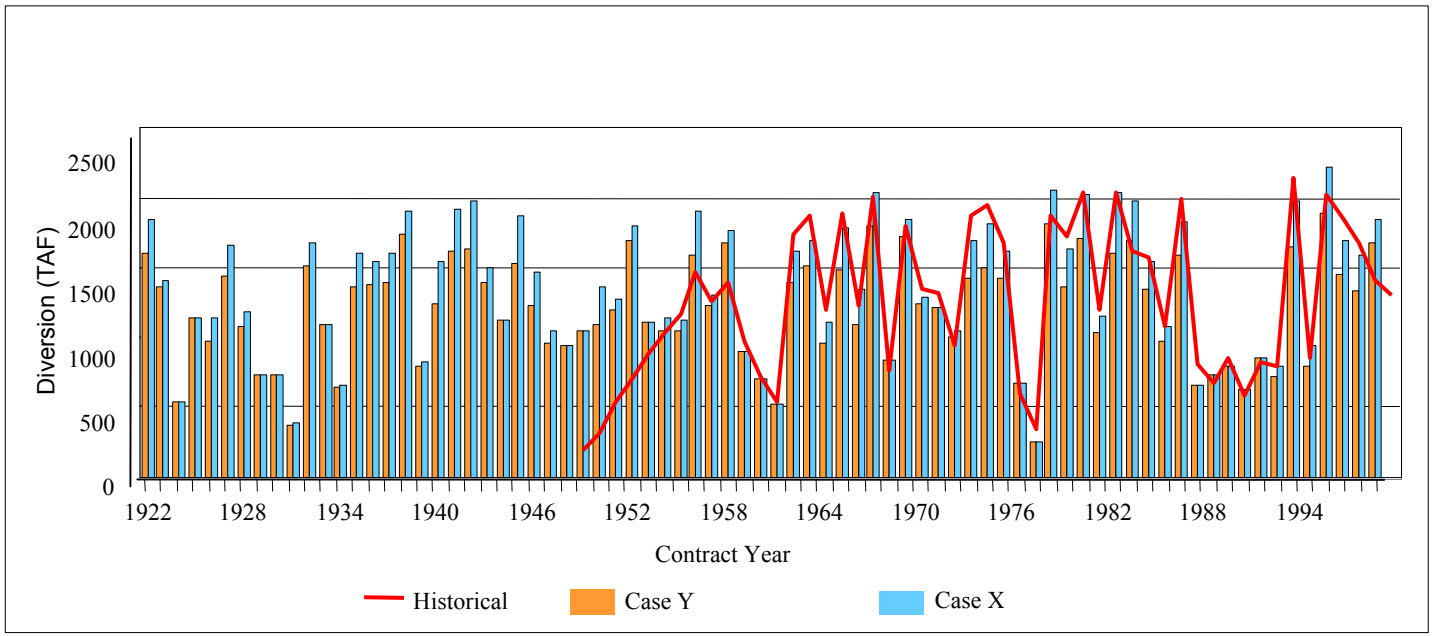

Figure 6.1-2: Total Friant Division Canal Diversions: Historical, Case X and Case Y Baseline Demands

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- The other set estimated flow requirements for a channel **modified** with actions such as gravel augmentation, pit filling, and channel re-sizing. The magnitude and volume of flow requirements are lower for a channel modified for restoration purposes.

Each set of hydrographs, termed "Existing Channel" and "Modified Channel" for the two channel scenarios, includes different flow requirements by water year type. Flow volumes and their distribution vary according to the wetness of the year. For purposes of this analysis only, the consultant team divided years into four classifications based on unimpaired water year runoff at Friant Dam for the 1909-2000 hydrologic record. The wettest 20 percent of the years are classified as "Wet," the driest 20 percent of the years are classified as "Dry," and the intermediate 60 percent of the years are split equally between "Normal-Wet" and "Normal-Dry" classifications. Within the modeling, the year type classification is established during March and continues to apply through the following February. Refinements concerning diversion re-scheduling or year-type establishment would improve future evaluations. Table 6-1 provides the modeled annual release requirement below Friant for each channel scenario, inclusive of requirements for both riparian/prior user rights (116,700 acre-feet) and assumed incremental restoration flows.

Table 6-1
Modeled Annual Flow Requirement by Water Year below Friant Dam

Year Type	Modified Channel (acre-feet)			Existing Channel (acre-feet)		
	Existing Requirement	Incremental Restoration Requirement	Total Modeled Requirement	Existing Requirement	Incremental Restoration Requirement	Total Modeled Requirement
Wet	116,700	456,300	573,000	116,700	773,300	890,000
Normal-Wet	116,700	383,300	500,000	116,700	474,300	591,000
Normal-Dry	116,700	341,300	458,000	116,700	374,300	491,000
Dry	116,700	231,300	348,000	116,700	244,300	361,000

The monthly distribution of the annual flow requirements is illustrated in Figure 6.1-3. An explanation of the development of the hydrographs is included in Appendix C.

6.1.5 Costing Assumptions

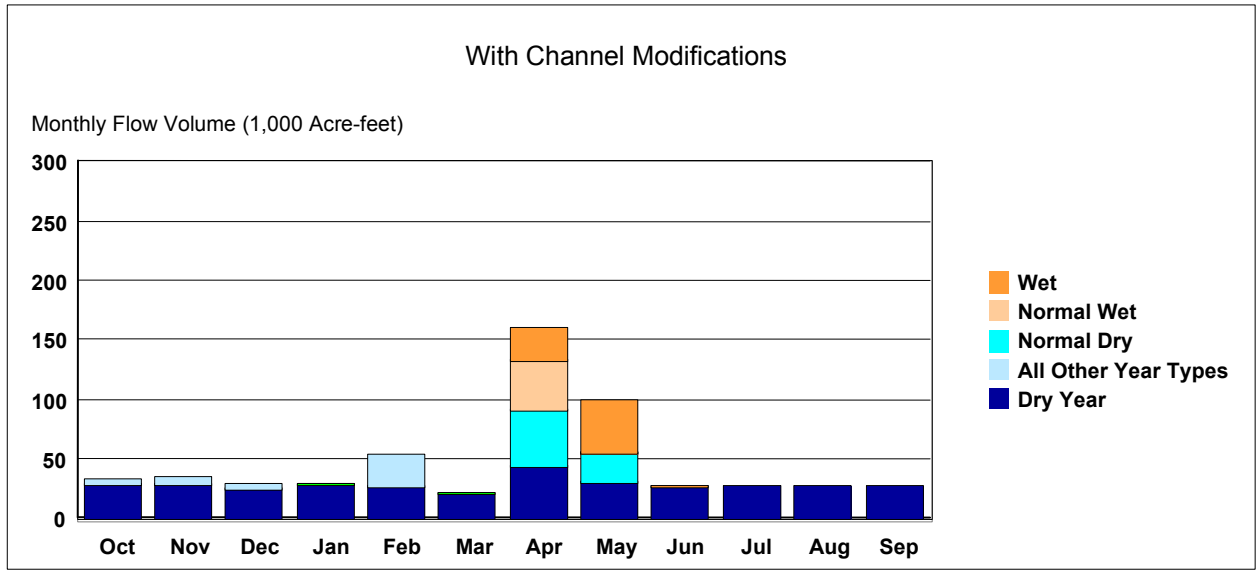
Fixed and variable costs are assigned to each bundle based on the components assumed to be within a bundle and the operation of those components. The long-term model is structured to facilitate the use of alternative assumptions for the physical attributes of certain bundle facilities. These attributes become constraints within the modeling and also affect the determination of the cost of the component. For instance, the bundles assume the use of a pumping facility where the Kaweah River crosses the Friant-Kern Canal. The size of the facility is assumed to be 1,000 cfs, and is priced accordingly. Alternatively, the facility size could be set differently and the facility's cost (and pumping capacity) would be prorated. The following is a summary of fixed and variable cost assumptions used in this analysis.

There are a number of limitations associated with the estimates provided. These include:

- Cost estimates regarding San Joaquin River streambed modifications are not included; the associated work is not yet defined.
- The costs estimated for the various components are based on a pre-feasibility level of design and are, therefore, of a very preliminary nature.
- No engineering site work or engineering calculations have been performed. Depending on geotechnical or other engineering limitations, it may not be feasible to construct certain components as assumed.
- Only cursory environmental review has been performed. There may be significant extraordinary environmental mitigation costs associated with implementation of various components.
- Cost estimates do not include an allowance for mitigation costs associated with negative impacts to recreation.

6.1.5.1 Fixed Capital and Maintenance Costs

Fixed capital and maintenance costs are provided for all bundle components. The estimated direct construction cost for each component is based on preliminary quantity estimates and unit prices for similar facilities. Unless otherwise noted, cost estimates were prepared independently by the consultant team and were not compared to estimates prepared by others. Refer to Appendix F for additional information regarding the cost estimates. The direct cost was multiplied by a cost factor of 1.99 to arrive at the total capital cost of the component. This cost factor was included to account for: (1) unidentified items not included in the estimate at this conceptual level; (2) an allowance for environmental mitigation; (3) design engineering; (4) construction management services; (5) the owner's administrative, legal, and financing costs; and (6) contingencies. The annual cost of the component is derived by adding the assumed annual maintenance cost (a percentage of the total capital cost) to the annualized recovery of the total capital cost. Provisions for inflation of maintenance costs is not included in the cost. Component financing assumes a 30-year recovery period with 6 percent financing. Based on comments to the current analysis, the sensitivity of economic results to a different assumption for



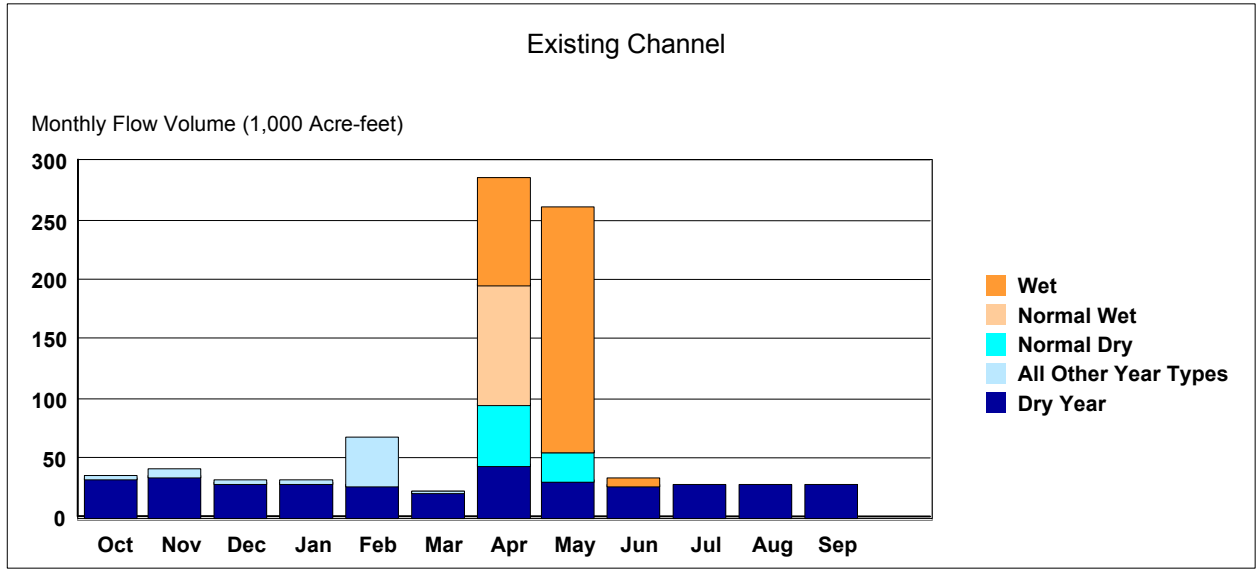


Figure 6.1-3

Assumed Monthly Distribution of Restoration Flows With Channel Modifications and Existing Channel

(Including 116,700 acre-feet annual existing requirement)

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capital financing will be examined in future evaluations. Table 6-2 provides the fixed capital and maintenance cost assumptions used in this analysis.

Table 6-2
Fixed Capital and Maintenance Cost Assumptions

Component	Size	Capital Cost ($1,000)	Maintenance Cost Factor	Annual Cost ($1,000)
Millerton Pumps to Friant-Kern (FK) Canal	2,000* cfs	44,735	3.1 %	4,637
Millerton Pumps to Madera Canal	800 cfs	Included with FK (above)	3.1 %	Included with FK (above)
Friant River Release Generator	450 cfs	18,358	1.0 %	1,517
Millerton Lake Enlargement	105,000 af	89,953	1.0 %	7,435
Cross Valley Canal Improvements	337 cfs	42,250	2.0 %	3,914
Friant-Kern Reverse Pumping	500 cfs	9,950	4.0 %	1,121
Tulare Lake Storage and Pumping	500 cfs/ 100,000 af	50,148	2.0 %	4,646
Patterson Pumping Plant	500 cfs	70,148	2.0 %	6,499
Kings River Pumping Plant	1,000 cfs	2,420	4.0 %	273
Kaweah River Pumping Plant	1,000 cfs	1,936	4.0 %	218
Tule River Pumping Plant	1,000 cfs	2,033	4.0 %	229
Merced River Intertie	100 cfs	41,338	2.5 %	4,037
Fine Gold Reservoir	400,000 af	420,288	1.0 %	34,736
Mammoth Pool Enlargement	30,000 af	18,806	1.0 %	1,554

* Model results show that the assumed Millerton Pump capacity is inadequate during a limited portion of the simulated long-term model period. For those months an additional Friant-Kern pump capacity of 1,300 cfs (at an approximate cost of $3,000,000/year) would be necessary to fully meet the modeled demand. Alternatively, the demand might be satisfied with additional water purchases. If physically possible to construct given the site limitations, full redundant lake pumping capacity (5,000 cfs) in lieu of diversion capacity would be expected to increase the annual cost to over $11,500,000.

6.1.5.2 Power Costs/Revenues

The generation or consumption of energy is associated with many of the bundle components. For modeling purposes, power generation through potential new facilities was evaluated. Impacts to individual existing power facilities, including Southern California Edison's Mammoth Pool and Big Creek No. 3 and No. 4 power plants; Friant Power Authority's Friant-Kern, Madera, and River Outlet plants; Madera and Chowchilla Power Authority's Madera canal plants; and Orange Cove ID's fish hatchery and Kings River siphon plants, were not analyzed. Potential impacts and mitigation measures for changed power operations should be fully evaluated before any water supply alternative is finalized and implemented. Estimates of net head and mechanical efficiencies used in the analysis for the various components are listed in Table 6-3.

Table 6-3
Power Generation/Consumption Assumptions

Component	Tailwater Elev (ft)	Net Head (ft)	Efficiency (%)	kWh/AF
Friant-Kern Canal (FKC) Generation*	470	Varies depending on Millerton Lake elevation	85	Varies depending on Millerton Lake elevation
Madera Canal (MC) Generation*	446		85	
Friant River Release	307		85	
Pumping to Friant-Kern Canal	470		70	
Pumping to Madera Canal	446		70	
Delta Pumping	NA	see average kWh/AF		300
O'Neill Pumping	NA	see average kWh/AF		60
Patterson Pumping	NA	220	75	299
San Luis Reservoir P/G	NA	Varies	Rating Table	Rating Table
Dos Amigos Pumping	NA	see average kWh/AF		150
Tulare Lake Pumping	NA	180	80	229
Cross Valley Canal	NA	132	80	168
FKC Reverse Pumping	NA	20	80	25
Madera Canal Area GW Pumping	NA	180	70	262
FKC 1 Area GW Pumping	NA	130	70	189
FKC 2 Area GW Pumping	NA	100	70	146
FKC 3 Area GW Pumping	NA	120	70	175
FKC 4 Area GW Pumping	NA	260	70	379
FKC 5 Area GW Pumping	NA	410	70	597
Kern County Area GW Pumping	NA	270	70	393
Kings River Crossing Pumping	NA	25	70	36
Kaweah River Crossing Pumping	NA	20	70	29
Tule River Crossing Pumping	NA	21	70	31
Merced River Intertie Pumping	NA	106	75	144
Fine Gold Pumping*	NA	Varies	75	Varies by net reservoir head
Fine Gold Generation*	NA	Varies	87	

* Generation is evaluated but not included in cost or revenue results.

Additional information on how power impacts were derived for the bundles analysis are:

- Effects of changes in head on generation at both Millerton and Fine Gold reservoirs were considered.
- Generation revenues presented include generation through a new river outlet powerhouse with capacity of 450 cfs. Modeling assumes that the first 150 cfs of river release will be diverted through the existing powerhouse. Any remaining release, up to 450 cfs will be

diverted through the new powerhouse and its generation credited to revenues of the bundle. The results do not incorporate generation at any existing facility of Friant Dam nor does it evaluate the difference in generation compared to existing conditions. Generation under existing conditions is expected to average about 80,000,000 kWh per year.

- Energy requirements and generation for Fine Gold Reservoir is a simple accounting of energy that follows monthly amounts of water pumped into or released from Fine Gold Reservoir. It does not include any additional pumping or generation that would occur if the facility is operated as a daily pump storage facility. Pumping energy costs and generation revenues are not included the results. The facility costs also do not include any costs for the dam outlet facilities (tunnel, outlet tower etc.) and power/pumphouse that would be needed to operate as a pump storage facility. It has been assumed that these benefits and costs would largely offset each other. A more detailed analysis of the potential benefits of a pump storage facility at this site is not possible at this time given the limited understanding of potential component operation and constraints in completing this study.
- Effects on generators on the Madera Canal downstream of Friant Dam that might be impacted by modified diversions to the Madera Canal were not considered.
- As with the existing generation facilities at Friant Dam and along Madera Canal, the effect of additional storage at Mammoth Pool for those bundles including Mammoth Pool as a component was not considered.
- Net energy requirements at San Luis Reservoir are based on the storage and head information for the modeled existing condition.

Existing institutional arrangements for the marketing of power generated by Friant facilities are ignored within this analysis. It is assumed that all generation and power consumption associated with a bundle's operation are attributes of a future self-contained project. For simplicity of evaluation, it is also assumed that cost to purchase power consumed is fixed at $60/MWh and net proceeds of power sold is fixed at $40/MWh.

Impacts to existing generation facilities are not addressed in this analysis. The nature and magnitude of these impacts will be addressed in a subsequent phase of the FWUA and NRDC Coalition restoration planning process.

6.1.5.3 Wheeling Charges

Certain conveyance facilities used in the bundles are assessed a wheeling charge for their use. Specific wheeling charges may vary from minimal cost to higher values depending on arrangements with facility operators. For purposes of this study, use of the Cross Valley Canal is assigned a wheeling charge of $13 per acre-foot of conveyed water in addition to a pumping charge associated with energy use. Water conveyed through state and federal Westside facilities is assigned a wheeling charge of approximately $49 per acre-foot along with an energy use cost.

6.1.5.4 Groundwater Put Charge

Groundwater banking and pumping is an integral component of each bundle. Groundwater put charges could vary considerably depending on assumptions regarding recharge rates, conveyance to and from basins, in-lieu potential, and other factors. It is assumed that use of existing or newly developed groundwater storage systems will be facilitated through contractual arrangements. Therefore, instead of a fixed annual cost being assigned to the bundles for inclusion of such facilities, a put unit charge of $180 per acre-foot is assigned to water banked to a groundwater basin.[1] This cost includes development of the spreading basin and extraction facilities but does not include major new conveyance facilities to and from the basin. It also does not include variable (pumping) costs associated with extraction. These costs are included separately. Refer to Table 6-3 for groundwater (GW) pumping lifts and energy requirements and also to Appendix F, Cost Estimates.

6.1.6 Water Purchases and Sales

Several types of water purchases are assumed within each bundle, and these purchases vary in their magnitude and frequency of use. In addition, the supply components of reclamation and conservation are packaged under purchases for modeling ease. Refer to Table 6-4 and the following sections for descriptions of the types of water purchases/reclamation/conservation assumed to be available to meet restoration demand.

Table 6-4
Water Purchases/Reclamation/Conservation Assumptions

Category	Description	Quantity* (AF)	Cost ($/AF)
1	Oil-field water	10,000	$200–500
1	Urban conservation	10,000	$200–$1,900
2	Agricultural conservation	40,000	$325
2	Long-term purchases	80,000	$187**
3	All short-term purchases	As needed	See Table 6-7
	Residual shortage purchases	As needed	$134–311

* Average annual amount over study period
** Effective price of fixed annual option payment and exercise payment

6.1.6.1 Category 1 Purchases

One form of purchase, termed a "Category 1" purchase, is functionally incorporated into the long-term model as an annually constant purchase of water. This category of purchase is assumed to represent the purchase and use of water from a combination of urban conservation measures and reclaimed oil-field wastewater totaling 20,000 acre-feet per year. This category is

[1] The $180/acre-foot put charge was developed by combining an average cost of $250/acre-foot for developing all new groundwater basins (including extraction facilities), and a cost of $100-150/acre-foot when developing additional storage at locations where extraction facilities are already in place.

assigned a composite cost of $325 per acre-foot. The $325 average cost was established as an upper limit for development of Category 1 water. (During implementation, if insufficient water can be developed for this average cost, the quantity of Category 1 water could be reduced and additional Category 3 water purchased at approximately this cost.) This relatively small annual volume of purchase is distributed evenly throughout the year and serves as a direct offset to baseline demands.

Oil-Field Water

Oil-field water is a potential source of reclaimed water that could be used for irrigation purposes and become part of an exchange program for restoration water supply. The reclaimed water is blended with better quality water for irrigation of crops. There are over 490 oil fields in the San Joaquin Valley that may have the potential to produce oil-field water for irrigation use, but only a very small number of these have sufficient water in their oil wells for practical consideration as a source of supply. Oil-field water volume and water quality data were collected from the 18 oil fields in the San Joaquin Valley that produce more than 500 acre-feet of water per year, a volume criterion chosen to represent a reasonable water production amount. Water yields and water quality data were compared for those 18 fields. The following subsections summarize the findings of the comparison. Appendix E, Section 1 contains a full discussion of the assumptions, methodology, and results of the study.

Yield and Quality. A summary of the yield and quality results concludes that oil-field water is typically available at a relatively constant rate, 365 days per year. There is more volume of oil-field water on the west side of the San Joaquin Valley, but the water quality is better on the east side. Oil-field water of sufficient quantities (greater than 500 acre-feet per year) is found only in Kern and Fresno Counties. There are 18 fields (3.7 percent of the 490 fields in the San Joaquin Valley) in those two counties, each with a potential supply in excess of 500 acre-feet per year. Average production of these 18 fields is 9,000 acre-feet per year of oil-field water, with one field producing over 53,000 acre-feet per year (California Department of Conservation 2000).

Oil-field water has levels of salt and boron that can damage sensitive crops if not diluted or removed. Salt levels northeast of Bakersfield are 1,000 to 1,500 ppm of total dissolved solids (TDS). Of the 18 oil fields in the San Joaquin Valley that produce greater than 500 acre-feet per year of oil-field water, average TDS ranges from 800 ppm to 32,749 ppm TDS. The Kern River fields vary but have an average TDS of 2,294 ppm TDS. Water currently reclaimed from these Kern fields is limited to water with lower TDS than this average. Water with higher TDS that is potentially available would require additional treatment in order to be usable. Acceptability criteria will need to be more thoroughly evaluated in addressed in a subsequent phase of the FWUA and NRDC Coalition restoration planning process. Assuming the Kern River field average as an upper limit of acceptability, there are five fields altogether that have an average TDS of 2,294 ppm TDS or less and could potentially be used as a source of irrigation water, although the water would likely have to be blended with other sources to reduce the salinity. The five fields with relatively low average TDS in their oil-field water (Kern Front, Mount Poso, Poso Creek, Round Mountain, and Kern River) range in water productivity from 1,433 acre-feet

per year (Poso Creek) to 53,052 acre-feet per year (Kern River) (California Department of Conservation 1998).

The water available for consideration in this Study cannot be water that is already purchased by others from oil fields. Some of the available water from the five above-mentioned fields is already being purchased or is in the planning stages to be purchased. Adding up all of the remaining potential available amounts, there is approximately 20,800 acre-feet available. However, to account for unknown water quality and conveyance issues, the amount of water potentially available from oil-field water has been limited to 10,000 acre-feet per year in the model. The assumed amount will need to be verified in a subsequent phase of the FWUA and NRDC Coalition restoration planning process.

Cost and Conveyance. The location of oil fields in relation to existing conveyance facilities or roads will affect the accessibility and cost of reclaiming oil-field water. Several of the 18 fields are near canals or aqueducts that could potentially serve as conveyance facilities for reclaimed oil-field water if the water quality meets the necessary standards. The arrangements for the purchase or disposal of oil-field water appear diverse. The cost of oil-field water developed to date ranges from approximately $76 to $155 per acre-foot but could cost as much as $775 per acre-foot to develop and treat new fields if pumping is required (Bright 2001). To estimate the cost to reclaim oil-field water for this Study, it was assumed that the average net cost to develop, treat, and deliver water for use was $400 per acre-foot. At this rate, it would be reasonable to treat 10,000 acre-feet per year, approximately half the amount of Category 1 water used in the model.

Implementation Issues. Environmental concerns accompany the use of oil-field water. These concerns include high water temperatures that could exacerbate algal blooms in the holding ponds and accidental oil spill contamination. Water quality constraints may limit use or distribution of this water unless treated to levels permissible for intended use. In addition, in some areas, farmers and the environmental community may resist the use of oil-field water for crop irrigation.

Municipal/Industrial Wastewater and Urban Conservation

Numerous wastewater treatment facilities are located throughout the San Joaquin Valley and the effluent from these wastewater treatment plants was investigated as a potential water supply for river restoration. If available, this water could be applied to nonhuman consumption crops or applied to land for groundwater recharge.

CALFED investigated conservation measures for urban water supplies in the San Joaquin River. Urban conservation can focus on indoor water use that attempts to reduce the total water used or outdoor water use that focuses on reducing the total water used and recover water lost to the atmosphere or salt sinks. The studies of reclaimed wastewater and water conservation are described in Appendix E, Section 2.

Yield and Quality. The Study evaluates potential “new” water supplies from municipal and industrial wastewater treatment facilities. Water is considered “new” water if it is not currently used for other purposes and would not have to be replaced if used for river restoration. Wastewater effluent that currently is treated and disposed is not considered new water because it

is being used already for irrigation or groundwater recharge. In addition, the uncertainty of future disposal options and previous commitments limit the availability of reclaimed wastewater. Therefore, there is no yield from this source for the Study.

Urban conservation measures were investigated by CALFED, and a potential supply of 9-18 TAF could be available on the eastside of the Valley. The portion of these savings that is lost to evaporation or seepage to a salt sink is potentially new water. The remainder, however, is not new water because it is returned to the hydrologic system. For this analysis as directed by the Water Supply Oversight Team, it is assumed that 10,000 acre-feet is available through urban conservation.

Cost and Conveyance. The cost of urban conservation was investigated by CALFED and found to range from $200-$1,900 per acre-foot (Table 5-16, CALFED 2000). Conveying this water to the eventual point of use could involve additional cost. It has been assumed that the amount of water developed would be limited to that which results in an average cost of $325 per acre-foot for Category 1 water.

Agricultural Drainwater

Agricultural drainwater can be a source of water supply for irrigation or a problem water requiring disposal depending on the quality of the drainwater. The principal water quality concerns are high levels of selenium and salts. Selenium can bioaccumulate with adverse effects on aquatic wildlife (with the principal example being the closure of Kesterson Reservoir in 1986 due to deformities observed in water fowl), and high levels of salt can adversely impact crop production. Boron is also a constituent of concern.

As reported in Technical Memorandum 4 (URS 2000d), the San Joaquin Valley Drainage Program (SJVDP) projected that there would be 231,500 acre-feet of drainage reuse on 48,900 acres in the San Joaquin Valley by 2040 (SJVDP 1990). Drainage reuse is defined by the SJVDP as a planned system of drainwater reuse on progressively more salt-tolerant plants to reduce the volume of drainage to be managed and to concentrate salts and trace elements for easier containment/disposal. The SJVDP's proposed estimates of drainage reuse are reported by subarea in Table 6-5.

Table 6-5
Annual Drainage Problem Water Reduction through Reuse by 2040

Area	2040 (TAF)
Northern	0.0
Grasslands	13.6
Westlands	61.0
Tulare	113.3
Kern	43.6
San Joaquin Valley Total	231.5

Source: SJVDP, *A Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San Joaquin Valley*, 1990, Table 2.

More recently, Reclamation has estimated that the San Luis Unit (an area within the San Joaquin Valley of 293,000 acres which includes 225,000 acres in Westlands Water District) will require

drainage service based on a drainage production rate of 0.3 to 0.5 acre-foot per acre depending on the extent of efficient on-farm management systems and aggressive management. Total projected drainwater volume projected over a 50-year period ranges from 78,180 acre-feet to 130,300 acre-feet (USBR 2001).

At issue is whether drainwater can be recycled or reclaimed in a manner to make it or other irrigation water supplies available in practical terms for river restoration.

- First of all, water quality regulations for receiving waters, especially the selenium limits but also the future application of Total Maximum Daily Loads (TMDLs) limits on discharges, will reduce the direct discharge of poor quality drainwater to the San Joaquin River system.
- Secondly, the reuse or recycling of drainwater occurs in part due to shortages of irrigation water supplies experienced by the Westside districts. Drainwater is increasingly being used on-farm through recycling or blending with higher quality surface and ground water supplies to meet local irrigation water needs.

For the water that cannot be recycled, volume reduction methods including agro-forestry and other land application projects involving salt-tolerant crops are employed. If the districts have to resort to expensive treatment technologies such as reverse osmosis, the cost of treatment alone (not including land costs) can be around $500/acre-foot or more. The Grassland Area Farmers proposed facility to reuse and treat 35,000 acre-feet of drainwater is about $3,000/acre-foot of drainwater including the acquisition of land, installation of subsurface drainage collection, and the construction of a treatment facility. The resulting product water is proposed to be used for irrigation as the districts involved experience water shortages and do not get all of the water they need from the CVP.

Consequently, no agricultural drainwater from the San Luis Unit (of the CVP) and nearby lands was assumed to be directly available for river restoration. Drainwater that has good water quality is in short supply. It is managed similarly to tailwater recovery programs and can become available for transfer and use for agriculture. This type of water is already accounted for in Category 3 water purchases, so it is not considered Category 1 reclaimed water.

6.1.6.2 Category 2 Purchases

A second form of purchase, termed a “Category 2” purchase, can be modeled within the bundles.

This form of purchase represents annual purchases (e.g., long-term contract purchases that are exercised annually) of water from Eastside sources that are triggered in magnitude and frequency by year-type. Year to year requirements for supplemental water do not always show a systematic trend for every bundle configuration. The need for supplemental water in a systematic fashion is highly dependent upon the assumed facilities and assets of a particular bundle configuration. However, it was desired to illustrate the functionality of this form of purchase.

The greatest need for supplemental purchases occurs within Bundle A. It was found that purchases are necessary in almost all Normal-Dry and Dry year types. Direction was given to the Consultant Team to fashion Category 2 purchases to represent two components of supply: (1) a component representing water conservation improvements that would amount to 40,000 acre-feet per year; and (2) a component of purchased supply that would amount to an average 80,000

acre-feet per year over the entire study period. This latter component of water could be fashioned by year type in greater or lesser quantities, but the average use over the study period could not exceed 80,000 acre-feet per year.

As modeled, both components of Category 2 purchases are assumed to have a source from entities that could provide water that would in effect directly offset Friant water user diversions from the canals. The historical delivery pattern and geographical distribution of Class 1 and Class 2 water is used to distribute the offset of diversion requirements due to Category 2 purchases.

Only Bundle A is evaluated using Category 2 purchases. As additional water supply components are included in the bundle configurations, the need for systematic purchases greatly diminishes. Therefore, these purchases were not included in the analysis of Bundles B, C, D, or E. The use of long-term purchases as an option is discussed in Section 8.2. As stated previously, the source of supply for Category 2 purchases is assumed to originate from Eastside entities to provide for direct offset of Friant water user diversions from the canals. Although the source of this form of purchase could originate from other geographic areas, such as the Westside of the San Joaquin Valley, these sources of supply were not included due the complexity of including such options within the model. The inclusion of such options requires additional refinement of the model and purchase assumptions to consider the conveyance capacity constraints that would affect the utilization of Westside purchases within the Friant Division.

Water Conservation

Water conservation may be considered as either Category 1 or Category 2 water purchases. Conservation measures could apply to agricultural or urban water supplies. Conservation measures that address urban outdoor water use are considered in Category 1. Category 2 considers measures available to agricultural water use. As a long-term investment to increase irrigation water supplies, conservation measures such as canal lining to reduce conveyance losses are potentially the source of long-term purchase arrangements. Appendix E provides three different analyses of the potential for water savings through conservation measures: DWR's Bulletin 160-98 (DWR 1998), CALFED Water Use Efficiency Program (CALFED 2000), and USBR's Water Conservation Plans (White 2001). The analyses look at conservation from the following perspectives: valley wide, the groundwater subbasins, and the water/irrigation district. Key findings are summarized below.

Yield. The volume of new water that flows to saline sinks or is lost to evaporation is small: about 25,000 acre-feet annually from the Reclamation assessments and about 70,000 acre-feet from the CALFED assessment. Conservation measures directed at canal evaporation (about 19,770 acre-feet annually from the Reclamation estimates) and reduction of unwanted irrigation losses (about 17,300 acre-feet annually from the CALFED estimates) potentially yields additional water. However, CALFED acknowledged that a long-term reduction in these losses would have an impact on the groundwater supply, forcing groundwater users to seek other supplies.

For this analysis, the Water Supply Oversight Team assumed that agricultural water conservation measures could yield about 40,000 acre-feet from sources that are typically unrecoverable

(Appendix E). The first component of Category 2 purchase (40,000 acre-feet) is used every year of the study.

Cost and Conveyance. The cost of recovering percolation water to saline sinks will range from $110 to $700 per acre-foot (CALFED 2000). Conveying this water to the eventual point of use will involve additional cost. When included in a bundle, the cost of Category 2 conservation water is assigned a cost of $325 per acre-foot.

Long-Term Purchases

An "option" form of purchase arrangement is assumed for the second component of Category 2 purchase. This component of purchases is fashioned to occur as a purchase of 160,000 acre-feet per year, each Normal-Dry and Dry year. Pricing the option water consists of a fixed annual payment each year (equivalent to 10 percent of the "exercise" price times the quantity of water exercised during a Normal-Dry or Dry year) and a charge during a year of water delivery equal to the exercise price times the amount of water delivered. The exercise price is a function of a "floor" price plus an adder determined by the amount of water delivered in a year. Section 8.2 more fully describes the pricing mechanism.

Many different forms of a long-term purchase arrangement are possible and could in effect provide water to Friant water users, enabling the release of restoration flows. Section 8.2 describes several different arrangements.

6.1.6.3 Category 3 Purchases

This form of purchase represents short-term annual water that is acquired from Eastside sources (e.g., water users capable of facilitating a reduction in demand for surface water from the Friant Division). Functionally, these purchases reduce baseline demands.

The magnitude of the purchase is determined by the long-term model through an iterative process. For a given year, the model first identifies that volume of water necessary to maintain active storage throughout the year within Millerton Lake. An algorithm then determines the amount of water necessary to be "acquired" based on information available in February to keep Millerton Lake from being lowered below the minimum active storage level. The algorithm assumes water will become available during the year (February through September) on a irrigation/consumptive use pattern, assuming a combination of several crops will be fallowed. The assumed irrigation/consumptive use pattern is shown in Table 6-6.

Table 6-6
Assumed Irrigation/Consumptive Use (CU) Pattern for Category 3 Purchases
(Cotton, Grain, Alfalfa and Corn Average Surrogate)

	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Irrig/CU (AF/Acre)	0.13	0.19	0.18	0.26	0.49	0.65	0.59	0.23
Percent by Month	4.9%	7.2%	6.6%	9.5%	17.9%	23.8%	21.70%	8.5%
Cumulative Percent	4.9%	12.1%	18.7%	28.2%	46.1%	69.9%	91.5%	100.0%

The amount of water acquired varies from year to year and is assigned a price that varies both by year type and by the volume acquired. The price function for this category of purchase is shown in Table 6-7.

Table 6-7
Assumed Price Function for Eastside Short-term Purchases (Category 3 Purchases)

	Friant Restoration Flow Year Type	
	Wet, Normal Wet & Normal Dry	**Dry**
Constant ($/AF)	165	321
Market Variable ($/1,000 AF)	0.310	0.411

Price = Constant for Year Type + (Market Variable Year Type × AF/1000)

The cost of short-term water market purchases is estimated from an analysis of recent water sale transactions and estimates of hypothetical land fallowing transactions and is more fully discussed in Section 7.2.3. (See Appendix E, Section 3 for a detailed memorandum on the development of the water purchase supply curves.) It should be noted that the supply/price curve does not address long-term water purchases due to limited data on long-term transactions. Most of the information was on one-year or other short-term leases. These leases included water from a variety of sources, such as irrigation efficiencies (including tailwater recovery) and groundwater.

The Category 3 purchase algorithm and iterative model process are at times limited in their ability to balance purchases with Millerton Lake operations. This circumstance occurs because of the spreadsheet structure of the long-term model. At times when the iteration occurs another resource (such as the groundwater operation) may trigger a different operation (i.e., banking or extraction) as the result of the purchase and thus fault the calculation of required purchases. Also, during certain sequences of winter and spring months, there occur instances of water shortages that would not be appropriately met with such a purchase mechanism. The long-term model accommodates these intermittent water shortages as "Residual" purchases when needed to maintain Millerton Lake storage no lower than minimum pool storage. The price function assumed for residual purchases is a surrogate representing the cost of SWP entitlement water from the Westside of the San Joaquin Valley. The price is assumed to vary according to year type, representing the fixed costs associated with the SWP being applied to reduced entitlements during drier conditions. Table 6-8 depicts the pricing assumed for residual purchases.

Table 6-8
Assumed Price Function for Residual Purchases

	Sacramento Valley 40-30-30 Index				
	Wet	**Above Normal**	**Below Normal**	**Dry**	**Critical**
Price ($/AF)	134	155	191	262	311

Pricing of this type of purchase is dependent upon the determination of a Sacramento Valley wetness index, which more closely reflects the availability of SWP supplies. This index is not always reflective of San Joaquin Valley or Friant wetness conditions.

6.1.6.4 Credit for Residual Storage in Groundwater

Groundwater banking and extraction are key elements of the bundles. The assumed availability of banking allows otherwise surplus Friant runoff to be stored and then used at a later time. Groundwater banking also is used to store surplus flows from the Eastside tributaries and provides regulation storage for recirculated restoration flows. As can be seen in the modeling results, periods of groundwater banking are irregular and dependent on the occurrence of sequentially wet hydrology. For the sequential period investigated (1922 through 1999), no significant storage to the groundwater basins occurs until the mid-1930s.

Typically, the groundwater extraction side of a banking program is bounded by the amount of water that has been previously banked. For this analysis, this premise along with an initial balance of zero within each incremental groundwater basin is assumed. Due to the assumed sequence of hydrology (1922-1999), there is only minimal previously banked water available for extraction during the drought of the 1920s-1930s. Deficits in supply are met instead with purchases. Had an alternative sequence of hydrology preceded this period of drought, a sequence that had been wet in nature, an alternative result that would have used previously banked water would have occurred.

All of the bundles develop groundwater supplies that are not fully used by the end of the simulation period (herein termed "Residual Groundwater storage"). Residual storage is manifest in both the groundwater basin operation and in the "California Aqueduct Account" operation. Positive balances in either of these operations are indications that more water is developed during the simulation period and stored in these mechanisms than is necessary to meet demand or that can be delivered through assumed pumping and conveyance facilities to areas with demand. Some of the residual groundwater storage is due to modeling constraints and configuration assumptions that caused a storage of water in a location where it could not be fully utilized by Friant Division entities. A more refined optimization of a bundle's simulation, or comparison between bundles, would include a modification of facility sizing to create bundles that produce the same amount of water. However, that iteration is beyond the scope of this analysis. Instead, a credit to the costs of a bundle is included to at least account for the overproduction of water stored in the incremental groundwater basin operation. The credit assigned for Residual Groundwater storage is the "put charge" previously assigned as a cost to the bundle ($180 per acre-foot of water banked) times the amount of Residual Groundwater storage remaining at the end of the study period.

6.1.6.5 Credit for Other Residual Storage or Water Supply Indicators

In addition to the difference in Residual Groundwater storage that can occur between bundle configurations and operation, other water supply indicators may differ. The California Aqueduct Account within the model reflects a balance indicative of occasional storage of Eastside Tributary surplus flow not storable in Eastside groundwater basins. It also reflects an occasional storage of San Luis Reservoir recirculation water that was not usable in the Friant Division at the time that it needed evacuation from storage due to CVP/SWP operations. No credit is given to this residual storage in the results, but it should be recognized as an asset of the bundle. The

residual storage in this account is fairly consistent among comparable bundles, which makes its value, if a value is assigned, consistent for each bundle.

Different bundle configurations may also cause different amounts of water to be "spilled" from Millerton Lake to the San Joaquin River. Placing a value on the incremental spills between the bundles is very difficult, and its value is assumed to be zero for purposes of this analysis.

6.2 ANALYSIS OF BUNDLES

6.2.1 Bundle Configurations and Sensitivities

Five distinctly different bundle configurations are evaluated and described herein. The many components that are potentially in one bundle or another are illustrated in Figure 5-2. These components range from water purchases to surface water storage facilities and can include the use of storage and conveyance facilities of various entities.

Table 6-9 illustrates the various components included in each of the bundles, which were introduced in Section 5 and repeated below for convenience.

- Bundle A generally represents the use of existing storage and conveyance systems along with a major groundwater storage and extraction system and high reliance on water purchases to meet deliveries and restoration flows. Bundle A components are common to all of the other bundles, but their relative use varies as other supply and conveyance components are added for other bundles.
- Bundle B builds on the configuration of Bundle A with a component of additional recirculation (the ability to capture restoration flows downstream for re-use), and a component of additional storage at Millerton Lake by way of operating the reservoir down to 40,000 acre-feet (currently the minimum pool or "dead pool" is approximately 140,000 acre-feet).
- Bundle C evaluates the use of a new storage reservoir in the Tulare Lakebed for both regulation of recirculation flows and for capture of flood flows.
- Bundle D evaluates additional storage at Millerton Lake through an assumed enlargement of the reservoir (105,000 acre-feet) and through modifications to Mammoth Pool facilities (30,000 acre-feet).
- Bundle E evaluates the facilities of Bundle D together with additional storage developed at the proposed Fine Gold Reservoir (400,000 acre-feet).

In the following sections, the five distinctly different bundle configurations are evaluated four different times to include two different restoration flow hydrographs and the two different baseline delivery scenarios. Results are explained in general qualitative terms for each bundle incorporating specific numeric values separately for the Modified Channel Case X baseline demand condition and the Existing Channel Case Y baseline demand condition. These values represent two of the four possible scenarios for each bundle. It is important to consider the numeric values from all four scenarios when evaluating a bundle. The numeric results for all four scenarios are subsequently presented in table form. The reader is cautioned to not compare directly one baseline delivery scenario with the other baseline delivery scenario for the same bundle in terms of absolute values derived from the analyses. The two delivery scenarios are fundamentally different in terms of baseline assumptions and operations, with the Case Y delivery scenario suggesting a different water balance than has historically occurred within the Tulare Lake Basin.

Table 6-9
Bundle Configurations

	Groundwater Storage and Extraction Programs	Mendota Pool Recirculation	Conveyance in CA and DMC/San Luis Storage	East-West Conveyance in Southern San Joaquin Valley	Friant-Kern Canal Reverse Pumping	Eastside Tributary Pump-in	California Aqueduct Account	Water Purchases/ Reclamation/Conservation	Delta Recirculation	Millerton Minimum Pool Storage	Tulare Lakebed Storage and Conveyance	Millerton Enlargement/ Mammoth Modifications	Fine Gold Reservoir
Bundle A: Existing Facilities	■	■	■	■	■	■	■	■					
Bundle B: Expanded Recirc plus Millerton Minimum Pool	■	■	■	■	■	■	■	■	■	■			
Bundle C: Tulare Lakebed Storage	■	■	■	■	■	■	■	■	■		■		
Bundle D: Millerton Enlargement/Mammoth Pool	■	■	■	■	■	■	■	■	■			■	
Bundle E: Millerton/Mammoth and Fine Gold	■	■	■	■	■	■	■	■	■			■	■
	COMMON ELEMENTS												

In addition to these primary bundle configurations, several configuration enhancements are evaluated. These configuration enhancements are included to test the performance of a configuration with a single additive facility or component. Added to Bundle B is a 100 cfs capacity intertie with the Merced River Basin system. Added to Bundles B, C, D, and E is additional recirculation from the San Joaquin River (represented as a 500 cfs capacity Patterson Pump Station) to permit capture of river flow not necessary for downstream river restoration. When incorporating the additional San Joaquin River diversion capacity, the bundles also include a component to increase west-to-east capacity on the Cross Valley Canal by 337 cfs to provide a total of 500 cfs of available capacity in the CVC.

Each bundle's results are also evaluated for their sensitivity to the incorporation of Eastside tributary surplus flows. The availability of this component of water supply is removed from each configuration and the results are described.

6.2.2 Bundle Components

The bundles are made up of a number of components including existing facilities, proposed upgrades to existing facilities, and proposed new facilities. All the facilities originally considered for water supply are described in Technical Memorandum 5 (with addenda) (URS 2001a). The facilities chosen for inclusion in the five evaluated bundles are described in Section 5.4. The estimated annualized value of capital and maintenance costs for both upgraded and new facilities are included in Table 6-2. The energy gain or loss in terms of kWh per acre-foot for use of existing, upgraded, and new facilities is provided in Table 6-3.

6.2.3 General Operation Protocols

Through gaming and multiple refinements of the long-term modeling results, several fundamental operation protocols evolved and were used to analyze the bundle alternatives. These protocols, which are summarized below, were developed taking into account economic considerations, knowledge of externalities potentially affecting the availability of conveyance and storage facilities, and significant review of iterative results.

6.2.3.1 Protocol for Management and Acquisition of Water

The following general priorities and assumptions are employed in the analyses with regard to the management and acquisition of water in the project area:

Concurrently,

- Use of Category 1 purchases as an offset of baseline demands.
- Use of Category 2 purchases (when incorporated) as an offset of baseline demands.

Then,

- Diversion of surplus flows (either Millerton or Eastside tributary surplus flows) as an offset of direct demands or to storage (whether to groundwater or to surface storage).

Simultaneously,

- The capture and direct re-use of restoration releases.
- The use of other stored assets

Then,

- Category 3 and residual purchases to make up any remaining deficits in water supply.

6.2.3.2 Protocol for Use of Recaptured Water

The following general priorities are employed in the analyses with respect to the use of recaptured water:

- First priority for use for this water (based on economics and the acquired knowledge to not forego conveyance opportunities) is to directly offset demands for water along the lower reaches of the Friant-Kern Canal.
- Second priority for management of this water is storage in Eastside groundwater basins (to maximize its physical proximity to areas of demand).
- Third priority is to store water temporarily in San Luis Reservoir (if space is available).
- Any remaining water is then impounded in Tulare Lakebed storage (if included in the configuration) or put to Kern County area groundwater storage.
- Water stored in Westside storage is released as soon as possible (first from San Luis) for direct-use offset so as to avoid potential future storage constraints.

6.2.3.3 Other Operational Protocols

The triggering of groundwater banking and extraction as well as the operation of Fine Gold Reservoir have been developed through review of study iterations. The key objectives used to hone the groundwater operations include the avoidance of pumping and banking in the same year and the overall reduction of spills to the San Joaquin River. Fine Gold Reservoir operations have been developed similarly, with an added consideration of integration with the groundwater operation. The net energy requirement difference between using a pumped storage facility and a groundwater operation as the means to store water suggests using pumped storage in priority to a groundwater operation. Also, the greater instantaneous capacity of the Fine Gold Reservoir component suggests its operation prior to a groundwater operation.

6.3 BUNDLE A: EXISTING FACILITIES WITH GROUNDWATER PROGRAMS, EASTSIDE TRIBUTARIES, MENDOTA POOL RECIRCULATION, AND WATER PURCHASES

This bundle integrates several existing and new facilities and water purchases to satisfy restoration flows and water deliveries. These components serve as core features of all the bundles evaluated in this analysis. Although each bundle has been evaluated under four different scenarios (i.e., Modified Channel/Case X Demands, Existing Channel/Case X Demands, Modified Channel/Case Y Demands, and Existing Channel/Case Y Demands), narrative descriptions of results are only presented for the Modified Channel/Case X Demands and Existing Channel/Case Y Demands scenarios.

The key parts of this configuration are groundwater programs, direct-use or storage of surplus Eastside tributary flows, recirculation, and water purchases. Figure 6.3-1 illustrates the components of this bundle.

All bundles incorporate water purchases (Category 1, Category 3, and residual purchases) at some level, as both an assumed constant asset to offset baseline demands or as an annual mechanism to balance the remaining water demands with supplies. Bundle A incorporates an additional water purchase mechanism in the form of Category 2 purchases. For each scenario in Bundle A, 40,000 acre-feet of purchases is assumed each year as a representation of long-term demand offset due to improvements in water delivery and management practices. This form of purchase has been fashioned as an asset that occurs year to year, varying in quantity by water-year classification. The premise of the asset is to represent a long-term contractual purchase that would function akin to an "option" arrangement (see Section 6.1.6). Within the model, this mechanism displaces the need for Category 3 and residual purchases.

In addition to this water 160,000 acre-feet of Category 2 purchases have been incorporated into "normal-dry" and "dry" years (for a study-period average of about 80,000 acre-feet per year).

Costing analysis is applied to the bundle under each scenario. That analysis provides results for the annual capital and variable costs of the bundle. Those results, along with the operational results for Bundle A, are shown in Table 6-10. More detailed results, including sequential monthly and year-to-year summaries and hydrographs, are found in Appendix D.

Table 6-10
Bundle A Operational and Economic Results

	Parameter	Case X Demands		Case Y Demands	
		Modified Channel	Existing Channel	Modified Channel	Existing Channel
Quantities (1,000 acre-feet)	Total Purchases	173	208	146	155
	Category 1 Purchases	20	20	20	20
	Category 2 Purchases	124	124	124	124
	Category 3 Purchases	26	55	1	8
	Residual Purchases	3	9	1	3
	Levelized Groundwater Residual Balance	34	17	82	56
	Levelized California Aqueduct Balance	16	16	16	16
	Total Release to San Joaquin River	648	704	711	750
	Annual Average Spill	182	142	245	188
	Total Eastside GW Recharge	90	75	131	111
	Total Eastside GW Extraction	62	64	53	60
	Total Diversion of Tributary Surplus into FKC	91	91	94	93
	Recaptured Water for Recirculation (at Mendota Pool)	41	44	39	41
	Uncaptured Water	164	207	143	177
	Total CVC	39	42	37	40
	Madera Canal Diversion	242	233	245	239
	Friant-Kern Canal Diversion	846	806	776	746
	Baseline Diversion to Madera Canal	267	267	255	255
	Baseline Diversion to Friant-Kern Canal	1,071	1,071	943	943
Costs ($1,000)	Fixed Costs	$3,358	$3,358	$3,358	$3,358
	GW Put Charge	$16,280	$13,513	$23,567	$19,955
	Wheeling Costs	$225	$241	$210	$224
	Pumping Energy	$2,943	$3,139	$2,554	$2,839
	Generation Sales	($1,906)	($1,935)	($2,008)	($2,027)
	Category 1 Purchases	$6,500	$6,500	$6,500	$6,500
	Category 2 Purchases	$29,978	$29,978	$29,978	29,978
	Category 3 Purchases	$6,141	$13,302	$156	$2,002
	Residual Purchases	$760	$1,932	$194	$674
	Offset for Groundwater Residual Storage	($6,192)	($3,065)	($14,838)	($10,050)
	Total Average Annual Net Cost	**$58,087**	**$66,961**	**$49,669**	**$53,451**

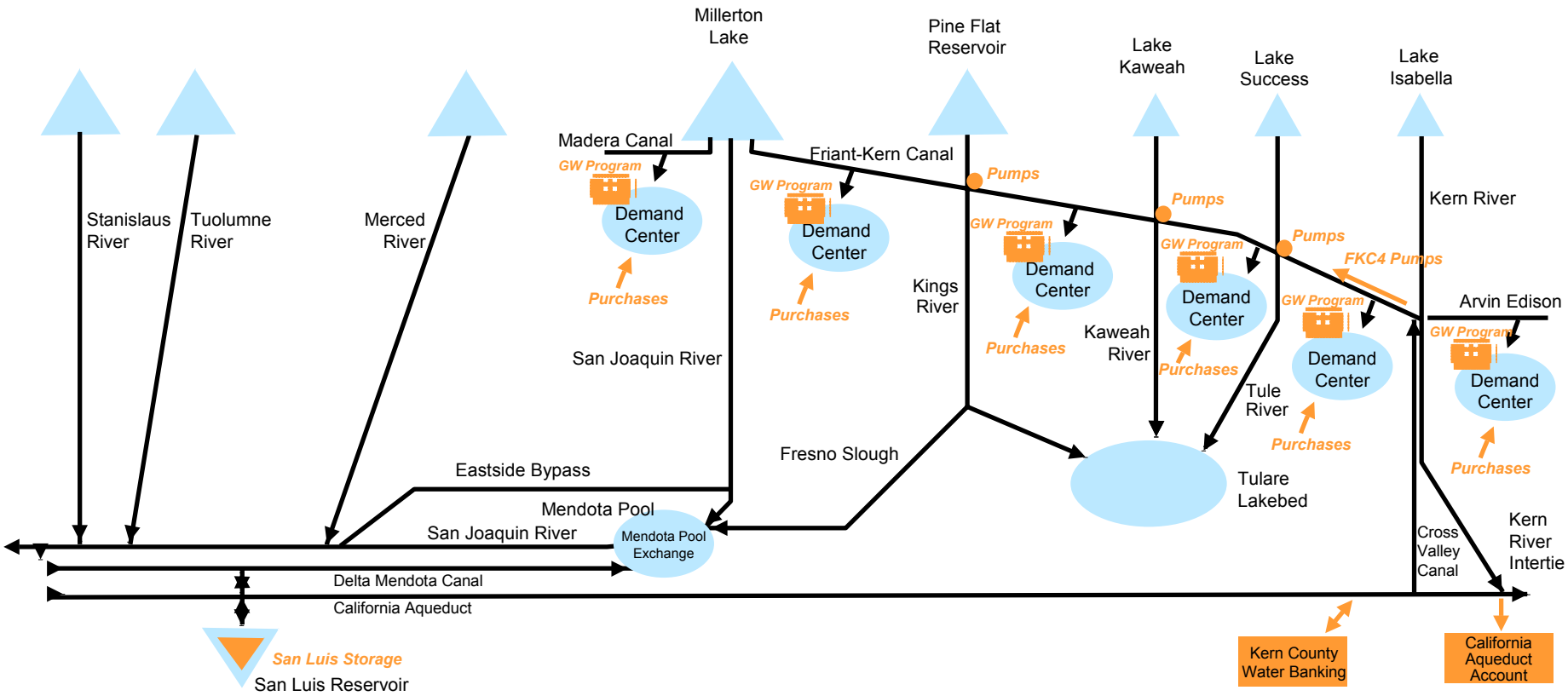

Figure 6.3-1

Bundle A: Existing Facilities with Groundwater Programs, Eastside Tributaries, Mendota Pool Recirculation, and Water Purchases

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6.3.1 Case X Demands with Modified Channel – Operations and Water Supply

Use of Eastside Tributary Surplus Flows: As described earlier, captured surplus flows are the first component of water developed to offset deficits resulting from restoration flow releases. Modeling protocols established that Eastside tributary surplus flows are captured prior to capturing Millerton Lake spills.

An annual average 91,000 acre-feet of Eastside tributary surplus flows were diverted to directly offset baseline demands or into bundle storage components. Figure 6.3-2 illustrates the frequency that Eastside tributary surplus flows are assumed to be available and the amount of water derived from each source for this scenario. The availability of Eastside tributary surplus flow was estimated from historical records and an analysis that extended that record for the entire hydrologic study period. These flows represent water that would otherwise create flood flows to the Tulare Lakebed or would flow to the San Joaquin River via the James Bypass. For purposes of this study these flows are defined as surplus and available for project use. An annual average 76,000 acre-feet were used for direct-use demand offset or banked and then extracted through the groundwater operation. The remaining average annual 15,000 acre-feet of Eastside tributary flows were credited to the California Aqueduct Account. This crediting was due to the bundle configuration's inability to directly use or store the full amount of surplus water available.

Mendota Pool Recirculation: The second component of water developed by the bundle is water captured and recirculated at Mendota Pool. Releases from Friant Dam that reach Mendota Pool are used by Mendota Pool water users as long as minimum required flow bypass conditions are met. These flow bypass requirements are very restrictive during fish migration periods, resulting in essentially no San Joaquin River flows being captured during the second half of October through the middle of December and during February, April, and May. During the remainder of the year an annual average of 41,000 acre-feet of water provides an offset to Mendota Pool water user demands and is thereby credited to the Westside SWP/CVP facilities for recirculation back to the Friant-Kern Canal.[2] Figure 6.3-3 illustrates the average monthly offset of Mendota Pool DMC deliveries. The pattern and potential magnitude of the offset is generally constant from year to year, as the availability of incremental flow associated with the assumed restoration hydrographs is fairly constant for the months during which flow can be captured. During months when significant flow is provided for the restoration hydrographs (February, April, and May) all flow is bypassed. The results for the months of October and December reflect the half-month of limited recapture potential. The year-to-year capture of flow at the Mendota Pool is shown in Figure 6.3-4 and Figure 6.3-5. The year-to-year variation in recapture occurs primarily as function of the wetness of the year. In general, a wetter year results in less demand at the Mendota Pool. In many instances demands are satisfied from sources other than the DMC (James Bypass and Millerton Spills).

[2] A significant change in reservoir operations is required as a result of the magnitude and distribution of restoration flows. This change in operation results in a substantial change in the timing and frequency of spills from Millerton Lake that otherwise would have (historically) occurred. Combined with assumed flow bypass requirements for San Joaquin River flows, the availability of San Joaquin River flows to Mendota Pool water users is decreased compared to existing baseline conditions. Although the Mendota Pool water user demands will still be met from Delta-Mendota Canal deliveries, the diminishment of supplies from the San Joaquin River will decrease the CVP supply for Westside contractors. This circumstance is described more in Section 6.9.

The majority of the recirculation water (an annual average of 36,000 acre-feet) occurs on a pattern coincidental with available conveyance capacity and Friant-Kern Canal direct-use demands or available Eastside groundwater storage capacity. During the occasions when recirculation does not favorably coincide with these factors, the water is temporarily stored in San Luis Reservoir until water use and conveyance conditions become suitable.

Groundwater Storage: On an average annual basis, the Bundle A configuration provides groundwater banking of 90,000 acre-feet and extraction of 62,000 acre-feet. The year-to-year groundwater operation is illustrated in Figure 6.3-6. The coincidence of Eastside tributary surplus flows, Category 2 purchases, and other fortunate hydrologic circumstances during the later third of the study period results in accrual of a groundwater balance amounting to over 2,500,000 acre-feet by the end of the study. During the middle portion of the study period, assumed resources, demands, and operation protocols result in a generally balanced groundwater operation. The early portion of the study period is plagued by a drought period that did not provide an opportunity to divert flows to groundwater storage and an assumption that a positive or zero balance must be maintained; thus, very little groundwater could be extracted. Had an initial balance been assumed, groundwater would have been extracted during this period.

San Joaquin River Spill Reduction: Current average annual spills to the San Joaquin River (releases in excess of those necessary for current downstream requirements) are estimated to be 276,000 acre-feet. Spills are reduced by 94,000 acre-feet on an average annual basis as "spill" water is used to make restoration flows, to refill Millerton Lake after it has been drawn down by restoration flows, and to fill groundwater banks.

Water Purchases/Reclamation/Conservation: An annual average of 173,000 acre-feet of purchases are required to make up the remaining shortages. Of this quantity of purchases, an annual average of 20,000 acre-feet are Category 1 purchases that do not vary on a yearly basis. Category 2 purchases amount to an average 124,000 acre-feet per year (by year type as described previously). The remaining 29,000 acre-feet of annual average purchases occur as Category 3 and Residual purchases, varying from year to year. Figure 6.3-7 illustrates the year-to-year purchases for this scenario. Category 1 and Category 2 purchases are generally sufficient to avoid the need for Category 3 purchases. At times these purchases are in excess of that amount necessary to simply balance supplies with demands. During these instances the purchases offset the amount of groundwater otherwise extracted. Figure 6.3-8 and Figure 6.3-9 further illustrate the occurrence of Category 3 and Residual purchases in relation to San Joaquin River unimpaired runoff. As can be seen in these figures, these purchases are primarily limited to below-average years.

Releases from Friant Dam: All restoration flow requirements are met in this scenario, with the annual average required release amounting to 466,000 acre-feet (including 117,000 acre-feet of releases required for current downstream requirements). In addition to minimum releases, spills still occasionally occur from Millerton Lake. These spills average 182,000 acre-feet annually.

Millerton Lake Storage: Restoration flow requirements, together with baseline canal deliveries, present a significant challenge to Millerton Lake operation with the Bundle A configuration. The very shape of the restoration hydrograph (mimicking spring peak runoff) requires passage of inflow that otherwise would be stored for later release to the canals during summer. The additional demands placed on Millerton Lake result in a generally lower reservoir throughout the year. As an indicator of this effect, monthly average Millerton Lake storage under current

Figure 6.3-2 Eastside Tributary Surplus Flow Availability and Use -- Case X, Modified Channel

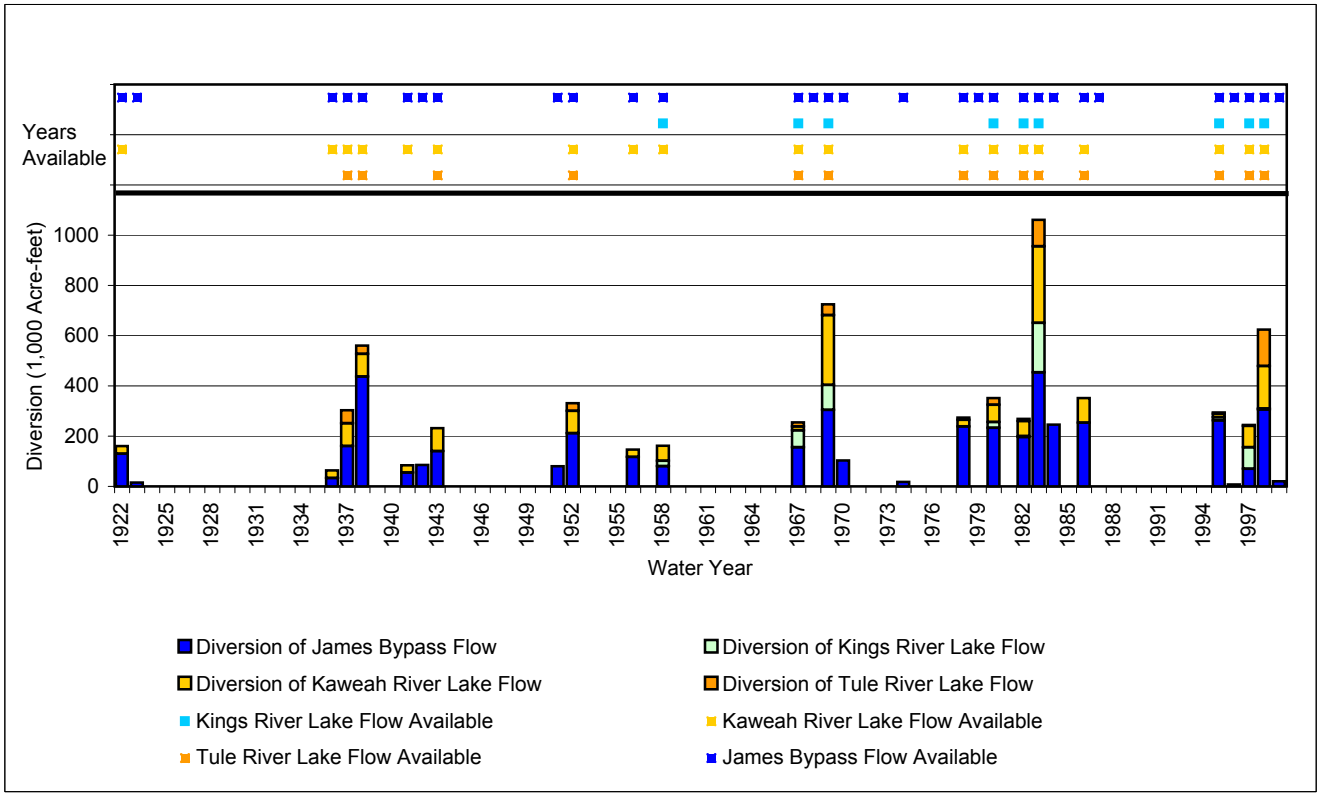

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Figure 6.3-3 Average Monthly Offset of Mendota Pool DMC Deliveries -- Case X, Modified Channel

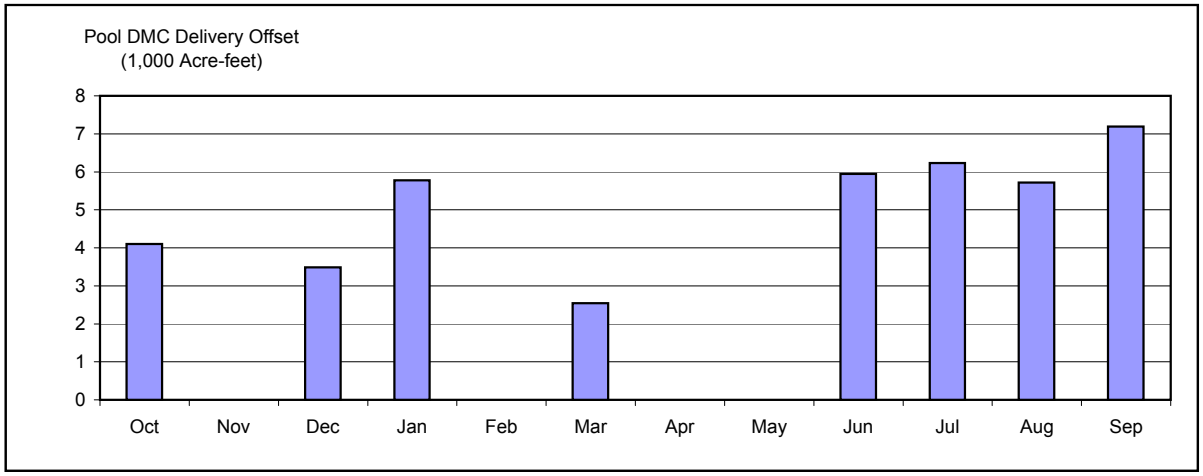

Figure 6.3-4 Annual Offset of Mendota Pool DMC Deliveries -- Case X, Modified Channel

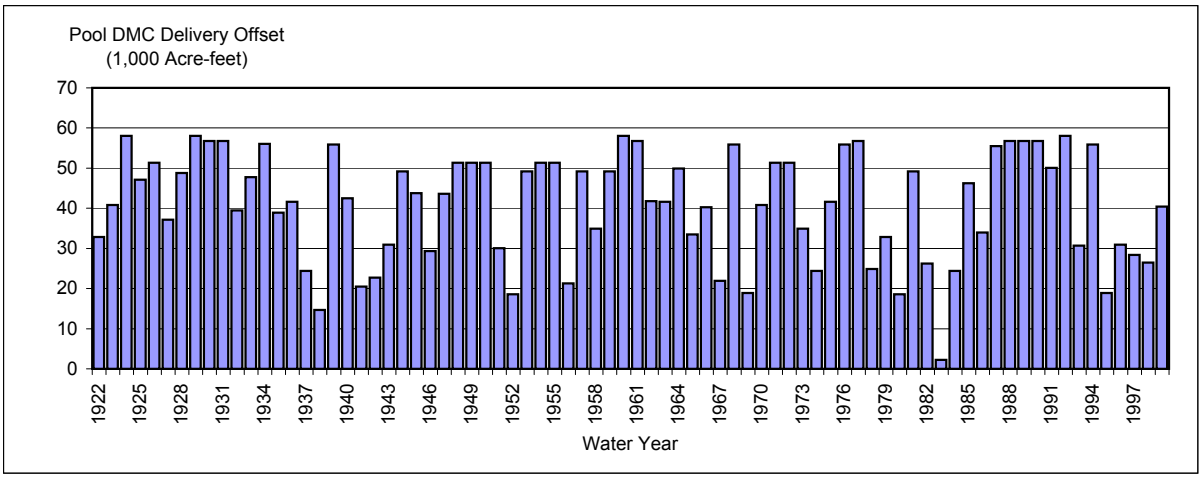

Figure 6.3-5 Annual Offset of Mendota Pool DMC Deliveries by Wetness of Year -- Case X, Modified Channel

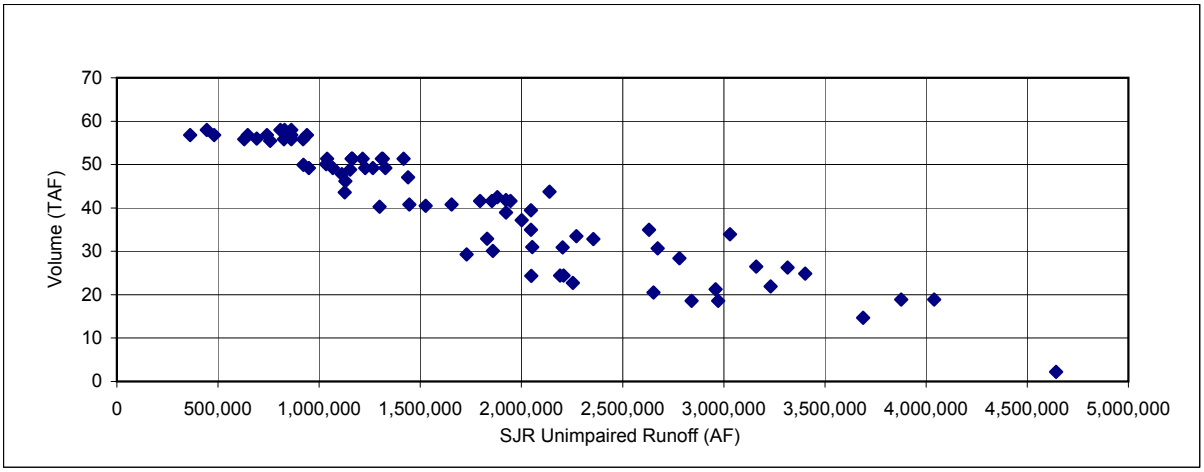

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Figure 6.3-6 Groundwater Operation -- Case X, Modified Channel

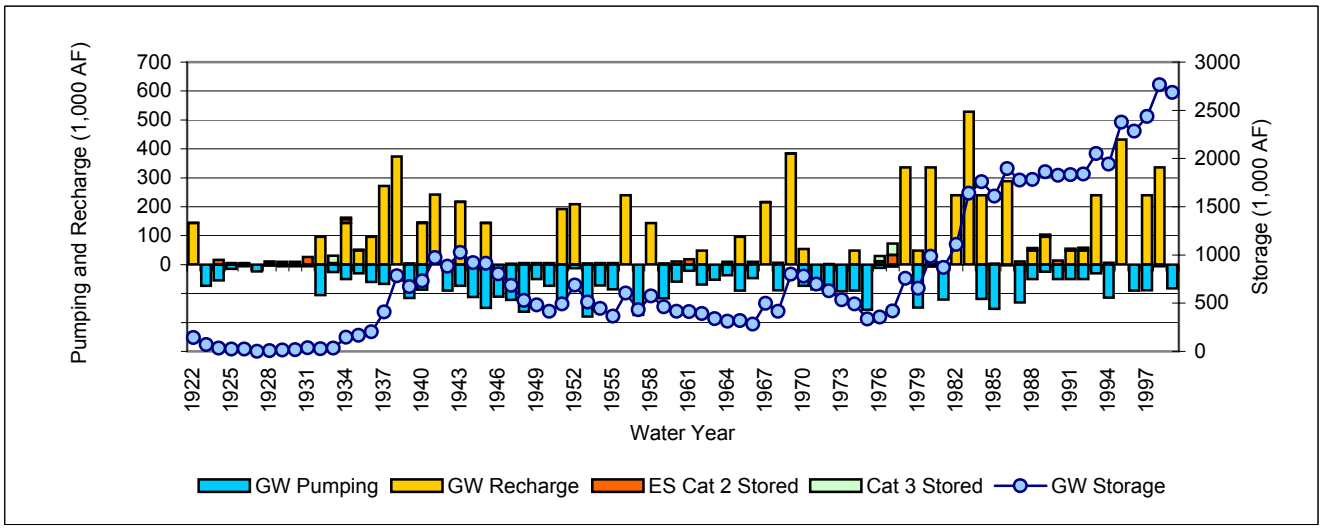

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Figure 6.3-7 Water Purchases -- Case X, Modified Channel

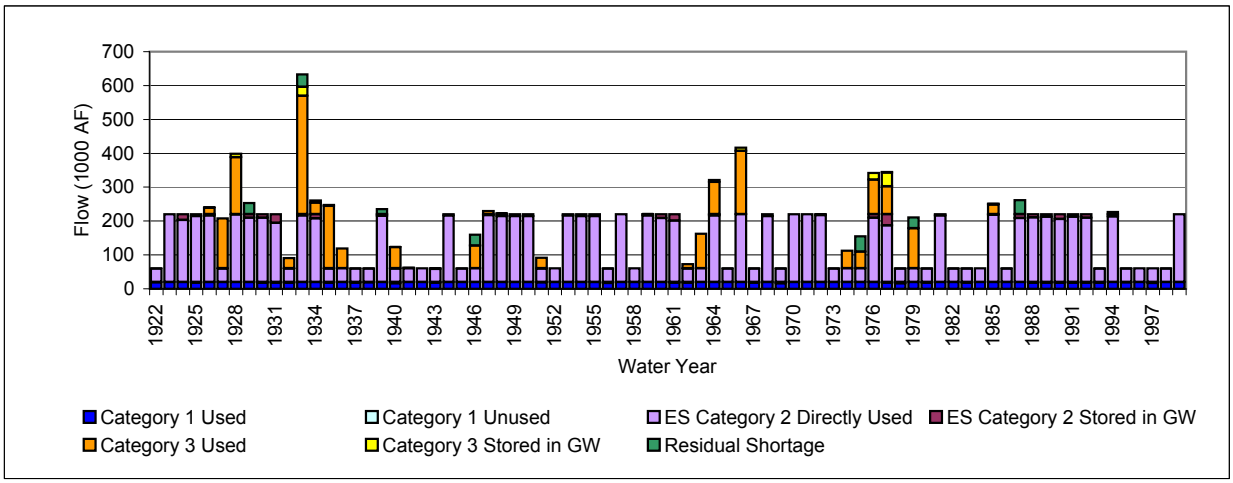


Figure 6.3-8 Category 3 Purchases -- Case X, Modified Channel

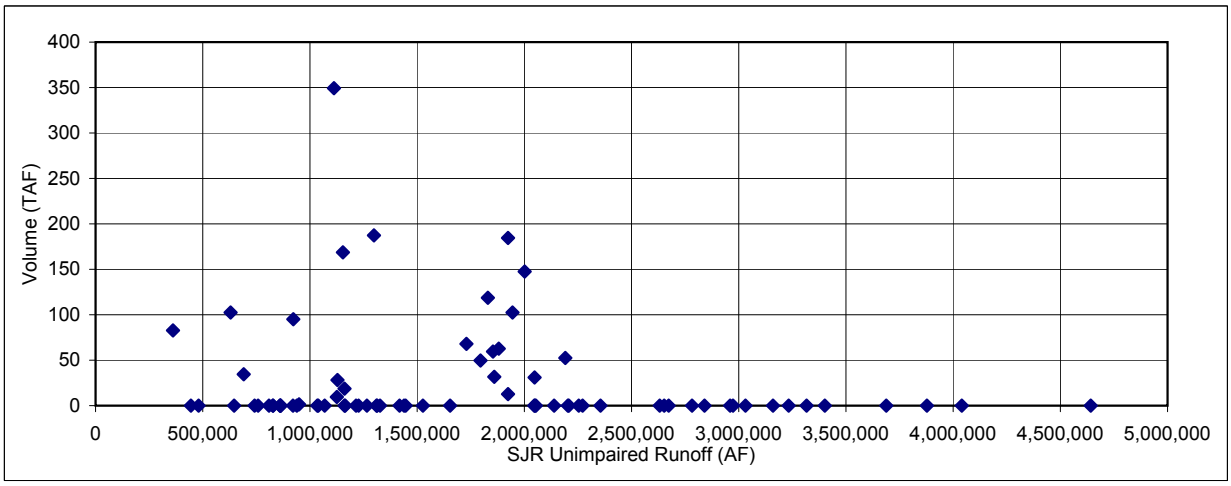
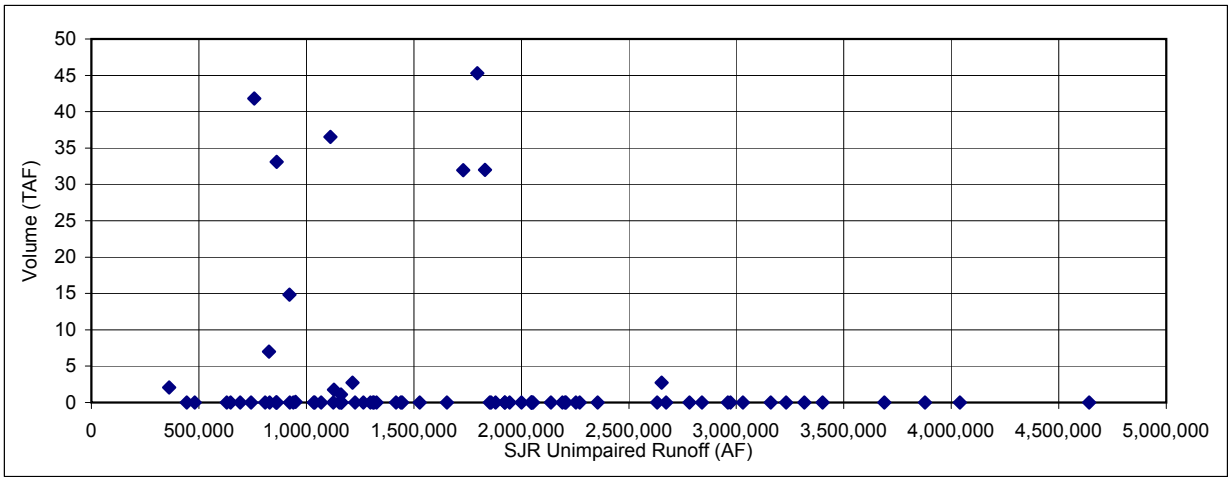


Figure 6.3-9 Residual Purchases -- Case X, Modified Channel



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operations is approximately 350,000 acre-feet. Under a Modified Channel/Case X Demand scenario, monthly average reservoir storage is 289,000 acre-feet, with extended periods (up to 5 years in duration) when storage would not exceed 300,000 acre-feet. Figure 6.3-10 and Figure 6.3-11 illustrate Millerton Lake storage at two different times of the year. Figure 6.3-10 depicts Millerton Lake storage at the end of June, a time the reservoir is normally at its fullest. The data show that Millerton Lake will not be filled during years that have less than average runoff. Figure 6.3-11 shows Millerton Lake storage anticipated for the end of September. There are many periods when the reservoir is operated near minimum storage. The reduced reservoir storage would impact lake recreation and power generation and present some risk for water supplies. Operating at near minimum reservoir conditions results in the loss of a reserve for unforeseen events such as variations in inflow and curtailments in conveyed supplies, purchases, or offsets provided by groundwater programs. Operation at this lower level especially jeopardizes the ability to divert water at a sufficient capacity to the Friant-Kern Canal.

6.3.2 Case Y Demands with Existing Channel – Operations and Water Supply

Use of Eastside Tributary Surplus Flows: Captured surplus flows are the first component of water developed to offset deficits resulting from restoration flow releases. Modeling protocols established that Eastside tributary surplus flows are captured prior to capturing Millerton Lake spills.

An annual average of 93,000 acre-feet of Eastside tributary surplus flows were diverted to directly offset baseline demands or into bundle storage components. Figure 6.3-12 illustrates the frequency with which Eastside tributary surplus flows are assumed to be available and the amount of water derived from each source for this scenario. The availability of Eastside tributary surplus flow was estimated from historical records and an analysis that extended that record for the entire hydrologic study period. These flows represent water that would otherwise create flood flows to the Tulare Lakebed or would flow to the San Joaquin River via the James Bypass. For the purposes of this study these flows are defined as surplus and available for project use. An annual average of 77,000 acre-feet were used for direct-use demand offset or banked and then extracted through the groundwater operation. The remaining annual average of 16,000 acre-feet of Eastside tributary flows were credited to the California Aqueduct Account. This crediting was due to the bundle configuration's inability to directly use or store the full amount of surplus water available.

Mendota Pool Recirculation: The second component of water developed by the bundle is water captured and recirculated at Mendota Pool. Releases from Friant Dam that reach Mendota Pool are used by Mendota Pool water users as long as minimum required flow bypass conditions are met. These flow bypass requirements are very restrictive during fish migration periods, resulting in essentially no San Joaquin River flows being captured during the second half of October through the middle of December and during February, April, and May. During the remainder of the year an annual average of 41,000 acre-feet of water provide an offset to Mendota Pool water user demands and are thereby credited to the Westside SWP/CVP facilities for recirculation back

to the Friant-Kern Canal.[3] Figure 6.3-13 illustrates the average monthly offset of Mendota Pool DMC deliveries. The pattern and potential magnitude of the offset is generally constant from year to year, as the availability of incremental flow associated with the assumed restoration hydrographs is fairly constant for the months during which flow can be captured. During months when significant flow is provided for the restoration hydrographs (February, April, and May) all flow is bypassed. The results for the months of October and December reflect the half-month of limited recapture potential. The year-to-year capture of flow at the Mendota Pool is shown in Figure 6.3-14 and Figure 6.3-15. The year-to-year variation in recapture occurs primarily as a function of the wetness of the year. In general, a wetter year results in less demand at the Mendota Pool. In many instances demands are satisfied from sources other than the DMC.

The majority of the recirculation water (an annual average of 36,000 acre-feet) occurs on a pattern coincidental with available conveyance capacity and Friant-Kern Canal direct-use demands or available Eastside groundwater storage capacity. During the occasions when recirculation does not favorably coincide with these factors, the water is temporarily stored in San Luis Reservoir until water use and conveyance conditions become suitable.

Groundwater Storage: On an average annual basis, the Bundle A configuration provides groundwater banking of 110,000 acre-feet and extraction of 60,000 acre-feet. The year-to-year groundwater operation is illustrated in Figure 6.3-16. The coincidence of Eastside tributary surplus flows, Category 2 purchases, and other fortunate hydrologic circumstances during the later third of the study period results in accrual of a groundwater balance amounting to almost 4,500,000 acre-feet by the end of the study. During the middle portion of the study period, assumed resources, demands, and operation protocols result in a generally balanced groundwater operation. The early portion of the study period is plagued by a drought period that did not provide an opportunity to divert flows to groundwater storage and an assumption that a positive or zero balance must be maintained; thus, very little groundwater could be extracted. Had an initial balance been assumed, groundwater would have been extracted during this period.

San Joaquin River Spill Reduction: Current average annual spills to the San Joaquin River (releases in excess of those necessary for current downstream requirements) are estimated to be 417,000 acre-feet. Spills are reduced by 229,000 acre-feet on an average annual basis as "spill" water is used to make restoration flows, to refill Millerton Lake after it has been drawn down by restoration flows, and to fill groundwater banks.

Water Purchases/Reclamation/Conservation: An annual average of 155,000 acre-feet of purchases are required to make up the remaining shortages. Of this quantity of purchases, an annual average of 20,000 acre-feet are Category 1 purchases that do not vary on a yearly basis. Category 2 purchases amount to an average of 124,000 acre-feet per year (by year type as described previously). The remaining 11,000 acre-feet of annual average purchases occur as Category 3 and Residual purchases, varying from year to year. Figure 6.3-17 illustrates the year-

[3] A significant change in reservoir operations is required as a result of the magnitude and distribution of restoration flows. This change in operation results in a substantial change in the timing and frequency of spills from Millerton Lake that otherwise would have (historically) occurred. Combined with assumed flow bypass requirements for San Joaquin River flows, the availability of San Joaquin River flows to Mendota Pool water users is decreased compared to existing baseline conditions. Although the Mendota Pool water user demands will still be met from Delta-Mendota Canal deliveries, the diminishment of supplies from the San Joaquin River will decrease the CVP supply for Westside contractors. This circumstance is described more in Section 6.9.

Figure 6.3-10 End-of-June Millerton Storage -- Case X, Modified Channel

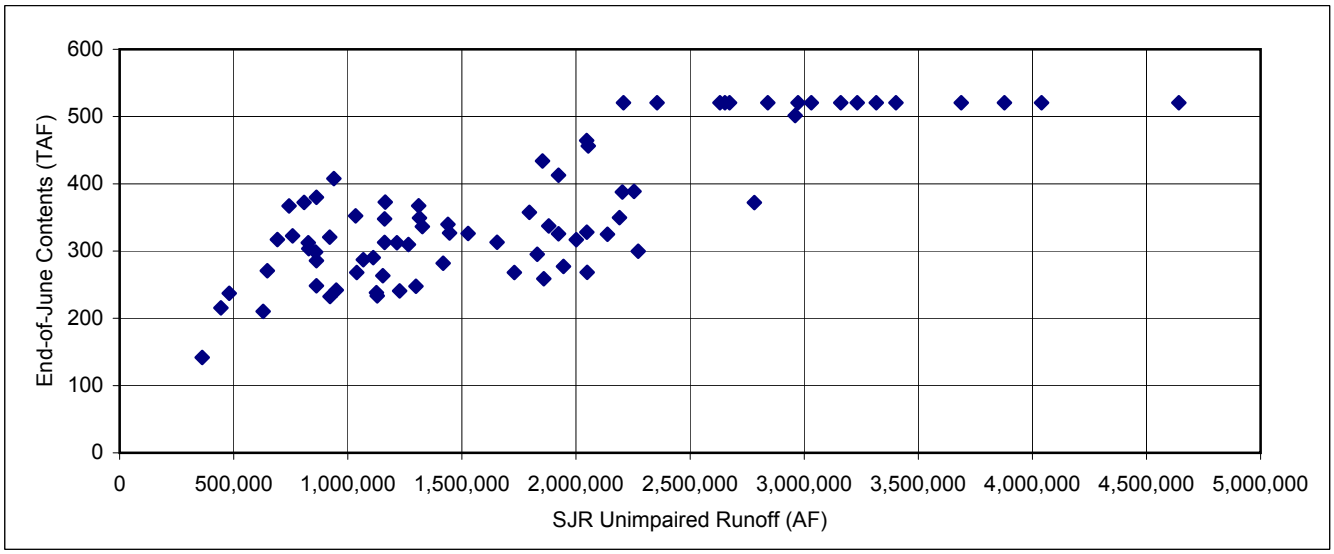

Figure 6.3-11 End-of-September Storage -- Case X, Modified Channel

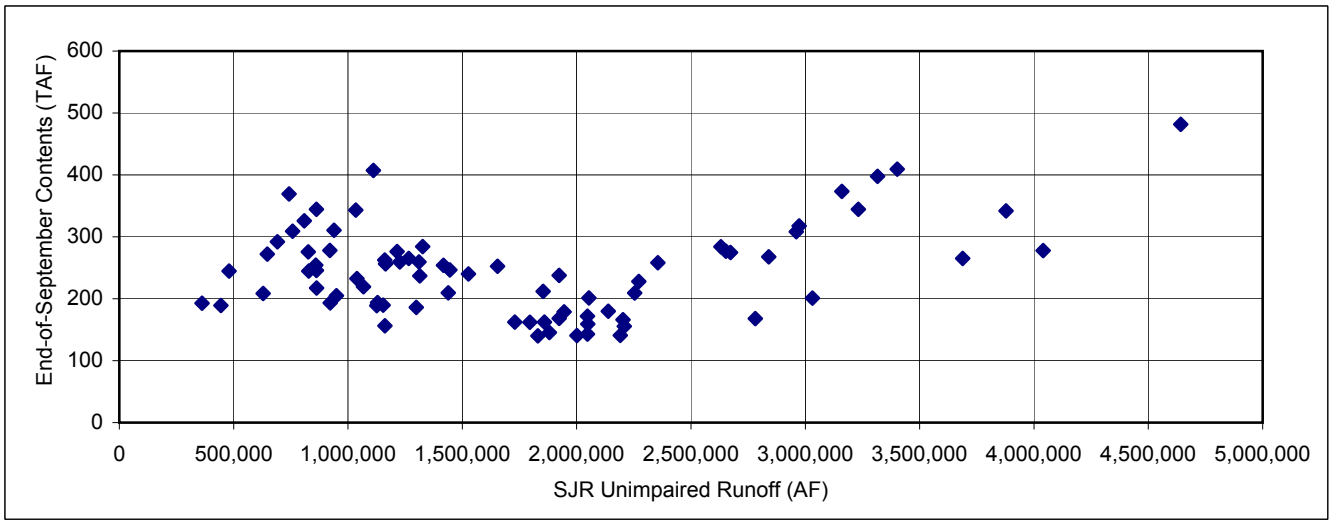

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Figure 6.3-12 Eastside Tributary Surplus Flow Availability and Use -- Case Y, Existing Channel

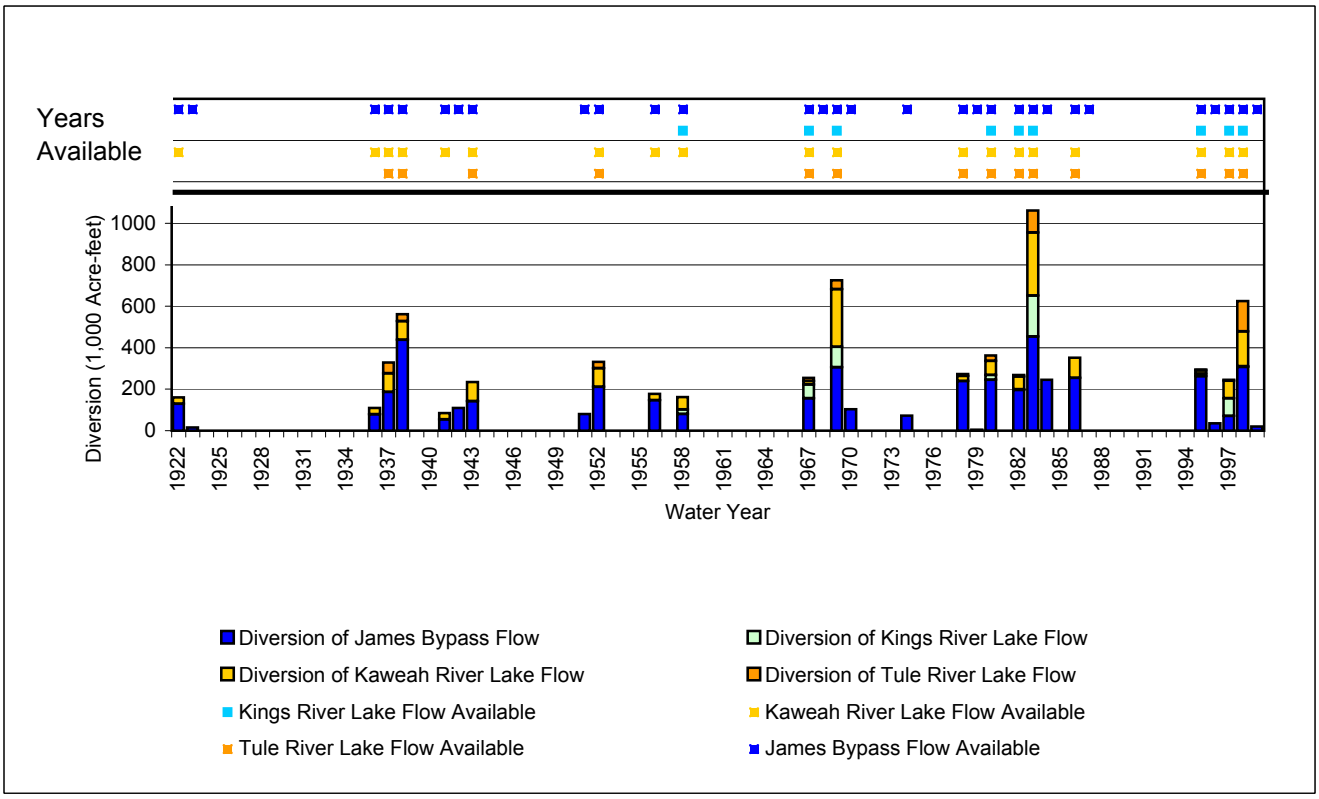

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Figure 6.3-13 Average Monthly Offset of Mendota Pool DMC Deliveries -- Case Y, Existing Channel

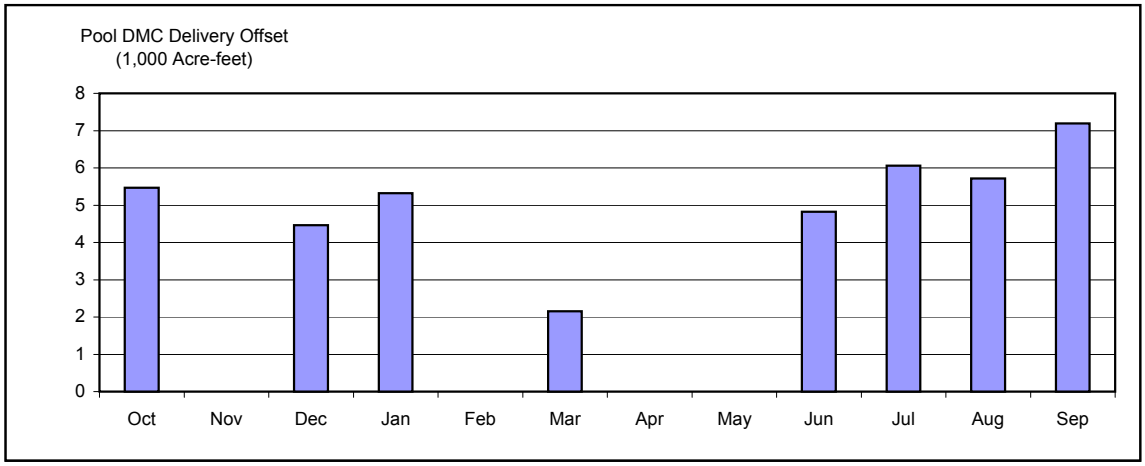

Figure 6.3-14 Annual Offset of Mendota Pool DMC Deliveries -- Case Y, Existing Channel

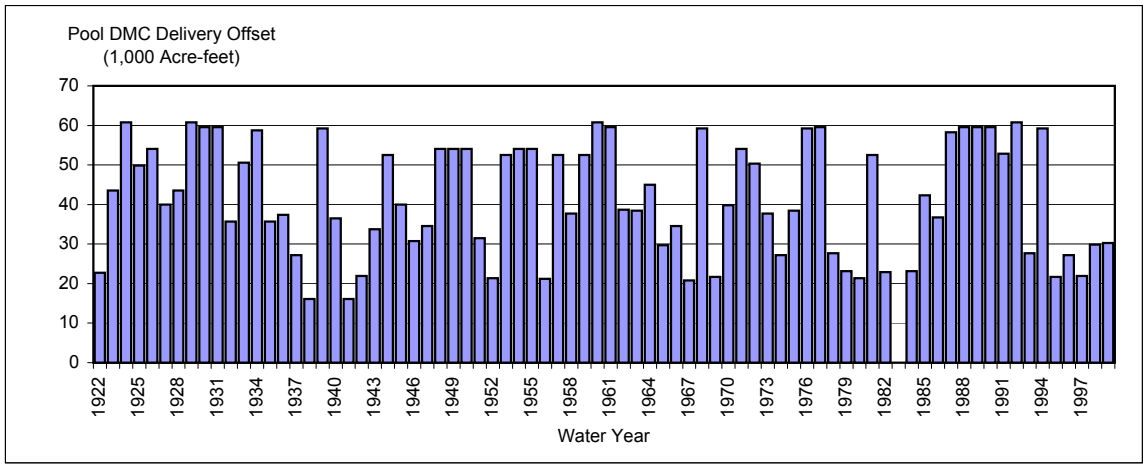

Figure 6.3-15 Annual Offset of Mendota Pool DMC Deliveries by Wetness of Year -- Case Y, Existing Channel

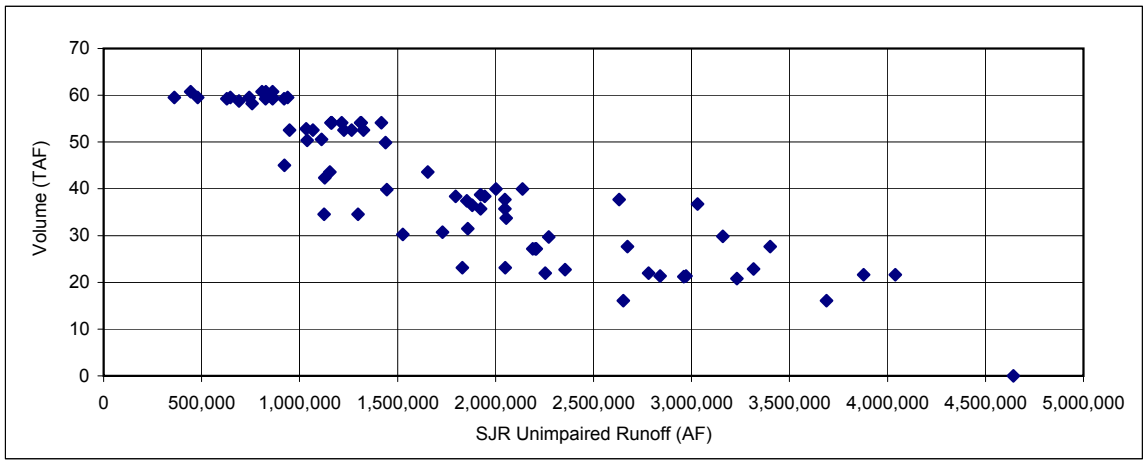

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Figure 6.3-16 Groundwater Operation -- Case Y, Existing Channel

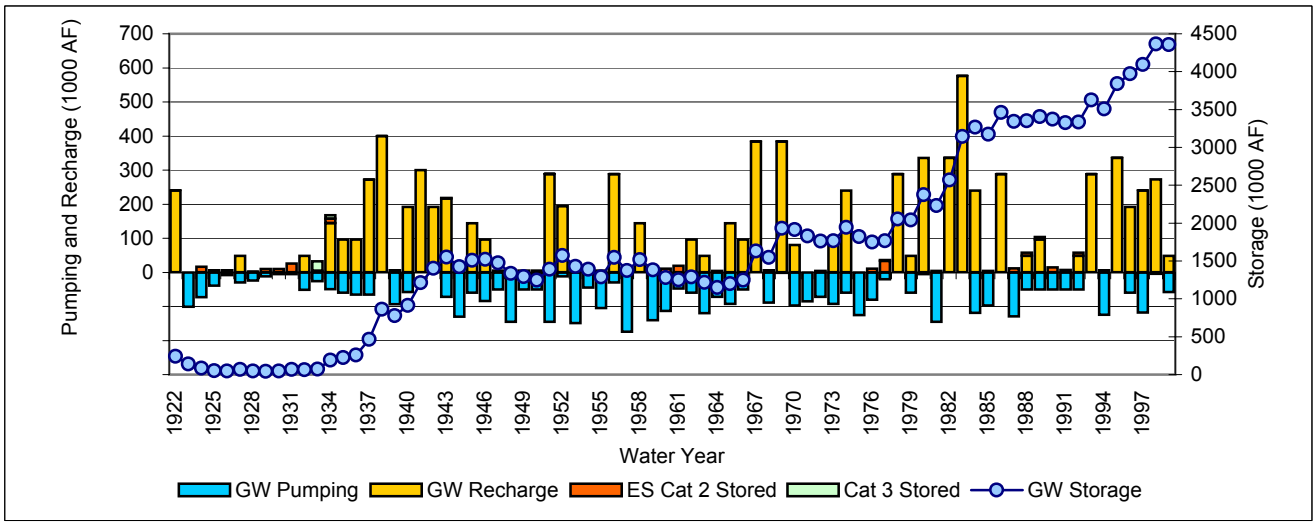

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Figure 6.3-17 Water Purchases -- Case Y, Existing Channel

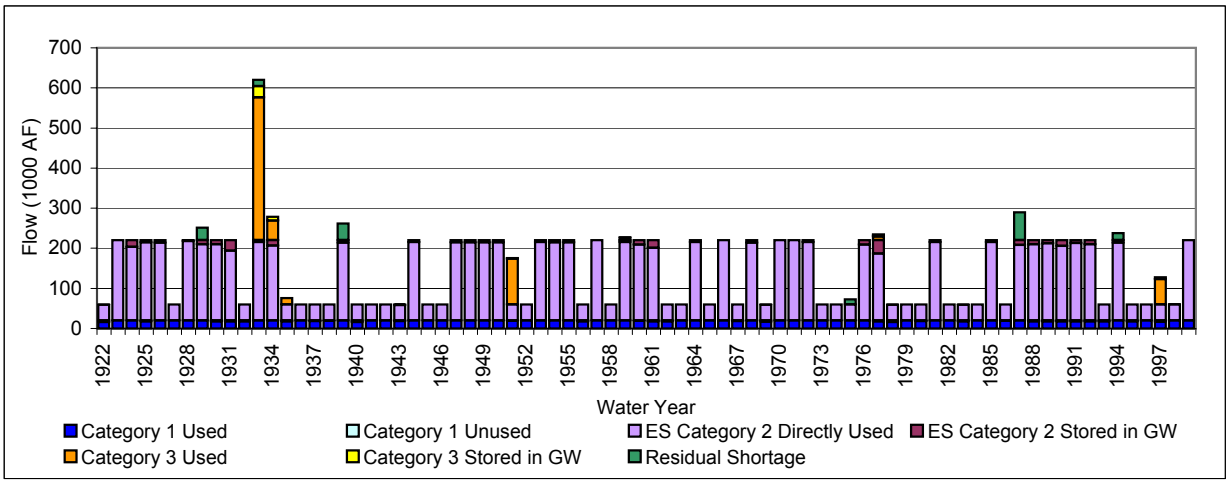


Figure 6.3-18 Category 3 Purchases -- Case Y, Existing Channel

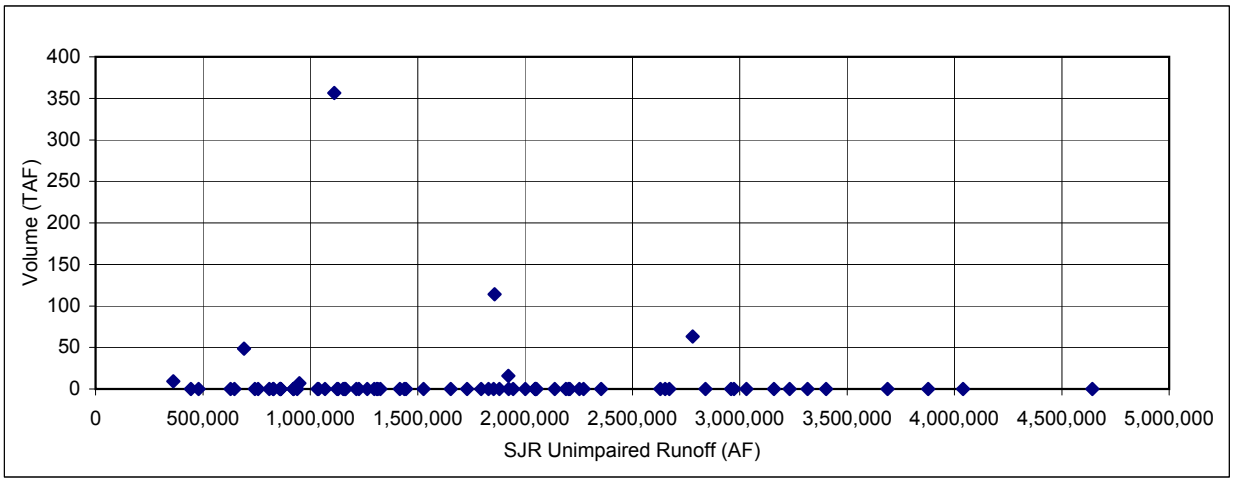
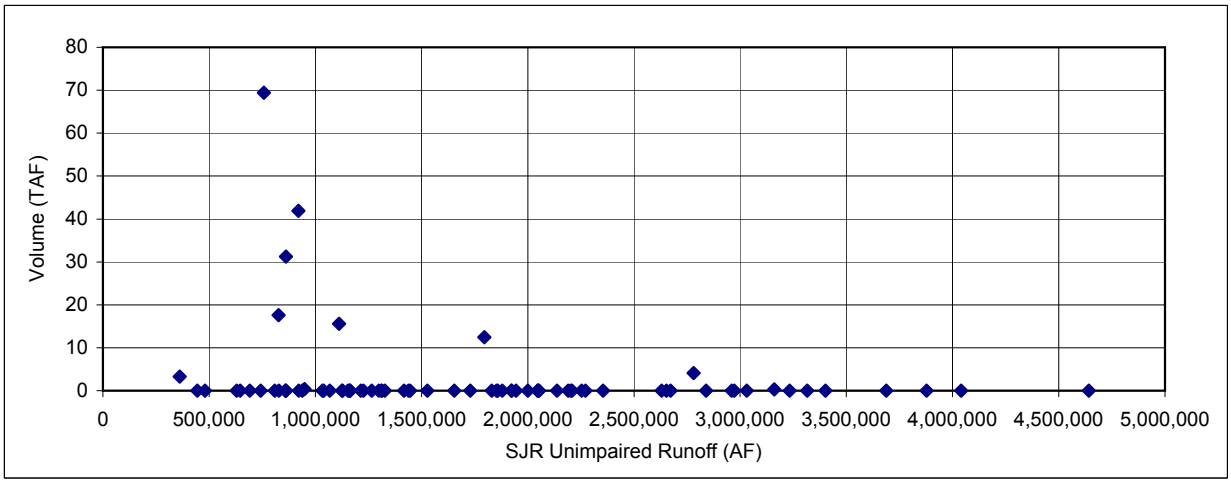


Figure 6.3-19 Residual Purchases -- Case Y, Existing Channel



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to-year purchases for this scenario. Category 1 and Category 2 purchases are generally sufficient to avoid the need for Category 3 purchases. At times these purchases are in excess of the amount necessary to simply balance supplies with demands. During these instances the purchases offset the amount of groundwater otherwise extracted. Figure 6.3-18 and Figure 6.3-19 further illustrate the occurrence of Category 3 and Residual purchases in relation to San Joaquin River unimpaired runoff. As can be seen in these figures, these purchases are primarily limited to below-average years.

Releases from Friant Dam: All restoration flow requirements are met in this scenario, with the annual average required release amounting to 562,000 acre-feet (including 117,000 acre-feet of releases required for current downstream requirements). In addition to minimum releases, spills still occasionally occur from Millerton Lake. These spills average 188,000 acre-feet annually.

Millerton Lake Storage: Restoration flow requirements, together with baseline canal deliveries, present a significant challenge to Millerton Lake operation with the Bundle A configuration. The very shape of the restoration hydrograph (mimicking spring peak runoff) requires passage of inflow that otherwise would be stored for later release to the canals during summer. The additional demands placed on Millerton Lake result in a generally lower reservoir throughout the year. As an indicator of this effect, monthly average Millerton Lake storage under current operations is approximately 350,000 acre-feet. Under an Existing Channel/Case Y Demand scenario, monthly average reservoir storage is 306,000 acre-feet, with extended periods (over 3 years in duration) when storage would not exceed 300,000 acre-feet. Figure 6.3-20 and Figure 6.3-21 illustrate Millerton Lake storage at two different times of the year. Figure 6.3-20 depicts Millerton Lake storage at the end of June, a time the reservoir is normally at its fullest. The data show that Millerton Lake will not be filled during years that have less than average runoff. Figure 6.3-21 shows Millerton Lake storage anticipated for the end of September. There are many periods when the reservoir is operated near minimum storage. The reduced reservoir storage would impact lake recreation and power generation and present some risk for water supplies. Operating at near minimum reservoir conditions results in the loss of a reserve for unforeseen events such as variations in inflow, curtailments in conveyed supplies, purchases, or offsets provided by groundwater programs. Operation at this lower level especially jeopardizes the ability to divert water at a sufficient capacity to the Friant-Kern Canal.

6.3.3 Technical Concerns

Bundle A relies heavily on outside purchases and additional use of existing conveyance facilities to meet the water supply demands. However, implementation of this bundle would still entail the construction of a number of new facilities. These facilities are common to the other bundles. Construction and other technical issues associated with each facility are briefly discussed below. Additional issues are discussed in Section 6.9.

- **Groundwater Storage and Extraction.** The cost analysis for this component is based on use of facilities constructed by others. Although there has been a great deal of activity by other entities to develop such facilities in recent years, the implementation of this bundle (or any of the other bundles under consideration) would require the development of a number of additional groundwater banking facilities. This development would entail acquisition of land in locations convenient for both acceptance of Friant water and for delivery of banked water to Friant contractors. This development would also require a means (and local agreements)

for groundwater accounting and development of new extraction facilities. Also, percolation of flood flows with high suspended solids into recharge ponds is detrimental to the ponds (sealing of the ponds by the suspended fines has been a common experience). See Section 6.3.5.1.

- **Purchase of Urban Conservation and Oil-Field Water (Category 1 Long-Term Purchases).** The cost analysis for this component is based on others developing these sources of water. New construction would include additional water treatment facilities to improve water quality to a level acceptable for irrigation use and additional conveyance facilities to deliver this water to locations for direct use, storage, or conveyance elsewhere. Although no technical or overall constructability review has been performed, development of these sources of water has been feasible at a number of locations. Technical feasibility for development of a particular source is dependent on the baseline water quality, the site conditions at the source, and the delivery location.
- **Friant-Kern Canal Reverse Pumping.** This component involves improving the intertie between the Cross Valley Canal and the Friant-Kern Canal and constructing lift stations to move 500 cfs of water up the Friant-Kern Canal. The improvements and lift stations would allow water to move upstream from the Kern River (milepost 151.78) to an existing equalizing reservoir at mile post 121.5, a distance of 30.28 miles, and a net elevation change of approximately 12 feet. This component would also involve the improvement of sections of the canal to accommodate the higher water surface elevations in the sections of the canal associated with reverse flow. Neither the location of the expected lift stations nor the locations of other canal improvements have been determined. Existing turnouts, road crossings, and right-of-way limitations along the canal could affect both final location and costs. However, given that this component involves relatively minor improvements to an existing facility, no serious technical or constructability issues that would preclude construction of this component are expected.
- **Eastside Tributary Pump-in.** This component involves constructing 1,000 cfs pump stations where the Friant-Kern Canal crosses the Kings, Kaweah, and Tule Rivers. Since temporary pump stations of a similar size have been placed in service at each of these locations to reduce flooding in the Tulare Lake Basin in the past, minimal technical and constructability issues with respect to development of permanent facilities are expected.
- **Mendota Pool Recirculation.** Recapture and recirculation of restoration flows (with attendant fish within that stream) at Mendota Pool assumes the use of San Joaquin River flow by Mendota Pool water users in lieu of Delta-Mendota Canal deliveries. The facilities (channel) necessary to maintain a stream to, and possibly through, Mendota Pool have not been evaluated in this Plan. Although recirculation has been accomplished through an experimental program, a large-scale program inclusive of considerations for attendant fish has not occurred.

6.3.4 Institutional Challenges

Given that the components of Bundle A are common to all the other bundles, and given that this bundle configuration has fewer components than the others, it follows that the threshold institutional challenges confronting this bundle should be no more difficult than those facing the

Figure 6.3-20 End-of-June Millerton Storage -- Case Y, Existing Channel

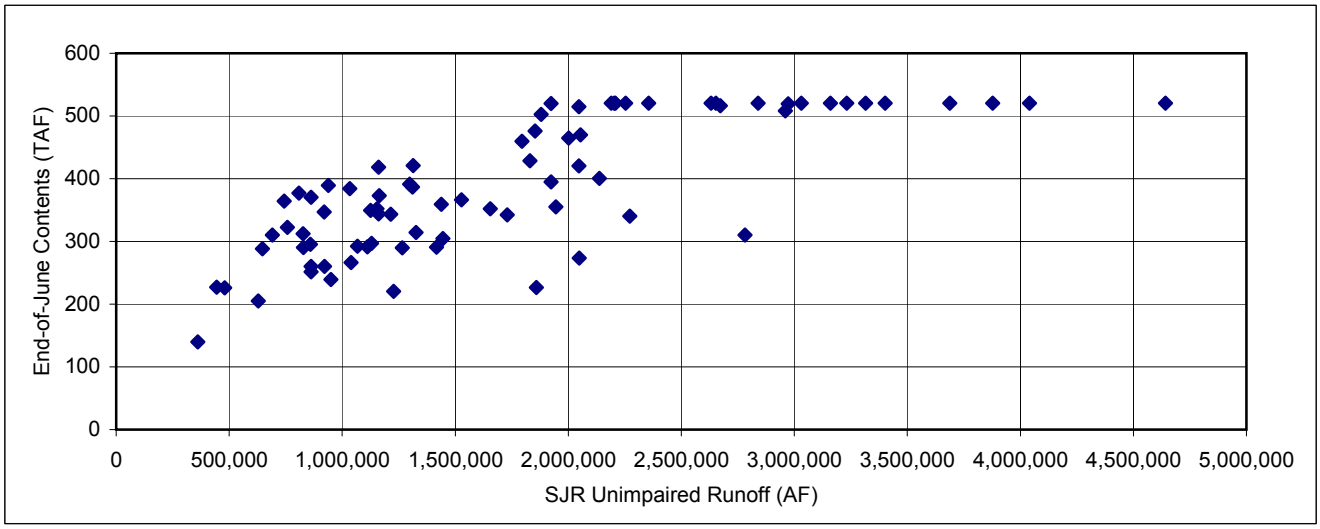
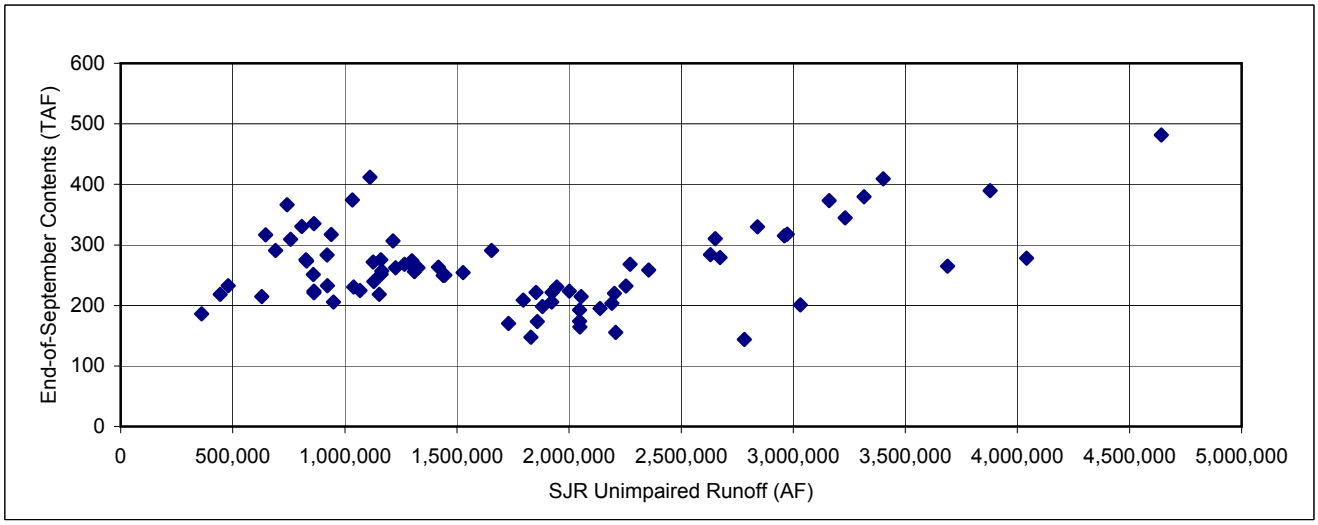


Figure 6.3-21 End-of-September Storage -- Case Y, Existing Channel



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other bundles and will be consistent with those of the other bundles. Institutional challenges would likely include regulatory proceedings concerning instream flow requirements below Friant and the supportive flow bypass requirements downstream of Mendota Pool. Permitting will be required for channel modifications and rediversion of releases.

Recirculation is dependent on the successful negotiation of numerous multi-party arrangements inclusive of state, federal, and local entities. The assumed groundwater programs also depend on the successful development of banking and extraction protocols that assure the availability of water without unacceptable impacts to the local area.

Bundle A relies heavily on water purchases in a competitive water market. The conservation of Eastside tributary surplus flows is also not free of concern. Local-area interests are also vying for these supplies for their own local needs or as marketing opportunities. The permitting requirements related to the change of place of use will likely pose certain challenges. For instance, other parties, including local entities with superior rights and interests, are investigating or developing some of these sources. The potential competition for these flows must be acknowledged.

The groundwater program is heavily reliant on groundwater storage (about 25% of the supply is being regulated by this form of storage). The assumption is that an additional 5,800 acres of land area will be needed throughout the area to accomplish this task. For modeling, the study assumes that costs will induce local agencies and individuals to implement the program. As has been demonstrated in the past, issues related to impacts to wells, groundwater overdraft, subsidence, groundwater exportation, water rights, groundwater storage rights, and the like are local concerns that must be addressed. Local projects are expected to be smaller and scattered throughout the area rather than consisting of one or two larger projects. Therefore, the success of a groundwater program is reliant on a thorough understanding of the operational parameters, requires the support of local agencies and a local champion, and requires significant time spent addressing the specifics of each party in the underlying contracts. The limitations of groundwater banking are that it takes a long time to put water into the bank and get it out. Therefore, decisions need a long lead time and significant forward planning to be a success. Also, the modeling to date has not addressed the storage space available for banking activities.

6.3.5 Environmental Concerns

6.3.5.1 Water Quality

The water quality implications of this bundle relate to reducing the storage in Millerton Lake and expanding groundwater use. Although extensive data are not available that describe the water quality near the bottom of Millerton Lake, data from similar reservoirs on the Eastside indicate a potential problem with metals, such as iron and mercury, near lake bottom. Maintaining the lake at lower storage would expose this deeper lake water and allow wind-driven mixing to occur. If Millerton Lake has a similar problem with metals in the deeper water, then this bundle could degrade lake water quality.

The Eastside pump-in component of this bundle would access outflow from several Eastside reservoirs. Water quality measurements from these reservoirs indicate that occasionally the iron and manganese concentrations detected in the outflow exceed drinking water or aquatic life

water quality standards. However, because this bundle uses surplus Eastside flows (during high-flow periods), high metals concentrations in the outflow are not expected to be present in concentrations that would violate standards.

Groundwater storage and extraction programs are sensitive to the location of the groundwater bank and the existing water quality conditions of the groundwater. Past water quality studies conducted by the USGS has found high nitrate and pesticide concentrations in San Joaquin Valley groundwater. The groundwater storage locations for this bundle must be selected to avoid areas where degradation of program water may occur. Also, percolation of flood flows with high suspended solids into recharge ponds is detrimental to the ponds (sealing of the ponds by the suspended fines has been a common experience).

6.3.5.2 Land Use

The Millerton Lake State Recreation Area essentially surrounds much of Millerton Lake. The primary land uses associated with the park include many water-dependent or water-related activities, such as swimming, boating, water skiing, jet skiing, sailing, fishing, camping, hiking, and horseback riding. In the winter, recreation activities include bald eagle watching. The proximity of Millerton Lake to both Fresno and Madera makes the reservoir popular with the public, particularly in the spring and summer.

As described above, under a Modified Channel/Case X Demand scenario the monthly average reservoir storage in Millerton Lake would be 289,000 acre-feet, and under an Existing Channel/Case Y Demand scenario it would be 306,000 acre-feet, with extended periods when storage would not exceed 300,000 acre-feet. In addition, there would be many periods when Millerton Lake would be operated near minimum storage (approximately 140,000 acre-feet). The water surface elevations associated with these lake volumes range from 471 feet at minimum storage to 526 feet at 300,000 acre-feet of storage.

This potential operation under Bundle A could affect recreation on and around the reservoir; however, Millerton Lake water surface elevations fluctuate each year under normal operations. Normally, the lake is at its lowest storage in September or October and fills in the winter and spring. The highest storage values are reached in late spring or early summer, and releases in excess of inflow are made from the reservoir from that time to meet irrigation demand. Under Bundle A, the reservoir would tend to begin releasing water earlier in the year to provide for restoration flows in spring. This timing could reduce some recreation use of Millerton Lake due to reduced surface area and length of shoreline earlier in the summer. However, recent annual attendance figures for Millerton Lake indicate that visitor use has been influenced more by the reduction in entrance and boating fees rather than by the water year type and resultant reduced lake surface area. The boat ramps at the lake are designed such that there are launches available from full pool to the minimum lake elevation of 471 feet.

As described above under the use of recaptured water, protocol dictates that the water would be stored first in Eastside groundwater basins, then put to Kern County groundwater storage. Under Bundle A there would be groundwater banking. The first areas for water banking are located at six possible Eastside sites in Madera, Fresno, Kings, Tulare, and Kern Counties (see Figure 6-4). Each groundwater banking demand center is assumed to have a collection of programs capable of banking 8,000 acre-feet per month, using approximately 800 acres of active recharge area. Each of the counties to be used for groundwater recharge has large amounts of land in

agricultural production that would be suitable for these programs. The six Eastside demand centers are as follows: Madera Canal; between San Joaquin and Kings Rivers; between Kings and Kaweah Rivers; between Kaweah and Tule Rivers; between Tule and Kern Rivers; and south of Kern River.

- The Madera Canal is located in Madera County. The canal carries water northerly from Millerton Lake to the Chowchilla River and crosses land that is covered with native vegetation or is in field, hay, or grain crops. The canal supplies water to such users as the Chowchilla Water District, Madera Irrigation District, Adobe Ranch, and Gravelly Ford (www.mp.usbr.gov/cvo/vungvari).
- The land between the San Joaquin and Kings Rivers is primarily located in Fresno County with a small area in Kings County. The land that could be used for groundwater recharge would not be in the urban areas, such as Fresno, in the northeast portion of the county. The land directly south and west of Fresno increasingly has been planted in vineyards with some field, hay, and grain crops (http://wwwdpla.water.ca.gov/sjd/).
- The land between the Kings and Kaweah Rivers is located in Kings and Tulare Counties. Urban areas, such as Corcoran, Hanford, or Lemoore in Kings County or Tulare or Visalia in Tulare County, would not be the areas used for groundwater recharge. In Kings County the majority of the land outside these urban areas is in field crops, while in Tulare County the lands are used for a mixture of field crops, grain and hay crops, vineyards, and citrus and subtropical plants along the eastern edge of the county (http://wwwdpla.water.ca.gov/sjd/).
- The land between the Kaweah and Tule Rivers is located in Tulare County. Porterville and Lindsay are two urban areas located in the eastern portion of the county. Land to the west of these areas is used for a mixture of field crops, grain and hay crops, and vineyards. In the area surrounding Porterville and Lindsay citrus and subtropical plants are grown. (http://wwwdpla.water.ca.gov/sjd/).
- The land between the Tule and Kern Rivers is located in Tulare and Kern Counties. The lands outside of urban areas in both counties are used for a mixture of field crops, grain and hay crops, vineyards, and citrus and subtropical plants along the eastern edge of the county (http://wwwdpla.water.ca.gov/sjd/).
- The land south of Kern River is located in Kern County. The lands outside of urban areas in the county are used for a mixture of field crops, grain and hay crops, vineyards, and citrus and subtropical plants along the eastern edge of the county and south and west of Bakersfield (http://wwwdpla.water.ca.gov/sjd/).

If there is further groundwater banking in Kern County, one of the policies of the Resource Element of the General Plan encourages effective management of the groundwater resource for the long-term economic benefit of the county by any or all of the following: (1) artificial groundwater replenishment; (2) conjunctive use of surface water supplies and groundwater supplies; (3) development of alternative local and imported surface water supplies; and (4) requiring permits for well construction, modification, or abandonment. Thus, groundwater banking would be compatible with land use and resource conservation policies in Kern County (Kern County General Plan 1994).

If agricultural land is used for groundwater banking, crop production and rotation may be altered, depending on the amount and location of water stored. If the land is recharged in early spring, planting may be delayed until later in the year. Thus, the overall land use would not be affected but the land management practices and timing of use could change.

Under Bundle A, the last component that could affect land use is the Friant-Kern Canal reverse pumping. To redirect the water, new lift stations will be necessary, and the canal lining would need to be raised. However, because the Friant-Kern Canal currently is used to transport water south from Millerton Lake as far as the Kern River, this component of Bundle A is compatible with existing land uses.

6.3.5.3 Biological Resources

Several vernal pool species have been recorded in the area around Millerton Lake. These species include Boggs Lake hedge-hyssop (state listed as endangered and a California Native Plant Society [CNPS] List 1B plant), succulent owl's clover (federally listed as threatened, state listed as endangered and a CNPS List 1B plant), tree anemone (state listed as threatened and a CNPS List 1B plant), vernal pool tadpole shrimp (federally listed as endangered), and vernal pool fairy shrimp (federally listed as threatened). These species would not be affected by the operations under Bundle A because the lake elevations would generally be lower than under current conditions.

Although no fish species were recorded in the California Natural Diversity Database (CNDDB) within half a mile of Millerton Lake, Kern Brook lamprey, a federal and state species of concern, may be in the vicinity of Friant Dam in Millerton Lake. The potential fishery issues from developed water relate to water management activities that may result in altered flow regimes in the Eastside tributaries that could alter flushing flows, riparian vegetation, sediment transport, and fish habitat in the channels downstream of the diversion locations. Under Bundle A, Millerton Lake will undergo more frequent or larger magnitude drawdowns that could be detrimental to the largemouth bass fishery in the lake. Restoration of chinook salmon runs on the San Joaquin River will require managed flows to be released from Friant Dam during the spring and fall months to aid in upstream and downstream migrations. Bundle A operations may make these flows unavailable for salmon restoration. These factors are applicable to all the Bundles that include these water management activities. The degree of the potential impacts of these activities would need to be more thoroughly evaluated to better understand their impacts and the potential damage to existing resources supporting fishery resources or the need for facilities to prevent damage to future (restored) fishery resources. For the purposes of the following discussion, fishery resource issues are discussed relative to facilities needed on the San Joaquin River and in the context of elements that are dependent on the Delta, present in existing rivers, or potential (restored) fishery resources in the San Joaquin River.

Water is extracted from the Eastside tributaries during wet years. Water is also rerouted through the Mendota Pool. Environmental issues associated with these circumstances are discussed in Section 6.9.

Assessment of any impacts to biological resources due to the development of a new groundwater recharge spreading basin or an aboveground pump facility would include:

- A site visit to assess the available habitats within the project area as well as which habitats and special-status species could potentially be impacted by the project
- A species search of the CNDDB within a 10-mile radius of the project area
- A formal species list from the U.S. Fish and Wildlife Service for the USGS 7.5 minute quadrangle in which the project lies, as well as the 8 quadrangles adjacent to it

In the event that there are potential impacts to special-status species, surveys or further assessment of the habitat should be conducted at the site and appropriate mitigation measures should be implemented.

6.3.5.4 Cultural Resources

There are a large number of recorded cultural resource sites in the Millerton Lake area, and potentially many more could exist in areas that have not been surveyed. The majority of the known sites in the area are either extensive milling sites with multiple bedrock mortars, or large camp sites with house pits, bedrock mortars, and formal tools. Of the 47 sites recorded in the inundation area, approximately 30 percent are located within the existing pool and may be affected by the operations under Bundle A. The generally lower lake elevations could expose some sites, and the timing of the operations could allow for destruction or vandalism of sites because the lower elevations would occur during the prime visitation season. However, because the range of operations of the reservoir under Bundle A could be similar to the range of operations under existing conditions, the impacts on cultural resources would be the same as under a no-action alternative.

6.4 BUNDLE B: DELTA RECIRCULATION AND MILLERTON MINIMUM POOL STORAGE

In addition to the core components described for Bundle A, the Bundle B configuration includes the use of Millerton Lake minimum pool storage (an incremental 100,000 acre-feet of potential storage) for additional management of San Joaquin River runoff and the use of SWP/CVP Delta pumping facilities to recirculate restoration or surplus San Joaquin River flows. Figure 6.4-1 illustrates the components of this bundle.

The subtle difference in operation occurring with this configuration is the availability of additional storage at Millerton Lake to satisfy demands within any given year. This storage decreases the need for other resources (e.g., purchases). The modeled operation of Millerton Lake with a lower minimum storage is the same as the operation without the lower limit, except that during drier years, when purchases would be needed to maintain Millerton Lake above the existing minimum level, additional storage is available to serve demands. Also, during the fall the trigger for groundwater extraction is relaxed to draw water more often from Millerton Lake. This additional draw from Millerton Lake creates more reservoir space to capture flows that might otherwise be spilled in subsequent months.

This configuration also provides an additional component of capture and recirculation of San Joaquin River flows. The combined capacity of the SWP/CVP pumping facilities available to increase exports from the Delta was estimated from recent studies. This capacity, along with estimates of available storage capacity in San Luis Reservoir, feeds into the model's simulation of the integration between Westside operations and Friant operations. The model attempts to capture restoration flows reaching the Delta and surplus San Joaquin River flows.

Category 1 purchases (20,000 acre-feet per year, each year) are included in this configuration. Water shortages are met with Category 3 and Residual purchases.

The results of the costing analysis and other operational parameters for the four scenarios of Bundle B are shown in Table 6-11. More detailed results, including sequential monthly and year-to-year summaries and hydrographs, are found in Appendix D.

Table 6-11
Bundle B Operational and Economic Results

	Parameter	Case X Demands		Case Y Demands	
		Modified Channel	Existing Channel	Modified Channel	Existing Channel
Quantities (1,000 acre-feet)	Total Purchases	72	101	34	44
	Category 1 Purchases	20	20	20	20
	Category 2 Purchases	0	0	0	0
	Category 3 Purchases	51	79	13	21
	Residual Purchases	1	2	1	3
	Levelized Groundwater Residual Balance	23	11	66	41
	Levelized California Aqueduct Balance	18	21	18	22
	Total Release to San Joaquin River	636	691	689	736
	Annual Average Spill	170	129	223	174
	Total Eastside GW Recharge	74	62	111	90
	Total Eastside GW Extraction	52	55	45	50
	Total Diversion of Tributary Surplus into FKC	91	91	94	94
	Recaptured Water for Recirculation	121	137	113	127
	Recirculation at Delta	80	93	74	86
	Recirculation at Mendota Pool	41	44	39	41
	Uncaptured Water	74	104	52	79
	Total CVC	114	126	106	117
	Madera Canal Diversion	260	252	263	257
	Friant-Kern Canal Diversion	843	798	785	747
	Baseline Diversion to Madera Canal	267	267	255	255
	Baseline Diversion to Friant-Kern Canal	1,071	1,071	943	943
Costs ($1,000)	Fixed Costs	$7,995	$7,995	$7,995	$7,995
	GW Put Charge	$13,447	$11,478	$20,087	$16,416
	Wheeling Costs	$678	$756	$615	$689
	Pumping Energy	$5,837	$6,572	$5,204	$5,858
	Generation Sales	($1,902)	($1,979)	($1,945)	($2,037)
	Category 1 Purchases	$6,500	$6,500	$6,500	$6,500
	Category 2 Purchases	$0	$0	$0	$0
	Category 3 Purchases	$14,663	$22,335	$4,017	$6,225
	Residual Purchases	$152	$494	$215	$621
	Offset for Groundwater Residual Storage	($4,213)	($1,921)	($11,955)	($7,351)
	Total Average Annual Net Cost	**$43,187**	**$52,229**	**$30,734**	**$34,916**

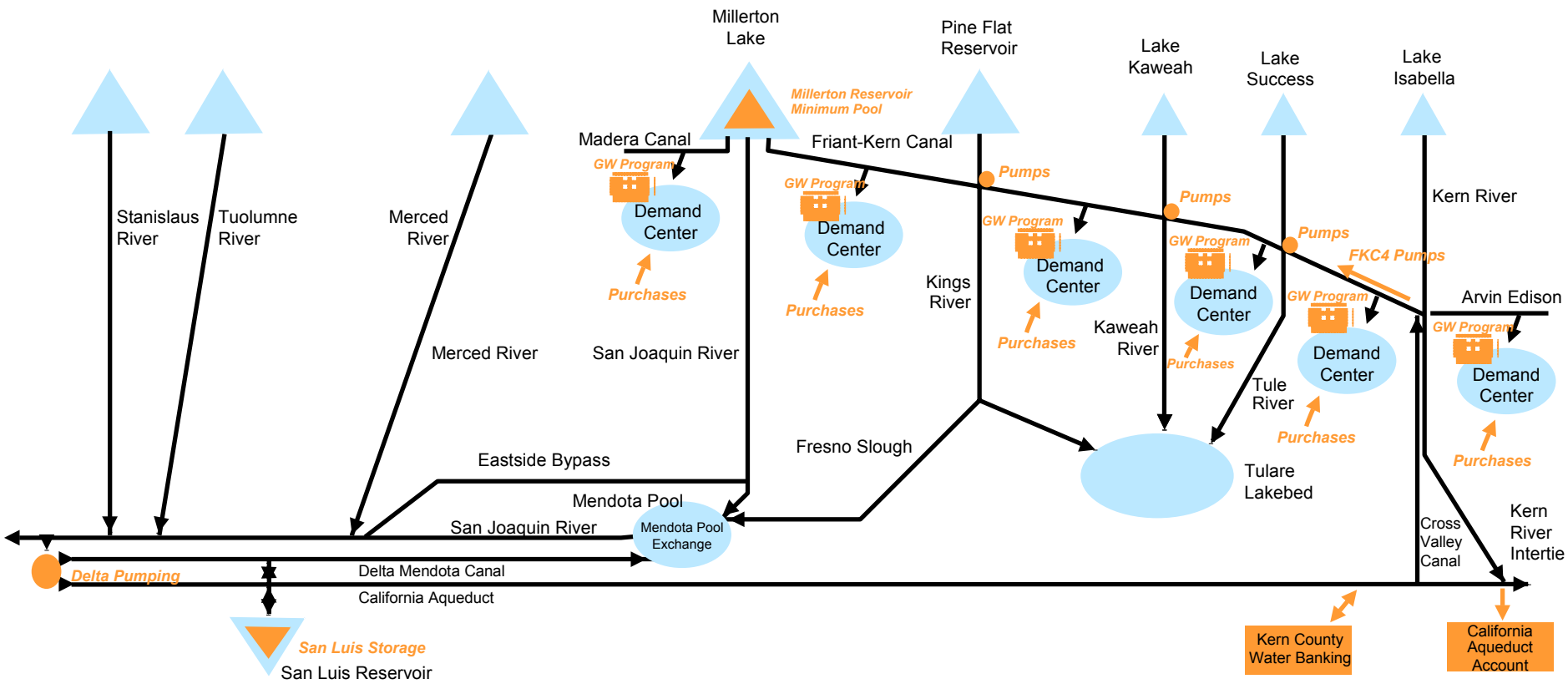

Figure 6.4-1

Bundle B: Delta Recirculation and Millerton Minimum Pool Storage

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6.4.1 Case X Demands with Modified Channel – Operations and Water Supply

Use of Eastside Tributary Surplus Flows: Consistent with the priority of operations established for Bundle A, the capture and management of surplus flows of the system become the first component of water developed to offset the deficit in deliveries caused by the release of restoration flows. Even with additional storage space occasionally available at Millerton Lake, the amount of Eastside tributary surplus flows captured by the bundle did not increase. An average annual 91,000 acre-feet of Eastside tributary surplus flows were diverted into bundle components. The availability and utilization of Eastside tributary flows would be very similar if not identical to that illustrated for Bundle A (refer to Figure 6.3-2). Similar performance of the Eastside tributary component under either bundle indicates that its use is limited by the capacity of the component and coincidence of Millerton Lake and Eastside tributary wet hydrology. Any available space created by use of Millerton Lake minimum pool storage in any given year is likely to be refilled with San Joaquin River runoff prior to the availability of Eastside tributary surplus flows.

Mendota Pool and Delta Recirculation: Water is captured and recirculated at Mendota Pool and the SWP/CVP Delta pumping plants. Pumping at the SWP/CVP Delta pumping plants is constrained by protocols developed for this analysis in connection with SWRCB Decision 1641, ESA, EWA and CVPIA conditions. An annual average of 41,000 acre-feet of water again offsets Mendota Pool water user demands and is thereby credited into the Westside SWP/CVP facilities for recirculation back to the Friant-Kern Canal. The monthly and annual pattern and magnitude of recirculation at Mendota Pool would be nearly identical to that occurring for Bundle A (refer to Figures 6.3-3, 6.3-4, and 6.3-5). Another annual average of 80,000 acre-feet of water are recirculated at the SWP/CVP Delta pumping plants. The occurrence of capture and recirculation at the Delta is illustrated in Figures 6.4-2, 6.4-3, and 6.4-4. Figure 6.4-2 illustrates the average monthly distribution of Delta recirculation and the range of pumping that occurred in a month. Figure 6.4-3 illustrates the year-to-year Delta recirculation component of this scenario. The complex set of parameters and constraints that determine the availability of flow and export capacity makes it difficult to draw general conclusions. Figure 6.4-4 illustrates the annual Delta recirculation volumes in relation to San Joaquin River unimpaired runoff.

Of the combined annual average of 121,000 acre-feet of recirculated water (at the Delta and the Mendota Pool), a majority (an annual average of 90,000 acre-feet) occurs on a pattern coincidental with available conveyance capacity and Friant-Kern Canal direct-use demands or available Eastside groundwater storage capacity. When the recirculation does not favorably coincide with these factors, the water is temporarily stored in San Luis Reservoir or the Westside Kern County Water Bank until water use conditions became suitable (an annual average of 27,000 acre-feet). Temporary San Luis Reservoir storage is used practically every year for regulation of recirculation flows. On occasion, the storage of recirculation flow in San Luis Reservoir conflicts with SWP/CVP available space and thus requires release and storage in the California Aqueduct Account.

Groundwater Storage: An annual average groundwater banking of 74,000 acre-feet and extraction of 52,000 acre-feet occur with this scenario. The year-to-year groundwater operation is illustrated in Figure 6.4-5. The coincidence of Eastside tributary surplus flows and other fortunate hydrologic circumstances during the later third of the study period results in accrual of a groundwater balance amounting to over 1,750,000 acre-feet by the end of the study. During the middle portion of the study period, assumed resources, demands, and operation protocols result in a generally balanced groundwater operation. The early portion of the study period is plagued by a drought period that did not provide an opportunity to divert flows to groundwater storage and an assumption that a positive or zero balance must be maintained; thus, very little groundwater could be extracted. Had an initial balance been assumed, groundwater would have been extracted during this period.

Water Purchases: To satisfy shortages resulting from the additional demand, an annual average of 72,000 acre-feet of purchases are required. Of this quantity, 20,000 acre-feet per year occur as Category 1 purchases. An annual average of 52,000 acre-feet are Category 3 and Residual purchases that vary from year to year. Figure 6.4-6 illustrates the year-to-year purchases for this scenario. The addition of the Delta recirculation supply reduces the need for purchases. Purchases are generally needed during water short years when the draw from the groundwater balance is limited. This is particularly true during the early years of the study period, when no groundwater balance exists. Figure 6.4-7 and Figure 6.4-8 further illustrate the occurrence of Category 3 and Residual purchases, in relation to San Joaquin River unimpaired runoff. As can be seen in these figures, these purchases occur sporadically and are primarily limited to below-average runoff years.

Releases from Friant Dam: Restoration flow requirements are met in this scenario, with the annual average required release amounting to 466,000 acre-feet (including 117,000 acre-feet of releases required for current downstream needs) subject to providing sufficient pumping capacity from Millerton Lake to the Friant-Kern and Modern Canals. See "Effect on Millerton Lake Storage," below. In addition to minimum releases, spills occasionally occur from Millerton Lake (an annual average of 170,000 acre-feet). Additional available reservoir space (caused by reservoir drawdown to meet demands) provides additional room in Millerton Lake to manage runoff that otherwise would spill.

Millerton Lake Storage: Under a Modified Channel/Case X Demand scenario, monthly average reservoir storage is 226,000 acre-feet, again with extended periods when storage does not exceed 300,000 acre-feet and with many periods when the reservoir is being operated at a very low level. This circumstance significantly impacts lake recreation and the availability of reliable sources of supply. More direct in this scenario is the risk associated with maintaining adequate diversion capacity for the canals. Operating Millerton Lake below 140,000 acre-feet requires complete reliance on pumping facilities. Figure 6.4-9 illustrates the range in storage that occurs each month. A storage level below 140,000 acre-feet can occur in any month, including during the peak diversion months of July and August. This circumstance suggests that pumping capacity equal to full diversions or other additional resources (at additional costs) would be necessary to ensure delivery capacity from the canals. During some months, diversions to the Friant-Kern Canal are modeled to be greater than 2,000 cfs during periods when Millerton Lake is operated below 140,000 acre-feet. This circumstance suggests increasing the assumed capacity and cost of the pumping components.

Figure 6.4-2 Monthly Delta Recirculation -- Case X, Modified Channel

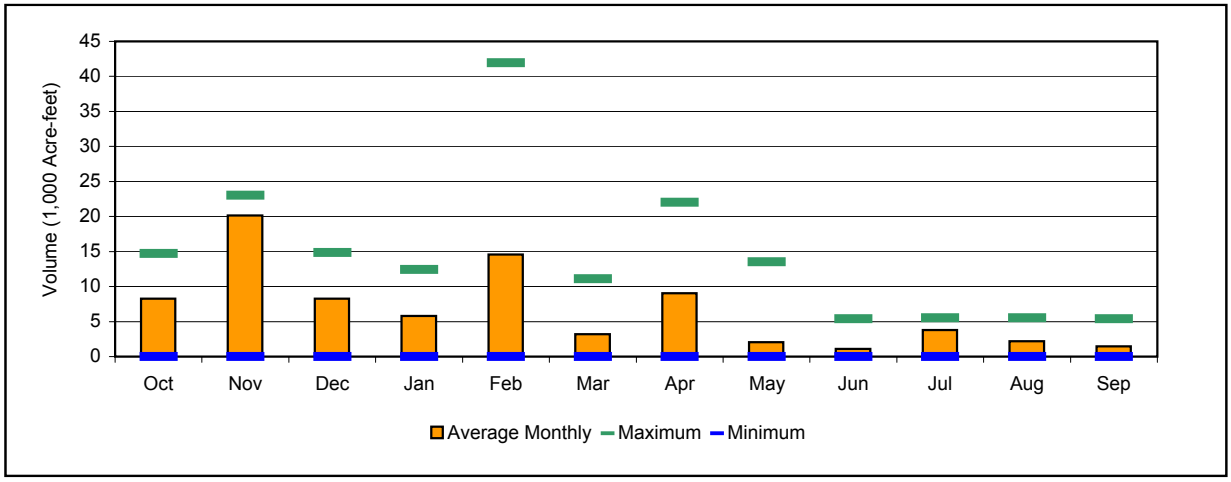

Figure 6.4-3 Annual Delta Recirculation -- Case X, Modified Channel

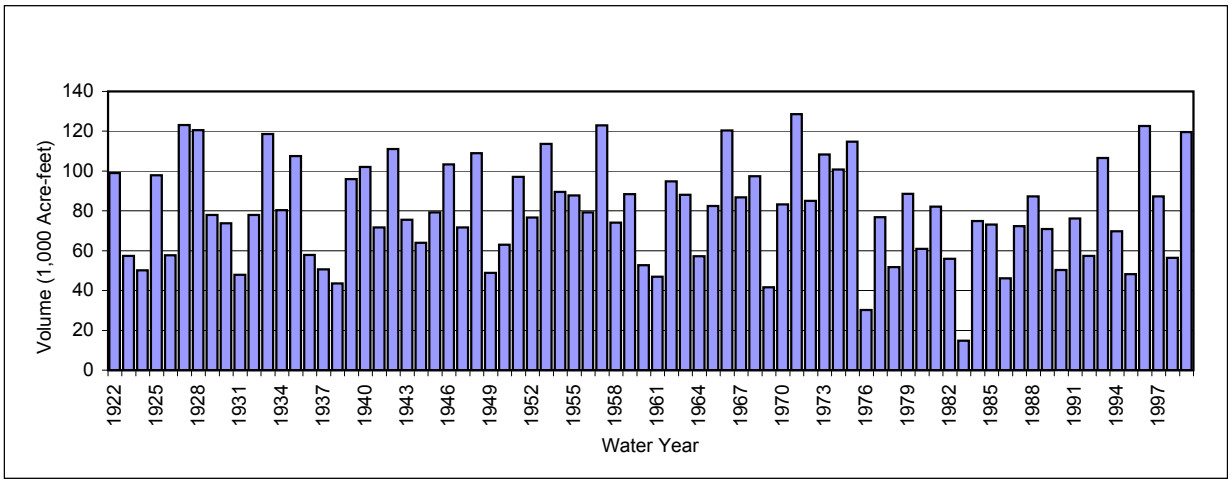

Figure 6.4-4 Delta Recirculation by Wetness of Year -- Case X, Modified Channel

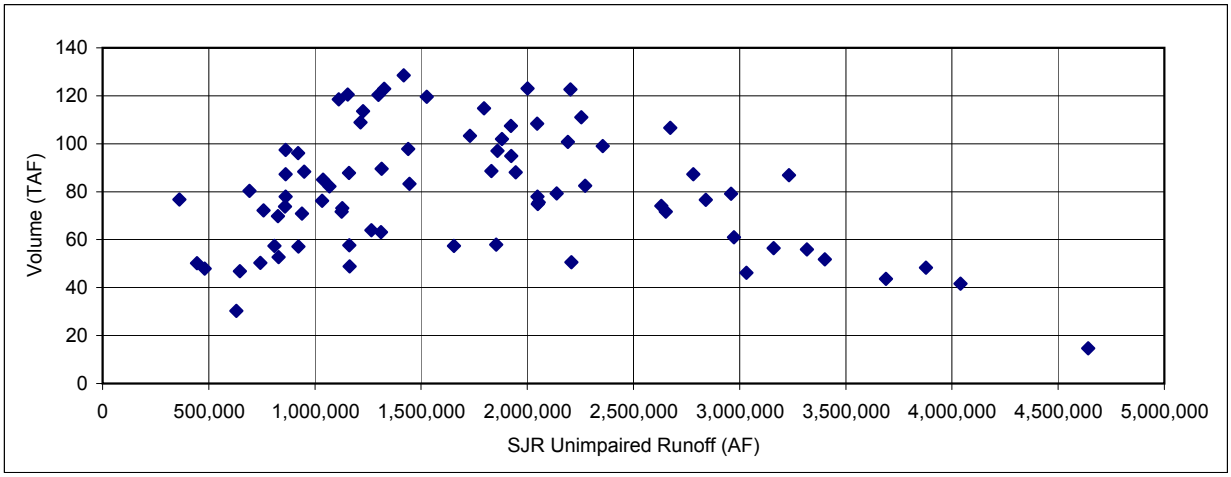

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Figure 6.4-5 Groundwater Operation -- Case X, Modified Channel

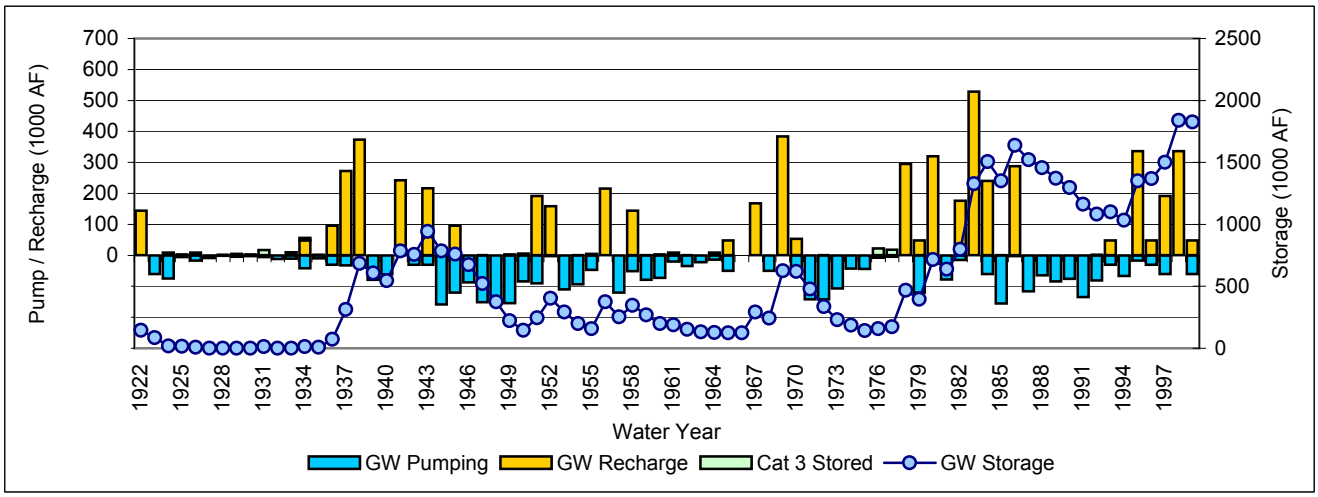

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Figure 6.4-6 Water Purchases -- Case X, Modified Channel

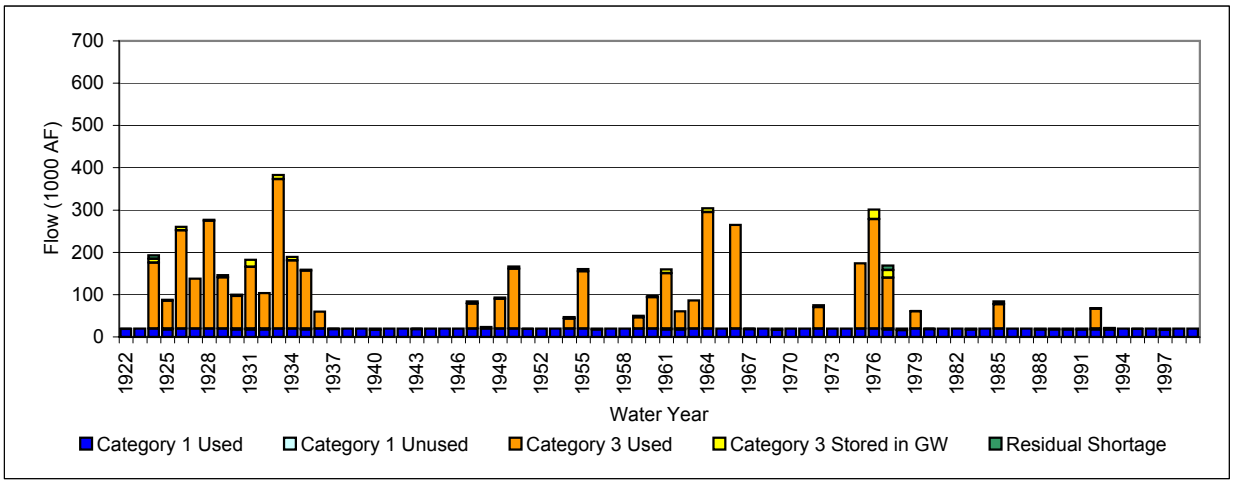

Figure 6.4-7 Category 3 Purchases -- Case X, Modified Channel

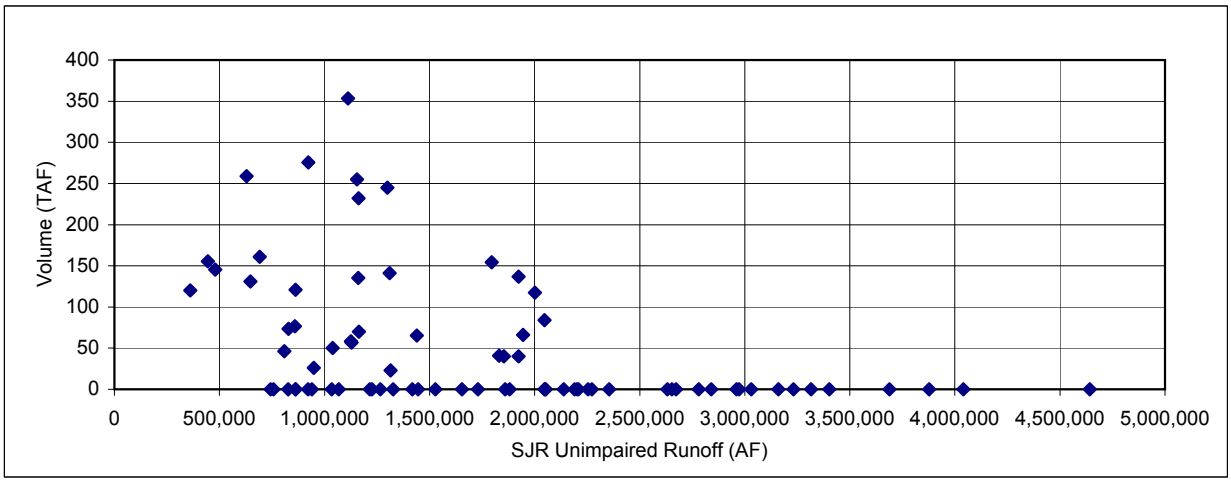

Figure 6.4-8 Residual Purchases -- Case X, Modified Channel

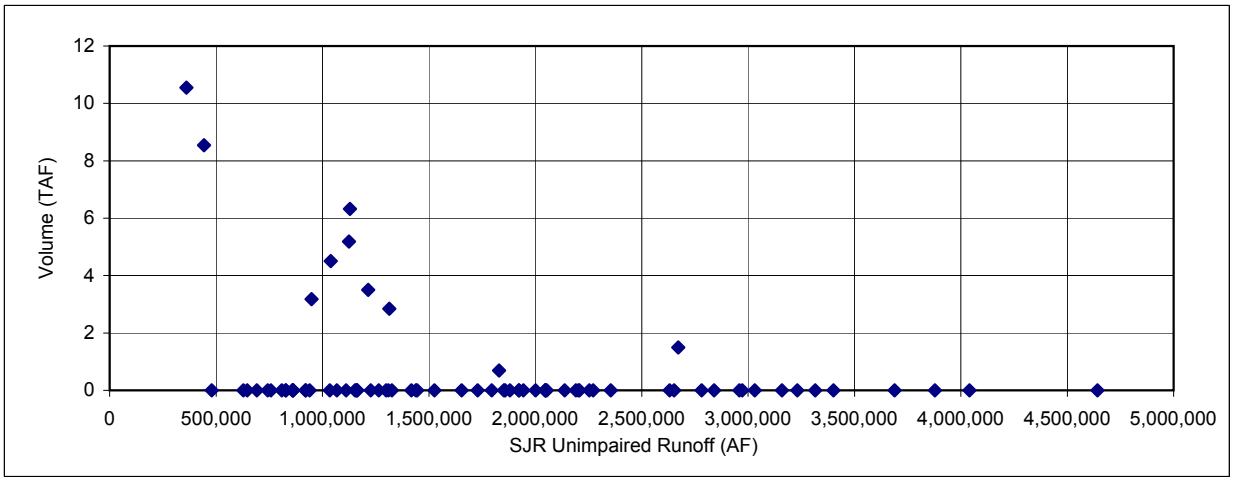

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Figure 6.4-9 Millerton Lake Storage -- Case X, Modified Channel

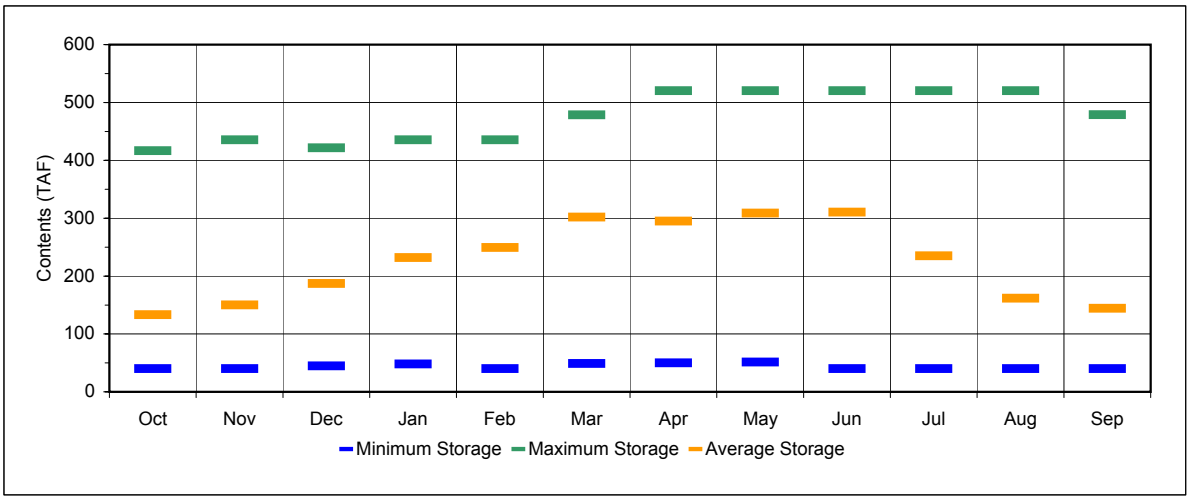

Figure 6.4-10 End-of-June Millerton Storage -- Case X, Modified Channel

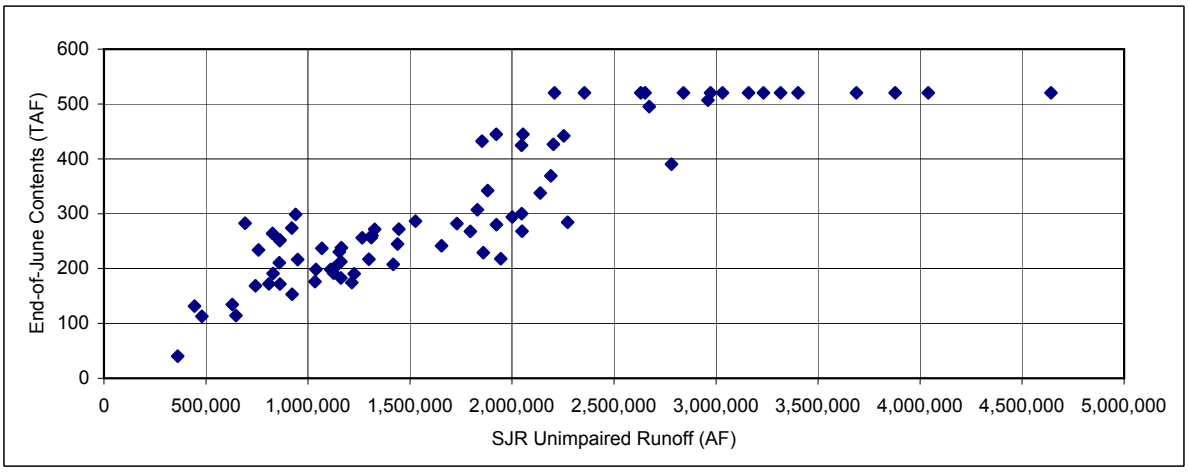

Figure 6.4-11 End-of-September Storage -- Case X, Modified Channel

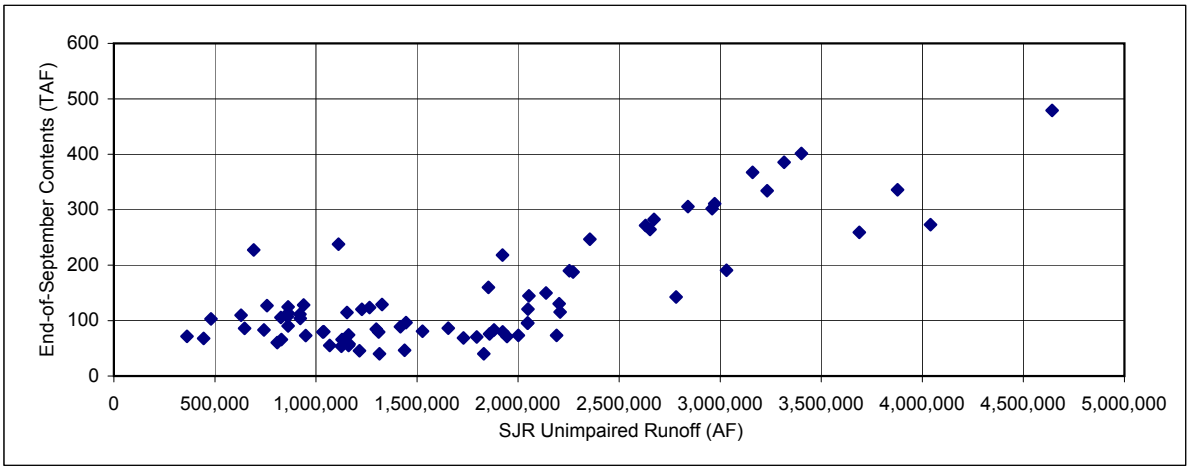

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Figure 6.4-10 and Figure 6.4-11 illustrate additional results regarding Millerton Lake storage levels for this scenario. Specifically, Figure 6.4-10 depicts Millerton Lake storage for the end of June, and Figure 6.4-11 depicts storage at the end of September.

6.4.2 Case Y Demands with Existing Channel – Operations and Water Supply

Use of Eastside Tributary Surplus Flows: Consistent with the priority of operations established for Bundle A, the capture and management of surplus flows of the system become the first component of water developed to offset the deficit in deliveries caused by the release of restoration flows. Even with additional storage space occasionally available at Millerton Lake, the amount of Eastside tributary surplus flows captured by this bundle did not increase. An annual average of 94,000 acre-feet of Eastside tributary surplus flows were diverted into bundle components. The availability and utilization of Eastside tributary flows would be very similar if not identical to that illustrated for Bundle A (refer to Figure 6.3-12). Similar performance of the Eastside tributary component under either bundle indicates that its use is limited by the capacity of the component and coincidence of Millerton Lake and Eastside tributary wet hydrology. Any available space created by use of Millerton Lake minimum pool storage in any given year is likely to be refilled with San Joaquin River runoff prior to the availability of Eastside tributary surplus flows.

Mendota Pool and Delta Recirculation: Water is captured and recirculated at Mendota Pool and the SWP/CVP Delta pumping plants. Pumping at the SWP/CVP Delta pumping plants is constrained by protocols developed for this analysis in connection with SWRCB Decision 1641, ESA, EWA, and CVPIA conditions. An annual average of 41,000 acre-feet of water again offsets Mendota Pool water user demands and is thereby credited into the Westside SWP/CVP facilities for recirculation back to the Friant-Kern Canal. The monthly and annual pattern and magnitude of recirculation at Mendota Pool would be nearly identical to that occurring for Bundle A (refer to Figures 6.3-13, 6.3-14, and 6.3-15). Another annual average of 86,000 acre-feet of water is recirculated at the SWP/CVP Delta pumping plants. The occurrence of capture and recirculation at the Delta is illustrated in Figures 6.4-12, 6.4-13, and 6.4-14. Figure 6.4-12 illustrates the average monthly distribution of Delta recirculation and the range of pumping that occurred in a month. Figure 6.4-13 illustrates the year-to-year Delta recirculation component of this scenario. The complex set of parameters and constraints that determine the availability of flow and export capacity make it difficult to draw general conclusions. Figure 6.4-14 illustrates the annual Delta recirculation volumes in relation to San Joaquin River unimpaired runoff.

Of the combined annual average of 127,000 acre-feet of recirculated water (at the Delta and the Mendota Pool), a majority (an annual average of 87,000 acre-feet) occurs on a pattern coincidental with available conveyance capacity and Friant-Kern Canal direct-use demands or available Eastside groundwater storage capacity. When the recirculation does not favorably coincide with these factors, the water is temporarily stored in San Luis Reservoir or the west side Kern County Water Bank until water use conditions became suitable (an annual average of 35,000 acre-feet). Temporary San Luis Reservoir storage is used practically every year for regulation of recirculation flows. On occasion, the storage of recirculation flow in San Luis Reservoir conflicts with SWP/CVP available space and thus requires release and storage in the California Aqueduct Account.

Groundwater Storage: An annual average groundwater banking of 90,000 acre-feet and extraction of 50,000 acre-feet occur with this scenario. The year-to-year groundwater operation is illustrated in Figure 6.4-15. The coincidence of Eastside tributary surplus flows and other fortunate hydrologic circumstances during the later third of the study period results in accrual of a groundwater balance amounting to over 3,000,000 acre-feet by the end of the study. During the middle portion of the study period, assumed resources, demands, and operation protocols result in a generally balanced groundwater operation. The early portion of the study period is plagued by a drought period that did not provide an opportunity to divert flows to groundwater storage and an assumption that a positive or zero balance must be maintained; thus, very little groundwater could be extracted. Had an initial balance been assumed, groundwater would have been extracted during this period.

Purchases: To satisfy shortages resulting from the additional demand, an annual average of 44,000 acre-feet of purchases are required. Of this quantity, 20,000 acre-feet per year occur as Category 1 purchases. An annual average of 24,000 acre-feet are Category 3 and Residual purchases that vary from year to year. Figure 6.4-16 illustrates the year-to-year purchases for this scenario. The addition of the Delta recirculation supply reduces the need for purchases. Purchases are generally needed during water-short years when the draw from the groundwater balance is limited (the early years of the study period, when no groundwater balance exists). Figure 6.4-17 and Figure 6.4-18 further illustrate the occurrence of Category 3 and Residual purchases in relation to San Joaquin River unimpaired runoff. As can be seen in these figures, these purchases sporadically occur and are primarily limited to below-average runoff years.

Releases from Friant Dam: Restoration flow requirements are met in this scenario, with the annual average required release amounting to 562,000 acre-feet (including 117,000 acre-feet of releases required for current downstream needs) subject to providing sufficient pumping capacity from Millerton Lake to the Friant-Kern and Madera Canals. See "Effect on Millerton Lake Storage," below. In addition to minimum releases, spills occasionally occur from Millerton Lake (an annual average of 174,000 acre-feet). Additional available reservoir space (caused by reservoir drawdown to meet demands) provides additional room in Millerton Lake to manage runoff that otherwise would spill.

Millerton Lake Storage: Under an Existing Channel/Case Y Demand scenario, monthly average reservoir storage is 229,000 acre-feet, again with extended periods when storage does not exceed 300,000 acre-feet, and many periods when the reservoir is being operated at a very low level. This circumstance significantly impacts lake recreation and the availability of reliable sources of supply. More direct in this scenario is the risk associated with maintaining adequate diversion capacity for the canals. Operating Millerton Lake below 140,000 acre-feet requires complete reliance on pumping facilities. Figure 6.4-19 illustrates the range in storage that occurs each month. A storage level below 140,000 acre-feet can occur in any month, including during the peak diversion months of July and August. This circumstance suggests that pumping capacity equal to full diversions or other additional resources (at additional costs) would be necessary to ensure delivery capacity from the canals. During some months, diversions to the Friant-Kern Canal are modeled to be greater than 2,000 cfs during periods when Millerton Lake is operated below 140,000 acre-feet. This circumstance suggests increasing the assumed capacity and cost of the pumping components.

Figure 6.4-12 Monthly Delta Recirculation -- Case Y, Existing Channel

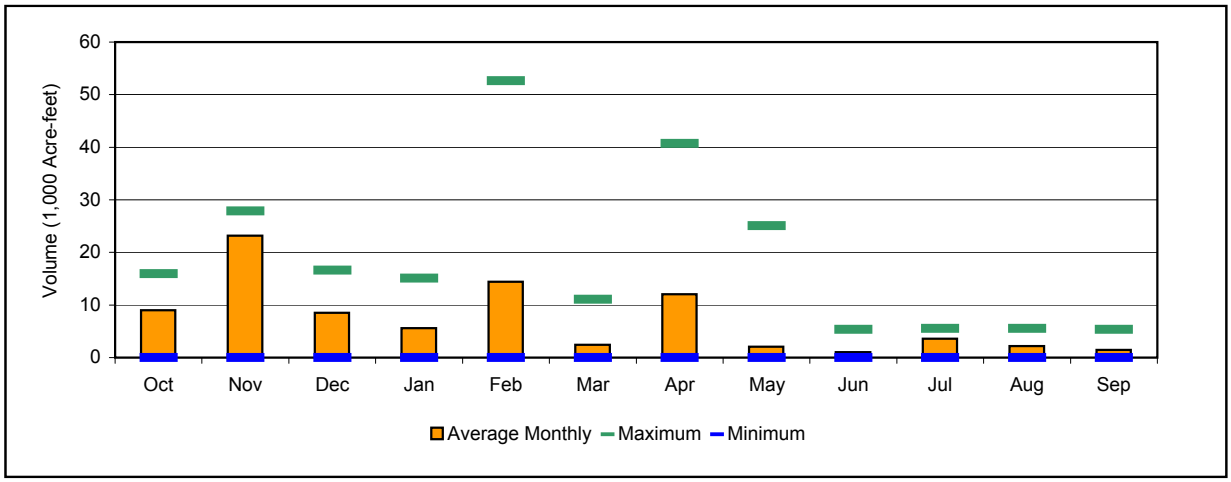

Figure 6.4-13 Annual Delta Recirculation -- Case Y, Existing Channel

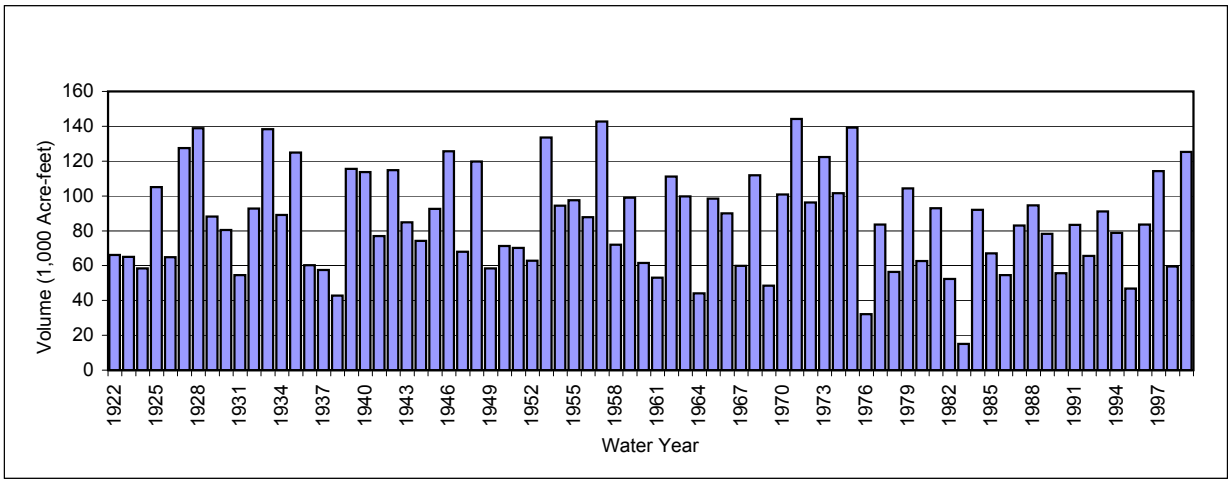

Figure 6.4-14 Delta Recirculation by Wetness of Year -- Case Y, Existing Channel

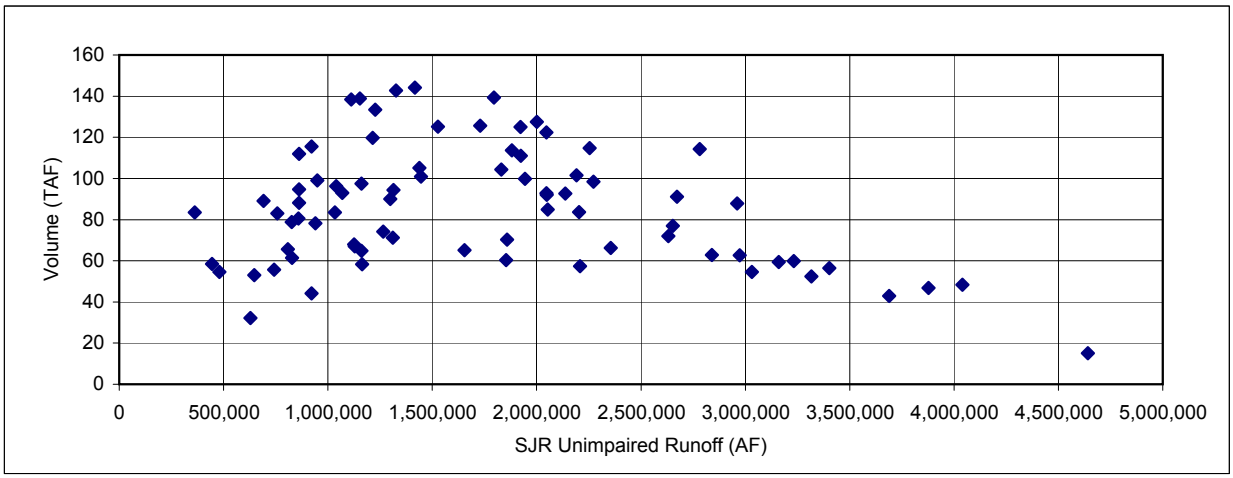

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Figure 6.4-15 Groundwater Operation -- Case Y, Existing Channel

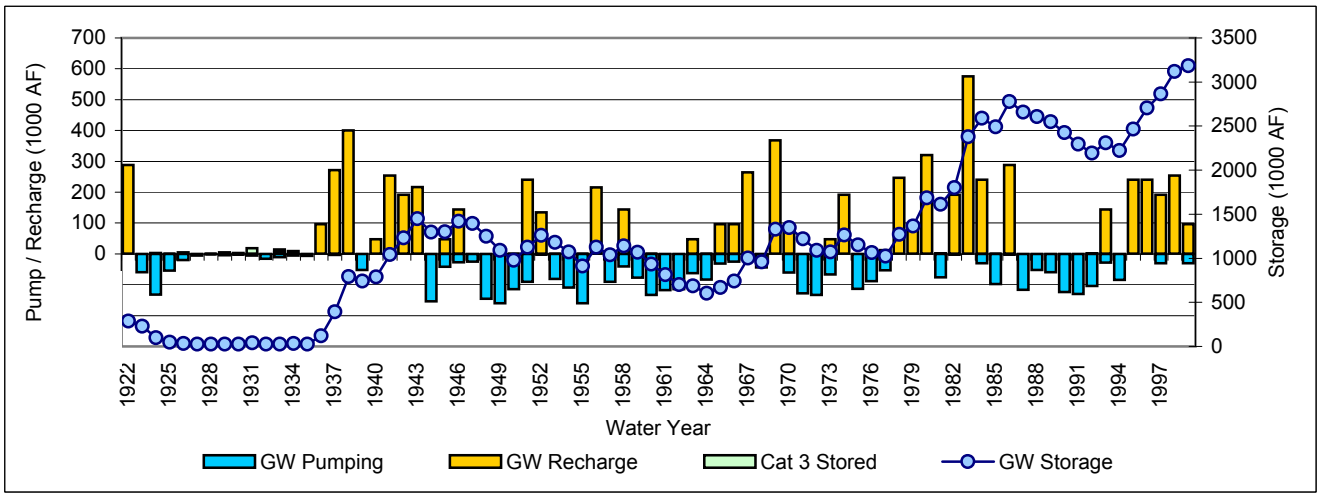

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Figure 6.4-16 Water Purchases -- Case Y, Existing Channel

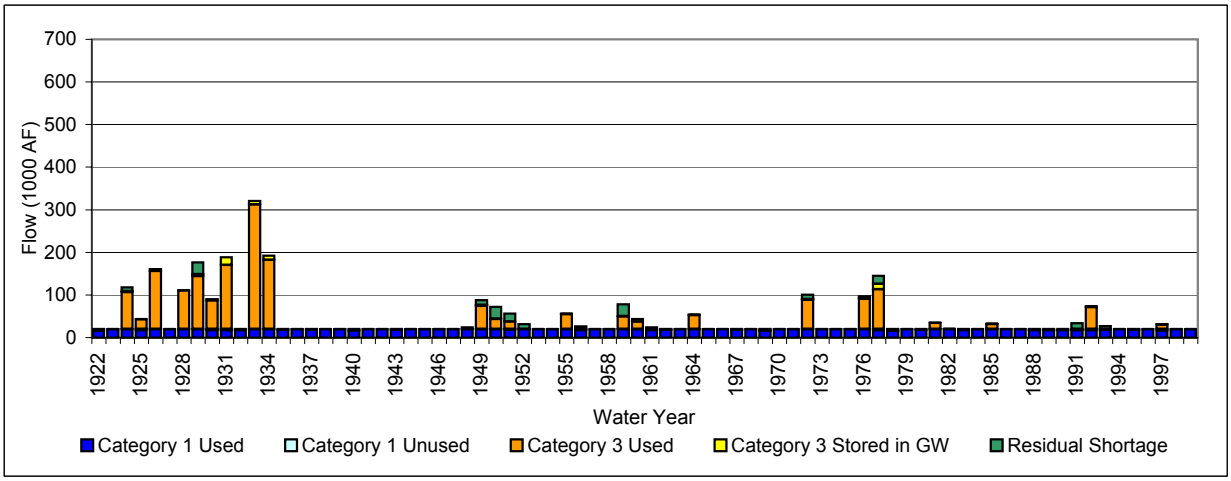

Figure 6.4-17 Category 3 Purchases -- Case Y, Existing Channel

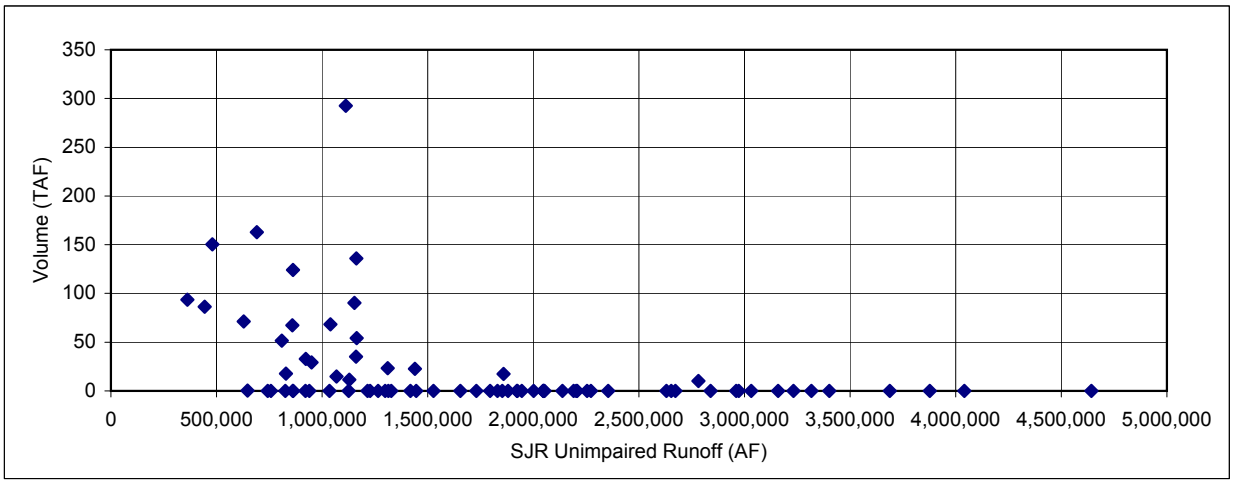

Figure 6.4-18 Residual Purchases -- Case Y, Existing Channel

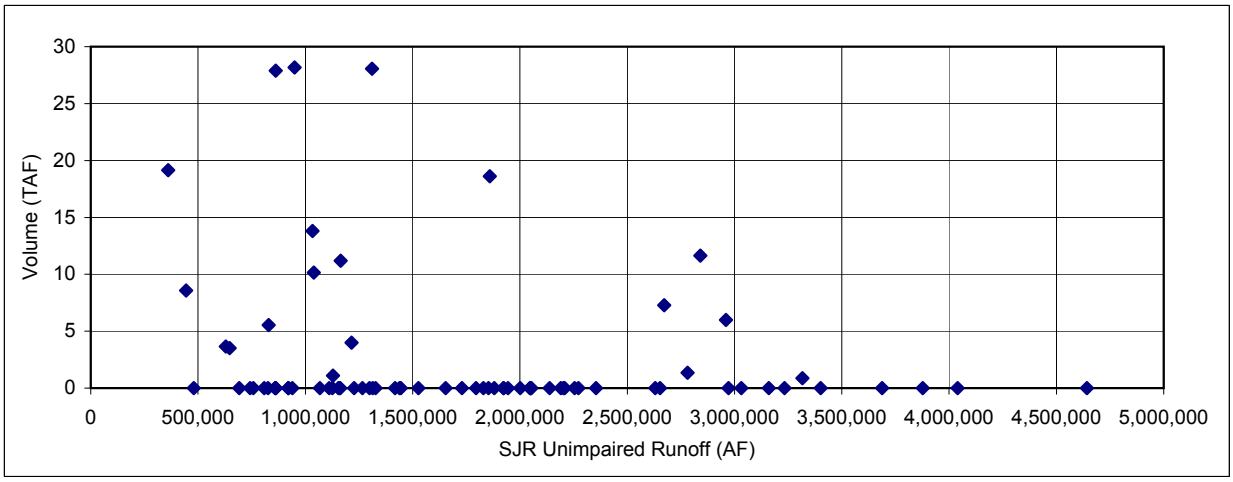

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Figure 6.4-19 Millerton Lake Storage -- Case Y, Existing Channel

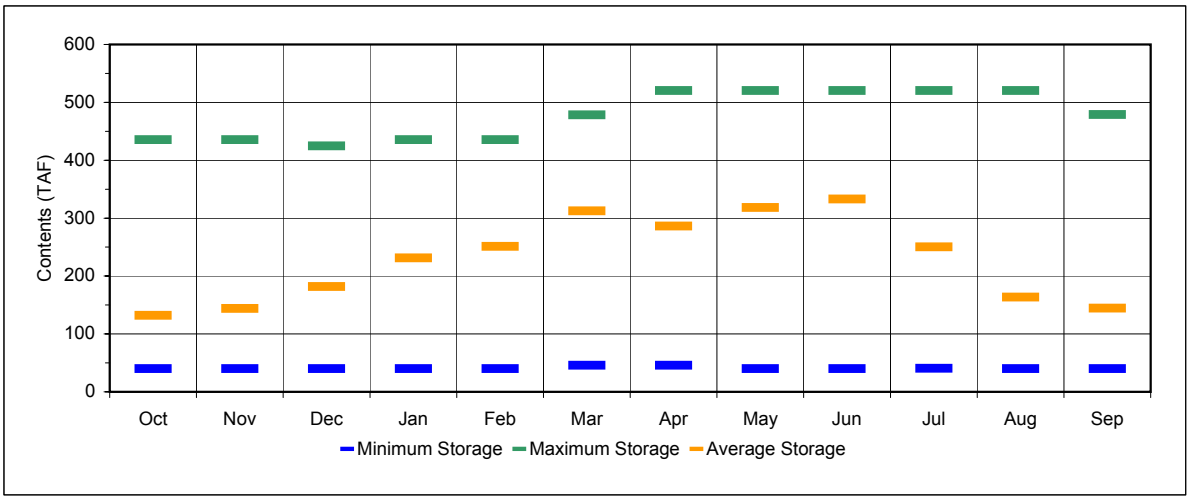


Figure 6.4-20 End-of-June Millerton Storage -- Case Y, Existing Channel

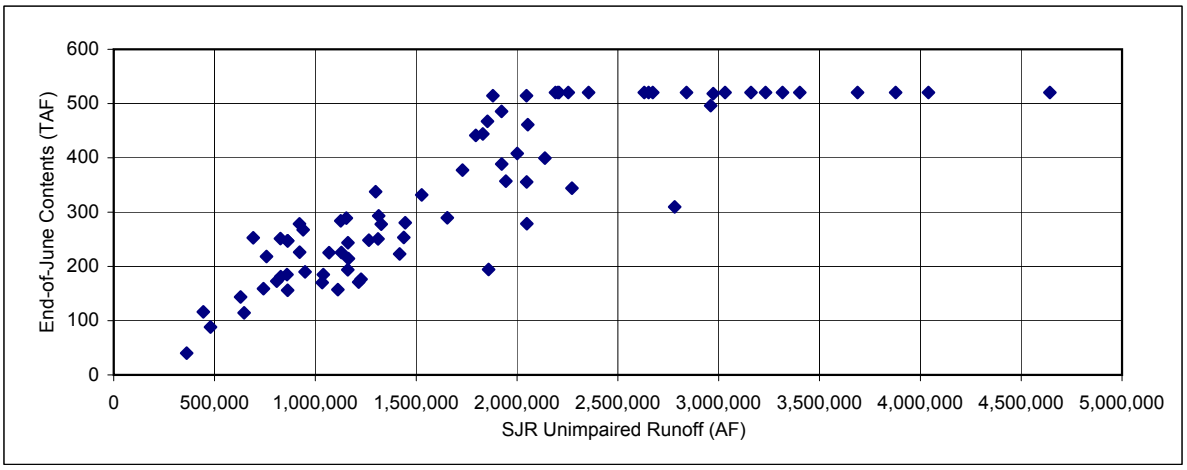
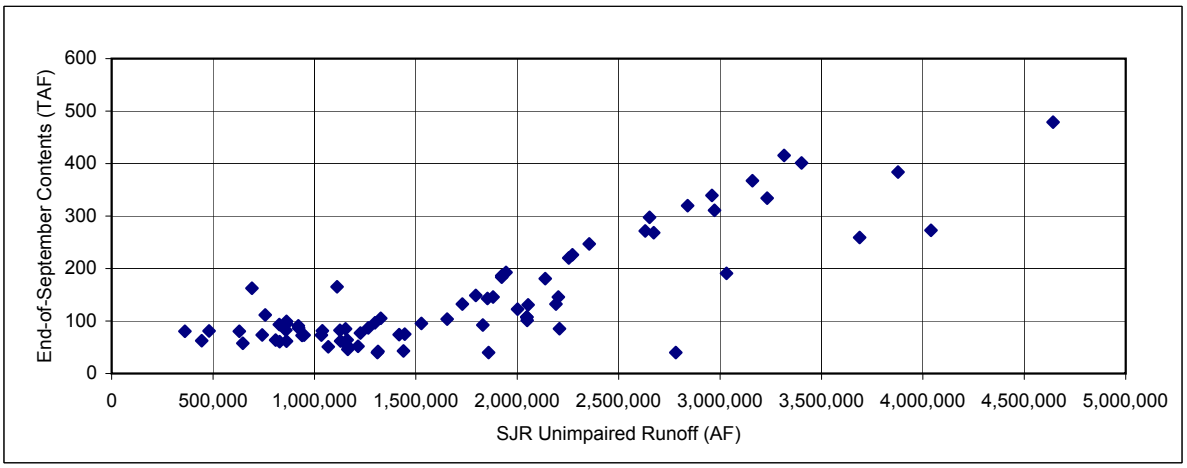


Figure 6.4-21 End-of-September Storage -- Case Y, Existing Channel



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Figures 6.4-20 and 6.4-21 illustrate additional results regarding Millerton Lake storage levels for this scenario. Specifically, Figure 6.4-20 depicts Millerton Lake storage for the end of June, and Figure 6.4-21 depicts storage at the end of September.

6.4.3 Technical Concerns

Since all of the Bundle A components are included in Bundle B, all of the technical and constructability issues described previously for Bundle A components apply to Bundle B. The following additional issues also apply:

- Millerton Minimum Pool Storage. To access 100,000 acre-feet of Millerton Lake storage between elevation 404 feet and elevation 471 feet, major new pumping facilities are required to lift water from Millerton Lake to the Friant-Kern and Madera Canals. The cost estimate is based on conceptual arrangements that include 52 500-horsepower pumps mounted on 26 barges discharging to two manifolds connecting to the Friant-Kern Canal and 16 500-horsepower pumps mounted on 8 barges discharging to a manifold connecting to the Madera Canal. These arrangements also involve developing access to the lowered pool for operating and maintaining the floating pump system, trashrack modifications, and construction of a new electrical substation and power lines. Alternatively, the outlets discharging to the San Joaquin River could be tapped and new pump stations and pipelines constructed to lift water from these low level outlets back up to the two canals. Although no detailed technical or constructability review has been performed, initial review of this alternative concept shows construction of this component to be highly complex (but not impossible) given the release requirements and the space limitations of the site. Detailed cost information for the alternative was not developed as part of the study. It will be developed at the time of site-specific analysis if this option is pursued in the future. A third alternative could involve construction of an afterbay downstream of the river outlet and pumping from the afterbay back up to the canals. In this alternative the pump stations would require more than twice the power capacity of the other alternatives. The pumping head would be the elevation difference between the river and the canals (approximately 155 feet to Friant-Kern Canal) compared to the elevation difference between the lowered reservoir and the canals (approximately 70 feet if the reservoir is lowered to 40,000 acre-feet). This arrangement would also require longer pipelines to convey the water back to the canals.
- Delta Recirculation. This bundle configuration includes the use of existing SWP/CVP Delta pumping facilities. No technical issues occur. Environmental concerns are discussed in Section 6.4.5.

6.4.4 Institutional Challenges

The component of recirculation at SWP/CVP Delta facilities is dependent on the additional successful negotiation of numerous multi-party arrangements inclusive of state, federal, and local entities and is complicated by the current state of regulations and programs affecting operations in the Delta.

Beyond the water diversion capacity issues associated with operating Millerton Lake below its current operating range, congressionally authorized cost allocations for Millerton Lake may be required to reassign costs between water conservation and other purposes.

6.4.5 Environmental Concerns

6.4.5.1 Water Quality

The water quality effects of Bundle B are expected to be similar to those of Bundle A except relative to Millerton Lake. Bundle B will draw water from the minimum pool storage of Millerton Lake and expose the remaining water to wind and wave mixing. Subsequent diversions would reflect the quality of the lower water column. Long-term water quality samples collected at other Eastside lakes have shown occasional high metals concentrations near the lake bottom. Assuming that Millerton Lake has similar conditions, the quality of diversions could be affected by the minimum pool storage.

Changes in minimum pool position may have operational, water quality or other impacts, including impacts on water users, that were not evaluated for this study. These impacts will be evaluated as necessary at the time of site-specific analysis if this option is pursued in future.

6.4.5.2 Land Use

Similar to the effects mentioned under Bundle A, the operations under Bundle B will significantly impact recreation in and around Millerton Lake. Under either scenario the monthly average storage in Millerton Lake would be approximately 230,000 acre-feet, with extended periods when storage would not exceed 300,000 acre-feet. The water surface elevations associated with these lake volumes range from 404 feet at minimum storage (40,000 acre-feet) to 503 feet at 230,000 acre-feet and 526 feet at 300,000 acre-feet. Again, this alternative operation could affect recreation on and around the reservoir. Millerton Lake water surface elevations fluctuate each year under normal operations; however, the lake currently does not normally lower below 140,000 acre-feet.

As with Bundle A, groundwater recharge would also be included under Bundle B with potential storage locations at up to six Eastside areas or in Kern County.

6.4.5.3 Biological Resources

The effects of Bundle B on biological resources would be similar to those under Bundle A. The water surface elevations would be drawn down even further than under Bundle A. Operations under Bundle B include the addition of Delta recirculation that could have an effect on fishery resources. The current ESA and other regulatory constraints were considered in Study development with incremental pumping at the Delta limited to windows of time that are estimated to have limited or not a negative impact on fishery resources. However, these windows of pumping opportunity cannot adequately foresee additional curtailments caused by take limits for each species. The potential exists for pumping curtailments greater than those modeled in this analysis that could affect the recapture of restoration flows in the Delta. The impact of these curtailments would be a decrease in the amount of water recaptured in the Delta

and a resultant need to increase water supplies for the restoration flows through other mechanisms.

6.4.5.4 Cultural Resources

The operations under Bundle B could affect cultural resources in the reservoir site of Millerton Lake, as some sites could be exposed by the lower reservoir water surface elevations and potentially more vandalism of the sites could occur.

6.5 BUNDLE C: TULARE LAKEBED STORAGE AND DELTA RECIRCULATION

In addition to the core components described for Bundle A, this configuration adds (1) the use of storage developed in Tulare Lakebed (an incremental 100,000 acre-feet of potential storage) for additional management of recirculation flows and capture of Eastside tributary surplus flows and (2) the use of SWP/CVP Delta pumping facilities to recirculate restoration or surplus San Joaquin River flows. Figure 6.5-1 illustrates the components of this bundle.

The Bundle C configuration builds on opportunities developed in Bundle A for storage and re-use of surplus flows. Recirculation capacity at the SWP/CVP Delta facilities increases the use of San Luis Reservoir storage relative to its use in Bundle A. With more water recirculated to the Westside of the valley, more instances of non-coincidental demands occur, thus requiring more regulation storage. Also in this configuration the Tulare Lakebed provides an increment of additional storage to manage surplus flows from Eastside tributaries and to manage recirculation water.

A choice exists in this bundle concerning whether to prioritize storing recirculation water in San Luis Reservoir or in Tulare Lakebed storage. Analyses show that storing recirculation water in San Luis Reservoir in priority to Tulare Lakebed provides more potential water supply than switching the priority because early filling of Tulare Lakebed storage can preclude the capture of Eastside tributary surplus flows later in the year, thus forgoing a storable water supply. Tulare Lakebed storage is used to store recirculation water that cannot be stored in San Luis Reservoir. Tulare Lakebed also stores Eastside tributary surplus flows not captured at the Friant-Kern Canal river crossings. Tulare Lakebed storage is evacuated as soon as possible due to the magnitude of evaporative losses. With the mixture of conveyance facilities assumed in the configuration, San Luis Reservoir and Tulare Lakebed storage essentially operate as annual regulation facilities.

Category 1 purchases (20,000 acre-feet per year, each year) are included in this configuration. Water shortages are met with Category 3 and Residual purchases.

The results of the costing analysis and other operational parameters for the four scenarios of Bundle C are shown in Table 6-12. More detailed results, including sequential monthly and year-to-year summaries and hydrographs are found in Appendix D.

Table 6-12
Bundle C Operational and Economic Results

	Parameter	Case X Demands		Case Y Demands	
		Modified Channel	Existing Channel	Modified Channel	Existing Channel
Quantities (1,000 acre-feet)	Total Purchases	89	116	53	56
	Category 1 Purchases	20	20	20	20
	Category 2 Purchases	0	0	0	0
	Category 3 Purchases	65	90	30	33
	Residual Purchases	4	6	3	3
	Levelized Groundwater Residual Balance	38	22	80	50
	Levelized California Aqueduct Balance	18	20	18	21
	Total Release to San Joaquin River	646	703	703	747
	Annual Average Spill	180	141	237	185
	Total Eastside GW Recharge	89	76	127	114
	Total Eastside GW Extraction	53	57	48	65
	Total Diversion of Tributary Surplus into FKC	91	91	94	94
	Recaptured Water for Recirculation	121	137	113	127
	Recirculation at Delta	80	93	74	86
	Recirculation at Mendota Pool	41	44	39	41
	Uncaptured Water	65	97	45	70
	Total CVC	120	133	113	124
	Project Diversion to Tulare Lakebed	23	23	24	24
	Use of Tulare Lakebed Source	17	19	17	19
	Madera Canal Diversion	260	252	262	257
	Friant-Kern Canal Diversion	833	787	772	734
	Baseline Diversion to Madera Canal	267	267	255	255
	Baseline Diversion to Friant-Kern Canal	1,071	1,071	943	943
Costs ($1,000)	Fixed Costs	$8,004	$8,004	$8,004	$8,004
	GW Put Charge	$16,040	$13,777	$22,834	$20,544
	Wheeling Costs	$678	$756	$615	$689
	Pumping Energy	$5,657	$6,333	$5,241	$6,208
	Generation Sales	($2,083)	($2,203)	($2,128)	($2,250)
	Category 1 Purchases	$6,500	$6,500	$6,500	$6,500
	Category 2 Purchases	$0	$0	$0	$0
	Category 3 Purchases	$17,510	$24,852	$8,628	$9,485
	Residual Purchases	$839	$1,307	$657	$731
	Offset for Groundwater Residual Storage	($6,869)	($3,954)	($14,338)	($9,603)
	Total Average Annual Net Cost	**$46,227**	**$55,372**	**$36,012**	**$40,847**

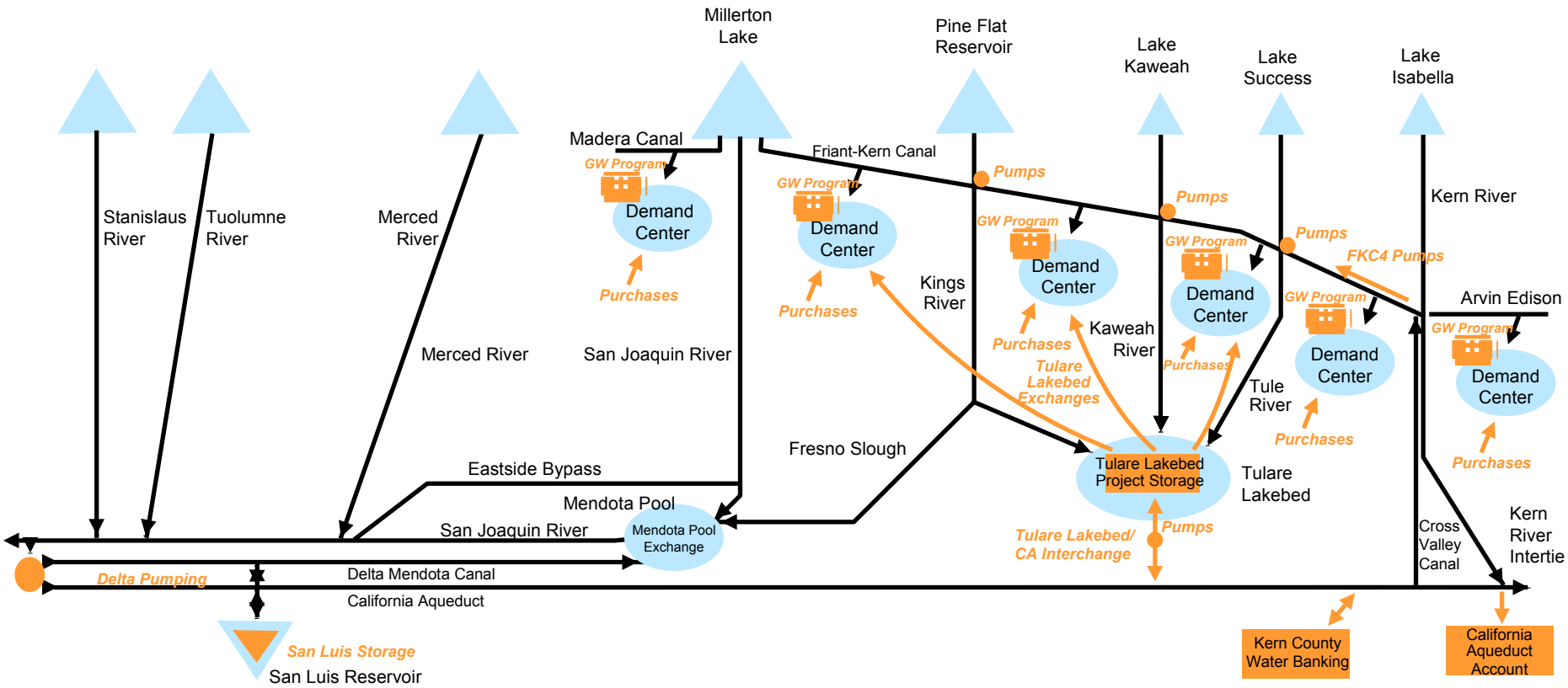

Figure 6.5-1

Bundle C: Tulare Lakebed Storage and Delta Recirculation

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6.5.1 Case X with Modified Channel – Operations and Water Supply

Use of Eastside Tributary Surplus Flows: With San Luis Reservoir serving as the primary storage site for recirculation flows, Tulare Lakebed storage is mainly used to regulate Eastside tributary surplus flows. An annual average of 24,000 acre-feet of water is diverted to Tulare Lakebed storage from both Eastside tributary and recirculation operations. Of this amount, an annual average of 23,000 acre-feet are derived from Eastside tributary surplus flows. As described in Section 6.3.1, the availability of this water is intermittent and is assumed surplus to the needs of other entities. It is water that is estimated to otherwise flood the Tulare Lakebed or escape to the San Joaquin River via the James Bypass. This water is in excess of the water that is captured at Friant-Kern Canal crossings of the Kings, Kaweah, and Tule Rivers.

Water from Tulare Lakebed storage is pumped to the California Aqueduct (an annual average of 7,000 acre-feet), is delivered to adjacent lands for exchanges that reduce Millerton Lake diversions (an annual average of 10,000 acre-feet), or would be lost to evaporation. The amount of water diverted to adjacent lands is based on operational limitations as provided by representatives of Tulare Lakebed interests during the gaming process. Evaporation quantities are based on the modeled reservoir surface area and monthly evaporation rates.

An annual average of 91,000 acre-feet of Eastside tributary surplus flows continues to be diverted into bundle components by way of the Friant-Kern Canal pump-in facilities. As described above, an additional annual average of 23,000 acre-feet of Eastside tributary surplus flows would be developed through Tulare Lakebed storage. The diversion of Eastside tributary surplus flows to the Friant-Kern Canal is described in Section 6.3.1 and illustrated in Figure 6.3-2. Surplus flow is captured in Tulare Lakebed storage during about 30 percent of the years, normally during the February through May period.

Mendota Pool and Delta Recirculation: With Bundle C, water is also captured and recirculated at Mendota Pool and the SWP/CVP Delta pumping plants. As in Bundle B, an annual average of 41,000 acre-feet of water offsets Mendota Pool water user demands and another annual average of 80,000 acre-feet of water is recirculated at the SWP/CVP Delta pumping plants. Of the annual average of 121,000 acre-feet of recirculated water, a majority (an annual average of 90,000 acre-feet) occurs on a pattern coincidental with available conveyance capacity and Friant-Kern Canal direct-use demands or available Eastside groundwater storage capacity. The monthly and annual patterns of the recirculation flows are illustrated in Section 6.4.1.

Groundwater Storage: An annual average groundwater banking of 89,000 acre-feet and extraction of 53,000 acre-feet occur with this configuration. The year-to-year groundwater operation is illustrated in Figure 6.5-2. Due to the coincidence of Eastside tributary surplus flows and other fortunate hydrologic circumstances during the later third of the study period, a groundwater balance amounting to about 1,750,000 acre-feet accrues by the end of the study. During the middle portion of the study period, assumed resources, demands, and operation protocols result in a generally balanced groundwater operation. The early portion of the study period is plagued by a drought period that did not provide an opportunity to divert flows to groundwater storage and an assumption that a positive or zero balance must be maintained; thus, very little groundwater could be extracted. Had an initial balance been assumed, groundwater would have been extracted during this period.

Purchases: After all other assets are exercised, remaining shortages are met with Category 3 and Residual purchases. An annual average of 69,000 acre-feet of purchases are required. Of this quantity, an annual average of 65,000 acre-feet are Category 3 purchases. Figure 6.5-3 illustrates the year-to-year purchases for this scenario. Figure 6.5-4 and Figure 6.5-5 further illustrate the occurrence of Category 3 and Residual purchases in relation to San Joaquin River unimpaired flow. As can be seen in these figures, these purchases occur sporadically during all periods that are below-average runoff years.

Releases from Friant Dam: Restoration flow requirements are met, with the annual average required release amounting to 466,000 acre-feet, including 117,000 acre-feet of releases required for current downstream needs. In addition to minimum releases, spills occasionally occur from Millerton Lake (an annual average of 180,000 acre-feet).

Millerton Lake Storage and Exchange: Under a Modified Channel/Case X Demand scenario, the monthly average reservoir storage operation is 264,000 acre-feet and experiences extended periods when storage does not exceed 300,000 acre-feet. The reduced overall storage would impact lake recreation and power generation and poses some risk to the ability to divert the Millerton Lake supply at a sufficient capacity to meet Friant-Kern Canal demand. Figure 6.5-6 illustrates the range in storage that occurs each month. Figure 6.5-7 and Figure 6.5-8 illustrate additional results regarding Millerton Lake storage levels for this scenario. Specifically, Figure 6.5-7 depicts Millerton Lake storage for the end of June, and Figure 6.5-8 depicts storage at the end of September.

The ability to use Tulare Lakebed storage as a source of exchange for Millerton Lake deliveries (through adjacent lands) requires the coincidence of several events. One example of these exchanges could include entities that collectively have Kings River, Millerton Lake, and SWP water entitlements. Water availability from these sources changes year to year and is highly dependent on a number of complex factors. The favorable coincidence of circumstances is required to facilitate exchanges of this nature.

6.5.2 Case Y with Existing Channel – Operations and Water Supply

Use of Eastside Tributary Surplus Flows: With San Luis Reservoir serving as the primary storage site for recirculation flows, Tulare Lakebed storage is mainly used to regulate Eastside tributary surplus flows. An annual average of 26,000 acre-feet of water is diverted to Tulare Lakebed storage from both Eastside tributary and recirculation operations. Of this amount, an annual average of 24,000 acre-feet are derived from Eastside tributary surplus flows. As described in Section 6.3.2, the availability of this water is intermittent and is assumed to be surplus to the needs of other entities. It is water that is estimated to otherwise flood the Tulare Lakebed or escape to the San Joaquin River via the James Bypass. This water is in excess of the water that is captured at the Friant-Kern Canal crossings of the Kings, Kaweah, and Tule Rivers.

Water from Tulare Lakebed storage is pumped to the California Aqueduct (an annual average of 8,000 acre-feet), is delivered to adjacent lands for exchanges that reduce Millerton Lake diversions (an annual average of 11,000 acre-feet), or would be lost to evaporation. The amount of water diverted to adjacent lands is based on operational limitations as provided by representatives of Tulare Lakebed interests during the gaming process. Evaporation quantities are based on the modeled reservoir surface area and monthly evaporation rates.

Figure 6.5-2 Groundwater Operation -- Case X, Modified Channel

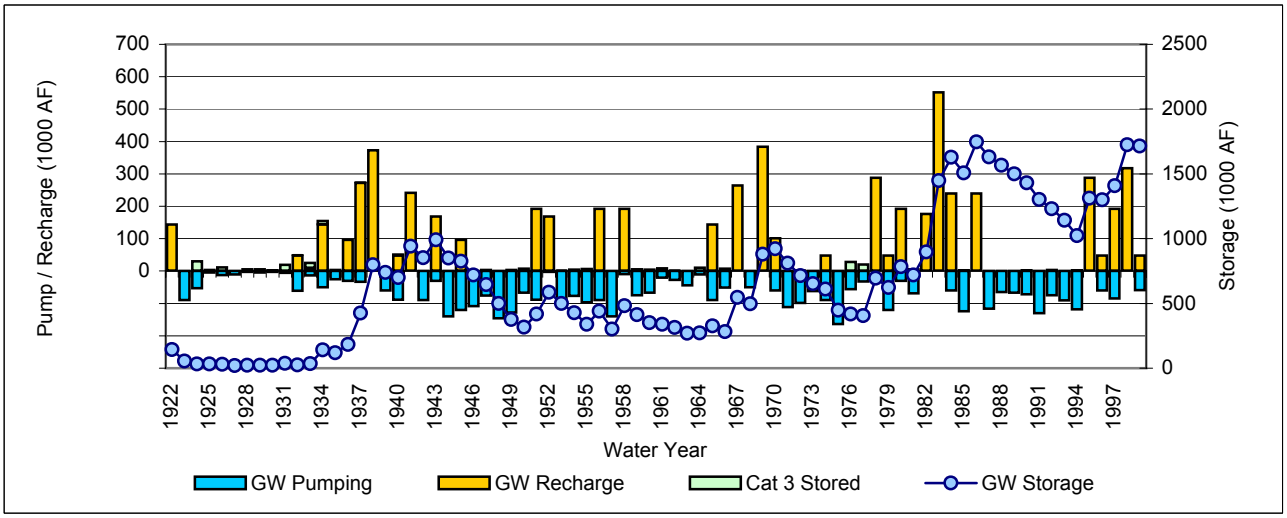

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Figure 6.5-3 Water Purchases -- Case X, Modified Channel

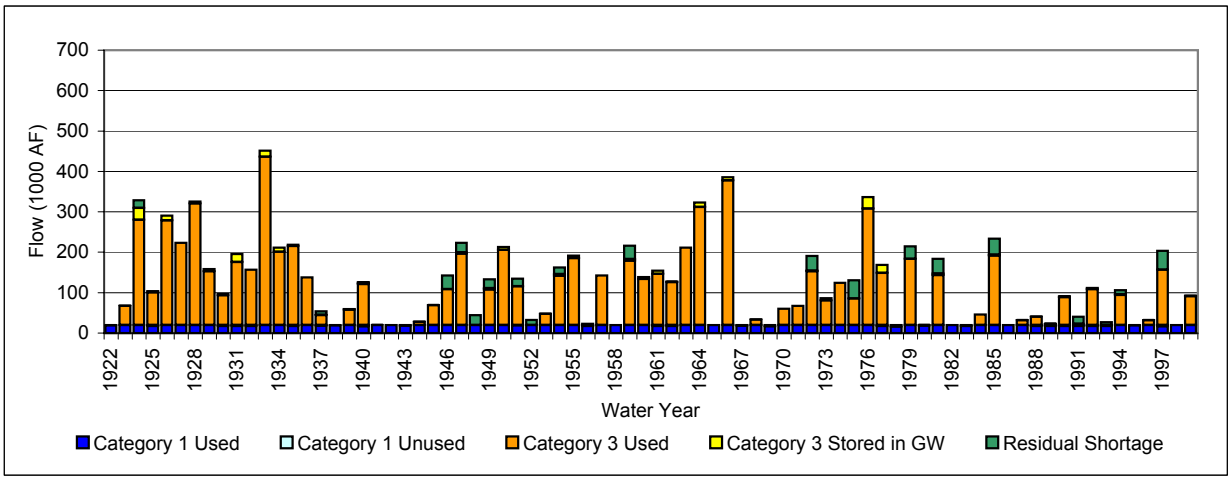

Figure 6.5-4 Category 3 Purchases -- Case X, Modified Channel

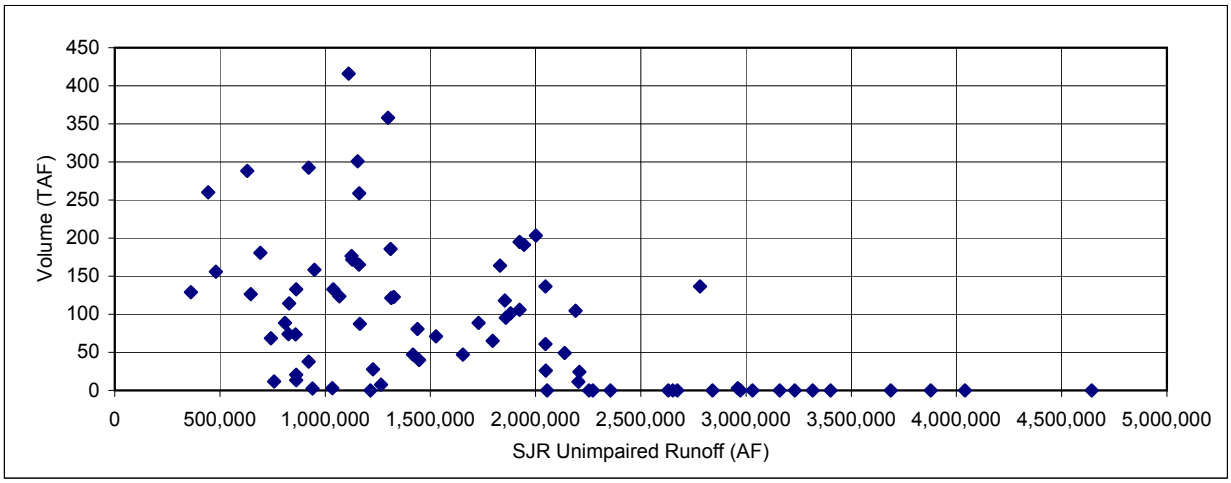

Figure 6.5-5 Residual Purchases -- Case X, Modified Channel

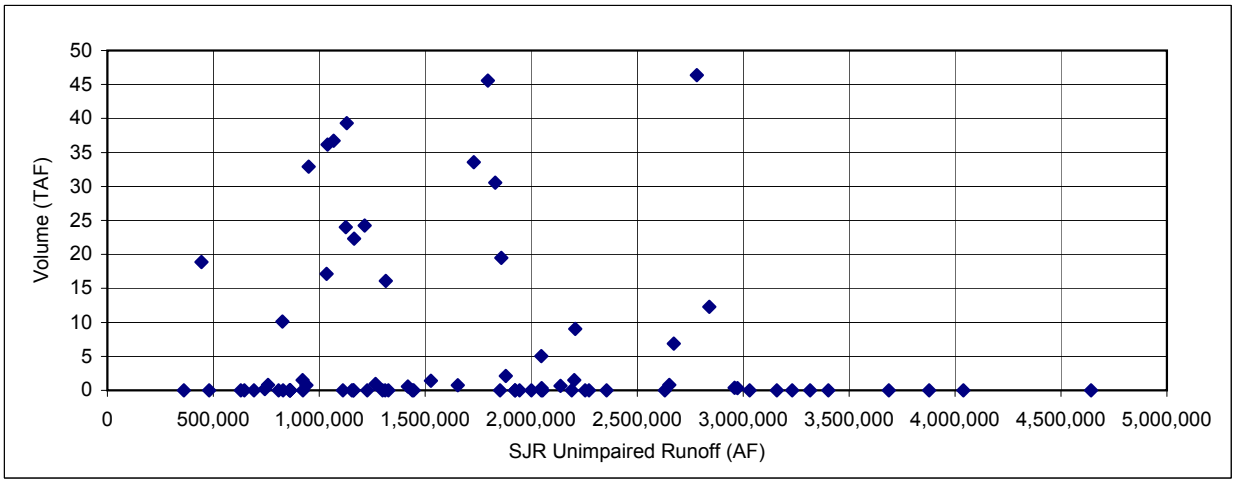

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Figure 6.5-6 Millerton Lake Storage -- Case X, Modified Channel

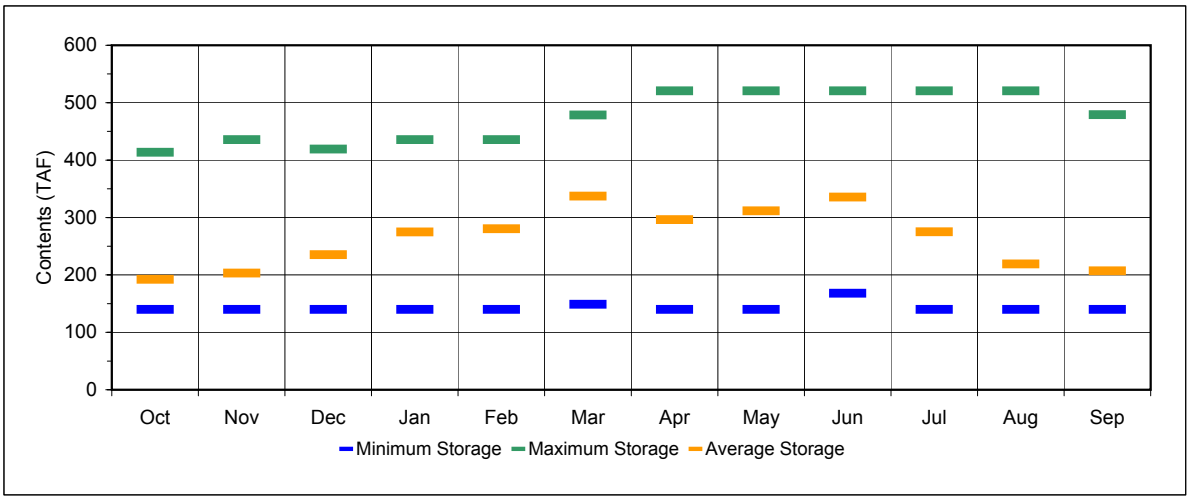


Figure 6.5-7 End-of-June Millerton Storage -- Case X, Modified Channel

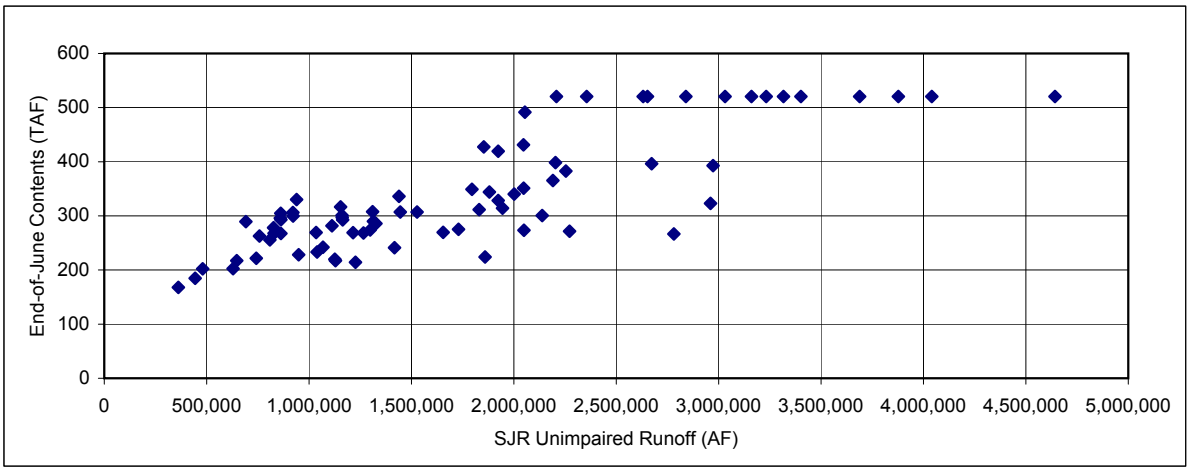
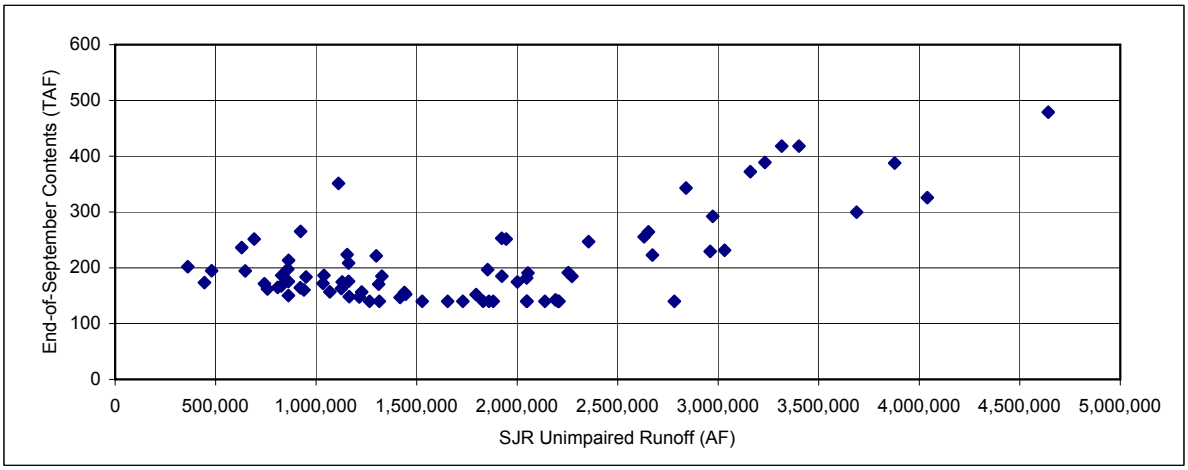


Figure 6.5-8 End-of-September Storage -- Case X, Modified Channel



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An annual average of 94,000 acre-feet of Eastside tributary surplus flows continues to be diverted into bundle components by way of the Friant-Kern Canal pump-in facilities. As described above, an additional annual average of 24,000 acre-feet of Eastside tributary surplus flows would be developed through Tulare Lakebed storage. The diversion of Eastside tributary surplus flows to the Friant-Kern Canal is described in Section 6.3.2 and illustrated in Figure 6.3-12. Surplus flow is captured in Tulare Lakebed storage during about 30 percent of the years, normally during the February through May period.

Mendota Pool and Delta Recirculation: With Bundle C, water is also captured and recirculated at Mendota Pool and the SWP/CVP Delta pumping plants. As in Bundle B, an annual average of 41,000 acre-feet of water offsets Mendota Pool water user demands, and another annual average of 86,000 acre-feet of water is recirculated at the SWP/CVP Delta pumping plants. Of the annual average of 127,000 acre-feet of recirculated water, a majority (an annual average of 87,000 acre-feet) occurs on a pattern coincidental with available conveyance capacity and Friant-Kern Canal direct-use demands or available Eastside groundwater storage capacity. The monthly and annual patterns of the recirculation flows are illustrated in Section 6.4.2.

Groundwater Storage: An annual average groundwater banking of 114,000 acre-feet and extraction of 65,000 acre-feet occur with this configuration. The year-to-year groundwater operation is illustrated in Figure 6.5-9. Due to the coincidence of Eastside tributary surplus flows and other fortunate hydrologic circumstances during a brief period in the early portion of the study period and during the later third of the study period, a groundwater balance amounting to about 4,000,000 acre-feet accrues by the end of the study. During the middle portion of the study period, assumed resources, demands, and operation protocols result in a generally balanced groundwater operation. The early portion of the study period is plagued by a drought period that did not provide an opportunity to divert flows to groundwater storage and an assumption that a positive or zero balance must be maintained; thus, very little groundwater could be extracted. Had an initial balance been assumed, groundwater would have been extracted during this period.

Purchases: After all other assets are exercised, remaining shortages are met with Category 3 and Residual purchases. An annual average of 36,000 acre-feet of purchases are required. Of this quantity, an annual average of 33,000 acre-feet are Category 3 purchases. Figure 6.5-10 illustrates the year-to-year purchases for this scenario. Figure 6.5-11 and Figure 6.5-12 further illustrate the occurrence of Category 3 and Residual purchases, in relation to San Joaquin River unimpaired runoff. As can be seen in these figures, these purchases sporadically occur during all periods that are below-average runoff years, but are not needed in all drier years.

Releases from Friant Dam: Restoration flow requirements are met, with the annual average required release amounting to 562,000 acre-feet, including 117,000 acre-feet of releases required for current downstream needs. In addition to minimum releases, spills occasionally occur from Millerton Lake (an annual average of 185,000 acre-feet).

Millerton Lake Storage and Exchange: Under an Existing Channel/Case Y Demand scenario, the monthly average reservoir storage operation is 282,000 acre-feet and experiences extended periods when storage does not exceed 300,000 acre-feet. The reduced overall storage would impact lake recreation and power generation and poses some risk to the ability to divert Millerton Lake supply at a sufficient capacity to meet Friant-Kern Canal demand. Figure 6.5-13 illustrates the range in storage that occurs each month. Figure 6.5-14 and Figure 6.5-15 illustrate additional results regarding Millerton Lake storage levels for this scenario. Specifically,

Figure 6.5-14 depicts Millerton Lake storage for the end of June, and Figure 6.5-15 depicts storage at the end of September.

The ability to use Tulare Lakebed storage as a source of exchange for Millerton Lake deliveries (through adjacent lands) requires the coincidence of several events. One example of these exchanges could include entities that collectively have Kings River, Millerton Lake, and SWP water entitlements. Water availability from these sources changes year to year and is highly dependent on a number of complex factors. The favorable coincidence of circumstances is required to facilitate exchanges of this nature.

6.5.3 Technical Concerns

Because all of the Bundle A components are included in Bundle C, all of the technical and constructability issues described previously for Bundle A components apply to Bundle C. The following additional issue also applies: Tulare Lakebed storage and conveyance. The Tulare Lakebed is already divided into a number of sub-basins to accept flood waters. The conversion of one of these sub-basins to store water on a more regular basis should present minimal technical or constructability issues. However, additional permanent facilities would be required to enable use of this water to meet San Joaquin River supply needs. First, a new pumping plant would be needed to pump water out of lakebed storage to the existing system of canals serving the Tulare Lake Basin Water Storage District. This system can deliver water to within approximately two miles of the California Aqueduct. At times this water can be used directly to serve local needs in lieu of taking delivery from the aqueduct. However, a second new pumping facility would be needed to pump water stored in the Tulare Lakebed up to the aqueduct during those times that supply exceeds local demands from the aqueduct. Alternatively, a second pumping facility could be used to lift the water to one of the District's main canals and a third pumping facility would lift the water to the California Aqueduct (and thereby reduce the length of pressure pipe needed). It is also assumed that an alignment following one of the two existing turnouts connecting the aqueduct to the District's canals can be used to minimize issues associated with construction of the conveyance pipeline. No special technical or constructability issues are expected with the pipeline or with these new pumping facilities.

The model results show minimal releases from the California Aqueduct to the proposed Tulare Lakebed storage. Therefore, a pump/generation system has not been investigated further at this time.

The storage estimates and routing developed are based on a preliminary review of U.S. Geological Survey 7.5-minute topographic maps of the area. It is assumed to be independent of existing South Wilbur storage and may not be compatible with similar projects (e.g., Argiola) currently being planned by others. The Tulare Lakebed storage facility contemplated in this bundle would be a multi-use facility that would include potential for wildlife, wetlands habitat, Westside flood control, and California Aqueduct turbidity control. Compatibility with similar projects will be evaluated as necessary at the time of site-specific analysis if this option is pursued in the future.

Figure 6.5-9 Groundwater Operation -- Case Y, Existing Channel

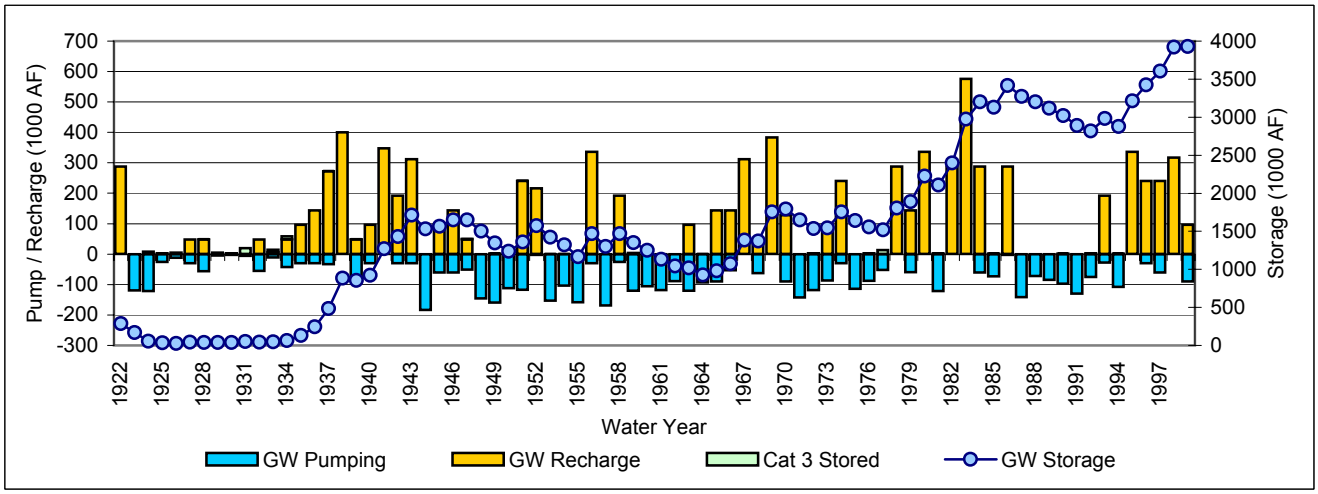

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Figure 6.5-10 Water Purchases -- Case Y, Existing Channel

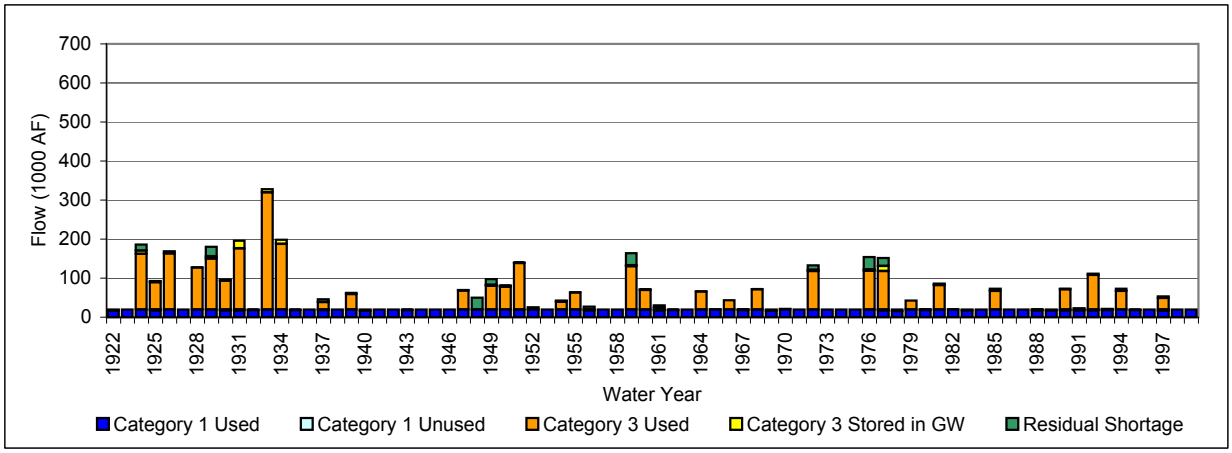

Figure 6.5-11 Category 3 Purchases -- Case Y, Existing Channel

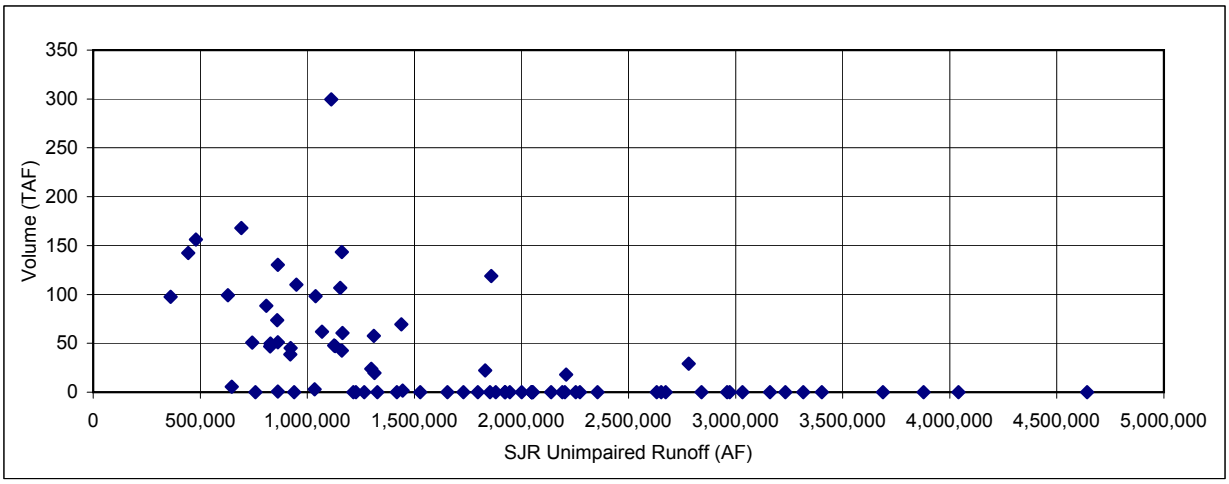

Figure 6.5-12 Residual Purchases -- Case Y, Existing Channel

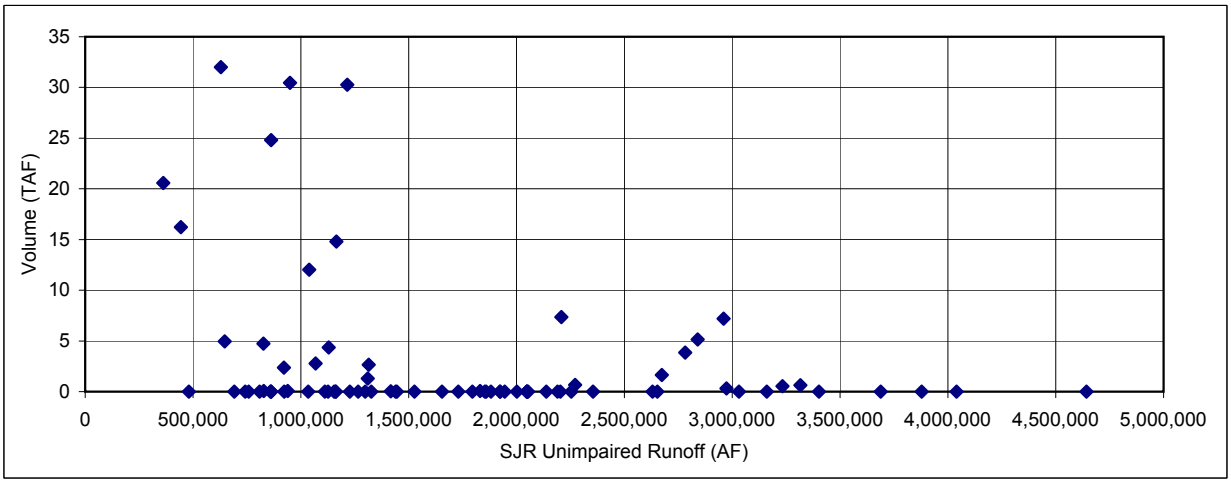

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Figure 6.5-13 Millerton Lake Storage -- Case Y, Existing Channel

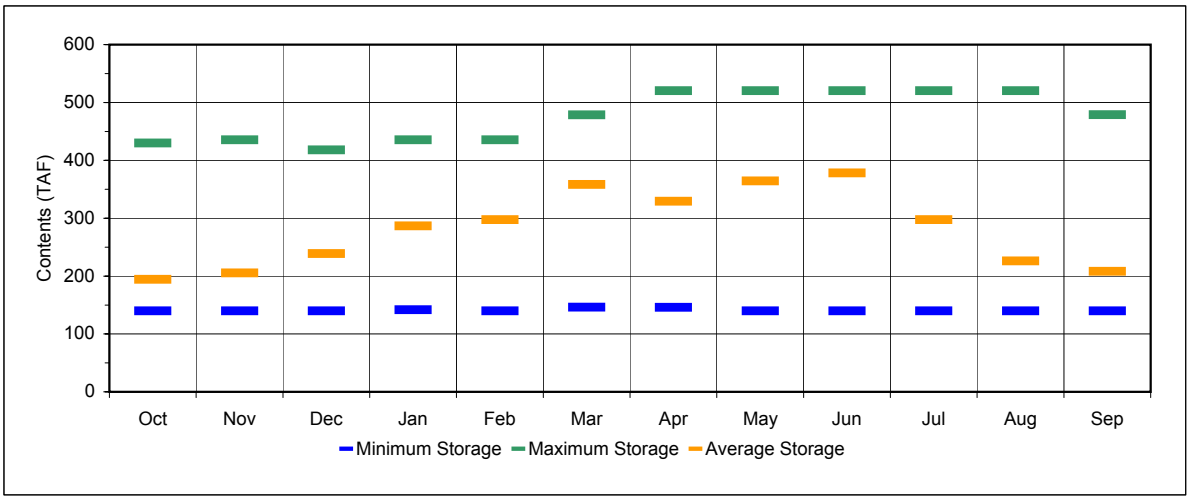


Figure 6.5-14 End-of-June Millerton Storage -- Case Y, Existing Channel

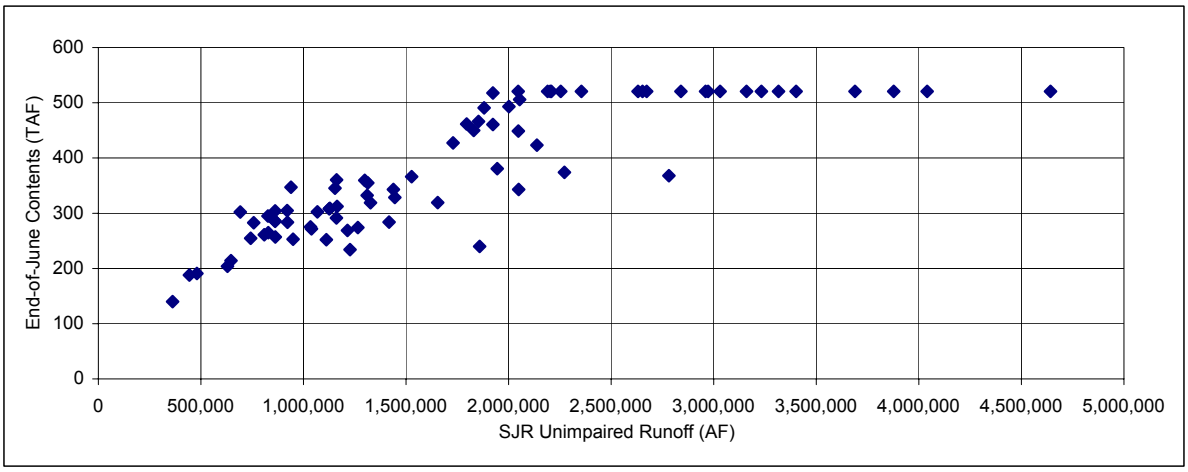
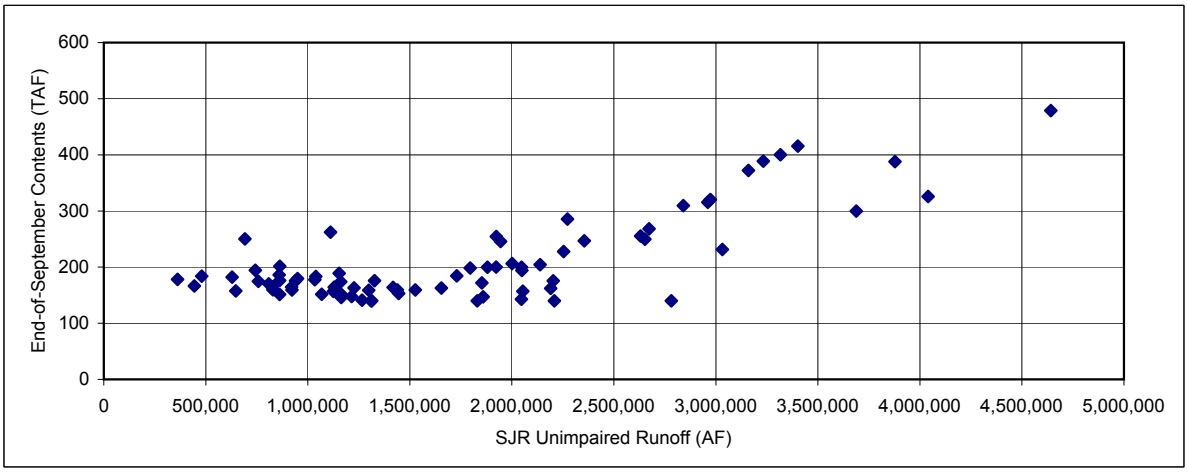


Figure 6.5-15 End-of-September Storage -- Case Y, Existing Channel



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6.5.4 Institutional Challenges

Issues concerning recirculation at SWP/CVP Delta facilities and for the diversion of Eastside tributary flow to the Friant-Kern Canal are the same as those described for Bundles A and B. The transition of areas in Tulare Lakebed from intermittent flood zones to intentional impoundment area would probably not appreciably change the operation from existing conditions. Exchanges across the Tulare Lakebed have occurred previously. Specifically, exchanges for the purpose of providing water for San Joaquin River restoration pilot projects have occurred.

6.5.5 Environmental Concerns

6.5.5.1 Water Quality

The potential water quality effects of Bundle C are similar to those of Bundle A. The water quality implications of recirculating San Joaquin River flow through the Delta pumping facilities depend on San Joaquin River flow. During periods of low flow and high Delta salinity, recirculation may result in exporting an increased salt load to San Luis Reservoir. This Bundle proposes to export during periods of surplus San Joaquin River flow, presumably when salinity is low, and therefore should not adversely affect water quality. After the development of a specific recirculation plan, detailed water quality analyses can be performed to assess the change in salt loading to the San Joaquin Valley.

6.5.5.2 Land Use

The operations under Bundle C are similar to those under Bundle A with the additional component of storage developed in Tulare Lakebed. Under either scenario, the monthly average Millerton Lake reservoir storage will range between 264,000 and 282,000 acre-feet, which corresponds to a water surface elevation of about 521 feet. The current operation of the reservoir fluctuates between full and minimum storage on a regular basis. The operation of the reservoir under this configuration would operate at a lower level more often.

Groundwater recharge would occur under Bundle C with potential storage sites at up to six locations in the Eastside areas or a location in Kern County, as described under Bundle A.

The Tulare Lakebed is primarily located in Kings County with a small portion in Tulare County. The land in the vicinity of the Tulare Lakebed has been used primarily to grow field crops, grain and hay crops, and pasture with some land in native vegetation (California Department of Water Resources 1998). At issue is the extent to which use of the lakebed for storage would reduce agricultural production on the 25,000-acre site. The site currently floods with high rainfall events, although snow runoff events are probably a greater cause of flood releases on the Eastside streams than rainfall events.

Agricultural production is a major component of the Kings County economy. The agricultural area of Kings County may provide appropriate areas for certain predominantly open uses of land that are not injurious to agricultural uses but that may not be compatible with the more densely

populated urban areas. Such uses may include waste management facilities, wastewater treatment facilities, and communication towers.

In the Resource Conservation Element of the General Plan, water availability, beneficial use, and conservation are described as important for the economic survival of Kings County (Kings County General Plan 1998). To beneficially use, conserve, and protect water resources to ensure an adequate long-term supply of water, the General Plan states that an objective to achieve this goal is to apply development standards that seek to prevent pollution of surface or groundwater and net loss of natural water features. One of the county's policies relative to this objective is to work with other municipalities to acquire surface water as mitigation and offset for future urban growth.

6.5.5.3 Biological Resources

The effects on biological resources under Bundle C would be similar to the effects described in the discussion under Bundle B, with the addition of surface storage in the Tulare Lakebed. San Joaquin kit fox, a federally listed endangered and state-listed threatened species, have been recorded within half a mile of Tulare Lakebed. Habitat for this fox includes grasslands, scrublands, and agricultural lands, including grazed annual grasslands. The Tipton kangaroo rat and the blunt-nosed leopard lizard are two additional species found within the area, and both are federally and state listed as endangered. Habitat for the Tipton kangaroo rat includes arid land communities in the Tulare Basin with shrubs such as spiny saltbush, iodine bush, and mesquite in areas that have scant to moderate ground cover of grasses and forbs. The blunt-nosed leopard lizard inhabits sparsely vegetated plains, alkali flats, low foothills, grasslands, canyon floors, large river washes, and arroyos along the west side of the San Joaquin Valley (http://www.dfg.ca.gov/hcpb/species).

The amount and types of impact mitigation for a project involves consultation with the USFWS as well as the CDFG. Although mitigation is suggested for some federal or state species of concern, mitigation is typically required only for federally listed species. Determinations for mitigation of special status species depend on the quality of habitat, including the size of the area, the numbers of special status species that use the habitat, and how that habitat is used. For example, foraging habitat (such as that provided by agricultural fields) would not require as extensive mitigation as breeding or nesting habitat. Mitigation can be on-site and/or off-site in the form of mitigation banks (land pre-approved by the USFWS as mitigation for future projects), or restoration or preservation of existing land. Precautions during construction must also be taken to avoid or lessen the impact to the resource. These precautions include monitoring for special status species or fencing off a sensitive area during construction.

6.5.5.4 Cultural Resources

The proposed Tulare Lakebed storage alternative would affect all cultural resources within the inundation area and along any associated roads and construction areas. Although only six sites have been recorded in the area, they are very large in size and contain artifacts showing evidence of early human existence in this area. The six sites are all prehistoric multi-component camp sites consisting of various lithic and bone tools and human remains. These sites contain fluted projectile points that date back possibly over 10,000 years. At least three Yokuts tribes once occupied the Tulare Lake shore, and the potential to discover new sites along the original

shoreline is high. The research on these known sites and the discovery of new sites in the Tulare Lakebed have had notable significance in the study of the prehistory of North America and particularly the Far West.

The proposed Area of Potential Effect (APE) covers only a portion of the original shoreline and therefore reduces the chance of discovering new sites in the project area. The majority of the APE is within the original lake basin, which currently floods naturally. Therefore, the use of Tulare Lakebed as a storage site would not cause many new effects to resources within the basin. However, the sites that do exist in the APE have a good chance of being multi-component camp sites and/or very old sites that may have the potential to be eligible for listing in the NRHP or the CRHR and would require further study or avoidance.

6.6 BUNDLE D: ENLARGED MILLERTON LAKE AND MAMMOTH POOL WITH DELTA RECIRCULATION

This configuration includes the core components of Bundle A and incorporates the use of additional storage developed at or upstream of Millerton Lake (an incremental 135,000 acre-feet of potential storage) and the use of SWP/CVP Delta pumping facilities to (1) directly capture surplus San Joaquin River flows and (2) recirculate restoration surplus San Joaquin River flows. The additional storage is developed by a raised Friant Dam (105,000 acre-feet) and modifications to Mammoth Pool facilities (30,000 acre-feet). Figure 6.6-1 illustrates the components of this bundle.

The increased storage at Mammoth Pool is treated functionally the same as the increase in storage at Millerton Lake (see Section 5.4.12 for explanation). The total additional 135,000 acre-feet of storage is simply assumed to increase the impoundment capacity of Millerton Lake. The reservoir space reserved for flood control is assumed to be the same as that required for the existing reservoir.

The Bundle D configuration is similar in terms of its operation to Bundle B, which exercises Millerton Lake to a lower minimum pool to increase the active storage range. For Bundle D the reservoir is also exercised through an increased active storage range to meet reservoir demands. This increased active range decreases the need for other resources. Capacity at the SWP/CVP Delta facilities increases recirculation relative to recirculation occurring in Bundle A and is consistent with the other bundle configurations.

Category 1 purchases (20,000 acre-feet per year, each year) are included in this configuration. Water shortages are met with Category 3 and Residual purchases.

The results of the costing analysis and other operational parameters for the four scenarios of Bundle D are shown in Table 6-13. More detailed results, including sequential monthly and year-to-year summaries and hydrographs, are found in Appendix D.

Table 6-13
Bundle D Operational and Economic Results

	Parameter	Case X Demands		Case Y Demands	
		Modified Channel	Existing Channel	Modified Channel	Existing Channel
Quantities (1,000 acre-feet)	Total Purchases	73	103	35	45
	Category 1 Purchases	20	20	20	20
	Category 2 Purchases	0	0	0	0
	Category 3 Purchases	52	79	14	23
	Residual Purchases	1	4	1	2
	Levelized Groundwater Residual Balance	27	14	66	42
	Levelized California Aqueduct Balance	18	21	18	22
	Total Release to San Joaquin River	629	683	685	729
	Annual Average Spill	163	121	219	167
	Total Eastside GW Recharge	68	59	104	86
	Total Eastside GW Extraction	43	47	38	44
	Total Diversion of Tributary Surplus into FKC	91	91	94	94
	Recaptured Water for Recirculation	121	137	113	127
	Recirculation at Delta	80	93	74	86
	Recirculation at Mendota Pool	41	44	39	41
	Uncaptured Water	69	99	49	75
	Total CVC	114	126	106	117
	Madera Canal Diversion	260	253	263	257
	Friant-Kern Canal Diversion	845	801	784	747
	Baseline Diversion to Madera Canal	267	267	255	255
	Baseline Diversion to Friant-Kern Canal	1,071	1,071	943	943
Costs ($1,000)	Fixed Costs	$12,347	$12,347	$12,347	$12,347
	GW Put Charge	$12,465	$10,851	$18,832	$15,639
	Wheeling Costs	$678	$750	$616	$689
	Pumping Energy	$5,249	$5,922	$4,765	$5,401
	Generation Sales	($2,212)	($2,313)	($2,273)	($2,383)
	Category 1 Purchases	$6,500	$6,500	$6,500	$6,500
	Category 2 Purchases	$0	$0	$0	$0
	Category 3 Purchases	$14,884	$22,458	$4,297	$6,923
	Residual Purchases	$274	$803	$165	$425
	Offset for Groundwater Residual Storage	($4,798)	($2,592)	($11,963)	($7,642)
	Total Average Annual Net Cost	**$45,386**	**$54,724**	**$33,284**	**$37,898**

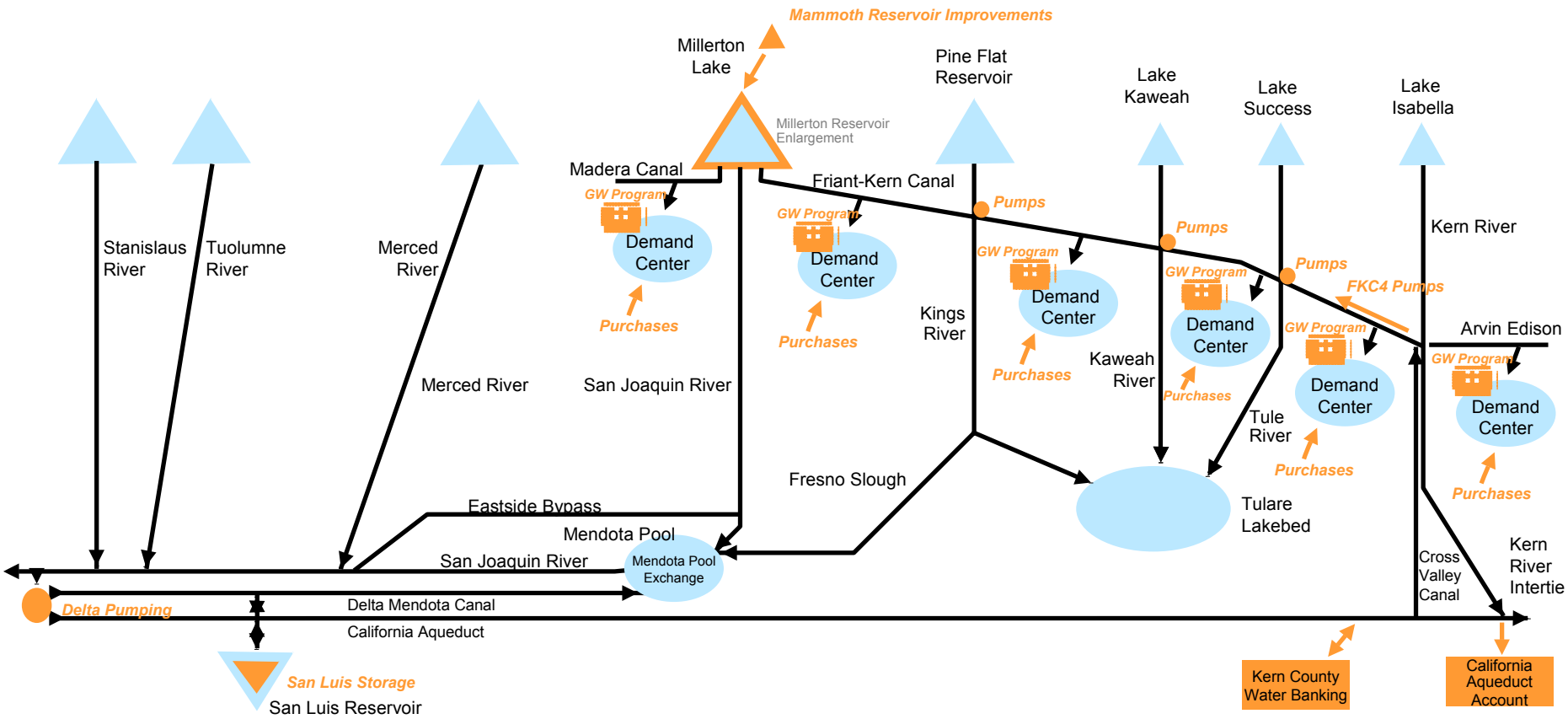

Figure 6.6-1

Bundle D: Enlarged Millerton Lake and Mammoth Pool and Delta Recirculation

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6.6.1 Case X with Modified Channel – Operations and Water Supply

Use of Eastside Tributary Flows: The addition of storage space in Millerton Lake does not change the amount of Eastside tributary surplus flow used by the project compared to Bundles A and B. The availability and use of this water is described in Section 6.3.1. An annual average of 91,000 acre-feet of Eastside tributary surplus flows is diverted into bundle components by way of the Friant-Kern Canal pump-in facilities.

Mendota Pool and Delta Recirculation: Water is captured and recirculated at Mendota Pool and the SWP/CVP Delta pumping plants consistent with all the Bundles that recirculate water at Mendota Pool and the Delta. An annual average of 41,000 acre-feet of water offsets Mendota Pool water user demands and another annual average of 80,000 acre-feet of water is recirculated at the SWP/CVP Delta pumping plants. Of the annual average of 121,000 acre-feet of recirculated water, a majority (an annual average of 90,000 acre-feet) occurs on a pattern coincidental with available conveyance capacity and Friant-Kern Canal direct-use demands or available Eastside groundwater storage capacity. The monthly and annual patterns of the recirculation flows are illustrated in Section 6.4.1.

Groundwater Storage: An annual average groundwater banking of 68,000 acre-feet and extraction of 43,000 acre-feet occurs with this Bundle. The year-to-year groundwater operation is illustrated in Figure 6.6-2. Due to the coincidence of Eastside tributary surplus flows and other fortunate hydrologic circumstances during the later third of the study period, a groundwater balance amounting to about 2,000,000 acre-feet accrues by the end of the study. During the middle portion of the study period, assumed resources, demands, and operation protocols result in a generally balanced groundwater operation. The early portion of the study period is plagued by a drought period that did not provide an opportunity to divert flows to groundwater storage and an assumption that a positive or zero balance must be maintained; thus, very little groundwater could be extracted. Had an initial balance been assumed, groundwater would have been extracted during this period.

Purchases: After all other assets are exercised, remaining shortages are met with Category 3 and Residual purchases. An annual average of 53,000 acre-feet of purchases is required. Of this quantity, an annual average of 52,000 acre-feet is Category 3 purchases. Figure 6.6-3 illustrates the year-to-year purchases for this scenario. The purchases are generally required during water-short years when groundwater assets have become limited. Figure 6.6-4 and Figure 6.6-5 further illustrate the occurrence of Category 3 and Residual purchases in relation to San Joaquin River unimpaired runoff. As can be seen in these figures, these purchases sporadically occur during periods that are below-average runoff years; however, purchases are not needed in all drier years.

Releases from Friant Dam: Restoration flow requirements are met, with the annual average required release amounting to 466,000 acre-feet, including 117,000 acre-feet of releases required for current downstream needs. In addition to minimum releases, spills occasionally occur from Millerton Lake (an annual average of 163,000 acre-feet). The availability of additional space in Millerton Lake reduces the amount of water spilled when compared to Bundles that do not have additional space.

Millerton Lake Storage: Under a Modified Channel/Case X Demand scenario, the monthly average reservoir storage operation is 335,000 acre-feet, close to the estimated historical average of 350,000 acre-feet. However, the average storage in this configuration includes a larger reservoir, which means that although the average is nearly the same, the reservoir is fluctuating to a greater degree. The reservoir still experiences extended periods when storage does not appreciably exceed 300,000 acre-feet. This is due to the assumed management of the additional storage. The additional storage is utilized early in a year (or sequence of years) to offset the need for the use of other assets, and to ready the reservoir for the capture of future inflow that would otherwise be spilled. During a sequence of dry years, the Millerton Lake operation will look very similar to an operation that does not include the additional storage. Figure 6.6-6 illustrates the range in storage that occurs each month. Figure 6.6-7 and Figure 6.6-8 illustrate additional results regarding Millerton Lake storage levels for this scenario. Specifically, Figure 6.6-7 depicts Millerton Lake storage for the end of June, and Figure 6.6-8 depicts storage at the end of September.

6.6.2 Case Y with Existing Channel – Operations and Water Supply

Use of Eastside Tributary Flows: The addition of storage space in Millerton Lake does not change the amount of Eastside tributary surplus flow used by the project compared to Bundles A and B. The availability and use of this water is described in Section 6.3.2. An annual average of 94,000 acre-feet of Eastside tributary surplus flows is diverted into bundle components by way of the Friant-Kern Canal pump-in facilities.

Mendota Pool and Delta Recirculation: Water is captured and recirculated at Mendota Pool and the SWP/CVP Delta pumping plants consistent with all the Bundles that recirculate water at Mendota Pool and the Delta. An annual average of 41,000 acre-feet of water offsets Mendota Pool water user demands and another annual average of 80,000 acre-feet of water is recirculated at the SWP/CVP Delta pumping plants. Of the annual average of 121,000 acre-feet of recirculated water, a majority (an annual average of 87,000 acre-feet) occurs on a pattern coincidental with available conveyance capacity and Friant-Kern Canal direct-use demands or available Eastside groundwater storage capacity. The monthly and annual patterns of the recirculation flows are illustrated in Section 6.4.2.

Groundwater Storage: An annual average groundwater banking of 86,000 acre-feet and an annual average extraction of 44,000 acre-feet occur with this Bundle. The year-to-year groundwater operation is illustrated in Figure 6.6-9. Due to the coincidence of Eastside tributary surplus flows and other fortunate hydrologic circumstances during a brief period in the early portion of the study period and during the later third of the study period, a groundwater balance amounting to about 3,250,000 acre-feet accrues by the end of the study. During the middle portion of the study period, assumed resources, demands, and operation protocols result in a generally balanced groundwater operation. The early portion of the study period is plagued by a drought period that did not provide an opportunity to divert flows to groundwater storage and an assumption that a positive or zero balance must be maintained; thus, very little groundwater could be extracted. Had an initial balance been assumed, groundwater would have been extracted during this period.

Figure 6.6-2 Groundwater Operation -- Case X, Modified Channel

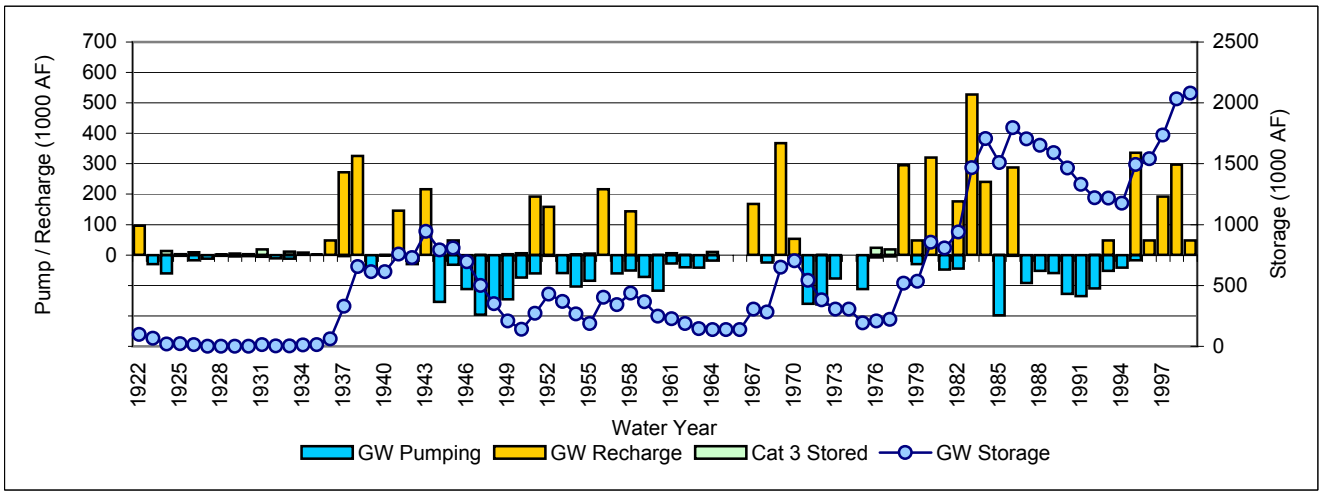

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Figure 6.6-3 Water Purchases -- Case X, Modified Channel

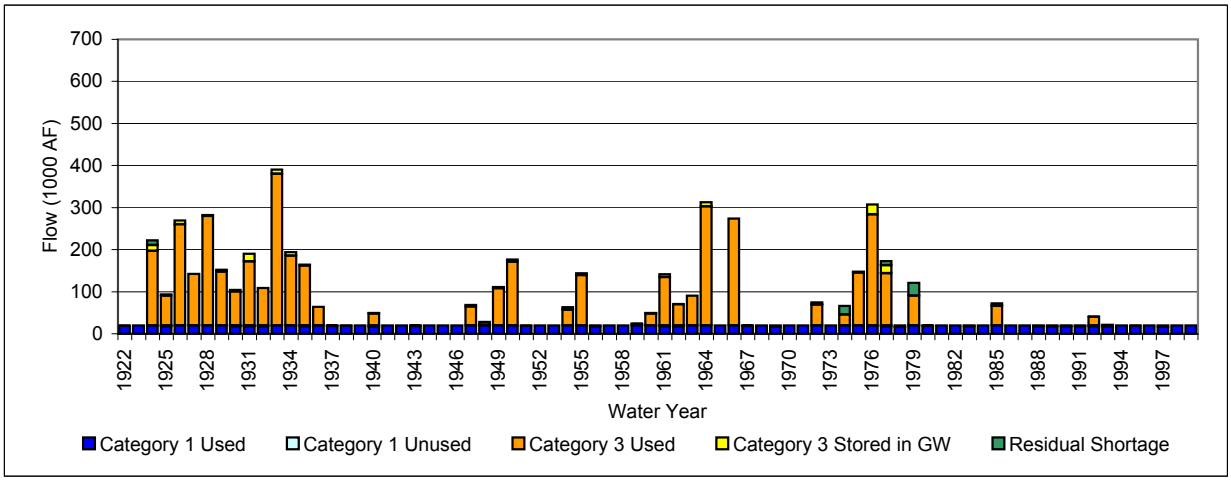

Figure 6.6-4 Category 3 Purchases -- Case X, Modified Channel

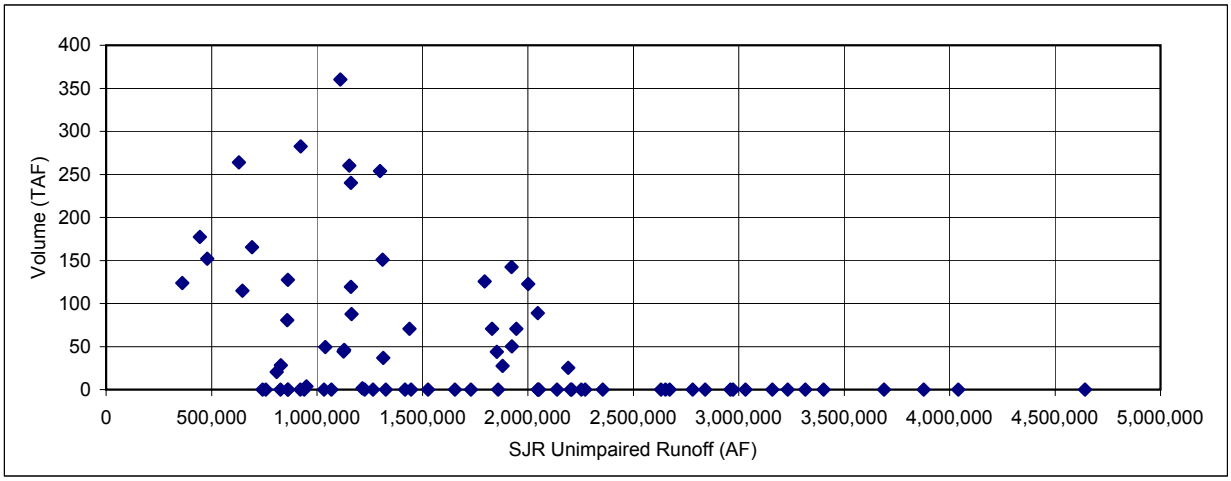

Figure 6.6-5 Residual Purchases -- Case X, Modified Channel

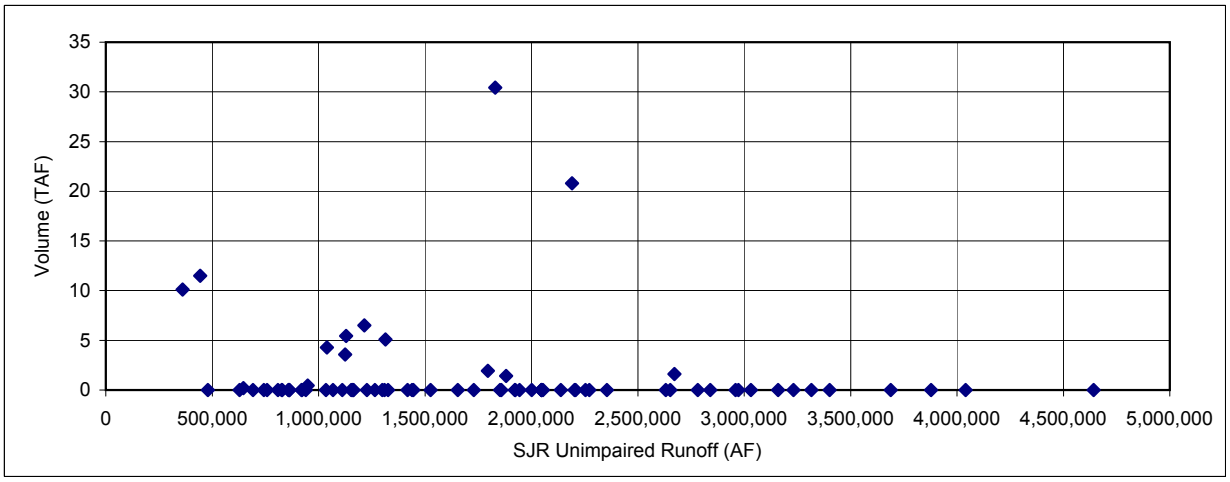

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Figure 6.6-6 Millerton Lake Storage -- Case X, Modified Channel

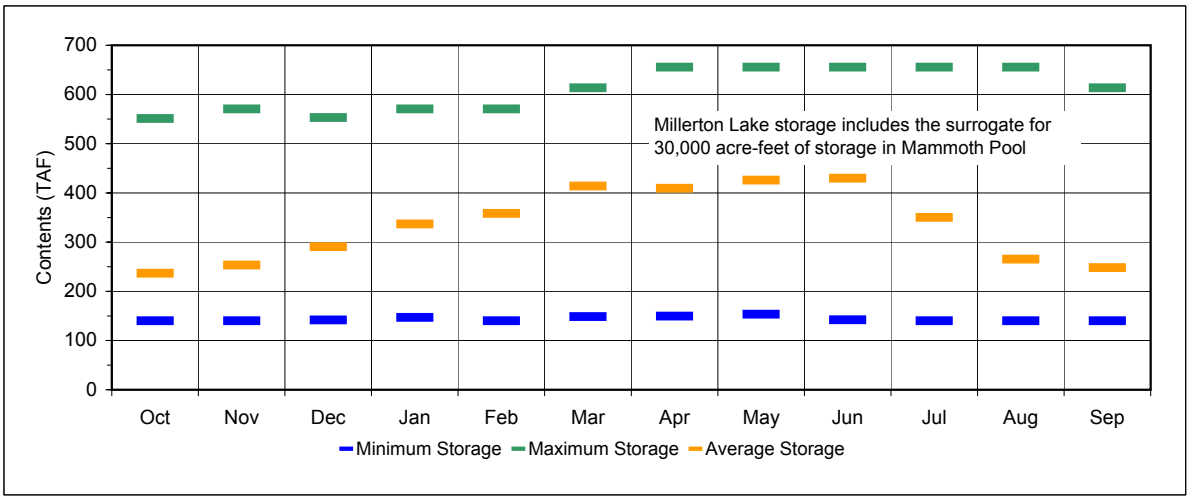

Figure 6.6-7 End-of-June Millerton Storage -- Case X, Modified Channel

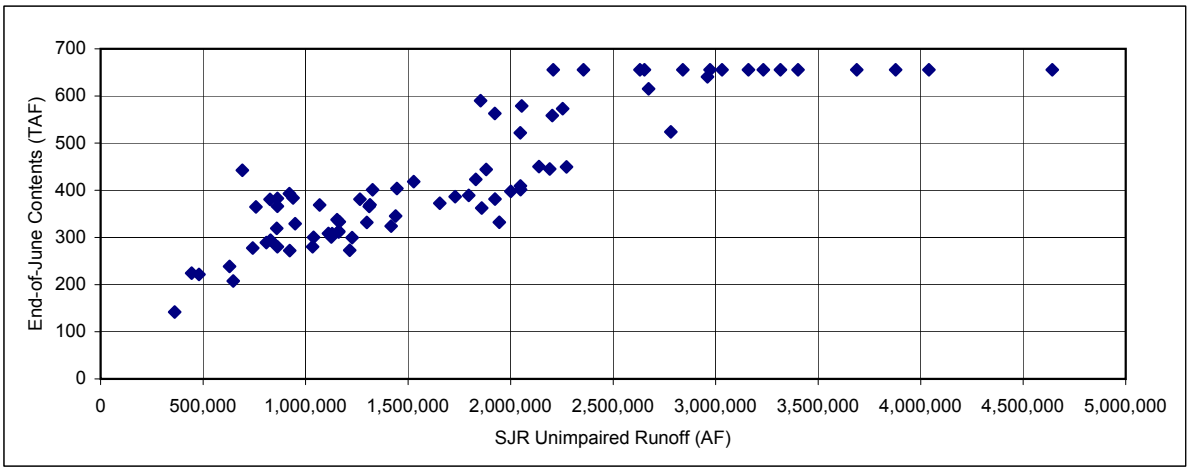

Figure 6.6-8 End-of-September Storage -- Case X, Modified Channel

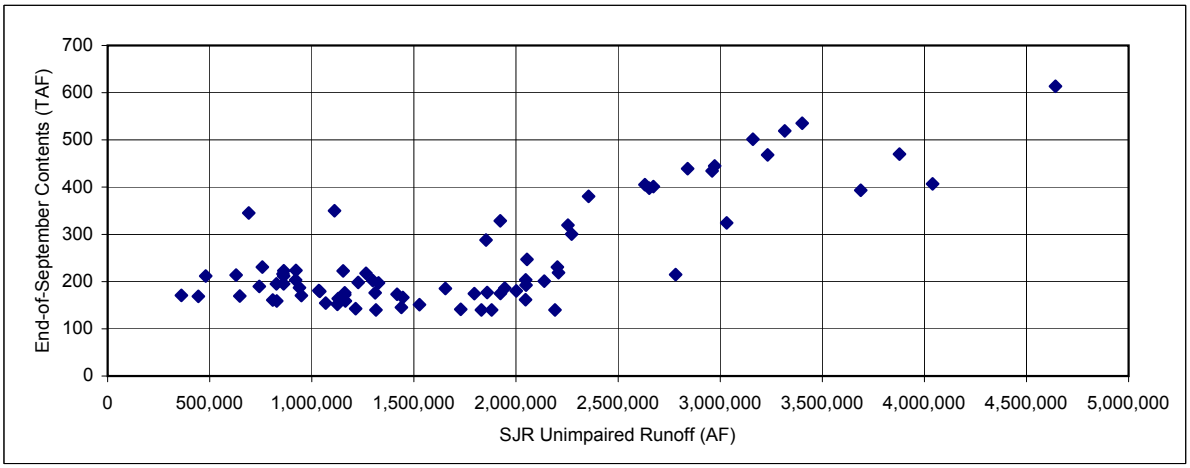

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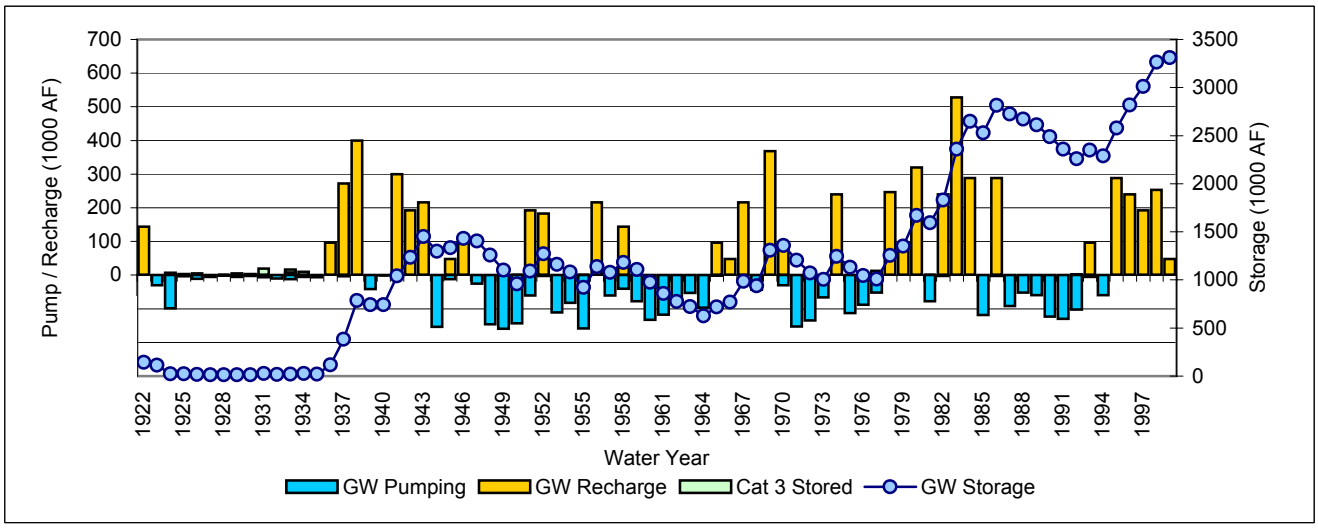
Figure 6.6-9 Groundwater Operation -- Case Y, Existing Channel



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Purchases: After all other assets are exercised, remaining shortages are met with Category 3 and Residual purchases. An annual average of 25,000 acre-feet of purchases is required. Of this quantity, an annual average of 23,000 acre-feet is Category 3 purchases. Figure 6.6-10 illustrates the year-to-year purchases for this scenario. Figure 6.6-11 and Figure 6.6-12 further illustrate the occurrence of Category 3 and Residual purchases in relation to San Joaquin River unimpaired runoff. As can be seen in these figures, these purchases sporadically occur during periods that are below-average runoff years; however, purchases are not needed in all drier years.

Millerton Lake Storage: Under a Modified Channel/Case X Demand scenario, the monthly average reservoir storage operation is 344,000 acre-feet, close to the estimated historical average of 350,000 acre-feet. However, the average storage in this configuration includes a larger reservoir, which means that although the average is nearly the same, the reservoir is fluctuating to a greater degree. The reservoir still experiences extended periods when storage does not appreciably exceed 300,000 acre-feet. This is due to the assumed management of the additional storage. The additional storage is utilized early in a year (or sequence of years) to offset the need for the use of other assets and to ready the reservoir for the capture of future inflow that would otherwise be spilled. During a sequence of dry years, the Millerton Lake operation will look very similar to an operation that does not include the additional storage. Figure 6.6-13 illustrates the range in storage that occurs each month. Figure 6.6-14 and 6.6-15 illustrate additional results regarding Millerton Lake storage levels for this scenario. Specifically, Figure 6.6-14 depicts Millerton Lake storage for the end of June, and Figure 6.6-15 depicts storage at the end of September.

Releases from Friant Dam: Restoration flow requirements are met, with the annual average required release amounting to 562,000 acre-feet, including 117,000 acre-feet of releases required for current downstream needs. In addition to minimum releases, spills occasionally occur from Millerton Lake (an annual average of 167,000 acre-feet). The availability of additional space in Millerton Lake reduces the amount of water spilled when compared to Bundles that do not have additional space.

6.6.3 Technical Concerns

Because all of the Bundle A components are included in Bundle D, all of the technical and constructability issues described previously for Bundle A components apply to Bundle D. The following additional issues also apply:

- Millerton Enlargement. This component includes raising Friant Dam by 20 feet to obtain 105,000 acre-feet of additional storage. The main dam is a concrete gravity structure that would be raised by adding a 20-foot-wide by 20-foot-high concrete section. A new embankment saddle dam (30 feet high by 3,000 feet long) is also required, along with spillway modifications and road relocations. The major technical and constructability risks are associated with raising the concrete gravity dam. No analysis has been performed regarding the structural stability of the revised cross section or to determine the modifications that might be necessary to achieve such stability. There is also risk associated with construction of a new embankment saddle dam, as no investigation has been performed regarding the foundation conditions.

- Mammoth Pool Enlargement. This component also includes adding spillway gates to the Mammoth Pool Dam to raise the maximum water surface by approximately 27 feet and thereby provide 30,000 acre-feet of additional storage. In addition to major modifications to the spillway, the dam itself would need to be built up to accommodate the increased maximum pool. (The dam currently has 31 feet of freeboard.) No analysis has been performed regarding dam stability with the increased maximum pool. Until detailed engineering review is completed, considerable risk is associated with the conceptual cost estimates.

6.6.4 Institutional Challenges

There are likely to be water rights and environmental challenges similar to what is described for Fine Gold. The relocation of recreational facilities and other structures will pose institutional and technical challenges. Cost allocations for Millerton Lake may require modification and be reassigned between water conservation and other purposes. Increases in storage at Millerton Lake may require an allocation to flood control, which would potentially decrease the storage available for conservation. Modifying facilities at Mammoth Pool would require coordination and agreement with Southern California Edison Company and would potentially create a forum for comprehensive changes to the operation of their project. Nonetheless, protocols would need to be established to create the storage benefit envisioned by this configuration. Previous issues have also been property issues, including property ownership and impact to other property owners, impact to existing facilities, and potential increase in flood hazard downstream due to potential dam failure.

Issues concerning recirculation at SWP/CVP Delta facilities and diversion of Eastside tributary surplus flows to the Friant-Kern Canal are the same as those discussed for Bundles A and B.

6.6.5 Environmental Concerns

6.6.5.1 Water Quality

Bundle D is expected to have similar or reduced water quality effects compared with those of Bundle A. If Millerton Lake is expanded to provide additional storage, the potential for water quality effects in the lake during reduced storage periods decreases.

6.6.5.2 Land Use

Bundle D is similar in terms of its operation to Bundle A, with the addition of increased storage in Millerton Lake and modifications to Mammoth Pool. Groundwater recharge sites would be located at up to six potential Eastside locations or in Kern County, as discussed previously.

Millerton Lake

The Millerton Lake State Recreation Area essentially surrounds Millerton Lake. The primary land uses associated with the park include many water-dependent or water-related activities, such as swimming, boating, water skiing, jet skiing, sailing, fishing, camping, hiking, and horseback

Figure 6.6-10 Water Purchases -- Case Y, Existing Channel

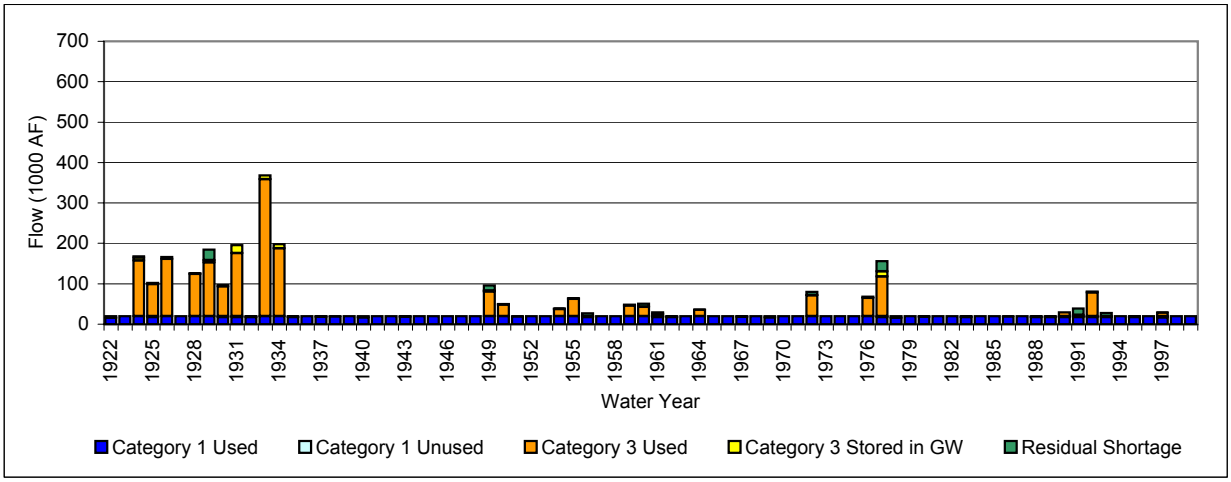

Figure 6.6-11 Category 3 Purchases -- Case Y, Existing Channel

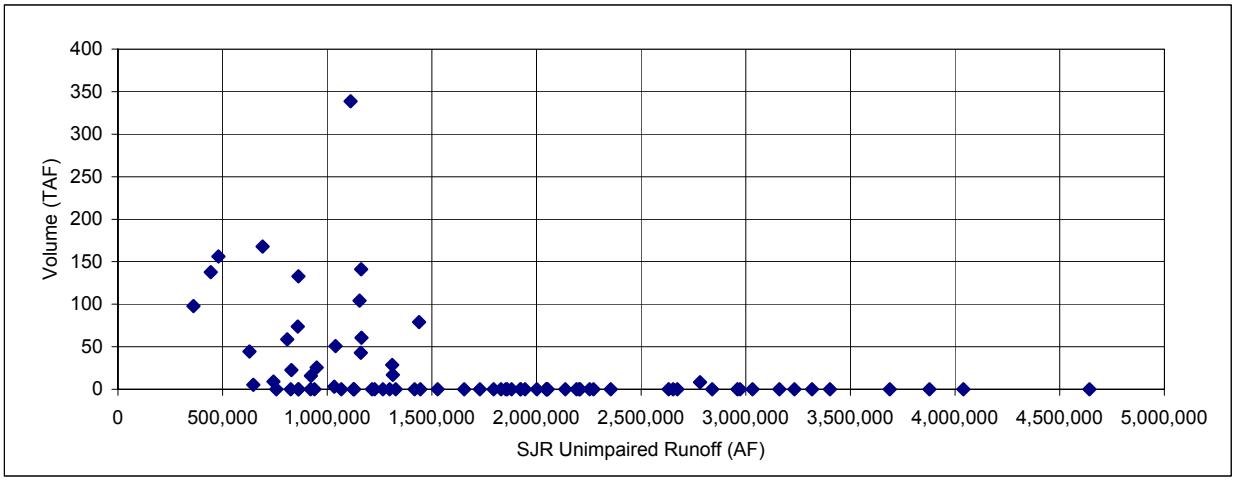

Figure 6.6-12 Residual Purchases -- Case Y, Existing Channel

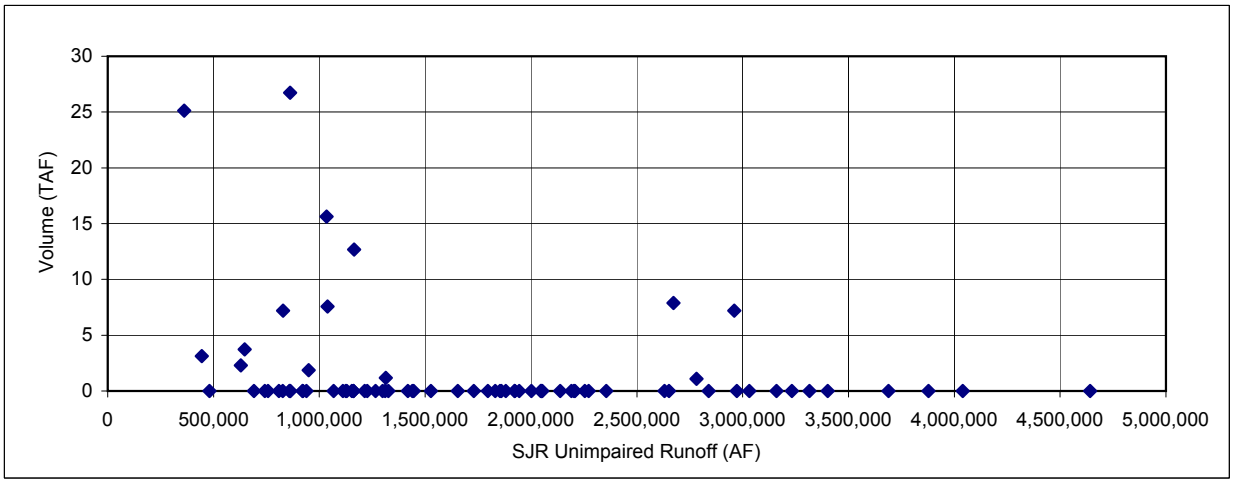

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Figure 6.6-13 Millerton Lake Storage -- Case Y, Existing Channel

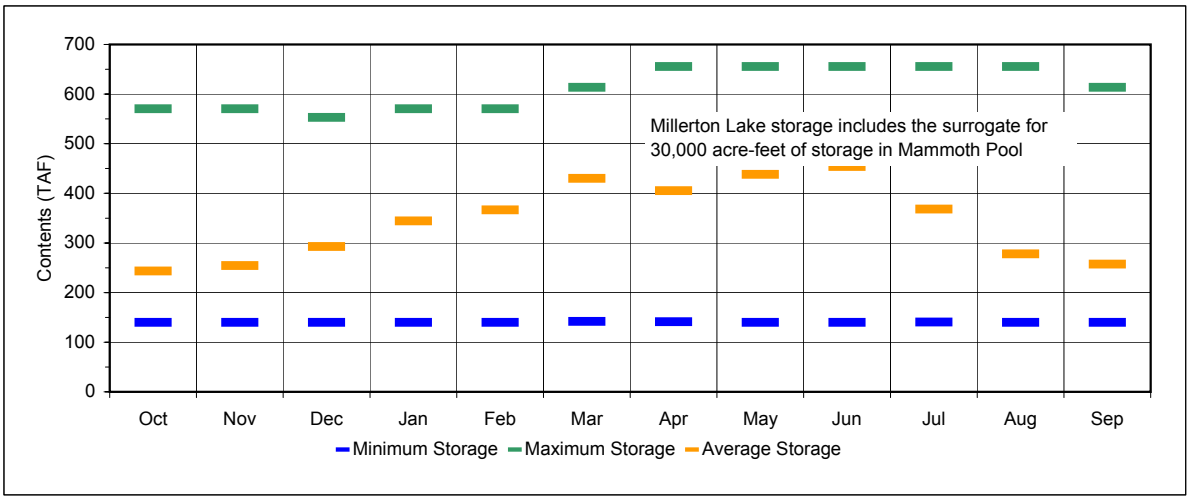


Figure 6.6-14 End-of-June Millerton Storage -- Case Y, Existing Channel

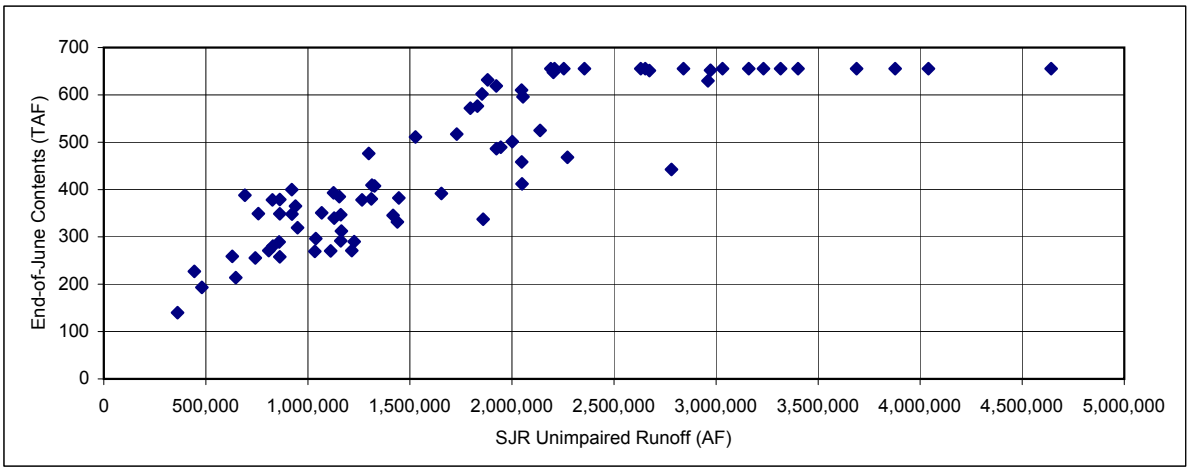
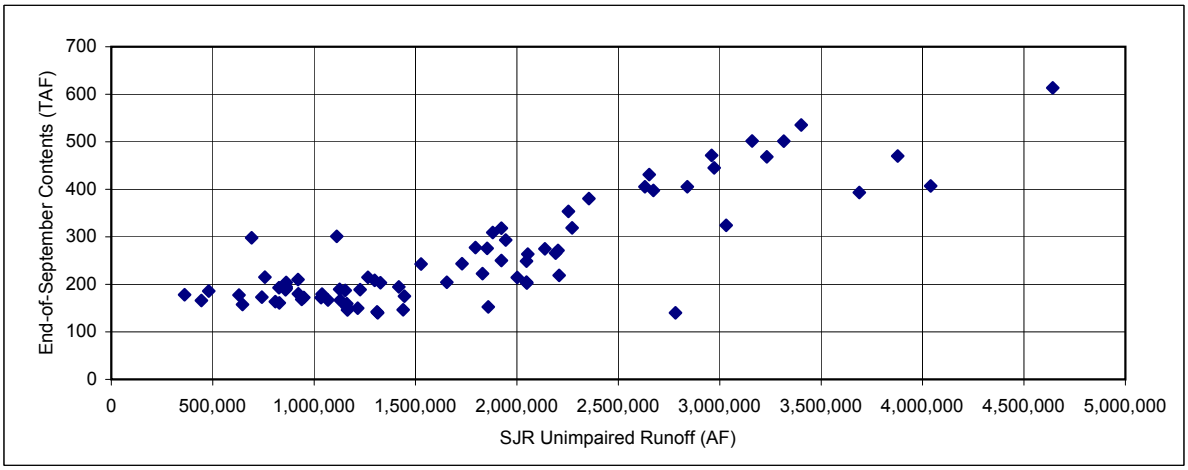


Figure 6.6-15 End-of-September Storage -- Case Y, Existing Channel



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riding. The proximity of Millerton Lake to both Fresno and Madera make the reservoir popular with the public.

All of the campgrounds are located on the northern shore of the reservoir with two group campgrounds, numerous individual camp sites, a horse/camping facility, and a boat-launching area. In addition, there are two boat-in camping areas, one located in the North Fine Gold area (no facilities) and one at Temperance Flat. Many of these campsites are located near the shoreline and would have to be relocated, as an enlarged reservoir would inundate them.

Private residences are also located around the reservoir. Hidden Lakes Estates is located in Madera County on the west side of Fine Gold Creek. In addition, approximately 1,400 undeveloped acres were recently purchased by a developer along the northern shores of Millerton Lake and surrounding Fine Gold Creek.

On the southern side of Millerton Lake are state offices, several picnic sites, five boat ramps, some historic sites (Millerton courthouse and pioneer cemetery), and a marina with approximately 500 boat slips. There are also numerous private residences in the Sky Harbor area. Several of these sites would have to be relocated because they would be inundated if the reservoir were enlarged.

Mammoth Pool

Mammoth Pool is located upstream of Millerton Lake on the San Joaquin River in Madera and Fresno Counties about 90 miles northeast of Fresno. The elevation of the reservoir is 3,300 feet, and land use in this area reflects the area's abundance of natural resources. Chief among these are forests, water, and wildlife. The area's scenic beauty has also created the base for an important tourism and recreation industry (Madera County General Plan 1995). Recreation uses include fishing, boating, swimming, hiking, camping, and scenic vistas. The reservoir is closed to the public from May 1 until June 16 to allow the migrating deer to swim across the reservoir. (http://www.gorp.com/gorp/resource/US_National_Forest/ca/wat_sie2.htm).

Seven Forest Service and one privately owned campgrounds are located within 13 miles of the reservoir. Any campsites located near the shore of the reservoir would have to be relocated because they would be inundated if the reservoir were enlarged. In addition, the Ansel Adams Wilderness is located approximately one mile from the northern end of the reservoir.

6.6.5.3 Biological Resources

Under Bundle D, Friant Dam would be raised and the inundation area of Millerton Lake would increase. Vernal pool species such as Boggs Lake hedge-hyssop (state listed as endangered and a CNPS List 1B plant), succulent owl's clover (federally listed as threatened, state listed as endangered, and a CNPS List 1B plant), vernal pool tadpole shrimp (federally listed as endangered), and vernal pool fairy shrimp (federally listed as threatened) have been recorded in the area around Millerton Lake. These species imply the presence of vernal pools in the area, and it is likely that the vernal pool habitat is more widespread than what is recorded on the CNDDB. In addition, valley elderberry longhorn beetle (federally listed as threatened*)* is recorded in a small area. This species is dependent on elderberry bushes, which could also have a greater range than that which is mapped on the CNDDB. Tree anemone (state listed as threatened and a CNPS List 1B plant) are present predominantly in streambanks, chaparral, and

oak woodland. California tiger salamander, a federal candidate for listing and a state species of concern, inhabits annual grasslands, open woodlands, and breeding sites in seasonal ponds such as vernal pools.

Although no fish species were recorded in the CNDDB within half a mile of Millerton Lake, Kern Brook lamprey, a federal and state species of concern, may be in the vicinity of Friant Dam in the Friant-Kern Canal and may have been collected in the San Joaquin River between Millerton Lake and Kerchoff Reservoir (http://www.dft.ca.gov/hcpb/species).

Sierra Nevada red fox, a federal species of concern, and flaming trumpet, a CNPS List 1B plant, have been recorded within half a mile of Mammoth Pool. Sierra Nevada red fox are found in alpine dwarf shrub, wet meadows, sub-alpine conifer and montane chaparral, and mixed conifer habitats. Flaming trumpet is endemic to Madera County and grows primarily within the Sierra National Forest. It is restricted to riparian habitats and meadows in conifer forests at elevations of 3,000 to 7,000 feet.

The amount and types of impact mitigation for a project involve consultation with the USFWS and the CDFG. Although mitigation is suggested for some federal or state species of concern, mitigation is typically only required for federally listed species. Determinations for mitigation of special status species depend on the quality of habitat, including the size of the area, the numbers of special status species that use the habitat, and how that habitat is used.

6.6.5.4 Cultural Resources

In expanding Millerton Lake the greatest direct physical impact to cultural resources would be to those sites located between the lowest level of the existing pool and the highest level of the proposed pool, and those areas slated for recreational use. Under Bundle D, Millerton Lake would be raised approximately 20 feet. This may cause the inundated area to be very wide in the areas of flatter slopes. Therefore, this alternative has the potential to capture many sites within the new inundation area. There are a large number of recorded sites in the area, and potentially many more exist in areas that have not been surveyed. The majority of the known sites in the area are either extensive milling sites with multiple bedrock mortars or large camp sites with house pits, bedrock mortars, and formal tools. Of the 47 sites recorded in the inundation area, approximately 30 percent are located within the existing pool and would only be affected minimally, if at all, by the proposed reservoir expansion. No historic sites have been recorded; however, Friant Dam would need to be formally evaluated for significance by an architectural historian before any structural changes could take place.

The Millerton Lake expansion alternative appears to be moderately sensitive due to the potential for sites with human burials and the potential for valuable data to be destroyed. Because the proposed expansion area at Millerton Lake covers a large area and includes recreation areas and new roads, the Millerton expansion will likely have more direct physical impact on cultural resources than enlargement of Mammoth Pool. However, this assessment is based on limited information and could change once a systematic cultural resource survey and further research on all alternatives is completed.

When expanding Mammoth Pool the greatest direct physical impact to cultural resources would be to those sites located between the lowest level of the existing pool and the highest level of the proposed pool. Of the 17 known sites in the inundation area, only one is a historic site; the

others appear to consist mainly of features such as rock rings and bedrock mortars that show less evidence of formal tools or lithic scatters. A number of the sites were recorded over 40 years ago as large prehistoric sites with unknown depths and few site details. This suggests that further site characterization and data collection are needed to assess the current condition and sensitivity of these sites. One quarter of the prehistoric sites were recorded as temporary camp sites, indicating that the areas that have not yet been surveyed for cultural resources and likely contain camp sites or associated ancillary sites. These sites have the potential to contain data that would be vital to the archaeological record and may be eligible for listing in the NRHP or the CRHR.

Considering the large area of Mammoth Pool, the recorded number of archaeological sites in the area appears to be low. It is unknown what percentage of the total research area has been surveyed for cultural resources, when the previous surveys were conducted and the standards to which these surveys were performed. Many unrecorded sites could exist in the APE.

The Mammoth Pool expansion project could impact cultural resources, as Native Americans used this area extensively for thousands of years. However, because the proposed expansion area in this alternative is relatively small compared to the expansion area in other alternatives, this alternative would likely have fewer effects on cultural resources than other alternatives. However, this assessment is based on limited information and could change depending on the results of a systematic cultural resource survey and further research.

6.7 BUNDLE E: ENLARGED MILLERTON LAKE AND MAMMOTH POOL, FINE GOLD RESERVOIR, AND DELTA RECIRCULATION

This configuration includes the core components of Bundle A, the reservoir storage improvements of Bundle D, the use of SWP/CVP Delta pumping facilities to capture and recirculate restoration or surplus San Joaquin River flows, and additional storage upstream of Millerton Lake at Fine Gold Reservoir. The additional storage is developed by a raised Friant Dam (105,000 acre-feet) and modifications to Mammoth Pool facilities (30,000 acre-feet) and Fine Gold Reservoir (400,000 acre-feet with a 40,000 acre-foot minimum pool). Figure 6.7-1 illustrates the several components of this bundle.

As in Bundle D, the increased storage at Mammoth Pool is treated functionally in the same way as the increased storage at Millerton Lake. The total additional 135,000 acre-feet of storage is simply assumed to increase the impoundment capacity of Millerton Lake. Reservoir space reserved for flood control is assumed to be the same as required for the existing reservoir. Fine Gold Reservoir is located on a tributary to Millerton Lake, with Millerton Lake serving as the tailwater for the project. Local Fine Gold Creek runoff (an annual average of 28,000 acre-feet) occurs to the reservoir; however, the majority of inflow to Fine Gold Reservoir would occur from Millerton Lake pumping.

The configuration illustrates the effect that significant incremental surface storage can have on the operation of the components previously evaluated. Combining pumped-storage with increased Millerton Lake storage and groundwater banking opportunities requires operating protocols. The development of a reasonable set of operating protocols that maximizes water supply while minimizing pumping/generation and banking/extraction as well as improves the management of surplus flows, is an iterative process. One key protocol that is established for this and other alternatives maximizes carryover surface water storage into the summer. Surface water storage is given higher priority than groundwater banking because surface storage has fewer constraints of operation and occurs at the site of the source for both restoration flows and canal diversions. Groundwater banking is reduced from the levels of the other bundles due to this prioritization (water is stored in surface reservoirs instead of groundwater basins). Withdrawal of water occurs first from Fine Gold Reservoir (although it is usually simultaneously withdrawn from groundwater) to better ensure that the unknown inflows of future years can be stored. The protocols draw on the collective storage of Millerton Lake and Fine Gold Reservoir to create storage space for the future year's inflow.

Capacity at the SWP/CVP Delta facilities increases recirculation relative to Bundle A. Category 1 purchases (20,000 acre-feet per year, each year) are included in this configuration. Water shortages are met with Category 3 and Residual purchases.

The results of the costing analysis and other operational parameters for the four scenarios of Bundle E are shown in Table 6-14. More detailed results, including sequential monthly and year-to-year summaries and hydrographs, are found in Appendix D.

Table 6-14
Bundle E Operational and Economic Results

	Parameter	Case X Demands		Case Y Demands	
		Modified Channel	Existing Channel	Modified Channel	Existing Channel
Quantities (1,000 acre-feet)	Total Purchases	65	92	32	40
	Category 1 Purchases	20	20	20	20
	Category 2 Purchases	0	0	0	0
	Category 3 Purchases	44	69	11	19
	Residual Purchases	1	3	1	1
	Levelized Groundwater Residual Balance	22	11	60	37
	Levelized California Aqueduct Balance	18	21	18	21
	Total Release to San Joaquin River	614	667	674	718
	Annual Average Spill	148	105	208	156
	Total Eastside GW Recharge	50	41	77	62
	Total Eastside GW Extraction	29	33	18	26
	Fine Gold Pump-in	32	33	39	38
	Fine Gold Release (includes local runoff)	51	52	55	56
	Total Diversion of Tributary Surplus into FKC	91	91	94	94
	Recaptured Water for Recirculation	121	137	114	127
	Recirculation at Delta	80	93	75	86
	Recirculation at Mendota Pool	41	44	39	41
	Uncaptured Water	58	87	41	68
	Total CVC	114	126	107	117
	Madera Canal Diversion	261	254	262	256
	Friant-Kern Canal Diversion	848	807	782	746
	Baseline Diversion to Madera Canal	267	267	255	255
	Baseline Diversion to Friant-Kern Canal	1,071	1,071	943	943
Costs ($1,000)	Fixed Costs	$47,083	$47,083	$47,083	$47,083
	GW Put Charge	$9,225	$7,627	$14,093	$11,406
	Wheeling Costs	$678	$750	$618	$689
	Pumping Energy	$4,876	$5,505	$4,254	$4,913
	Generation Sales	($2,243)	($2,337)	($2,329)	($2,443)
	Category 1 Purchases	$6,500	$6,500	$6,500	$6,500
	Category 2 Purchases	$0	$0	$0	$0
	Category 3 Purchases	$12,728	$20,101	$3,120	$5,752
	Residual Purchases	$216	$646	$151	$194
	Offset for Groundwater Residual Storage	($4,013)	($1,907)	($10,787)	($6,642)
	Total Average Annual Net Cost	**$75,050**	**$83,968**	**$62,702**	**$67,484**

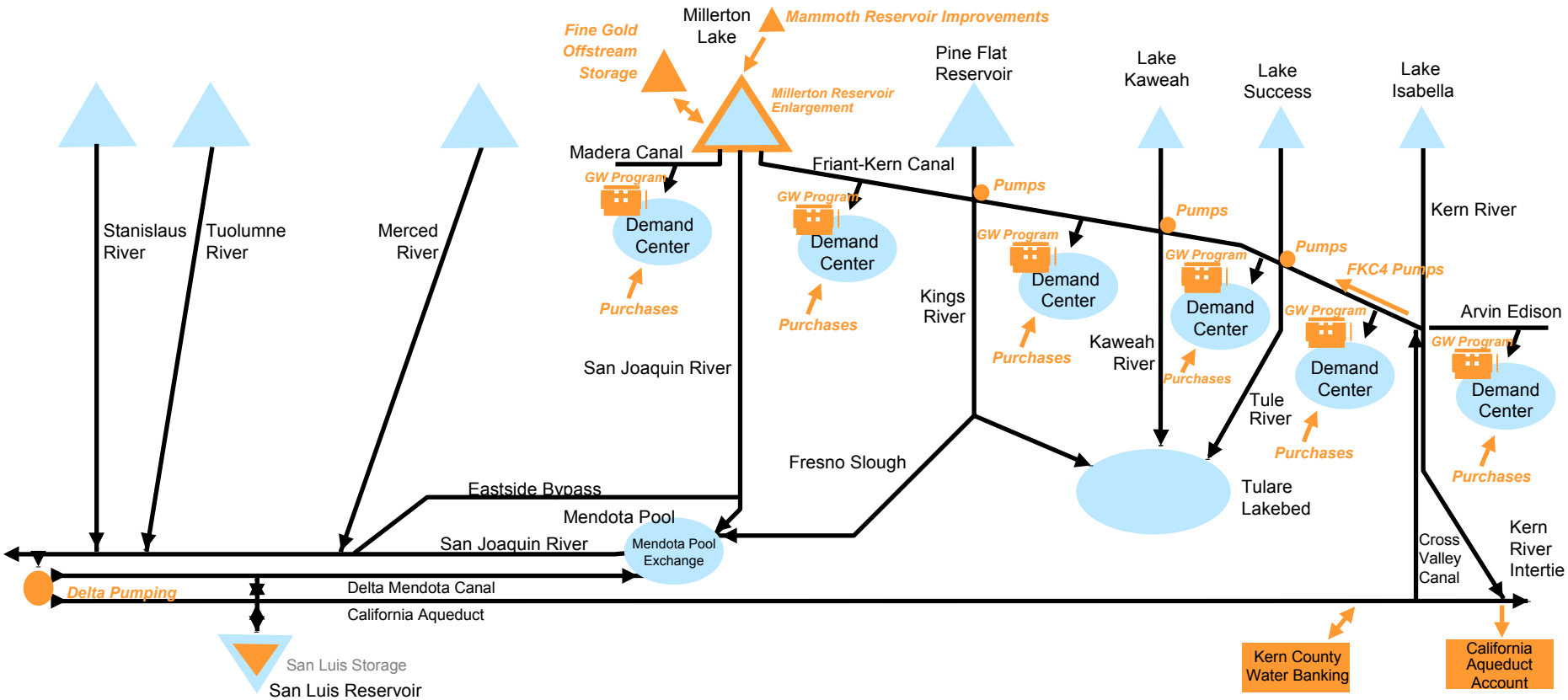

Figure 6.7-1

Bundle E: Enlarged Millerton Lake and Mammoth Pool, Fine Gold Reservoir, and Delta Recirculation

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6.7.1 Case X with Modified Channel – Operations and Water Supply

Use of Eastside Tributary Flows: An annual average of 91,000 acre-feet of Eastside tributary surplus flows is again diverted into bundle components by way of the Friant-Kern Canal pump-in facilities. The availability and diversion of this water is described in Section 6.3.1.

Mendota Pool and Delta Recirculation: Water is captured and recirculated at Mendota Pool and the SWP/CVP Delta pumping plants. Consistent with all the Bundles that recirculate water at Mendota Pool and the Delta, an annual average of 41,000 acre-feet of water offsets Mendota Pool water user demands and another annual average of 80,000 acre-feet of water is recirculated at the SWP/CVP Delta pumping plants. Of the annual average of 121,000 acre-feet of recirculated water, a majority (an annual average of 90,000 acre-feet) occurs on a pattern coincidental with available conveyance capacity and Friant-Kern Canal direct-use demands or available Eastside groundwater storage capacity. Even with the decrease in spills below Millerton Lake the recirculation operation does not change. This circumstance indicates that modifying the occurrence of spills does not change the recirculation operation, likely because Millerton Lake spills occur during periods when recirculation is not allowed (e.g., during April and May). The monthly and annual pattern of the recirculation flows are illustrated in Section 6.4.1.

Groundwater Storage: An annual average groundwater banking of 50,000 acre-feet and extraction of 29,000 acre-feet occurs with this Bundle. Groundwater banking is reduced relative to the other storage configurations because the priority of storing surplus flows is directed to surface storage. The year-to-year groundwater operation is illustrated in Figure 6.7-2. Due to the coincidence of Eastside tributary surplus flows and other fortunate hydrologic circumstances during the later third of the study period, a groundwater balance amounting to about 1,750,000 acre-feet accrues by the end of the study. During the middle portion of the study period, assumed resources, demands, and operation protocols result in a generally balanced groundwater operation. The early portion of the study period is plagued by a drought period that did not provide an opportunity to divert flows to groundwater storage and an assumption that a positive or zero balance must be maintained; thus, very little groundwater could be extracted. Had an initial balance been assumed, groundwater would have been extracted during this period.

Purchases: After all other assets are exercised, remaining shortages are met with Category 3 and Residual purchases. An annual average of 45,000 acre-feet of purchases is required. Of this quantity, an annual average of 44,000 acre-feet is Category 3 purchases. Figure 6.7-3 illustrates the year-to-year purchases for this scenario. The purchases are generally required during water-short years when groundwater assets have become limited. Figure 6.7-4 and Figure 6.7-5 further illustrate the occurrence of Category 3 and Residual purchases in relation to San Joaquin River unimpaired runoff. As can be seen in these figures, these purchases sporadically occur during periods that are below-average runoff years; however, purchases are not needed in all drier years.

Releases from Friant Dam: Restoration flow requirements are met, with the annual average required release amounting to 466,000 acre-feet, inclusive of 117,000 acre-feet of releases required for current downstream need. In addition to minimum releases, spills occasionally occur from Millerton Lake (an annual average of 163,000 acre-feet). The increased storage capacity in addition to now-available groundwater banking potential reduces spills to the lower San Joaquin River in comparison to configurations that do not include additional storage.

Millerton Lake Storage: The availability of Fine Gold Reservoir as a pumped-storage component allows flexibility in the maintenance of storage in Millerton Lake during periods following the filling of Fine Gold Reservoir. The combined storage between the two reservoirs allows discretion for where the storage is located. The protocol used to store water (pumped from Millerton Lake and occurring from local runoff of Fine Gold Creek) is based on the protocol (trigger) used to store water to groundwater in Bundle D (enlarged Millerton Lake and Mammoth Pool). The protocol developed in Bundle D attempts to maximize Millerton Lake carryover storage and minimize spill. Bundle E builds on that relationship and places Fine Gold Reservoir as the priority location for storing water from Millerton Lake. Storing water to groundwater is deferred until the full potential of storing water to Fine Gold Reservoir is exhausted. The priority for using water from Fine Gold Reservoir is similarly linked to the protocol created for groundwater use in Bundle D. In Bundle E, water is released from Fine Gold Reservoir (in concept) prior to water being pumped from groundwater. In most circumstances, groundwater pumping occurs coincidentally with the release of water from Fine Gold Reservoir.

Storage in Fine Gold Reservoir is dependent on local inflow and pumping from Millerton Lake. Pumping from Millerton Lake occurs during a third of the years, while there will be storage above minimum pool in Fine Gold Reservoir about 60 percent of the time. Fine Gold Reservoir could be at maximum or minimum pool any month of the year, and could be empty or full for several years in a row. Its operation is primarily dependent on the sequential occurrence of hydrology. Average Millerton Lake storage is 349,000 acre-feet in this configuration, and its operation is similar to the Bundle D operation. The reservoir still experiences extended periods when storage does not appreciably exceed 300,000 acre-feet. Fine Gold Reservoir (after use during the early years of a drought) does not provide relief to Millerton Lake storage during the later years of a drought. Figures 6.7-6 and 6.7-7 illustrate results regarding Millerton Lake storage levels for this scenario. Specifically, Figure 6.7-6 depicts Millerton Lake storage for the end of June, and Figure 6.7-7 depicts the combined storage of Millerton Lake and Fine Gold Reservoir at the end of June.

6.7.2 Case Y with Existing Channel – Operations and Water Supply

Use of Eastside Tributary Flows: An annual average of 94,000 acre-feet of Eastside tributary surplus flows is again diverted into bundle components by way of the Friant-Kern Canal pump-in facilities. The availability and diversion of this water is described in Section 6.3.2.

Mendota Pool and Delta Recirculation: Water is captured and recirculated at Mendota Pool and the SWP/CVP Delta pumping plants. Consistent with all the Bundles that recirculate water at Mendota Pool and the Delta, an annual average of 41,000 acre-feet of water offsets Mendota Pool water user demands and another annual average of 86,000 acre-feet of water is recirculated at the SWP/CVP Delta pumping plants. Of the annual average of 127,000 acre-feet of recirculated water, a majority (an annual average of 83,000 acre-feet) occurs on a pattern coincidental with available conveyance capacity and Friant-Kern Canal direct-use demands or available Eastside groundwater storage capacity. Even with the decrease in spills below Millerton Lake the recirculation operation does not change. This circumstance indicates that modifying the occurrence of spills does not change the recirculation operation, likely because Millerton Lake spills occur during periods when recirculation is not allowed (e.g., during April

Figure 6.7-2 Groundwater Operation -- Case X, Modified Channel

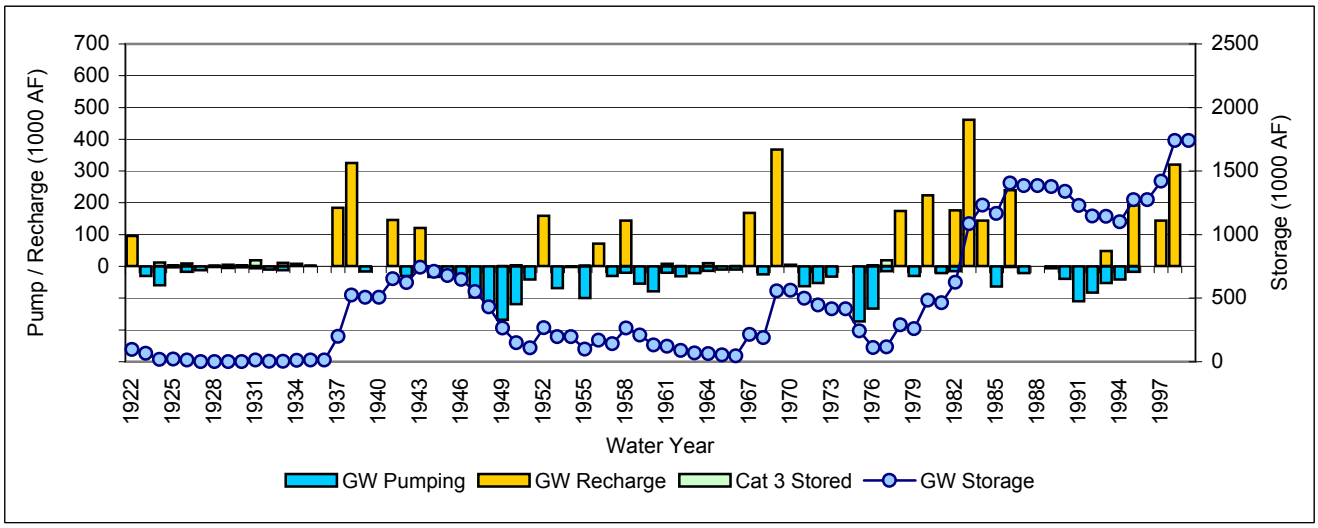

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Figure 6.7-3 Water Purchases -- Case X, Modified Channel

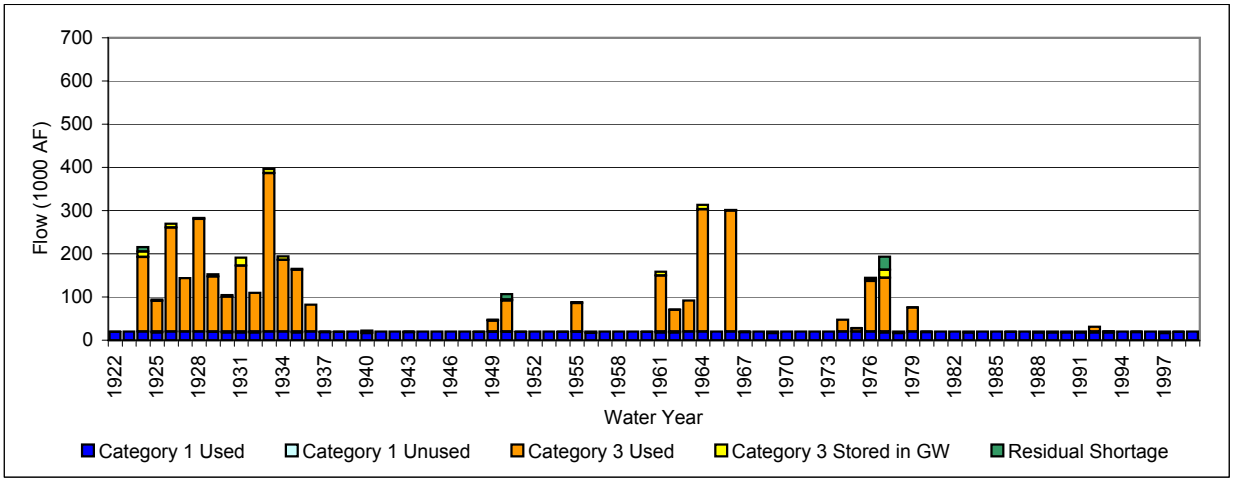

Figure 6.7-4 Category 3 Purchases -- Case X, Modified Channel

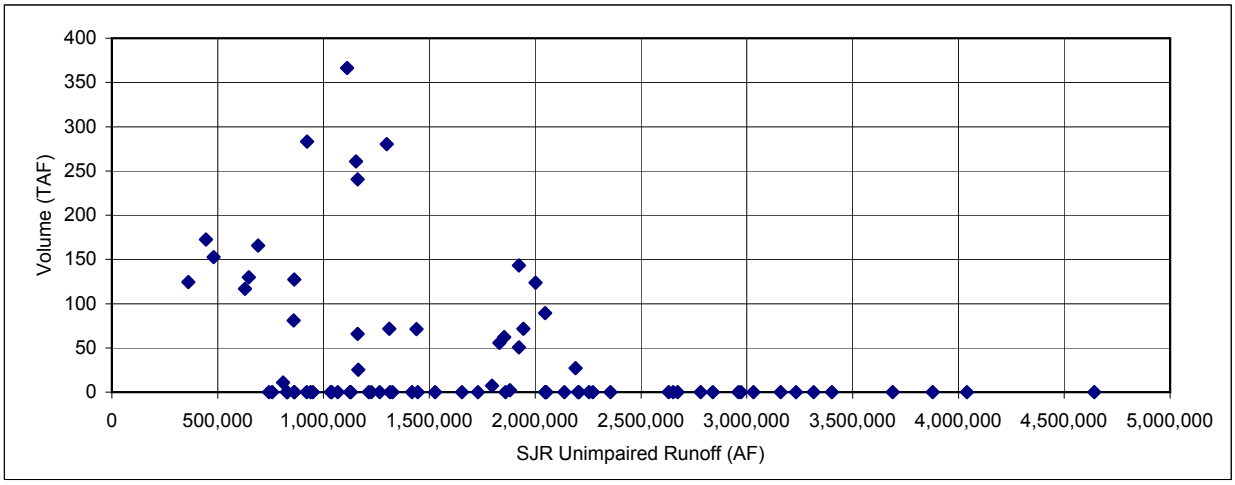

Figure 6.7-5 Residual Purchases -- Case X, Modified Channel

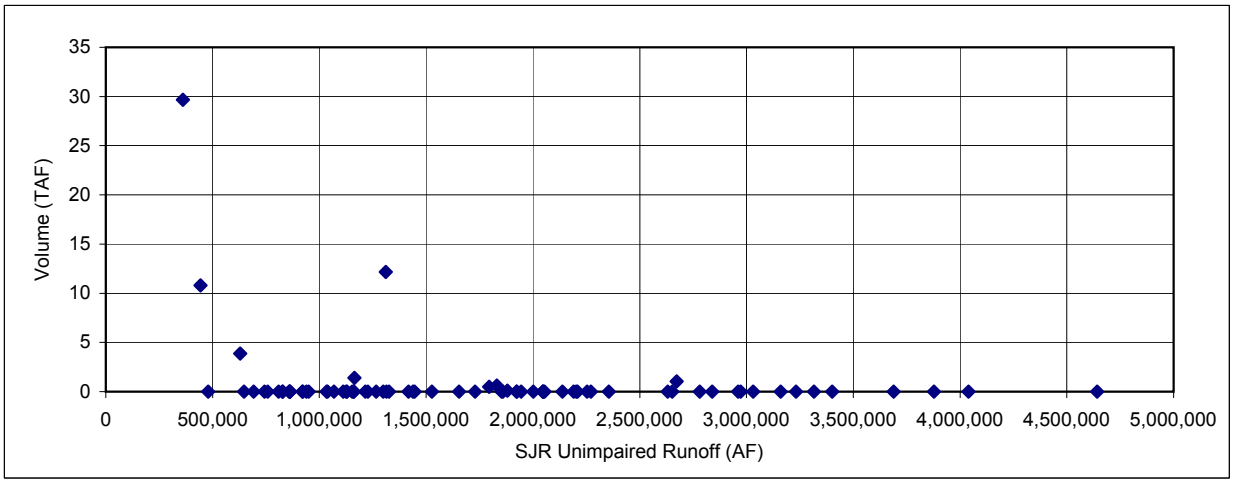

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Figure 6.7-6 Millerton Lake Storage -- Case X, Modified Channel

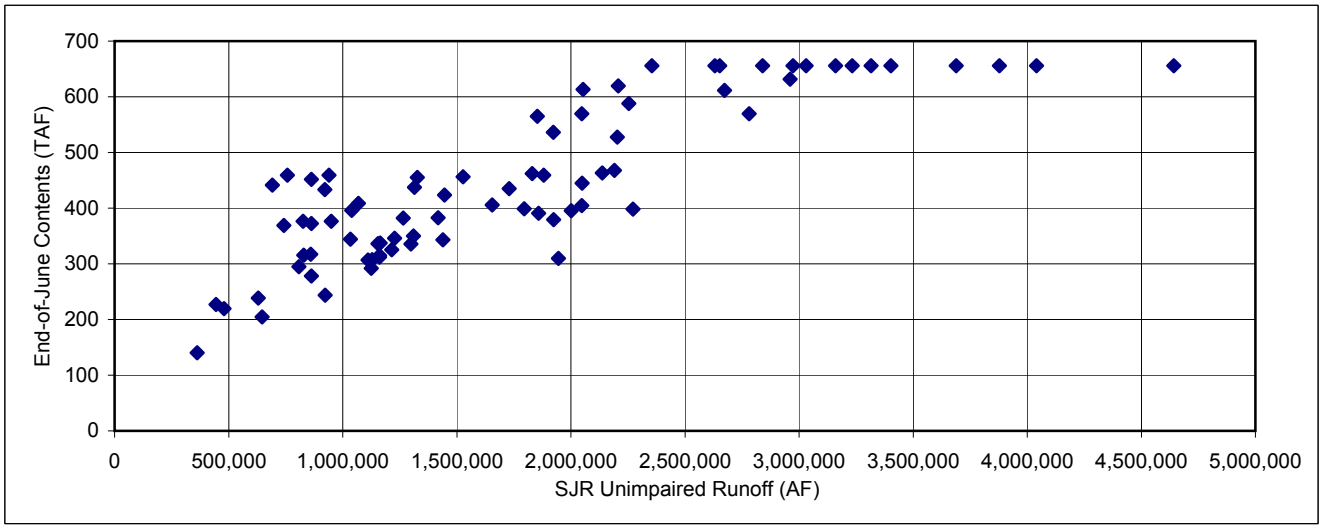
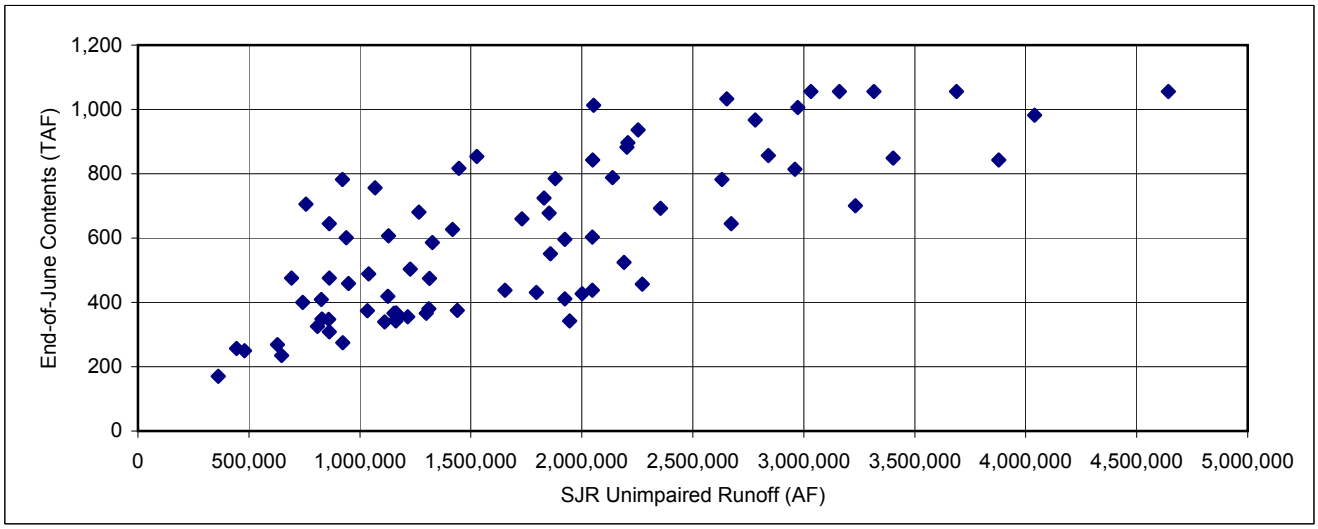


Figure 6.7-7 Millerton Lake and Fine Gold Reservoir Combined Storage -- Case X, Modified Channel



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and May). The monthly and annual pattern of the recirculation flows are illustrated in Section 6.4.2.

Groundwater Storage: An annual average groundwater banking of 62,000 acre-feet and an annual average extraction of 26,000 acre-feet occur with this bundle. Groundwater banking is reduced relative to the other comparable storage configurations because the priority of storing surplus flows is directed to surface storage. The year-to-year groundwater operation is illustrated in Figure 6.7-8. Due to the coincidence of Eastside tributary surplus flows and other fortunate hydrologic circumstances during a brief period early in the study period and during the later third of the study period, a groundwater balance amounting to about 3,000,000 acre-feet accrues by the end of the study. During the middle portion of the study period, assumed resources, demands, and operation protocols result in a generally balanced groundwater operation. The early portion of the study period is plagued by a drought period that did not provide an opportunity to divert flows to groundwater storage and an assumption that a positive or zero balance must be maintained; thus, very little groundwater could be extracted. Had an initial balance been assumed, groundwater would have been extracted during this period.

Purchases: After all other assets are exercised, remaining shortages are met with Category 3 and Residual purchases. An annual average of 20,000 acre-feet of purchases is required. Of this quantity, an annual average of 19,000 acre-feet is Category 3 purchases. Figure 6.7-9 illustrates the year-to-year purchases for this scenario. The purchases are minimal and are mostly required during the water-short years when groundwater assets were limited (the first drought period of the study). Figure 6.7-10 and Figure 6.7-11 further illustrate the occurrence of Category 3 and Residual purchases in relation to San Joaquin River unimpaired runoff. As can be seen in these figures, these purchases sporadically occur during periods that are below-average runoff years; however, purchases are not needed in all drier years.

Releases from Friant Dam: Restoration flow requirements are met, with the annual average required release amounting to 562,000 acre-feet, inclusive of 117,000 acre-feet of releases required for current downstream need. In addition to minimum releases, spills occasionally occur from Millerton Lake (an annual average of 156,000 acre-feet). The increased storage capacity in addition to now-available groundwater banking potential reduces spills to the lower San Joaquin River in comparison to configurations that do not include additional storage.

Millerton Lake Storage: The availability of Fine Gold Reservoir as a pumped-storage component allows flexibility in the maintenance of storage in Millerton Lake during periods following the filling of Fine Gold Reservoir. The combined storage between the two reservoirs allows discretion for where the storage is located. The protocol used to store water (pumped from Millerton Lake and occurring from local runoff of Fine Gold Creek) is based on the protocol (trigger) used to store water to groundwater in Bundle D (enlarged Millerton Lake and Mammoth Pool). The protocol developed in Bundle D attempts to maximize Millerton Lake carryover storage and minimize spill. Bundle E builds on that relationship and places Fine Gold Reservoir as the priority location for storing water from Millerton Lake. Storing water to groundwater is deferred until the full potential of storing water to Fine Gold Reservoir is exhausted. The priority for using water from Fine Gold Reservoir is similarly linked to the protocol created for groundwater use in Bundle D. In Bundle E, water is released from Fine Gold Reservoir (in concept) prior to water being pumped from groundwater. In most circumstances, groundwater pumping occurs coincidentally with the release of water from Fine Gold Reservoir.

Storage in Fine Gold Reservoir is dependent on local inflow and pumping from Millerton Lake. Pumping from Millerton Lake occurs during approximately 40 percent of the years, while there is storage above minimum pool in Fine Gold Reservoir about 70 percent of the time. Fine Gold Reservoir could be at maximum or minimum pool any month of the year and could be empty or full for several years in a row. Its operation is primarily dependent on the sequential occurrence of hydrology. Average Millerton Lake storage is 366,000 acre-feet in this configuration, and its operation is similar to the Bundle D operation. The reservoir still experiences extended periods when storage does not appreciably exceed 300,000 acre-feet. Fine Gold Reservoir (after use during the early years of a drought) does not provide relief to Millerton Lake storage during the later years of a drought. Figures 6.7-12 and 6.7-13 illustrate results regarding Millerton Lake storage levels for this scenario. Specifically, Figure 6.7-12 depicts Millerton Lake storage for the end of June, and Figure 6.7-13 depicts the combined storage of Millerton Lake and Fine Gold Reservoir at the end of June.

6.7.3 Technical Concerns

Because all of the Bundle A and Bundle D components are included in Bundle E, all of the technical and constructability issues described previously for Bundles A and D components apply to Bundle E. The following additional issue also applies: Fine Gold Reservoir. This component consists of constructing a new dam on Fine Gold Creek at its confluence with Millerton Lake. The dam would be approximately 440 feet high, with 400,000 acre-feet of storage. As with the other storage alternatives, only conceptual engineering work has been performed. No geotechnical site investigation or detailed engineering work has been performed. In addition, development of this component includes several assumptions that could affect costs/constructability. First, there are no provisions for a separate emergency spillway. Rather, because of the small drainage basin and large size of reservoir, it has been assumed that the combination of outlet facility and reserve storage can contain the design flood. Second, it has been assumed that construction and operating costs balance potential pump storage benefits for development of the outlet facilities and an underground powerhouse. The major technical and constructability risks are those associated with developing a dam and outlet facility at this site for the estimated cost given these major assumptions.

6.7.4 Institutional Challenges

The challenges induced by changes to the Millerton Lake or Mammoth Pool facilities would be the same as those described for Bundle D. Additional challenges would be associated with the construction of Fine Gold Reservoir, including water rights and environmental documentation. Operation protocols concerning the collective operation of Millerton Lake, Mammoth Pool, and Fine Gold Reservoir would likely require a balancing of benefits.

Issues concerning recirculation at SWP/CVP Delta facilities and diversion of Eastside tributary surplus flows to the Friant-Kern Canal are the same as previously described.

Figure 6.7-8 Groundwater Operation -- Case Y, Existing Channel

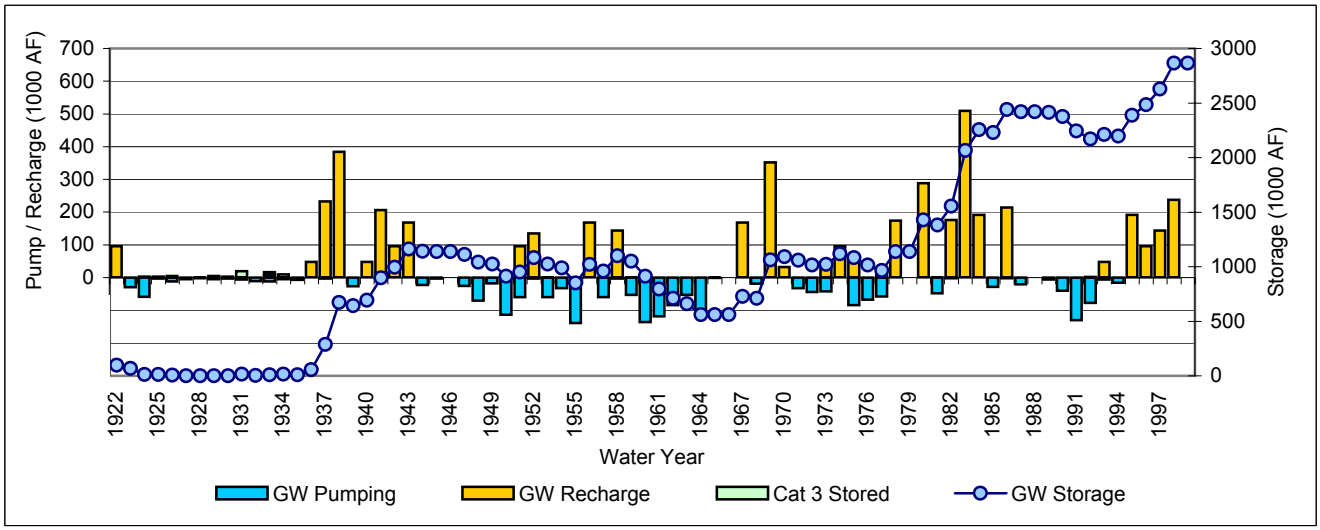

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Figure 6.7-9 Water Purchases -- Case Y, Existing Channel

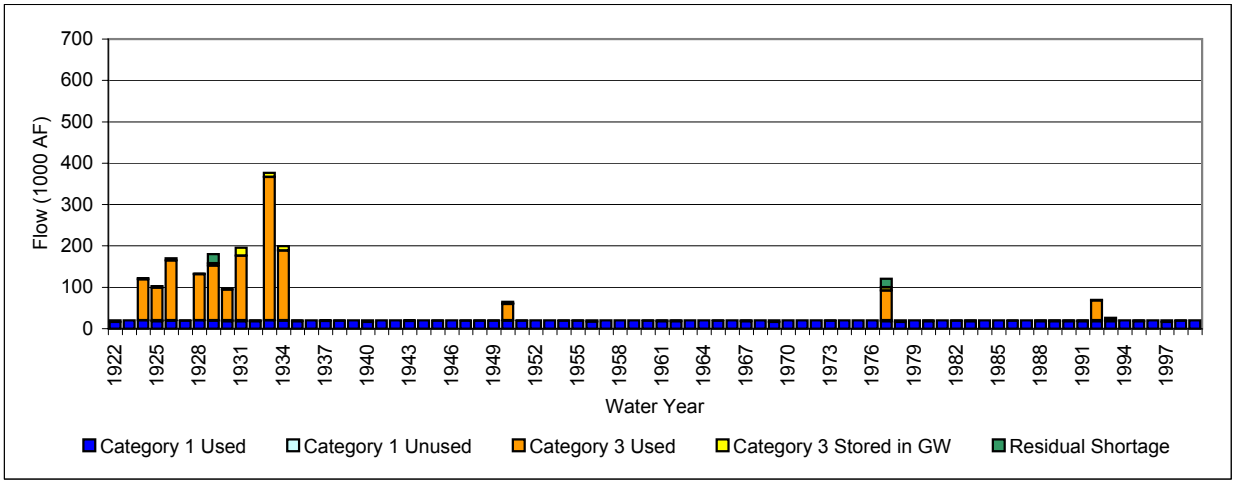

Figure 6.7-10 Category 3 Purchases -- Case Y, Existing Channel

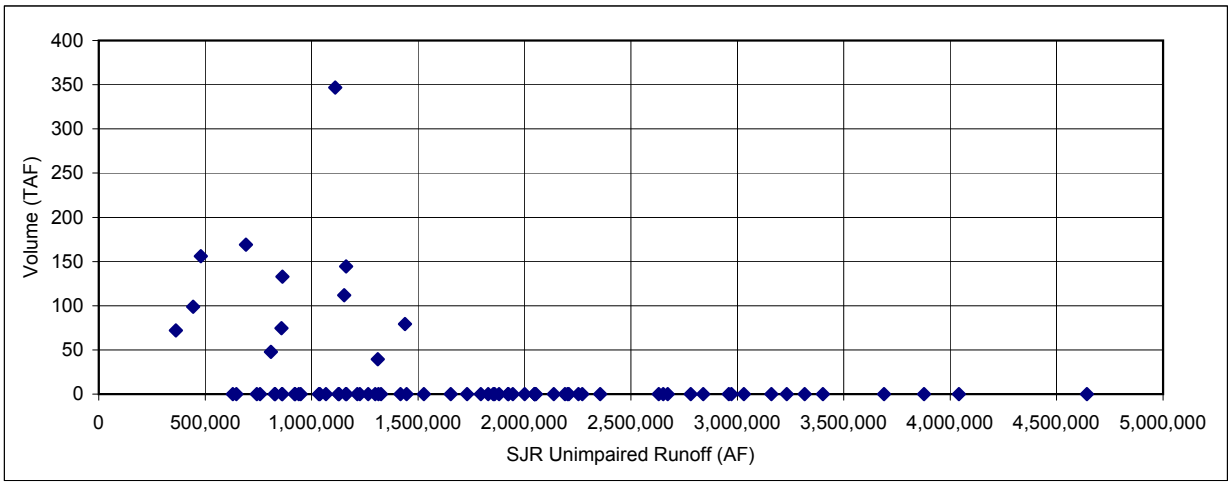

Figure 6.7-11 Residual Purchases -- Case Y, Existing Channel

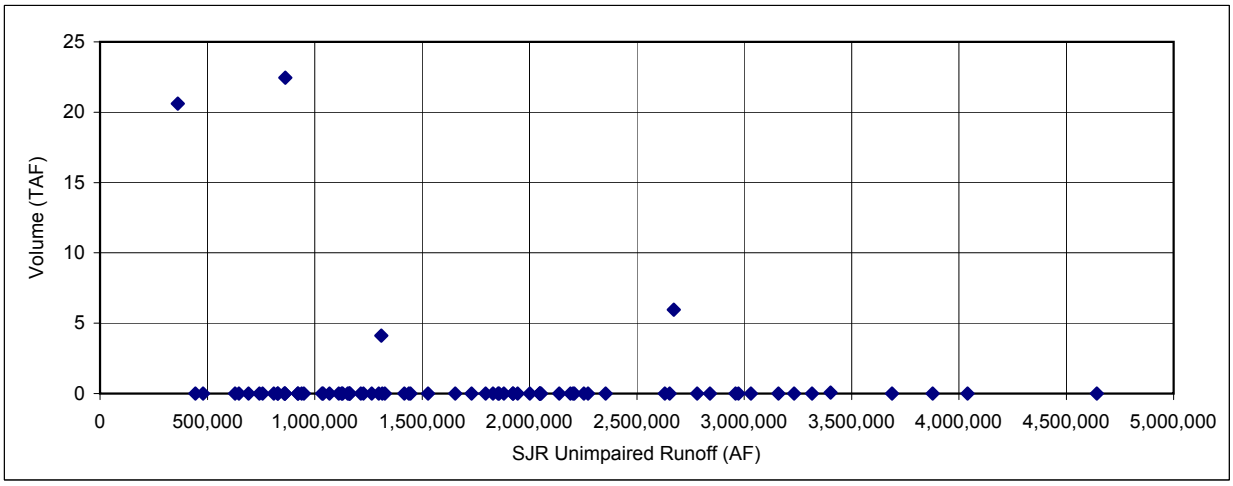

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Figure 6.7-12 Millerton Lake Storage -- Case Y, Existing Channel

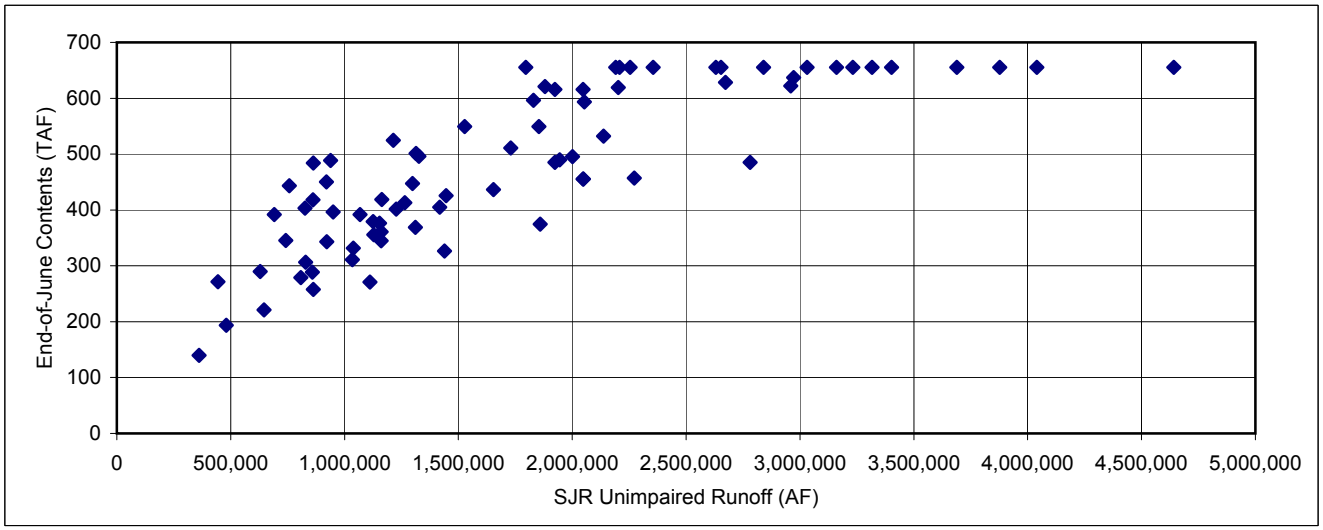
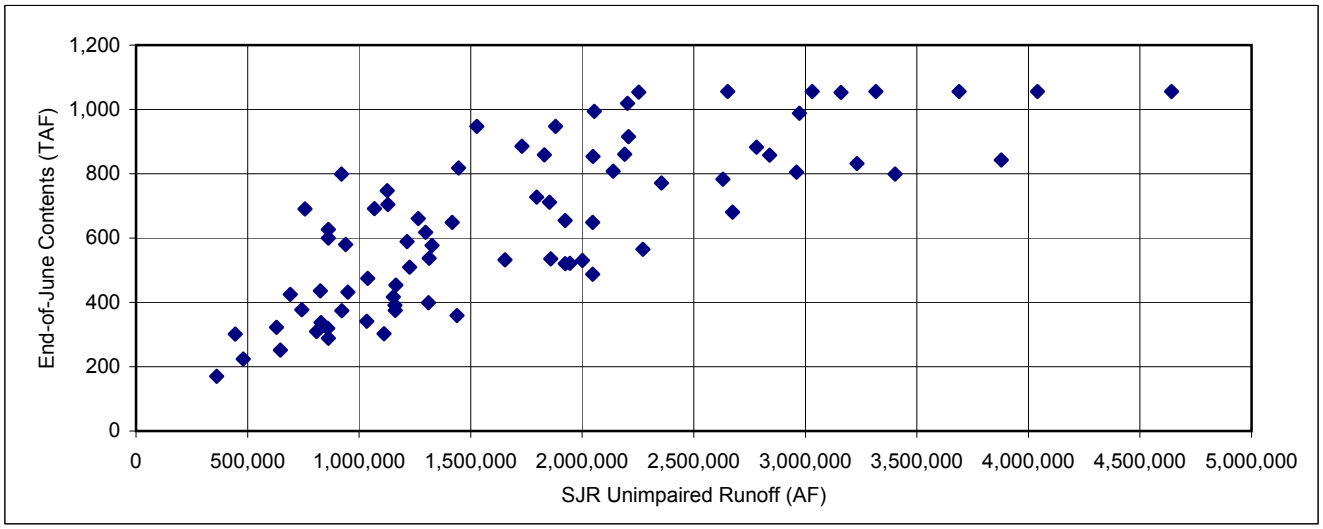


Figure 6.7-13 Millerton Lake and Fine Gold Reservoir Combined Storage -- Case Y, Existing Channel



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6.7.5 Environmental Concerns

6.7.5.1 Water Quality

Bundle E is expected to have similar water quality effects as Bundle D.

6.7.5.2 Land Use

Bundle E would be similar in terms of its operation to that discussed under Bundle D with additional storage upstream of Millerton Lake in the form of Fine Gold Reservoir. The proposed dam would be located in Madera County and would be constructed just upstream of the junction of Fine Gold Creek with Millerton Lake.

The area in the vicinity of the proposed dam is primarily composed of native vegetation (California Department of Water Resources 1998). According to the Madera County General Plan, the Fine Gold Creek area is in the Foothills region of the county (Madera County General Plan 1995). This region is used for grazing and, increasingly, for urban land uses. Extensive agriculture (irrigated pasture, grazing, and animal husbandry) is a major land use in the county. The duration of this activity is somewhat fluid and dependent on the availability of suitable grazing areas, vegetation, and climatic conditions (e.g., availability of water).

Although effects will vary depending on the exact location of the dam and inundation area, the private landowners on the west side of the creek could be affected by the implementation of this alternative project component. There currently are residences located in the Hidden Lakes Estates, and approximately 1,400 undeveloped acres were recently purchased by a developer along the northern shores of Millerton Lake and surrounding Fine Gold Creek. This area could be inundated by a 400,000 acre-foot reservoir depending on the location of the dam. Road 210 could be inundated.

6.7.5.3 Biological Resources

Fine Gold Reservoir would inundate up to approximately 5.5 miles of Fine Gold Creek, potential habitat for the western pond turtle. The western pond turtle, a state and federal species of concern, has been observed and recorded within half a mile of Fine Gold Reservoir. The habitat of this species includes streams, large rivers, and slow-moving water. These turtles frequently bask on large rocks and boulders in this area.

As discussed under Bundle D, the amount and types of impact mitigation required for a project involve consultation with the USFWS and the CDFG. Although mitigation is suggested for some federal or state species of concern, mitigation is typically only required for federally listed species. Determinations for mitigation of special status species depend on the quality of habitat, including the size of the area, the numbers of special status species that use the habitat, and how that habitat is used.

6.7.5.4 Cultural Resources

Construction of the Fine Gold Dam would affect all cultural resources within the inundation area of the new reservoir, along any newly constructed roads, and in areas where any new

construction takes place, including laydown areas. The recorded sites in the area are few in number. This paucity of sites likely reflects a lack of cultural resource inventories within the area rather than the absence of historic or prehistoric resources. Data from the nearby Millerton Lake show that Native Americans used this area extensively, especially near the water's edge. The same is likely true within the proposed inundation area for the Fine Gold Dam, where a few natural creeks exist. Of the six known sites in the inundation area, most are large camps consisting of multiple bedrock mortars, lithic scatters, and midden soils. Three of the sites have a known subsurface component. One large historic site with built environment features also exists.

Due to the lack of previous studies in the area, the large inundation and construction area, and a high potential to discover numerous other prehistoric camp sites in the APE, this alternative is highly sensitive and likely to have direct physical impacts on numerous cultural resources. If, as appears to be the case, few cultural resource surveys have been conducted in this area, this alternative may be a significant undertaking involving extensive surveying, site recordation, testing, and assessment.

6.8 BUNDLE CONFIGURATION MODIFICATION AND SENSITIVITY

Several potential modifications to the bundle configurations are evaluated. An additional recirculation facility located along the San Joaquin River is evaluated to complement or replace Delta recirculation. Also, an intertie between the Merced River system and the Friant system is evaluated to investigate the opportunity of using Merced River water within the Madera Canal service area. A third evaluation investigates the effect of not utilizing Eastside tributary surplus flows.

6.8.1 Patterson Pumping Facility

Recirculation of restoration flows and surplus flows is a key element of each bundle. Analyses show that an annual average of 39,000 to 44,000 acre-feet of flow is recirculated at Mendota Pool. When SWP/CVP recirculation is added to the configurations, an additional annual average of 74,000 to 93,000 acre-feet of recirculation can occur. Because of the uncertainties in the amount of SWP/CVP Delta pumping capacity available for the Study, an alternative recirculation facility is evaluated. Specifically, a pumping and conveyance facility (500 cfs) near the community of Patterson (exact site undetermined) is considered as a potential alternative or complement to the SWP/CVP pumping to convey water from the San Joaquin River to the Westside facilities of the SWP/CVP. The 500 cfs size was established from information learned during the gaming sessions. Refinement of this value may be needed in future evaluations. The same flow bypass rules assigned to recirculation at Mendota Pool are assumed for the Patterson facility.

As an alternative to SWP/CVP Delta pumping, the Patterson recirculation component provides a near-functional equivalent to the volume pumped at the Delta facilities. Based on a modification to the configuration of Bundle A (Modified Channel/Case X Demand scenario), Patterson adds 102,000 acre-feet of capture and recirculation water to that already recirculated at Mendota Pool. As a complement to Delta pumping and Mendota Pool recirculation, the facility improves recirculation by an annual average of 68,000 acre-feet of water.

Additional information learned during the gaming sessions led to an assumption to increase the capacity of conveyance through the Cross Valley Canal. This additional capacity reduced the constraints that would occur when conveying water to the Friant Division demand centers from the Westside. This configuration sensitivity analysis includes a component to expand the Cross Valley Canal by 337 cfs. Together with assumed unused existing capacity, this assumption provides a minimum of 500 cfs west-to-east conveyance capacity in a month.

The occurrence of additional recirculation has an influence on the operation of other components of each bundle. Table 6-15 shows the results of the configuration sensitivity analyses as they affect Bundle A, assuming the Modified Channel/Case X Demand scenario. The results show the incremental differences in recirculation (at Mendota Pool, Delta, and Patterson) as different combinations of those components are assumed. The configuration sensitivity analysis was also performed for Bundles B, C, D, and E assuming the Modified Channel/Case X Demand scenario. These bundles already incorporate recirculation at the Delta. Table 6-16 shows the results of adding Patterson recirculation to the Mendota Pool and Delta recirculation for these bundles.

Table 6-15
Bundle A Modification Sensitivity (Delta and Patterson Recirculation)
Operational and Economic Results (Modified Channel/Case X Demand Scenario)

		Mendota Pool with		
Parameter (Annual Average values, 1,000 acre-feet unless otherwise noted)	**Mendota Pool Only**	**Only Delta**	**Only Patterson**	**Delta plus Patterson**
Total Purchases	173	109	108	60
Category 1 Purchases	20	20	20	20
Category 2 Purchases	124	66	66	0
Category 3 Purchases	26	22	21	38
Residual Purchase	3	1	1	2
Levelized Groundwater Residual Balance	34	38	45	44
Levelized California Aqueduct Account	16	18	20	19
Total Release to San Joaquin River	648	655	666	665
Average Annual Spill	182	189	200	200
Total Eastside GW Recharge	90	96	102	106
Total Eastside GW Extraction	62	60	58	63
Total Diversion of Tributary Surplus into FKC	91	91	91	91
Recaptured Water for Recirculation	41	121	143	189
Recirculation at Patterson	Not Applicable	Not Applicable	102	102
Recirculation at Delta	Not Applicable	80	Not Applicable	46
Recirculation at Mendota Pool	41	41	41	41
Total CVC	39	114	134	179
Madera Canal Diversion	242	256	257	264
Friant-Kern Canal Diversion	846	824	812	798
Fixed Costs ($1,000)	$3,358	$3,358	$9,857	$13,771
GW Put Charge ($1,000)	$16,280	$17,529	$18,509	$19,209
Wheeling Costs ($1,000)	$225	$678	$709	$968
Pumping Energy ($1,000)	$2,943	$5,698	$6,425	$8,229
Generation Sales ($1,000)	($1,906)	($2,140)	($2,232)	($2,261)
Category 1 Purchases ($1,000)	$6,500	$6,500	$6,500	$6,500
Category 2 Purchases ($1,000)	$29,978	$18,926	$18,926	$0
Category 3 Purchases ($1,000)	$6,141	$5,172	$5,068	$9,816
Residual Purchases ($1,000)	$760	$271	$388	$475
Offset for GW Residual Storage ($1,000)	($6,192)	($6,887)	($8,153)	($7,886)
Total Average Annual Net Cost ($1,000)	$58,087	$49,106	$55,998	$48,821

Table 6-16
Bundle Configuration Sensitivity (Patterson) - Operational and Economic Results
(Page 1 of 2)

	Bundle B Delta Recirculation Millerton Dead Pool		Bundle C Tulare Lakebed Storage		Bundle D Millerton Enlargement Mammoth Pool		Bundle E Millerton/Mammoth Fine Gold Reservoir	
Parameter (Annual Average values, 1,000 acre-feet unless otherwise noted)	**No Patterson**	**With Patterson**	**No Patterson**	**With Patterson**	**No Patterson**	**With Patterson**	**No Patterson**	**With Patterson**
Total Purchases	72	43	89	55	73	46	65	43
Category 1 Purchases	20	20	20	20	20	20	20	20
Category 2 Purchases	0	0	0	0	0	0	0	0
Category 3 Purchases	51	23	65	32	52	25	44	22
Residual Purchase	1	0	4	3	1	1	1	1
Levelized Groundwater Residual Balance	23	39	38	51	27	44	22	39
Levelized California Aqueduct Account	18	20	18	19	18	20	18	20
Total Release to San Joaquin River	636	655	646	664	629	647	614	638
Average Annual Spill	170	189	180	198	163	182	148	172
Total Eastside GW Recharge	74	91	89	110	68	84	50	60
Total Eastside GW Extraction	52	53	53	60	43	40	29	21
Total Diversion of Tributary Surplus into FKC	91	91	91	91	91	91	91	91
Recaptured Water for Recirculation	121	189	121	189	121	189	121	189
Recirculation at Patterson	0	102	0	102	0	102	0	102
Recirculation at Delta	80	46	80	46	80	46	80	46
Recirculation at Mendota Pool	41	41	41	41	41	41	41	41
Total CVC	114	178	120	185	114	178	114	179
Tulare Lakebed Disposition to CVC	Not Applicable	Not Applicable	7	7	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Total Tulare Lakebed Return to ES Exchanges	Not Applicable	Not Applicable	10	10	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Project Tributary Flow to Tulare Lakebed	Not Applicable	Not Applicable	23	23	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Fine Gold Reservoir Pump-in	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	32	31
Fine Gold Reservoir Release	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	51	48

Table 6–16
Bundle Configuration Sensitivity (Patterson) - Operational and Economic Results
(Page 2 of 2)

	Bundle B Delta Recirculation Millerton Dead Pool		Bundle C Tulare Lakebed Storage		Bundle D Millerton Enlargement Mammoth Pool		Bundle E Millerton/Mammoth Fine Gold Reservoir	
Parameter (Annual Average values, 1,000 acre-feet unless otherwise noted)	**No Patterson**	**With Patterson**	**No Patterson**	**With Patterson**	**No Patterson**	**With Patterson**	**No Patterson**	**With Patterson**
Madera Canal Diversion	260	268	260	269	260	269	261	268
Friant-Kern Canal Diversion	843	813	833	805	845	816	848	814
Fixed Costs ($1,000)	$7,995	$18,408	$8,004	$18,417	$12,347	$22,760	$47,083	$57,496
GW Put Charge ($1,000)	$13,447	$16,563	$16,040	$19,855	$12,465	$15,190	$9,225	$10,905
Wheeling Costs ($1,000)	$678	$968	$678	$968	$678	$968	$678	$968
Pumping Energy ($1,000)	$5,837	$8,170	$5,657	$8,363	$5,249	$7,569	$4,876	$7,104
Generation Sales ($1,000)	$1,902	$2,111	$2,083	$2,256	$2,212	$2,386	$2,243	$2,441
Category 1 Purchases ($1,000)	$6,500	$6,500	$6,500	$6,500	$6,500	$6,500	$6,500	$6,500
Category 2 Purchases ($1,000)	$0	$0	$0	$0	$0	$0	$0	$0
Category 3 Purchases ($1,000)	$14,663	$6,047	$17,510	$8,239	$14,884	$6,493	$12,728	$5,741
Residual Purchases ($1,000)	$152	$139	$839	$812	$274	$289	$216	$252
Offset for GW Residual Storage ($1,000)	$4,213	$6,975	$6,869	$9,211	$4,798	$7,995	$4,013	$7,053
Total Average Annual Net Cost ($1,000)	$43,187	$47,710	$46,227	$51,688	$45,386	$49,389	$75,050	$79,472

6.8.1.1 Technical Concerns

For the Patterson facility, concerns arise regarding the design and operation of fish screens to mitigate potential environmental impacts. Both physical design issues and regulatory permitting issues will be key issues in facility approval. Protocols will be required for operation of the facilities. The quality of the water pumped from the San Joaquin River, as pumped into the Delta-Mendota Canal or California Aqueduct, may also be an issue.

Other technical and constructability issues associated with this component are described below:

- Patterson Facility. Patterson recirculation involves construction of a major new pumping facility on the San Joaquin River and conveyance of the recirculated water approximately four miles to the Delta-Mendota Canal (DMC). It is assumed that an alignment following an existing turnout or wasteway connecting the DMC to a nearby distribution canal or to the river can be used to minimize issues associated with construction of the conveyance pipeline. Other than the previously described fish screen concerns, no special technical or constructability issues are expected with the pipeline or the new pumping facility.
- Cross Valley Canal Improvements. This component includes increasing the size of the pumps at the six lift stations along the Cross Valley Canal, installing larger (or additional) siphons at some roadway crossings, and raising the canal liner to accommodate the increased capacity. No engineering design has been performed as part of this analysis. However, given that this component involves relatively minor improvements to an existing facility, no serious technical or constructability issues are expected to preclude construction of this component.

6.8.1.2 Institutional Challenges

Challenges can also be anticipated for the development of an additional diversion facility upstream of the Delta. Historically, attempts to bypass the Delta with peripheral conveyance facilities have encountered resistance. The San Joaquin River is currently listed as an impaired water body under Section 303(d) of the Clean Water Act. A SWRCB process is currently under way to establish a TMDL for salt and boron and to implement an existing TMDL for selenium. Although on face value the addition of relatively clean Eastside source water by way of restoration flows from Friant appears to be an improvement to current water quality problems, extraction of a portion of the improved flow prior to the Delta may be fraught with entanglements. At the least, permitting such a diversion may be delayed until a comprehensive solution to the river's restoration is accomplished.

6.8.1.3 Environmental Concerns

Water Quality

Recirculation of San Joaquin River flows has the potential to recirculate the salts and pesticides that flow to the river from nonpoint sources. Continuous recirculation would concentrate these constituents. However, if recirculation is performed during surplus flow conditions, the potential for concentrating salts and other constituents is reduced.

Land Use

Under the bundle configuration sensitivities, recirculation at the SWP/CVP Delta facilities is proposed as well as the addition of a Patterson recirculation component. With this option, pumps would be established to provide the recirculation. The potential sites for locating the Patterson pumps are in northern Stanislaus County, either just south of the town of Patterson or northwest of the small towns of Westley and Grayson. The land near Westley and Grayson as well as near Patterson has been used primarily to grow field crops, hay and grain crops, and truck, nursery, and berry farms (California Department of Water Resources 1998).

The major portion of Stanislaus County is productive and potentially productive agricultural land. The agricultural land use designation is intended for areas of land that are presently or potentially desirable for agricultural usage, typically areas with location, topography, parcel size, soil classification, water availability, and adjacent usage that provide a favorable agricultural environment. This designation establishes agriculture as the primary land use but allows dwelling units, limited agriculturally related commercial services, agriculturally related light industrial uses, and other uses that are not compatible with urban uses, provided they do not conflict with the primary use.

If the potential location for the Patterson pumps is near Westley or Grayson, it would most likely follow the existing West Stanislaus Main Canal from the San Joaquin River to the Delta-Mendota Canal. A separate system could be built or the current system could be enlarged to accommodate the recirculated water. If the pump location were to be near Patterson, the pumps would be located along the Main Canal to Patterson and then follow an as-yet-undetermined route from Patterson to the Delta-Mendota Canal. It would be desirable to locate this route along an existing developed line, such as a road or lateral. The land south of Patterson is in agricultural production, and because the pumps would be augmenting water supply in the area, the addition of the pumps would be a compatible use with agriculture.

Biological Resources

In addition to the fish passage issues at Mendota Pool described for the bundles, there presently are no facilities at Patterson for such an activity. New pumps, fish screens, and a conveyance system would need to be constructed to connect the pumps to the DMC. These facilities would require footprints along the San Joaquin River in the vicinity of Patterson.

Assessment of any impacts to biological resources due to the development of an aboveground pump facility for the Patterson pumps would include:

- A site visit to assess the available habitats within the project area as well as which habitats and special-status species could potentially be impacted by the project;
- A species search of the CNDDB within a 10-mile radius of the project area; and
- A formal species list from the U.S. Fish and Wildlife Service for the USGS 7.5 minute quadrangle in which the project lies as well as the 8 quadrangles adjacent to it.

In the event of potential impacts to special-status species, surveys or further assessment of the habitat would be conducted at the site, and appropriate mitigation measures would be implemented.

Cultural Resources

If a new aboveground facility is built for the Patterson pumps, it would have the potential for visual and other effects to nearby historic structures and the potential for direct impacts to archaeological resources, particularly if any excavation is involved. Any significant excavation could also have the potential to affect paleontological resources. However, in the agricultural lands in the Central Valley, prehistoric sites most often are buried.

Because the alignment of the Patterson pumps is yet undetermined, flexibility can be incorporated into their placement to avoid impacts to standing structures, existing facilities, and archaeological sites. A site-specific records search would need to be conducted, and an archaeological survey of the footprint would occur. If there are standing structures, including possibly existing canals, their age would be determined, and an architectural historian might be needed to assess their significance and mitigation alternatives.

6.8.2 Merced River Intertie

A second bundle configuration modification was to evaluate the potential supply available from a Merced River intertie. A 100 cfs intertie between the Merced River Basin and the Madera Canal service area is assumed. Flows assumed surplus to the needs of the Merced and San Joaquin Rivers or required for Vernalis Adaptive Management Plan (VAMP) flows during April and May are modeled as available for conveyance to the Madera Canal service area, and subsequently provide an offset for Millerton Lake demands.

The operation of this component is modeled by first evaluating the availability of VAMP flows and surplus flows from the Merced River. The data for these parameters originate from other basin studies described in Appendix A, Section 4. When water is available, the conveyance is utilized to bring water into the Madera Canal service area. The first priority use of the water is to offset direct deliveries from the Madera Canal. If canal deliveries are not equal to the full conveyance, the water is stored in the Madera Canal groundwater basin for subsequent extraction, if needed (triggered by the Millerton Lake Storage–groundwater trigger protocol). Surplus Merced River flows are conveyed only during the months that surplus conditions to the Merced River and the San Joaquin River occur. VAMP flows required of the Merced River are assumed to be met with restoration releases from Friant. The Merced River VAMP flow offset by Friant releases is conveyed to the Madera Canal service area in the same fashion as Merced River surplus flows. Because the conveyance capacity of the intertie is limited, a portion of the VAMP flow offset by Friant releases (which normally occurs during April and May) may be temporarily stored in Exchequer Reservoir for conveyance during subsequent months.

An annual average of 33,000 acre-feet of water is conveyed into the Madera Canal service area through this component. Compared to the Modified Channel/Case X Demand scenario of Bundle B, the Merced component develops an annual average of 19,000 acre-feet of water through transfer of VAMP flows and another 14,000 acre-feet through the conveyance of Merced

River surplus flows. The majority of the conveyance (an average annual of 25,000 acre-feet) is used to offset direct deliveries from the Madera Canal, with the remaining 8,000 acre-feet regulated by the groundwater basin. The annual average of 33,000 acre-feet of water of this component represents the maximum value that could be conveyed under the assumptions of the bundle. The full amount of this water may not be entirely usable as restoration flow. Under the assumed configuration and operation of the bundle, some portion of this water may result in additional spill from Millerton Lake.

The Merced component, as configured, adds an annual cost of approximately $4,000,000 to a bundle. When added to the Modified Channel/Case X Demand Scenario, this additional cost is almost entirely offset by a reduction in water purchases. It is anticipated that circumstance will occur for any of the other bundle scenarios provided that purchases can be offset by the importation of Merced River water.

6.8.2.1 Technical Concerns

Water supply and operational issues arise for the Merced River Basin Intertie concept. The exchange of VAMP water will require protocols to ensure that water release responsibilities in the context of the San Joaquin River Agreement (SJRA) are not jeopardized. Also, the SJRA itself only covers an institutional period through 2011. The water supply responsibilities of its successor, if any, are not known at this time. Also, the availability of surplus flows from the Merced River used in this analysis are essentially based on current requirements and uses for the river. The surplus condition of the river may change in the future as additional water development occurs in the basin and as the regulatory requirements for the river change.

There is a technical and constructability issue associated with the Merced River intertie. This component includes improvements to the existing Merced Irrigation District diversion facility and approximately 20 miles of upgrades to existing canals. It also includes two pumping stations and approximately 10.5 miles of new canal to reach a point on the Chowchilla River and an additional pump station and six miles of pipeline to reach Berenda Reservoir. From this location approximately 43 percent of the demand on the Madera Canal can be serviced with up to 100 cfs to replace water that would otherwise be supplied by the Madera Canal. The institutional challenges are discussed elsewhere. No engineering design has been performed as part of this analysis. However, given the size and nature of the proposed facilities, no serious technical or constructability issues are expected to preclude construction of this component as long as political and institutional concerns can be addressed.

6.8.2.2 Institutional Challenges

There are likely to be challenges to inter-basin exchanges from the Merced River Basin to the Tulare Lake Basin for the benefit of the lower San Joaquin River, but they are difficult to quantify.

The rerouting of VAMP flows has the potential to interfere with the Merced River Adaptive Management Plan (MRAMP), currently being negotiated with the California Department of Fish and Game (CDFG) and under review by the State Water Resources Control Board. MRAMP

relies on VAMP flows in the Merced River to satisfy CDFG concerns related to flows and the consolidation of Merced Irrigation District and the El Nido Irrigation District.

6.8.2.3 Environmental Concerns

Water Quality

The 100 cfs intertie with the Merced River may influence flows in the lower Merced River and therefore could have an effect on water temperature and other water quality constituents. However, because the intertie is proposed to be operated during surplus periods, any effects would be greatly reduced. The VAMP flows are met under this bundle from restoration flows from Millerton Lake releases, and therefore the water quality of Delta inflow is expected to be maintained.

Land Use

The Merced River Basin Intertie component includes improvements to existing Merced Irrigation District (MID) canals and diversion facilities and construction of new sections of canal, pump stations, 10.5 miles of new canal, and six miles of pipeline. No engineering design has yet been proposed for this component. The proposed new facilities primarily would be in Merced County, beginning at MID's Yosemite Lake. Improvements would be made to MID's LeGrand Canal, which makes its way from Yosemite Lake south to Rascal Creek, continuing on to the Chowchilla River.

Lake Yosemite is located northeast of the city of Merced, the largest city in Merced County. While this area is currently agricultural and/or open in nature, the proposed University of California Merced Campus and University Community would be located on the southeast side of Yosemite Lake. The first phase of the campus is proposed for the existing Merced Hills Golf Course and is slated to open in 2004.

Since the alignment of the new pipeline the location of the new facilities is not yet determined, flexibility can be incorporated into their placement to avoid impacts to land use. It would be desirable to locate this route along an existing developed line, such as a road or lateral.

Biological Resources

Assessment of any impacts to biological resources due to the development of a Merced River Intertie would include:

- A site visit to assess the available habitats within the project area as well as which habitats and special-status species could potentially be impacted by the project;
- A species search of the CNDDB within a 10-mile radius of the project area; and
- A formal species list from the U.S. Fish and Wildlife Service for the USGS 7.5 minute quadrangle in which the project lies as well as the 8 quadrangles adjacent to it.

In the event of potential impacts to special-status species, surveys or further assessment of the habitat should be conducted at the site and appropriate mitigation measures should be implemented.

Water is swapped via exchange between the Merced and San Joaquin River systems. Water supplied to the San Joaquin would be withheld from the Merced. Flows not released down the Merced may impair juvenile chinook rearing on the Merced River or may, over the longer term, have detrimental effects on Merced River channel morphology and riparian corridor. Flows not released down the Merced could adversely affect the Merced River Adaptive Management Plan which provides a backstop for VAMP and the San Joaquin River Agreement.

Cultural Resources

If new aboveground facilities are built for the Merced River Basin Intertie, they would have the potential for visual and other effects to nearby historic structures and the potential for direct impacts to archaeological resources, particularly if any excavation is involved. Any significant excavation also could have the potential to affect paleontological resources. However, in agricultural lands in the Central Valley, prehistoric sites most often are buried.

Because the alignment of the new facilities and pipeline is as yet undetermined, flexibility can be incorporated into their placement to avoid impacts to standing structures, existing facilities, and archaeological sites. A site-specific records search would need to be conducted, and an archaeological survey of the footprint would occur. If there are standing structures, including possibly existing canals, their age would be determined, and an architectural historian might be needed to assess their significance and mitigation alternatives.

6.8.3 Eastside Tributary Surplus Flows

The diversion of Eastside tributary surplus flows at the Friant-Kern Canal crossings of the Kings, Kaweah, and Tule Rivers contributes an annual average of 91,000 acre-feet to the water supply of the bundles. The viability of developing this quantity of water has its obstacles, including the following issues:

- Local plans for supply
- Place of use/water rights
- Water quality (Has been issue in the Friant-Kern Canal before.)
- Other statewide interest (Can the project compete, and at what cost?)

However, including or not including the component in all of the bundles does not significantly affect the comparison of the bundles. Separate configuration sensitivity analyses of each bundle configuration show that without the Eastside tributary operation, the majority of the foregone Eastside tributary water (an annual average of 60,000 acre-feet) will be replaced by a reduction in Millerton Lake spills. This result illustrates the coincidence of Eastside tributary surplus conditions with Millerton Lake spills. If the Eastside tributary operation is not included, inflow to Millerton Lake that would otherwise spill would often be used to replace the operation of the Eastside tributary surplus flow (storage to the groundwater basins). In addition, 15,000 acre-feet

of the 91,000 acre-feet annual average are foregone from the California Aqueduct Account balance, representing the loss of the storage of Eastside tributary flow that was surplus to the direct diversion needs or storage capability of the Friant Division. The remaining annual average of 16,000 acre-feet of utilized Eastside tributary surplus would be replaced by additional purchases.

6.9 SUMMARY OF RESULTS AND OTHER CONSIDERATIONS

Each bundle configuration accomplishes the goal of providing the hypothetical restoration flow requirement while meeting baseline deliveries from the Friant Division. Each bundle relies first on new or re-operated facilities and long-term purchases (including conservation) to meet the total demand. Short-term purchases make up the difference in unmet demand, and vary for each bundle. Bundle A relies heavily on water purchases to meet the goal, while the other bundles develop water through alternative means, thus reducing reliance on water purchases. Each bundle is unique in terms of its respective physical attributes and associated costs.

Tables 6-17 through 6-20 compare the results for the bundles assuming a common channel condition and baseline demand scenario. For instance, Table 6-17 compares the bundles for the Modified Channel/Case X Demand scenario, and Table 6-20 compares the bundles for the Existing Channel/Case Y Demand scenario. The reader is cautioned not to make a comparison between a bundle in one scenario and the same bundle in a different scenario. The meaningful use of this analysis is derived from a comparison of the performance of components of one bundle to the performance of other components under the same scenario. The relative differences in component utilization among the bundles across the four scenarios is consistent. That is, the difference between the operation of Bundle A and Bundle B in one scenario will be very similar to the difference in operation found for the two bundles in another scenario. Absolute values and differences may differ slightly, but the trend in change will be the same.

The comparison of bundles requires the observance of several salient parameters:

- Water purchases are an important parameter for bundle comparisons. Water purchases other than Category 1 and Category 2 purchases are reactive to the performance of all the other components of a bundle. To the extent that these other components do not completely satisfy water demands, Category 3 and Residual purchases will fill the deficit.
- The residual balances of the groundwater basins and the California Aqueduct Account are also an indicator of the water produced by a bundle. Positive balances are an indication that the bundle created (stored) water that could not be utilized during the study period due to modeling and facility sizing limitations. This water should be considered an asset of the bundle, and with more refined analysis would be utilized or eliminated by the bundle.
- The third parameter to monitor is the average annual spill from Millerton Lake. At times the operation of a bundle leads to a different management, among the bundles, of Millerton Lake storage.

The difference in operation can lead to either less or more spills from the reservoir. Although other parameters also change among the bundles (e.g., reservoir evaporation and Millerton Lake end-of-study storage), the combined difference between three parameters, (1) total purchases, (2) residual storage, and (3) spills between bundles, describes the relative difference in water developed by one set of components as compared to another set of components.

For an illustration of the interpretation of the results, the Modified Channel/Case X Demand scenario and the Existing Channel/Case Y Demand scenario are described below.

Table 6-17
Bundle Operational and Economic Results
Modified Channel/Case X Demands

		Bundle Configuration				
	Parameter (Annual Average Values)	**A**	**B**	**C**	**D**	**E**
Quantities (1,000 acre-feet)	Total Purchases	173	72	89	73	65
	Category 1 Purchases	20	20	20	20	20
	Category 2 Purchases	124	0	0	0	0
	Category 3 Purchases	26	51	65	52	44
	Residual Purchases	3	1	4	1	1
	Levelized Groundwater Residual Balance	34	23	38	27	22
	Levelized California Aqueduct Account	16	18	18	18	18
	Total Release to San Joaquin River	648	636	646	629	614
	Average Annual Spill	182	170	180	163	148
	Total Eastside GW Recharge	90	74	89	68	50
	Total Eastside GW Extraction	62	52	53	43	29
	Diversion of Tributary Surplus into FKC	91	91	91	91	91
	Recaptured Water for Recirculation	41	121	121	121	121
	Recirculation at Delta	0	80	80	80	80
	Recirculation at Mendota Pool	41	41	41	41	41
	Total CVC	39	114	120	114	114
	Project Diversion to Tulare Lakebed	NA	NA	23	NA	NA
	Use of Tulare Lakebed Source	NA	NA	17	NA	NA
	Fine Gold Reservoir Pump-in	NA	NA	NA	NA	32
	Fine Gold Reservoir Release	NA	NA	NA	NA	51
	Madera Canal Diversion	242	260	260	260	261
	Friant-Kern Canal Diversion	846	843	833	845	848
Costs ($1,000)	Fixed Costs	$3,358	$7,995	$8,004	$12,347	$47,083
	GW Put Charge	$16,280	$13,447	$16,040	$12,465	$9,225
	Wheeling Costs	$225	$678	$678	$678	$678
	Pumping Energy	$2,943	$5,837	$5,657	$5,249	$4,876
	Generation Sales	($1,906)	($1,902)	($2,083)	($2,212)	($2,243)
	Category 1 Purchases	$6,500	$6,500	$6,500	$6,500	$6,500
	Category 2 Purchases	$29,978	$0	$0	$0	$0
	Category 3 Purchases	$6,141	$14,663	$17,510	$14,884	$12,728
	Residual Purchases	$760	$152	$839	$274	$216
	Offset for GW Residual Storage	($6,192)	($4,213)	($6,869)	($4,798)	($4,013)
	Total Average Annual Net Cost	**$58,087**	**$43,187**	**$46,227**	**$45,386**	**$75,050**

Table 6-18
Bundle Operational and Economic Results
Existing Channel/Case X Demands

		Bundle Configuration				
	Parameter (Annual Average Values)	**A**	**B**	**C**	**D**	**E**
Quantities (1,000 acre-feet)	Total Purchases	208	101	116	103	92
	Category 1 Purchases	20	20	20	20	20
	Category 2 Purchases	124	0	0	0	0
	Category 3 Purchases	55	79	90	79	69
	Residual Purchases	9	2	6	4	3
	Levelized Groundwater Residual Balance	17	11	22	14	11
	Levelized California Aqueduct Account	16	21	20	21	21
	Total Release to San Joaquin River	704	691	703	683	667
	Average Annual Spill	142	129	141	121	105
	Total Eastside GW Recharge	75	62	76	59	41
	Total Eastside GW Extraction	64	55	57	47	33
	Diversion of Tributary Surplus into FKC	91	91	91	91	91
	Recaptured Water for Recirculation	41	137	137	137	137
	Recirculation at Delta	0	93	93	93	93
	Recirculation at Mendota Pool	44	44	44	44	44
	Total CVC	42	126	133	126	126
	Project Diversion to Tulare Lakebed	NA	NA	23	NA	NA
	Use of Tulare Lakebed Source	NA	NA	19	NA	NA
	Fine Gold Reservoir Pump-in	NA	NA	NA	NA	33
	Fine Gold Reservoir Release	NA	NA	NA	NA	52
	Madera Canal Diversion	233	252	252	253	254
	Friant-Kern Canal Diversion	806	798	787	801	807
Costs ($1,000)	Fixed Costs	$3,358	$7,995	$8,004	$12,347	$47,083
	GW Put Charge	$13,513	$11,478	$13,777	$10,851	$7,627
	Wheeling Costs	$241	$756	$756	$750	$750
	Pumping Energy	$3,139	$6,572	$6,333	$5,922	$5,505
	Generation Sales	($1,935)	($1,979)	($2,203)	($2,313)	($2,337)
	Category 1 Purchases	$6,500	$6,500	$6,500	$6,500	$6,500
	Category 2 Purchases	$29,978	$0	$0	$0	$0
	Category 3 Purchases	$13,302	$22,335	$24,852	$22,458	$20,101
	Residual Purchases	$1,932	$494	$1,307	$803	$646
	Offset for GW Residual Storage	($3,065)	($1,921)	($3,954)	($2,592)	($1,907)
	Total Average Annual Net Cost	**$66,961**	**$52,229**	**$55,372**	**$54,724**	**$83,968**

Table 6-19
Bundle Operational and Economic Results
Modified Channel/Case Y Demands

		Bundle Configuration				
	Parameter (Annual Average Values)	**A**	**B**	**C**	**D**	**E**
Quantities (1,000 acre-feet)	Total Purchases	146	34	53	35	32
	Category 1 Purchases	20	20	20	20	20
	Category 2 Purchases	124	0	0	0	0
	Category 3 Purchases	1	13	30	14	11
	Residual Purchases	1	1	3	1	1
	Levelized Groundwater Residual Balance	82	66	80	66	60
	Levelized California Aqueduct Account	16	18	18	18	18
	Total Release to San Joaquin River	711	689	703	685	674
	Average Annual Spill	245	223	237	219	208
	Total Eastside GW Recharge	131	111	127	104	77
	Total Eastside GW Extraction	53	45	48	38	18
	Diversion of Tributary Surplus into FKC	94	94	94	94	94
	Recaptured Water for Recirculation	44	113	113	113	114
	Recirculation at Delta	0	74	74	74	75
	Recirculation at Mendota Pool	39	39	39	39	39
	Total CVC	37	106	113	106	107
	Project Diversion to Tulare Lakebed	NA	NA	24	NA	NA
	Use of Tulare Lakebed Source	NA	NA	17	NA	NA
	Fine Gold Reservoir Pump-in	NA	NA	NA	NA	39
	Fine Gold Reservoir Release	NA	NA	NA	NA	55
	Madera Canal Diversion	245	263	262	263	262
	Friant-Kern Canal Diversion	776	785	772	784	782
Costs ($1,000)	Fixed Costs	$3,358	$7,995	$8,004	$12,347	$47,083
	GW Put Charge	$23,567	$20,087	$22,834	$18,832	$14,093
	Wheeling Costs	$210	$615	$615	$616	$618
	Pumping Energy	$2,554	$5,204	$5,241	$4,765	$4,254
	Generation Sales	($2,008)	($1,945)	($2,128)	($2,273)	($2,329)
	Category 1 Purchases	$6,500	$6,500	$6,500	$6,500	$6,500
	Category 2 Purchases	$29,978	$0	$0	$0	$0
	Category 3 Purchases	$156	$4,017	$8,628	$4,297	$3,120
	Residual Purchases	$194	$215	$657	$165	$151
	Offset for GW Residual Storage	($14,838)	($11,955)	($14,338)	($11,963)	($10,787)
	Total Average Annual Net Cost	**$49,669**	**$30,734**	**$36,012**	**$33,284**	**$62,702**

Table 6-20
Bundle Operational and Economic Results
Existing Channel/Case Y Demands

		Bundle Configuration				
	Parameter (Annual Average Values)	**A**	**B**	**C**	**D**	**E**
Quantities (1,000 acre-feet)	Total Purchases	155	44	56	45	40
	Category 1 Purchases	20	20	20	20	20
	Category 2 Purchases	124	0	0	0	0
	Category 3 Purchases	8	21	33	23	19
	Residual Purchases	3	3	3	2	1
	Levelized Groundwater Residual Balance	56	41	50	42	37
	Levelized California Aqueduct Account	16	22	21	22	21
	Total Release to San Joaquin River	750	736	747	729	718
	Average Annual Spill	188	174	185	167	156
	Total Eastside GW Recharge	111	90	114	86	62
	Total Eastside GW Extraction	60	50	65	44	26
	Diversion of Tributary Surplus into FKC	93	94	94	94	94
	Recaptured Water for Recirculation	41	127	127	127	127
	Recirculation at Delta	0	86	86	86	86
	Recirculation at Mendota Pool	41	41	41	41	41
	Total CVC	40	117	124	117	117
	Project Diversion to Tulare Lakebed	NA	NA	24	NA	NA
	Use of Tulare Lakebed Source	NA	NA	19	NA	NA
	Fine Gold Reservoir Pump-in	NA	NA	NA	NA	38
	Fine Gold Reservoir Release	NA	NA	NA	NA	56
	Madera Canal Diversion	239	257	257	257	256
	Friant-Kern Canal Diversion	746	747	734	747	746
Costs ($1,000)	Fixed Costs	$3,358	$7,995	$8,004	$12,347	$47,083
	GW Put Charge	$19,955	$16,416	$20,544	$15,639	$11,406
	Wheeling Costs	$224	$689	$689	$689	$689
	Pumping Energy	$2,839	$5,858	$6,208	$5,401	$4,913
	Generation Sales	($2,027)	($2,037)	($2,250)	($2,383)	($2,443)
	Category 1 Purchases	$6,500	$6,500	$6,500	$6,500	$6,500
	Category 2 Purchases	29,978	$0	$0	$0	$0
	Category 3 Purchases	$2,002	$6,225	$9,485	$6,923	$5,752
	Residual Purchases	$674	$621	$731	$425	$194
	Offset for GW Residual Storage	($10,050)	($7,351)	($9,603)	($7,642)	($6,642)
	Total Average Annual Net Cost	**$53,451**	**$34,916**	**$40,847**	**$37,898**	**$67,484**

6.9.1 Modified Channel/Case X Demand Scenario

Bundle A relies heavily on water purchases to develop water. An annual average of 173,000 acre-feet of purchases (a combination of Category 1, Category 2, Category 3, and Residual purchases) occurs. The operation of the bundle results in a residual storage of 34,000 acre-feet (average annual levelized amount) in the groundwater basin and 16,000 acre-feet (average annual levelized amount) of residual storage in the California Aqueduct Account. Average annual spills from Millerton Lake are 182,000 acre-feet.

Adding the components of Delta recirculation and additional Millerton Lake storage by way of utilizing 100,000 acre-feet below elevation 471 feet (current minimum pool) results in the following: purchases are reduced by 101,000 acre-feet to a value of 72,000 acre-feet (all values hereafter are reported in terms of an average annual quantity unless otherwise described), residual storage in groundwater is reduced by 11,000 acre-feet to a value of 23,000 acre-feet and increased by 2,000 acre-feet to 18,000 acre-feet in the California Aqueduct Account, and spills are reduced by 12,000 acre-feet to a value of 170,000 acre-feet.

From a perspective of reconciling the change in purchase requirements, purchases are reduced by 101,000 acre-feet with the addition of Delta recirculation and a modification to the minimum pool of Millerton Lake. This reduction occurs because of an increase in Cross Valley Canal conveyance of recirculated flow (75,000 acre-feet, a derivative of Delta recirculation), less residual storage (11,000 acre-feet), and a gain in water supply through a reduction in Millerton Lake spills (12,000 acre-feet). The remaining 3,000 acre-feet are explained by the difference in evaporation and end-of-study storage in Millerton Lake. The additional hydrologic parameters included in Table 6-17 are subsets to these three major items. For instance, although an additional 80,000 acre-feet of water are captured with Delta pumping in Bundle B (compared to Bundle A), only 75,000 acre-feet of that amount is actually conveyed to the Eastside. Three percent of the incremental Delta pumping ($2{,}000^{+}$ acre-feet) is assumed to be conveyance loss and another $2{,}000^{+}$ acre-feet of water is incrementally stored in the California Aqueduct Account.

Comparing Bundle A performance to Bundle B performance, the additional components of Bundle B will increase nonpurchased supplies by about 100,000 acre-feet. Of this amount, recirculation at the Delta increases supplies by about 75,000 acre-feet. The remaining incremental gain in supply occurs through re-operation of Millerton Lake in combination with Eastside conjunctive use.

Similar comparisons between the other bundles can be made. Bundle D results (the addition of 135,000 acre-feet of storage “above” the existing Millerton Lake) are generally comparable to Bundle B results in terms of purchases, Millerton Lake spills, and residual storage. Bundle C results show that without any additional storage at Millerton Lake, purchases are still significantly reduced (84,000 acre-feet) in comparison to Bundle A purchases due primarily to the addition of Delta recirculation. Tulare Lakebed storage developed an annual average of 17,000 acre-feet of water. Bundle E (Fine Gold Reservoir as an addition to Bundle D) produces the same result (100,000 acre-feet) as Bundle D with an additional water supply of about 10,000 acre-feet.

Figure 6.9-1 illustrates the parameters of each bundle under the Modified Channel/Case X Demand scenario. Water is developed through several means: (1) through management of Eastside tributary surplus water; (2) through recirculation of water that would otherwise be lost from the system; (3) through regulation and storage of Millerton Lake spills by the use of groundwater reservoirs and new surface storage facilities; and (4) through purchases of agricultural and urban water conservation. The sum of these inputs is the simplest surrogate of where the additional water comes from to meet both deliveries and restoration flows. Residual storage is also tracked to adjust the summation of the other parameters.

Using Bundle A as the comparison, Figure 6.9-1 illustrates that 173,000 acre-feet of water is purchased to meet deliveries and restoration flows. With the addition of Bundle B facilities to the configuration, purchases are reduced to 72,000 acre-feet, a reduction of 101,000 acre-feet. Water developed through the Eastside facilities remains the same, and a slight amount of water is developed through a reduction in Millerton Lake spills. Recirculation at the Delta develops an additional 80,000 acre-feet (before losses). Residual storage also shows a difference between the two bundles.

The influence of incremental storage added to the bundle is not explicitly identified by the analysis. Storage provides a regulation function to the sources of water, but its benefit cannot be separately identified in value. The tally of values illustrated in Figure 6.9-1 will not completely close to zero due to other factors not shown in the illustration, such as losses in the Westside conveyance of recirculation flows, evaporation loss, and differences in Millerton Lake end-of-study storage.

Figure 6.9-2 provides the same illustration of parameters for the Existing Channel/Case X Demand scenario.

6.9.2 Existing Channel/Case Y Demand Scenario

Bundle A relies heavily on water purchases to develop water. An annual average of 155,000 acre-feet of purchases (a combination of Category 1, Category 2, Category 3, and Residual purchases) occurs. The operation of the bundle results in a residual storage of 56,000 acre-feet (average annual levelized amount) in the groundwater basin and 16,000 acre-feet (average annual levelized amount) of residual storage in the California Aqueduct Account. Average annual spills from Millerton Lake are 188,000 acre-feet.

Adding the components of Delta recirculation and additional Millerton Lake storage by way of utilizing 100,000 acre-feet below elevation 471 feet (current minimum pool) results in the following: purchases are reduced by 111,000 acre-feet to a value of 44,000 acre-feet (all values hereafter are reported in terms of an average annual quantity unless otherwise described), residual storage in groundwater is reduced by 15,000 acre-feet to a value of 41,000 acre-feet and increased by 6,000 acre-feet to 22,000 acre-feet in the California Aqueduct Account, and spills are reduced by 14,000 acre-feet to a value of 174,000 acre-feet.

From a perspective of reconciling the change in purchase requirements, purchases are reduced by 111,000 acre-feet with the addition of Delta recirculation and a modification to the minimum pool of Millerton Lake. This reduction occurs because of an increase in Cross Valley Canal conveyance of recirculated flow (77,000 acre-feet, a derivative of Delta recirculation), less

residual storage (15,000 acre-feet), and a gain in water supply through a reduction in Millerton Lake spills (14,000 acre-feet). The remaining 5,000 acre-feet are explained by the difference in evaporation and end-of-study storage in Millerton Lake. The additional hydrologic parameters included in Table 6-20 are subsets to these three major items. For instance, although an additional 86,000 acre-feet of water are captured with Delta pumping in Bundle B (compared to Bundle A), only 77,000 acre-feet of that amount is actually conveyed to the Eastside. Three percent of the incremental Delta pumping ($2{,}000^{+}$ acre-feet) is assumed to be conveyance loss and another $6{,}000^{+}$ acre-feet of water is incrementally stored in the California Aqueduct Account.

Comparing Bundle A performance to Bundle B performance, the additional components of Bundle B will increase nonpurchased supplies by about 110,000 acre-feet. Of this amount, recirculation at the Delta increases supplies by about 77,000 acre-feet. The remaining incremental gain in supply occurs through re-operation of Millerton Lake in combination with Eastside conjunctive use.

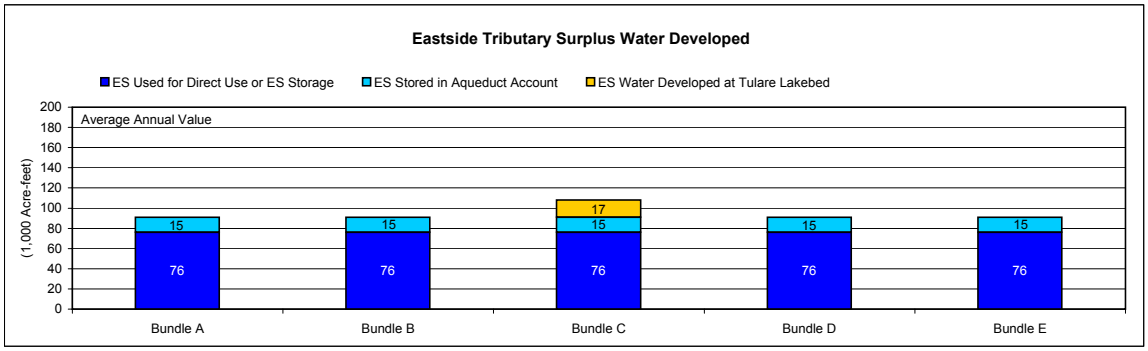
Similar comparisons between the other bundles can be made. Bundle D results (the addition of 135,000 acre-feet of storage "above" the existing Millerton Lake) are generally comparable to Bundle B results in terms of purchases, Millerton spills, and residual storage. Bundle C results show that without any additional storage at Millerton Lake, purchases are still significantly reduced (99,000 acre-feet) in comparison to Bundle A purchases due primarily to the addition of Delta recirculation. Tulare Lakebed storage developed an annual average of 17,000 acre-feet of water. Bundle E (Fine Gold Reservoir as an addition to Bundle D) produces the same result (100,000 acre-feet) as Bundle D with an additional water supply of about 10,000 acre-feet.

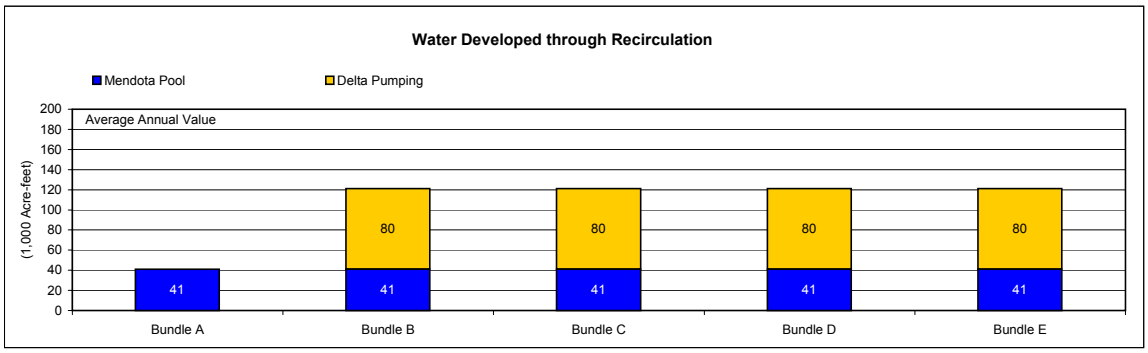
Figure 6.9-3 illustrates the parameters of each bundle under the Existing Channel/Case Y Demand scenario. Water is developed through several means: (1) through management of Eastside tributary surplus water; (2) through recirculation of water that would otherwise be lost from the system; (3) through regulation and storage of Millerton Lake spills by the use of groundwater reservoirs and new surface storage facilities; and (4) through purchases and agricultural and urban water conservation. The sum of these inputs is the simplest surrogate of where the additional water comes from to meet both deliveries and restoration flows. Residual storage is also tracked to adjust the summation of the other parameters.

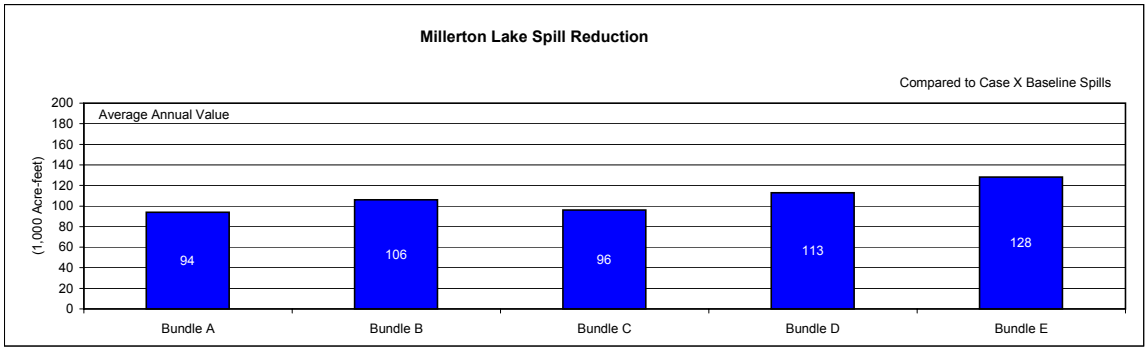
Using Bundle A as the comparison, Figure 6.9-3 illustrates that 155,000 acre-feet of water is purchased to meet deliveries and restoration flows. With the addition of Bundle B facilities to the configuration, purchases are reduced to 111,000 acre-feet, a reduction of 44,000 acre-feet. Water developed through the Eastside facilities remains the same and a slight amount of water is developed through a reduction in Millerton Lake spills. Recirculation at the Delta develops an additional 86,000 acre-feet (before losses). Residual storage also shows a difference between the two bundles.

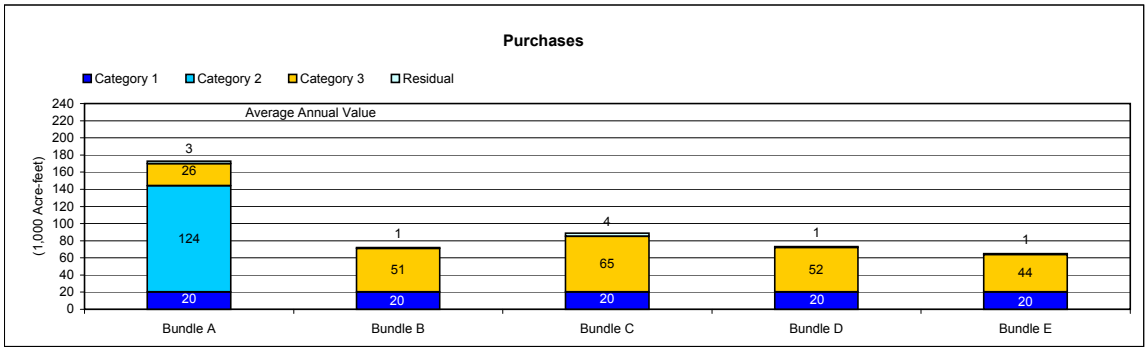
The influence of incremental storage added to the configuration is not explicitly identified by the analysis. Storage provides a regulation function to the sources of water but its benefit cannot be separately identified in value. The tally of values illustrated in Figure 6.9-3 will not completely close to zero due to other factors not shown in the illustration, such as losses in the Westside conveyance of recirculation flows, evaporation loss, and differences in Millerton Lake end-of-study storage.

Figure 6.9-1 Modified Channel -- Case X Demand Scenario









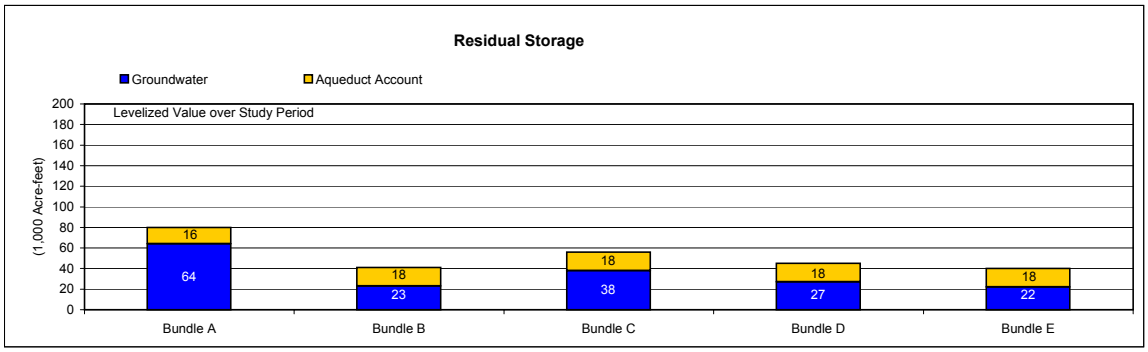


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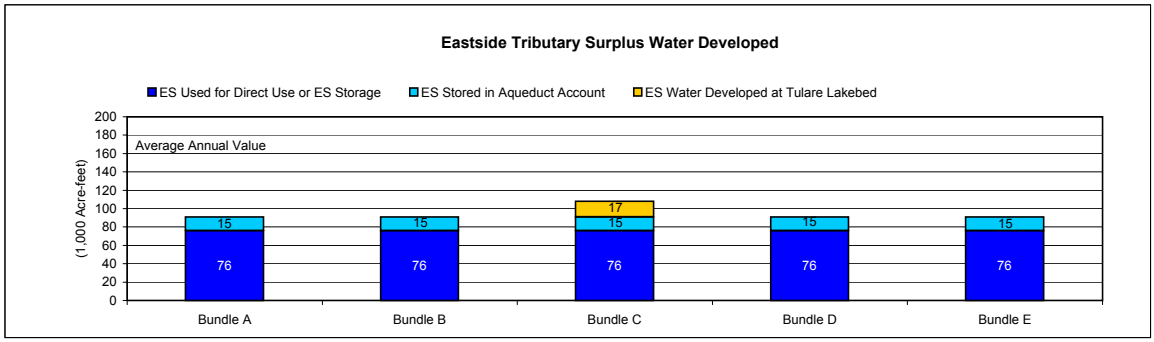
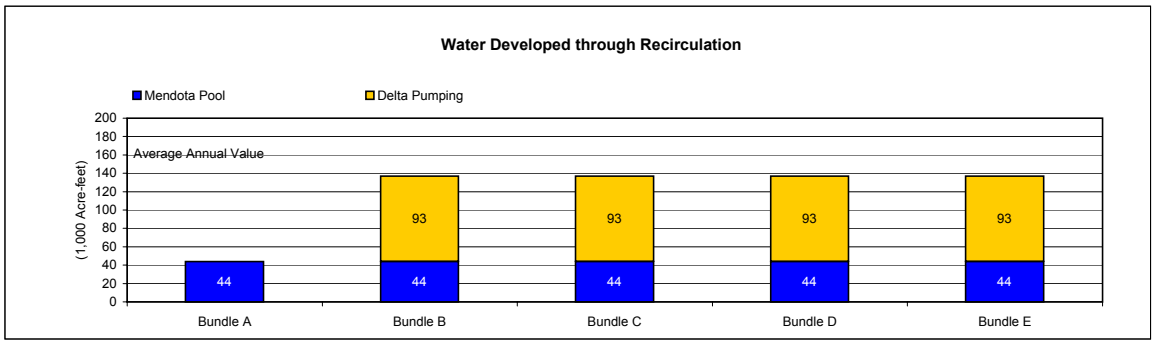
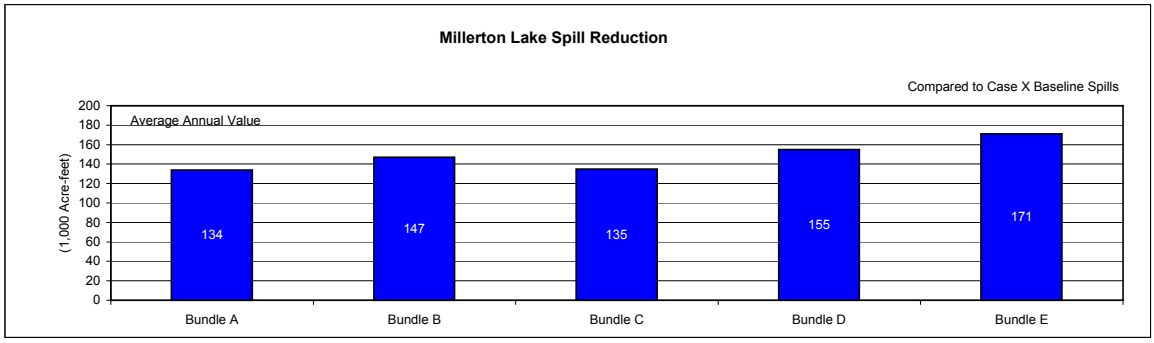
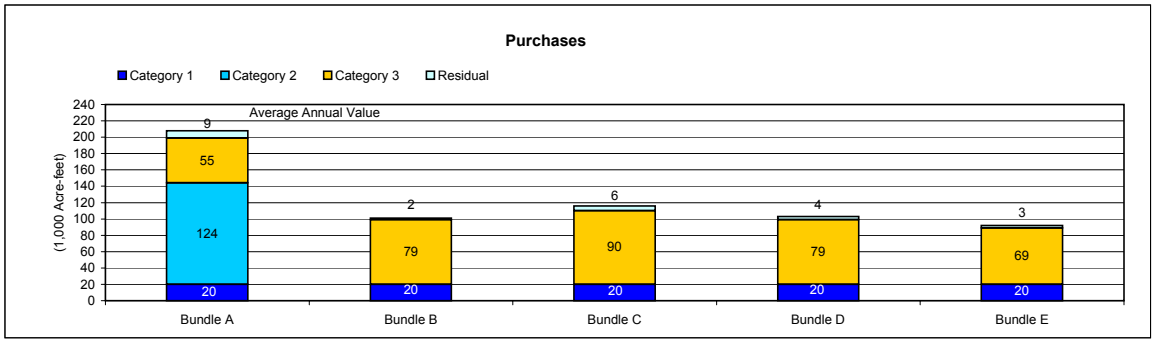
Figure 6.9-2 Existing Channel -- Case X Demand Scenario









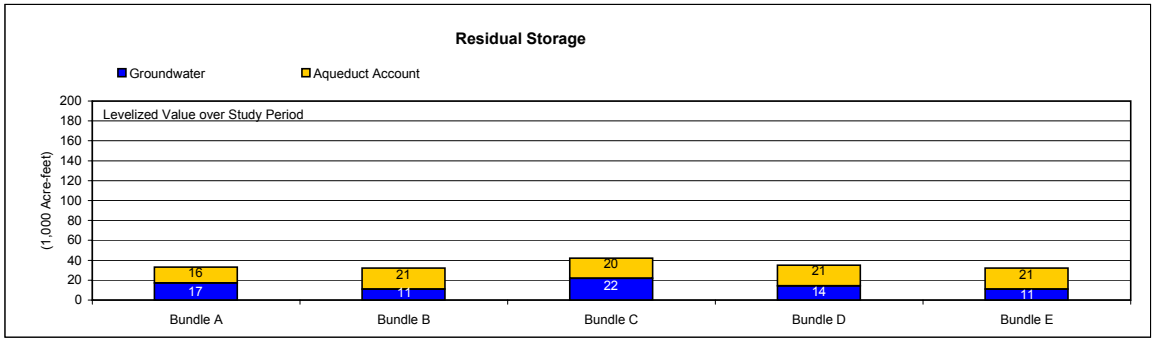


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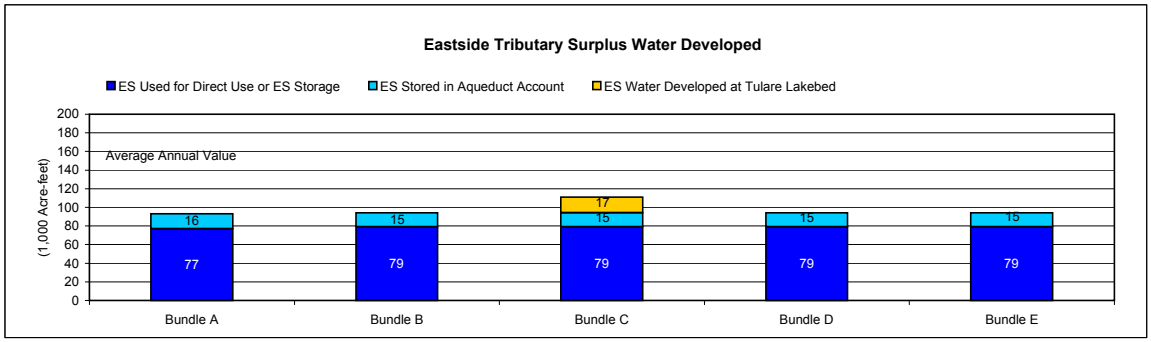
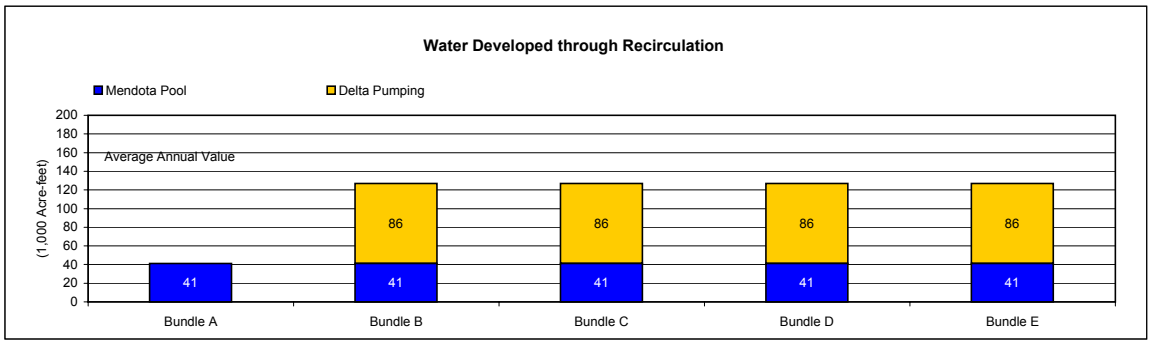
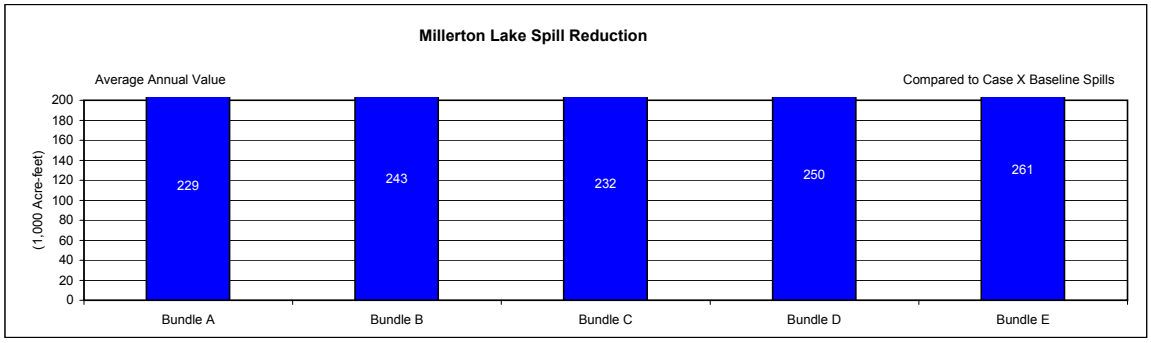
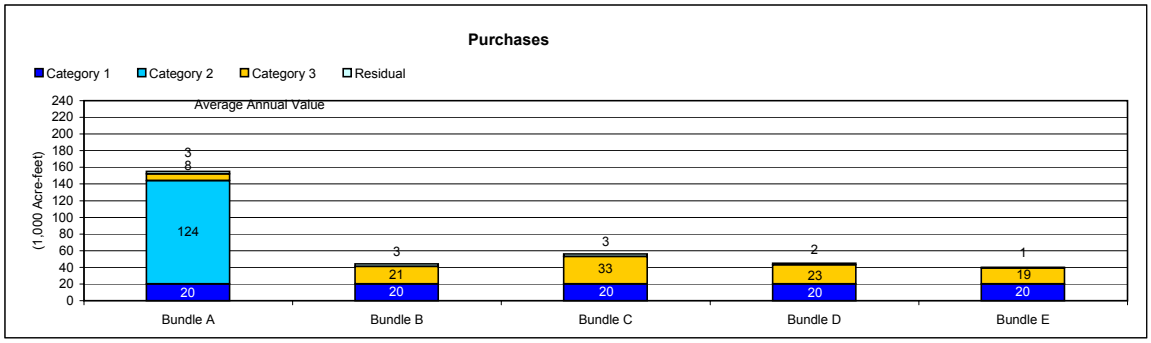
Figure 6.9-3 Existing Channel -- Case Y Demand Scenario









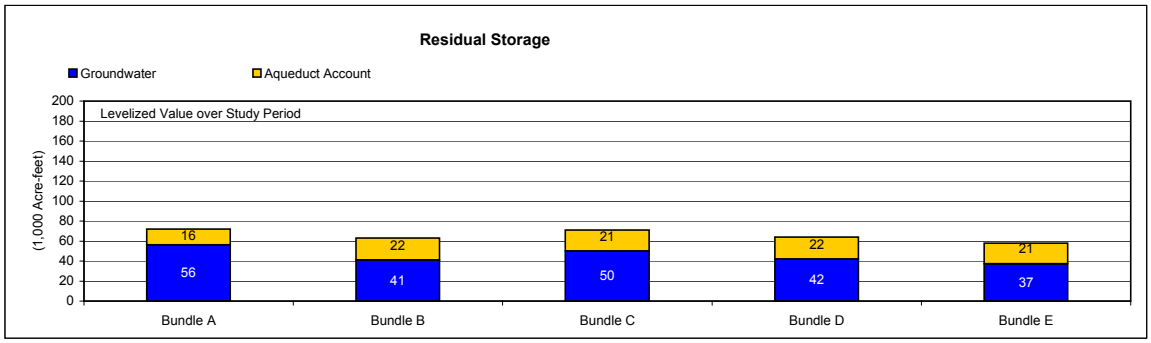


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Figure 6.9-4 provides the same illustration of parameters for the Modified Channel/Case Y Demand scenario.

6.9.3 Water Demands and Restoration Flow Requirements

The long-term operational modeling is constrained to assume a simulated historically based level and pattern (year-to-year) of canal diversions. Also, the designation of restoration flow requirements is based on water year unimpaired runoff that does not recognize anomalies in the pattern of runoff. Occasionally this crude parameter does not reflect well the availability of water during the peak restoration flow period. Significant shortages between supplies and demands occur during some years, and is reflected in the results for water purchases. Further refinement to the definition and triggering of restoration flows and a broader objective for maintaining Friant water user deliveries may result in water supply requirements and costs different from those derived by this analysis.

In the Case Y Demand scenarios, "surplus" water that has historically been diverted to the Friant-Kern and Madera Canals is not included as part of the Friant Division water user demand. In other words, a smaller amount of water is conveyed and delivered into the Tulare Lake Basin than has historically occurred. Whether or not the availability and use of this water is determined to be appropriate as a baseline, the water balance of the Tulare Lake Basin will be negatively affected without the diversions. This reduction in baseline diversions to the basin would likely result in additional groundwater dependence and less recharge within or adjacent to the Friant Division service area.

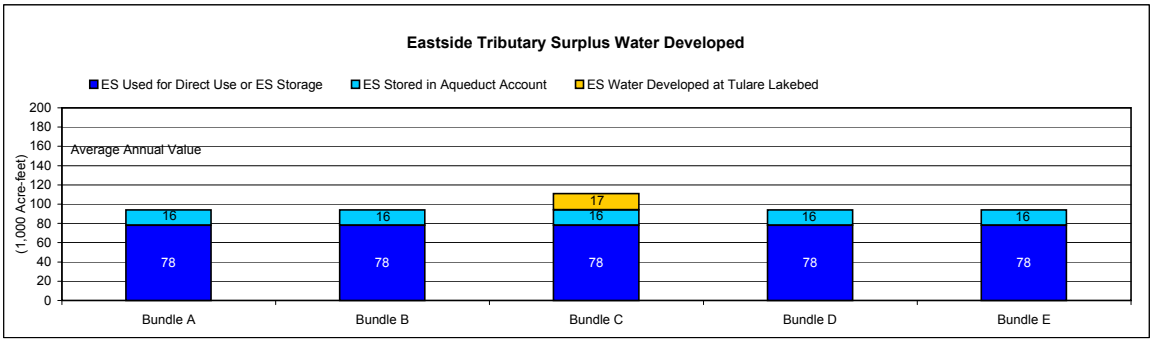
6.9.4 Water Purchases

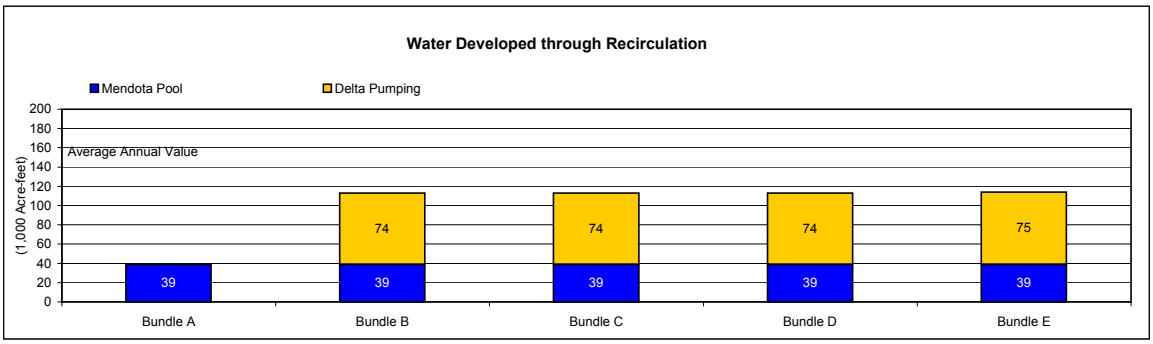
Explicit long-term purchases (e.g., the 80,000 acre-foot component of Category 2 purchases) are modeled only in Bundle A. That component of purchase along with the 40,000 acre-feet of conservation purchases within the Category 2 purchase mechanism fit well within the supplemental water needs of Bundle A but complicate the comparison of other bundle configurations that include other sources of supply such as Delta recirculation or additional reservoir storage. Within other bundles, this modeled "forced" purchase leads to large changes in residual storage and Millerton Lake spills.

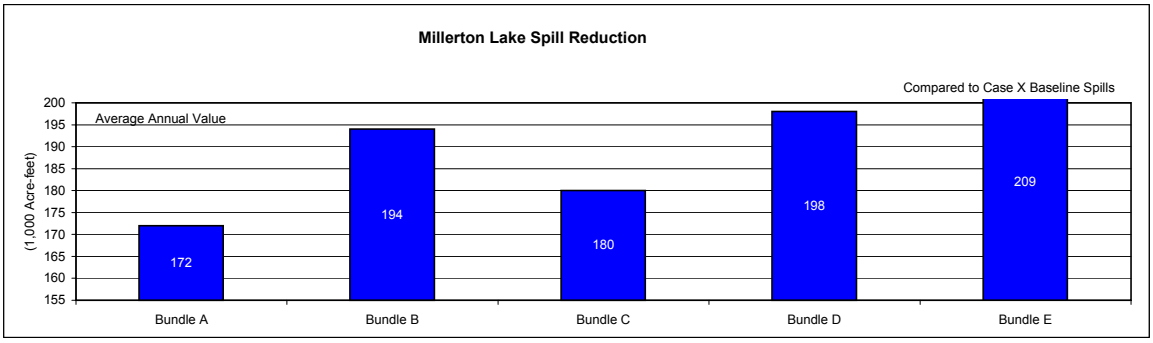
Although not included in bundles other than Bundle A, long-term purchases of a form similar to that modeled as Category 2 purchases could be viable. In effect, a Category 2 type of purchase replaces the need for the short-term Category 3 purchase determined by the model. The specific parameters of such a purchase could be fashioned to fit the supplemental water needs of a specific bundle. The quantity and timing of such a purchase can be determined by review of modeling results. For instance, results for Category 3 purchases in Bundle B (refer to Section 6.4, Figure 6.4-7) show that the required purchases are distributed across years that have less than average unimpaired runoff. There appears to be a need for approximately 150,000 acre-feet of water during many of these drier years; however, it is also seen that purchases are not needed in all dry years. Iterative analyses that include pricing assumptions for purchases and the valuing of unused purchases could lead to a solution that would support the replacement of short-term purchases with long-term purchases.

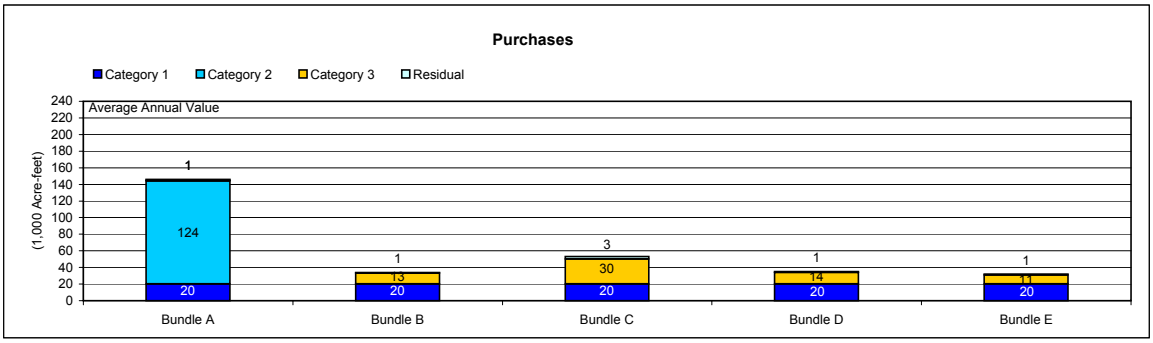
Also notable are the magnitude and cost of purchases that contribute to the total average annual net cost of the bundles. The hydrologic sequence (1922-1999) selected for the analysis contains a sustained drought from 1924 through 1934. With very little banked water in either new surface or groundwater reservoirs prior to this period, substantial purchases to balance supplies with demands are required. For the Modified Channel/Case X Demand scenario the total average annual net cost of the bundles (Bundle B through Bundle E) is affected by about $7,000,000 (in terms of annual net cost during the study period) of Category 3 and Residual purchases, or about $5,000,000 for the Existing Channel/Case Y Demand scenario. Although not all of the purchases would be avoided with an alternative modeling assumption that begins with substantial initial storage in the reservoirs or an alternative sequencing of the study period, the exposure to such an unfortunate sequence of years early in project operation needs to be recognized (see Section 8.2 for further discussion of potential water purchase arrangements).

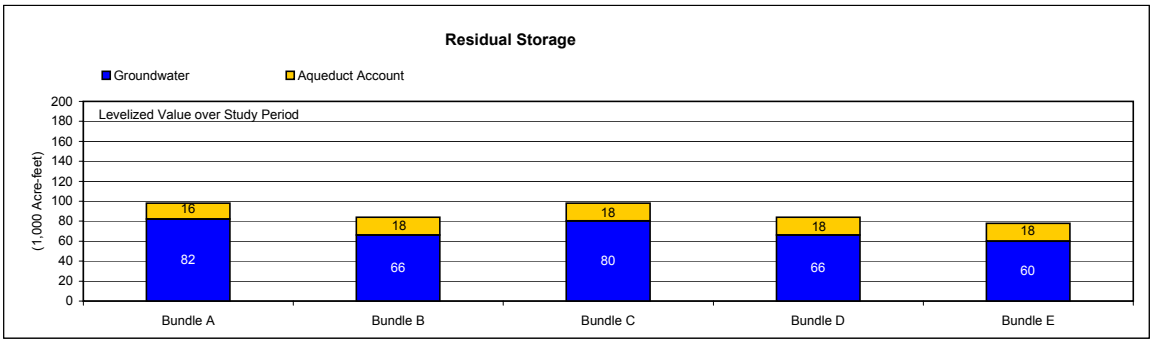
Figure 6.9-4 Modified Channel -- Case Y Demand Scenario











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The goal of the Water Supply Study (Study) is to analyze alternatives (bundles) that would provide adequate water to support restoration of San Joaquin River habitat and fisheries and concurrently cause no adverse impacts on Friant Division water users. This section describes a conceptual basis for the analysis of economic impacts and provides an analytical and methodological approach for the quantification of the impacts of the bundles. This section also identifies approaches and methodologies that may be used in the quantitative analysis at both the programmatic and site-specific levels. The discussion is qualitative aside from the data used to describe the Friant Division area.

The remainder of this section is organized into five parts. The first part is a brief overview of the economy of the Friant Division service area and surrounding area. The second part is a conceptual framework that includes a discussion of pertinent elements from economics and related disciplines and identifies the types of economic impacts[1] likely from the alternatives. The third part is a methodological framework that follows typical forms of economic impact analyses and that incorporates the types of impacts and their measurability into a structure for quantification. The fourth part discusses the timing of economic benefits and costs. The fifth part is a summary.

7.1 ECONOMIC OVERVIEW OF THE STUDY AREA

Any regional economic impact analysis should be for a "functional economic area,"[2] one which includes all key areas likely to be affected by the alternatives being considered. The functional economic area should have sufficiently diverse activities and scope to be relatively economically self-sufficient in terms of both using goods and services and providing employment. The functional economic area should also be centered on the area of economic influence for which the economic impact analysis is being undertaken.

The Friant Division is approximately 150 miles in length and includes parts of Merced,[3] Madera, Fresno, Kern, and Tulare Counties.[4] The Division delivers water to more than 1,000,000 acres of farmland on the Eastside of the San Joaquin Valley. Agriculture in the service area is diverse and includes a wide variety of annual and permanent crops as well as a large dairy sector. In 1996, the last year for which data for the entire service area are available, annual crops were grown on one-third of the land under cultivation and permanent crops (orchards, vineyards, and multi-year forage crops) on two-thirds.[5]

Population and employment characteristics vary considerably among the five counties. The entire five-county area had a population of 2,170,440 in 2000.[6] Fresno County had the largest

[1] "Impacts" as used in this section refer to both the benefits and costs attributable to the bundles.

[2] See Nourse 1968, 136.

[3] Part of the Chowchilla Water District, a Friant Division member, is within Merced County.

[4] Because of their proximity, San Joaquin, Stanislaus, and Kings Counties potentially should be included in the study area. The discussion here, however, includes only the five counties. Determination of the study area will be required early in the quantification of impacts.

[5] Data from the U.S. Bureau of Reclamation.

[6] See U.S. Department of Commerce. Employment data are underestimated. Employment in some industries is not reported because of disclosure issues (the possible attribution of specific data to individual employers).

population at 802,275, and Madera had the smallest at 123,608. Since 1980, population in the area has increased 58 percent, or 2.3 percent per year. The highest population growth rate over the 20 years was in Madera County at 93 percent, and the lowest was in Tulare County at 49 percent. Across the five counties, total employment in 2000 was 1,046,519, up from 688,695 in 1980. Farm employment in 2000 was 11 percent of total employment,[7] while services were 24 percent, government was 16 percent, and retail trade was 15 percent. In 1980, farm employment was 15 percent of total employment, services and government each were 17 percent, and retail trade was 15 percent.[8]

7.2 CONCEPTUAL FRAMEWORK FOR ANALYSIS OF ALTERNATIVES

The conceptual framework recommended for the economic impact analysis is a blend of pertinent topics from economics and related subjects. It incorporates the approach typically used in the "affected environment" section of an Environmental Impact Statement.

Some of the relevant topics from theoretical and applied economics include resource use and valuation, benefit-cost analysis, externalities, demand and supply relationships, markets and prices, and institutional factors. Complete discussions of these topics can be found in many references and are not repeated here.[9] Some environmental subjects overlap with those from economics, including resource use and valuation and externalities. Others are based on the content of analyses conforming to guidelines for implementing the National Environmental Policy Act (NEPA) and similar laws and regulations.

Two distinct, though related, kinds of assessment should be addressed in an economic impact analysis. First, the analysis should compare the economic benefits and costs of the water supply alternatives. If sufficient information is available to quantify all of the important impacts, a net benefits analysis (also referred to below as a Benefit Cost Analysis, or BCA) can also be provided. However, if significant categories of benefits or costs cannot be quantified accurately, a BCA may be misleading and inappropriate. Benefits, costs, and net benefits may be estimated for the study area, for major sub-areas, and for individual sites or projects, as appropriate. Second, the analysis should compare the overall changes in regional economic activity that result from the alternatives. Both kinds of analyses can also describe the likely distribution of impacts across regions or sectors.

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[7] Including both farm proprietors and farm employees.

[8] All data shown are for "direct" employment and do not include the interdependence among sectors of the economy. The distinction is important for the quantification of economic impacts. For example, while direct employment in agriculture was 11 percent of the five-county total employment in 2000, the University of California estimates that because of the many linkages between agriculture and other sectors, agricultural production and processing account for 25 percent of employment for the entire Central Valley. See Kuminoff, Sumner, and Goldman 2000.

[9] See, for example, Schmid 1989; Randall 1981; Anderson, Dillon, and Hardaker 1977; and Naylor and Vernon 1969.

7.2.1 Sectors and Variables Likely to Be Affected

Each bundle considered includes components that in the aggregate meet the restoration water requirements. The components incorporate various types of projects, including surface and groundwater storage, reservoir reoperation, conveyance, watershed yield enhancement, and water acquisitions, transfers, exchanges, and management. Each has direct and indirect economic impacts.[10] Appropriate analysis of the impacts must incorporate the competing uses for water, reflected in the resource areas discussed below. Each bundle can be expected to produce trade-offs among the resource areas, resulting in different mixes of benefits and costs.

Analysis of the economic impacts of the bundles requires a comparison of conditions likely in the study area with and without implementation of the alternatives. The analysis should focus on those resource areas and sectors apt to be affected. For this Study, these resource areas and sectors and types of direct impacts[11] are shown in Table 7-1. The direct impacts include both benefits and costs. Following Table 7-1 is an overview of some conceptual issues that should be reflected in the methodological approach for several resource areas.

Table 7-1
Resource Areas and Sectors Likely to Be Affected by the Alternatives

Resource Area or Sector	Potential Direct Impacts of Alternatives
Agricultural economics	Changes in water reliability, sources, and costs; pumping costs; cropping patterns; direct farm employment; production value and costs; net farm income; and land values
Energy	Changes in power production levels, timing (daily and seasonal), costs, and use; changes among energy sources (e.g., hydro for diesel or dual systems)
Surface water supplies and facility operations	Changes in seasonal river flows, reservoir levels, flood control, water quality, storage, and distribution
Groundwater	Changes in production and use, pumping depth, quality, and aquifer characteristics
Fisheries	Changes in anadromous fish migration and population, spawning and rearing habitat, instream, and minimum fishery flows
Vegetation	Costs for and changes in areas of natural terrestrial, riparian, aquatic, wetland, and agricultural habitat
Recreation	Changes in recreation opportunities at reservoirs and rivers and changes in nonuse values
Regional economics	Changes in output, employment, and income
Sacramento/San Joaquin Delta	Changes in seasonal flows and quality

Some of the direct impacts shown in Table 7-1 are likely to vary, possibly significantly, by water year type. This distinction, while implicit, may be important to the quantification of effects. For example, water agencies and irrigators outside the Friant Division service area may reliably offer

[10] Impacts may include both benefits and costs.

[11] Synonymous with "direct effects" and defined in the National Environmental Policy Act as those caused by the action under consideration and which occur at the same time and place. Indirect effects are defined as those caused by the action and later in time or farther removed in distance, but still reasonably foreseeable. See Council on Environmental Quality 1978.

water for sale in normal or wet years, but not in dry or critically dry years. Similarly, the value of additional restoration flow may vary greatly across water year types.

7.2.2 Overview of Pertinent Agricultural Economic Issues

Alternatives for developing water for restoration flows may have positive or negative economic impacts on agricultural production. New supplies developed for flow augmentation in some year types might be available for agricultural use or groundwater recharge in other year types. A water acquisition component of an alternative could purchase water made available through agricultural water conservation or land fallowing. The direct agricultural economic impacts of such components could include changes in water use that involve substitution among sources and water transfers, changes in crop patterns, and changes in farm income. The estimation of these impacts should follow established agricultural production economic theory and the empirical literature.[12]

Farm-level impacts can occur over both the short and the long run. The short run refers to a period in which changes cannot be made to such fixed inputs as land and machinery. The long run, however, is a period over which all production inputs can be varied. In this analysis, the primary short-run decisions by farmers concern which annual crops to plant, how much water to use or to sell, and what amounts of other inputs to use on the crops. Long-run decisions include those as well as permanent crop investment decisions and the purchase or sale of land, machinery, irrigation systems, and other long-term assets.

The short- and long-run elements of production economics may be found in many references and are not repeated here.[13] Economic analysis of agricultural production decisions typically begins with a set of assumptions about how decision-makers (farmers) act and respond under changing conditions. The most pertinent assumptions of production economics for this Study include:

1. Farmers act efficiently. They do not use more labor, machinery, chemicals, water, or other inputs than necessary to raise crops and livestock.
2. Farmers use an input (such as water or fertilizer) to the point at which any additional value of its contribution to the farm would be exceeded by the additional cost.
3. Farmers are price takers. Their individual actions have no effect either on the prices they pay for inputs or the prices they receive for the products they sell. However, aggregate changes made by many farmers responding independently to changing conditions can affect prices.
4. Farmers attempt to maximize profits subject to constraints such as resource limitations, regulatory requirements, uncertainty, and lack of information.
5. Only variable costs are relevant in short-run decision-making. As long as the unit price of a crop or livestock product exceeds unit variable costs of producing it in the short run, it is feasible to produce that product. In the long run, both fixed and variable costs must be covered by revenues from the product.

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[12] If some of the water for the alternatives is purchased from outside the study area, it can be assumed there will be impacts in those regions as well. The approach to analyzing those effects would be comparable to that of the study area.

[13] See, e.g., Baumol 1965 and Anderson, Dillon, and Hardaker 1977.

Economic models of agricultural production generally embrace these precepts of production theory. Models, however, do not always predict accurately what farmers are likely to do in different situations. Therefore, any agricultural economic analysis should temper these pure profit-maximizing objectives with consideration of other motives and constraints of farmers. For example, although a model might suggest that farmers growing a particular crop in a specific area would be better off selling their resources and going out of business, that "solution" may be moot because of a farmer's desire to keep the land in his or her family or because of other subjective factors. The development of a methodological framework should reflect these factors.

As another example, water acquisitions from agricultural users are included in some alternatives. Economic analysis using a tested and calibrated agricultural production model can provide an estimate of how farmers and districts might make water available for sale at the lowest cost to themselves. However, it is likely that third-party impacts would also be weighed in decisions on water sales. Water transfers may cause adverse effects on rural farming communities, including the idling of farmland, loss of jobs and local income, lower tax revenues, and higher costs of social programs.[14] Water transfers may affect other water users if sellers transfer water exceeding consumptive use and irrecoverable losses, if groundwater substitution for transferred water is permitted, or if water deemed to be in excess of requirements is actually needed. In addition, if land fallowed to accommodate water transfers is not maintained, third parties may be affected by pests, air quality problems due to wind erosion, or visual losses caused by changes in land use.

An appropriate economic analysis should use a combination of analytical tools, such as production models, and other information on how farmers and water managers make water use decisions.

7.2.3 Overview of Pertinent Recreation Economics Issues

Recreation supply and demand are influenced by factors similar to those for other goods and services. Recreation supply depends on inputs such as land, labor, and capital, which are combined to provide recreation capacity. Recreation demand at particular locations depends on such variables as recreationists' knowledge of the sites and attractions, income, and the cost of recreating at those locations, including travel expenses, lodging and food, and user fees. Often important as well are other variables, including age, quality or attractiveness of sites, availability of substitute sites, congestion, and individual tastes and preferences (see Loomis and Walsh 1997).

When individuals recreate, they are assumed to benefit in some way. The main objective in recreation economic impact analysis is to measure, for an improvement in recreation opportunities, the value of increased use and enjoyment related to the improvement. A dollar value for the benefits experienced by individuals is estimated, and various measurement approaches are available for that estimation. Recreation economic impact analysis must also include costs and other effects of the alternatives. For example, raising the mean elevation of a reservoir during the peak recreation season can be expected to attract more visitors, but the traffic from increased visitation may adversely affect the safety or condition of local roads.

[14] See USBR 1997a.

The alternatives in the Study are likely to have impacts on recreation resources such as reservoirs, rivers and streams controlled by reservoirs, recreational and sport fisheries, and wildlife habitat. Activities likely to be affected include boating, fishing, rafting and canoeing, swimming, picnicking, wildlife viewing, and hiking.

7.2.4 Overview of Pertinent Regional Economic Issues

The alternatives for this study involve a combination of activities in construction, machinery and equipment purchase and installation, water purchases and movements, operation of water facilities, and habitat improvement. The changes may have impacts not only on the agricultural, recreational, construction, and machinery sectors, but also on many other industries within the study area. Examples include:

- Construction workers use their additional income to purchases goods and services.
- Recreational users need to purchase food, fuel, and lodging.
- The fallowing of land to provide water for transfer may adversely influence farm labor as well as suppliers of purchased inputs such as fertilizer, chemicals, seed, and farm machinery.
- Income from the water sold would generally be spent on a combination of new consumption and investment. (Nonetheless, those who gain by selling water are unlikely to be those who lose employment and income because of fallowing.)

Each activity undertaken in an alternative produces one or more "direct effects." These are the "first-round" effects of the change.[15] For example, if new generators are purchased within the study area and installed, the direct effect would be increased sales for the suppliers of those units. The direct effects in turn set off a series of "indirect effects," as various sectors purchase inputs and provide goods and services in response to the direct effect. Thus, the firms supplying generators would increase their purchases of parts used to produce those units and possibly hire additional labor to meet the increased demand. The direct and indirect effects stimulate a series of "induced effects," as employees in the affected firms increase spending for other goods and services. The regional economic impact analysis approach must include all of these effects.

7.3 METHODOLOGICAL FRAMEWORK

7.3.1 Overview

In the broadest sense, economic impact analysis (EIA) provides an assessment of changes in various economic measures due to the implementation of a policy or action of some sort. Traditional BCA may be a component of an EIA, because BCA analyzes benefits and costs to determine which of a set of alternatives is the most efficient or whether a given alternative is feasible.[16] However, BCA does not consider interdependencies within a study area, nor does it take into account impacts that cannot be quantified. In contrast, an EIA usually does not assess

[15] Note that in a regional economic impact analysis, the direct effects are not the same as (although they are related to) net benefits, described earlier in this section.

[16] See Schmid 1989.

the comparative efficiency of alternatives. Instead, it estimates changes in key industries in an area attributable to a change or set of changes. Moreover, an EIA takes account of interdependencies among sectors in a study area and includes considerations of important nonquantifiable impacts.

An EIA usually includes several discrete steps:

- Description of changes to be analyzed
- Definition of existing conditions in the affected area
- Projection of likely future conditions with and without the changes being analyzed
- Calculation of differences (i.e., impacts) between the "with" and "without" cases
- Identification of those impacts likely to affect decision making
- Evaluation of significant beneficial and adverse impacts, quantitatively where possible or qualitatively where not

Table 7-1 listed general resource areas or sectors and the potential direct impacts of alternatives within those areas. The following includes more detail on possible impacts for several of the resource areas shown and presents a framework within which to evaluate them.

7.3.2 Agricultural Economics

Estimation of the agricultural economic impacts of the alternatives requires analysis of a variety of linkages and variables tied directly or indirectly to possible changes in water supplies. The two objectives of the Study, increased flows for restoration of the San Joaquin River and no adverse impacts on Friant Division water users, do not preclude changes in water supply conditions for districts and farmers in the Division or in other parts of the state. Thus, farmers may choose to utilize differing amounts of groundwater and surface water under the alternatives. For purposes of the analysis, the specification of initial conditions is required before each alternative can be analyzed, with those conditions taken directly from other parts of the Study. These conditions would include the impacts of the alternatives on groundwater pumping depths and costs, groundwater and surface water quality, and changes depending on the type of water year. Water deliveries in and outside the Friant Division in wet and dry years may have important implications for farmer behavior, sources of water for purchase, and other key economic variables.

Both water district-level[17] and farm-level responses may be important for impact analysis. District-level responses may differ in the short run and long run and by type of water year, depending on institutional, physical, financial, and other constraints. Farm-level responses may vary by type of water year and include changes in use of water sources (substitution of groundwater for surface water or vice versa) and changes in cropping patterns, farm income, and land values.[18]

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[17] A term used for simplicity that refers to all providers of water within the Friant Division service area.

[18] If it is assumed that the impacts of the alternatives on water users are neutral, some of these variables would not be affected.

It is suggested that the methodology for measuring agricultural economic impacts includes both analytical tools of production analysis (usually regional-scale optimization models) and survey-based data collection. The Central Valley Production Model (CVPM) is an example of a publicly available regional optimization model that simulates aggregate decision-making by Central Valley farmers.[19] It is described below for purposes of outlining an appropriate analytical approach, but other models could be used or developed.

CVPM contains four key sets of relationships and restrictions. First are marginal cost functions describing how production costs change with the quantity of land in production. Second are commodity demand functions, which relate market price to the quantity of crops produced. Third are specifications of the relationships between irrigation technology and the quantities of water that must be applied for any given crop. Fourth is a set of constraints that includes land and water resources as well as other legal, physical, and economic limitations. The objective of the model is to maximize the sum of net farm income (producer surplus) and the net value of agricultural products to consumers (consumer surplus). The solution specifies market prices for crops, water use by source, quantity of irrigated land by region and crop, and other variables.

The CVPM aggregates agricultural production in the Central Valley into 22 crop-producing regions. Each region is intended to represent a group of water districts with similar growing conditions. Each region is effectively assumed to be a single, large, homogeneous farm with one decision-maker. Soil, climate, hydrologic, and crop suitability factors are assumed to be homogeneous within each region. Six of the 22 regions include parts of the Friant Division. However, the aggregate region covered by the six CVPM regions also includes substantial areas that are not within the Friant Division.

Because of the size and diversity of the Friant Division service area, it is suggested that the CVPM or other model used should be complemented with information obtained directly from district- and farm-level focus groups. These groups could be used effectively to assess the extent to which actual behavior is likely to conform to the results from the model(s) used. Because the Friant Division service area covers such a large area, farmers likely differ significantly not only by types of crop grown but also by financial structure, age, and other objective and subjective characteristics. Because of this diversity, farmers' responses to the alternatives may also differ. The surveys would provide insights into these factors and would also provide important perspectives into the planned uses of income received from water sales, which may have important implications for regional economic impacts.

The responses would be useful to district managers undertaking short-run and long-run plans for their agencies. In addition, district-level responses to changes in seasonal and inter-year water supplies by year type would be useful in decisions on phasing the implementation of various bundles. The groups could be organized using standard statistical procedures to minimize the potential for bias.

Table 7-2 shows some of the key variables that should be included in the analysis of the agricultural economic impacts of the alternatives. Data permitting, agricultural economic impacts could also be estimated at a disaggregated level corresponding approximately to the regions of the CVPM.

[19] The CVPM was used extensively in the EIS for the Central Valley Project Improvement Act. See USBR 1997a.

Table 7-2
Specification and Measurement of Key Agricultural Economic Impact Variables

Variable	Measurement
Water use, by source, by type of water year	Acre-feet of groundwater and surface water used
Water quality	Changes in TDS of surface and groundwater supplies
Groundwater cost, by type of water year	Pumping lifts, power requirements, and variable cost of pumping groundwater
Crop yields	Effects of changing water quantity or quality on yield per acre and total production by crop
Cropping patterns	Acreage of annual and permanent crops; acreage of idled and fallowed land
Farm income (including value and costs)	Gross or net farm income

7.3.3 Energy

The bundles may have measurable impacts on hydropower production and power use arising from changes in reservoir operation, changes in pumping equipment, or construction of new reservoirs. Power generation may also be affected by quality requirements for downstream water and by possible changes in the timing of both daily and seasonal peak generation relative to peak loads. In some cases, meeting peak power loads and possibly baseload generation (depending on the extent of reservoir operation and level changes) may necessitate purchases in the spot market at higher prices or contracting for short- or long-term power purchases for any baseload generation losses. Another potential impact is the ability of a power project to provide ancillary services, such as automatic generation control (AGC), reserves, and load following, all of which are components of available capacity.

A spreadsheet model relating changes in power production benefits to changes in water flows and reservoir levels (head) could likely be used to analyze the energy-related economic impacts of the alternatives. The model could utilize information on historical hydropower operations to estimate the level and value of foregone power production during diversion periods as well as the incremental contribution of changes in flow timing to power production.

Table 7-3 shows some of the key variables that should be included in the analysis of the energy impacts of the alternatives.

Table 7-3
Specification and Measurement of Key Energy Impact Variables

Variable	Measurement
Generating capacity	Available capacity
Ancillary services	Available capacity
Power production	Generation in on- and off-peak periods (daily and seasonal)
Power costs	Cost per unit of power in on- and off-peak periods

7.3.4 Recreation Economics

The recreation impacts of the alternatives may be important. Reservoirs provide the greatest opportunities for slack water recreation when they are at or near full pool. Raising dams on reservoirs or constructing new reservoirs may create new recreation opportunities. Conversely, recreation may be adversely affected when reservoirs are drawn down, creating access

difficulties. Further, changes in the timing and volume of flows from the reservoirs can impact recreation opportunities on rivers downstream of the reservoirs.

Measurement of recreational impacts should consider the effects of the alternatives on both recreational opportunities and recreational demand. Changes in recreation opportunities could arise because of variations in reservoir levels, river flows, riparian habitat, and other factors. Such effects could vary by type of water year. Changes in reservoir levels in turn could affect access to recreation facilities such as marinas and beaches. Recreation activities affected could include picnicking, boating, recreational and commercial fishing, camping, swimming, and wildlife viewing.

The approach used to measure recreation impacts will likely involve outputs from models utilized in other sections of the Study. For example, outputs from the overall water balance model would be necessary to establish likely reservoir levels and river flow rates during different seasons and different types of water years. Those outputs could serve as inputs into recreational use equations, the latter taken either from previously published work for other areas [20] or estimated specifically for the study area. The equations for reservoir recreation would relate visitation to measures of population and reservoir levels. Similarly, if estimates are developed for fish numbers relative to various river flow regimes, relationships could be estimated to calculate impacts of the bundles on recreational fishing use (measured by angler visitation).[21]

Outputs from the reservoir and river recreation equations could be combined with estimates of visitor-day spending profiles for the different types of recreation. The U.S. Fish and Wildlife Service and U.S. Bureau of the Census have developed such profiles,[22] which typically include expenditures at food stores, service stations, eating and drinking establishments, hotels and motels, and for miscellaneous recreation services. Data from these sources could then be used to estimate changes in recreation-related spending within the study area.

Assessment of changes in recreation opportunities at Millerton Lake and other reservoirs requires an analysis of such factors as changes in access to boat ramps, changes in surface area for boating, and changes in beach area for beach use. Development of reservoir elevation impact thresholds (i.e., the thresholds below which recreation activities would be significantly affected) is required.

As an alternative or supplement to the development of models specific to this analysis, use could be made of other studies that have been completed for the Central Valley or other areas.[23] Such studies provide estimates of the consumer benefits from such recreational activities as hunting, fishing, boating, or wildlife viewing. In some cases, it may be necessary to use this "benefit transfer" approach because of limited data for the area under study.

The alternatives would all affect flows in the San Joaquin River; however, the Study does not recommend any specific flows. The hydrographs used in the analysis explained in Section 6.1.4 are likely to change to be consistent with the restoration demand being developed independently

[20] See Loomis and Walsh 1997.

[21] See USBR 1997b.

[22] See U.S. Fish and Wildlife Service and U.S. Bureau of the Census 1993.

[23] See USBR 1997b.

from the Study. River recreation opportunities such as canoeing, power boating, fishing, and water skiing would be affected. Development of river flow impact thresholds that measure significant impacts on recreation activities in response to changes in river flows will be required. Changes in recreation opportunities would be measured by the frequency with which river flows exceed or fall below these thresholds.

Table 7-4 shows some of the key variables that should be included in the analysis of the recreation impacts of the alternatives.

Table 7-4
Specification and Measurement of Key Recreation Impact Variables

Variable	Measurement
Thresholds	Threshold values for each reservoir and river for affected recreation sites
Peak and off-peak periods	Variations in visitor days by season
Recreation at reservoirs	Number and frequency of visitor days at and below threshold values
Recreation on river	Number and frequency of visitor days at and below threshold values

7.3.4.1 Measurement of Other Recreational Impacts

In addition to the potential impacts on implied "use" values for recreational activities, "non-use" values may also be affected. An example is "existence value," which is the worth that non-users place on a resource given their knowledge that the resource may be improved by the alternatives, regardless of whether the individuals use the resources themselves.

For many activities, valuation is relatively straightforward because prices are set in markets. Examples are clothing, food, admission fees, transportation, and travel. However, for other activities (e.g., boating, fishing, and camping) values are more difficult to determine because the activities do not have market prices. Measurement of such non-use values requires the utilization of "non-market" techniques. Absent such valuation, it would be difficult to establish a strict comparison of the benefits and costs of the alternatives. Such values in this project may be estimable with research specific to the study area or with research completed for other areas that may be transferable to this study area.[24]

Two frequently-used approaches for estimating the values of recreational activities are the travel cost method (TCM) and contingent valuation methods (CVM).[25] Both approaches require surveys of recreationists. The TCM uses visitor data on the time and monetary costs to visit a site. The data are used to estimate the difference between what visitors actually pay and what they would be willing to pay for a recreation experience. TCM is based on several assumptions, among them that visitors respond to the total costs of visitation regardless of the composition of those costs.[26]

The CVM approach is sometimes used when market prices or surrogates for those prices cannot be acquired. CVM studies are based on surveys that question respondents directly about how

[24] See USBR 1997b.

[25] See Dixon and Sherman 1990.

[26] See Schmid 1989.

they would respond to different situations. The answers to those questions are then used to estimate the value of a good or service for the pertinent population.

For the EIA for this project, it is unclear whether the TCM, CVM, or a combination of those two or other approaches would be best to measure the quantitative impacts of the alternatives. Final selection of the approach would depend on many factors, including time for completion, availability of data, and likely responsiveness of visitors to surveys.

7.3.5 Regional Economics and Related Issues

The bundles considered in this analysis may have several direct effects relative to agricultural economics, energy economics, recreation economics, and the other subjects listed in Table 7-1. Each of these effects in turn could cause impacts in many other sectors of the study area. The regional economic analysis should combine these dimensions into measures that allow for comparison among the alternatives.

Selection of an approach to measure regional economic impacts depends on many factors, including data availability, time and other constraints, and the desired degree of detail in the outputs of the analysis. Three common approaches are input-output (I-O) models, tables of multipliers generated from an already-completed I-O analysis, and computable general equilibrium (CGE) models.

Regional I-O models measure the extent of interdependencies within a geographic area. They incorporate relationships that quantify how the output of each sector in an area is distributed among other sectors and what the inputs to each sector are from other sectors. Details on this approach can be found in Miernyk 1967 and Miller and Blair 1985.

Software to estimate I-O models is available from different sources.[27] These sources typically use secondary data from federal, state, and local governments. The software generates multipliers that measure the indirect, induced, and total impacts attributable to a direct impact. I-O multipliers are also available for purchase separately from other sources.[28]

A CGE model mirrors an economy after an equilibrium has been reached. All demands, supplies, prices, and incomes are calculated simultaneously within the model.[29] The models allow for changes in output and input prices as resource availability changes. Consumers are assumed to attempt to maximize their utility, and their decisions establish the demands for goods and services as well as the supply of labor. Producers are assumed to be profit maximizers, and their decisions determine the outputs of goods and services as well as the demands for inputs. CGE models tend to be relatively aggregated because of their complexity and data requirements. Consequently, they are typically not used if extensive industry or commodity detail is required or if budgets are limited.[30]

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[27] See, e.g., Minnesota IMPLAN Group 1997.

[28] See, e.g., U.S. Department of Commerce 1992.

[29] See Berck, Robinson, and Goldman 1990.

[30] See Kraybill 1994.

Table 7-5 shows some of the key variables that should be included in the analysis of the regional economic impacts of the alternatives.

Table 7-5
Specification and Measurement of Key Regional Economic Impact Variables

Variable	Measurement
Economic baseline	Historical demographic and other economic descriptors
Output	Changes in regional output, by industry
Employment	Changes in regional employment, by industry
Income	Change in regional income, by industry

All benefits and costs of each bundle should be included in the analysis. The ultimate allocation of the costs of the bundles to the affected sectors will affect the regional impacts. The allocation will require a consideration of distributional equity and of the goals and objectives of the project.

The analytical framework developed for economic impact analysis should allow for testing of various important exogenous assumptions in sensitivity analyses. Some of the key assumptions may include different dates of completion for parts of the project, various combinations of water year types, and alternative rates for discounting benefits and costs.

7.4 TIMING OF ECONOMIC BENEFITS AND COSTS

An important characteristic of a particular bundle is the timing of when the benefits accrue relative to the costs. Bundles having high initial costs and delayed and/or uncertain benefits are, in traditional BCA, less preferred than bundles having immediate benefits with the same costs. In other words, if all else is equal, a bundle having more immediate benefits relative to costs would be preferred. Economic analysis uses discounting, or present worth, procedures to evaluate timing differences across bundles. Difficulties in applying present worth analysis can arise because (1) the timing of future benefits or costs may be uncertain (e.g., dependent on hydrology or institutional decisions); (2) all important benefits or costs may not be quantified in dollar terms; and (3) participants (even economists) disagree on an appropriate discounting rate. The economic analysis for the Study should acknowledge the importance of when benefits and costs occur and should include discounting of benefits and costs where possible. Uncertainties in the application of present worth analysis to the Study should be described, and particular features of bundles that could affect the timing of costs and benefits should be highlighted.

7.5 SUMMARY

This section develops both a conceptual and a methodological framework for analyzing the economic impacts of the bundles in the Study. It is specific to the study area, the five-county region within which the Friant Division is located. The conceptual framework presented focuses on those resource areas likely to be affected by the bundles. The assumed goal of the economic analysis is to provide a set of economic measures with which the bundles can be compared. The bundles include a combination of construction, machinery and equipment installation, reservoir and facility operation, water acquisitions, and the resultant changes in water supplies. The primary resource areas likely to be affected include agricultural economics, surface water

supplies and facilities, groundwater, fisheries, vegetation, recreation, regional economics, and the Sacramento/San Joaquin Delta.

Agricultural economic impacts are likely to include changes in water use, cropping patterns, employment, and farm income. These impacts are expected to occur over both the short run and the long run, and they are likely to vary by type of water year. It is possible that agricultural water use changes will occur both inside and outside the study area.

Changes in reservoir operation and river flows may have effects on recreation supply and demand. Recreation supply may change because access to reservoir and river recreation locations may change. Use of the recreation sites may be affected by those changes as well as availability and access to other sites, congestion, and quality and attractiveness.

The regional economic impacts of the bundles (or components of various bundles) depend on the specific activities and their respective direct, indirect, and induced effects. The relative magnitudes of the three types of impacts are likely to vary depending on the specific sectors impacted (e.g., suppliers of purchased agricultural inputs, pumps and related hardware, and concrete and other construction materials).

The methodological approach recommended for the economic impact analysis includes different models and measurements. It is suggested that direct agricultural economic impacts be measured using a regional agricultural production model such as CVPM. The economic impact estimates produced by a model should include changes in gross and net revenues, cropping mix, water use, and other farm-level variables. It is also suggested that focus groups be used to collect district- and farm-level primary data on responses to the bundles to improve the quality of the input data, to validate the model outputs, and to help define the sensitivity analyses to be run with the model.

The approach to measure energy impacts may include models to assess power production in response to changes in reservoir operation or capacity. The construction and use of such models are outside the domain of economic impact analysis, although the outputs of those models will be critical to the analysis by reflecting the competing uses for water.

The recreation impacts of the bundles may be important, and a detailed assessment of those impacts may require the consideration of both use and non-use values of recreationists. Changes in reservoir operation and capacity will likely influence the recreation "capacity" of the area as well as the relative attractiveness of the area to recreationists. Statistical relationships linking reservoir levels and population may be used to estimate recreation demand at reservoirs. A similar approach may be used to estimate riverine recreation demand. Other techniques may be required to estimate the non-use values associated with recreational sites.

Measurement of regional economic impacts should include both the direct and the indirect impacts on each of the other resource areas. Applicable approaches for regional impact estimation include input-output analysis, multiplier analysis, and computable general equilibrium models.

The future planning process includes the selection of a preferred alternative for supplying water for a comprehensive restoration plan. Section 8 discusses the issues and possible approaches for implementation of the preferred alternative or future negotiated water supply plan. This section describes the factors that need to be taken into account in implementing any of the bundles identified in this Water Supply Study or any other reconfigured bundle that would be selected as the preferred alternative. Discussions of funding sources are deferred primarily to the future negotiated plan. This section includes discussions pertaining to:

- Implementation issues
- Potential water purchase arrangements
- Capital improvements
- Funding sources/approaches
- Institutional arrangements for plan implementation
- Permitting and consultation requirements

Section 8 begins with a discussion of implementation issues and includes a summary of the concerns and impacts associated with the five bundles and the sensitivity analyses.

8.1 IMPLEMENTATION ISSUES

Implementation of the water supply measures identified in this Study or in future evaluations will require the necessary stakeholder support and a proactive approach to addressing the concerns of the affected parties. The issues that need to be addressed fall into four basic categories: environmental, institutional, engineering, and financial.

- **Environmental.** All of the proposed bundles include components having potential environmental issues that must be addressed through the CEQA-NEPA process. Direct environmental impacts are likely to be more critical for those components that involve major new construction or substantial changes to previous operations.
- **Institutional.** Institutional issues include resolution of water rights and water use concerns and negotiation of agreements for the use of facilities owned by others or obtaining approvals from other entities impacted by the construction or operation of the projects associated with a future water supply plan. For example, all bundles assume the use of "excess" capacity in facilities owned and operated as part of the State Water Project (SWP) and the Central Valley Project (CVP), including the California Aqueduct and San Luis Reservoir. Cooperation from a number of entities is essential to successful implementation of any of the bundles considered.
- **Engineering.** Engineering issues relate primarily to the technical feasibility of a component and whether it can physically be constructed or operated as planned while meeting the required factors of safety for a facility of its type. At this point, many assumptions have been made based on general and/or incomplete data on foundation and site conditions, hydraulic performance, existing stability, and other engineering aspects. These issues must be addressed in greater detail for any bundle chosen for additional investigation.

- **Financial.** Financial issues relate to the economic feasibility of the proposed bundles and assignment of the costs of the bundles. Specifically, the issues to be addressed include how and by whom the various aspects of the project are to be funded, acceptable levels of financial risk, contingencies, and other financial issues.

8.1.1 Summary of Environmental Concerns

Table 8-1 summarizes the land use, biological, and cultural resource concerns for all the bundles and the bundle configuration sensitivities. This information is based on a literature review and published database searches; no field investigations were done.

During years of surplus water, the Kings, Tule, and Kaweah Rivers contribute flows to the Central Valley. In these relatively infrequent very wet years, water would be transferred out of the rivers and into canals for delivery to groundwater recharge basins or other uses. This action could result in sufficient loss of flow to affect resources downstream of the diversion points on these three rivers. About 50 miles of channel could be affected. Loss of this flow component could affect geomorphic aspects of these channels or result in damage to riparian, fishery, or other aquatic resources. Similarly, there could be an effect on geomorphic aspects or damage to riparian, fishery, or other aquatic resources on the Merced River or Fine Gold Creek. This analysis of the potential impact of diversion of the high flows of the Kings, Tule, and Kaweah Rivers is based on theoretical considerations.

All of the bundles assume the recapture of restoration releases at the Mendota Pool. This action in and of itself requires no additional constraint on the water users taking their water from the Mendota Pool. However, should chinook salmon be restored to the San Joaquin River and the Mendota Pool is the path through which they will travel, there will be a need for two additional facilities at Mendota Pool. Adult salmon will have to be able to move upstream through the Mendota Pool in the fall and juvenile salmon will have to be able to move downstream through the pool in the spring. A fish ladder may need to be installed to provide fish passage over Mendota Dam for adults. Juvenile salmon will be passing downstream through the Mendota Pool from March through May. There are several canals that come off of the San Joaquin River in the vicinity of Mendota Pool. Fish screens may be needed on these canals to prevent juvenile salmon from entering these waterways and being lost from the San Joaquin River system.

The current ESA and other regulatory constraints were considered in bundle development with incremental pumping at the Delta limited to windows of time that are estimated to have limited or no negative impact on fishery resources. However, these windows of pumping opportunity cannot adequately foresee additional curtailments caused by take limits for each species. The potential exists for pumping curtailments greater than those modeled in this analysis that could affect the recapture of restoration flows in the Delta. The impact of these curtailments would be a decrease in the amount of water recaptured in the Delta and a resultant need to increase water supplies for the restoration flows through other mechanisms.

Additional Delta inflow is generally considered as beneficial, particularly from the San Joaquin River. Flow circulation and quality in the south Delta will likely improve with the occurrence of the incremental restoration flows contemplated in the analyses. At times, when the Delta is in balanced conditions, through the management of the flows with SWP/CVP operations, no additional Delta outflow may occur. During excess Delta conditions, additional Delta outflow

Table 8-1
Summary of Environmental Concerns
(Page 1 of 2)

	Water Quality			Land Use			Biological				Cultural				
	Millerton Lake	**Eastside Reservoirs**	**Groundwater**	**Millerton Lake Elevations (ft. msl)**	**Average Annual Use of Groundwater Banking (AF)**	**County Plans**	**Vernal Pool Species**	**Kern Brook Lamprey**	**Riparian and Wetland Resources/Habitats**	**Federal/State Listed Species**	**Millerton Lake Sites**	**Tulare Lakebed**	**Mammoth Pool**	**Fine Gold Reservoir**	**Patterson Pumps**
Bundle A	• Potential problem with metals, such as iron and mercury, near lake bottom • Expose deep lake to wind driven mixing that could degrade water quality	Iron and manganese contents high, but high metal concentrations not expected when using surplus flows	• High nitrate and pesticide concentrations in San Joaquin Valley groundwater • Percolation of flood flows with high suspended solids into recharge ponds can be detrimental to ponds	• 512 average elevation (ft. msl) under Modified Channel/Baseline Demands Scenario • Reduced earlier in year	• Case X, Modified Channel – provides 90,000 AF, extracts 62,000 AF • Case Y, Existing Channel – provides 110,000 AF, extracts 60,000 AF	Compatible with counties land use and resource conservation policies	Not affected	Not affected	Could affect riparian vegetation downstream of Friant Dam	If chinook restored to San Joaquin River, facilities needed at Mendota Pool for fall adult upstream migration and spring juvenile downstream migration	• 30% in inundation zone • Sites could be exposed more often • Sites could be subject to increased vandalism	--	--	--	--
Bundle B	Water at minimum pool storage exposed to wind and wave mixing that could affect water quality in the diversions	Same as included under Bundle A	Same as included under Bundle A	• 503 average elevation (ft. msl) under Modified Channel/Baseline Demands scenario • Reduced earlier in year	• Case X, Modified Channel – provides 74,000 AF, extracts 52,000 AF • Case Y, Existing Channel – provides 90,000 AF, extracts 50,000 AF	Same as included under Bundle A	Not affected	Not affected	Same as included under Bundle A	Same as included in Bundle A	Same as included in Bundle A	--	--	--	--
Bundle C	Recirculating San Joaquin River flow through the Delta pumping facilities may result in exporting an increased salt load to San Luis Reservoir	Same as included under Bundle A	Same as included under Bundle A	521 average elevation (ft. msl) under Modified Channel/Baseline Demands scenario	• Case X, Modified Channel – provides 89,000 AF, extracts 53,000 AF • Case Y, Existing Channel – provides 114,000 AF, extracts 65,000 AF	Storage in Tulare Lakebed compatible with Resource Conservation Element of Kings County General Plan	Not affected	Not affected	--	• Same as included in Bundle A • Tulare Lakebed storage may require mitigation for loss of habitat for San Joaquin kit fox	Same as included in Bundle A	• Six sites are all prehistoric multi-component camp sites; highly sensitive • Lakebed floods naturally, but further study or avoidance of sites recommended	--	--	--
Bundle D	Same as included under Bundle A, but potential for water quality effects in the lake during reduced storage periods decreases	Same as included under Bundle A	Same as included under Bundle A	• Up to 600 ft. msl elevation • Some campsites, homes, and other features could be inundated or require relocation	• Case X, Modified Channel – provides 68,000 AF, extracts 43,000 AF • Case Y, Existing Channel – provides 86,000 AF, extracts 44,000 AF	Compatible with water supply/flood control goals; incompatible with some environmental goals, riparian, habitat issues	Could inundate some vernal pools; mitigation could be required	Not affected	Vernal pool species could be adversely affected	• Same as included in bundle A • Mitigation could be required for loss of habitat for Sierra Nevada red fox and flaming trumpet, a riparian plant, at Mammoth Pool	Sites within existing pool would be affected only minimally; some new sites could be destroyed; moderately sensitive	--	• 17 known sites, many recorded over 40 years ago; moderately sensitive • One quarter of recorded sites were temporary camp sites; need survey for cultural resources	--	--

Table 8-1
Summary of Environmental Concerns
(Page 2 of 2)

	Water Quality			Land Use			Biological				Cultural				
	Millerton Lake	**Eastside Reservoirs**	**Groundwater**	**Millerton Lake Elevations (ft. msl)**	**Average Annual Use of Groundwater Banking (AF)**	**County Plans**	**Vernal Pool Species**	**Kern Brook Lamprey**	**Riparian and Wetland Resources/Habitats**	**Federal/State Listed Species**	**Millerton Lake Sites**	**Tulare Lakebed**	**Mammoth Pool**	**Fine Gold Reservoir**	**Patterson Pumps**
Bundle E	Same as included in Bundle D	Same as included in Bundle A	Same as included in Bundle A	• Up to 600 ft. msl elevation • Some campsites, homes, and other features could be inundated or require relocation	• Case X, Modified Channel – provides 50,000 AF, extracts 29,000 AF • Case Y, Existing Channel – provides 62,000 AF, extracts 26,000 AF	Compatible with water supply/flood control goals; incompatible with some environmental goals, riparian, habitat issues	Could inundate some vernal pools; mitigation could be required	Not affected	Western pond turtle habitat could be adversely affected	• Same as included in Bundle A • Mitigation could be required for loss of habitat for Sierra Nevada red fox and flaming trumpet, a riparian plant, at Mammoth Pool; western pond turtle at Fine Gold Creek	Sites within existing pool would be affected only minimally; some new sites could be destroyed; moderately sensitive	--	• 17 known sites, many recorded over 40 years ago; moderately sensitive • One quarter of recorded sites were temporary camp sites; need survey for cultural resources	Few sites recorded but likely to have more because of data from Millerton Lake; highly sensitive	--
Bundle Configuration Sensitivities				--	--	Compatible with general agricultural use; location and design can be flexible	--	--		• Same as included in Bundle A • Site specific habitat assessment of Patterson Pump location, search of CNDDB, check of USFWS formal lists by quads; further surveys or mitigation may be required • Flows supplied to the San Joaquin River (withheld from the Merced River) could impair juvenile chinook rearing on the Merced River or may, over the longer term, have detrimental effects on Merced River channel morphology and riparian corridor	--	--	--	--	Site specific records search whan alignment known, archaeological survey of footprint; mitigation may be required

would occur. Analyses of general or detailed impacts to Delta hydraulic or quality conditions due to the changes in flow estimated in this analysis are beyond the scope of assignment.

8.1.2 Summary of Institutional Challenges

Table 8-2 summarizes potential institutional challenges for all the bundles and the bundle configuration sensitivities.

Table 8-2
Summary of Institutional Challenges

	Regulatory	Agreements	Water Purchases	Groundwater Banking
Bundle A	• Instream flow requirements below Friant • Flow bypass requirements downstream of Mendota Pool • Permitting required for channel modifications and rediversion of releases • Regulations and programs affecting operations in Delta	• Multi-party agreements for recirculation • Groundwater banking and extraction agreements	• Heavily relied upon • Many local interests vying for these supplies	• Requires up to 5,800 acres of land throughout region • Success of program relies on thorough understanding of institutional and operational parameters
Bundle B	• Same as those in Bundle A • Congressionally authorized cost allocations for Millerton Lake may be required	Same as those in Bundle A	Same as those in Bundle A	Same as those in Bundle A
Bundle C	Same as those in Bundle A	• Same as those in Bundle A • May need land use change agreements/ permits	Same as those in Bundle A	Same as those in Bundle A

Table 8-2 (continued)
Summary of Institutional Challenges

	Regulatory	Agreements	Water Purchases	Groundwater Banking
Bundle D	Increases in Millerton may require an allocation to flood control, thus decreasing storage for conservation	• Same as those in Bundle A • Agreements with Southern Cal Edison for Mammoth Pool modifications • Property issues, property ownership, and impact to existing facilities • Potential increase in flood hazard downstream due to potential dam failure	Same as those in Bundle A	Same as those in Bundle A
Bundle E	• Increases in Millerton may require an allocation to flood control, thus decreasing storage for conservation • Water rights/ environmental challenges for building Fine Gold Reservoir	Same as those in Bundle D	Same as those in Bundle A	Same as those in Bundle A
Bundle Configuration Sensitivities	Permitting for fish screens	• Challenges likely to inter-basin exchange but difficult to quantify • Challenges likely for development of additional diversion facility upstream of the Delta	Exchange of VAMP water requires protocols to ensure SJRA not jeopardized	Same as those in Bundle A

8.1.3 Summary of Operational, Water Supply, and Other Technical Concerns

This section summarizes the operational, water supply, and technical concerns for all the bundles and the bundle configuration sensitivities.

8.1.3.1 Concerns for Eastside Tributary Pump-In

As described in Section 6, the Eastside tributary surplus water operation contributes greatly to the water supply of the bundles. An annual average of 91,000 acre-feet of water is developed

through the Eastside Tributary surplus flow operation. The viability of developing this quantity of water has its obstacles, including the following issues:

- Local plans for supply. Several programs are currently being implemented or investigated that could reduce, if not eliminate, the surplus flows assumed by this analysis.
- Place of use/water rights. Changes to the current disposition/use of these surplus flows may require permitting.
- Water quality. The quality of the flow associated with this operation is normally turbid, leading to utilization and maintenance concerns.
- Other statewide interest. Other statewide programs are evaluating the utilization of these flows. Competition for this supply could exist.

8.1.3.2 Effects of Bundles on Westside CVP Contractors

Each of the bundles includes the offset of CVP deliveries to the Mendota Pool (approximately an annual average of 40,000 acre-feet). This offset is due to the availability of additional supply at the Mendota Pool from Millerton Lake as a result of restoration releases. When captured at the Mendota Pool, the offset of baseline deliveries from the CVP's Delta-Mendota Canal is assumed to be credited to the restoration project and used by the Friant Division as a recirculation supply from the Westside of the Valley. The effect of this component of restoration operation is assumed neutral to the CVP's Westside water supply.

However, another result of bundle operations could affect water availability to Westside CVP contractors. Currently, water reaching Mendota Pool from the San Joaquin River and James Bypass (Fresno Slough) is integrated into the CVP Westside contractor supply. When water reaches the Mendota Pool from these sources it serves as an offset to CVP obligations to serve Mendota Pool water users. The reoperation of Millerton Lake to a different downstream flow regime, combined with anticipated flow bypass requirements at the Mendota Pool and the diminishment of Tulare Lake Basin overflows to the San Joaquin River through the Eastside tributary operation all have potential negative impacts to the CVP Westside contractor supply.

The bundle analyses limited the potential negative impact to Westside supply to be that impact caused by the reoperation of Millerton Lake and the reduction of Tulare Lake Basin overflows.

In the baseline operation, Millerton Lake spills reached the Mendota Pool at certain times. With the restoration operation, that flow regime is changed. Positive changes in the regime (water added) were credited to the restoration project (see description above). Effects due to negative changes (spills reduced) were counted as a potential impact to the CVP Westside supply. Also, due to the utilization of Eastside tributary surplus flows in the bundles, at times Tulare Lake Basin overflows to the San Joaquin River (Mendota Pool) can be reduced from that assumed in the baseline study. This impact is also counted as a potential impact to the CVP Westside supply. By design, impact to Westside supply due to San Joaquin River flow bypass requirements was not allowed.

The potential effects of bundle operations on Westside supply will vary depending on the baseline assumed (Case X demands or Case Y demands) and the utilization of Eastside tributary surplus flows. However, the method of analysis used to indicate a potential impact to the Westside supply did not include a linkage to Westside water supply operations (e.g., a

comprehensive evaluation integrating the results with CALSIM II modeling). As a result, the analysis of this issue should be considered only as an indication that an impact could occur. Additional analysis would be required to determine the actual existence, magnitude and frequency of such an impact.

8.1.3.3 Effects on Delta Supplies/Operations

Millerton Lake releases for restoration flows are not always captured downstream and recirculated. The water incrementally added to the San Joaquin River but not captured becomes an additional Delta supply, subject to use by the SWP/CVP. The amount of water recirculated is dependent on the facilities assumed to be available for capturing the releases and the assumptions for the constraints acting on those facilities. During portions of the year (June through September and November, January, and March), much of the incremental flow in the river is captured by restoration project components. However, during October, February, April, and May a significant part, if not all, of the incremental restoration flow is unavailable for restoration project capture. This unavailability is due to the lack of recapture potential (allowed pumping capacity) during periods when the restoration releases are greatest. For instance, during April and May when the restoration releases are greatest, assumed bypass requirements at the Mendota Pool preclude their capture. Delta capture during this period is also extremely limited due to export limitations.

When restoration releases are left uncaptured by project components, they become an additional water supply to the Delta. At times when the Delta is in a “balanced” condition (i.e., the SWP and CVP are explicitly balancing reservoir releases, Delta outflow, and exports to a certain condition), the incremental flow might be utilized by the SWP/CVP to reduce reservoir releases and thereby increase storage for later use. At other times when the Delta is in “excess” conditions (i.e., more Delta outflow exists than minimally required, and the SWP/CVP are not able to reduce releases or increase exports), the incremental flow will become additional Delta outflow lost to the control of any entity.

From a water supply standpoint, the incremental operation of the restoration project can cause changes to the Delta water supply. At times the operation will cause additional supply to the Delta that might be useful to the SWP/CVP, including the mitigation (if necessary) of the potential Westside water supply impacts described above, or through an institutional arrangement (involving storage) might become a supply for the restoration project. Similar to the potential impact to the Westside water supply described above, flows to the Delta might be decreased in some circumstances (e.g., due to the reoperation of Millerton Lake). However, the reduction in spills from Millerton Lake will likely normally occur when the Delta is excess conditions.

Similar to the discussion above, the method of analysis used to evaluate potential changes to the Delta water supply is limited in its ability to quantify values (e.g., a comprehensive evaluation integrating the results with CALSIM II modeling has not been performed). Therefore, the results cited above should be considered only as an indication that an impact could occur. The magnitude and frequency of such an impact needs to be refined through additional analyses.

8.1.3.4 Effects on Water Storage

Under Bundles A and B, Millerton Lake is often operated near minimum storage of 140,000 acre-feet, completely relying on pumping when storage falls below the 140,000 acre-feet level under Bundle B. Operating at near minimum reservoir conditions results in the loss of a reserve for unforeseen events such as variations in inflow and curtailments in conveyed supplies, purchases, or offsets provided by groundwater programs. Under Bundles D and E, storage at Millerton Lake is increased by 105,000 acre-feet. Similarly, under Bundles D and E, storage at Mammoth Pool is increased 30,000 acre-feet.

The ability to use Tulare Lakebed storage as a source of exchange for Millerton Lake deliveries (through adjacent lands) requires the coincidence of several events. One example of these exchanges could include entities that collectively have Kings River, Millerton Lake, and SWP water entitlements. Water availability from these sources changes year to year and is highly dependent on a number of complex factors. There is a relatively high risk that these circumstances will occur for an exchange.

8.1.3.5 Other Technical Concerns

In addition to the above-mentioned operational and water supply issues for implementation of components of the Water Supply Study, there are technical concerns for each of the bundles as well. The technical concerns for Bundle A include:

- The development of additional groundwater banking facilities is required.
- Additional water treatment facilities are needed for reclaimed wastewater or oil-field water.
- Improved interties are needed between the Cross Valley Canal (CVC) and the Friant-Kern Canal. Also need to construct lift stations.
- 1,000 cfs pump stations must be constructed for the Friant-Kern Canal to cross the Kings, Kaweah, and Tule Rivers.
- Long-term operation of Mendota Pool recirculation is a technical unknown.

In addition to the technical concerns raised for Bundle A, pumping dead storage (from elevation 404 feet to elevation 471 feet) would require a total of 68 500-horsepower pumps mounted on 34 barges to move water from Millerton Lake into canals for Bundle B. For Bundle C a new pumping plant would be needed to supply local use, and a second one would be needed to pump water stored in the Tulare Lakebed to the California Aqueduct.

There are many technical concerns with Bundles D and E because both would require construction of additional or new storage. Technical concerns for Bundle D include:

- There are major technical and constructability risks associated with raising the concrete gravity dam by 20 feet for Millerton Lake enlargement.
- Risks are associated with the construction of a new embankment saddle dam at Friant Dam.
- There is a need for an analysis regarding dam stability to raise Mammoth Pool Dam by 27 feet.

In addition to the concerns raised for Bundle D, Bundle E adds the following:

- There is a need for geotechnical site investigation for a new 440-foot-high dam on Fine Gold Creek.
- It is unknown if Millerton Lake storage and an outlet facility on Fine Gold (rather than a separate emergency spillway) can contain the design flood.
- Risks are associated with assuming that construction and operating costs balance potential pump storage benefits.

8.1.3.6 Power Projects

With the exception of marginal generation associated with the Mammoth Pool component, the long-term model calculated the total generation and total pumping associated with moving and storing the water for each of the bundles. The analyses included an estimation of the generation at Friant Dam, and the unit generation and pumping associated with increases or decreases in the use of features of the CVP, SWP, and Cross Valley Canal. These analyses also included the pumping costs associated with recovery of groundwater.

Because of the major changes expected in Millerton operation and the limits of the model and analysis, it is difficult to directly compare generation associated with existing facilities to generation associated with proposed operations at Friant Dam on a monthly component-by-component basis. That comparison would require an estimation of the existing power generation facilities under a baseline condition, which is beyond the scope of this analysis. As described in Section 6, the power costs and revenues associated with the bundles are only incorporated into the economic evaluation to a limited extent.

It is recognized that the operation associated with a restoration project will have an impact on the operation of existing power generation projects. The identification of that potential impact should be evaluated, with mitigation or other institutional remedies the subject of future discussions.

8.2 POTENTIAL WATER PURCHASE ARRANGEMENTS

Agreements for the purchase, transfer, or exchange of water supply can take any number of forms, as evidenced by the variety and creativity of past agreements. These agreements vary in their duration, their price and payment terms, the frequency and timing of actual transfers, and the allocation of financial and water supply risk between buyer and seller. Agreements may be made directly between buyer and seller or through an intermediary or broker (e.g., DWR's Drought Water Bank). Another possibility is an arrangement with the CALFED Environmental Water Account (EWA) to use the San Joaquin River system for conveyance or temporary storage of EWA water. All transfers, exchanges, or purchases of CVP water or use of CVP facilities will require USBR approval. The sections below include discussion of two possible purchase scenarios.

8.2.1 Long-Term Purchase Agreements

In these agreements a buyer and seller agree to a multi-year sale and transfer of water. The full and final purchase price is either negotiated and agreed to at the time the contract is signed or is defined in the contract in terms of a built-in pricing or escalation formula. The quantity to be

transferred in each year may be fixed, scaled in over time, or vary based on hydrologic or other conditions. An example of a long-term purchase agreement is the proposed transfer of water from Imperial Irrigation District to the San Diego County Water Authority. The agreement contains a baseline transfer quantity with an option to increase this quantity over time. The initial price paid is tied to the wholesale water rate charged by the Metropolitan Water District of Southern California (MWD), but the price would be adjusted in the future based on prices paid for other water transfers.

8.2.2 Long-Term Lease/Option Agreements

In these agreements a buyer agrees to lease the seller's water supply or contract entitlement for a period of years, often with an option to purchase the supply later on a permanent basis. An example of this type of agreement is the long-term lease of the Pajaro Valley Water Management Agency's (PVWMA's) contract supply by the Santa Clara Valley Water District (SCVWD) and the Westlands Water District (WWD). PVWMA purchased and was assigned 6,260 acre-feet of CVP water supply from the Mercy Springs Water District, though the future delivery schedule and demands in PVWMA were uncertain. This 20-year lease allows for the diversion and use of PVWMA contract water by SCVWD in dry years and WWD in other than dry years, with options for PVWMA use in still other years. Voters in the PVWMA recently voted to pursue the use of the CVP supplies.

8.2.3 Option Agreements

In an option agreement the buyer pays an option premium to the seller for the right to buy the water under certain future conditions. When the specified condition and other contract terms are met, the buyer has the right to pay the contract price (also called the exercise price or strike price) and receive the water. Options are a way for a buyer to increase its water supply reliability without taking on a long-term or permanent purchase of water supply. DWR has offered dry year options to purchase water from its Drought Water Bank. Although the procedures for setting up these options (including option contracts for both sellers and buyers) were prepared, no sellers were obtained in the initial year (winter 2001–02) of the program. As another example, MWD has paid farmers in the Palo Verde Irrigation District (PVID) a fee of just over $3,000 per acre (the option premium) for the right to purchase PVID irrigation water and transfer the water to MWD under certain conditions. The agreement specifies how often during the 35 years of the agreement the option can be exercised. This program provides an effective dry-year water supply program for MWD.

One purchase scenario is the water purchase pattern assumed in Section 6 of this Study. It would acquire 20,000 acre-feet per year of Category 1 water, purchase (or sponsor) of an additional 40,000 acre-feet per year from water conservation projects, and purchase options on sufficient additional water supply to meet nearly all of the remaining flow requirements. A small amount of residual, Category 3 purchases are also made. Option agreements allow the buyer to pay an option premium to the seller for the right to buy the water under certain future conditions. For purposes of this section, options are considered as Category 2 purchases because they can be structured to provide reasonably reliable water supply. Although the average purchase volume would average 80,000 acre-feet, this includes 160,000 acre-feet per year taken in the Dry and Normal-Dry years and none of it taken in Wet and Normal-Wet years. To meet the full flow

requirement in the 50 percent drier years, 160,000 acre-feet of options must be purchased, resulting in a fairly large initial or annual option premium payment. The remaining water payment, or exercise price of the option, would be paid only when the water is taken.

Although option agreements for many commodities are common, they are relatively unusual for purchases of water. Examples exist but are too few to be able to predict the likely terms of potential agreements. An assumed price structure is developed that is consistent with how options are generally priced relative to permanent long-term purchases and relative to pure spot market purchases. The following assumptions are used to estimate the option premium (the amount per acre-foot paid every year regardless of whether water is taken) and the exercise price (the additional amount paid per acre-foot when water is actually taken).

- A 10 to 1 ratio of exercise price to premium is assumed. (Note that the premium could be a lump-sum payment up-front. Some sellers might prefer this but it makes little difference to this analysis; the lump-sum payment could be financed.)
- An effective price paid per acre-foot (including both premiums and exercise price) is less than what would be required for pure spot market purchase, but greater than the price for a long-term purchase.
- Options pricing is also affected by overall demand: the higher the amount secured under option, the higher the price paid. This Study assumes that the price rises with quantity at the same rate estimated for the average year purchases in the price analysis described above.

Using these assumptions to set bounds for the analysis still leaves a range of possible prices. As an additional guide, the California Department of Water Resources' recent drought water option price offer of $10/acre-foot premium plus $65/acre-foot exercise price was not successful; therefore, the price curve is assumed to begin at a price higher than that. The following estimate is used for options pricing, but should be viewed as a reasonable estimate rather than a set of values estimated from actual transactions or uniquely derived by an algorithm.

- Assume that the starting prices for dry year options are: $12/acre-foot premium and $120/acre-foot exercise price.
- Assume that the exercise price rises according to the same formula as average year purchases derived above: 120 + 0.31*(1,000 acre-feet of options purchased).
- Assume that the premium rises accordingly to stay at one-tenth of the exercise price.

Using these assumptions to purchase options contracts sufficient to provide amounts ranging up to about 160,000 acre-feet annually, the premium price would be estimated at about $17/acre-foot and the exercise price would be estimated at about $170/acre-foot. Assuming that the options are exercised in the 50 percent drier year types, the effective price paid for water when it is taken (including 2 years of premium paid for each year of the water taken) is $170 plus 2×$17, or about $204/acre-foot. Cost estimates for this water purchase scenario are included in the analysis of Bundle A in Section 6.

8.2.4 Landowner Transfers

In these transfers, water from one district is moved to the same farmer/landowner in another district. Such transfers are subject to district policies, which vary from district to district. These

transfers might also be impeded by legal and contractual restrictions on the water supply's authorized place of use and conveyance restrictions. In some situations, it may be possible for an entity with land and/or water in one district to transfer that water to another district for subsequent release to the San Joaquin River.

8.2.5 Exchange Agreements

Two (or more) parties agree to exchange water supply in order to improve the timing, location, or quality of water supply to one or both parties. Arrangements have occurred for both even (balanced) and uneven (unbalanced) exchanges. Monetary payments may also be made as part of an exchange. Within the State Water Project (SWP), exchanges have been approved in which up to 2 acre-feet of water supply have been delivered in wet years for 1 acre-foot to be returned in dry years.

8.2.6 Short-Term (Year-to-Year) Purchases

Short-term purchases are agreements to transfer water supply within a relatively short period of time, usually a year or less. The transfer agreement is generally made after the buyer determines when and how much water it needs during a specified period. For example, a typical short-term purchase agreement would be made in the spring months after the potential buyer has determined that insufficient supply will be available from its normal sources that year. A potential seller knows reasonably well what its available supply is. Other conditions being equal, the price paid for water under short-term contracts tends to be higher than the price paid for longer-term contracts for two primary reasons: the buyer is clearly in need of additional water and is less sensitive to price paid, and the seller knows it; and there is a greater demand for short-term purchases during periods of low supply, so competition from other uses for the water is strong. Examples of these arrangements include a number of single-year purchases by the Environmental Water Account (EWA) and the CVPIA Water Acquisition Program. Westlands WD and other water-short districts have made a number of single-year transfers over the last decade.

A second purchase scenario uses a reasonable baseline of long-term purchases from water reclamation (Category 1) of 20,000 acre-feet per year and emphasizes short-term (Category 3) purchases of water for the remaining, large majority of the purchase program. This scenario should be viewed simply as one example of an approach to water purchasing.

As shown in Table 6-10, total purchases for the four configurations of Bundle A averaged from 146,000 to 208,000 acre-feet. After accounting for the assumed 20,000 acre-feet of Category 1 purchases every year, the residual Category 3 amount would average between 126,000 and 188,000 acre-feet. Actual purchases by year would, of course, vary widely depending on hydrology and on the operations of groundwater and other supply options. Cost per acre-foot purchased would also vary by year type, with dry year purchases more expensive that normal or wet year purchases (see Appendix E for a description of how water market prices can vary by year type). For purposes of estimating a potential cost, assume that 50 percent of spot market purchases would occur during Dry year market conditions and 50 percent under Normal year market conditions. The average cost of Category 3 (and Residual) water purchases in Bundle A ranges from $26 million to $42 million per year, depending on channel configuration and baseline demand. This cost will also vary widely as a result of hydrologic variability. The

methodology used to develop these water purchase cost estimates is described in Appendix E, Section 3.

8.2.7 Water Banking Programs

Water banks allow users to store water for longer periods of time (potentially years) in order to draw on the supply when needed. Although new surface storage reservoirs can serve as water banks, groundwater basins are currently the predominant form of new storage used in California. The banks can store water directly (by injection wells and percolation basins) or indirectly through "in lieu" recharge. Groundwater banks, by the nature of their operation, are normally not full; this is especially true for recently developed banks. Many of these banks look for opportunities to allow nonowners to store water for a fee. This allows agencies or individuals to store water for the short term or long term. Due to a lack of operational history for these programs, it is unclear how big a component of a long-term water supply water banks could be for the restoration program. Both the Kern Water Bank and the Semitropic Water Storage District operate water banks, and each is investigating ways to expand capacity and increase the number of users of its banking facilities. In addition to the banks that have been developed in Kern County, a number of other projects are undergoing study or design in neighboring counties. The most significant considerations in developing new projects are timing and duration of flows, conveyance facilities, local impacts, and water quality.

8.2.8 Permanent Purchases of Supply or Entitlement

Under these transfer agreements, the buyer purchases the seller's water right, CVP contract entitlement, or SWP contract entitlement. The buyer generally receives the same quantity, timing, and reliability of supply that the seller had, after adjusting for differences in conveyance and other losses. For purchase of CVP or SWP contract entitlement, the buyer also assumes the normal obligations of a contractor and must pay the existing water charges and assessments. A number of sales of SWP entitlement have occurred in recent years. Many of these sales were spurred by the signing of the Monterey Agreement amendments to the SWP. These types of permanent purchases may be subject to first right of refusal by others.

8.2.9 Short-Term Land Leases

In several instances, districts have entered into agreements with farmers to lease their lands during wet years. In these agreements, water is intentionally ponded on the land to recharge groundwater while still allowing the land to stay in agricultural production. These programs have historically been developed to increase recharge in wet years but not in conjunction with extraction facilities. It could be expected that similar programs could be developed that would include the ability to recover the water.

8.2.10 Fallowing Programs

In fallowing agreements water is made available for transfer by the seller to reduce land under irrigation. These agreements may be short-term, long-term, options, or other agreements. The MWD/PVID agreement described in Section 8.2.3, "Option Agreements," is also an example of a fallowing agreement. Land fallowing agreements can specify that the same lands are to be

fallowed every year of transfer or that different lands are to be fallowed each time water is transferred.

8.2.11 Water Conservation Programs

Water conservation programs specify that the seller reduce losses in its current delivery and use of water in order to make these reductions available for transfer. The avoided losses are then transferred to the buyer. These programs may use short-term, long-term, option, or other agreements. An example is the MWD/IID agreement under which MWD pays for water conservation programs in IID and receives the conserved water in return. Documentation and quantification of conserved water are important and potentially contentious features of such programs.

8.3 CAPITAL IMPROVEMENTS

All of the bundles include capital improvement components. Although no "fatal flaws" have been detected for any of the components included in the bundles to date, risk is always associated with the implementation of any component. Such risks may be environmental, institutional, or engineering in nature.

8.3.1 Implementation of Capital Improvements Common to All Bundles

All five bundles include the capital improvements associated with Bundle A. These capital improvements consist mainly of improvements to existing canal facilities, permanent installation of pumps at locations that have included temporary pumps in the past, and development of substantial new water banking facilities. At this time, no significant environmental issues have been identified for these components.

8.3.1.1 Pumping Facilities at Eastside Tributaries

One capital improvement common to all bundles includes installing permanent facilities to pump surplus water from the Kings, Kaweah, and Tule Rivers into the Friant-Kern Canal. From an institutional standpoint, water rights issues associated with pumping this "surplus" water need to be addressed. It should be recognized that developing supplies from other river systems and obtaining rights thereto could be a very contentious issue. Care will need to be exercised in discussions with local representatives. It is also expected that to gain support from local authorities, a portion of the "new" or developed supply will need to be utilized locally.

Water quality may also be an issue. The water quality of "surplus" water from the Eastside tributaries historically has been poorer than water diverted from Millerton Lake due to the fact that it comes usually during flood events. Turbidity is much higher than that usually occurring in the Friant-Kern Canal. During past occurrences the municipal and industrial users asked for assurances from the pump-ins on quality and, in some instances, paid for alternative sources of supply. It is also believed that the Friant Water Users realized additional cost to clean the additional sediment out of the canal.

8.3.1.2 Groundwater Banking

Groundwater banking is not a new development for water storage. Formal banks have been in existence in recent times and were initiated with the development of the Friant project within the CVP system. The early systems were developed as in lieu systems, whereby surface water supplies were delivered to more lands as more water was available. With the construction of the Arvin-Edison Water Storage District (AEWSD) system in the early 1960s, direct recharge of water supplies was added as an additional means to intentionally store water in the ground for later use and re-regulate the more erratic timing of surface supplies. Presently, the banks that have come into existence have been owned and operated for the benefit of the local water district. In this context "benefit" means "development of additional water supplies." Most of these recent banks have taken from five to ten years from conception to construction and have cost millions of dollars in capital. Most are so expensive and require extensive permitting that they are phased over time and many projects that had been initiated over ten years ago are still in the process of being constructed. The bottom line for large, district-owned banking facilities is that they require (1) favorable geologic conditions, (2) lots of storage space, (3) lots of capital, (4) extensive permitting, and (5) acceptance by neighbors.

Due to these physical and political requirements, there has recently been more interest in developing smaller banking programs to serve the same purpose. These smaller programs are presently planned to rely on existing infrastructure to deliver flood or "surplus" water at times when the conveyance systems have historically not been used or used at capacity. In most valley counties north of Kern, the groundwater pumping influences have not been as severe, posing less specific locations of groundwater depletions. It is with this understanding that many of the water agencies of the San Joaquin Valley are pursuing local projects. The projects are expensive, and due to the costs most districts look for partners, grants, or other means to finance the improvements. It is in this role that there is opportunity for the managers involved in the future water supply plan to acquire or achieve relationships or contractual agreements for water, storage, capacity, rights to store water, or a number of other beneficial arrangements. In general, the shorter the time frame of the agreement, the higher the unit cost of the supply. It is estimated that on the long term (e.g., on the order of 25 to 30 years), the unit cost for water would be approximately the same.

Both institutional and engineering issues are associated with the development of new groundwater banks. Institutional issues include the need for approval by regulatory authorities and landowners so that water can be both banked and recovered. The availability of land and the willingness of landowners to sell or lease their property are by far the most significant impairments to the development of these banking programs. A groundwater banking program must address impacts on surrounding lands and constraints on extraction regarding water balance and losses. All bundles assume that approximately 5,800 acres of land will be required to accomplish the needed storage to meet the restoration flow requirements. Groundwater storage and recovery affect the local water table. The local depth to groundwater where most of the banking activities are expected to occur varies from 40 to 150 feet. The Kern County Water Agency (KCWA) assumes an average design pumping depth for dry periods of 270 feet, and current pumping depth is 180 to 240 feet. AEWSD uses a pumping depth of 410 feet.

Because this groundwater storage would be developed throughout the San Joaquin Valley, it can be expected that there could be as many as 20 or more different project locations impacting

thousands of people on the local level. Local interests would need assurance that both the deposition and the recovery of water banked under this project would not adversely impact their own water supplies. Because of local knowledge and trust, it is likely that local agencies would need to take the lead in implementing these new banking programs.

Engineering issues also play a part due to limited sites near Friant demand centers with conditions best suited for percolation and recovery of banked water. Engineering of the programs is also important so that the projects operate as planned. As an example, flood flows typically have high suspended solids that may be detrimental to intentional recharge activities. The levels depend on the timing of diversion, the method of conveyance, and the ultimate end use of the supply. At the City of Fresno intentional recharge basins, sampling of the flows is made and at times the flood flows are bypassed. When diverted they enter a main settling basin and are then decanted into the remaining basins at the site. This helps to limit the fines from spreading throughout the site and limits the infiltration rates.

8.3.1.3 Friant-Kern Canal Reverse Pumping

This capital improvement involves improving the intertie between the Cross Valley Canal and the Friant-Kern Canal and constructing lift stations to move 500 cfs up the Friant-Kern Canal. While the details of implementation have not been investigated, no significant environmental, institutional, or engineering issues are anticipated with these improvements to existing facilities.

8.3.2 Implementation of Bundle-Specific Capital Improvements

Bundle A relies heavily on existing storage and conveyance systems. Bundles B through E all include components with more significant implementation issues. These bundles include either significant changes to the operation of existing surface reservoirs or new surface reservoirs. Environmental, institutional, and engineering issues are associated with implementation of all of these alternatives.

8.3.2.1 Bundle A

Bundle A relies extensively on existing storage and conveyance systems, so capital improvement issues are not as significant as for the other bundles. Bundle A also relies most heavily on water purchases to meet restoration demand. The urban conservation and oil field water reclamation components are likely to require some improvements to conveyance systems and possibly additional treatment facilities to make these supplies available, and these issues pertain to the other bundles as well.

8.3.2.2 Bundle B

In addition to the capital improvements common to all the bundles discussed above, Bundle B includes use of 100,000 acre-feet of minimum pool storage at Millerton Lake. The capital improvements consist of either deployment of a fleet of approximately 34 barges to pump the water out of the reservoir to the two canals or construction of two large pump stations and discharge pipes to deliver water from the river outlets to the two canals. A preliminary layout plan shows that deployment and interconnection of a barge-based pumping system will be

challenging from an engineering standpoint. The large pump station arrangement will be equally challenging, with two 108-inch-diameter pipes required to deliver water up to the Friant-Kern Canal and a 90-inch pipe under the spillway stilling basin needed to deliver water to the Madera Canal.

There are also significant institutional and environmental issues associated with implementing these capital improvements. The existing reservoir provides significant recreational benefits in addition to the benefits associated with water supply and flood control. Lowering the reservoir would adversely impact these functions. Potential impacts of changes in minimum pool on Friant and/or Exchange Contractor water supplies need to be identified and addressed.

8.3.2.3 Bundle C

In addition to the capital improvements common to the bundles discussed above, capital improvements for Bundle C include development of 100,000 acre-feet of storage within the Tulare Lakebed and development of new pumping facilities and conduits to connect the reservoir with the California Aqueduct. Development of these capital improvements is not expected to present any unique engineering challenges. Rather, there will likely be institutional and environmental issues associated with acquiring and changing the use of approximately 25,000 acres of land needed for the facility.

8.3.2.4 Bundle D

In addition to the capital improvements common to all the bundles discussed above, capital improvements for Bundle D include increasing the storage in Millerton Lake by 105,000 acre-feet by raising Friant Dam by 20 feet and increasing the storage in Mammoth Pool by 30,000 acre-feet by raising its water surface by 27 feet. No engineering analyses have been performed regarding the impacts on overall dam stability. Maintaining dam safety while raising the dam presents an engineering challenge for both of these facilities that could be expensive relative to other costs. There are also institutional and environmental issues associated with increasing the water surface. A total of approximately 1,000 acres of additional land would be inundated under high water conditions. Roads, boat ramps, camping and other recreational facilities and other improvements would need to be relocated to higher ground.

8.3.2.5 Bundle E

In addition to the capital improvements common to all the bundles discussed above, capital improvements for Bundle E consist of the Friant and Mammoth Pool improvements discussed in Bundle D along with construction a new 400,000 acre-feet Fine Gold Reservoir. Only conceptual engineering work has been performed. A geotechnical investigation and additional engineering layouts may reveal engineering issues with the site that could affect implementation. There are also significant environmental and institutional issues associated with developing a new dam and reservoir. The reservoir would inundate approximately 3,900 acres of land and require the relocation of an existing road.

8.3.3 Implementation of Capital Improvements Associated with Sensitivity Analyses

Three additional components were investigated in the sensitivity analysis associated with the bundles. Implementation issues for these components are briefly discussed below.

8.3.3.1 Patterson Recirculation

Capital improvements associated with Patterson recirculation include construction of a new pump station on the San Joaquin River and piping the discharge to the Delta-Mendota Canal. Design of a pump station that minimizes harm to fish and the overall ecosystem at the river intake is expected to be the major implementation issue from both an engineering and an environmental standpoint.

8.3.3.2 Expanded West to East Conveyance

This capital improvement would involve improving the Cross Valley Canal to expand its capacity. Although the details of implementation have not been investigated, any significant environmental and engineering issues associated with these improvements can be resolved. The need for mutually beneficial institutional arrangements must be addressed.

8.3.3.3 Merced Intertie

This capital improvement includes both improving existing Merced Irrigation District Canals and construction of new sections of canal pump stations and pipeline. While no significant engineering issues are expected to affect implementation, there are likely to be environmental issues associated with construction of the new facilities and diversion of flow from the Merced River. There are also institutional and environmental issues associated with the inter-basin transfer of flow from the Merced to the Friant service area. As with the capture of "surplus" water from the Eastside tributaries, it should be recognized that developing supplies from the Merced River system and obtaining rights thereto could be a contentious issue. Coordination with San Joaquin River Agreement parties would be necessary as well.

8.4 FUNDING SOURCES/APPROACHES

Whichever water supply alternative is ultimately selected, funding for the water supply will consist of three components: funds for water purchases, capital improvement funds, and operation and maintenance funds.

Analysis to date shows that the least-cost alternatives average in excess of $30 million annually. Costs could be substantially higher depending on bundle selection and channel (i.e. modified or existing) requirements. Funding a plan of this nature and magnitude is a major challenge. A number of questions need to be answered as the future plan is finalized. These include:

- Is state or federal legislation necessary? Federal authorizations, either new or modifying the Friant division authorization, would require new legislation. A state bond measure would require legislation or an initiative. Either would need to be coupled with a vote of the population.

- What cost sharing arrangements need to be developed? Funding for the project so far has come primarily from the state and federal governments but also from in-kind services locally. Future funding will need to be of at least an order of magnitude greater on an annual basis. Generally, programs that match funds are more likely to receive approval at all levels of government than programs that do not. For example, a proposed funding package composed of 25 to 50 percent federal funds, 25 to 50 percent state funds, and the balance in local funds could be attractive.
- Who should be responsible for developing funding? To date the efforts have been carried out jointly by the Friant water users and the NRDC Coalition. If a new entity is formed for implementation, it would have some responsibility in this area. Should the new entity have total responsibility for developing funding or should others have that responsibility, with the new entity strictly limited to carrying out the Plan with available funds? Either way, funding from all levels of government will require broad-based support.
- How should money be spent in the first few years of implementation? There will need to be a balance between water purchases and capital improvements. Too much emphasis on water purchases may drag out the schedules for the necessary capital improvements. Too much emphasis on capital improvements may result in loss of momentum on river restoration.

Resolving these and other implementation questions should begin to become a priority because of the lead times generally necessary to accomplish institutional and financial package development.

8.5 INSTITUTIONAL ARRANGEMENTS FOR PLAN IMPLEMENTATION

Successful implementation of the future negotiated water supply plan for river restoration may require the establishment of a single entity with the responsibility and authority to carry out the plan. In addition to having the responsibility and the authority, this entity must be fully accountable for implementation, which would include an accounting of water releases from Friant Dam and subsequent delivery at key points in the San Joaquin River system and the Delta.

The Environmental Water Account (EWA) is one model that could be used for the future negotiated plan. The purpose of the EWA is to obtain water for the benefit of the environment while keeping water users whole. In effect, the EWA is a water agency acting on behalf of the environment. Its responsibility, its actions, and the tools it can use are similar to those of a water agency in that it buys and sells water and it needs access to conveyance and storage facilities to move water around and store it. The EWA could own or lease storage and conveyance facilities. Another important issue is accounting for and control of water after it is released from Friant Dam, including control of water after it reaches the Delta. The EWA has grappled with this issue, and it is clear that resolution of the issue before commencing a full-fledged restoration program is imperative.

One limitation to the effectiveness of the existing EWA as developed and implemented by the CALFED agencies is that the agencies collectively manage it, and they do so in addition to their other responsibilities. Another limitation is that EWA currently has no funds for long-term arrangements or capital expenditures. A different model would consist of the CALFED agencies acting as a board of directors for a new entity that serves as the EWA water agency. This model could be developed and implemented on the San Joaquin River. Another version of this model

would be to simply use the authorities of an existing agency whose mission would be modified to include implementation of the plan. In any event the entity would need to have the authority to:

- Enter into contracts
- Purchase and sell water
- Lease, construct, operate, and maintain facilities
- Manage funding, including obtaining state and federal funds, charging fees, and issuing and paying bonds

The entity's responsibility would be to implement the future negotiated plan. This includes implementing specific measures, setting priorities based on available funds, monitoring and assessing success or failure, using adaptive management, developing additional sources of funds, and reviewing plan performance on a periodic basis, such as annually. Options that are available include:

- Existing agencies:
  - USBR. The USBR can perform all of the needed actions, but they are subject to annual redirection and reprioritization by Congress.
  - San Joaquin River Group Authority (SJRGA). They have the authority and experience at providing umbrella management of various activities.
  - FWUA. They have all of the requisite authorities, but their focus has been exclusively on the water supply side, historically.
  - NRDC. The NRDC Coalition does not include anyone with the existing authority or experience to manage an entity that must carry out a wide range of on-the-ground activities. In addition, their focus has historically been exclusively on river restoration.
  - San Joaquin River Parkway Trust. The Trust is gaining experience at project management and at developing broad-based support for projects.
  - Other state and federal agencies. These agencies include DFG, DWR, and USFWS. Their strength is in having an existing staff and infrastructure. Their weakness is in already having broad missions that could dilute effort to implement the Plan. Also, the resource agencies generally are not well equipped to implement infrastucture-focused programs.
- New agencies: One challenge in creating a new agency is establishing the relationship between the new agency and existing agencies. This is a significant but not insurmountable challenge.
  - New Joint Powers Authority. This would have the necessary authorities, similar to FWUA and the SJRGA, but would be created for the purpose of implementing this Plan to ensure total focus on it.
  - New local agency. Similarly, this entity would be created for the sole purpose of Plan implementation.
  - New CALFED entity. The state legislature has enacted and the governor has signed legislation to create a CALFED Bay-Delta agency. The entity created for that program has all of the necessary authorities to implement a future negotiated plan.

8.6 OTHER PROCESSES

Due to the complexity of California's water issues, there are a number of other processes and activities that may affect the implementability of the future plan. These include, but are not limited to, the area of origin petition by the Westlands Water District, CALFED and CVPIA implementation, potential new ESA listings, FERC licensing or re-licensing proceedings in the San Joaquin River Basin, projects and plans proposed by other San Joaquin River Group Authority members, and expansion of SWP export capacity. Any one of these could significantly alter the conditions of implementation. As a result, an important aspect of any implementation agreement or strategy will need to be the flexibility to adapt to changed conditions.

8.7 PERMITS AND APPROVALS

This section describes the major permits required to implement any of the alternatives described in this Water Supply Study. In addition to permits, some actions would require agency review and consultation. Table 8-3 lists the permits, the agency authority, and what types of activities could require these permits. Table 8-4 is a preliminary list of environmental review and consultation requirements that could be necessary for particular activities. Following the tables is a discussion of permits and approvals specific to each of the bundles.

Table 8-3
Permits Required for Alternatives Implementation

Agency and Permits	Agency Authority	Activities Subject to Permits
Federal		
U.S. Army Corps of Engineers		
Clean Water Act Section 404 Permit	The Corps issues permits for discharge of dredged or fill materials into waters of the United States	Dam construction or alteration, road relocation, and other activities requiring fill of surface waters or wetlands
River and Harbors Act of 1899 Section 10 Permit	The Corps issues permits for activities in or affecting navigable waters of the United States	Construction of intake structures, fish screens, or other facilities affecting navigable waters
U.S. Bureau of Reclamation		
Petition to amend water rights	Reclamation petitions SWRCB to modify rights to allow changes in diversion location, quantity, or rate	Many components would involve a petition for either new or amendment of existing water rights to change point of diversion, storage, or place of use
Contract amendments or approval	Reclamation amends contracts with water agencies to allow modification, construction, abandonment, or change in use of Reclamation facilities, or any modification to service areas	Modifications to canals or intakes, changes in operating and maintaining canals
Federal Energy Regulatory Commission		
Hydropower generation license amendments or new issuance	FERC amends existing hydropower generation licenses or grants new licenses	Raising Millerton Lake or Mammoth Pool, use of Fine Gold Reservoir for pumped storage

Table 8-3 (continued)
Permits Required for Alternatives Implementation

Agency and Permits	Agency Authority	Activities Subject to Permits
State		
California Department of Fish and Game		
Streambed Alteration Agreement	DFG enters into agreements with entities proposing changes in natural conditions of rivers, streams, or lakes	Intake construction, pipeline construction, relocation of roads, construction or alteration of dams and reservoirs
California Department of Water Resources		
Approval to use DWR facilities	DWR evaluates and gives consent to agency plans to modify or tie into DWR facilities	Pumping facilities at Harvey Banks, California Aqueduct, storage at San Luis Reservoir
California Department of Water Resources, Division of Safety of Dams		
Approvals of plans and specifications	DSOD reviews and grants approval to plans and specifications to construct or enlarge dams and reservoirs	Design and construction or alteration of dams
Notice of completion and statement of actual cost; certificate of approval to impound water	DSOD evaluates the safety of newly constructed and enlarged reservoirs and grants approval to initiate storage operations	Storage of water in a reservoir
Reclamation Board		
Encroachment permit on project levees	The Reclamation Board reviews and grants approval to any activity affecting a Corps flood control project	Possibility that flood control operations could be affected inherently by changing storage in Millerton Lake or Mammoth Pool
State Water Resources Control Board		
Permit to appropriate water rights and/or amendment or amendment to existing rights	SWRCB issues permits to allow the appropriation of unappropriated water from surface sources and grants approval to divert water to storage and to change purpose and place of use	Change in point of diversion, storage of project water, and change in water uses
Regional Water Quality Control Board		
Clean Water Act Section 401 Water Quality Certification	SWRCB certifies that an applicant for a Section 404 and Section 10 permit complies with certain water quality standards	Any earth-moving activities, such as grading, excavating, and other construction; discharge of water from dewatering activities into storm drains and creeks, and discharge of wastewater from conveyance cleaning operations
State Lands Commission		
Land use lease for encroachment on state lands	The State Lands Commission grants a lease to use state-owned lands for purposes other than dredging, mining, or oil, gas, or geothermal exploration	Use of state-owned land for construction or siting of project facilities, if such use occurs

Table 8-3 (continued)
Permits Required for Alternatives Implementation

Agency and Permits	Agency Authority	Activities Subject to Permits
California Division of Mines and Geology		
Surface Mining and Reclamation Act	The California Division of Mines and Geology requires an approved reclamation plan before excavation activities	Excavation of dam construction materials from watershed quarry area
Regional and Local Agencies and Utilities		
Air Quality Management Districts		
Authority to construct/permit to operate	Local districts issue permits based on emission estimates and subsequent tests performed at the construction facility	Use, during construction and operation of project
Irrigation Districts		
Encroachment permits	Permits to allow construction of facilities that cross irrigation district system	Construction of project facilities that cross irrigation district system
Counties – Madera, Fresno, Kings, Tulare, and Kern		
Land use permits	Counties issue permits to change use of property, transport and excavate material	Construction or alteration of dams and reservoirs, groundwater banking facilities
Building permits	Counties issue permits to develop permanent structures	Construction of pump facilities, other structures
Reclamation Districts		
Access easement and permission to cross levees	Individual reclamation districts grant easements and regulate access to levees under district jurisdiction	Construction of conveyance and related facilities on reclamation district lands

Table 8-4
Other Environmental Review and Consultation Requirements

Agency and Requirements	Agency Authority	Activities Initiating Review and Consultation Requirements
Federal		
U.S. Fish and Wildlife Service		
Endangered Species Act Section 7 consultation	Federal agencies must consult with USFWS when their actions may affect listed or proposed endangered or threatened species or critical habitat	Any project activity that may affect listed or proposed endangered or threatened species or critical habitat
Fish and Wildlife Coordination Act	Federal agencies must consult with USFWS when undertaking projects that control or modify surface water	Any project activity that may affect or modify surface water

Table 8-4 (continued)
Other Environmental Review and Consultation Requirements

Agency and Requirements	Agency Authority	Activities Initiating Review and Consultation Requirements
National Marine Fisheries Service		
Endangered Species Act Section 7 consultation	Federal agencies must consult with NMFS when their actions may affect listed or proposed endangered or threatened species or critical habitat	Any project activity that may affect listed or proposed endangered or threatened species or critical habitat
Environmental Protection Agency		
Clean Water Act and Clean Air Act	EPA has oversight responsibility to ensure that federal and state agencies comply with the provisions of these acts	Need for permit under Section 404 of the Clean Water Act and for preparation of EIS under NEPA
State		
California Department of Fish and Game		
Endangered Species Act	DFG enforces the intent of the act when state or local agency actions may affect state-listed or proposed endangered or threatened species of critical habitat	Reservoir construction or alteration, conveyance facility construction, road relocations, and overall project operation
Fish and Wildlife Coordination Act	Federal agencies must consult with state fish and game agencies when undertaking projects that control or modify surface water	Control and modification of surface water
Office of Historic Preservation (SHPO) and Advisory Council on Historic Preservation		
Archeological survey review (Archeological Resource Protection Act, National Historic Preservation Act)	SHPO reviews and comments on any archeological surveys; if resources are identified, the SHPO must be consulted to determine the eligibility for nomination to the National Register of Historic Places. The Advisory Council on Historic Preservation must concur if a programmatic memorandum of agreement is prepared	Archeological survey conducted and determinations of eligibility and effect prepared
Native American Heritage Commission		
Consultation with certain Native Americans in compliance with California Public Resources Code Section 5097.98 and California Health and Safety Code Section 7050.5	The commission identifies persons who may be likely descendants of Native Americans whose remains may be found and requires that consultation with identified persons be initiated	Plans for physical alteration of a known cultural resource site that has a likely potential for containing remains of Native Americans
Regional and Local Agencies and Utilities		
Counties – Madera, Fresno, Kings, Tulare, and Kern		
Conformance with general plans	Counties review local agency projects for conformity with the general plan	Effects on land use

8.7.1 Bundle A

Bundle A relies heavily on outside purchases and additional use of existing conveyance facilities. Implementation of this bundle would entail the construction of new facilities primarily related to groundwater banking. Purchase of Category 1 water could include construction of new conveyance and water treatment facilities. Pump stations would be constructed for either the Friant-Kern Canal reverse pumping or Eastside tributary pump-in components. Permits for the groundwater banking would be primarily local county land use permits; it is assumed that the 5,800 acres needed would be scattered throughout the counties of Madera, Fresno, Kings, Tulare, and Kern. Additional building permits from the counties would also be required for building pumping facilities. Locally, irrigation districts may need to issue encroachment permits if any of the facilities cross their systems.

At the state level, water rights permits from the SWRCB would be required to allow the appropriation of unappropriated water from surface sources and grant approval to divert water to storage for groundwater banking. A Clean Water Act Water Section 401 Quality Certification would be needed from the SWRCB for any earth-moving activities that could occur during construction or dewatering activities that discharge into storm drains and creeks. In addition the California Department of Water Resources (DWR) would have to give consent to plans that modify or tie into DWR facilities.

Federal permits that may be required include the Clean Water Act Section 404 permit that the U.S. Army Corps of Engineers issues for construction activities that could fill surface waters or wetlands. The U.S. Bureau of Reclamation may have to amend contracts with water agencies to allow modification, construction, or change in use of facilities or modifications to service areas.

In addition to the above permits, several agencies may need to be consulted depending on the actual site location of Bundle A components. Table 8-4 lists these agencies and the types of activities that could require consultation.

8.7.2 Bundle B

Given that the components of Bundle A are common to all other bundles, the same permits would be required under Bundle B. Bundle B includes using Millerton Lake minimum pool storage water. To do this, several pumping alternatives are discussed in Section 6.4. Additional pumping facilities and pipelines may be installed for these alternatives, requiring the addition of California Department of Fish and Games Streambed Alteration Permits. It also may be necessary to get congressionally authorized cost allocations for Millerton Lake to reassign costs between water conservation and other purposes.

In addition, this bundle configuration includes the use of existing SWP/CVP Delta pumping facilities. This component is dependent on numerous multi-party arrangements among state, federal, and local entities in the Delta region.

8.7.3 Bundle C

Bundle C includes all the components of Bundle A with the addition of Tulare Lakebed storage and conveyance. A new pumping plant would be needed to pump water out of lakebed storage to the existing system of canals that service the Tulare Lake Basin Water Storage District. Other

pumping facilities would also be required with this bundle. The Tulare Lakebed is already divided into a number of sub-basins to accept flood waters, so the transition of areas in the Tulare Lakebed from intermittent flood zones to intentional impoundment may not require additional permitting. Approval for this change would probably come from Kings County. It also may be necessary for the DWR Division of Safety of Dams (DSOD) to review and grant approval for storage in Tulare Lakebed. Consultation with the USFWS and CDFG would be necessary to mitigate any impacts on biological resources. In addition, it may be necessary to consult with SHPO with regards to the multi-component campsites that may be eligible for listing in the National Register of Historic Places or for possible disturbance to other cultural resources.

8.7.4 Bundle D

Bundle D includes all the components of Bundle A with the addition of Millerton Lake enlargement and Mammoth Pool enlargement. All of the permits under Bundle A would be required under Bundle D. Additional federal requirements may be required from FERC for the changes in power generation associated with raising both of these dams. For Millerton Lake, the U.S. Bureau of Reclamation would need to amend contracts with water agencies. Increases in storage at Millerton Lake or Mammoth Pool may change flood control, requiring approval from the Reclamation Board for affecting a U.S. Army Corps of Engineers flood control projects. The DSOD would need to review and grant approval to the modification of both dams. Modifying facilities at Mammoth Pool would require coordination and agreement with Southern California Edison Company. Relocation of recreation facilities or roads would require California Department of Parks and Recreation and U.S. Bureau of Reclamation approval for Millerton Lake and U.S. Forest Service approval for Mammoth Pool. Consultation with the USFWS and CDFG would be necessary to mitigate any impacts on biological resources. In addition, it may be necessary to consult with SHPO with regards to cultural resources or historic artifacts that may exist in the area of the enlargement of either reservoir.

8.7.5 Bundle E

All the Bundle A and Bundle D components are found in Bundle E, so the permits discussed above for those bundles apply to Bundle E. In addition, Bundle E includes the construction of a new dam on Fine Gold Creek. Fine Gold Reservoir could be operated by the U.S. Bureau of Reclamation or some other entity; it is currently unknown if an approval from DSOD to construct a new dam would be required. If Fine Gold Reservoir is operated as a pumped storage facility, FERC would have to license the project. Consultation with the USFWS and CDFG would be necessary to mitigate any impacts on biological resources. In addition, it may be necessary to consult with SHPO with regards to cultural resources or historical artifacts that may exist in the area of Fine Gold Reservoir.

9.1 PRIORITIZATION PROCESS

The process for prioritization of the alternatives uses a decision analysis screening methodology. This methodology consists of six steps. The objective is to see how the five bundles (i.e., short list of alternatives) described in Section 6 rank relative to each other according to several criteria, subcriteria, value scales, and the relative weights of the criteria/subcriteria. In summary, implementing the process for prioritization of the short list of alternatives involved developing the screening criteria (including agreement on project goals and objectives), developing the subcriteria, developing the values scales and weighting of criteria and subcriteria, and finally using this information to prioritize the bundles included in the Study.

The complete decision analysis process for the prioritization of alternatives consists of the following steps:

1. Define evaluation criteria/subcriteria and their scales
2. Develop a short list of bundles
3. Assess value scales for individual subcriteria
4. Assess the relative weights of criteria and subcriteria
5. Develop raw impact data for each bundle
6. Evaluate bundles and assist in prioritization of the bundles

Figure 9-1 shows a flow chart of these six steps. (Please note that the tables and figures for this section are grouped at the end of the section.) A brief description of each step follows.

9.1.1 Step 1: Define Evaluation Criteria/Subcriteria and Their Scales

In this step, the WSOT identified all relevant criteria for evaluation of alternative projects (October 31, 2000). Each criterion was further divided into appropriate subcriteria that address distinct important aspects of the criterion (Table 9-1). An appropriate scale was then defined for each subcriterion (Tables 9-2 through 9-7). Two types of scales were defined: natural and constructed. A natural scale is a commonly accepted and understood scale that follows from the definition of a given subcriterion. For example, acre-feet of water is a natural scale for the criterion of water supply volume. When a natural scale is not available, such as for the subcriterion “short/long term,” a constructed scale is created to define specific levels of impact on the criterion. For example, one can create a 0 to 5 scale with a clear definition of the key points on the scale.

9.1.2 Step 2: Develop a Short List of Bundles

In this step, the WSOT examined the various components of feasible solutions (see Technical Memoranda 3 and 4, URS 2000b and 2000d, on the long list alternatives) on November 30, 2000, and subsequently combined them logically by themes to define alternative bundles (Technical Memorandum 5, URS 2001a). Each alternative project/preliminary bundle was refined to produce the preliminary short list of bundles (Technical Memorandum 8, URS 2001b). This preliminary short list was subsequently evaluated through the gaming and hydrologic

modeling efforts to produce the final short list of bundles for prioritization on May 23, 2002. The scope of each alternative is defined in sufficient detail in Section 6 of this Study so that its impact on the selected criteria/subcriteria can be estimated.

9.1.3 Step 3: Assess Value Scales for Individual Subcriteria

In this step, the WSOT, under the facilitation of a decision analyst, obtained consensus value judgments regarding the relative importance of different impact levels of each subcriterion at a workshop on November 30, 2000. The "Delphi" method was used to promote consensus among the various WSOT members. The Delphi method is based on using statistical feedback of responses of different participants and an open exchange of opinions and perspectives. If no convergence of value judgments occurs in the first iteration, a second iteration of responses is made and again the statistical closeness of the responses is evaluated. This iterative process of assessments and feedback is continued until a reasonable group consensus is achieved, or it becomes clear that further iteration would not bring the group any closer.

The value judgments obtained from the Delphi session were used to develop value functions for individual subcriteria. The value functions provide the means to convert the raw impact data (which are in disparate scales) to a common value scale of 0 to 1. Note that in this step, the focus is only on comparisons between different impact levels of each subcriterion by itself. That is, cross comparisons of different subcriteria are not assessed in this step. The next step makes these cross comparisons, from which the relative weights of the different criteria are derived.

9.1.4 Step 4: Assess the Relative Weights of Criteria and Subcriteria

In this step, the WSOT, under the facilitation of a decision analyst, assessed their value judgments regarding the relative importance of the different criteria/subcriteria at a workshop on December 19, 2000. These value judgments provided the means to derive the relative weights of the criteria/subcriteria. A Delphi method was again used to identify consensus values.

9.1.5 Step 5: Develop Raw Impact Data for Each Bundle

In this step, the consultant team, or other technical staff, will analyze available data collected for each bundle and project the expected conditions under each bundle. Guidance for assessing impact levels was developed and is illustrated in Tables 9-8 through 9-10. The projected data were used to estimate each bundle's impact on the criteria/subcriteria. These are termed "raw" data, because at this stage the relative degree of concern about the impact levels is not evaluated. The completion of this step will produce an impact matrix, which is shown as Step 5 in Figure 9-1. The impact matrix was discussed at a team meeting on November 30, 2000. The rows in the impact matrix are bundles, and the columns are the impact of a given bundle on each of the subcriteria.

9.1.6 Step 6: Evaluate Bundles and Assist in Prioritization of the Bundles

In this step, the Consultant Team would synthesize the information from the previous steps and calculate the total weighted value of each bundle on a scale of 0 to 1. The higher this value, the

more desirable the corresponding bundle. Thus, the bundles can be ranked in a descending order of their total weighted value.

An important part of decision analysis is to evaluate the sensitivity of the ranking of alternatives to the various assumptions and value judgments used in the analysis. For example, the acceptable value trade-offs between conflicting criteria may vary among different stakeholders. The degree of acceptability of various alternatives among the stakeholders can be evaluated by examining the influence of the different value trade-offs on the overall value of each alternative. Results of such sensitivity analysis assist in identifying one or more alternatives that are consistently ranked high under a variety of plausible value judgments and, hence, are likely to receive wider acceptance among the stakeholders.

9.2 COMPLETION OF PRIORITIZATION PROCESS

Should the WSOT decide to complete the prioritization process, either with the bundles defined in this Study or other bundles developed by WSOT, Steps 5 and 6 will have to be completed. This section provides tools and guidelines that may facilitate completing these steps. Step 5 will involve developing the impact matrix for the bundles to be evaluated in the prioritization process. The forms provided as Figure 9-2 may be used as templates for recording the impact assessments.

Step 6 will involve calculating the total weighted value of each bundle under evaluation. An Excel application may be prepared to automate these calculations. The application will access the results of Steps 3, 4, and 5, calculate the total values of the alternative bundles, and display the results in informative tabular and graphical formats. The following formats are suggested for the display of results:

- **Value of each bundle with regard to each criterion (or subcriterion)**
  Figure 9-3 illustrates the format for displaying these results. The relative value of each bundle is shown on a scale of –100 to +100. To understand the significance of a given criterion (or subcriterion) in discriminating among the alternative bundles, the basic statistics on the distribution of the values for the criterion (or subcriterion) over all bundles are also displayed. The basic statistics include the mean, standard deviation, and the coefficient of variation of the values over all bundles. The coefficient of variation is defined as the ratio of the standard deviation to the mean; it expresses the variation of the values over the alternative bundles on a normalized scale. If the coefficient of variation for a particular criterion (or subcriterion) is relatively low (e.g., less than 20 percent), one may conclude that the criterion (or subcriterion) is not significant in discriminating among the alternative bundles. This information may be used to decide whether certain criteria (or subcriteria) may be combined without losing any important information that could help in evaluating the alternative bundles.

- **Total weighted value of each alternative bundle**
  Figure 9-4 illustrates the format for displaying these results. The total value of each alternative bundle is displayed on a scale of –100 to +100. (Figure 9-4 only shows the 0 to 100 portion of the scale.)

- **Comparison of pair of alternative bundles**
  Figure 9-5 illustrates the format for displaying these results. The figure shows a side-by-side

comparison of a specified pair of alternative bundles. A visual inspection of the figure will provide a quick understanding of how the two bundles compare with regard to different criteria. For each criterion, the figure displays a bar extending on the side of the bundle that has a greater value with regard to the criterion. The length of the bar is proportional to the difference in the value for the two bundles with regard to the given criterion.

- **Evaluation of trade-offs between a specified pair of criteria**
  Figure 9-6 illustrates the format for displaying these results. The figure shows how the alternative bundles compare with regard to a specified pair of criteria. For example, it clearly shows if a particular bundle is better with regard one criterion, but worse with regard to the other criterion. One can also quickly determine whether a particular bundle "dominates" another bundle; that is, it is better with regard to every criterion.

- **Value contribution for a given bundle**
  Figure 9-7 illustrates the pie format for displaying these results. The "pie" shows the percentage contribution of each criterion to the total value of a specified bundle. One can also further subdivide a particular piece of the pie into the corresponding subcriteria. This display provides a quick understanding of which criteria are contributing significantly to the overall value of a given bundle.

Tables
for
Section 9

Table 9-1
Revised List of Criteria and Subcriteria

Criteria	Subcriteria
Water Supply (Yield)	Volume of water supply generated relative to restoration need Timing of flow Sustained availability Potential competition for water Reliability of supply for consumptive water use Reliability of supply for environmental use Impact to water quality supplied for consumptive use Current uses of water Short/long term (sustainability) Use versatility of supply Predictability Opportunity cost of water Groundwater loss
Environmental Effects	Impact to GW levels Impact to GW quality Impact to special-status species (excluding anadromous fish) Impact to anadromous fish Impact to other aquatic species (trout, other native species) Impact to Delta ecosystem Impact to riparian habitat (direct and indirect effects) Impact to non-riparian habitat (direct and indirect effects) Impact to water quality in river flow Subsidence due to lowering of GW table Geomorphology
Implementability	Public acceptance Interdependence Permitting/Institutional requirements Ease of integration with existing operations Flexibility for incremental implementation Vulnerability to third-party challenges Time to reach acceptable flow regime Special land use designation Opportunity foregone to use a potential source of water Assurances/Institutional complexity
Cost	Funding sources Operation & Maintenance costs (including cost of debt service) Capital costs (including construction, mitigation, and environmental documentation costs) Impact to income generation from water sales Equity of costs and benefits to beneficiaries Cost-effectiveness
Ancillary Effects	Impact to flood control Impact to power production revenues Impact to recreation Impact to land use/management Impact to third-party economics Impact to third-party water supply benefits
Engineering Feasibility	Technology Safety Public health risk Physical constraints

Table 9-2
Definitions of Subcriteria and Scales Criteria: Water Supply (Yield)

Subcriteria	Scales
Volume of water supply generated relative to restoration need	• Volume sufficient to meet minimum restoration need • Volume sufficient to meet average restoration need • Volume sufficient to meet full restoration need
Timing of flow	Percent of pulse flow needs met
Sustained availability	Number of years of water supply
Potential competition for water	• High degree of potential competition • Medium degree of potential competition • Low degree of potential competition • No potential competition
Reliability of supply for consumptive water use	Percent of time current consumptive water user needs are met
Reliability of supply for environmental water use	Percent of time base flow needs for environmental use are met
Impact to water quality supplied for consumptive use	• Large improvement • Moderate improvement • No effect • Moderate adverse impact • Large adverse impact
Current uses of water	Addressed in "potential competition for water"
Short/Long term (sustainability)	Addressed in "sustained availability"
Use versatility of supply	Addressed in "timing of flow"
Predictability	Addressed in "assurance/institutional complexity" under "Implementability"
Opportunity cost of water	Addressed in developing bundles
Groundwater loss	Addressed in "volume of water generated"

Table 9-3
Definitions of Subcriteria and Scales Criteria: Environmental Effects

Subcriteria	Scales
Impact to GW levels	• Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact
Impact to GW quality	• Large improvement in GW quality • Moderate improvement in GW quality • No effect • Moderate deterioration in GW quality • Large deterioration in GW quality
Impact to special-status species (excluding anadromous fish)	• Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact
Impact to anadromous fish	• Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact
Impact to other aquatic species (trout, other native species)	• Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact
Impact to Delta ecosystem	• Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact
Impact to riparian habitat (direct and indirect effects)	• Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact
Impact to non-riparian habitat (direct and indirect effects)	• Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact
Impact to water quality in river flow	• Large improvement • Moderate improvement • No effect • Moderate adverse impact • Large adverse impact
Subsidence due to lowering of GW table	Since this is the effect of lowering GW levels, it is addressed in the relative values of "impact to GW levels"
Geomorphology	Addressed in the habitat impact

Table 9-4
Definitions of Subcriteria and Scales Criteria: Implementability

Subcriteria	Scales
Public acceptance	Degree of acceptance among stakeholders • Very High: Acceptable to most or all stakeholders, no strong opposition from any group • High: Acceptable to a majority of stakeholders, tolerable to most stakeholders • Medium: Not acceptable to most stakeholders, but tolerable to a majority of stakeholders, moderate opposition from some groups • Low: Not acceptable to most of stakeholders, not tolerable to a majority of stakeholders, strong opposition from some groups • Very low: Neither acceptable nor tolerable to most stakeholders, strong opposition from a majority of stakeholders
Interdependence	Degree of interdependence on multiple components • Low: Stand-alone system, requires little dependence on other components • Medium: 2 to 5 components need to be combined to form the system • High: More than 5 components need to be combined to form the system
Permitting/institutional requirements	Number of complex permitting/institutional requirements
Ease of integration with existing operations	• High: The system can be integrated with Friant Division operations without requiring a significant change • Medium: A significant change will be needed in no more than 2 elements of the current operations • Low: A significant change will be required in 3 to 4 elements of the current operations • Very low: A significant change will be required in more than 5 elements of the current operations
Flexibility for incremental implementation	• High: Staged implementation is feasible with smooth transition from one stage to the next; less than 20% impact to the overall cost and schedule • Medium: Staged implementation is feasible; however, transition from one stage to the next would require additional effort, including additional project components and new permits; 20% to 50% impact on the overall cost and schedule • Low: Staged implementation is difficult and can be achieved only with major reworking of the prior stages, new projects components, and difficult new permits would be required • Very low: Staged implementation is infeasible
Vulnerability to third-party challenges	• Low • Medium • High
Time to reach acceptable flow regime	Number of years
Special land use designation	Addressed in “public acceptance” and “permitting/institutional requirements”
Opportunity foregone to use a potential source of water	Addressed in packaging components to develop bundles
Assurance/institutional complexity	Addressed in “permitting/institutional requirements”; will also be used in identifying a preferred alternative

Table 9-5
Definitions of Subcriteria and Scales Criteria: Cost

Subcriteria	Scales
Funding sources	Number of identifiable funding sources
Operation & maintenance costs (including cost of debt service)	Factor relative to the bundle with the lowest O&M cost
Capital costs (including construction, mitigation, and environmental documentation costs)	Factor relative to the bundle with the lowest capital cost
Impact to income generation from water sales	• Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact
Equity of costs and benefits to beneficiaries	Highly equitable: Costs and benefits evenly distributed among most or all stakeholders Moderately equitable: Costs and benefits unevenly distributed among a significant portion of stakeholders Not equitable: Cost and benefits unevenly distributed among most or all stakeholders
Cost-effectiveness	Considered in developing bundles; it is also reflected in the various cost and benefit measures

Table 9-6
Definitions of Subcriteria and Scales Criteria: Ancillary Effects

Subcriteria	Scales
Impact to flood control	• Large improvement: Frequency of flooding reduced by a factor of at least 5 (e.g., a 100-year flood scenario becomes a 500-year flood scenario) • Moderate improvement: Frequency of flooding reduced by a factor of 2 • No effect • Moderate adverse impact: Frequency of flooding increased by a factor of 2 (e.g., a 100-year flood scenario becomes a 50-year flood scenario) • Large adverse impact: Frequency of flooding increased by a factor of 5
Impact to power production revenues	• Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact
Impact to recreation	• Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact
Impact to land use/management	Degree of consistency with the current land use/management plan • High • Medium • Low
Impact to third-party economics; includes such factors as water sales, value of better water quality (for example, in water sold to Southern California), reduced cost of GW pumping, and potential for a new powerhouse	• Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact
Impact to third-party water supply benefits	• Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact

Table 9-7
Definitions of Subcriteria and Scales Criteria: Engineering Feasibility

Subcriterion	Scale
Technology	Years of demonstrated experience with the technology
Safety	All bundles will be designed to achieve an acceptable level of safety. Hence the subcriterion is not relevant to differentiating among the alternatives.
Public health risk	All bundles will be designed to achieve an acceptable level of public health protection. Hence the subcriterion is not relevant to differentiating among the alternatives.
Physical constraints	Addressed in the engineering design and the capital cost

Table 9-8
Guidance for Assessing Impact Levels for Criteria/Subcriteria
Criterion: Water Supply (Yield)

Subcriterion	Impact Level	Typical Conditions under Which this Impact Level Would Be Assessed
Impact to water quality supplied for consumptive uses (see Table 9-2)	High	TDS concentration less than 100 ppm
	Medium	TDS concentration between 100 and 800 ppm
	Low	TDS concentration between 800 and 1,500 ppm
	Very low	TDS concentration greater than 1,500 ppm

Notes: Westside is dominated by Delta supplies, which are 300-400 ppm TDS. Friant water is closer to 50 ppm TDS. Maximum acceptable TDS for irrigation water is 800 TDS.

TDS = total dissolved solids
ppm = parts per million

Table 9-9
Guidance for Assessing Impact Levels for Criteria/Subcriteria
Criterion: Environmental Effects
(Page 1 of 2)

Subcriteria	Impact Levels	Typical Conditions under Which this Impact Level Would Be Assessed
Impact to GW levels	Large benefit	More water added to GW than taken out for all or most years
	Moderate benefit	More water added to GW than taken out for some of the years, no effect in other years
	No effect	The current situation remains unchanged
	Moderate adverse impact	More water taken out of GW than added; the impact in dry years is moderate, making current water users somewhat worse off with the project than without
	Large adverse impact	More water taken out of GW than added; the impact in dry years is high, making current water users worse off with the project than without
Impact to GW quality	Large improvement in GW quality	High-quality water added, resulting in large dilution of existing contaminants (TDS in the Westside and pesticides in the Eastside)
	Moderate improvement in GW quality	High-quality water added, resulting in moderate dilution of existing contaminants
	No effect	The current GW quality remains unchanged
	Moderate deterioration in GW quality	Poor-quality water added, resulting in a moderate increase in the concentration of existing contaminants
	Large deterioration in GW quality	Poor-quality water added, resulting in a large increase in the concentration of existing contaminants
Impact to special-status species (excluding anadromous fish)	Large benefit	Large increase in the natural habitat of special-status species (e.g., large wetland created by groundwater banking project)
	Moderate benefit	Moderate increase in the natural habitat of special-status species
	No effect	The current habitat remains unchanged
	Moderate adverse impact	Moderate loss of the natural habitat of special-status species (e.g., canal lining removes habitat)
	Large adverse impact	Large loss of the natural habitat of special-status species (e.g., reservoir floods red-legged frog habitat)
Impact to anadromous fish (e.g., issue is flow)	Large benefit	Net large increase in the population of anadromous fish
	Moderate benefit	Net moderate increase in the population of anadromous fish
	No effect	The current population of anadromous fish remains unchanged
	Moderate adverse impact	Net moderate decrease in the population of anadromous fish
	Large adverse impact	Net large decrease in the population of anadromous fish

* See Table 9-3.

Table 9-9
Guidance for Assessing Impact Levels for Criteria/Subcriteria
Criterion: Environmental Effects
(Page 2 of 2)

Subcriterion	Impact Level	Typical Conditions under Which This Impact Level Would Be Assessed
Impact to other aquatic species (e.g., trout, other native species)	Large benefit	Net large increase in the population of other aquatic species
	Moderate benefit	Net moderate increase in the population of other aquatic species
	No effect	The current population of other aquatic species remains unchanged
	Moderate adverse impact	Net moderate decrease in the population of other aquatic species
	Large adverse impact	Net large decrease in the population of other aquatic species
Impact to Delta ecosystem	Large benefit	Large increase in the flow of high-quality water to Delta during the critical summer months
	Moderate benefit	Moderate increase in the flow of high-quality water or large increase in the flow of moderate-quality water to Delta during the critical summer months
	No effect	No change in the current flow to Delta
	Moderate adverse impact	Moderate reduction in the flow of high-quality water to Delta during the critical summer months
	Large adverse impact	Large reduction in the flow of high-quality water to Delta during the critical summer months
Impact to riparian habitat (direct/indirect effects)	Large benefit	Large increase in the riparian habitat
	Moderate benefit	Moderate increase in the riparian habitat
	No effect	The riparian habitat remains unchanged
	Moderate adverse impact	Moderate loss of riparian habitat
	Large adverse impact	Large loss of riparian habitat (e.g., new reservoir floods riparian areas)
Impact to non-riparian habitat (direct/indirect effects)	Large benefit	Large increase in the non-riparian habitat
	Moderate benefit	Moderate increase in the non-riparian habitat
	No effect	The non-riparian habitat remains unchanged
	Moderate adverse impact	Moderate loss of non-riparian habitat
	Large adverse impact	Large loss of non-riparian habitat
Impact to water quality in river flow (e.g., other criteria that affect beneficial uses in Basin Plan)	Large improvement	Large improvement in the water quality criteria set up by the Regional Board for beneficial uses of water
	Moderate improvement	Moderate improvement in the water quality criteria set up by the Regional Board for beneficial uses of water
	No effect	No change in the current water quality
	Moderate adverse impact	Moderate decrease in the water quality criteria set up by the Regional Board for beneficial uses of water
	Large adverse impact	Large decrease in the water quality criteria set up by the Regional Board for beneficial uses of water

* See Table 9-3.

Table 9-10
Guidance for Assessing Impact Levels for Criteria/Subcriteria
Criterion: Ancillary Effects
(Page 1 of 2)

Subcriteria	Impact Levels	Typical Conditions under Which this Impact Level Would Be Assessed
Impact to flood control	Large improvement	Large reduction in the frequency of flooding
	Moderate improvement	Moderate reduction in the frequency of flooding
	No effect	The current frequency of flooding remains unchanged
	Moderate adverse impact	Moderate increase in the frequency of flooding
	Large adverse impact	Large increase in the frequency of flooding
Impact to power production revenues	Large benefit	Large increase in the revenues from power sales
	Moderate benefit	Moderate increase in the revenues from power sales
	No effect	No change in the current revenues from power sales
	Moderate adverse impact	Moderate decrease in the revenues from power sales
	Large adverse impact	Large decrease in the revenues from power sales
Impact to recreation	Large benefit	Creates new recreational opportunities and improves current recreational opportunities
	Moderate benefit	Improves current recreational opportunities, no creation of new recreational opportunities
	No effect	The current recreational opportunities remain unchanged
	Moderate adverse impact	Moderate degradation of current recreational opportunities
	Large adverse impact	Large degradation of current recreational opportunities
Impact to land use/management	High	No changes or only minor changes (conditional use) would be required in the current city/county land use planning (i.e., consistent with General Plan and zoning)
	Medium	A small number of substantial changes would be required in the current land use planning (i.e., consistent with General Plan but zoning changes needed)
	Low	Many substantial changes would be required in the current land use planning (i.e., changes in both General Plan and zoning; e.g., GW banks in Kern Co. are being surrounded by urban development and pressured to convert)

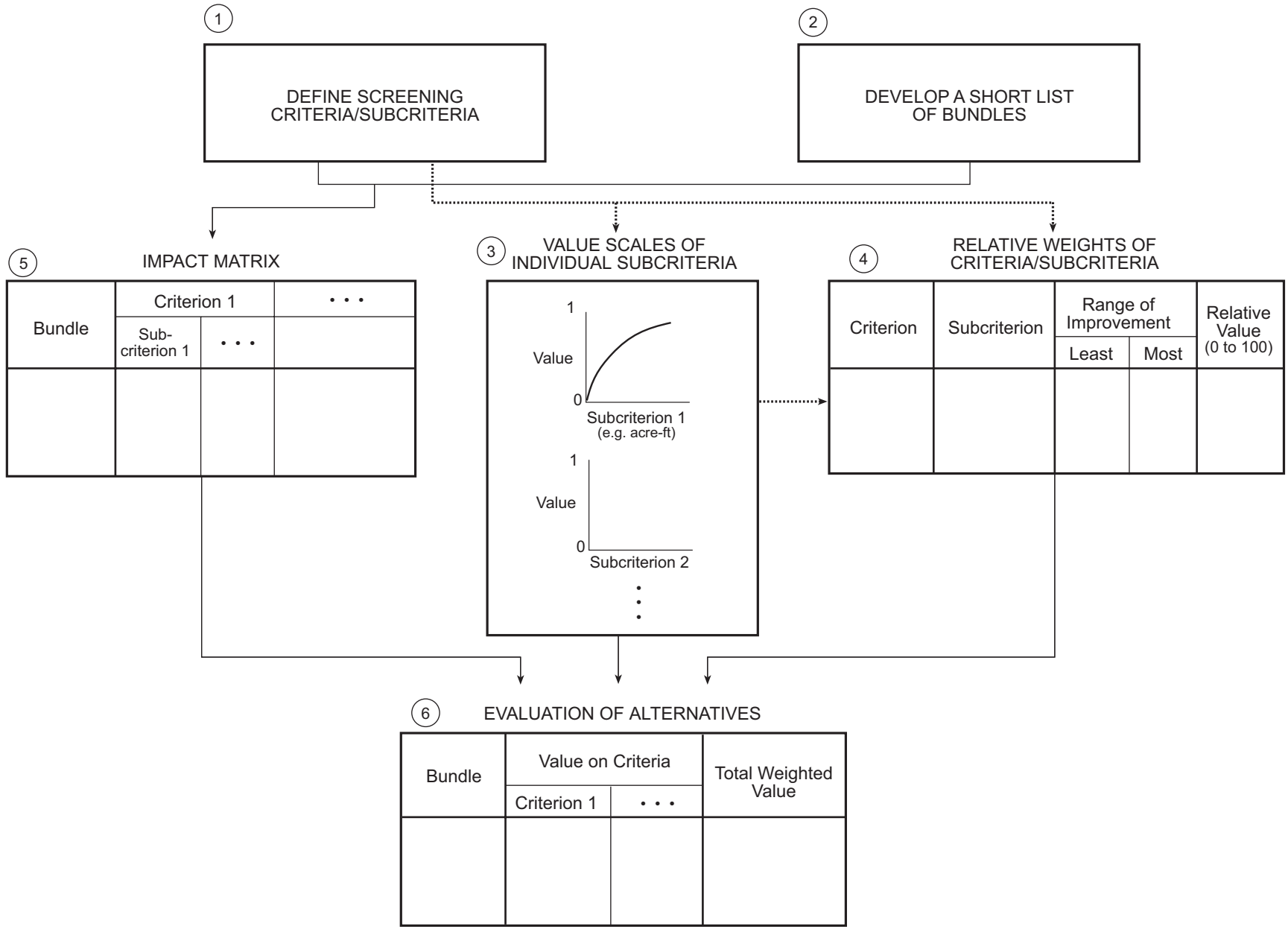
* See Table 9-6.

Table 9-10
Guidance for Assessing Impact Levels for Criteria/Subcriteria
Criterion: Ancillary Effects*
(Page 2 of 2)

Subcriteria	Impact Levels	Typical Conditions under Which this Impact Level Would Be Assessed
Impact to third party economics; includes such factors as water sales, value of better water quality (e.g., in water sold to Southern California), reduced cost of GW pumping, and potential for a new powerhouse	Large benefit	Large cost savings for the third parties in the region or large incomes generated from sales to parties outside the region (e.g., sales to MWD for M&I uses)
	Moderate benefit	Moderate cost savings for the third parties in the region or moderate incomes generated from transactions with parties outside the region
	No effect	No effect in the current third party economics
	Moderate adverse impact	Moderate cost increases/loss of income for the third parties in the region or moderate loss of income generated from transactions with parties outside the region (e.g., loss of recreation from draining Shaver Lake)
	Large adverse impact	Large cost increases/loss of income for the third parties in the region or large loss of income generated from transactions with parties outside the region (e.g., retiring land from crop production)
Impact to third part water supply benefits	Large benefit	Substantial improvement in the predictability of water supply to third parties
	Moderate benefit	Moderate improvement in the predictability of water supply to third parties
	No effect	No effect on the current reliability of water supply to third parties
	Moderate adverse impact	Moderate decrease in the predictability of water supply to third parties
	Large adverse impact	Large decrease in the predictability of water supply to third parties

* See Table 9-6.

Figures
for
Section 9



URS	Project No. 26812392.00600 San Joaquin River Water Supply Study	DECISION ANALYSIS PROCESS FOR PRIORITIZATION OF ALTERNATIVES	Figure 9-1

26812392.00600/093002/gos

Figure 9-2
Templates for Recording Impact Assessments
(Page 1 of 6)
Template 1: Impact Matrix for Criterion = Water Supply (Yield)

Bundle	**Volume of water generated relative to restoration need** Scale: Volume of water generated sufficient to meet: • Minimum restoration need • Average restoration need • Full restoration need	**Timing of flow** Scale: % of pulse flow need met	**Sustained availability** Scale: Number of years of water supply	**Potential competition for water** Scale: • High • Medium • Low • None	**Reliability of supply for consumptive water use** Scale: % of time current consumptive water user needs are met	**Reliability of supply for environmental water use** Scale: % of time base flow needs for environmental use are met	**Impact to water quality supplied for consumptive use** Scale: • Large improvement • Moderate improvement • No effect • Moderate adverse impact • Large adverse impact
A							
B							
C							
D							
E							
B_s							
C_s							
D_s							
E_s							

Figure 9-2
Templates for Recording Impact Assessments
(Page 2 of 6)
Template 2. Impact Matrix for Criterion = Environmental Effects

Bundle	Impact to GW Levels Scale: • Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact	Impact to GW quality Scale: • Large improvement in GW quality • Moderate improvement in GW quality • No effect • Moderate deterioration in GW quality • Large deterioration in GW quality	Impact to special status species (excluding anadromous fish) Scale: • Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact	Impact to anadromous fish Scale: • Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact	Impact to other aquatic species (trout, other native species) Scale: • Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact	Impact to Delta ecosystem Scale: • Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact	Impact to riparian habitat (direct and indirect effects) Scale: • Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact	Impact to non-riparian habitat (direct and indirect effects) Scale: • Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact	Impact to water quality in river flow Scale: • Large improvement • Moderate improvement • No effect • Moderately adverse impact • Large adverse impact
A									
B									
C									
D									
E									
B_s									
C_s									
D_s									
E_s									

Figure 9-2
Templates for Recording Impact Assessments
(Page 3 of 6)
Template 3. Impact Matrix for Criterion = Implementability

Bundle	Public Acceptance Scale: Degree of acceptance among stakeholders • Very high • High • Medium • Low • Very low	Interdependence Scale: Degree of interdependence on multiple components • Low • Medium • High	Permitting/ institutional requirements Scale: Number of complex permitting/institutional requirements	Ease of integration with existing operations Scale: • High • Medium • Low • Very low	Flexibility for incremental implementation Scale: • High • Medium • Low • Very low	Vulnerability to third-party challenges Scale: • High • Medium • Low	Time to reach acceptable flow regime Scale: Number of years
A							
B							
C							
D							
E							
B_s							
C_s							
D_s							
E_s							

Figure 9-2
Templates for Recording Impact Assessments
(Page 4 of 6)
Template 4. Impact Matrix for Criterion = Cost

Bundle	**Funding sources** Scale: Number of identifiable funding sources	**Operation & maintenance costs (including cost of debt service)** Scale: Factor relative to the bundle with the lowest O&M cost	**Capital costs (including construction, mitigation, and environmental documentation costs)** Scale: Factor relative to the bundle with the lowest capital cost	**Impact to income generation from water sales** Scale: • Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact	**Equity of costs and benefits to beneficiaries** Scale: • Highly equitable • Moderately equitable • Not equitable
A					
B					
C					
D					
E					
B_s					
C_s					
D_s					
E_s					

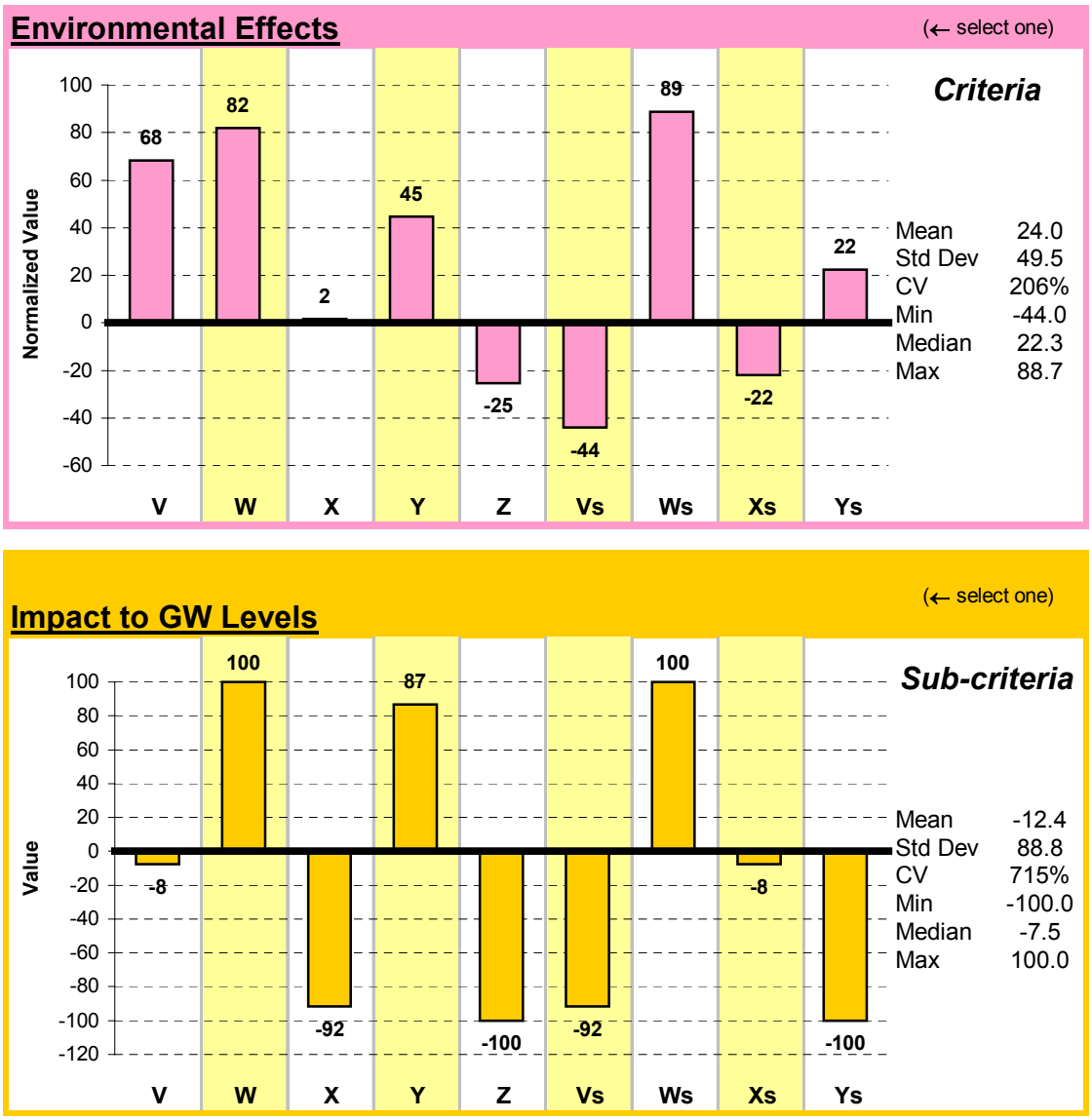
Figure 9-2
Templates for Recording Impact Assessments
(Page 5 of 6)
Template 5. Impact Matrix for Criterion = Ancillary Effects

Bundle	Impact to flood control Scale: • Large improvement • Moderate improvement • No effect • Moderate adverse impact • Large adverse impact	Impact to power production revenues Scale: • Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact	Impact to recreation Scale: • Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact	Impact to land use/management Scale: Degree of consistency with current land use/management plan • High • Medium • Low	Impact to third-party economics Scale: • Large benefit • Moderate benefit • No effect • Moderate adverse impact • Large adverse impact	Impact to third-party water supply benefits Scale: • Large adverse impact • Moderate adverse impact • No impact
A						
B						
C						
D						
E						
B_s						
C_s						
D_s						
E_s						

Figure 9-2
Templates for Recording Impact Assessments
(Page 6 of 6)
Template 6. Impact Matrix for Criterion = Engineering Feasibility

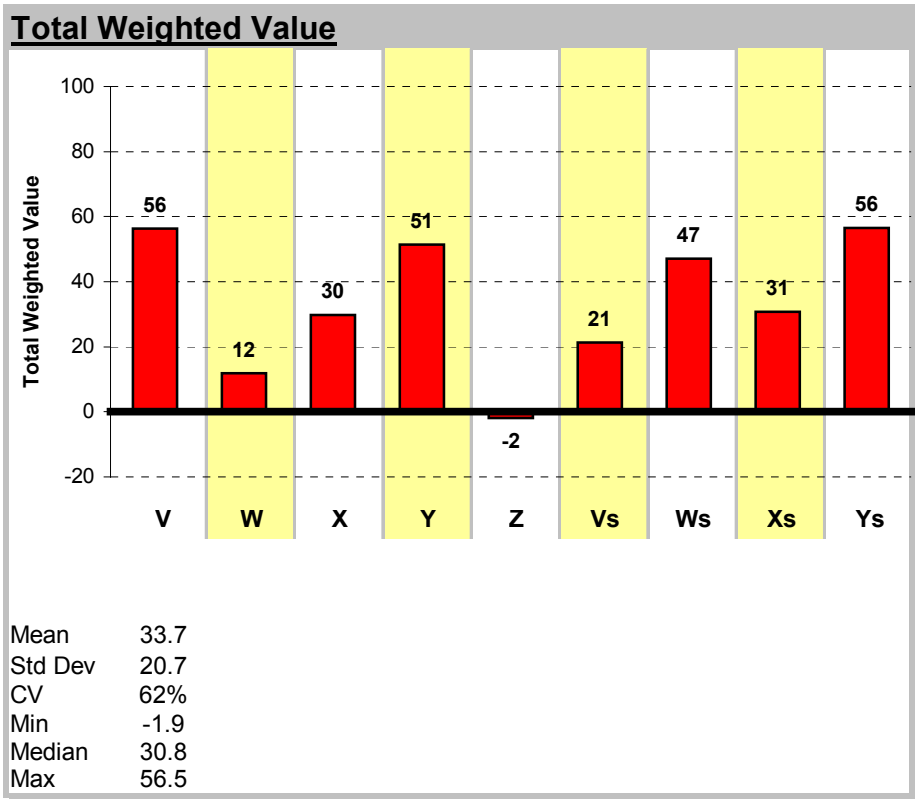
Bundle	Technology Scale: Years of demonstrated experience with the technology
A	
B	
C	
D	
E	
B_s	
C_s	
D_s	
E_s	

Figure 9-3
Value of Each Bundle with Regard to Each Criterion and Subcriterion (Illustration)



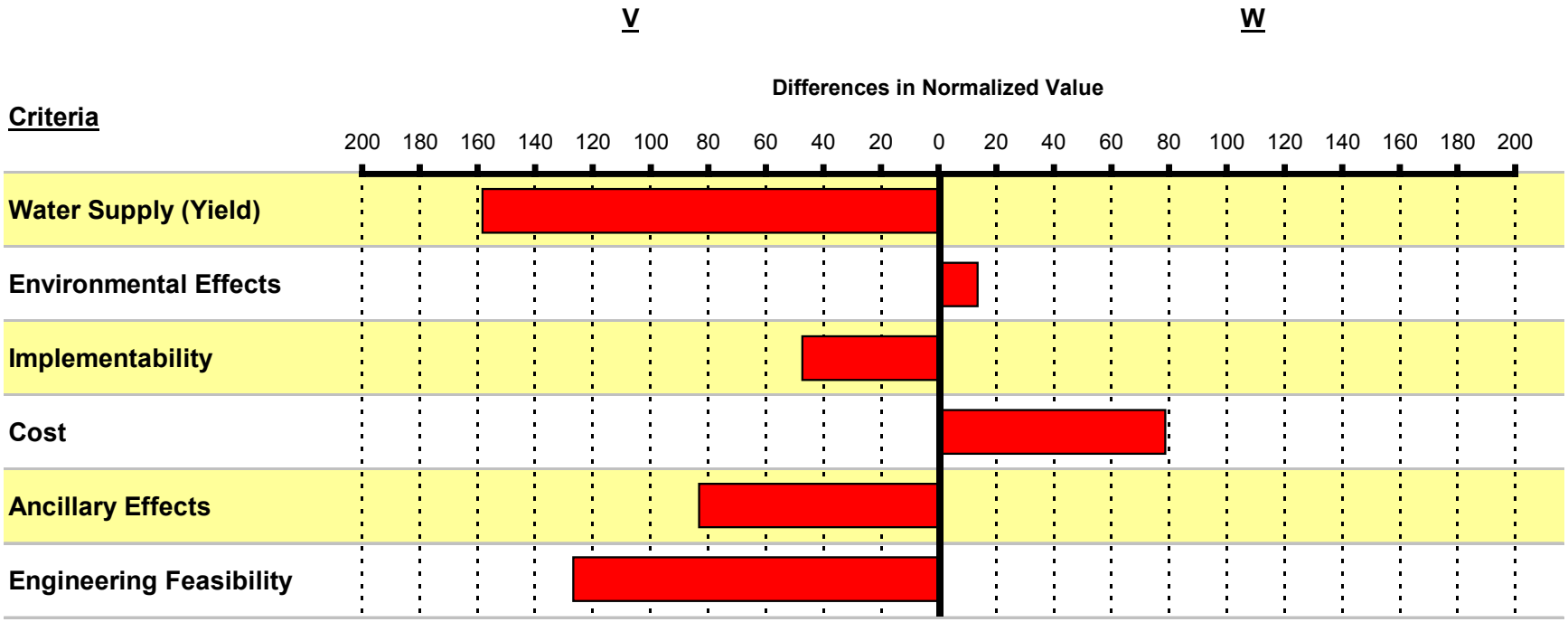
Note: The values for each hypothetical bundle are arbitrary and not based on any analysis.

Figure 9-4
Total Weighted Value of Each Alternative Bundle (Illustration)



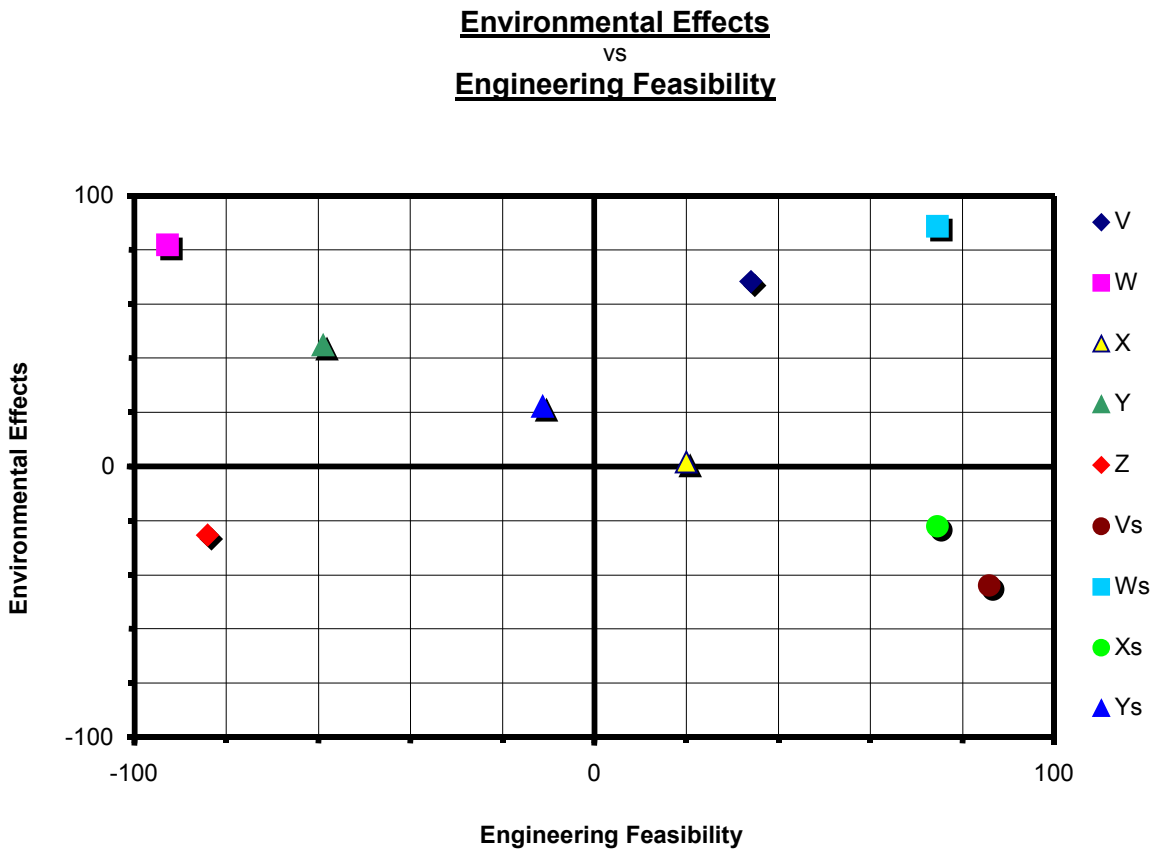
Note: The values for each hypothetical bundle are arbitrary and not based on any analysis.

Figure 9-5
Comparison of Pair of Alternative Bundles (Illustration)



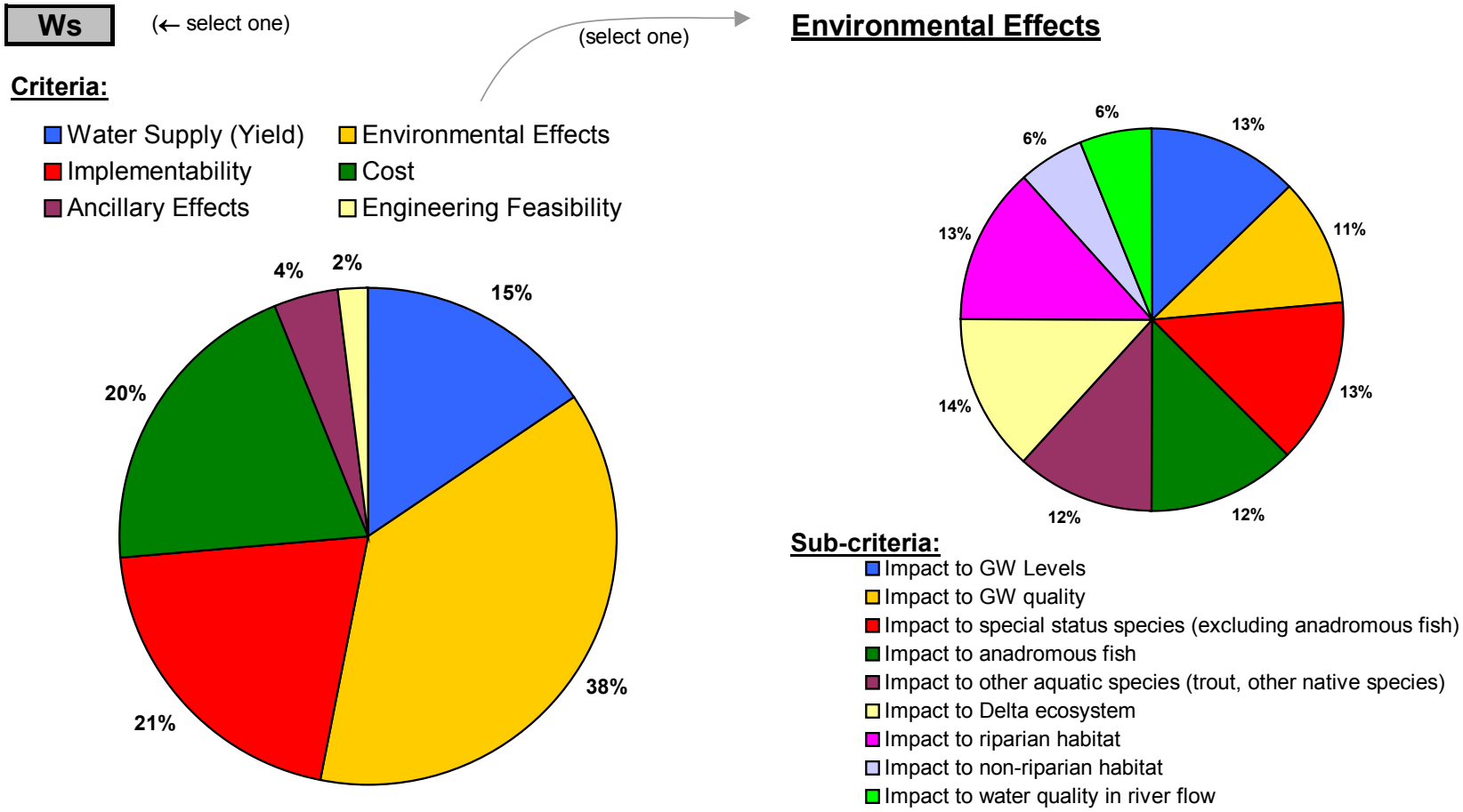
Note: The values for each hypothetical bundle are arbitrary and not based on any analysis.

Figure 9-6
Evaluation of Trade-offs between a Specified Pair of Criteria (Illustration)



Note: The values are arbitrary and not based on any analysis.

Figure 9-7
Value Contribution for a Given Bundle (Illustration)



Note: The values are arbitrary and not based on any analysis.

The Water Supply Study has been prepared by the URS Consultant Team and includes the following persons, their affiliations, and their role:

URS CORPORATION

John Bischoff	Principal In Charge
Steve Ritchie	Project Director/Senior Review
Susan Hootkins	Project Manager
Tom MacDonald	Project Engineer
Gregory Reichert	Project Engineer
Phil Mineart	Project Engineer
Jeanne Hudson	Water Resources Engineer
Sandra Davidson	Water Resources Planner
Corinna Lu	Biologist
Rachael Egherman	Archaeologist
Jay Plano	Technical Editor
Lynn McIntyre	Technical Editor
Reinhold Dillon	Technical Editor
Fumiko Goss	Graphic Artist
Matthew Smith	Graphic Artist
Iris Eschen	Word Processor
Deborah Fournier	Word Processor
Rachel Rivera	Word Processor
Katherine Schwarz	Word Processor
Roger Ocampo	Reproduction
Grace Baldoz	Reproduction

ENTRIX

Paul Wisheropp	Hydrologist
Tom Taylor	Fisheries Biologist

NORTHWEST ECONOMIC ASSOCIATES, INC.

Duane Paul	Senior Economist
Harry Seely	Economist

MBK ENGINEERS, INC.

Walter Bourez III	Water Supply Planner/Modeler

PROVOST & PRITCHARD

Brian Ehlers	Groundwater Expert/Local Conditions

WESTERN RESOURCE ECONOMICS

Stephen Hatchett	Economist

INDEPENDENT CONSULTANTS

Daniel Steiner	Water Supply Planner/Engineer
Huxley Madeheim	Water System Modeler
Michael Hanemann	Chancellor's Professor, Department of Agriculture and Resource Economics and Goldman School of Public Policy, U.C. Berkeley

WATER SUPPLY OVERSIGHT TEAM

Guidance and direction in the alternatives development process for the Water Supply Study has been provided by the Water Supply Oversight Team (WSOT), and their assistance is respectfully acknowledged. Past and present members of the WSOT (and alternates) are:

Jared Huffman	Co-Manager, Natural Resources Defense Council
Mario Santoyo	Co-Manager, Friant Water Users Authority
Gary Bobker	Co-Chair, The Bay Institute
Dale Brogan	Delano-Earlimart Irrigation District
John Roldan	Co-Chair, Friant Water Users Authority
Robert Beeby/William O'Brien	Science Applications International Corporation
Steve Chedester	San Joaquin River Exchange Contractors Water Authority
David Fullerton	Natural Heritage Institute
Dave Hoffman	Porterville Irrigation District
Dennis Keller	Keller-Wegley Engineering
Stephen Lee	U. S. Bureau of Reclamation
Edwin B. Orrett	Pacific Technologies
Roger Robb	R.W. Robb Engineering
Peter Vorster	The Bay Institute
Chris White	Central California Irrigation District

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Appendix A
Hydrologic Inventory Data

Section 1. San Joaquin River
Section 2. Water Supply
Section 3. Tulare Lake Basin Tributaries
Section 4. Northern San Joaquin Valley/Other
Section 5. Agricultural Water Requirement Determination

Appendix A

Section 1
San Joaquin River

Unimpaired Flow for San Joaquin River at Friant
Friant April-July Forecasted and Actual Runoff
Computed Inflow to Millerton Lake
Friant Dam Release to San Joaquin River
Diversions to the Friant-Kern Canal
Diversions to the Madera Canal
Historical End-of-month Storage at Friant
Historical Precipitation at Friant
Huntington Precipitation
Simulated Inflow to Millerton (USAN)
Simulated Mammoth Pool Storage (USAN)
Friant Division Cumulative Groundwater Storage
USBR Water Supply Report and FWUA 2002 Update

Files

Name	Size	Type	Last Modified
Tulare Lake Basin Tributaries.123	4,095KB	Lotus 1-2-3 9 Workbook	4/21/02 8:45 AM
USAN Output.123	234KB	Lotus 1-2-3 9 Workbook	4/21/02 12:20 PM

Unimpaired Flow for San Joaquin River at Friant
(1,000 Acre-feet)

Section 1

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Apr-Jul	WY Total
1909	24	16	19	277	183	133	352	646	827	309	78	37	2,134	2,901
1910	25	50	220	188	86	190	378	479	239	98	38	50	1,194	2,042
1911	28	23	31	254	206	351	430	571	943	593	114	43	2,537	3,586
1912	29	25	20	28	26	58	81	261	371	92	34	18	805	1,044
1913	13	17	17	19	24	38	99	262	180	104	67	39	646	879
1914	12	18	26	277	151	238	388	606	608	387	131	42	1,989	2,883
1915	29	21	21	32	92	126	259	401	615	281	58	32	1,556	1,966
1916	14	13	31	183	145	341	479	581	582	282	78	31	1,925	2,761
1917	58	30	38	41	135	110	238	397	598	210	58	22	1,444	1,936
1918	13	12	13	13	34	158	193	341	515	110	29	38	1,159	1,467
1919	98	36	39	26	67	94	224	482	150	53	19	10	909	1,298
1920	13	10	26	21	26	105	172	456	350	100	30	14	1,077	1,323
1921	27	35	34	64	78	169	204	368	434	145	32	16	1,151	1,604
1922	11	10	59	66	99	105	205	685	758	266	69	24	1,914	2,355
1923	13	28	84	63	66	97	221	506	304	194	50	28	1,225	1,654
1924	28	16	14	14	21	26	95	164	35	17	9	6	310	444
1925	10	26	27	27	85	101	219	419	313	146	53	13	1,097	1,439
1926	20	16	21	17	57	96	347	378	146	43	12	7	915	1,161
1927	6	56	50	47	155	151	275	508	496	197	48	15	1,475	2,001
1928	20	69	33	33	48	150	189	373	176	44	14	6	781	1,154
1929	9	10	15	16	23	65	107	309	211	75	19	5	702	862
1930	5	6	8	18	36	80	165	214	244	61	17	6	683	859
1931	11	13	10	16	23	39	100	174	60	16	11	7	349	480
1932	6	8	72	59	168	157	238	492	544	239	51	15	1,512	2,047
1933	13	9	15	27	30	73	159	213	410	119	29	15	901	1,111
1934	7	10	38	47	50	109	166	146	69	27	13	8	409	692
1935	13	27	36	73	85	111	357	497	519	144	44	19	1,517	1,923
1936	14	16	16	38	196	164	349	510	348	151	42	11	1,357	1,853
1937	11	13	36	35	253	191	304	705	457	160	34	11	1,625	2,208
1938	10	12	211	71	207	434	434	795	913	431	128	43	2,573	3,688
1939	39	33	29	33	43	103	240	209	110	43	25	14	602	921
1940	35	14	11	134	140	210	290	559	363	97	21	7	1,308	1,881
1941	10	12	98	106	183	209	242	711	642	331	86	23	1,926	2,653
1942	22	30	96	113	103	129	299	466	633	284	65	17	1,681	2,254
1943	10	43	43	170	113	268	335	503	325	179	50	16	1,342	2,054
1944	11	15	20	31	55	112	141	408	280	143	35	16	971	1,265
1945	13	58	56	44	238	148	276	477	488	240	74	27	1,481	2,138
1946	59	66	118	79	54	126	310	464	280	118	37	19	1,172	1,730
1947	29	65	85	48	64	100	171	348	146	43	17	12	707	1,126
1948	23	18	15	19	20	43	165	391	373	108	26	15	1,036	1,215
1949	11	8	15	16	26	73	235	410	268	63	26	15	976	1,164
1950	10	16	17	43	90	90	280	379	263	87	22	14	1,009	1,311
1951	17	247	300	111	104	119	202	322	278	115	32	12	917	1,859
1952	12	20	83	133	99	177	385	820	641	335	101	33	2,181	2,840
1953	17	19	43	85	48	72	197	211	320	172	30	13	900	1,227
1954	9	17	17	33	65	127	278	440	218	80	20	9	1,016	1,314
1955	6	18	31	42	49	74	127	338	348	88	30	11	900	1,161
1956	6	13	461	271	141	170	278	568	614	318	87	34	1,778	2,960
1957	26	22	21	30	67	90	142	327	440	115	32	16	1,024	1,327
1958	16	19	43	43	113	181	363	796	622	288	108	41	2,068	2,631
1959	16	15	15	37	89	114	203	209	153	41	17	42	606	949
1960	18	9	10	18	55	86	178	240	148	43	17	8	608	829
1961	8	22	31	19	31	49	124	172	128	27	25	10	451	647
1962	10	15	23	23	185	110	381	397	505	203	52	20	1,486	1,924
1963	18	11	11	82	208	101	192	464	492	265	71	31	1,413	1,945
1964	26	64	36	31	30	52	127	257	200	60	29	11	643	922
1965	10	34	204	188	114	128	250	432	473	267	138	35	1,421	2,272
1966	18	101	66	62	56	126	277	362	148	51	25	9	837	1,299
1967	6	29	213	92	101	243	250	660	823	595	154	67	2,327	3,232
1968	27	23	34	37	75	83	146	231	131	44	22	9	552	862
1969	15	40	52	396	234	227	464	1,096	874	463	137	41	2,898	4,040
1970	33	32	47	159	83	137	146	376	279	107	37	11	907	1,446
1971	10	39	73	75	72	110	172	293	365	141	48	22	970	1,418
1972	13	26	58	41	50	138	124	268	213	47	16	45	653	1,039
1973	20	34	47	82	128	131	248	708	463	127	45	15	1,546	2,047
1974	21	88	82	138	66	210	267	597	482	162	60	20	1,508	2,191
1975	19	17	32	37	76	136	131	546	575	161	41	26	1,413	1,796
1976	49	33	24	18	38	59	82	174	60	35	24	35	350	629
1977	20	10	7	12	15	19	57	75	111	20	11	4	262	362
1978	6	9	80	159	196	326	346	697	826	462	149	146	2,332	3,402
1979	34	30	33	96	101	183	243	599	339	114	42	17	1,295	1,830
1980	24	29	34	327	282	216	315	528	642	426	113	37	1,911	2,973
1981	24	19	29	36	57	87	206	318	208	51	19	13	783	1,068
1982	19	70	65	119	199	231	613	725	585	371	148	170	2,294	3,316
1983	126	146	212	227	271	428	280	728	1,166	686	280	92	2,860	4,642
1984	53	149	227	126	107	162	203	489	266	162	67	36	1,120	2,049
1985	31	50	41	40	56	84	254	308	169	55	22	19	786	1,129
1986	24	38	68	93	472	426	361	624	593	222	76	32	1,801	3,031
1987	24	14	15	21	40	66	172	229	121	33	15	10	554	758
1988	16	24	25	59	48	91	153	220	142	49	23	12	563	862
1989	7	14	20	22	37	133	237	240	149	41	19	19	668	939
1990	23	22	17	25	34	85	173	165	122	54	14	8	514	743
1991	8	6	9	10	11	118	135	277	321	102	24	13	836	1,034
1992	12	19	18	21	68	77	209	238	76	46	17	9	568	809
1993	13	17	32	189	124	243	330	701	599	317	82	26	1,947	2,673
1994	19	17	21	23	42	75	150	258	159	36	14	12	602	826
1995	43	45	48	213	122	485	350	634	881	752	239	66	2,616	3,878
1996	24	15	50	70	229	222	333	589	412	184	55	18	1,518	2,203
1997	18	99	213	735	181	219	302	539	280	130	44	21	1,251	2,782
1998	18	24	36	102	210	232	288	446	886	686	159	72	2,306	3,160
1999	36	39	50	69	111	102	182	446	337	105	32	17	1,070	1,527
2000	12	12	16	80	155	164	280	530	351	91	37	15	1,251	1,742
2001	20	17	16	26	42	126	188	445	115	47	13	10	795	1,065
Average	21	32	57	87	103	147	242	437	392	177	54	25	1,247	1,774
Minimum	5	6	7	10	11	19	57	75	35	16	9	4	262	362
Maximum	126	247	461	735	472	485	613	1,096	1,166	752	280	170	2,898	4,642

Friant April-July Runoff (Published DWR Bulletin 120)
Medain Forecast (1,000 Acre-feet)

Section 1

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Recorded
1961					760	510	490	430					451
1962					820	1440	1620	1530					1,486
1963					740	820	960	1300					1,413
1964					820	520	540	520					643
1965					1520	1215	1150	1340					1,421
1966					1190	1020	760	710					837
1967					1480	1200	1620	2440					2,327
1968					900	760	690	570					552
1969					2300	3050	3050	3180					2,898
1970					1250	1130	1030	990					907
1971					1340	1020	950	870					970
1972					1140	885	575	580					653
1973					1220	1540	1660	1540					1,546
1974					1400	1085	1490	1600					1,508
1975					820	1010	1350	1510					1,413
1976					505	425	370	340					350
1977					470	270	230	185					262
1978					1700	2070	2560	2890					2,332
1979					1145	1240	1410	1280					1,295
1980					1500	1960	2080	2060					1,911
1981					925	760	960	920					783
1982					1480	1280	1830	2200					2,294
1983					1920	2300	2800	2880					2,860
1984					1400	1320	1160	1100					1,120
1985					1000	830	980	870					786
1986					1060	2000	2100	2000					1,801
1987					590	570	640	460					554
1988					980	740	500	560					563
1989					800	670	750	980					668
1990					700	670	530	490					514
1991					450	290	900	830					836
1992					670	780	730	630					568
1993					1630	1900	1960	1880					1,947
1994					690	780	620	620					602
1995					1740	1480	2280	2440					2,616
1996					1080	1300	1400	1470					1,518
1997					2200	1900	1600	1440					1,251
1998					1200	1840	1940	2050					2,306
1999					980	1060	980	1030					1,070
2000					880	1370	1190	1240					1,251
2001					730	830	740	870					747

Computed Inflow to Millerton Lake
(1,000 acre-feet)

Section 1

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Apr-Jul	WY Total	Contract Year
1944	59	49	43	46	54	115	128	269	200	141	85	76	738	1,265	1,547
1945	60	83	93	76	221	163	259	371	367	223	108	86	1,219	2,109	2,110
1946	99	104	146	110	75	116	259	327	220	127	84	73	933	1,740	1,634
1947	62	87	116	83	81	112	135	218	97	72	61	55	521	1,178	942
1948	55	38	38	31	32	43	123	268	273	105	69	65	769	1,140	1,159
1949	54	44	35	36	44	103	203	278	200	87	75	51	768	1,209	1,264
1950	35	24	44	58	106	112	222	272	196	97	80	70	786	1,315	1,854
1951	61	205	274	139	128	131	173	215	210	133	90	58	732	1,818	1,485
1952	49	45	105	154	121	200	353	666	569	313	131	85	1,901	2,790	2,697
1953	75	53	82	112	58	73	150	137	230	155	90	61	671	1,276	1,156
1954	53	43	46	45	73	129	233	292	172	91	71	52	787	1,300	1,323
1955	39	48	70	66	60	83	118	215	217	106	73	55	654	1,148	1,849
1956	36	35	401	308	205	188	266	443	434	298	124	99	1,440	2,834	2,197
1957	91	67	73	46	70	101	133	220	287	133	85	66	773	1,372	1,436
1958	58	60	82	80	132	211	370	594	488	261	134	100	1,713	2,568	2,549
1959	85	78	67	59	102	128	151	160	133	66	44	60	509	1,132	923
1960	35	22	16	26	83	79	103	106	103	100	107	82	412	863	847
1961	33	29	43	27	35	49	98	105	95	40	49	47	337	647	770
1962	19	19	34	29	187	157	214	288	333	181	146	118	1,015	1,725	1,878
1963	76	56	35	57	217	115	223	261	335	251	163	156	1,070	1,945	1,868
1964	62	102	96	52	52	74	98	114	143	108	119	102	463	1,121	1,311
1965	26	43	108	204	173	188	212	211	321	219	167	156	964	2,029	2,033
1966	91	110	144	119	95	122	157	168	133	101	79	53	558	1,371	1,383
1967	49	52	135	139	196	247	319	467	632	521	194	177	1,940	3,129	3,005
1968	95	87	96	73	95	84	105	93	105	111	106	84	414	1,135	1,423
1969	27	44	58	280	326	299	330	885	772	417	186	174	2,404	3,798	3,614
1970	67	84	93	169	137	156	132	168	157	146	117	90	602	1,515	1,399
1971	44	58	111	113	109	115	145	154	156	154	140	118	610	1,417	1,334
1972	59	49	91	75	79	119	99	104	129	96	93	52	428	1,043	1,170
1973	74	61	76	96	171	193	211	388	353	161	124	96	1,112	2,003	2,127
1974	73	91	128	184	126	219	253	338	337	175	161	114	1,103	2,200	1,942
1975	66	67	70	48	93	136	214	296	415	147	123	125	1,071	1,798	1,791
1976	78	93	70	44	52	81	65	46	67	60	78	94	238	828	591
1977	28	23	17	15	16	9	10	10	67	75	61	45	163	378	744
1978	8	13	53	152	240	343	320	480	647	409	201	175	1,856	3,042	3,143
1979	106	100	84	129	149	214	232	327	260	142	139	94	961	1,976	2,117
1980	74	29	60	260	287	280	284	428	490	406	193	136	1,609	2,926	2,570
1981	74	66	58	62	94	97	149	151	114	101	97	79	514	1,140	1,359
1982	55	58	115	156	188	266	476	584	499	349	209	185	1,908	3,140	3,707
1983	102	163	244	282	347	467	336	600	1,032	620	298	212	2,588	4,704	4,452
1984	109	163	222	228	166	207	188	190	195	163	147	116	736	2,091	1,588
1985	82	56	61	89	95	106	192	172	107	78	82	96	549	1,215	1,541
1986	77	80	94	103	356	424	329	450	520	254	136	102	1,552	2,923	2,498
1987	90	56	41	40	58	88	117	140	100	105	113	54	462	1,000	954
1988	36	37	41	70	54	93	97	103	98	101	70	53	399	853	787
1989	32	32	30	36	42	109	140	123	114	106	112	52	483	927	931
1990	47	37	25	27	40	86	103	99	61	121	72	49	384	766	697
1991	24	20	19	26	18	112	107	129	164	157	92	58	558	925	1,045
1992	56	34	25	41	70	114	117	109	64	106	92	63	396	891	1,098
1993	49	5	27	180	172	242	271	463	471	307	131	138	1,511	2,456	2,332
1994	92	61	61	46	49	84	102	124	113	105	104	78	445	1,020	1,172
1995	51	14	27	196	174	424	349	572	696	706	256	118	2,324	3,584	3,667
1996	112	71	79	94	188	288	267	414	359	207	137	120	1,247	2,337	3,003
1997	46	96	236	646	187	246	248	395	314	150	129	139	1,107	2,832	2,201
1998	83	67	69	119	244	250	270	298	702	608	189	175	1,878	3,072	2,995
1999	81	97	114	94	118	120	159	209	254	129	143	120	751	1,637	1,458
2000	66	38	47	51	121	219	217	312	288	152	117	79	969	1,708	1,642
2001	82	75	31	37	34	94	139	221	142	79	102	85	581	1,121	
Avg	62	62	86	110	126	162	198	280	289	192	120	96	958	1,783	1,795
Min	8	5	16	15	16	9	10	10	61	40	44	45	163	378	591
Max	112	205	401	646	356	467	476	885	1,032	706	298	212	2,588	4,704	4,452

Friant Dam Release to San Joaquin River
(1,000 acre-feet)

Section 1

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Contract Year
1976	5	4	3	4	3	7	6	11	10	10	10	8	81	88
1977	6	5	6	4	5	7	9	8	10	12	12	9	93	187
1978	8	7	5	2	98	290	419	332	156	8	6	6	1,338	1,263
1979	6	3	4	17	15	6	6	11	7	7	7	6	96	387
1980	6	5	4	122	199	237	103	138	23	89	10	8	944	625
1981	5	4	2	3	3	3	5	6	8	11	8	7	65	68
1982	6	6	3	3	2	9	409	231	89	22	6	5	790	1,599
1983	4	92	228	223	281	437	466	380	527	311	81	119	3,150	2,867
1984	73	76	133	241	22	5	13	6	8	9	8	7	601	70
1985	6	3	2	2	2	3	7	8	9	10	9	8	67	271
1986	7	4	3	3	201	416	288	17	32	10	8	7	997	795
1987	4	5	2	2	3	2	8	8	9	10	9	8	70	75
1988	7	4	4	3	4	7	6	8	9	12	11	9	84	86
1989	8	6	3	2	4	6	8	9	10	13	13	9	92	96
1990	8	7	6	3	5	7	10	12	12	14	14	11	107	118
1991	10	8	7	7	8	5	7	11	12	14	13	11	111	106
1992	10	8	7	5	5	7	9	13	16	17	18	15	130	128
1993	13	8	7	3	2	26	72	57	64	42	18	15	327	332
1994	10	7	6	7	7	10	10	11	13	17	16	15	128	141
1995	11	8	7	3	21	228	341	452	157	324	29	12	1,592	1,606
1996	10	8	5	5	35	97	68	100	20	15	14	12	390	1,305
1997	11	7	63	545	353	80	14	17	17	19	21	18	1,165	405
1998	16	12	11	6	174	146	273	252	393	270	25	26	1,603	1,513
1999	24	24	35	17	28	5	6	9	25	35	20	14	242	142
2000	10	6	5	5	3	54	8	8	28	14	15	14	170	189
2001	13	11	11	8	5	5	7	9	16	14	16	20	137	

Diversions to the Friant-Kern Canal
(1,000 Acre-feet)

Section 1

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Contract Year
1949	0	0	0	0	0	1	1	0	0	16	24	0	43	43
1950	0	0	0	0	0	15	22	18	53	46	42	0	195	195
1951	0	0	0	0	0	24	37	12	66	108	86	36	368	396
1952	14	9	0	0	5	3	12	29	56	126	138	70	462	526
1953	73	17	0	0	1	56	54	40	99	164	160	75	741	691
1954	23	7	0	0	12	53	58	124	153	172	146	63	811	813
1955	25	6	0	0	12	87	77	64	135	167	157	74	805	950
1956	27	10	0	0	151	155	121	108	182	201	222	142	1,320	1,235
1957	50	31	0	1	22	92	78	63	211	181	152	108	990	1,012
1958	28	4	0	5	89	67	34	89	170	256	260	143	1,145	1,143
1959	63	18	0	0	43	149	71	57	143	133	97	35	810	769
1960	58	10	0	0	15	70	38	32	115	111	87	46	582	565
1961	23	3	1	0	40	51	26	23	75	80	81	38	442	428
1962	24	9	0	0	19	165	266	150	190	217	216	113	1,370	1,456
1963	54	22	0	1	61	74	164	221	244	238	260	173	1,513	1,593
1964	95	17	0	7	100	76	31	37	113	158	152	52	838	981
1965	29	0	0	82	250	218	77	187	207	214	207	159	1,631	1,555
1966	72	36	14	83	81	152	72	68	148	156	124	60	1,066	997
1967	36	12	0	16	153	148	101	59	139	242	267	240	1,413	1,599
1968	132	52	27	51	141	61	51	70	111	110	100	61	967	610
1969	18	2	3	1	22	14	53	123	160	237	260	190	1,082	1,351
1970	59	51	39	32	134	73	94	96	158	189	208	82	1,214	1,089
1971	35	15	0	12	126	107	72	52	123	234	218	98	1,092	1,055
1972	48	24	19	6	54	106	51	84	128	149	92	51	812	789
1973	21	1	0	0	106	103	158	222	215	211	203	130	1,371	1,497
1974	48	26	0	43	137	137	218	231	242	241	243	103	1,668	1,578
1975	49	16	0	9	90	81	153	243	226	232	174	119	1,392	1,365
1976	52	14	0	5	67	54	34	48	77	95	79	47	571	494
1977	17	12	0	3	28	10	8	5	36	55	60	29	264	286
1978	20	4	0	0	59	16	19	115	207	242	237	147	1,067	1,413
1979	190	81	0	0	157	144	202	188	231	222	182	84	1,681	1,369
1980	42	20	0	0	54	65	159	136	222	241	261	156	1,357	1,532
1981	117	44	22	25	84	45	52	81	133	205	117	57	981	990
1982	29	11	2	69	190	116	104	217	262	275	258	145	1,678	1,570
1983	106	40	10	20	17	2	35	55	170	236	177	128	996	1,102
1984	72	51	0	0	175	111	84	129	218	234	167	104	1,344	1,262
1985	80	23	0	0	112	80	81	105	150	141	90	58	919	851
1986	52	10	1	11	73	56	122	202	255	251	209	166	1,407	1,490
1987	79	37	25	18	70	30	67	54	90	116	90	58	734	670
1988	46	4	3	11	102	47	24	52	106	139	76	43	653	547
1989	29	6	0	0	25	36	74	62	126	182	94	45	679	700
1990	37	22	5	2	14	33	36	40	57	96	95	51	489	474
1991	36	10	0	0	19	0	18	69	128	182	124	64	651	667
1992	52	12	0	5	12	12	41	77	156	108	104	50	627	660
1993	34	4	0	12	64	179	232	261	270	302	244	104	1,705	1,726
1994	70	24	8	15	17	27	39	40	133	149	111	55	690	709
1995	24	6	0	7	116	119	84	138	251	276	265	162	1,449	1,601
1996	113	71	34	27	61	100	206	221	269	266	185	92	1,645	1,477
1997	64	10	1	61	1	108	162	138	224	234	155	109	1,268	1,330
1998	109	37	20	10	24	9	2	28	94	224	200	126	882	997
1999	96	21	57	33	108	61	69	146	202	224	165	73	1,254	1,034
2000	62	15	0	12	6	116	117	259	214	210	166	96	1,272	1,277
2001	44	16	15	12	11	18	36	126	187	164	101	59	790	
Avg (All)	52	19	6	13	67	74	81	104	157	182	158	90	1,004	1,010
Avg (1961 on)	59	22	7	17	78	77	90	119	169	195	166	97	1,096	1,104

Diversions to the Madera Canal
(1,000 Acre-feet)

Section 1

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Contract Year
1949	0	0	0	0	0	1	10	12	25	41	40	21	152	152
1950	0	0	0	0	0	0	3	12	24	37	25	17	118	118
1951	0	0	0	0	0	2	11	9	23	46	41	11	142	142
1952	0	0	0	0	0	0	1	14	34	47	54	29	179	181
1953	2	0	0	0	0	11	12	11	28	52	49	29	193	192
1954	1	0	0	0	0	4	18	24	41	54	51	20	212	211
1955	0	0	0	0	1	19	10	12	37	53	52	34	219	221
1956	0	0	0	0	3	10	15	15	45	60	57	33	239	236
1957	0	0	0	0	0	12	20	9	46	62	58	34	241	243
1958	2	0	0	0	0	4	6	28	52	64	59	29	244	250
1959	5	0	0	0	3	31	15	24	44	62	24	0	208	200
1960	0	0	0	0	0	19	6	0	42	58	17	0	144	144
1961	0	0	0	0	0	11	2	0	17	58	14	0	103	103
1962	0	0	0	0	0	8	30	30	53	67	63	26	277	278
1963	0	0	0	0	1	7	13	31	54	66	65	33	271	280
1964	10	0	0	0	1	29	0	6	50	76	50	6	228	223
1965	0	0	0	1	5	33	14	38	58	74	64	37	324	338
1966	12	0	0	0	8	31	16	8	48	72	29	0	224	229
1967	0	0	0	9	16	13	16	73	64	78	76	44	389	411
1968	24	7	0	0	15	9	0	8	43	38	22	2	170	145
1969	5	0	0	0	16	27	25	53	69	78	75	56	404	449
1970	21	6	3	7	30	17	38	41	55	57	24	1	298	258
1971	15	1	0	0	10	30	10	13	48	70	66	18	281	262
1972	1	0	0	0	6	39	0	2	40	49	17	0	153	149
1973	0	1	0	0	2	13	42	55	69	80	67	20	347	383
1974	0	0	0	29	9	21	38	59	72	79	71	16	395	367
1975	0	0	0	0	10	16	26	58	74	76	50	10	320	310
1976	0	0	0	0	0	0	0	0	13	48	33	0	94	94
1977	0	0	0	0	0	0	0	0	1	26	5	0	32	53
1978	0	0	0	0	21	50	63	75	76	78	51	22	437	457
1979	32	7	0	0	3	10	56	70	70	69	59	19	395	360
1980	1	0	0	0	5	67	75	77	75	72	71	40	484	510
1981	33	0	0	0	0	3	21	43	33	22	19	27	200	206
1982	0	0	0	11	27	26	53	78	75	76	68	42	456	472
1983	29	2	0	0	24	55	70	75	75	77	57	69	533	522
1984	37	0	0	0	8	47	34	32	31	63	51	38	340	318
1985	5	0	0	0	17	43	2	5	26	45	41	22	205	225
1986	5	0	0	0	37	60	71	76	76	79	67	42	513	506
1987	23	9	0	0	3	8	0	0	41	52	33	3	173	138
1988	0	0	0	0	0	0	0	8	43	60	10	0	122	122
1989	0	0	0	0	0	0	0	23	44	54	27	0	148	148
1990	0	0	0	0	0	0	0	0	22	56	31	1	112	112
1991	0	0	0	0	0	0	0	18	28	61	44	4	156	156
1992	0	0	0	0	0	0	0	23	50	47	6	0	127	127
1993	0	0	0	0	0	33	52	65	63	74	58	45	390	427
1994	32	5	0	0	0	0	0	15	35	44	44	8	182	148
1995	0	0	0	0	3	38	51	64	61	72	61	39	389	422
1996	27	6	0	0	3	40	41	61	61	55	43	27	363	387
1997	8	0	2	32	17	51	44	50	59	57	37	34	392	350
1998	18	0	0	0	0	33	52	58	62	69	34	29	355	404
1999	16	16	22	3	10	23	28	42	37	54	45	27	323	266
2000	9	0	0	0	0	9	36	47	52	55	38	22	269	273
2001	13	0	0	0	0	0	20	28	47	46	33	11	199	
Avg (All)	7	1	1	2	6	19	22	32	47	60	44	21	262	263
Avg (1961 on)	9	1	1	2	8	22	25	37	51	62	44	21	282	285

Historical End-of-Month Storage at Friant (CDEC)
Acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1942	9,860	21,300	26,900	25,500	22,900	23,500	26,800	28,000	28,100	23,200	21,900	21,700
1943	20,900	20,700	21,900	26,200	23,900	26,900	32,900	34,300	24,700	22,600	21,700	21,100
1944	20,800	22,200	21,400	21,400	33,500	81,700	80,400	223,000	293,000	260,000	179,000	127,000
1945	107,000	156,000	221,000	238,000	306,000	330,000	331,000	371,000	441,000	405,000	307,000	254,000
1946	238,000	251,000	298,000	265,000	273,000	276,000	402,000	430,000	427,000	359,000	256,000	195,000
1947	149,000	197,000	280,000	314,000	346,000	358,000	331,000	404,000	352,000	246,000	145,000	101,000
1948	94,900	109,000	129,000	139,000	140,000	133,000	193,000	338,000	473,000	371,000	241,000	153,000
1949	129,000	147,000	158,000	181,000	186,000	230,000	271,000	410,000	407,000	263,000	143,000	75,600
1950	47,500	49,000	66,500	120,000	203,000	205,000	287,000	403,000	380,000	238,000	120,000	77,600
1951	78,000	267,000	393,000	379,000	343,000	360,000	364,000	449,000	438,000	289,000	158,000	146,000
1952	141,000	149,000	244,000	385,000	303,000	268,000	153,000	293,000	396,000	242,000	259,000	189,000
1953	148,000	163,000	239,000	342,000	365,000	314,000	346,000	404,000	479,000	400,000	256,000	158,000
1954	139,000	156,000	187,000	208,000	251,000	317,000	454,000	513,000	475,000	329,000	184,000	143,000
1955	148,000	173,000	229,000	291,000	335,000	307,000	328,000	457,000	487,000	356,000	204,000	139,000
1956	138,600	157,900	467,100	454,300	289,100	204,700	256,700	394,200	441,700	462,500	291,200	192,700
1957	187,100	205,200	258,900	295,000	339,500	331,100	356,500	494,800	509,800	384,700	246,000	159,000
1958	180,000	231,100	307,100	376,400	414,500	478,900	395,200	481,700	520,700	436,400	238,000	156,600
1959	167,100	221,800	285,300	340,600	393,400	335,800	391,400	459,100	390,700	244,300	151,800	166,200
1960	134,300	139,000	151,100	174,600	239,000	220,800	269,700	331,300	260,100	172,400	158,700	182,700
1961	183,800	204,900	234,400	251,100	241,300	218,700	277,500	345,600	334,100	219,500	159,800	159,800
1962	145,700	149,600	179,600	204,400	370,300	351,300	261,700	360,100	437,400	321,100	176,300	146,000
1963	160,900	188,200	218,600	270,700	422,400	451,300	494,800	495,400	505,200	439,000	263,400	205,000
1964	156,800	237,000	329,200	370,800	318,000	281,700	340,700	402,600	371,900	232,900	137,300	172,400
1965	163,000	201,000	304,900	423,700	338,900	270,800	388,900	365,400	412,200	329,700	214,400	166,100
1966	167,200	237,600	364,600	398,300	401,800	336,200	398,100	478,600	403,400	263,600	177,100	161,600
1967	168,000	202,700	334,800	439,700	409,700	492,100	467,700	313,100	392,200	515,000	355,400	239,500
1968	172,400	196,700	263,900	283,300	220,800	232,100	279,700	287,100	228,300	179,600	152,600	165,600
1969	164,400	203,100	255,400	459,000	359,700	145,500	137,600	378,700	460,900	505,900	347,500	270,100
1970	253,900	278,900	327,800	445,600	387,200	448,900	443,000	465,200	400,900	291,500	168,800	169,700
1971	159,100	198,600	307,000	405,100	375,800	350,600	409,900	494,800	470,500	309,600	156,500	151,400
1972	155,600	178,200	248,200	315,000	330,400	298,000	337,600	346,300	296,200	181,600	154,400	146,500
1973	192,300	246,900	319,600	412,600	421,700	479,500	373,000	472,800	503,000	361,800	205,100	143,500
1974	163,500	225,500	351,200	433,500	404,300	462,500	434,100	470,900	469,000	312,600	150,500	139,100
1975	150,600	199,300	267,200	303,600	292,800	330,400	361,900	348,500	453,500	281,300	170,600	160,100
1976	181,000	255,100	321,400	355,900	337,700	357,800	381,000	365,500	328,100	231,900	185,900	224,200
1977	227,906	233,946	244,728	252,021	235,217	226,390	217,504	213,067	230,600	210,300	191,900	197,200
1978	176,400	179,000	226,500	375,500	436,900	422,200	240,900	197,700	402,500	479,700	381,100	379,000
1979	256,400	264,600	344,500	456,100	428,700	481,800	449,600	505,400	452,800	293,200	181,700	164,300
1980	188,300	191,300	246,800	383,700	411,500	321,200	267,800	343,100	510,200	510,800	358,200	287,600
1981	205,600	223,000	255,700	289,600	296,600	342,400	413,300	431,400	368,200	227,700	178,500	164,300
1982	183,600	224,600	334,600	407,200	375,000	489,500	399,300	455,500	525,800	497,700	371,800	363,500
1983	325,300	353,800	359,200	398,400	423,600	395,000	159,500	249,100	507,000	497,900	477,100	371,100
1984	297,100	332,300	420,600	406,800	372,400	415,400	471,500	490,800	425,300	278,700	197,200	162,300
1985	153,300	182,800	242,200	329,100	292,200	270,900	372,100	424,300	343,100	222,500	163,200	170,600
1986	182,700	248,100	337,200	425,600	470,400	361,100	207,600	359,700	514,000	425,100	273,900	158,600
1987	141,300	146,900	159,400	178,000	159,600	205,800	246,400	322,400	280,465	204,677	183,979	167,700
1988	150,200	178,968	212,396	267,565	215,700	253,900	319,995	351,701	288,400	176,000	146,673	145,938
1989	139,400	159,200	185,300	219,200	231,500	297,400	355,000	381,100	311,900	166,300	143,100	139,900
1990	141,800	149,100	162,600	183,800	204,700	249,500	305,200	350,200	316,500	268,500	198,700	183,300
1991	160,138	161,900	173,706	192,300	182,705	288,785	370,002	398,217	391,486	289,204	197,244	174,735
1992	167,234	181,910	200,208	230,133	283,117	377,583	443,297	435,688	274,344	206,446	168,492	164,637
1993	165,900	159,400	179,200	343,700	448,700	451,300	365,100	443,000	513,800	399,600	207,200	179,300
1994	157,792	181,595	227,937	251,988	278,987	325,545	377,215	434,316	363,469	255,876	183,129	183,793
1995	198,100	197,200	216,800	402,200	436,500	474,600	346,700	263,500	488,100	518,400	416,100	319,200
1996	279,400	265,200	304,200	366,500	455,900	505,400	454,400	484,800	489,000	357,700	249,300	237,200
1997	200,293	283,914	448,501	455,331	269,676	275,465	301,199	488,411	497,147	334,266	247,626	224,063
1998	162,781	179,726	218,064	320,069	365,785	425,561	368,311	326,632	478,022	518,815	446,027	437,951
1999	382,417	418,167	417,735	457,744	428,012	458,746	513,346	522,103	508,445	320,180	230,805	234,876
2000	218,983	235,744	277,500	311,500	423,200	462,000	516,300	511,500	501,400	371,600	266,900	211,900
2001	222,600	269,600	273,800	289,100	305,949	375,751	450,484	504,726	392,821	244,474		

Historical Precipitation at Friant (USBR Report of Operations)
Inches

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1976	1.69	0.47	0.29	0.08	5.30	0.74	1.14	0.02	0.45	0.00	0.26	1.22	11.66
1977	1.18	1.22	0.77	0.82	0.25	1.05	0.00	1.42	0.47	0.00	0.00	0.00	7.18
1978	0.05	0.68	4.67	3.84	5.12	5.23	3.79	0.00	0.00	0.00	0.00	1.22	24.60
1979	0.00	1.99	1.15	3.97	2.65	2.86	0.14	0.13	0.00	0.17	0.00	0.00	13.06
1980	0.67	1.29	0.88	4.71	3.81	2.24	0.63	0.28	0.00	0.00	0.00	0.00	14.51
1981	0.05	0.31	0.68	2.89	1.28	4.38	0.82	0.02	0.00	0.00	0.00	0.00	10.43
1982	0.53	1.84	1.63	3.75	1.93	5.64	2.98	0.00	0.22	0.06	0.04	1.63	20.25
1983	1.66	3.93	2.43	5.35	4.15	6.79	2.25	0.39	0.00	0.00	0.13	0.40	27.48
1984	0.71	3.78	3.79	0.16	1.34	1.03	0.21	0.00	0.31	0.09	0.01	0.00	11.43
1985	0.86	2.49	1.94	0.89	1.09	2.12	0.33	0.00	0.17	0.00	0.01	0.54	10.44
1986	0.98	3.77	1.24	1.27	5.22	3.78	0.44	0.22	0.00	0.00	0.00	0.36	17.28
1987	0.00	0.04	0.59	1.86	2.21	2.70	0.18	0.00	0.01	0.00	0.20	0.00	7.79
1988	1.11	0.94	1.57	1.76	0.27	1.22	2.38	0.22	0.02	0.00	0.00	0.00	9.49
1989	0.00	1.98	3.31	0.55	1.41	3.08	0.11	0.73	0.03	0.00	0.01	1.05	12.26
1990	0.55	0.72	0.00	2.11	1.97	0.51	0.91	2.11	0.04	0.00	0.00	0.00	8.92
1991	0.01	0.52	1.65	0.33	1.75	8.79	0.01	0.06	0.03	0.00	0.03	0.08	13.26
1992	1.79	0.16	1.70	1.66	5.30	2.36	0.08	0.22	0.00	0.04	0.00	0.00	13.31
1993	2.21	0.05	2.84	7.72	3.42	2.21	0.24	0.45	0.60	0.00	0.00	0.00	19.74
1994	0.21	1.32	1.52	1.81	2.65	0.39	1.34	0.97	0.00	0.00	0.00	0.33	10.54
1995	1.15	2.53	2.51	6.48	1.01	7.69	1.67	0.95	0.42	0.02	0.00	0.00	24.43
1996	0.00	0.00	3.11	2.79	4.55	2.67	1.34	0.64	0.08	0.00	0.00	0.00	15.18
1997	2.31	3.68	6.27	6.92	0.12	0.06	0.00	0.00	0.08	0.04	0.00	0.15	19.63
1998	0.25	2.69	1.95	5.75	6.43	4.26	1.93	1.73	1.59	0.00	0.00	0.12	26.70
1999	0.20	0.62	1.16	3.06	1.68	1.01	1.61	0.06	0.52	0.00	0.00	0.00	9.92
2000	0.00	1.15	0.00	4.64	8.41	2.01	2.67	0.07	0.92	0.00	0.27	0.24	20.38
2001	3.16	0.13	0.14	3.54	2.83	1.31	1.70						
Ave	0.82	1.47	1.84	3.03	2.93	2.93	1.11	0.43	0.24	0.02	0.04	0.29	15.19

Accum Historical Precipitation at Friant (USBR Report of Operations)
Inches

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1976	1.69	2.16	2.45	2.53	7.83	8.57	9.71	9.73	10.18	10.18	10.44	11.66	11.66
1977	1.18	2.40	3.17	3.99	4.24	5.29	5.29	6.71	7.18	7.18	7.18	7.18	7.18
1978	0.05	0.73	5.40	9.24	14.36	19.59	23.38	23.38	23.38	23.38	23.38	24.60	24.60
1979	0.00	1.99	3.14	7.11	9.76	12.62	12.76	12.89	12.89	13.06	13.06	13.06	13.06
1980	0.67	1.96	2.84	7.55	11.36	13.60	14.23	14.51	14.51	14.51	14.51	14.51	14.51
1981	0.05	0.36	1.04	3.93	5.21	9.59	10.41	10.43	10.43	10.43	10.43	10.43	10.43
1982	0.53	2.37	4.00	7.75	9.68	15.32	18.30	18.30	18.52	18.58	18.62	20.25	20.25
1983	1.66	5.59	8.02	13.37	17.52	24.31	26.56	26.95	26.95	26.95	27.08	27.48	27.48
1984	0.71	4.49	8.28	8.44	9.78	10.81	11.02	11.02	11.33	11.42	11.43	11.43	11.43
1985	0.86	3.35	5.29	6.18	7.27	9.39	9.72	9.72	9.89	9.89	9.90	10.44	10.44
1986	0.98	4.75	5.99	7.26	12.48	16.26	16.70	16.92	16.92	16.92	16.92	17.28	17.28
1987	0.00	0.04	0.63	2.49	4.70	7.40	7.58	7.58	7.59	7.59	7.79	7.79	7.79
1988	1.11	2.05	3.62	5.38	5.65	6.87	9.25	9.47	9.49	9.49	9.49	9.49	9.49
1989	0.00	1.98	5.29	5.84	7.25	10.33	10.44	11.17	11.20	11.20	11.21	12.26	12.26
1990	0.55	1.27	1.27	3.38	5.35	5.86	6.77	8.88	8.92	8.92	8.92	8.92	8.92
1991	0.01	0.53	2.18	2.51	4.26	13.05	13.06	13.12	13.15	13.15	13.18	13.26	13.26
1992	1.79	1.95	3.65	5.31	10.61	12.97	13.05	13.27	13.27	13.31	13.31	13.31	13.31
1993	2.21	2.26	5.10	12.82	16.24	18.45	18.69	19.14	19.74	19.74	19.74	19.74	19.74
1994	0.21	1.53	3.05	4.86	7.51	7.90	9.24	10.21	10.21	10.21	10.21	10.54	10.54
1995	1.15	3.68	6.19	12.67	13.68	21.37	23.04	23.99	24.41	24.43	24.43	24.43	24.43
1996	0.00	0.00	3.11	5.90	10.45	13.12	14.46	15.10	15.18	15.18	15.18	15.18	15.18
1997	2.31	5.99	12.26	19.18	19.30	19.36	19.36	19.36	19.44	19.48	19.48	19.63	19.63
1998	0.25	2.94	4.89	10.64	17.07	21.33	23.26	24.99	26.58	26.58	26.58	26.70	26.70
1999	0.20	0.82	1.98	5.04	6.72	7.73	9.34	9.40	9.92	9.92	9.92	9.92	9.92
2000	0.00	1.15	1.15	5.79	14.20	16.21	18.88	18.95	19.87	19.87	20.14	20.38	20.38
2001	3.16	3.29	3.43	6.97	9.80	11.11	12.81	12.81	12.81	12.81	12.81	12.81	0.00

Huntington Precipitation (Inches)

Section 1

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1950				7.97	4.1	3.87	2.72	0.97	0.02	0.14	0.02	0.26	m
1951	3.75	13.65	9.35	3.42	3.39	1.73	3.13	0.95	0.48	0	0	0	39.85
1952	1.21	3.41	11.84	8.04	3.9	9.01	2.9	0.21	0.71	1	0.05	1.65	43.93
1953	0	2.33	6.59	4.28	0.13	2.79	2.78	3.33	1.11	0.09	0.02	0.09	23.54
1954	1.05	2.86	2.03	4.92	4.77	8.27	1.48	0.45	1.86	0.05	0	0	27.74
1955	0	4.48	4.65	6.7	3.46	0.67	3.92	2.04	0.07	0	0.13	0.24	26.36
1956	0.05	3.71	28.05	10.01	2.95	0.81	4.72	3.21	0.13	1.22	0	0.36	55.22
1957	2.69	0	1.39	5.93	4.69	3.24	3.18	5.91	0.64	0.17	0	0.8	28.64
1958	2.33	1.85	6.84	6.26	9.58	12.39	6.83	1.36	1.82	0.5	0.33	3.28	53.37
1959	0.08	1.15	0.92	5.03	12.51	0.53	0.96	0.52	0	0	0.1	5.45	27.25
1960	0	0	1.56	3.51	7.12	4.33	2.66	0.71	0	0.28	0	0.12	20.29
1961	0.35	4.64	3.21	1.88	1.64	4.43	1.34	1.93	0.18	0.44	0.84	1.24	22.12
1962	0.79	3.61	2.2	4.15	23.8	7.13	0.98	1.65	0.52	0.1	0	1.02	45.95
1963	2.1	0.75	0.27	10.83	5.63	8.23	9.73	3.05	0.8	0	0.13	1.15	42.67
1964	1.74	8.96	1.05	4.4	0.39	5.76	2.45	4.08	1.01	0.03	0.95	1.05	31.87
1965	2.47	9.25	15.5	8.49	2.02	3.86	6.37	0.23	0.36	0.67	0.49	0.67	50.38
1966	0.67	14.02	7.81	1.7	3.62	1.39	1.79	0.64	0.34	0.02	0.47	0.26	32.73
1967	0	4.36	12.11	8.57	1.09	10.9	12.4	2.13	0.37	0.05	0.33	1.51	53.82
1968	0.02	3.09	3.15	4.53	3.93	3.15	1.51	0.83	0.24	0.13	0.18	0	20.76
1969	3.57	4.95	9.79	24.93	17.82	3.3	5.42	1.08	1.07	0.52	0	0.36	72.81
1970	2.79	2.43	5.29	13.04	2.9	4.05	4.9	0	1.23	0	0	0	36.63
1971	0	0	0	m	m	m	m	m	m	m	m	m	m
1972	m	m	m	m	m	m	m	m	m	m	m	m	m
1973	m	m	m	m	m	m	m	m	m	m	m	m	m
1974	m	m	m	m	m	m	m	m	m	m	m	m	m
1975	3.3	2	4.8	4.3	9.2	12	7.6	1	0.4	0	1.1	0.5	46.2
1976	8.1	2.4	1	0.3	5.8	3.6	2.6	0.7	0	0.5	0.5	3.8	29.3
1977	1.2	0.6	0.6	3	2.7	3.5	0.3	4.3	0.9	0	0.3	0.1	17.5
1978	0.5	3.6	14.3	12.5	13.4	12.8	8.9	0.1	0.1	0.1	0.2	5	71.5
1979	0	4.1	5.4	11.7	10.62	9.4	1.2	1.7	0	0.5	0	0.2	44.82
1980	3.8	4.6	5.7	19.5	14.2	6.7	2.2	2.9	0	0.1	0	0.1	59.8
1981	0.98	0	0.98	m	m	m	m	m	m	m	m	m	m
1982	m	m	m	m	m	m	m	m	m	m	m	m	m
1983	7.2	11.5	10.5	12	15	m	6.52	1.1	0.6	0	1.8	1.8	m
1984	0.5	11.9	13.3	0	5.7	3.5	1.8	0.3	0.6	2.6	0.1	0.2	40.5
1985	2.9	9.7	3.4	2.2	3.4	8	0.7	0.1	0.5	0.5	0	1.6	33
1986	3.4	9.6	4.5	4.7	20.3	8.4	2.5	0.8	0	0.1	0	3.3	57.6
1987	0.2	0.2	0.9	4.6	7.1	6.6	1.2	2.3	1	0	0	0.3	24.4
1988	2.9	4.6	6.7	8	1.9	0.1	4.7	2.4	0.5	0.7	0.2	0.3	33
1989	0	5.02	7.1	1.7	5.1	7.2	1.4	2.2	0	0	0.8	3.8	34.32
1990	2.5	2.7	0	5.7	5.7	3.8	2.7	2.7	0	0.3	0.4	1.1	27.6
1991	0.4	1.1	3.3	0.9	2.5	22.7	1.4	3.3	1.1	0.1	0.03	0.3	37.13
1992	3.2	2.4	4.6	2.63	9.98	4.07	0.58	0.25	0.34	2.35	0	0.11	30.51
1993	4.7	0.3	13.31	16	13.6	6.3	2.1	0.17	2	0	0	0	58.48
1994	0.71	3.27	3.19	2.4	7.51	1.65	3.66	2.83	0.07	0	0	1.13	26.42
1995	3	7.99	2.64	24.91	2.16	19.4	10.53	5.26	m	0.1	0	0	75.99
1996	0.2	0.01	m	m	m	m	m	m	m	m	m	m	m
1997	4.65	9.67	14.57	22.37	m	m	m	m	m	m	m	m	m
1998	m	m	m	m	m	m	m	m	m	m	m	m	m
1999	m	m	m	m	m	m	m	m	m	m	m	m	m
2000	0	1.16	0.08	10.88	13.68	2.68	3.08	2.32	0.96	0.32	0	0.12	35.28
2001	2.92	0.68	0.64	5.5	9.6	3.92	5.24	0.04	0	0.88			29.42

Accum Huntington Precipitation (Inches)

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1950													
1951	3.75	17.40	26.75	30.17	33.56	35.29	38.42	39.37	39.85	39.85	39.85	39.85	39.85
1952	1.21	4.62	16.46	24.50	28.40	37.41	40.31	40.52	41.23	42.23	42.28	43.93	43.93
1953	0.00	2.33	8.92	13.20	13.33	16.12	18.90	22.23	23.34	23.43	23.45	23.54	23.54
1954	1.05	3.91	5.94	10.86	15.63	23.90	25.38	25.83	27.69	27.74	27.74	27.74	27.74
1955	0.00	4.48	9.13	15.83	19.29	19.96	23.88	25.92	25.99	25.99	26.12	26.36	26.36
1956	0.05	3.76	31.81	41.82	44.77	45.58	50.30	53.51	53.64	54.86	54.86	55.22	55.22
1957	2.69	2.69	4.08	10.01	14.70	17.94	21.12	27.03	27.67	27.84	27.84	28.64	28.64
1958	2.33	4.18	11.02	17.28	26.86	39.25	46.08	47.44	49.26	49.76	50.09	53.37	53.37
1959	0.08	1.23	2.15	7.18	19.69	20.22	21.18	21.70	21.70	21.70	21.80	27.25	27.25
1960	0.00	0.00	1.56	5.07	12.19	16.52	19.18	19.89	19.89	20.17	20.17	20.29	20.29
1961	0.35	4.99	8.20	10.08	11.72	16.15	17.49	19.42	19.60	20.04	20.88	22.12	22.12
1962	0.79	4.40	6.60	10.75	34.55	41.68	42.66	44.31	44.83	44.93	44.93	45.95	45.95
1963	2.10	2.85	3.12	13.95	19.58	27.81	37.54	40.59	41.39	41.39	41.52	42.67	42.67
1964	1.74	10.70	11.75	16.15	16.54	22.30	24.75	28.83	29.84	29.87	30.82	31.87	31.87
1965	2.47	11.72	27.22	35.71	37.73	41.59	47.96	48.19	48.55	49.22	49.71	50.38	50.38
1966	0.67	14.69	22.50	24.20	27.82	29.21	31.00	31.64	31.98	32.00	32.47	32.73	32.73
1967	0.00	4.36	16.47	25.04	26.13	37.03	49.43	51.56	51.93	51.98	52.31	53.82	53.82
1968	0.02	3.11	6.26	10.79	14.72	17.87	19.38	20.21	20.45	20.58	20.76	20.76	20.76
1969	3.57	8.52	18.31	43.24	61.06	64.36	69.78	70.86	71.93	72.45	72.45	72.81	72.81
1970	2.79	5.22	10.51	23.55	26.45	30.50	35.40	35.40	36.63	36.63	36.63	36.63	36.63
1971													
1972													
1973													
1974													
1975	3.30	5.30	10.10	14.40	23.60	35.60	43.20	44.20	44.60	44.60	45.70	46.20	46.20
1976	8.10	10.50	11.50	11.80	17.60	21.20	23.80	24.50	24.50	25.00	25.50	29.30	29.30
1977	1.20	1.80	2.40	5.40	8.10	11.60	11.90	16.20	17.10	17.10	17.40	17.50	17.50
1978	0.50	4.10	18.40	30.90	44.30	57.10	66.00	66.10	66.20	66.30	66.50	71.50	71.50
1979	0.00	4.10	9.50	21.20	31.82	41.22	42.42	44.12	44.12	44.62	44.62	44.82	44.82
1980	3.80	8.40	14.10	33.60	47.80	54.50	56.70	59.60	59.60	59.70	59.70	59.80	59.80
1981													
1982													
1983													
1984	0.50	12.40	25.70	25.70	31.40	34.90	36.70	37.00	37.60	40.20	40.30	40.50	40.50
1985	2.90	12.60	16.00	18.20	21.60	29.60	30.30	30.40	30.90	31.40	31.40	33.00	33.00
1986	3.40	13.00	17.50	22.20	42.50	50.90	53.40	54.20	54.20	54.30	54.30	57.60	57.60
1987	0.20	0.40	1.30	5.90	13.00	19.60	20.80	23.10	24.10	24.10	24.10	24.40	24.40
1988	2.90	7.50	14.20	22.20	24.10	24.20	28.90	31.30	31.80	32.50	32.70	33.00	33.00
1989	0.00	5.02	12.12	13.82	18.92	26.12	27.52	29.72	29.72	29.72	30.52	34.32	34.32
1990	2.50	5.20	5.20	10.90	16.60	20.40	23.10	25.80	25.80	26.10	26.50	27.60	27.60
1991	0.40	1.50	4.80	5.70	8.20	30.90	32.30	35.60	36.70	36.80	36.83	37.13	37.13
1992	3.20	5.60	10.20	12.83	22.81	26.88	27.46	27.71	28.05	30.40	30.40	30.51	30.51
1993	4.70	5.00	18.31	34.31	47.91	54.21	56.31	56.48	58.48	58.48	58.48	58.48	58.48
1994	0.71	3.98	7.17	9.57	17.08	18.73	22.39	25.22	25.29	25.29	25.29	26.42	26.42
1995	3.00	10.99	13.63	38.54	40.70	60.10	70.63	75.89	75.89	75.99	75.99	75.99	75.99
1996													
1997													
1998													
1999													
2000	0.00	1.16	1.24	12.12	25.80	28.48	31.56	33.88	34.84	35.16	35.16	35.28	35.28
2001	2.92	3.60	4.24	9.74	19.34	23.26	28.50	28.54	28.54	29.42	29.42	29.42	29.42

Simulated Inflow to Millerton (USAN Base Run) **Section 1**

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1901	69	122	94	230	225	239	246	450	612	256	203	101	2,845
1902	92	84	81	65	71	128	236	234	375	148	127	108	1,748
1903	76	82	65	80	89	93	215	313	356	145	101	102	1,717
1904	75	69	47	46	61	153	239	413	468	183	145	124	2,022
1905	206	99	77	71	85	153	188	218	338	177	125	112	1,847
1906	76	67	51	181	96	254	426	667	982	1,000	332	172	4,302
1907	93	65	74	140	151	258	439	434	546	530	259	139	3,127
1908	95	60	66	91	91	170	152	119	118	135	148	128	1,373
1909	64	33	36	221	227	129	246	440	700	340	144	114	2,695
1910	82	82	232	227	122	222	289	332	192	104	94	116	2,094
1911	84	70	58	180	243	309	419	430	819	597	204	106	3,517
1912	83	54	47	71	68	104	64	100	257	163	130	116	1,256
1913	41	36	37	38	29	44	74	111	108	123	115	130	885
1914	48	34	41	206	216	212	271	427	504	382	210	115	2,667
1915	94	60	47	65	123	154	240	213	453	297	123	93	1,962
1916	79	66	59	188	185	280	415	441	498	288	146	110	2,754
1917	117	71	64	75	135	163	223	209	437	235	124	107	1,959
1918	72	63	39	38	55	161	180	189	326	147	107	95	1,474
1919	149	83	65	51	84	99	178	252	147	69	99	105	1,379
1920	56	33	48	42	45	88	139	221	263	118	105	102	1,260
1921	77	72	59	84	95	168	181	206	267	166	112	104	1,589
1922	66	51	82	90	114	108	181	406	660	306	127	103	2,294
1923	76	68	109	95	97	123	219	266	213	195	127	115	1,703
1924	82	63	41	40	44	81	73	52	5	37	52	70	641
1925	31	37	39	40	90	80	188	208	201	155	106	89	1,263
1926	74	55	47	42	75	99	233	242	129	58	77	98	1,226
1927	51	74	74	66	158	141	230	297	377	207	113	98	1,885
1928	80	114	67	59	72	154	163	206	135	81	111	100	1,341
1929	31	29	34	34	38	62	79	156	119	112	85	97	877
1930	28	22	25	34	48	69	128	81	149	94	83	98	859
1931	34	30	28	32	37	40	77	59	18	39	46	69	507
1932	28	15	71	79	171	128	209	245	398	259	115	97	1,815
1933	73	62	42	51	55	95	124	57	259	186	124	110	1,237
1934	49	32	59	66	66	121	135	44	20	51	69	70	782
1935	39	40	50	81	93	84	251	322	385	158	101	98	1,703
1936	77	68	44	64	204	186	265	351	253	159	109	98	1,878
1937	66	60	61	59	236	231	269	442	401	173	87	87	2,172
1938	76	65	214	122	225	328	421	595	863	433	219	107	3,666
1939	92	64	55	75	83	153	218	105	66	70	83	99	1,164
1940	60	30	27	141	133	180	233	334	278	111	81	91	1,701
1941	64	59	113	136	199	213	248	414	556	348	159	100	2,608
1942	84	70	116	148	137	153	267	267	489	300	131	95	2,256
1943	77	91	70	153	178	255	280	344	251	170	118	102	2,090
1944	67	64	47	55	74	111	114	200	205	166	126	106	1,334
1945	64	83	80	66	243	146	216	296	356	254	138	110	2,051
1946	110	119	149	108	76	133	236	304	208	128	96	102	1,769
1947	81	107	110	72	82	128	134	200	98	74	98	104	1,289
1948	45	36	33	35	35	33	129	176	235	134	88	99	1,078
1949	63	41	40	40	46	72	170	218	203	83	101	105	1,181
1950	63	44	42	64	105	79	208	206	190	106	89	102	1,295
1951	70	191	313	217	135	119	170	141	178	146	125	106	1,909
1952	57	42	90	163	114	151	287	571	592	334	195	110	2,705
1953	73	50	67	122	83	108	146	103	169	211	132	108	1,372
1954	51	38	39	53	79	110	206	253	164	100	82	80	1,255
1955	61	50	56	63	68	83	99	144	247	123	121	106	1,221
1956	48	35	319	284	224	226	251	327	505	306	182	112	2,818
1957	92	67	47	61	92	103	115	157	291	168	120	105	1,417
1958	69	50	68	64	125	170	285	541	561	313	176	117	2,538
1959	77	51	41	71	118	168	171	103	98	71	79	123	1,171
1960	49	26	26	33	66	73	140	105	92	72	78	77	837
1961	31	38	48	34	44	46	97	55	55	54	79	71	652
1962	37	29	38	37	183	88	264	270	335	213	115	103	1,711
1963	79	63	38	63	243	142	197	229	365	269	149	118	1,955
1964	83	110	69	56	54	94	94	117	134	91	119	100	1,121
1965	32	50	148	248	141	104	192	237	319	264	216	122	2,072
1966	77	140	101	89	77	145	224	204	116	74	100	107	1,453
1967	37	46	232	101	121	181	233	391	720	596	246	141	3,044
1968	83	51	61	77	109	137	126	117	87	74	86	94	1,101
1969	38	55	67	258	245	237	410	836	849	466	229	104	3,793
1970	86	61	73	186	119	176	142	166	222	139	129	106	1,604
1971	52	58	96	92	88	92	147	144	199	158	138	115	1,380
1972	65	53	81	63	68	150	93	126	141	81	107	131	1,159
1973	44	49	64	94	131	110	190	425	393	147	96	93	1,835
1974	84	130	118	165	91	218	262	354	388	170	123	99	2,201
1975	80	70	60	63	97	150	136	279	473	185	107	110	1,809
1976	105	83	53	44	59	117	63	56	20	59	80	102	840
1977	46	23	21	25	26	21	45	10	29	38	36	62	383
1978	25	15	86	166	198	241	263	492	725	464	242	216	3,133
1979	90	59	59	131	134	209	250	337	283	126	104	102	1,884
1980	80	77	57	261	274	260	290	385	500	425	211	114	2,932
1981	87	60	55	69	87	130	151	191	137	82	114	109	1,272
1982	44	88	82	133	177	219	454	547	529	347	238	187	3,046
1983	225	185	221	242	264	376	313	531	1,119	687	332	195	4,688
1984	106	176	208	200	142	192	215	245	209	164	150	127	2,134
1985	81	90	68	63	74	106	197	187	109	79	97	115	1,266
1986	50	56	86	106	325	394	349	464	518	245	133	107	2,831
1987	90	59	41	52	69	120	130	125	71	64	76	88	984
1988	43	40	41	71	58	79	119	88	82	79	82	83	865
1989	31	28	36	37	49	111	194	120	86	71	79	89	931
1990	50	39	34	40	46	76	136	53	55	80	76	70	754
1991	32	20	24	25	24	99	103	122	199	126	95	110	978
1992	42	39	38	40	80	80	156	120	32	73	76	78	855
1993	35	33	47	195	131	185	247	472	518	323	153	104	2,443
1994	82	56	48	57	72	129	118	130	106	67	87	98	1,050
1995	67	60	65	217	131	324	330	465	762	752	306	157	3,635
1996	78	44	73	108	237	258	281	402	358	184	124	104	2,248
1997	74	137	224	606	244	260	277	404	258	137	104	107	2,831
1998	73	71	62	122	227	203	267	273	704	673	251	148	3,073
1999	91	68	77	105	144	135	164	215	262	129	113	105	1,608
Average	70	64	76	105	120	152	207	266	322	207	130	108	1828

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	32,296	29,247	27,737	23,500	21,433	22,899	45,153	123,000	123,000	90,744	61,712	36,116
1923	32,896	30,658	28,743	26,572	24,011	20,207	24,789	123,000	121,841	87,420	60,972	36,342
1924	32,583	29,516	26,528	23,521	20,834	10,726	16,641	67,041	82,982	59,070	35,242	12,213
1925	17,429	17,082	16,287	13,897	13,196	18,956	27,198	116,023	120,087	87,006	60,880	36,045
1926	32,305	29,130	25,928	22,818	20,558	16,134	89,576	123,000	105,020	78,957	53,581	29,173
1927	27,410	26,240	22,286	19,592	24,372	22,896	60,172	123,000	121,351	87,462	60,919	36,071
1928	33,332	30,863	28,033	25,628	23,302	32,568	28,850	92,353	92,076	66,578	41,613	17,631
1929	20,244	18,420	16,641	14,709	13,062	11,843	21,698	74,287	94,171	64,233	39,356	15,478
1930	17,805	16,875	15,193	13,684	12,678	12,703	21,334	74,481	89,719	63,938	39,261	15,508
1931	18,594	17,039	15,214	13,744	12,265	10,876	17,809	68,101	84,370	60,270	36,461	13,240
1932	16,168	16,975	23,280	14,863	14,270	23,967	29,596	123,000	123,000	86,653	60,119	35,288
1933	32,835	30,340	27,921	25,756	23,408	14,702	22,526	102,367	118,466	78,213	52,542	28,123
1934	26,806	24,038	21,683	19,022	17,179	13,156	17,699	65,733	85,319	61,013	36,951	13,659
1935	18,699	17,314	15,558	14,535	12,993	23,708	96,208	123,000	121,829	87,061	60,978	36,102
1936	32,865	30,427	27,997	25,638	31,604	24,170	97,578	123,000	121,359	86,761	60,052	35,184
1937	32,692	29,880	28,074	25,157	47,725	23,735	63,964	123,000	123,000	87,135	60,831	36,019
1938	32,821	30,381	42,553	26,377	25,387	121,411	123,000	123,000	123,000	122,492	62,071	36,602
1939	33,545	30,630	28,070	25,852	23,510	12,605	25,634	73,962	88,055	63,625	38,602	15,161
1940	18,799	16,989	15,270	15,029	25,356	34,814	65,167	123,000	115,645	85,877	59,917	35,154
1941	32,588	29,744	33,875	25,326	24,114	23,533	32,818	123,000	123,000	103,820	61,150	36,110
1942	33,078	30,975	32,144	27,180	24,074	23,034	61,646	123,000	123,000	96,090	61,018	36,080
1943	32,831	30,802	28,532	58,084	24,642	54,317	109,619	123,000	116,226	87,566	60,910	36,090
1944	32,585	29,933	27,221	24,758	23,183	16,856	23,110	110,741	112,689	83,561	57,611	32,938
1945	30,533	27,901	24,883	21,394	23,644	23,106	74,925	123,000	123,000	87,585	60,968	36,112
1946	38,999	31,014	29,677	25,893	23,795	22,990	84,184	123,000	114,006	87,005	60,889	36,114
1947	32,423	30,221	27,141	23,642	21,307	12,534	22,772	75,024	89,538	64,187	39,501	15,721
1948	19,089	17,049	15,304	13,669	12,270	16,754	23,048	118,241	121,665	85,845	59,965	35,277
1949	32,036	28,737	25,544	22,250	19,650	15,804	49,125	123,000	110,985	84,611	58,766	34,144
1950	30,616	27,773	24,403	21,546	19,582	17,875	62,063	123,000	113,919	86,525	60,775	35,999
1951	32,658	93,498	89,393	23,412	20,157	15,846	23,319	106,344	115,127	79,372	53,748	29,265
1952	27,703	25,047	33,373	20,691	18,049	29,995	112,893	123,000	123,000	119,705	60,298	35,414
1953	32,819	30,370	28,885	26,152	23,707	15,088	41,437	84,539	121,885	78,346	52,479	28,101
1954	26,707	24,132	21,448	18,957	17,273	17,969	64,646	123,000	113,542	86,903	60,738	35,992
1955	31,912	28,812	25,666	22,612	19,832	15,264	21,881	108,446	109,845	77,931	52,481	28,081
1956	26,578	24,201	123,000	122,284	68,230	28,216	53,012	123,000	123,000	120,999	60,506	35,543
1957	33,226	30,503	28,025	25,596	24,599	16,740	23,850	100,307	123,000	86,064	60,128	35,421
1958	31,818	28,530	25,265	22,443	21,493	33,070	103,849	123,000	123,000	99,073	61,277	36,342
1959	32,890	30,439	27,870	25,472	24,357	12,192	22,988	72,799	88,089	63,247	38,563	15,302
1960	18,551	16,902	15,256	13,733	12,476	12,127	20,370	75,323	87,237	62,655	37,782	14,185
1961	18,584	17,198	15,393	13,835	12,308	11,386	18,128	70,098	85,825	61,418	37,291	13,979
1962	18,616	17,236	15,445	13,830	16,649	23,321	107,286	123,000	123,000	87,521	60,999	36,165
1963	32,852	30,237	27,659	57,522	41,120	22,095	24,326	123,000	123,000	97,263	61,045	35,913
1964	32,975	30,537	27,662	25,033	22,403	11,922	21,613	75,986	88,472	62,929	38,421	14,598
1965	18,668	17,338	67,799	28,439	14,190	21,873	54,410	123,000	123,000	97,984	61,401	36,246
1966	32,768	31,230	29,859	25,429	23,009	16,750	40,271	98,675	98,290	72,413	47,026	23,206
1967	23,279	22,344	19,326	23,299	15,641	54,476	62,957	123,000	123,000	123,000	61,813	36,687
1968	32,860	31,214	28,119	25,809	24,548	12,874	22,266	74,390	86,642	62,302	37,383	13,825
1969	18,489	17,064	15,916	122,591	119,026	110,770	123,000	123,000	123,000	121,953	61,448	36,431
1970	33,156	30,656	28,256	26,934	25,121	15,773	21,717	118,583	109,749	78,805	53,006	28,589
1971	27,045	25,192	22,315	20,076	17,353	18,124	22,824	88,535	121,216	84,778	58,359	33,455
1972	30,458	27,428	24,871	21,608	18,943	11,551	22,279	77,257	88,528	63,005	38,421	14,503
1973	18,603	17,373	15,682	14,226	16,838	22,318	53,961	123,000	123,000	86,875	60,854	35,960
1974	33,004	31,005	29,376	26,602	23,702	26,101	47,357	123,000	121,435	88,452	60,629	36,154
1975	33,089	30,558	28,051	25,575	24,195	21,083	23,551	123,000	119,811	86,884	60,916	36,352
1976	33,407	30,337	27,522	24,789	23,211	11,372	16,718	69,639	83,623	60,427	35,587	12,565
1977	18,529	16,915	15,344	13,641	12,168	10,479	14,511	52,722	83,541	59,230	35,654	12,649
1978	15,267	16,957	16,705	14,493	14,207	70,310	123,000	123,000	123,000	123,000	61,503	36,353
1979	33,066	30,768	28,113	26,541	24,653	27,964	36,959	123,000	114,436	87,039	60,927	36,240
1980	32,731	30,019	29,499	90,612	107,566	92,995	123,000	123,000	123,000	122,989	60,486	35,659
1981	32,948	30,488	28,023	25,884	23,635	12,666	37,228	81,732	93,291	67,817	42,785	18,597
1982	20,670	19,124	18,167	15,956	38,744	32,797	123,000	123,000	123,000	122,921	62,066	72,937
1983	43,761	38,339	52,416	58,078	73,382	123,000	123,000	123,000	123,000	123,000	99,782	37,830
1984	33,625	33,197	63,629	26,604	24,437	19,305	22,950	123,000	114,752	87,080	60,327	35,349
1985	32,764	29,913	26,288	22,939	20,929	12,991	31,719	77,055	93,677	68,450	43,401	19,380
1986	20,996	19,922	18,554	17,545	123,000	123,000	123,000	123,000	123,000	87,693	61,229	36,664
1987	32,994	30,400	27,886	25,370	23,155	11,565	24,030	71,730	87,483	62,541	38,140	14,738
1988	18,985	17,032	15,526	14,151	14,047	12,253	20,238	73,489	87,034	62,136	37,643	13,913
1989	17,568	17,296	15,469	13,838	12,708	13,002	24,197	72,610	88,898	63,698	39,071	15,891
1990	18,683	17,185	15,388	13,716	12,815	12,031	19,687	70,604	86,890	62,013	37,818	14,354
1991	18,284	16,974	15,256	13,616	12,579	13,974	23,475	88,491	101,136	72,007	46,550	22,699
1992	23,111	20,845	18,619	16,216	15,363	12,212	28,623	73,203	86,575	61,977	37,543	14,073
1993	19,118	17,089	15,721	14,851	14,067	48,815	101,580	123,000	123,000	100,645	61,291	35,974
1994	32,766	30,885	27,910	25,393	23,819	11,969	19,904	76,819	88,198	62,993	38,664	15,362
1995	18,899	17,737	15,889	16,739	14,262	123,000	123,000	123,000	123,000	123,000	85,680	36,351
1996	33,266	30,472	28,595	27,864	36,269	25,214	79,222	123,000	115,325	86,708	60,206	35,216
1997	32,922	30,540	41,505	123,000	91,093	78,172	115,575	123,000	116,008	87,170	60,926	36,280
1998	32,674	30,112	27,101	24,835	23,219	51,244	80,718	123,000	123,000	122,845	62,118	36,631
1999	33,129	31,715	28,480	26,669	24,078	18,330	25,140	123,000	118,036	86,911	61,252	36,235

Friant Division Cumulative Groundwater Storage
USBR Water Supply Report & FWUA 2002 Update

April 9, 2002
Friant Water Users Authority

Friant Division Cumulative Groundwater Storage
USBR Water Supply Report & FWUA 2002 Update

After reviewing the Friant Water Users Authority (FWUA) Informational Report (2000), Dan Steiner requested to use the Friant Division Groundwater Storage Change graph (Figure 1 of the Informational Report) as an integral piece of the Hydrologic Inventory section of the Water Supply Plan. The foundation of this graph is data from the United States Bureau of Reclamation's (USBR) Water Supply Report, which was discontinued in 1992. Because the FWUA had already agreed, but had not yet begun, to assume production of the Water Supply Reports from 1993 to the present, it was decided that FWUA would immediately update the groundwater storage data from 1993 to 1999 so that a more current set of groundwater data could be incorporated into the Water Supply Plan.

In order to update the USBR's data, it was necessary to acquire the methodology used in the previous Water Supply Reports to calculate groundwater storage changes. Once this was acquired from the USBR, the Water Supply Oversight Team (WSOT) decided it was appropriate to attempt to duplicate the USBR's results from a few of the pre-1992 years to ensure consistency with the USBR's approach. The following is the general approach used by the USBR, and subsequently the FWUA, to calculate the groundwater storage changes for the Friant Division Districts.

General Methodology

Within a District, the groundwater elevations for an established set of monitoring wells are measured in the spring as well as in the fall. The fall values are only used to show the impacts from summer pumping and are not used to calculate groundwater changes. The change in groundwater elevation is determined from the annual spring-to-spring change. The spring measurements are more representative of the annual change because they are less impacted by recent pumping. Generally, the wells have been shut off during the winter months. The following two components of the collected well data are used in the calculation:

1. Ground surface to water surface distance (GSWSD) – This information is taken directly out of the well data. The GSWSD for all monitored wells within a District for a specific year are averaged to obtain an average GSWSD.
2. Water surface elevation change (WSEC) – This information is derived from the well data. For each well, the water surface elevation for a particular year is compared with the water surface elevation from the previous year to determine a WSEC. The WSEC for all monitored wells are then averaged to obtain an average WSEC. (note that a WSEC value for a particular well is only possible when monitoring occurred in consecutive years at that well, which is not always the case.)

The average GSWSD for a particular year (from Item 1 above) is then subtracted from the average GSWSD from the previous year. This difference is then averaged with the

average WSEC (from Item 2 above) to obtain the final WSEC used in the Water Supply Report for the subject District.

Refer to Figures 1 and 2 for a comparison of the FWUA-calculated WSEC and the WSEC reported in the Water Supply Report between 1990 and 1992.

While we were able to closely reproduce most of the Districts' WSEC's, our calculated values for a few of the Districts differed somewhat from the Water Supply Report. Arvin-Edison Water Storage District was the most notable of these Districts, and because it contains a significant percentage of the groundwater within the Friant Division, we felt it was necessary to resolve the discrepancies between our calculations and the Water Supply Report values. The following is a summary of the process used to resolve the discrepancies:

Arvin's Groundwater Monitoring Wells

There are approximately 190 wells that have been measured within Arvin Edison Water Storage District (AEWSD). The USBR provided FWUA the data dating back to 1972 for all of these wells. The data includes a Well I.D. #, the measurement date, the well head elevation, the measured depth to water and calculated groundwater surface elevation with respect to mean sea level.

How the USBR Arrives at Calculated Change in Groundwater Elevation

Arvin Edison's District is divided into three regions based on earthquake faults present within the District. The USBR refers to these regions as Main District, N.E. Fault and S.E. Fault. The bulk of the 190 wells are in the Main District (around 160) and the majority of the remaining wells are in the S.E. Fault area. There are only a handful of wells in the area designated as N.E. Fault.

Groundwater changes for AEWSD are based on calculating two groups of three averages, (three averages are based on the aforementioned fault-created areas). Weighting factors are applied to values calculated for each region (Main – 0.75, N.E. - 0.07, S.E. - 0.18) then the individual values are summed to arrive at a final value. The USBR historically determined values of WSEC for the Water Supply Report as follows:

1. For a given year, average the **measured depth to water** for each region, multiply by weighting factor and sum three values. This gives the average depth to water.
2. For a given year, average the **groundwater surface elevation** for each region, multiply by the weighting factor and sum the three values. This gives the average groundwater surface elevation for the district.
3. Use a predetermined (constant) value that represents the average ground surface elevation (544 according to the USBR worksheets) and with the value determined in number 2 above, calculate an estimated depth to water by subtracting the # 2 value from 544.
4. Average the value determined in #'s 1 and 3 above to arrive at the average depth to water for that particular year.

5. Subtract #4 from the average depth to water determined the previous year; this gives the WSEC from spring to spring for the year prior to the year the latest spring measurement was performed.

Implementation of USBR's Method and Results

The above method was incorporated into a spreadsheet to perform all calculations.

The USBR provided the specific details of their calculation from the 1994 data, which would go into the 1993 Water Supply Report. The detail sheets showed which wells were used and the area designation prescribed (Main, S.E., N.E.) to each well. This level of detail was not available for any other water year, and therefore it was presumed that the same wells were used to arrive at values in previous years.

Not all of the wells measured in 1994 were used to calculate the above averages. The USBR's details show the following numbers of wells were used for the respective areas in the District: 38 wells from the Main District, 6 wells from the N.E. Fault and 9 wells from the S.E. Fault for a total of 63 wells of the total 190 wells. Of these 63 wells, seven in the Main District were not measured in 1994, one in the N.E. Fault was not measured in 1994 and four in the S.E. Fault were not measured in 1994.

The data set that was provided does not include 2 of the 38 wells in the Main district and one of the six wells in the N.E. Fault. All of the nine wells in the S.E. Fault were in the data set provided. Therefore, the provided data set for 1994 does not match exactly with the USBR's detail and therefore the values that the spreadsheet generates cannot (beyond coincidence) match the USBR's values.

In previous attempts to calculate groundwater elevation changes for AEWSD, we used all of the 190 wells, and positioned them based on their relative position with respect to the two earthquake faults in the District. In doing so, calculated values differed significantly from the USBR's historical values, as published in their Water Supply Report.

Using the subset of 63 wells (remember that we actually had only 60 of these wells) we then performed the calculation, noticing for some years the change in water elevation did not match what was published in the Water Supply Report.

Based on this we looked at the data individually, well by well, to see if we could find problems with the raw data. From this we found anomalies, and therefore did not include these values to arrive at the final calculation for a given year.

All of these "problem data" were extracted from the Main District (we did not find inconsistencies within the S.E. or N.E. Fault areas), and review of these show problems related to:

- Unreasonable swings in groundwater elevation from one year to the next, especially within the context of what the other wells were manifesting in the Main District;

- Unreasonable groundwater elevations compared to wells within the Main District, indicating that there was a problem with the well, or that it was not prescribed to the correct region within the district.

In doing so, we found that the precision of the calculated values, relative to historical Water Supply Report values, improved. For years in which there were no published values (1994-1999), we followed the same procedure of discarding particularly unreasonable data.

A ten-year comparison of FWUA-calculated WSEC's and WSEC's from the Water Supply Report can be found in Figure 3.

Final Steps

Once the final WSEC's were calculated for all the Districts between 1993 and 1999, they were multiplied by the Districts' specific yield and gross acreage to obtain the annual groundwater volume change per District. All the District volumes were then added together to determine the total Friant Division volume change per year. Refer to Figure 4 for this portion of the analysis.

The final result, an updated (1965-1999) Cumulative Groundwater Storage Chart is located within Figure 5. The chart was developed by adding or subtracting the total Friant Division volume changes, depending on whether there was a net gain or loss, from a 1965 baseline on a cumulative basis.

Interpretation of Results

A 1965 starting point was chosen for the FWUA Informational Report Friant Division Groundwater Storage Change graph and for Figure 5 because the current long-term contractors were all in operation by 1965. However, because the time period between 1965-1999 is limited, care should be taken in interpreting Figure 5. The USBR Water Supply Reports tracked the cumulative groundwater storage changes for the Friant-Kern Canal service area and the Madera Canal service area individually, using the completion date of each canal as a starting point for analysis: 1944 for the Madera Canal and 1949 for the Friant-Kern Canal. If one were to extend the time period for Figure 5 back to 1949, the first year both canals were in operation, the cumulative groundwater storage graph shown in Figure 5 would shift downward by 175,000 acre-feet. Furthermore, between 1944 and 1949, the Madera Canal service area groundwater storage graph shows a drop in groundwater storage volume of approximately 275,000 acre-feet. This represents 450,000 acre-feet of decreased storage that is not accounted for when using a 1965 starting point.

The most important aspect of the analysis time period issue is the fact that even a 1944 starting point does not represent the natural or "pre-development" condition of the groundwater reservoir beneath the Friant Division. Severe groundwater overdraft along the Eastside of the San Joaquin Valley prior to the construction of the Friant Division,

and associated land subsidence, has been well documented by the United States Geological Survey and the California Department of Water Resources. One of the main reasons behind the construction of the Friant Division was to stabilize the groundwater table and eliminate this downward trend.

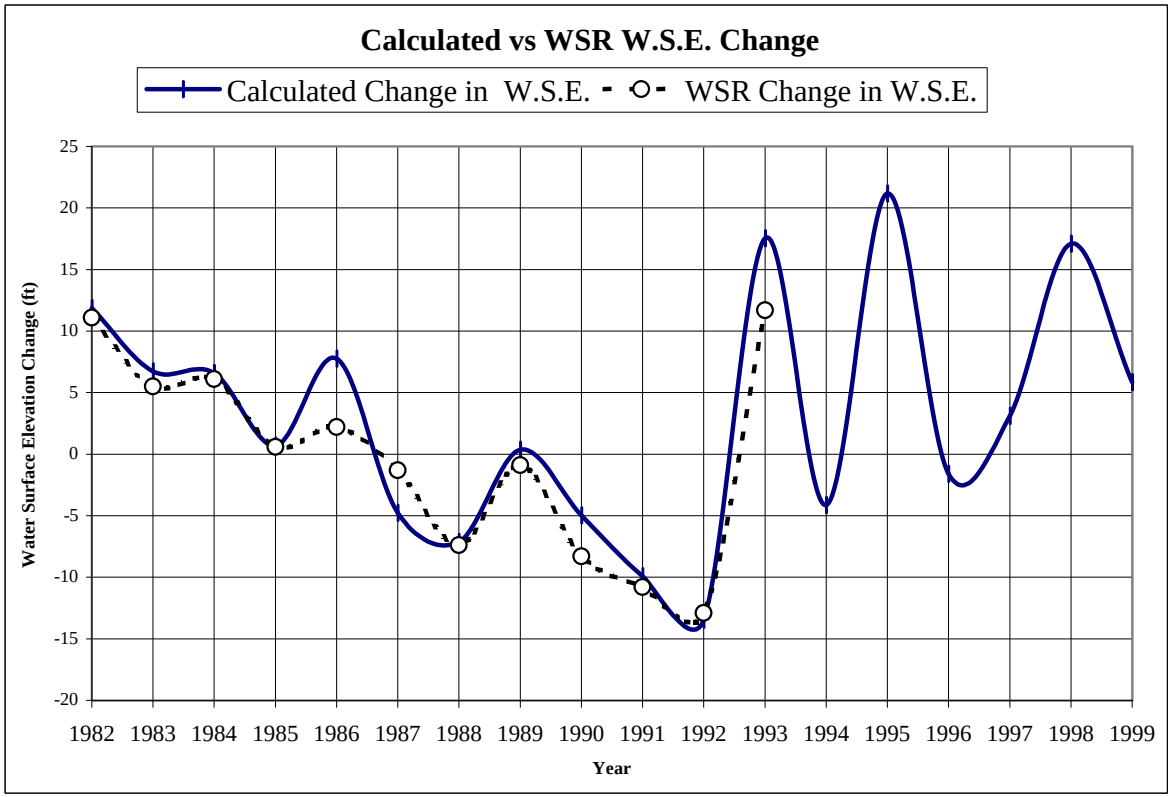
Figure 5 shows that, while there have been short term increases and decreases in storage in the Friant Division, on an average basis the operation of the Friant Division has been successful in regulating and stabilizing groundwater supplies over the 1965 to 1999 period. However, it is noted that groundwater levels are generally lower than under historical, pre-development conditions. Also, Figure 5 indicates that any reduction in water supply made available from the Friant Division would have an adverse impact on the groundwater. In addition, it must be remembered that this data and analysis applies only to those Districts with Friant contracts and does not include the majority of the groundwater area in the San Joaquin Valley.

IIRRIGATION DISTRICT		CHANGE IN WATER SURFACE ELEVATION FROM PREVIOUS YEAR (feet)									
		Water Supply Report Year									
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
ARVIN EDISON	FWUA Analysis	-5.0	-9.9	-13.4	17.5	-4.1	21.2	-1.6	3.1	17.1	5.8
	USBR WSR	-8.3	-10.8	-12.9	11.7						
CHOWCHILLA	FWUA Analysis	-14.7	-8.3	-2.8	-1.9	-1.1	-4.7	0.7	17.8	4.7	0.6
	USBR WSR	-14.5	-7.4	-2.3							
DELANO-EARLIMART	FWUA Analysis	-13.2	-1.4	1.5	0.7	-6.3	6.9	No Data	7.0	8.3	1.4
	USBR WSR	-12.9	-2.7	1.8							
EXETER	FWUA Analysis	-10.6	2.9	-2.8	7.3	-3.3	9.4	2.9	2.3	8.2	-2.8
	USBR WSR	-10.7	2.7	-3.0							
FRESNO	FWUA Analysis	-2.8	-3.2	-0.8	5.3	-6.0	5.8	-1.9	1.1	3.1	No Data
	USBR WSR	-2.5	-2.6	-1.4							
GARFIELD	FWUA Analysis	-4.7	0.1	-0.6	-2.4	2.7	-7.2	-4.3	5.2	19.5	-25.5
	USBR WSR	-5.7	0.0	-0.1							
INTERNATIONAL	FWUA Analysis	0.0	1.8	3.4	2.3	-1.3	6.3	5.8	-2.2	2.9	-9.1
	USBR WSR	0.0	1.8	3.4							
IVANHOE	FWUA Analysis	-10.1	0.1	-3.9	6.9	-4.7	7.5	2.3	2.2	6.8	-1.1
	USBR WSR	-10.2	0.1	-3.9							
LEWIS CREEK	FWUA Analysis	-17.3	8.3	-0.1	2.2	-2.5	7.0	9.4	4.3	-13.7	13.8
	USBR WSR	-17.3	8.3	-0.2							
LINDMORE	FWUA Analysis	-14.6	2.8	-4.0	6.6	-5.1	6.8	4.0	3.9	7.6	0.7
	USBR WSR	-14.6	2.8	-4.2							
LINDSAY STRATHMORE	FWUA Analysis	-9.0	2.3	1.9	3.9	0.9	4.0	2.9	-2.1	12.5	-4.3
	USBR WSR	-8.5	0.1	1.9							
LOWER TULE	FWUA Analysis	-20.1	-1.7	-8.9	15.2	-11.5	20.7	5.2	4.3	15.1	-14.1
	USBR WSR	-19.8	-2.1	-9.2							
MADERA	FWUA Analysis	-8.1	-1.6	-4.3	4.0	-2.3	1.8	1.0	1.9	1.4	-4.9
	USBR WSR	-8.7	-2.0	-4.6							
ORANGE COVE	FWUA Analysis	-9.8	2.8	10.0	-2.9	2.7	3.0	7.7	0.7	4.0	-5.4
	USBR WSR	-9.5	2.7	12.8							
PORTERVILLE	FWUA Analysis	-9.3	0.6	-6.0	13.4	2.2	6.0	4.0	-2.1	6.0	-7.4
	USBR WSR	-9.4	0.4	-4.0							
SAUCELITO	FWUA Analysis	-15.7	-6.2	-9.6	13.5	-8.2	12.8	4.7	7.2	11.0	0.2
	USBR WSR	-16.5	-5.3	-9.9							
SHAFTER-WASCO	FWUA Analysis	-18.5	-6.2	-8.6	6.3	-7.0	5.8	5.1	5.6	9.9	10.2
	USBR WSR	-19.4	-6.0	-8.5							
SSMUD	FWUA Analysis	0.5	-13.0	-4.7	5.4	1.0	5.7	8.5	7.0	-1.5	-21.0
	USBR WSR	-0.8	-8.2	-8.2							
STONE CORRAL	FWUA Analysis	-3.7	-1.4	-4.2	10.6	-3.8	-2.6	11.0	-8.8	13.1	-0.1
	USBR WSR	-3.4	-1.3	-4.1							
TEA POT DOME	FWUA Analysis	-22.0	2.4	17.2	2.0	9.2	5.9	No Data	13.4	5.9	-6.3
	USBR WSR	-6.7	7.1	17.5							
TERRA BELLA	FWUA Analysis	-6.7	2.2	7.8	-6.3	-17.1	35.4	No Data	-17.4	10.2	2.0
	USBR WSR	-5.8	2.6	8.0							
TRANQUILITY	FWUA Analysis	-13.0	-5.9	4.7	0.6	-13.4	0.3	0.9	4.2	18.2	-12.8
	USBR WSR	-18.7	-8.3	8.6							
TULARE	FWUA Analysis	-20.5	-7.6	-10.9	6.9	-8.7	16.4	-0.8	10.2	15.6	No Data
	USBR WSR	-20.6	-7.8	-10.9							

FIGURE 1

	Summary of Observations Regarding Data Used in Volume Calculations (based on comparison with 1994 analysis provided by the Bureau)
ARVIN EDISON	Method of calculation complicated by earthquake faults within the District.
CHOWCHILLA	Same well observations used (121 and 119 wells). Average 1993 depth data differs by 0.5 feet (128.5 vs 128.0). 1994 average change in gw elevation is identical. I calculate a -1.9 change, worksheet suggests -1.7 feet in groundwater elevation, due to the 2.80 vs 2.85 discrpepancy.
DELANO-EARLIMART	Data set provided to the Authority has two additional observations that the spring 94 detail does not include. Well 23S26E35H01M, and an observation made 1/28 and 1994 for well 24S26E02P. 1994 sample computation does not include the 1/28 date but does have a 1/31 measurement. I did not delete data from the data set.
EXETER	1994 Bureau example has two additional wells - 19S26E16J02M and 19S26E20A01M. Computation is just slightly different. Bureau calculates change of +7.5, Authority's data set results in +7.3 change in gw elelvation for 1994.
FRESNO	1994 Bureau example has one additional well 15S18E02A01M. 1993 average distance to gw surface also varies by 2.6 feet Authority calculates change of +5.3 feet, Bureau +6.0 feet.
GARFIELD	Same well observation used in example and Authority Calculated data. Distance to gw surface used in Bureau example for 1993 is 110.2 whereas data set results in 107.84. All other values are identical. Bureau calculates -1.7 foot change, data set results in -2.4 foot change.
INTERNATIONAL	Match (only four wells)
IVANHOE	Identical result. Error in Bureau final calculation provided with 1994 example.
LEWIS CREEK	Identical data set. Error in Bureau calculation.
LINDMORE	Authority's data set is missing two wells compared to the Bureau's 1994 detail - 20S26E32A and 21S27E09G. Results are essentially the same. There are 140 wells used to arrive at the averages so missing two has little impact. 1994 bottom line number (+6.5) match.
LSID	Discrepancy related to rounding differences. Essentially identical.
LOWER TULE	Authority's data set is missing one well compared to the Bureau's 1994 detail - 20S26E32A. This well is also missing from the Lindmore data set. Results are essentially the same. There are 110 wells used to arrive at the averages so missing two has little impact. 1994 bottom line number (+15.2) match.
MADERA	Identical result. 187 wells in 1994
ORANGE COVE	1994 data identical. Discrepancy in 1993 average depth. Complete data set values are more consistent than the
PORTERVILLE	Data set provided to the Authority is missing 4 wells 21S27E-19G and 17R and 34J and 22S27E04A. Averages are different because there are only 8 wells in the data set provided and 12 in the Bureau's detail. Bottom line comparison - Bureau's +11.9, Authority's +13.4
SAUCELITO	Identical except for rounding discrepancy
SHAFTER-WASCO	Bureau used a subset of the wells (24) to calculate values. Some of the wells listed as used are not in the data set
SSMUD	Data does not lend itself to averaging by the conventional method or alternate method (Bureau's).
STONE CORRAL	Identical Result
TEA POT DOME	1994 data identical. Discrepancy in 1993 average depth of 0.4 feet. (Total of three wells)
TERRA BELLA	Same result except for 1993 gw depth used in Bureau's detail. Bottom line Authority -6.3 feet, Bureau -4.5 feet.
TRANQUILITY	Bureau used wells from James Irrigation District and two of the wells for Tranquility. Do not have data for one of the two wells measured in 1994 in Tranquility District.
TULARE	Bureau's 1993 value different from data set, data set has one less well than the 1994 detail (19S23E20C01), minor bottom line discrepancy +6.9 vs. + 6.4 feet gw depth change for 1994.

FIGURE 2



	Calculated Change in WSE	WSR Change in WSE
1982	11.9	11.1
1983	6.7	5.5
1984	6.6	6.1
1985	0.7	0.6
1986	7.8	2.2
1987	-4.8	-1.3
1988	-7.1	-7.4
1989	0.4	-0.9
1990	-5.0	-8.3
1991	-9.9	-10.8
1992	-13.4	-12.9
1993	17.5	11.7

FIGURE 3

DISTRICT	CHANGE IN WATER SURFACE ELEVATION FROM PREVIOUS YEAR (feet) 1990	1991	1992	1993	1994	1995	1996	1997	1998	Report 1999	District's Specific Yield	District's Gross Acreage	Acre-ft/ft elevation change
ARVIN EDISON	-8.3	-10.8	-12.9	11.7	-4.1	21.2	-1.6	3.1	17.1	5.8	14.0%	132,849	18,599
CHOWCHILLA	-14.5	-7.4	-2.3	-1.9	-1.1	-4.7	0.7	17.8	4.7	0.6	10.0%	79,884	7,988
DELANO-EARLIMART	-12.9	-2.7	1.8	0.7	-6.3	6.9	no data	7.0	8.3	1.4	9.0%	56,505	5,085
EXETER	-10.7	2.7	-3.0	7.3	-3.3	9.4	2.9	2.3	8.2	-2.8	9.1%	14,945	1,360
FRESNO	-2.5	-2.6	-1.4	5.3	-6.0	5.8	-1.9	1.1	3.1	no data	11.0%	247,862	27,265
GARFIELD	-5.7	0.0	-0.1	-2.4	2.7	-7.2	-4.3	5.2	19.5	-25.5	13.1%	1,797	235
INTERNATIONAL	0.0	1.8	3.4	2.3	-1.3	6.3	5.8	-2.2	2.9	-9.1	12.2%	736	90
IVANHOE	-10.2	0.1	-3.9	6.9	-4.7	7.5	2.3	2.2	6.8	-1.1	11.0%	11,202	1,232
LEWIS CREEK	-17.3	8.3	-0.2	2.2	-2.5	7.0	9.4	4.3	-13.7	13.8	7.4%	1,233	91
LINDMORE	-14.6	2.8	-4.2	6.6	-5.1	6.8	4.0	3.9	7.6	0.7	7.4%	27,561	2,040
LINDSAY STRATHMORE	-8.5	0.1	1.9	3.9	0.9	4.0	2.9	-2.1	12.5	-4.3	5.0%	15,751	788
LOWER TULE	-19.8	-2.1	-9.2	15.2	-11.5	20.7	5.2	4.3	15.1	-14.1	10.0%	103,270	10,327
MADERA	-8.7	-2.0	-4.6	4.0	-2.3	1.8	1.0	1.9	1.4	-4.9	13.0%	130,689	16,990
ORANGE COVE	-9.5	2.7	12.8	-2.9	2.7	3.0	7.7	0.7	4.0	-5.4	8.0%	29,133	2,331
PORTERVILLE	-9.4	0.4	-4.0	13.4	2.2	6.0	4.0	-2.1	6.0	-7.4	12.5%	17,065	2,133
SAUCELITO	-16.5	-5.3	-9.9	13.5	-8.2	12.8	4.7	7.2	11.0	0.2	10.2%	19,415	1,980
SHAFTER-WASCO	-19.4	-6.0	-8.5	6.3	-7.0	5.8	5.1	5.6	9.9	10.2	9.3%	38,734	3,602
SSMUD	-0.8	-8.2	-8.2	5.4	1.0	5.7	8.5	7.0	-1.5	-21.0	7.2%	59,938	4,316
STONE CORRAL	-3.4	-1.3	-4.1	10.6	-3.8	-2.6	11.0	-8.8	13.1	-0.1	7.3%	6,587	481
TEA POT DOME	-6.7	7.1	17.5	2.0	9.2	5.9	no data	13.4	5.9	-6.3	8.5%	3,508	298
TERRA BELLA	-5.8	2.6	8.0	-6.3	-17.1	35.4	no data	-17.4	10.2	2.0	8.7%	13,912	1,210
TRANQUILITY	-18.7	-8.3	8.6	0.6	-13.4	0.3	0.9	4.2	18.2	-12.8	8.9%	10,188	907
TULARE	-20.6	-7.8	-10.9	6.9	-8.7	16.4	-0.8	10.2	15.6	no data	10.0%	73,668	7,367

DISTRICT	AQUIFER WATER VOLUME CHANGE FROM PREVIOUS YEAR (1,000 Acre Feet) 1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(= District Change in Water Depth * District Specific Yield * District Gross Acreage)									
ARVIN EDISON	-154.4	-200.9	-239.9	217.6	-76.3	394.3	-29.8	57.7	318.0	107.9
CHOWCHILLA	-115.8	-59.1	-18.4	-15.5	-9.0	-37.6	5.4	141.8	37.9	5.0
DELANO-EARLIMART	-65.6	-13.7	9.2	3.5	-31.9	35.2	no data	35.8	42.4	7.3
EXETER	-14.6	3.7	-4.1	10.0	-4.4	12.7	4.0	3.1	11.1	-3.9
FRESNO	-68.2	-70.9	-38.2	143.1	-164.2	158.7	-51.8	30.2	85.1	no data
GARFIELD	-1.3	0.0	0.0	-0.6	0.6	-1.7	-1.0	1.2	4.6	-6.0
INTERNATIONAL	0.0	0.2	0.3	0.2	-0.1	0.6	0.5	-0.2	0.3	-0.8
IVANHOE	-12.6	0.1	-4.8	8.5	-5.7	9.3	2.8	2.7	8.4	-1.4
LEWIS CREEK	-1.6	0.8	0.0	0.2	-0.2	0.6	0.9	0.4	-1.2	1.3
LINDMORE	-29.8	5.7	-8.6	13.5	-10.3	13.9	8.2	8.0	15.5	1.4
LINDSAY STRATHMORE	-6.7	0.1	1.5	3.1	0.7	3.2	2.3	-1.7	9.8	-3.4
LOWER TULE	-204.5	-21.7	-95.0	156.6	-118.9	214.0	53.9	44.7	156.4	-145.8
MADERA	-147.8	-34.0	-78.2	67.9	-38.6	31.0	16.6	31.5	24.3	-84.1
ORANGE COVE	-22.1	6.3	29.8	-6.7	6.3	7.0	18.0	1.6	9.3	-12.7
PORTERVILLE	-20.1	0.9	-8.5	28.5	4.6	12.8	8.4	-4.5	12.8	-15.8
SAUCELITO	-32.7	-10.5	-19.6	26.7	-16.2	25.4	9.2	14.2	21.7	0.4
SHAFTER-WASCO	-69.9	-21.6	-30.6	22.7	-25.2	20.9	18.4	20.2	35.7	36.7
SSMUD	-3.5	-35.4	-35.4	23.3	4.3	24.5	36.7	30.2	-6.5	-90.6
STONE CORRAL	-1.6	-0.6	-2.0	5.1	-1.8	-1.2	5.3	-4.2	6.3	-0.1
TEA POT DOME	-2.0	2.1	5.2	0.6	2.7	1.8	no data	4.0	1.8	-1.9
TERRA BELLA	-7.0	3.1	9.7	-7.6	-20.7	42.8	no data	-21.0	12.3	2.4
TRANQUILITY	-17.0	-7.5	7.8	0.5	-12.2	0.3	0.8	3.8	16.5	-11.6
TULARE	-151.8	-57.5	-80.3	50.9	-64.2	121.1	-5.6	75.4	114.7	no data
Division Volume Change	-1150.3	-510.5	-600.1	752.0	-580.6	1089.4	103.2	474.8	937.2	-215.4
Cumulative Volume Change	-1150.3	-1660.8	-2260.8	-1508.8	-2089.4	-1000.1	-896.9	-422.0	515.2	**299.8**

FIGURE 4

YEAR	Friant Division Yearly Groundwater Storage Change (1,000 Acre-feet)	Friant Division Cumulative Groundwater Storage Change (1,000 Acre-feet)
1965	251.830	251.830
1966	-403.530	-151.700
1967	724.097	572.397
1968	-475.951	96.446
1969	644.755	741.201
1970	-31.149	710.052
1971	-481.453	228.599
1972	-513.860	-285.261
1973	225.514	-59.747
1974	286.983	227.236
1975	-548.927	-321.691
1976	-645.173	-966.864
1977	-799.356	-1766.220
1978	1274.453	-491.767
1979	343.792	-147.975
1980	428.994	281.019
1981	-125.919	155.100
1982	1032.360	1187.460
1983	656.828	1844.288
1984	23.107	1867.395
1985	-220.487	1646.908
1986	502.953	2149.861
1987	-630.714	1519.147
1988	-854.471	664.676
1989	-653.584	11.092
1990	-1086.873	-1075.781
1991	-501.218	-1576.999
1992	-605.785	-2182.784
1993	752.022	-1430.762
1994	-580.618	-2011.380
1995	1089.387	-921.993
1996	103.191	-818.802
1997	474.826	-343.976
1998	937.227	593.250
1999	-215.396	377.855

Values calculated by FWUA

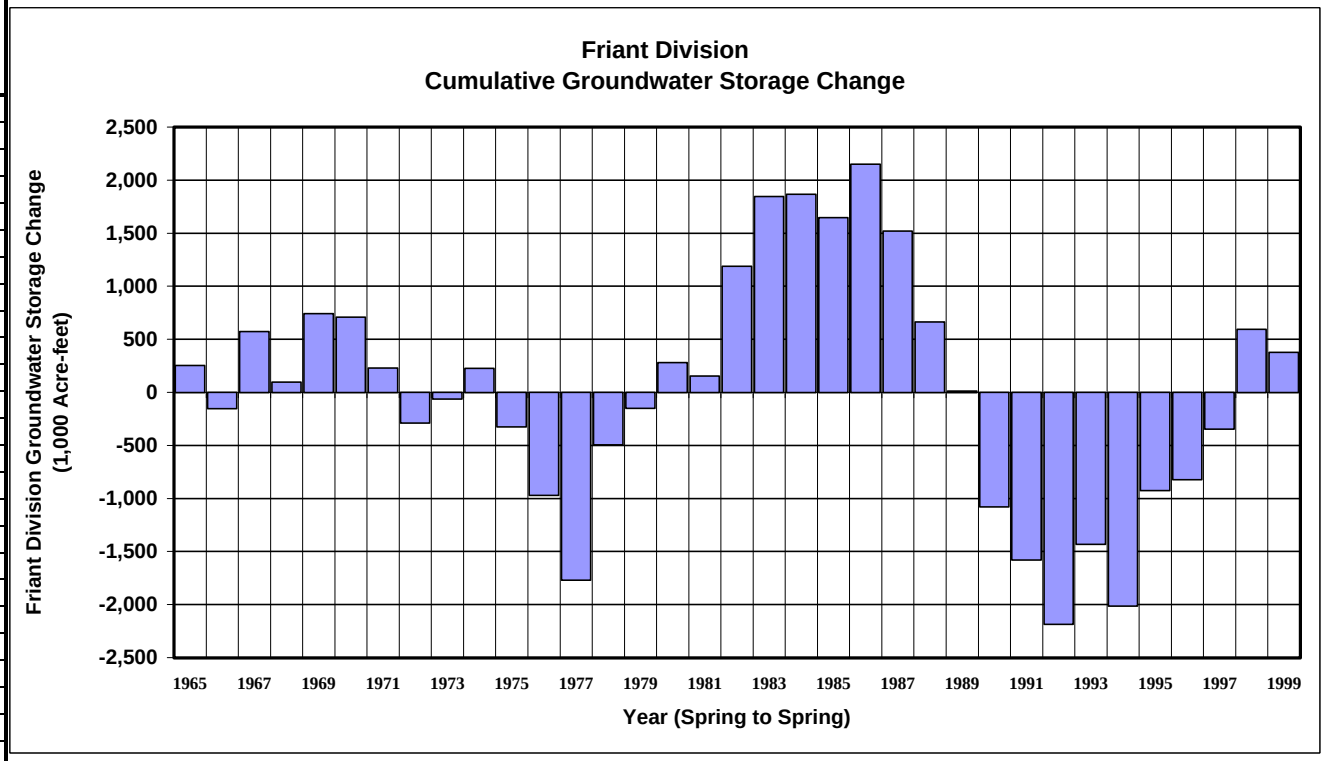


FIGURE 5

Appendix A

Section 2
Water Supply

Historical Friant Water Supply Allocations
Friant-Kern Canal Deliveries - USBR/CVOCO Report of Operations CY 1998-2001
Madera Canal Deliveries - USBR/CVOCO Report of Operations CY 1998-2001
Water Delivery Subtype Definitions
Friant Division Deliveries (by Subtype) WY 1983-1993
Friant-Kern Canal Deliveries (from Delivery Database) Contract Year 1982-83 through 1998-99
Madera Canal Deliveries (from Delivery Database) Contract Year 1982-83 through 1998-99
Friant-Kern Canal Deliveries (by Subtype Classification from Delivery Database)
Madera Canal Deliveries (by Subtype Classification from Delivery Database)

Files

Name	Size	Type	Last Modified
Class Deliveries.123	2,014KB	Lotus 1-2-3 9 Workbook	12/4/01 12:46 AM
delivery data_10_30_2001.zip	1,943KB	WinZip File	10/30/01 4:23 PM

Mar - Feb	Class 1	Class 2
2001-02	85	0
2000-01	100	17
1999-00	100	20
1998-99	100	10
1997-98	100	60
1996-97	100	58
1995-96	100	100
1994-95	80	0
1993-94	100	90
1992-93	83	0
1991-92	100	0
1990-91	68	0
1989-90	98	0
1988-89	78	0
1987-88	91	0
1986-87	100	100
1985-86	100	14
1984-85	100	50
1983-84	100	100
1982-83	100	100
1981-82	100	6
1980-81	100	100
1979-80	100	63
1978-79	100	100
1977-78	25	0
1976-77	75	0
1975-76	100	60
1974-75	100	82
1973-74	100	77
1972-73	100	4
1971-72	100	35
1970-71	100	29
1969-70	100	100
1968-69	92	0
1967-68	100	100
1966-67	100	23
1965-66	100	100
1964-65	100	12
1963-64	100	80
1962-63	100	62
1961-62	75	0
1960-61	100	0
1959-60	100	0
1958-59	100	0
1957-58	100	0

Class 1 & 2 100% Allocation Totals

Friant-Kern Service Area:

Class 1 = 659,650 acre-feet

Class 2 = 1,041,475 acre-feet

Madera Service Area:

Class 1 = 140,000 acre-feet

Class 2 = 346,000 acre-feet

Millerton Lake Service Area:

Class 1 = 350 acre-feet

Class 2 = 14,000 acre-feet

Total for Friant-Kern, Madera, and Millerton Lake Service Areas:

Class 1 = 800,000 acre-feet

Class 2 = 1,401,475 acre-feet

U.S. Department of Interior - Bureau of Reclamation
Central Valley Operations Office
Friant-Kern Canal

Section 2

1998
Monthly Deliveries in AF

Water User	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Arvin-Edison WSD	5,750	12,981	0	0	0	6,192	27,370	14,252	0	0	0	5,394	71,939
Delano-Earlimart ID	229	321	0	0	0	6,199	31,745	23,904	11,156	7,297	3,090	1,462	85,403
Exeter ID	0	0	0	0	0	391	3,313	3,545	3,259	1,690	198	357	12,753
City of Fresno	0	0	0	0	0	0	0	0	25,333	33,598	42	46	59,019
County of Fresno SA #34	0	0	5	16	28	39	115	81	49	35	10	1	379
Fresno ID	0	0	0	0	0	40	382	443	630	0	0	0	1,495
Garfield WD	0	0	0	0	0	189	698	494	317	225	136	9	2,068
Hills Valley ID	0	0	0	0	0	35	748	779	582	269	58	77	2,548
International WD	0	0	0	0	0	81	366	398	364	219	106	19	1,553
Ivanhoe ID	0	0	0	0	0	295	2,437	2,559	2,336	1,228	518	584	9,957
Kawaeah Delta WCD	0	1,017	0	0	0	0	0	0	0	0	0	0	1,017
Kern County Water Agency	0	8,383	8,260	0	0	0	12,720	0	0	0	0	16,143	45,506
Kern-Tulare WD	0	0	0	0	0	1,589	5,966	4,874	3,198	1,879	1,337	951	19,794
Lewis Creek WD	0	0	0	0	0	38	495	459	370	179	3	0	1,544
Lindmore ID	0	0	0	0	0	1,300	9,757	10,103	6,978	3,747	926	0	32,811
City of Lindsay	49	0	0	0	0	7	203	224	145	207	138	170	1,143
Lindsay-Strathmore ID	124	10	0	0	0	712	4,169	4,457	3,829	2,362	738	605	17,006
Lower Tule River ID	217	379	553	0	0	3,022	18,611	22,493	16,782	12,047	4,807	2,712	81,623
City of Orange Cove	52	27	40	28	0	43	149	158	126	89	61	50	823
Orange Cove ID	0	0	0	5	0	577	6,493	6,399	4,990	2,716	432	799	22,411
Pixley ID	0	0	0	0	0	659	12,248	12,444	9,098	5,190	964	0	40,603
Porterville ID	155	0	326	0	0	360	3,364	2,816	1,301	721	174	0	9,217
Rag Gulch WD	0	0	0	0	0	78	2,577	3,104	1,696	489	68	293	8,305
Rosedale Rio Bravo WSD	0	0	0	0	0	0	0	0	0	0	0	0	0
Saucelito ID	0	82	0	0	0	1,657	10,611	9,190	4,642	1,957	151	159	28,449
Semitropic WSD	0	0	0	0	0	0	0	0	0	0	0	0	0
Shafter Wasco ID	438	288	0	0	0	2,347	13,901	8,924	4,663	3,926	799	101	35,387
Southern San Joaquin MUD	0	0	0	0	0	3,877	25,290	18,807	10,196	5,717	1,198	494	65,579
Smallwood Vineyards	0	0	0	0	0	25	94	147	49	4	0	0	319
Stone Corral ID	0	0	0	0	0	53	1,369	1,547	1,281	817	136	263	5,466
Strathmore PUD	32	18	24	0	0	12	72	79	60	17	33	32	379
Styro Tek, Inc.	0	0	0	0	0	0	0	1	1	1	0	0	3
Tea Pot Dome WD	0	306	0	0	0	167	1,086	1,190	1,515	1,096	579	214	6,153
Terra Bella ID	73	45	0	0	0	556	3,581	3,835	2,937	1,766	332	679	13,804
Tri-Valley WD	0	0	0	0	0	0	131	185	135	40	12	0	503
Tulare ID	0	0	0	0	0	0	16,018	36,099	2,867	0	0	9,660	64,644
TOTAL	7,119	23,857	9,208	49	28	30,540	216,079	193,990	120,885	89,528	17,046	41,274	749,603

* Data supplied by Fresno Field Division, Contracts Administration Division

U.S. Department of Interior - Bureau of Reclamation
Central Valley Operations Office
Friant-Kern Canal

Section 2

1999
Monthly Deliveries in AF

Water User	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Alpaugh ID	0	0	0	0	0	0	0	0	0	0	0	0	0
Arvin-Edison WSD	7,632	12,558	8,240	6,342	11,604	13,477	7,864	6,464	2,222	7,333	4,314	0	88,050
Atwell Island WD	0	0	0	0	0	0	0	0	0	0	0	0	0
Delano-Earlimart ID	1,007	1,219	8,076	11,490	19,237	25,023	29,041	18,782	10,385	8,525	5,087	59	137,931
Exeter ID	41	0	61	269	1,241	2,277	3,177	3,143	2,599	1,674	425	0	14,907
City of Fresno	0	0	0	0	0	0	26,900	14,035	65	0	0	0	41,000
County of Fresno SA #34	1	0	8	8	84	67	82	65	51	43	12	11	432
Fresno ID	989	4,124	5,632	89	1,332	3,643	712	0	9,608	9,073	0	0	35,202
Garfield WD	21	43	245	266	451	296	622	529	373	234	26	0	3,106
Hills Valley ID	0	0	23	32	0	518	942	840	748	429	103	0	3,635
International WD	15	0	0	67	229	230	64	81	280	247	25	0	1,238
Ivanhoe ID	646	27	0	57	432	1,402	2,274	2,186	2,633	711	266	0	10,634
Kawaeah Delta WCD	0	0	0	0	0	0	0	0	0	0	0	0	0
Kern County Water Agenc	8,572	26,659	0	1,485	7,262	0	0	0	0	0	0	2,067	46,045
Kern-Tulare WD	44	79	578	522	3,046	5,044	5,414	4,495	3,898	2,660	1,114	0	26,894
Lewis Creek WD	0	0	0	0	164	302	314	298	242	128	46	0	1,494
Lindmore ID	0	0	326	1,277	4,253	6,957	9,408	8,465	6,479	4,130	1,531	0	42,826
City of Lindsay	137	0	73	211	240	245	260	256	229	235	99	0	1,985
Lindsay-Strathmore ID	323	127	0	622	2,405	3,376	4,198	4,135	3,761	3,060	1,323	95	23,425
Lower Tule River ID	3,864	4,243	14,424	7,144	27,343	30,743	36,582	33,946	2,490	567	1,002	0	162,348
North-Kern WSD	0	0	0	0	0	0	1,800	0	0	0	0	0	1,800
City of Orange Cove	46	39	50	63	134	172	194	176	144	164	180	120	1,482
Orange Cove ID	128	0	64	454	2,744	4,794	5,884	5,717	5,010	3,225	667	0	28,687
Pixley ID	0	1,288	1,238	2,283	3,028	7,791	7,459	5,476	64	0	0	0	28,627
Porterville ID	0	54	808	951	3,035	2,908	3,683	2,558	1,215	1,948	0	0	17,160
Rag Gulch WD	0	61	626	553	2,144	2,078	2,651	3,063	1,475	935	284	0	13,870
Rosedale Rio Bravo WSD	0	0	0	0	0	0	0	0	0	0	0	0	0
Saucelito ID	282	618	2,402	2,868	6,116	5,503	8,367	5,099	3,529	2,803	635	0	38,222
Semitropic WSD	500	0	0	0	0	0	0	0	0	0	0	0	500
Shafter Wasco ID	1,034	3,798	4,980	5,514	7,402	9,983	12,049	7,195	3,134	4,492	1,309	0	60,890
Southern San Joaquin MU	431	1,652	8,134	9,777	15,446	20,426	23,373	16,522	9,297	7,420	2,090	0	114,568
Smallwood Vineyards	0	0	114	53	98	86	0	0	0	0	0	0	351
Stone Corral ID	8	0	0	64	482	1,136	1,440	1,301	812	599	104	0	5,946
Strathmore PUD	28	25	32	35	58	63	74	65	59	51	36	33	559
Styro Tek, Inc.	0	0	1	0	1	0	1	1	1	1	1	0	7
Tea Pot Dome WD	239	1,414	43	219	666	1,041	1,328	1,220	1,159	815	246	0	8,390
Terra Bella ID	134	44	49	403	1,846	2,640	3,619	3,152	2,885	2,000	922	0	17,694
Tri-Valley WD	0	0	0	0	41	159	215	245	162	79	16	0	917
Tulare ID	4,976	14,248	0	5,545	14,613	32,407	25,696	12,934	0	0	0	0	110,419
Total	31,098	72,320	56,227	58,663	137,177	184,787	225,687	162,444	75,009	63,581	21,863	2,385	1,091,241

* Data supplied by Fresno Field Division, Contracts Administration Division

U.S. Department of Interior - Bureau of Reclamation
Central Valley Operations Office
Friant-Kern Canal

Section 2

2000
Monthly Deliveries in AF

Water User	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Alpaugh ID	0	0	0	0	0	0	0	0	0	0	0	0	0
Arvin-Edison WSD	0	1,644	19,884	14,787	15,986	11,635	7,498	13,154	12,616	7,511	0	3,085	107,800
Atwell Island WD	0	0	23	300	0	0	0	0	0	0	0	0	323
Delano-Earlimart ID	0	201	2,400	13,032	20,526	28,618	27,340	20,561	11,426	7,156	2,469	1,259	134,988
Exeter ID	0	0	9	425	1,355	2,768	2,793	3,171	3,351	889	246	278	15,285
City of Fresno	0	0	0	0	0	0	0	21,291	17,327	0	0	0	38,618
County of Fresno SA #34	3	1	21	28	28	67	78	64	43	25	13	9	380
Fresno ID	0	0	2	9,235	10,905	2,425	21,685	331	3,899	60	7	9	48,558
Garfield WD	0	0	60	270	527	462	596	446	328	60	0	0	2,749
Hills Valley ID	0	0	27	107	348	617	784	873	599	295	17	57	3,724
International WD	0	14	0	22	194	218	279	271	228	81	0	59	1,366
Ivanhoe ID	112	207	0	132	454	1,348	2,199	2,390	1,846	1,104	523	436	10,751
Kawaeah Delta WCD	0	0	11,063	0	0	0	0	0	0	0	0	0	11,063
Kern County Water Agenc	0	0	33,742	553	0	0	0	0	0	0	0	0	34,295
Kern-Tulare WD	34	85	2,458	1,772	10,857	4,930	4,795	4,707	3,865	1,601	996	1,052	37,152
Lewis Creek WD	0	0	0	0	0	0	0	85	88	6	0	0	179
Lindmore ID	0	0	8	1,439	4,797	8,008	8,926	9,218	5,751	2,180	672	0	40,999
City of Lindsay	0	53	42	169	226	229	242	236	229	180	91	0	1,697
Lindsay-Strathmore ID	5	60	40	848	710	3,396	3,835	4,245	3,238	1,484	803	513	19,177
Lower Tule River ID	0	301	26,086	23,968	27,779	36,021	23,094	25,933	799	450	845	3,660	168,936
North-Kern WSD	0	0	427	0	0	0	0	0	0	0	0	0	427
City of Orange Cove	0	20	63	93	111	154	170	173	150	107	68	68	1,177
Orange Cove ID	0	0	60	926	3,224	4,453	5,597	5,695	4,357	1,797	221	631	26,961
Pixley ID	0	0	2,281	4,821	7,699	10,111	10,803	3,460	0	0	0	0	39,175
Porterville ID	0	0	267	1,996	2,501	3,861	3,832	644	496	1,576	1,560	509	17,242
Rag Gulch WD	0	0	321	1,168	2,449	3,294	3,616	2,988	1,607	716	257	72	16,488
Rosedale Rio Bravo WSD	0	0	8,693	0	33,268	2,343	0	0	0	0	0	0	44,304
Saucelito ID	20	11	812	4,825	6,694	7,252	7,632	5,650	3,400	1,034	204	249	37,783
Semitropic WSD	0	0	0	0	0	0	0	0	0	0	0	0	0
Shafter Wasco ID	832	3,925	3,141	5,191	7,987	11,089	11,186	8,199	4,284	3,395	1,334	947	61,510
Southern San Joaquin MU	0	1,220	5,278	11,285	17,836	23,290	24,553	18,420	10,692	6,333	1,918	1,336	122,161
Smallwood Vineyards	0	0	36	128	0	98	16	39	41	20	2	0	380
Stone Corral ID	0	0	0	241	757	1,413	1,740	1,621	973	340	68	121	7,274
Strathmore PUD	35	29	39	49	0	76	70	69	54	35	26	25	507
Styro Tek, Inc.	0	0	1	1	0	1	1	1	0	1	1	0	7
Tea Pot Dome WD	0	0	0	300	877	1,385	1,263	1,331	974	486	172	118	6,906
Terra Bella ID	0	0	5	782	2,104	3,223	3,542	3,852	2,686	1,321	427	425	18,367
Tri-Valley WD	0	0	0	0	67	112	278	305	241	129	0	0	1,132
Tulare ID	0	0	1,460	11,757	34,425	40,983	23,024	951	0	0	0	0	112,600
Total	1,041	7,771	118,749	110,650	214,691	213,880	201,467	160,374	95,588	40,372	12,940	14,918	1,192,441

* Data supplied by Fresno Field Division, Contracts Administration Division

U.S. Department of Interior - Bureau of Reclamation
Central Valley Operations Office
Friant-Kern Canal

Section 2

2001
Monthly Deliveries in AF

Water User	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Alpaugh ID	0	0	0	0	0	0	0	0	0	0	0	0	0
Arvin-Edison WSD	4,734	0	329	829	7,492	7,291	5,423	2,975	2,175	0	0	950	32,198
Atwell Island WD	0	0	0	0	0	0	0	0	0	0	0	0	0
Delano-Earlimart ID	676	921	2,792	7,686	19,749	24,226	22,839	16,685	10,353	7,499	1,495	28	114,949
Exeter ID	120	39	110	192	1,709	2,471	2,773	2,680	2,056	1,388	179	6	13,723
City of Fresno	0	0	0	0	5,697	23,805	25,207	1,291	2,000	0	0	0	58,000
County of Fresno SA #34	3	1	19	28	60	87	75	66	54	32	5	2	432
Fresno ID	12	2	0	0	160	154	168	255	978	236	30	10	2,005
Garfield WD	19	0	80	270	465	500	567	449	270	197	4	0	2,821
Hills Valley ID	1	18	12	20	673	785	853	911	NR	577	79	7	3,936
International WD	0	14	5	7	242	268	258	233	246	192	0	0	1,465
Ivanhoe ID	186	0	0	19	446	1,298	1,623	1,396	1,303	1,490	482	128	8,371
Kawaeah Delta WCD	0	0	0	0	0	0	0	0	0	0	0	0	0
Kern County Water Agency	0	0	0	0	0	0	0	0	0	0	0	0	0
Kern-Tulare WD	65	82	845	1,489	1,549	4,831	5,758	6,352	NR	2,425	NR	0	23,396
Lewis Creek WD	0	0	0	0	0	51	46	56	38	13	0	0	204
Lindmore ID	0	0	630	1,000	5,380	8,203	9,402	8,796	2,610	836	707	0	37,564
City of Lindsay	0	0	0	0	36	65	112	132	165	205	97	118	930
Lindsay-Strathmore ID	258	131	393	568	3,086	3,845	4,228	4,367	6,036	2,437	584	137	26,070
Lower Tule River ID	827	37	0	0	18,892	21,583	24,319	11,284	NR	0	0	498	77,440
North-Kern WSD	0	0	0	0	0	0	0	0	0	0	0	0	0
City of Orange Cove	68	59	81	90	165	189	180	189	178	130	83	76	1,488
Orange Cove ID	238	0	184	375	4,274	5,446	5,946	5,780	4,880	2,818	362	9	30,312
Pixley ID	0	0	0	0	0	8,015	985	0	NR	0	0	0	9,000
Porterville ID	0	0	0	1,203	2,843	2,930	3,089	2,503	731	739	27	0	14,065
Rag Gulch WD	4	20	311	1,118	2,552	3,074	3,199	2,435	NR	1,279	NR	0	13,992
Rosedale Rio Bravo WSD	0	0	0	0	0	0	0	0	NR	0	0	0	0
Saucelito ID	367	87	1,356	1,754	4,713	4,788	4,615	3,622	1,602	2,082	401	4	25,391
Semitropic WSD	0	0	0	0	0	0	0	0	0	1,262	0	0	1,262
Shafter Wasco ID	1,297	3,072	2,459	4,589	7,767	9,555	9,781	6,241	7,439	2,766	426	1,011	56,403
Southern San Joaquin MUD	1,287	1,766	4,749	8,276	14,807	19,532	18,631	12,068	7,610	5,862	1,108	259	95,955
Smallwood Vineyards	0	0	0	26	102	145	119	0	NR	0	0	0	392
Stone Corral ID	64	0	84	155	1,109	1,669	1,822	1,896	113	660	71	0	7,643
Strathmore PUD	25	21	28	31	71	88	80	74	14	47	27	35	541
Styro Tek, Inc.	0	0	1	1	0	1	1	1	1	0	0	0	6
Tea Pot Dome WD	74	0	0	206	895	1,171	1,255	1,221	858	727	119	0	6,526
Terra Bella ID	146	21	255	518	2,621	3,272	3,612	3,779	3,297	1,944	356	67	19,888
Tri-Valley WD	0	0	0	0	69	223	313	306	NR	193	4	0	1,108
Tulare ID	1,271	1,216	0	1,266	5,804	17,274	218	0	NR	1,611	NR	0	28,660
Total	11,742	7,507	14,723	31,716	113,428	176,835	157,497	98,043	55,007	39,647	6,646	3,345	716,136

* Data supplied by Fresno Field Division, Contracts Administration Division

U.S. Department of Interior - Bureau of Reclamation
Central Valley Operations Office

1998
Monthly Deliveries in AF

Water User	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
MADERA CANAL													
Chowchilla WD	0	0	0	0	0	0	24,766	5,859	12,131	13,168	4,461	12,932	73,317
Madera ID (215 water)	0	0	181	2,904	12,919	11,885	34,553	26,672	14,956	1,744	9,598	10,338	125,750
Soquel	0	0	0	0	0	99	217	112	69	11,820	0	0	12,317
Total	0	0	181	2,904	12,919	11,984	59,536	32,643	27,156	26,732	14,059	23,270	211,384
MILLERTON LAKE													
County of Madera	2	1	2	2	3	5	8	6	6	4	2	1	42
Fresno County # 18	5	4	6	6	9	12	22	18	15	11	6	6	120
Gravelly Ford WD	0	0	297	578	1,208	235	2,916	1,311	39	50	0	0	6,634
Total	7	5	305	586	1,220	252	2,946	1,335	60	65	8	7	6,796

U.S. Department of Interior - Bureau of Reclamation
Central Valley Operations Office

1999
Monthly Deliveries in AF

Water User	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
MADERA CANAL													
Chowchilla WD	1,736	9,027	14,374	13,881	17,981	10,040	22,354	23,245	15,805	9,339	0	0	137,782
Madera ID (215 water)	0	0	6,255	12,869	20,827	25,183	27,973	19,228	11,179	11,491	0	0	135,005
Soquel	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1,736	9,027	20,629	26,750	38,808	35,223	50,327	42,473	26,984	20,830	0	0	272,787
MILLERTON LAKE													
County of Madera	2	1	2	3	5	5	7	6	5	5	3	3	47
Fresno County # 18	6	4	6	8	17	17	22	19	15	16	9	8	147
Gravelly Ford WD	0	0	0	0	240	1,119	1,857	0	0	213	0	0	3,429
Total	8	5	8	11	262	1,141	1,886	25	20	234	12	11	3,623

U.S. Department of Interior - Bureau of Reclamation
Central Valley Operations Office

2000
Monthly Deliveries in AF

Water User	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
MADERA CANAL													
Chowchilla WD	0	149	4,096	17,516	20,595	27,341	30,330	15,965	12,107	0	0	0	128099
Madera ID	0	0	2,773	15,628	22,594	24,636	21,362	19,980	128	11,988	296	0	119385
Soquel	0	0	0	0	0	0	0	0	11,491	0	0	0	11491
Total	0	149	6,869	33,144	43,189	51,977	51,692	35,945	23,726	11,988	296	0	258,975
MILLERTON LAKE													
County of Madera	2	1	2	3	5	6	8	7	5	5	2	0	46
Fresno County # 18	5	4	8	9	14	18	23	20	15	13	7	7	143
Gravelly Ford WD	0	0	460	1,278	1,421	1,611	161	0	64	212	0	0	5207
Total	7	5	470	1,290	1,440	1,635	192	27	84	230	9	7	5,396

U.S. Department of Interior - Bureau of Reclamation
Central Valley Operations Office

2001
Monthly Deliveries in AF

Water User	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
MADERA CANAL													
Chowchilla WD	0	0	0	8,394	3,511	18,401	17,502	15,945	NR	1,738	0	0	65,491
Madera ID	0	0	0	7,736	23,366	27,045	23,681	19,299	NR	2,132	0	0	103,259
Soquel	0	0	0	0	0	0	0	5,891	2,000	0	0	0	7,891
Total	0	0	0	16,130	26,877	45,446	41,183	41,135	2,000	3,870	0	0	176,641
MILLERTON LAKE													
County of Madera	2	1	2	3	6	7	7	7	NR	6	2	1	44
Fresno County # 18	5	4	6	10	7	22	19	17	NR	15	8	6	119
Gravelly Ford WD	0	0	0	0	0	0	933	1,413	NR	209	0	0	2,555
Total	7	5	8	13	13	29	959	1,437	0	230	10	7	2,718

Water Delivery Subtype Definitions:
Data From USBR

B1	Cost of Service Water. Also known as Class 1. This is the contracted amount o water which the water or irrigation districts receive.
MI B1	Municipal and Industrial Water. Also known as Class 1 M&I. Water which goes to entities such as The Cities of Fresno, Lindsay, and Orange Cove. Some districts can have M&I uses within their boundaries, though the amount used is usually small.
B2	With the exception of Fresno Irrigation District and Gravelly Ford Water District that are Class 2 water users only, this water is made available to those districts that have Class 2 provisions in their contracts, over and above their Class 1 allocation. For Class 2 water to be declared, there must first be a 100% Class 1 declaration.
C1	215 water.
CA	Special rate 215 water.
C2	Class 2 converted 215 water. Class 2 water which can be 'converted' to 215 water with the same advantages (can be used on full-cost lands) as regular 215.
C3	Flood or free water. Water entity not charged for taking this water. No restoratio or surcharge fees are paid
B8 B9 C6	Subtypes established for some water transfers as means of tracking. Same cos paid for water.
AG RS	Carryover water. Also referred to as rescheduled water. This is water not used from the previous water year that the entity is allowed to 'carryover' into the new water year. The fee charged for this water is the same rate as the previous year, though a carryover fee must be paid for each acre-foot delivered in the new water year.

Friant Division Deliveries - Data from USBR

Section 2

WY 1982-83

Friant-Kern Canal

Alpaugh	AG C3 - 2,200
AEWSD	AG C6 - 25,000
	AG B1 - 1,645
	AG B2 - 299,008
	AG C3 - 8,552
Atwell Is.	AG C3 - 494
BVWSD	AG C3 - 35,957
Cawelo	AG C3 - 9,334
Ci. of Fres.	MI B1 - 15,967
Ci. of O.C.	MI B1 - 574
Corcoran	AG C6 - 2,860
DEID	AG B1 - 84,234
	AG B2 - 74,500
Exeter	AG B1 - 8,630
	AG B2 - 19,000
Fresno I.D.	AG B1 - 23,000
	AG B2 - 75000
Garfield	AG B1 - 2,306
	AG C3 - 765
Hills Valley	C3 - 103
	C4 - 950
	C6 - 950
Intern'l	C6 - 200
	B1 - 1,057
	C3 - 324
Ivanhoe	B1 - 7,700
	B2 - 7,900
KDWCD	C6 - 27,150
Kern-Tulare	C3 - 2,466
KCWA	C3 - 20,807
KCWD	C6 - 3322
LIWD	C6 - 396
Lewis Crk.	B1 - 1,450
Lindmore	B1 - 28,988
	B2 - 21,753
LSID	B1 - 20,485
	C4 - 7,735
LTRID	C6 - 13,000
	B1 - 43,322
	B2 - 229,863
Mrphy Slgh	AG C6 - 1,144
OCID	B1 - 37,624
	C3 - 4,977
Pixley	C3 - 8,458
	C6 - 817
Pond Poso	C3 - 9,450
Porterville	B1 - 15,131
	B2 - 30,000
Rag Gulch	C3 - 3,059
	C6 - 2,500
RRBWSD	C3 - 4,732
Saucelito	B1 - 17,941
	B2 - 32,800
	C3 - 1,354
SWID	B1 - 45,955
	B2 - 39,040
SSJMUD	B1 - 90,306
	B2 - 49,563
SCID	B1 - 7,544
Tea Pot	B1 - 6,338
TBID	B1 - 26,355
Tri-Valley	C3 - 79
Tulare I.D.	B1 - 6,147
	B2 - 140,987
Kern NWR	C6 - 8,285

Madera Canal

Chowchilla	B1 - 55,000
	B2 - 159,435
	C3 - 27,992
Gravelly	B2 - 14,000
Madera I.D.	B1 - 83,740
	B2 - 183,705
	C3 - 16,381

Millerton Lake

Madera Co.	MI B1 - 51
FCWW#18	MI B1 - 86

Friant Division Deliveries - Data from USBR

Section 2

WY83-84

Friant-Kern Canal

AEWSD	B1 - 34,025
	B2 - 302,284
Ci. of Fres.	MI B1 - 39,000
Ci. of O.C.	MI B1 - 478
DEID	B1 - 101,420
	B2 - 74,500
Exeter	B1 - 11,351
	B2 - 19,000
Fresno I.D.	B1 - 9,067
	B2 - 75,000
Garfield	B1 - 2,679
Intern'l	B1 - 1,199
Ivanhoe	B1 - 7,700
	B2 - 7,900
Lewis Crk.	B1 - 1,378
Lindmore	B1 - 33,000
	B2 - 22,000
LSID	B1 - 30,000
	C4 - 8,714
LTRID	B1 - 32,228
	B2 - 238,000
OCID	B1 - 39,200
Pond Poso	C3 - 2,627
Porterville	B1 - 9,533
	B2 - 3,000
Saucelito	B1 - 21,200
	B2 - 32,800
SWID	B1 - 50,000
	B2 - 39,600
SSJMUD	B1 - 95,620
	B2 - 50,000
SCID	B1 - 10,033
Tea Pot	B1 - 2,766
TBID	B1 - 17,589
Tulare I.D.	B1 - 30,000
	B2 - 141,000

Madera Canal

Chowchilla	B1 - 52,919
	B2 - 160,000
	C3 - 56,291
Gravelly	B2 - 14,000
Madera I.D.	B1 - 84,777
	B2 - 185,691
	C2 - 107
	C3 - 117,165
	C7 - 309

Millerton Lake

Madera Co. M	MI B1 - 63
FCWW#18	MI B1 86

Friant Division Deliveries - Data from USBR

Section 2

WY84-85

Friant-Kern Canal

AEWSD	B1 - 40,611
	B2 - 152,985
Ci. of Fres.	MI B1 - 41,000
Ci. of O.C.	MI B1 - 632
DEID	B1 - 108,800
	B2 - 37,250
Exeter	B1 - 11,500
	B2 - 9,500
Fresno I.D.	B1 - 19,000
	B2 - 37,500
Garfield	B1 - 3,500
Intern'l	B1 - 1,200
Ivanhoe	B1 - 7,700
	B2 - 3,950
Lewis Crk.	B1 - 1,450
Lindmore	B1 - 33,000
	B2 - 11,000
LSID	B6 - 893
	B1 - 30,000
	C4 - 7,337
LTRID	B1 - 61,200
	B2 - 119,000
OCID	B1 - 39,200
Porterville	B1 - 16,109
	B2 - 15,000
Saucelito	B1 - 21,200
	B2 - 16,400
SWID	B1 - 50,012
	B2 - 19,800
SSJMUD	B1 - 97,000
	B2 - 25,000
SCID	B1 - 9,967
Tea Pot	B1 - 7,563
TBID	B1 - 29,039
Tulare I.D.	B1 - 30,000
	B2 - 70,500

Madera Canal

Chowchilla	B1 - 55,848
	B2 - 80,000
Gravelly	B2 - 7,000
Madera I.D.	B1 - 85,000
	B2 - 93,000

Millerton Lake

Madera Co. M	MI B1 - 38
FCWW#18	MI B1 - 85

Friant Division Deliveries - Data from USBR

Section 2

WY85-86

Friant-Kern Canal

AEWSD	B1 - 38,214
	B2 - 42,354
Ci. of Fres.	MI B1 - 43,000
Ci of Lind.	MI B1 - 1,953
Ci of O.C.	MI B1 - 643
DEID	AG A6 - 1,251
	B1 - 108,422
	B2 - 9,685
Exeter	B1 - 11,456
	B2 - 2,280
Fresno I.D.	B1 - 17,000
	B2 - 10,500
Garfield	B1 - 3,214
Intern'l	B1 - 1,192
Ivanhoe	B1 - 7,700
	B2 - 1,106
Lewis Crk.	B1 - 1,450
Lindmore	B1 - 33,000
	B2 - 4,620
LSID	B6 - 3,748
	B1 - 28,125
	C4 - 6,299
LTRID	B1 - 61,200
	B2 - 29,348
OCID	B1 - 39,200
Porterville	B1 - 15,891
	B2 - 3,313
Saucelito	B1 - 21,200
	B2 - 4,244
SWID	B1 - 49,988
	B2 - 5,544
SSJMUD	B1 - 94,634
	B2 - 7,000
SCID	B1 - 9,976
Tea Pot	B1 - 7,437
TBID	B1 - 28,961
Tulare I.D.	B1 - 29,323
	B2 - 10,354

Madera Canal

Chowchilla	B1 - 54,152
	B2 - 22,400
	C3 - 17,529
Gravelly	B2 - 1,680
Madera I.D.	B1 - 85,000
	B2 - 26,040
	C3 - 1,585

Millerton Lake

Madera Co. M	MI B1 - 30
FCWW#18	MI B1 - 56

Friant Division Deliveries - Data from USBR

Section 2

WY86-87

Friant-Kern Canal

AEWSD	C1 - 1,215
	B1 - 38,000
	B2 - 305,279
Ci. of Fres.	MI B1 - 45,000
Ci of Lind.	MI B1 - 2,422
Ci of O.C.	MI B1 - 455
DEID	C1 - 3,718
	B1 - 103,969
	B2 - 74,500
Exeter	B1 - 11,364
	B2 - 19,000
Fresno I.D.	B1 - 15,000
	B2 - 75,000
Garfield	B1 - 3,461
Intern'l	B1 - 1,200
Ivanhoe	B1 - 7,700
	B2 - 7,900
Lewis Crk.	B1 - 1,450
Lindmore	B1 - 32,299
	B2 - 22,000
LSID	B1 - 23,940
	C4 - 6,646
LTRID	B1 - 60,700
	B2 - 238,000

OCID	B1 - 38,778
Porterville	B1 - 15,975
	B2 - 30,000
Saucelito	C1 - 1,020
	B1 - 18,342
	B2 - 32,800
SWID	C1 - 527
	B1 - 49,864
	B2 - 39,600
SSJMUD	C1 - 685
	B1 - 94,684
	B2 - 50,000
SCID	B1 - 9,997
Tea Pot	B1 - 7,211
TBID	B1 - 29,000
Tulare I.D.	B1 - 30,000
	B2 - 141,000

Madera Canal

Chowchilla	B1 - 49,797
	B2 - 160,000
	C3 - 29,038
Gravelly	B2 - 14,000
Madera I.D.	B1 - 85,000
	B2 - 186,000
	C3 - 20,785
	C1 - 279

Millerton Lake

Madera Co. M	MI B1 - 33
FCWW#18	MI B1 - 60

Friant Division Deliveries - Data from USBR

Section 2

WY87-88

Friant-Kern Canal

AEWSD	B1 - 36,400
Ci. of Fres.	MI B1 = 42,770
Ci of Lind.	MI B1 = 2,275
Ci of O.C.	MI B1 = 648
DEID	B1 = 109037
Exeter	B1 = 10387
Fresno I.D.	B1 = 11830
Garfield	B1 - 3224
Intern'l	B1 - 1,092
Ivanhoe	B1 - 7,007
Lewis Crk.	B1 - 1,320
Lindmore	B1 - 25,738
LSID	B6 - 2,438
	B1 - 26,585
	C4 = 11,115
LTRID	B1 - 66,810
OCID	B1 - 36,094
Porterville	B1 - 14,585
Saucelito	B1 - 21,827
SWID	C4 - 1,009
	B1 - 45,069
SSJMUD	B1 - 87,219
SCID	B1 - 9,147
Tea Pot	B1 - 7,195
TBID	B1 - 26,791
Tulare I.D.	B1 - 27,300

Madera Canal

Chowchilla	B1 - 55,193
Gravelly Madera I.D.	B1 - 74,087

Millerton Lake

Madera Co. M	MI B1 - 38
FCWW#18	MI B1 - 119

Friant Division Deliveries - Data from USBR

Section 2

WY89-90

Friant-Kern Canal

AEWSD	B1 - 38340
Ci. of Fres.	MI B1 - 49980
Ci of Lind.	MI b1 - 2656
Ci of O.C.	MI B1 - 979
DEID	B1 - 105061
Exeter	B1 - 11562
Fresno I.D.	B1 - 8820
Garfield	B1 - 3234
Intern'l	B1 - 1,240
Ivanhoe	B1 - 7546
Lewis Crk.	B1 - 1,421
Lindmore	B1 - 33268
LSID	B6 - 525
	B1 - 27142
	C4 - 951
LTRID	B1 - 57729

OCID	B1 - 33453
Porterville	B1 - 15364
Saucelito	B1 - 20389
SWID	B1 - 48519
	MI D2 - 91
SSJMUD	B1 - 90109
SCID	B1 - 9763
Tea Pot	B1 - 7350
TBID	B1 - 28444
Tulare I.D.	B1 - 31086

Madera Canal

Chowchilla	B1 - 54002
Gravelly	
Madera I.D.	B1 - 83970

Millerton Lake

Madera Co. M	MI B1 - 40
FCWW#18	MI B1 - 126

Friant Division Deliveries - Data from USBR

Section 2

WY90-91

Friant-Kern Canal

AEWSD	B1 - 21862
	B2 - 3511
	B9 - 217
Ci. of Fres.	MI B1 - 37330
Ci of Lind.	MI B1 - 1211
Ci of O.C.	MI B1 - 948
DEID	B1 - 76632
Exeter	B1 - 2699
Fresno I.D.	B1 - 4930
Garfield	B1 - 2907
Intern'l	B1 - 846
Ivanhoe	B1 - 2093
Lewis Crk.	B1 - 1021
Lindmore	B1 - 3764
LSID	B6 - 1758
	B1 - 5628
LTRID	B1 - 45352
OCID	B1 - 26189
Porterville	B1 - 11230
Saucelito	B1 - 14474
SWID	B1 - 31263
	MI D2 - 66
SSJMUD	B1 - 68942
SCID	B1 - 7043
Tea Pot	B1 - 5283
TBID	B1 - 20086
Tulare I.D.	B1 - 14505
	B9 - 3400

Madera Canal

Chowchilla	B1 - 38739
Gravelly	
Madera I.D.	B1 - 60084

Millerton Lake

Madera Co. M	MI B1 - 74
FCWW#18	MI B1 - 106

Friant Division Deliveries - Data from USBR

Section 2

WY91-92

Friant-Kern Canal

AEWSD	B1 - 35906
Ci. of Fres.	MI B1 - 55000
Ci of Lind.	MI B1 - 2880
Ci of O.C.	MI B1 - 883
DEID	B1 - 4685
Exeter	B1 - 11506
Fresno I.D.	9B - 1500
	B1 - 3500
Garfield	B1 - 2610
Intern'l	B1 - 1198
Ivanhoe	B1 - 7700
Lewis Crk.	B1 - 1468
Lindmore	B1 - 31138
LSID	B1 - 22208
	B6 - 4002
LTRID	B1 - 61104
OCID	B1 - 32362
Porterville	9B - 2500
	B1 - 11866
Saucelito	B1 - 21491
SWID	B1 - 43528
	MI D2 - 396
SSJMUD	B1 - 82576
SCID	B1 - 9861
Tea Pot	9B - 752
	B1 - 5649
TBID	B1 - 26751
	MI B1 - 716
Tulare I.D.	B1 - 33232

Madera Canal

Chowchilla	B1 - 55044
Gravelly	
Madera I.D.	B1 - 85089

Millerton Lake

Madera Co. M	MI B1 - 178
FCWW#18	MI B1 - 97

Friant Division Deliveries - Data from USBR

Section 2

WY92-93

Friant-Kern Canal

AEWSD	B1 - 46020
	B1 - 3764
	B9 - 708
Ci. of Fres.	MI B1 - 47310
Ci of Lind.	MI B1 - 2355
Ci of O.C.	MI B1 - 1503
DEID	B1 - 90809
Exeter	B1 - 9545
Fresno I.D.	B1 - 2490
	B2 - 526
Garfield	B1 - 3795
Intern'l	B1 - 998
Ivanhoe	B1 - 6391
Lewis Crk.	B1 - 1186
Lindmore	B1 - 29242
LSID	B1 - 28570
LTRID	B1 - 50982
OCID	B1 - 33380
Porterville	B1 - 15070
Saucelito	B1 - 35562
SWID	B1 - 51854
SSJMUD	B1 - 99264
SCID	B1 - 8439
Tea Pot	B1 - 7324
TBID	B1 - 25943
Tulare I.D.	B1 - 24921

Madera Canal

Chowchilla	B1 - 45650
Gravelly	
Madera I.D.	B1 - 70549

Millerton Lake

Madera Co. M	MI B1 - 149
FCWW#18	MI B1 - 170

Friant Kern Canal **Section 2**

Class 1 (Absolute Delivery TAF)

Data Derived from USBR Delivery Database

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	4	20	87	176	85	59	29	9	12	16	497	100/100
1983-84	0	0	2	6	69	147	119	66	55	3	0	152	619	100/100
1984-85	5	27	60	123	171	76	45	43	27	1	0	83	661	100/50
1985-86	78	77	99	135	132	69	17	18	4	1	3	18	651	100/14
1986-87	0	4	11	28	124	132	128	71	33	24	16	69	640	100/100
1987-88	26	62	49	84	110	85	53	39	3	2	6	101	620	91/0
1988-89	44	22	48	101	133	71	38	27	9	0	0	13	506	78/0
1989-90	33	68	61	122	155	89	42	32	19	4	2	11	638	98/0
1990-91	50	28	34	52	88	92	46	31	15	0	0	8	444	68/0
1991-92	1	14	60	122	175	107	58	57	17	1	0	7	619	100/0
1992-93	21	40	66	144	100	97	42	28	9	0	0	53	600	83/0
1993-94	0	1	13	58	173	165	79	48	21	6	12	16	592	100/90
1994-95	25	34	35	129	147	97	47	19	5	1	4	38	581	80/0
1995-96	0	1	2	9	51	75	85	61	36	15	2	34	371	100/100
1996-97	0	3	16	106	227	133	67	55	7	1	0	0	615	100/58
1997-98	2	6	34	108	178	125	67	46	22	10	6	8	612	100/60
1998-99	0	0	0	2	38	122	119	88	16	3			388	100/10
1999-00														100/20
2000-01														100/17

Class 1 (Montly Distribution % of Annual)

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	75 Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	1	4	18	35	17	12	6	2	2	3	100	100/100
1983-84	0	0	0	1	11	24	19	11	9	0	0	25	100	100/100
1984-85	1	4	9	19	26	11	7	7	4	0	0	13	100	100/50
1985-86	12	12	15	21	20	11	3	3	1	0	0	3	100	100/14
1986-87	0	1	2	4	19	21	20	11	5	4	3	11	100	100/100
1987-88	4	10	8	14	18	14	9	6	0	0	1	16	100	91/0
1988-89	9	4	9	20	26	14	8	5	2	0	0	3	100	78/0
1989-90	5	11	10	19	24	14	7	5	3	1	0	2	100	98/0
1990-91	11	6	8	12	20	21	10	7	3	0	0	2	100	68/0
1991-92	0	2	10	20	28	17	9	9	3	0	0	1	100	100/0
1992-93	4	7	11	24	17	16	7	5	2	0	0	9	100	83/0
1993-94	0	0	2	10	29	28	13	8	4	1	2	3	100	100/90
1994-95	4	6	6	22	25	17	8	3	1	0	1	7	100	80/0
1995-96	0	0	1	2	14	20	23	16	10	4	1	9	100	100/100
1996-97	0	0	3	17	37	22	11	9	1	0	0	0	100	100/58
1997-98	0	1	6	18	29	20	11	8	4	2	1	1	100	100/60
1998-99														100/10
1999-00														100/20
Avg	5	6	9	20	26	15	8	6	2	0	0	3	100	
Avg	0	0	2	7	24	24	17	10	4	2	2	7	100	

Class 2 (Absolute Delivery TAF)

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	111	71	118	230	174	75	14	1	0	0	0	0	794	100/100
1983-84	3	50	108	156	154	21	0	0	0	0	0	0	492	100/100
1984-85	98	48	57	83	52	82	52	31	1	2	0	13	519	100/50
1985-86	0	0	0	6	3	15	35	31	2	0	3	36	131	100/14
1986-87	42	108	181	215	118	69	33	3	0	0	0	0	769	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	1	1	0	0	2	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	1	2	0	0	3	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	2	2	0	2	6	83/0
1993-94	171	141	218	198	100	71	17	18	0	0	0	0	934	100/90
1994-95	1	1	1	2	2	1	1	1	0	0	0	24	34	80/0
1995-96	50	67	47	90	150	168	58	36	26	13	20	12	737	100/100
1996-97	54	123	153	130	26	51	21	0	0	0	0	0	558	100/58
1997-98	95	146	103	112	52	29	20	26	2	2	0	0	587	100/60
1998-99	0	0	0	4	20	71	2	1	1	0			99	100/10
1999-00														100/20
														100/17

Class 2 (Montly Distribution % of Annual)

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	14	9	15	29	22	9	2	0	0	0	0	0	100	100/100
1983-84	1	10	22	32	31	4	0	0	0	0	0	0	100	100/100
1984-85	19	9	11	16	10	16	10	6	0	0	0	3	100	100/50
1985-86	0	0	0	5	2	11	27	24	2	0	2	27	100	100/14
1986-87	5	14	24	28	15	9	4	0	0	0	0	0	100	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	50	50	0	0	100	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	33	67	0	0	100	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	33	33	0	33	100	83/0
1993-94	18	15	23	21	11	8	2	2	0	0	0	0	100	100/90
1994-95	3	3	3	6	6	3	3	3	0	0	0	71	100	80/0
1995-96	7	9	6	12	20	23	8	5	4	2	3	2	100	100/100
1996-97	10	22	27	23	5	9	4	0	0	0	0	0	100	100/58
1997-98	16	25	18	19	9	5	3	4	0	0	0	0	100	100/60
1998-99														100/10
1999-00														100/20
														100/17

Friant-Kern Canal Other (Absolute Delivery TAF)

Section 2

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	24	89	0	0	0	0	0	0	0	0	0	113	100/100
1983-84	0	0	0	0	3	0	0	0	0	0	0	0	3	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	9	4	2	2	0	0	0	0	0	0	0	0	17	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	80	25	8	9	0	0	0	0	0	0	0	122	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	22	22	80/0
1995-96	20	8	77	141	32	1	0	0	0	0	0	0	279	100/100
1996-97	19	44	49	20	0	0	0	0	0	0	13	18	163	100/58
1997-98	5	0	0	0	0	0	0	0	0	0	0	13	18	100/60
1998-99	29	33	61	114	159	0	0	0	0	45			441	100/10
1999-00														100/20
														100/17

Total (Absolute Delivery TAF)

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	111	95	211	250	261	251	99	60	29	9	12	16	1404	100/100
1983-84	3	50	110	162	226	168	119	66	55	3	0	152	1114	100/100
1984-85	103	75	117	206	223	158	97	74	28	3	0	96	1180	100/50
1985-86	78	77	99	141	135	84	52	49	6	1	6	54	782	100/14
1986-87	51	116	194	245	242	201	161	74	33	24	16	69	1426	100/100
1987-88	26	62	49	84	110	85	53	39	3	2	6	101	620	91/0
1988-89	44	22	48	101	133	71	38	27	10	1	0	13	508	78/0
1989-90	33	68	61	122	155	89	42	32	19	4	2	11	638	98/0
1990-91	50	28	34	52	88	92	46	31	16	2	0	8	447	68/0
1991-92	1	14	60	122	175	107	58	57	17	1	0	7	619	100/0
1992-93	21	40	66	144	100	97	42	28	11	2	0	55	606	83/0
1993-94	171	222	256	264	282	236	96	66	21	6	12	16	1648	100/90
1994-95	26	35	36	131	149	98	48	20	5	1	4	84	637	80/0
1995-96	70	76	126	240	233	244	143	97	62	28	22	46	1387	100/100
1996-97	73	170	218	256	253	184	88	55	7	1	13	18	1336	100/58
1997-98	102	152	137	220	230	154	87	72	24	12	6	21	1217	100/60
1998-99	29	33	61	120	217	193	121	89	17	48				100/10
1999-00														100/20
														100/17

Total (Percentage of Annual Total)

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	8	7	15	18	19	18	7	4	2	1	1	1	100	100/100
1983-84	0	4	10	15	20	15	11	6	5	0	0	14	100	100/100
1984-85	9	6	10	17	19	13	8	6	2	0	0	8	100	100/50
1985-86	10	10	13	18	17	11	7	6	1	0	1	7	100	100/14
1986-87	4	8	14	17	17	14	11	5	2	2	1	5	100	100/100
1987-88	4	10	8	14	18	14	9	6	0	0	1	16	100	91/0
1988-89	9	4	9	20	26	14	7	5	2	0	0	3	100	78/0
1989-90	5	11	10	19	24	14	7	5	3	1	0	2	100	98/0
1990-91	11	6	8	12	20	21	10	7	4	0	0	2	100	68/0
1991-92	0	2	10	20	28	17	9	9	3	0	0	1	100	100/0
1992-93	3	7	11	24	17	16	7	5	2	0	0	9	100	83/0
1993-94	10	13	16	16	17	14	6	4	1	0	1	1	100	100/90
1994-95	4	5	6	21	23	15	8	3	1	0	1	13	100	80/0
1995-96	5	5	9	17	17	18	10	7	4	2	2	3	100	100/100
1996-97	5	13	16	19	19	14	7	4	1	0	1	1	100	100/58
1997-98	8	12	11	18	19	13	7	6	2	1	0	2	100	100/60
1998-99														100/10
1999-00														100/20
Avg	7	11	15	17	17	14	9	5	2	1	1	3	100	

Madera Canal **Section 2**

Class 1 (Absolute Delivery TAF)

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	48	39	28	2	0	0	11	128	100/100
1983-84	0	0	0	0	4	44	30	15	0	0	0	6	99	100/100
1984-85	0	0	10	32	43	29	13	0	0	0	0	13	140	100/50
1985-86	41	2	3	25	35	28	6	0	0	0	0	0	140	100/14
1986-87	0	0	0	0	14	50	39	23	9	0	0	1	136	100/100
1987-88	9	0	0	37	51	29	3	0	0	0	0	0	129	91/0
1988-89	0	0	4	41	54	13	0	0	0	0	0	0	112	78/0
1989-90	0	0	17	43	55	22	1	0	0	0	0	0	138	98/0
1990-91	0	0	0	18	49	32	2	0	0	0	0	0	101	68/0
1991-92	0	0	15	27	57	36	6	0	0	0	0	0	141	100/0
1992-93	0	0	20	49	41	9	0	0	0	0	0	0	119	83/0
1993-94	0	0	0	0	0	12	45	34	5	0	0	0	96	100/90
1994-95	0	0	11	34	42	38	10	0	0	0	0	0	135	80/0
1995-96	0	0	0	0	0	0	10	23	5	0	0	1	39	100/100
1996-97	0	0	0	10	53	35	15	8	0	0	0	0	121	100/58
1997-98	0	0	0	1	47	36	32	18	0	0	0	0	134	100/60
1998-99	0	0	0	0	25	33	27	2	3	0			90	100/10
1999-00														100/20
2000-01														100/17

Class 1 (Montly Distribution % of Annual)

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	68 Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	38	30	22	2	0	0	9	100	100/100
1983-84	0	0	0	0	4	44	30	15	0	0	0	6	100	100/100
1984-85	0	0	7	23	31	21	9	0	0	0	0	9	100	100/50
1985-86	29	1	2	18	25	20	4	0	0	0	0	0	100	100/14
1986-87	0	0	0	0	10	37	29	17	7	0	0	1	100	100/100
1987-88	7	0	0	29	40	22	2	0	0	0	0	0	100	91/0
1988-89	0	0	4	37	48	12	0	0	0	0	0	0	100	78/0
1989-90	0	0	12	31	40	16	1	0	0	0	0	0	100	98/0
1990-91	0	0	0	18	49	32	2	0	0	0	0	0	100	68/0
1991-92	0	0	11	19	40	26	4	0	0	0	0	0	100	100/0
1992-93	0	0	17	41	34	8	0	0	0	0	0	0	100	83/0
1993-94	0	0	0	0	0	13	47	35	5	0	0	0	100	100/90
1994-95	0	0	8	25	31	28	7	0	0	0	0	0	100	80/0
1995-96	0	0	0	0	0	0	26	59	13	0	0	3	100	100/100
1996-97	0	0	0	8	44	29	12	7	0	0	0	0	100	100/58
1997-98	0	0	0	1	35	27	24	13	0	0	0	0	100	100/60
1998-99														100/10
1999-00														100/20
Avg	0	0	9	28	40	20	3	0	0	0	0	0	100	100/17
Avg	0	0	0	0	5	25	38	26	6	0	0	0	100	

Class 2 (Absolute Delivery TAF)

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	24	23	70	71	71	15	0	0	0	0	0	0	274	100/100
1983-84	16	30	52	66	67	7	0	0	0	0	0	0	238	100/100
1984-85	43	34	23	0	17	21	22	6	0	0	0	1	167	100/50
1985-86	0	0	0	0	0	11	16	4	0	0	0	12	43	100/14
1986-87	28	49	74	72	62	10	0	1	0	0	0	0	296	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	29	49	63	62	74	47	0	0	0	0	0	0	324	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	12	17	21	31	40	61	28	5	0	0	0	0	215	100/100
1996-97	13	42	54	46	0	9	12	0	0	0	0	0	176	100/58
1997-98	38	42	49	58	11	0	0	0	0	0	0	0	198	100/60
1998-99	0	0	0	0	33	0	0	1	0	0			34	100/10
1999-00														100/20
														100/17

Class 2 (Montly Distribution % of Annual)

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	100 Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	9	8	26	26	26	5	0	0	0	0	0	0	100	100/100
1983-84	7	13	22	28	28	3	0	0	0	0	0	0	100	100/100
1984-85	26	20	14	0	10	13	13	4	0	0	0	1	100	100/50
1985-86	0	0	0	0	0	26	37	9	0	0	0	28	100	100/14
1986-87	9	17	25	24	21	3	0	0	0	0	0	0	100	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	9	15	19	19	23	15	0	0	0	0	0	0	100	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	6	8	10	14	19	28	13	2	0	0	0	0	100	100/100
1996-97	7	24	31	26	0	5	7	0	0	0	0	0	100	100/58
1997-98	19	21	25	29	6	0	0	0	0	0	0	0	100	100/60
1998-99														100/10
1999-00														100/20
														100/17

Madera Canal Other (Absolute Delivery TAF)

Section 2

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	29	2	0	0	0	0	0	0	0	0	13	44	100/100
1983-84	42	38	18	4	2	8	38	23	0	0	0	0	173	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	19	19	100/14
1986-87	30	20	1	1	0	0	0	0	0	0	0	0	52	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	1	1	2	2	0	0	0	0	0	0	0	6	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	28	33	41	31	33	3	0	0	0	0	0	0	169	100/100
1996-97	30	0	9	1	0	0	0	0	0	0	34	17	91	100/58
1997-98	12	0	0	0	0	0	0	0	0	0	0	0	12	100/60
1998-99	32	49	57	59	8	0	0	0	4	13			222	100/10
1999-00														100/20
														100/17

Total (Absolute Delivery TAF)

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	24	52	72	71	71	63	39	28	2	0	0	24	446	100/100
1983-84	58	68	70	70	73	59	68	38	0	0	0	6	510	100/100
1984-85	43	34	33	32	60	50	35	6	0	0	0	14	307	100/50
1985-86	41	2	3	25	35	39	22	4	0	0	0	31	202	100/14
1986-87	58	69	75	73	76	60	39	24	9	0	0	1	484	100/100
1987-88	9	0	0	37	51	29	3	0	0	0	0	0	129	91/0
1988-89	0	0	4	41	54	13	0	0	0	0	0	0	112	78/0
1989-90	0	0	17	43	55	22	1	0	0	0	0	0	138	98/0
1990-91	0	0	0	18	49	32	2	0	0	0	0	0	101	68/0
1991-92	0	0	15	27	57	36	6	0	0	0	0	0	141	100/0
1992-93	0	0	20	49	41	9	0	0	0	0	0	0	119	83/0
1993-94	29	50	64	64	76	59	45	34	5	0	0	0	426	100/90
1994-95	0	0	11	34	42	38	10	0	0	0	0	0	135	80/0
1995-96	40	50	62	62	73	64	38	28	5	0	0	1	423	100/100
1996-97	43	42	63	57	53	44	27	8	0	0	34	17	388	100/58
1997-98	50	42	49	59	58	36	32	18	0	0	0	0	344	100/60
1998-99														100/10
1999-00														100/20
														100/17

Total (Percentage of Annual Total)

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	5	12	16	16	16	14	9	6	0	0	0	5	100	100/100
1983-84	11	13	14	14	14	12	13	7	0	0	0	1	100	100/100
1984-85	14	11	11	10	20	16	11	2	0	0	0	5	100	100/50
1985-86	20	1	1	12	17	19	11	2	0	0	0	15	100	100/14
1986-87	12	14	15	15	16	12	8	5	2	0	0	0	100	100/100
1987-88	7	0	0	29	40	22	2	0	0	0	0	0	100	91/0
1988-89	0	0	4	37	48	12	0	0	0	0	0	0	100	78/0
1989-90	0	0	12	31	40	16	1	0	0	0	0	0	100	98/0
1990-91	0	0	0	18	49	32	2	0	0	0	0	0	100	68/0
1991-92	0	0	11	19	40	26	4	0	0	0	0	0	100	100/0
1992-93	0	0	17	41	34	8	0	0	0	0	0	0	100	83/0
1993-94	7	12	15	15	18	14	11	8	1	0	0	0	100	100/90
1994-95	0	0	8	25	31	28	7	0	0	0	0	0	100	80/0
1995-96	9	12	15	15	17	15	9	7	1	0	0	0	100	100/100
1996-97	11	11	16	15	14	11	7	2	0	0	9	4	100	100/58
1997-98	15	12	14	17	17	10	9	5	0	0	0	0	100	100/60
1998-99														100/10
1999-00														100/20
Avg	9	13	15	15	17	13	9	6	2	0	0	0	100	100/17

Friant Kern Canal Class 1 Category
1B1

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	4	20	87	176	75	52	29	9	12	16	480	100/100
1983-84	0	0	2	6	69	147	102	66	54	3	0	130	579	100/100
1984-85	5	27	59	123	150	73	39	33	27	1	0	83	620	100/50
1985-86	70	72	88	114	131	69	17	18	4	0	3	18	604	100/14
1986-87	0	3	11	28	124	132	96	57	33	23	16	69	592	100/100
1987-88	26	45	49	74	106	78	49	36	3	2	6	101	575	91/0
1988-89	44	21	38	73	131	70	38	26	9	0	0	12	462	78/0
1989-90	25	40	59	122	141	88	42	32	19	4	2	10	584	98/0
1990-91	30	28	30	52	87	80	44	31	14	0	0	8	404	68/0
1991-92	1	14	60	108	134	105	57	56	16	1	0	7	559	100/0
1992-93	4	13	45	108	95	96	41	27	8	0	0	45	482	83/0
1993-94	0	1	12	48	126	130	73	43	19	6	11	10	479	100/90
1994-95	11	19	20	71	110	87	43	16	5	1	3	37	423	80/0
1995-96	0	0	2	8	51	74	73	56	34	15	1	34	348	100/100
1996-97	0	3	15	87	189	120	61	51	6	1	0	0	533	100/58
1997-98	2	6	32	90	137	111	62	44	21	10	6	8	529	100/60
1998-99	0	0	0	1	36	119	92	54	16	3				100/10
1999-00														100/20
														100/17

Friant Kern Canal Class 1 Category
1RS

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	9	27	21	6	5	0	0	0	0	0	0	0	68	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	8	11	9	26	15	2	0	0	0	0	0	0	71	80/0
1995-96	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	0	0	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20
														100/17

Friant Kern Canal Class 1 Category
1Z1

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	8	9	6	4	2	0	0	0	4	33	100/90
1994-95	3	2	3	6	5	4	2	1	0	0	0	1	27	80/0
1995-96	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	0	0	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20
														100/17

Friant Kern Canal Class 1 Category
1Z2

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	2	4	2	2	1	0	1	1	13	100/90
1994-95	2	2	1	2	3	2	1	0	0	0	0	0	13	80/0
1995-96	0	0	0	0	0	0	1	1	1	0	0	0	3	100/100
1996-97	0	0	0	1	5	2	2	2	0	0	0	0	12	100/58
1997-98	0	0	1	4	4	3	2	1	0	0	0	0	15	100/60
1998-99	0	0	0	0	1	1	1	0	0	0				100/10
1999-00														100/20

Friant Kern Canal Class 1 Category
1Z3

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	1	0	0	0	0	0	0	1	100/90
1994-95	0	0	0	1	1	1	0	0	0	0	0	0	3	80/0
1995-96	0	0	0	0	0	0	0	1	0	0	0	0	1	100/100
1996-97	0	0	0	1	1	1	1	1	0	0	0	0	5	100/58
1997-98	0	0	1	1	1	1	1	0	0	0	0	0	5	100/60
1998-99	0	0	0	0	1	1	0	0	0	0				100/10
1999-00														100/20
														100/17

Friant Kern Canal Class 1 Category
3B1

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	10	6	0	0	0	0	16	100/100
1983-84	0	0	0	0	0	0	16	0	1	0	0	22	39	100/100
1984-85	0	0	0	0	21	4	6	10	0	0	0	0	41	100/50
1985-86	8	4	11	20	1	0	0	0	0	0	0	1	45	100/14
1986-87	0	0	0	0	0	0	31	13	0	1	0	1	46	100/100
1987-88	0	17	0	10	3	6	4	3	0	0	0	1	44	91/0
1988-89	0	0	10	28	2	0	0	0	0	0	0	0	40	78/0
1989-90	8	27	2	0	14	0	0	0	0	0	0	1	52	98/0
1990-91	20	0	5	0	0	12	2	0	0	0	0	0	39	68/0
1991-92	0	0	0	14	41	1	1	0	1	0	0	0	58	100/0
1992-93	8	0	0	30	0	1	2	1	1	0	0	7	50	83/0
1993-94	0	0	0	0	35	24	1	0	0	0	0	0	60	100/90
1994-95	0	0	0	24	14	1	1	0	0	0	1	0	41	80/0
1995-96	0	0	1	0	1	1	11	3	1	0	0	0	18	100/100
1996-97	0	0	0	17	32	11	3	0	0	0	0	0	63	100/58
1997-98	0	0	0	13	36	10	2	0	1	0	0	0	62	100/60
1998-99	0	0	0	0	0	1	26	34	0	0				100/10
1999-00														100/20
														100/17

Friant Kern Canal Class 2 Category
1B2

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	111	71	118	230	174	75	14	1	0	0	0	0	794	100/100
1983-84	3	50	108	156	154	21	0	0	0	0	0	0	492	100/100
1984-85	98	48	57	83	52	82	52	31	1	2	0	13	519	100/50
1985-86	0	0	0	6	3	15	35	31	2	0	3	36	131	100/14
1986-87	42	108	181	215	118	69	33	3	0	0	0	0	769	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	1	1	0	0	2	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	1	2	0	0	3	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	2	2	0	2	6	83/0
1993-94	164	132	200	183	90	70	17	18	0	0	0	0	874	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	10	10	80/0
1995-96	39	43	25	55	115	140	55	35	25	12	19	11	574	100/100
1996-97	35	79	108	116	26	47	20	0	0	0	0	0	431	100/58
1997-98	69	131	98	110	52	29	20	25	1	2	0	0	537	100/60
1998-99	0	0	0	4	19	71	2	0	0	0				100/10
1999-00														100/20
														100/17

Friant Kern Canal Class 2 Category
1C2

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	2	4	9	14	4	0	0	0	0	0	0	0	33	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	14	14	80/0
1995-96	10	23	22	36	33	27	0	0	0	0	0	0	151	100/100
1996-97	19	44	45	12	0	0	0	0	0	0	0	0	120	100/58
1997-98	25	9	0	0	0	0	0	0	0	0	0	0	34	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20

Friant Kern Canal Class 2 Category
1Z4

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	5	5	8	0	0	0	0	0	0	0	0	0	18	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	0	0	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20
														100/17

Friant Kern Canal Class 2 Category
1Z5

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	6	1	0	0	0	0	0	0	7	100/90
1994-95	1	0	1	2	2	1	1	1	0	0	0	0	9	80/0
1995-96	0	0	0	0	1	1	2	1	0	0	0	1	6	100/100
1996-97	0	0	0	2	0	3	1	0	0	0	0	0	6	100/58
1997-98	0	4	5	1	0	0	0	0	0	0	0	0	10	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20
														100/17

Friant Kern Canal Class 2 Category
1Z6

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	0	0	0	1	0	0	0	0	0	0	0	1	100/100
1996-97	0	0	0	0	0	1	0	0	0	0	0	0	1	100/58
1997-98	0	1	1	0	0	0	0	0	0	0	0	0	2	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20
														100/17

Friant Kern Canal Other Category
1C1

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	7	4	2	2	0	0	0	0	0	0	0	0	15	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	22	22	80/0
1995-96	0	8	0	0	0	1	0	0	0	0	0	0	9	100/100
1996-97	19	44	26	20	0	0	0	0	0	0	0	0	109	100/58
1997-98	2	0	0	0	0	0	0	0	0	0	0	0	2	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20

Friant Kern Canal Other Category
1C3

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	24	89	0	0	0	0	0	0	0	0	0	113	100/100
1983-84	0	0	0	0	3	0	0	0	0	0	0	0	3	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	2	0	0	0	0	0	0	0	0	0	0	0	2	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	80	25	8	9	0	0	0	0	0	0	0	122	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	20	0	0	0	0	0	0	0	0	0	0	0	20	100/100
1996-97	0	0	23	0	0	0	0	0	0	0	13	18	54	100/58
1997-98	3	0	0	0	0	0	0	0	0	0	0	0	3	100/60
1998-99	20	33	61	89	0	0	0	0	0	0				100/10
1999-00														100/20
														100/17

Friant Kern Canal Other Category
1CA

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	0	77	141	32	0	0	0	0	0	0	0	250	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	13	13	100/60
1998-99	9	0	0	25	159	0	0	0	0	45				100/10
1999-00														100/20
														100/17

Friant Kern Canal Other Category
1CO

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	0	0	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20
														100/17

Friant Kern Canal Other Category
3C1

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	0	0	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20

Friant Kern Canal Other Category
1C3

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	24	89	0	0	0	0	0	0	0	0	0	113	100/100
1983-84	0	0	0	0	3	0	0	0	0	0	0	0	3	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	2	0	0	0	0	0	0	0	0	0	0	0	2	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	80	25	8	9	0	0	0	0	0	0	0	122	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	20	0	0	0	0	0	0	0	0	0	0	0	20	100/100
1996-97	0	0	23	0	0	0	0	0	0	0	13	18	54	100/58
1997-98	3	0	0	0	0	0	0	0	0	0	0	0	3	100/60
1998-99	20	33	61	89	0	0	0	0	0	0				100/10
1999-00														100/20
														100/17

Friant Kern Canal Other Category
1CA

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	0	77	141	32	0	0	0	0	0	0	0	250	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	13	13	100/60
1998-99	9	0	0	25	159	0	0	0	0	45				100/10
1999-00														100/20
														100/17

Friant Kern Canal Other Category
1CO

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	0	0	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20
														100/17

Friant Kern Canal Other Category
3C1

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	0	0	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20

Friant Kern Canal Other Category **Section 2**

3C2

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	0	0	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20
														100/17

Madera Canal Class 1 Category
1B1

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	48	39	28	2	0	0	11	128	100/100
1983-84	0	0	0	0	4	44	30	15	0	0	0	6	99	100/100
1984-85	0	0	10	32	43	29	13	0	0	0	0	13	140	100/50
1985-86	41	2	3	25	35	28	6	0	0	0	0	0	140	100/14
1986-87	0	0	0	0	14	50	39	23	9	0	0	1	136	100/100
1987-88	9	0	0	37	51	29	3	0	0	0	0	0	129	91/0
1988-89	0	0	4	41	54	13	0	0	0	0	0	0	112	78/0
1989-90	0	0	16	43	55	22	1	0	0	0	0	0	137	98/0
1990-91	0	0	0	18	49	32	2	0	0	0	0	0	101	68/0
1991-92	0	0	15	27	57	36	6	0	0	0	0	0	141	100/0
1992-93	0	0	20	49	41	9	0	0	0	0	0	0	119	83/0
1993-94	0	0	0	0	0	12	44	34	5	0	0	0	95	100/90
1994-95	0	0	0	22	42	37	10	0	0	0	0	0	111	80/0
1995-96	0	0	0	0	0	0	10	23	5	0	0	1	39	100/100
1996-97	0	0	0	10	52	35	15	8	0	0	0	0	120	100/58
1997-98	0	0	0	1	47	35	32	18	0	0	0	0	133	100/60
1998-99	0	0	0	0	25	32	27	2	3	0				100/10
1999-00														100/20
														100/17

Madera Canal Class 1 Category
1RS

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	11	13	0	0	0	0	0	0	0	0	24	80/0
1995-96	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	0	0	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20
														100/17

Madera Canal Class 1 Category
1Z1

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	0	0	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20
														100/17

Madera Canal Class 1 Category
1Z2

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1996-97	0	0	0	0	1	0	0	0	0	0	0	0	1	100/58
1997-98	0	0	0	0	0	1	0	0	0	0	0	0	1	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20

Madera Canal Class 1 Category
1Z3

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	0	0	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20
														100/17

Madera Canal Class 1 Category
3B1

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	0	0	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20
														100/17

Madera Canal Class 2 Category
1B2

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	24	23	70	71	71	15	0	0	0	0	0	0	274	100/100
1983-84	16	30	52	66	67	7	0	0	0	0	0	0	238	100/100
1984-85	43	34	23	0	17	21	22	6	0	0	0	1	167	100/50
1985-86	0	0	0	0	0	11	16	4	0	0	0	12	43	100/14
1986-87	28	49	74	72	62	10	0	1	0	0	0	0	296	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	29	48	63	61	74	46	0	0	0	0	0	0	321	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	12	17	21	30	40	56	28	5	0	0	0	0	209	100/100
1996-97	13	41	53	45	0	9	12	0	0	0	0	0	173	100/58
1997-98	38	42	49	57	11	0	0	0	0	0	0	0	197	100/60
1998-99	0	0	0	0	33	0	0	1	0	0				100/10
1999-00														100/20
														100/17

Madera Canal Class 2 Category
1C2

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	1	1	1	0	0	0	0	0	0	0	3	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	0	0	0	0	5	0	0	0	0	0	0	5	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	0	0	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20

Madera Canal Class 2 Category
1Z4

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	0	0	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20
														100/17

Madera Canal Class 2 Category
1Z5

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	0	0	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20
														100/17

Madera Canal Class 2 Category
1Z6

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	0	0	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20
														100/17

Madera Canal Other Category
1C1

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	1	1	0	0	0	0	0	0	0	0	2	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	1	0	0	0	3	0	0	0	0	0	0	4	100/100
1996-97	0	0	0	1	0	0	0	0	0	0	0	0	1	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	0	0	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20

Madera Canal Other Category
1C3

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	29	2	0	0	0	0	0	0	0	0	13	44	100/100
1983-84	42	38	18	4	2	8	38	23	0	0	0	0	173	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	19	19	100/14
1986-87	30	20	0	0	0	0	0	0	0	0	0	0	50	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	1	1	2	2	0	0	0	0	0	0	0	6	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	28	32	35	28	7	0	0	0	0	0	0	0	130	100/100
1996-97	30	0	9	0	0	0	0	0	0	0	34	17	90	100/58
1997-98	12	0	0	0	0	0	0	0	0	0	0	0	12	100/60
1998-99	31	46	44	47	7	0	0	0	4	13				100/10
1999-00														100/20
														100/17

Madera Canal Other Category
1CA

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	0	6	2	25	0	0	0	0	0	0	0	33	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	0	0	100/60
1998-99	0	3	13	12	1	0	0	0	0	0				100/10
1999-00														100/20
														100/17

Madera Canal Other Category
1CO

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	0	0	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20
														100/17

Madera Canal Other Category
3C1

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	0	0	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20

Madera Canal Other Category **Section 2**

3C2

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1983-84	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	0	0	0	0	0	0	0	0	0	0	0	0	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	0	0	0	0	0	0	0	0	0	0	0	0	0	100/100
1996-97	0	0	0	0	0	0	0	0	0	0	0	0	0	100/58
1997-98	0	0	0	0	0	0	0	0	0	0	0	0	0	100/60
1998-99	0	0	0	0	0	0	0	0	0	0				100/10
1999-00														100/20
														100/17

Appendix A

Section 3
Tulare Lake Basin Tributaries

Kings River - Full Natural Runoff
Kings River - James Bypass / Kings River Empire Weir No. 2
Kings River Pumping into Friant-Kern Canal
Simulated Flow from James Bypass to San Joaquin River
Simulated Kings River Flood Release to Tulare Lake
Kaweah River - Full Natural Runoff
Kaweah - Tulare Lakebed Flooding Assumption
Tule River - Full Natural Runoff
Tule - Tulare Lakebed Flooding Assumption

Files

See Section 1 for “Tulare Lake Basin Tributraries.123"

KINGS R-PINE FLAT DAM (CDEC-KGF)

Section 3

FULL NATURAL RUNOFF - Acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	% Avg
1909	24,830	18,600	19,760	174,960	152,260	116,530	277,510	602,870	849,010	375,680	89,780	38,200	2,739,990	165
1910	24,630	40,140	103,730	151,080	68,410	152,870	339,650	461,960	227,940	95,290	31,400	20,500	1,717,600	103
1911	20,450	17,900	25,040	138,280	126,750	240,260	302,370	514,550	748,320	477,560	98,380	38,400	2,748,260	165
1912	28,720	23,570	21,180	24,000	22,000	41,400	73,200	268,450	339,590	80,600	30,600	13,400	966,710	58
1913	13,770	14,000	10,300	14,300	21,100	38,900	114,990	293,260	204,000	104,980	68,190	42,200	939,990	57
1914	14,360	20,250	22,870	226,150	97,830	163,250	248,830	579,060	593,800	355,700	111,970	40,500	2,474,570	149
1915	32,710	20,450	15,400	24,000	78,360	93,680	217,280	387,530	623,710	232,840	45,890	22,800	1,794,650	108
1916	12,870	12,500	22,400	214,210	149,710	247,190	433,340	660,430	724,400	330,730	94,680	36,000	2,938,460	177
1917	68,690	37,600	40,400	41,020	108,040	87,280	223,970	398,450	582,840	195,880	59,790	17,800	1,861,760	112
1918	12,870	12,600	13,200	13,000	21,800	108,740	190,510	327,990	498,100	92,800	26,300	31,100	1,349,010	81
1919	85,840	31,950	34,180	24,700	45,530	74,560	200,070	457,990	151,000	54,400	18,400	11,200	1,189,820	72
1920	14,070	11,700	25,700	20,200	24,400	97,490	160,880	482,800	391,430	112,970	34,100	16,000	1,391,740	84
1921	25,630	31,460	35,120	47,420	58,030	122,580	180,000	388,530	443,270	128,950	29,500	16,100	1,506,590	91
1922	13,970	12,100	53,880	63,110	81,680	92,130	159,920	660,430	706,450	225,840	71,290	26,400	2,167,200	130
1923	14,260	23,280	64,710	52,280	51,910	77,760	202,940	499,670	304,700	173,900	41,700	27,500	1,534,610	92
1924	22,340	15,500	11,800	13,800	16,700	20,800	86,900	149,000	31,100	13,000	6,460	4,520	391,920	24
1925	7,680	20,740	28,060	27,700	57,520	81,480	187,640	395,470	292,730	118,970	44,290	12,900	1,275,180	77
1926	17,750	14,200	17,780	12,000	38,900	65,470	288,980	375,630	137,000	37,000	12,900	6,840	1,024,450	62
1927	7,610	59,040	42,940	38,200	140,350	119,990	233,530	529,440	510,060	194,880	46,490	18,800	1,941,330	117
1928	16,460	63,720	29,280	29,100	32,300	94,890	157,050	323,030	152,000	38,900	14,900	7,320	958,950	58
1929	7,740	11,400	15,200	15,200	21,000	57,170	98,540	329,980	199,000	62,700	18,900	11,100	847,930	51
1930	7,180	6,660	8,300	15,000	31,600	69,710	167,570	230,740	240,900	55,000	16,500	7,620	856,780	52
1931	8,590	11,800	8,980	12,600	17,500	30,900	97,970	184,100	58,700	14,300	10,100	10,100	465,640	28
1932	6,690	8,500	59,530	53,980	142,900	119,120	222,060	510,590	592,800	249,820	54,790	17,200	2,037,980	123
1933	15,660	10,000	11,300	27,200	29,800	63,920	155,140	231,740	457,220	135,950	27,400	10,300	1,175,630	71
1934	8,380	10,800	36,630	39,480	36,430	92,130	172,350	143,420	63,100	25,100	11,400	7,400	646,620	39
1935	6,690	16,200	24,190	45,110	57,860	79,230	288,790	451,140	467,090	116,570	31,800	13,900	1,598,570	96
1936	13,440	14,080	13,740	27,530	158,640	124,490	335,730	567,740	361,720	149,030	48,300	14,880	1,829,320	110
1937	14,230	14,770	39,320	37,890	230,750	163,600	266,420	741,900	528,700	179,900	40,370	15,560	2,273,410	137
1938	12,070	12,610	165,350	51,130	150,050	330,860	340,890	698,040	858,080	401,450	117,970	42,980	3,181,480	192
1939	43,020	34,480	26,860	31,250	41,630	89,510	239,040	241,150	126,400	46,990	28,230	13,730	962,290	58
1940	25,350	12,470	11,420	70,150	107,050	157,390	258,690	570,910	373,680	92,520	25,260	11,800	1,716,690	103
1941	15,200	15,270	63,610	77,680	133,520	155,530	185,620	684,410	675,570	341,850	91,150	25,290	2,464,700	148
1942	18,390	25,590	62,580	80,000	66,570	103,860	233,440	446,760	616,670	247,080	59,710	18,930	1,979,580	119
1943	13,150	28,420	33,300	141,020	89,590	233,590	310,460	553,030	337,230	171,340	46,430	15,830	1,973,390	119
1944	13,660	12,850	15,580	21,100	39,540	83,680	116,380	398,290	286,320	122,300	27,470	12,110	1,149,280	69
1945	11,180	40,140	38,910	32,110	180,290	107,970	248,650	500,070	529,770	232,600	70,120	25,970	2,017,780	121
1946	63,050	63,830	84,680	66,030	45,900	105,620	290,810	467,160	265,730	100,400	31,420	14,050	1,598,680	96
1947	26,940	61,350	77,550	45,460	51,320	83,320	169,250	369,090	145,700	41,470	16,190	10,450	1,098,090	66
1948	15,890	16,330	12,930	11,900	14,160	29,320	133,840	373,460	285,180	71,570	16,810	8,090	989,480	60
1949	7,880	7,820	10,380	13,040	18,380	48,910	193,150	368,610	211,880	45,750	18,000	9,280	953,080	57
1950	8,230	15,910	15,230	31,610	71,230	73,170	276,930	389,420	279,300	79,540	18,560	12,640	1,271,770	77
1951	14,000	219,080	216,820	76,670	69,160	95,690	189,890	317,560	255,160	88,920	22,510	10,340	1,575,800	95
1952	10,740	14,860	71,330	124,880	72,820	140,610	306,960	831,180	687,450	350,700	106,920	32,900	2,751,350	166
1953	19,410	18,580	34,830	64,690	42,420	59,340	171,320	215,570	325,600	150,400	30,700	12,710	1,145,570	69
1954	10,542	13,297	15,342	24,558	53,460	105,776	265,100	479,200	227,800	77,828	17,100	10,260	1,300,263	78
1955	8,543	17,818	26,724	38,892	49,901	61,677	121,924	329,400	330,800	77,600	25,678	10,820	1,099,777	66
1956	8,509	12,887	397,019	204,342	98,671	127,543	237,710	517,188	556,556	266,800	63,553	25,484	2,516,262	152
1957	23,992	17,875	16,433	22,312	50,177	65,979	121,751	317,487	466,142	100,700	31,970	10,941	1,245,759	75
1958	15,507	24,274	44,080	38,840	84,900	149,185	300,400	751,400	646,801	273,388	90,990	34,420	2,454,185	148
1959	18,460	14,890	13,240	25,860	66,382	91,020	188,100	196,800	124,700	30,510	14,070	25,540	809,572	49
1960	13,904	8,116	8,270	13,960	42,480	63,070	168,100	229,800	121,100	24,610	10,680	8,420	712,510	43
1961	10,483	20,517	23,568	14,476	21,616	38,672	115,047	159,049	100,811	17,703	24,441	9,009	555,392	33
1962	7,115	11,707	22,146	21,840	151,528	86,066	361,264	417,700	514,625	185,681	43,145	13,841	1,836,658	111
1963	15,563	10,897	8,664	66,481	193,441	81,343	171,791	455,164	502,371	258,597	65,408	25,472	1,855,192	112
1964	25,607	56,438	34,235	25,216	24,310	43,014	125,548	260,233	183,730	47,001	20,339	9,880	855,551	52
1965	8,817	31,655	144,890	142,014	78,808	90,208	210,062	407,161	455,949	224,679	108,476	27,019	1,929,738	116
1966	15,503	67,449	57,006	50,254	41,876	101,565	274,088	368,620	141,200	48,370	22,253	9,096	1,197,280	72
1967	6,754	26,847	295,135	94,780	97,118	202,406	207,121	600,433	828,797	638,877	159,013	67,697	3,224,978	194
1968	23,721	23,858	36,042	33,097	52,640	69,325	138,418	244,762	136,700	39,290	17,970	6,360	822,183	50
1969	14,801	31,458	41,828	392,457	200,772	184,372	396,476	1,114,637	1,015,000	586,500	170,300	49,300	4,197,901	253
1970	33,579	29,140	34,927	116,172	60,025	100,656	130,558	396,800	254,900	98,830	29,360	13,380	1,298,327	78
1971	9,810	27,220	58,628	60,108	56,064	80,068	152,462	272,194	297,468	96,781	30,716	14,686	1,156,205	70
1972	12,702	23,921	40,065	35,441	37,764	114,047	114,101	234,537	158,142	37,790	11,639	28,937	849,086	51
1973	17,334	27,922	39,063	76,756	87,106	111,610	208,258	747,696	549,838	154,265	49,891	15,154	2,084,893	126
1974	21,896	57,236	59,707	109,102	53,368	159,202	233,368	617,940	515,444	155,344	57,440	15,894	2,055,941	124
1975	15,929	18,238	26,264	28,455	54,011	101,422	97,060	521,654	520,188	126,208	32,837	15,699	1,557,965	94
1976	38,012	26,156	20,920	15,090	24,677	45,904	73,929	159,462	48,134	22,509	17,397	43,181	535,371	32
1977	29,641	13,321	9,061	13,230	14,023	19,004	70,992	83,246	105,042	15,211	6,742	6,494	386,007	23
1978	8,148	10,150	68,792	131,188	174,665	254,892	275,613	687,612	899,400	518,963	167,070	166,792	3,363,285	203
1979	31,454	27,287	32,008	73,050	81,422	140,741	214,430	598,763	336,558	110,346	38,545	16,840	1,701,444	102
1980	32,264	28,065	29,100	308,426	270,480	190,328	290,091	523,142	713,844	454,872	118,224	32,748	2,991,584	180
1981	18,380	17,879	25,194	27,469	46,394	69,202	200,248	342,658	213,210	40,459	14,934	12,278	1,028,305	62
1982	18,429	57,174	54,905	100,212	130,266	177,148	528,055	699,263	600,419	369,040	133,406	184,570	3,052,887	184
1983	125,825	141,292	203,575	195,052	224,451	329,398	209,055	662,900	1,155,140	671,664	277,537	90,814	4,286,703	258
1984	51,273	116,776	176,752	105,090	93,756	148,048	205,891	511,422	252,364	165,801	75,806	31,532	1,934,511	116
1985	28,562	44,615	41,691	42,356	49,619	77,914	267,439	354,695	206,230	77,269	22,735	22,923	1,236,048	74
1986	23,491	38,174	67,020	95,057	385,981	369,694	371,664	735,795	702,458	267,471	96,326	36,508	3,189,639	192
1987	30,500	18,900	16,400	19,600	34,300	56,400	181,300	230,800	113,900	35,000	14,500	12,660	764,260	46
1988	13,527	20,920	23,796	60,968	40,118	79,543	151,832	224,311	130,612	31,995	23,718	18,607	819,947	49
1989	9,290	17,354	24,217	26,172	40,785	112,472	250,407	232,682	130,116	25,670	12,385	15,844	897,394	54
1990	18,954	15,904	13,395	21,297	26,962	70,398	168,588	181,018	114,248	32,055	12,202	9,009	684,030	41
1991	10,445	8,505	9,602	10,749	9,265	124,239	127,606	305,060	337,709	85,933	15,622	16,199	1,060,934	64
1992	14,240	21,971	15,219	20,694	50,480	59,386	190,380	223,060	61,947	24,284	10,207	7,456	699,324	42
1993	14,462	20,325	32,849	159,836	102,841	193,849	278,537	709,667	602,421	285,120	56,738	22,574	2,479,219	149
1994	16,384	15,618	22,709	20,085	39,987	76,888	167,953	273,515	177,313	33,238	4,370	19,222	867,282	52
1995	45,995	35,620	39,428	158,662	100,125	370,464	261,066	539,123	877,332	698,041	186,005	59,090	3,370,951	203
1996	23,756	17,717	39,622	57,571	180,504	176,976	314,165	611,638	420,907	153,200	43,721	21,973	2,061,750	124
1997	16,899	79,965	166,711	549,840	144,312	190,499	308,293	595,312	321,978	115,884	44,399	29,308	2,563,400	154
1998	20,172	24,466	39,357	81,369	174,270	186,505	252,351	422,499	911,462	660,099	143,855	64,837	2,981,242	180
1999	33,444	35,173	36,276	48,497	74,310	75,986	146,396	398,416	256,538	83,337	32,789	20,628	1,241,790	75
2000	12,333	13,103	11,449	45,099	111,268	123,834	247,075	550,578	288,131	61,290	23,937	12,524	1,500,621	90
2001	17,461	19,155	13,042	20,960	33,585	99,556	179,531	445,643	109,285					
Avg	20,774	28,752	48,474	71,568	82,558	117,216	215,669	435,534	395,292	169,785	50,592	24,517	1,660,731	

Kings River Release to San Joaquin River

Monthly Discharge in Acre-Feet at James Bypass Gaging Station

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TOTAL	Water Year % of Avg.
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	66%
1956	0	0	3,681	468	57,672	29,384	0	0	0	0	0	0	91,205	153%
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	73%
1958	0	0	0	0	0	958	27,241	93,363	90,610	625	0	0	212,797	147%
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	48%
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	42%
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	33%
1962	0	0	0	0	0	0	0	0	0	0	0	0	0	109%
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	111%
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	51%
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	115%
1966	0	0	0	0	0	0	0	0	0	0	0	0	0	71%
1967	0	0	2,884	0	0	0	48,657	194,665	149,853	88,811	0	0	484,870	194%
1968	0	0	0	0	0	0	0	0	0	0	0	0	0	49%
1969	0	0	0	38,510	184,090	285,920	278,860	302,640	318,170	132,580	10,570	0	1,551,340	255%
1970	0	0	1,370	53,320	4,780	2,700	0	0	0	0	0	0	62,170	77%
1971	0	0	0	0	0	0	0	0	0	0	0	0	0	68%
1972	0	0	0	0	0	0	0	0	0	0	0	0	0	50%
1973	0	0	0	0	0	0	0	0	139	0	0	0	139	124%
1974	0	0	0	93	0	0	18,340	19,940	47,980	0	0	0	86,353	122%
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	92%
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	31%
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	23%
1978	0	0	0	0	6,670	94,810	198,670	202,040	48,820	176	0	0	551,186	201%
1979	0	0	0	0	397	218	640	9,430	730	337	0	0	11,752	101%
1980	0	0	0	57,150	86,990	252,370	77,650	70,020	12,230	23,170	0	0	579,580	177%
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	60%
1982	0	0	0	0	0	0	157,860	213,240	62,480	19,160	8	0	452,748	181%
1983	0	91,790	224,340	218,320	260,350	319,270	301,490	303,280	292,440	183,520	66,190	48,290	2,309,280	260%
1984	105,920	140,620	135,320	185,000	900	650	200	0	0	0	0	0	568,610	115%
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	73%
1986	0	0	0	0	10,580	211,520	215,290	139,540	90,820	0	0	0	667,750	190%
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	45%
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	48%
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	53%
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	40%
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	63%
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	41%
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	148%
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	50%
1995	0	0	0	0	0	32,644	158,918	228,382	87,044	77,364	0	0	584,352	201%
1996	0	0	0	0	0	6,637	67,441	464	0	0	0	0	74,542	122%
1997	0	0	0	169,558	223,588	38,887	0	0	0	0	0	0	432,033	154%
1998	0	0	0	494	6,179	65,325	212,350	278,273	266,025	155,032	0	0	983,678	180%
1999	0	3,500	16,542	0	0	0	0	0	0	0	0	0	20,042	73%
2000	0	0	0	0	0	0	0	0	0	0	0	0	0	90%
2001														
Total	105,920	235,910	384,137	722,913	842,196	1,341,293	1,763,607	2,055,277	1,467,341	680,775	76,768	48,290	9,724,427	
Min	0	0	0	0	0	0	0	0	0	0	0	0	0	
Max	105,920	140,620	224,340	218,320	260,350	319,270	301,490	303,280	318,170	183,520	66,190	48,290	2,309,280	
Average	2,303	5,128	8,351	15,716	18,309	29,159	38,339	44,680	31,899	14,799	1,669	1,050	211,401	

Kings River Flood Release to Tulare Lake

Monthly Discharge in Acre-Feet at Empire Weir No. 2 Gaging Station

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TOTAL	Water Year % of Avg.
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	66%
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	153%
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	73%
1958	0	0	0	0	0	0	0	1,920	19,319	0	0	0	21,239	147%
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	48%
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	42%
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	33%
1962	0	0	0	0	0	0	0	0	0	0	0	0	0	109%
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	111%
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	51%
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	115%
1966	0	0	0	0	0	0	0	0	0	0	0	0	0	71%
1967	0	0	0	0	0	0	0	34,495	3,894	28,552	0	0	66,941	194%
1968	0	0	0	0	0	0	0	0	0	0	0	0	0	49%
1969	0	0	0	9,491	19,252	10,409	0	0	157,069	0	0	0	196,221	255%
1970	0	0	0	0	0	0	0	0	0	0	0	0	0	77%
1971	0	0	0	0	0	0	0	0	0	0	0	0	0	68%
1972	0	0	0	0	0	0	0	0	0	0	0	0	0	50%
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	124%
1974	0	0	0	0	0	0	0	0	0	0	0	0	0	122%
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	92%
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	31%
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	23%
1978	0	0	0	0	0	0	0	0	0	0	0	0	0	201%
1979	0	0	0	0	0	0	0	0	0	0	0	0	0	101%
1980	0	0	0	0	13,531	9,447	0	0	0	0	0	0	22,978	177%
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	60%
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	181%
1983	0	0	0	0	0	0	69,936	37,276	74,837	41,709	0	0	223,758	260%
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	115%
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	73%
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	190%
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	45%
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	48%
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	53%
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	40%
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	63%
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	41%
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	148%
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	50%
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	201%
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	122%
1997	0	0	0	29,825	67,528	0	0	0	0	0	0	0	97,353	154%
1998	0	0	0	0	0	0	0	0	0	2,780	0	0	2,780	180%
1999	0			0	0	0	0	0	0	0	0	0	0	73%
2000	0	0	0	0	0	0	0	0	0	0	0	0	0	90%
2001														
Total	0	0	0	39,316	100,311	19,856	69,936	73,691	255,119	73,041	0	0	631,270	
Min	0	0	0	0	0	0	0	0	0	0	0	0	0	
Max	0	0	0	29,825	67,528	10,409	69,936	37,276	157,069	41,709	0	0	223,758	
Average	0	0	0	855	2,181	432	1,520	1,602	5,546	1,588	0	0	13,723	

Kings River Monthly Pumping into F-K Canal (Acre-feet)

Section 3

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TOTAL	Water Year % of Avg.
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	66%
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	153%
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	73%
1958	0	0	0	0	0	0	0	0	0	0	0	0	0	147%
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	48%
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	42%
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	33%
1962	0	0	0	0	0	0	0	0	0	0	0	0	0	109%
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	111%
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	51%
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	115%
1966	0	0	0	0	0	0	0	0	0	0	0	0	0	71%
1967	0	0	0	0	0	0	0	0	0	0	0	0	0	194%
1968	0	0	0	0	0	0	0	0	0	0	0	0	0	49%
1969	0	0	0	0	0	0	0	0	0	0	0	0	0	255%
1970	0	0	0	0	0	0	0	0	0	0	0	0	0	77%
1971	0	0	0	0	0	0	0	0	0	0	0	0	0	68%
1972	0	0	0	0	0	0	0	0	0	0	0	0	0	50%
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	124%
1974	0	0	0	0	0	0	0	0	0	0	0	0	0	122%
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	92%
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	31%
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	23%
1978	0	0	0	0	0	0	0	0	0	0	0	0	0	201%
1979	0	0	0	0	0	0	0	0	0	0	0	0	0	101%
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	177%
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	60%
1982	0	0	0	0	0	0	0	3,200	0	0	0	0	3,200	181%
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	260%
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	115%
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	73%
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	190%
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	45%
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	48%
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	53%
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	40%
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	63%
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	41%
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	148%
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	50%
1995	0	0	0	0	0	0	0	12,400	300	0	0	0	12,700	201%
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	122%
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	154%
1998	0	0	0	0	0	0	0	0	1,026	0	0	0	1,026	180%
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	73%
2000	0	0	0	0	0	0	0	0	0	0	0	0	0	90%
2001	0	0	0	0	0	0	0	0	0	0	0	0	0	

Simulated Flow from James Bypass to San Joaquin River

Section 3

MAYBAS.MCF - SJRA 2000 May Base 10-01-00 (1922 - 1992)

Equation is +inflo 15

Measured flow (1993 - 1999) Units are in TAF

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	0	0	0	0	0	40	50	40	0	0	0	0	130
1923	0	0	0	15	0	0	0	0	0	0	0	0	15
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0	0	0	0	0	0
1926	0	0	0	0	0	0	0	0	0	0	0	0	0
1927	0	0	0	0	0	0	0	0	0	0	0	0	0
1928	0	0	0	0	0	0	0	0	0	0	0	0	0
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	20	0	30	40	0	0	0	0	90
1937	0	0	0	60	40	0	75	100	25	0	0	0	300
1938	0	0	70	60	70	30	140	230	150	50	0	0	800
1939	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	0	0	0	0	0	0	0	0	0	0	0	0	0
1941	0	0	10	20	30	0	0	0	0	0	0	0	60
1942	0	0	10	20	20	0	0	25	75	0	0	0	150
1943	0	0	0	40	0	60	40	80	20	0	0	0	240
1944	0	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	0	0	0	0	0	0	0	0	0
1946	0	0	0	0	0	0	0	0	0	0	0	0	0
1947	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	30	50	0	0	0	0	0	0	0	0	80
1952	0	0	0	0	30	0	30	170	140	30	0	0	400
1953	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	100	100	30	0	0	0	0	0	230
1957	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	40	90	0	0	0	130
1959	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	40	180	150	80	0	0	450
1968	0	30	0	0	0	0	0	0	0	0	0	0	30
1969	0	0	0	35	160	250	260	270	280	120	0	0	1375
1970	0	0	0	92	42	0	0	0	0	0	0	0	134
1971	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	18	20	48	0	0	0	86
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	7	99	199	202	49	0	0	0	556
1979	0	0	0	0	0	0	1	9	1	0	0	0	11
1980	0	0	0	57	87	252	78	70	12	23	0	0	579
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	158	213	62	19	0	0	452
1983	0	92	224	218	260	319	301	303	292	184	66	48	2307
1984	106	141	135	185	1	1	0	0	0	0	0	0	569
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	11	212	215	140	91	1	0	0	670
1987	0	0	1	1	0	0	0	0	0	0	0	0	2
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	33	159	228	87	77	0	0	584
1996	0	0	0	0	0	7	67	0	0	0	0	0	75
1997	0	0	0	170	224	39	0	0	0	0	0	0	432
1998	0	0	0	0	6	65	212	278	266	155	0	0	984
1999	0	4	17	0	0	0	0	0	0	0	0	0	20
Average	1	3	6	13	14	19	27	34	24	9	1	1	153

Simulated Kings River Flood Release to Tulare Lake

Section 3

Assumed zero for 1922-1954 (Unimpaired less than 200% of average)
1955-1999 Weir 2 plus Pumping to F-K Canal (assumes pumping would have otherwise gone to lakebed)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TOTAL
1922	0	0	0	0	0	0	0	0	0	0	0	0	0
1923	0	0	0	0	0	0	0	0	0	0	0	0	0
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0	0	0	0	0	0
1926	0	0	0	0	0	0	0	0	0	0	0	0	0
1927	0	0	0	0	0	0	0	0	0	0	0	0	0
1928	0	0	0	0	0	0	0	0	0	0	0	0	0
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	0	0	0	0	0
1937	0	0	0	0	0	0	0	0	0	0	0	0	0
1938	0	0	0	0	0	0	0	0	0	0	0	0	0
1939	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	0	0	0	0	0	0	0	0	0	0	0	0	0
1941	0	0	0	0	0	0	0	0	0	0	0	0	0
1942	0	0	0	0	0	0	0	0	0	0	0	0	0
1943	0	0	0	0	0	0	0	0	0	0	0	0	0
1944	0	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	0	0	0	0	0	0	0	0	0
1946	0	0	0	0	0	0	0	0	0	0	0	0	0
1947	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	2	19	0	0	0	21
1959	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	34	4	29	0	0	67
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	9	19	10	0	0	157	0	0	0	196
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	14	9	0	0	0	0	0	0	23
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	3	0	0	0	0	3
1983	0	0	0	0	0	0	70	37	75	42	0	0	224
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	12	0	0	0	0	13
1996	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	30	68	0	0	0	0	0	0	0	97
1998	0	0	0	0	0	0	0	0	1	3	0	0	4
1999	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	0	0	0	1	1	0	1	1	3	1	0	0	8

KAWEAH R-TERMINUS DM (CDEC-KWT)

FULL NATURAL RUNOFF - Acre-feet

Section 3

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	% Avg
1909	6,300	4,500	5,500	92,800	77,200	53,400	89,800	162,300	217,200	70,700	16,000	6,600	802,300	188
1910	5,670	13,000	46,600	50,600	25,900	48,700	78,600	86,700	34,900	12,000	3,680	2,880	409,230	96
1911	4,430	4,240	6,580	53,400	35,800	70,100	75,600	106,000	122,000	51,800	11,400	4,680	546,030	128
1912	4,800	4,960	5,570	6,270	6,040	12,200	22,500	67,600	61,300	10,600	3,360	2,210	207,410	49
1913	2,340	3,040	2,900	5,020	7,610	15,400	37,800	68,200	43,100	15,600	10,700	8,990	220,700	52
1914	3,070	6,550	7,380	71,900	33,700	51,500	67,200	108,000	86,300	38,700	7,500	4,240	486,040	114
1915	4,300	3,460	4,950	8,300	19,200	27,000	52,800	104,000	105,000	30,700	6,400	3,400	369,510	86
1916	2,640	3,370	7,620	94,100	61,600	108,000	127,000	145,000	131,000	59,000	16,700	6,130	762,160	178
1917	19,600	8,630	17,400	17,200	38,300	35,700	70,800	102,000	120,000	30,600	7,870	3,370	471,470	110
1918	3,040	3,300	3,370	3,460	7,890	33,500	45,000	57,000	55,000	10,000	3,000	3,200	227,760	53
1919	11,000	7,700	8,600	6,200	14,000	27,000	56,000	88,000	30,000	7,000	2,000	1,300	258,800	61
1920	2,500	3,300	8,600	6,100	7,500	32,000	67,000	110,000	84,000	21,000	5,000	2,800	349,800	82
1921	6,600	7,300	9,500	15,000	20,000	39,000	49,300	89,200	85,100	20,000	4,060	2,610	347,670	81
1922	2,510	2,470	13,100	17,300	26,600	30,900	50,500	155,000	118,000	31,100	9,040	4,600	461,120	108
1923	4,090	7,800	20,300	15,200	15,000	22,200	67,200	111,000	62,500	27,400	5,400	5,360	363,450	85
1924	5,320	3,930	3,890	4,330	5,390	7,440	26,500	36,200	5,440	1,600	860	750	101,650	24
1925	2,680	10,900	10,300	11,000	21,000	27,500	55,000	92,800	64,300	20,800	5,950	3,250	325,480	76
1926	5,210	4,870	6,330	4,770	12,300	19,200	63,700	71,300	22,900	4,780	2,060	1,330	218,750	51
1927	1,560	23,200	12,900	12,400	58,300	50,200	79,100	121,000	88,100	27,300	5,920	3,200	483,180	113
1928	3,310	19,400	8,850	8,730	10,900	33,000	39,100	52,500	20,100	4,270	2,000	870	203,030	47
1929	1,290	4,860	7,260	7,130	8,160	19,400	30,700	79,300	49,200	10,800	2,880	1,810	222,790	52
1930	1,560	1,590	2,200	5,380	12,900	23,200	45,000	64,000	50,500	7,750	2,150	1,300	217,530	51
1931	1,450	3,680	3,140	5,790	7,330	11,300	23,600	40,600	12,600	2,390	1,310	1,080	114,270	27
1932	980	1,740	22,600	15,200	53,500	44,100	74,400	130,000	126,000	41,000	7,260	2,780	519,560	122
1933	2,570	2,170	3,290	8,240	9,550	22,500	43,400	61,100	104,000	21,200	3,700	2,030	283,750	66
1934	2,060	2,610	11,500	12,700	10,200	20,600	31,500	21,800	12,300	3,200	1,460	830	130,760	31
1935	1,270	5,150	8,110	9,280	14,520	23,360	84,180	104,400	84,560	16,210	4,220	2,370	357,630	84
1936	3,020	3,470	4,450	8,440	65,380	47,920	104,400	136,800	77,900	25,830	6,380	2,950	486,940	114
1937	3,410	3,850	13,250	11,420	108,800	70,260	100,500	191,900	121,100	40,230	8,450	4,060	677,230	158
1938	3,990	4,380	66,220	21,220	56,970	131,500	123,100	198,800	175,300	65,290	17,510	6,620	870,900	204
1939	10,440	9,530	8,390	9,630	13,850	30,870	66,410	59,870	25,340	7,110	3,130	2,610	247,180	58
1940	6,390	2,950	3,360	41,040	62,080	67,710	92,510	140,900	74,410	14,810	3,970	2,620	512,750	120
1941	4,960	5,980	28,010	28,400	55,680	55,680	72,400	173,300	143,700	55,850	12,950	4,820	641,730	150
1942	5,230	7,260	16,510	27,500	22,810	38,580	73,800	120,400	130,600	36,980	7,480	3,660	490,810	115
1943	3,220	7,340	12,590	59,540	37,750	151,040	115,990	151,950	84,350	35,510	8,440	3,570	671,290	157
1944	3,730	4,410	6,360	9,440	15,240	33,870	38,940	106,900	69,040	20,530	4,430	2,480	315,370	74
1945	2,380	12,500	11,640	9,910	67,490	51,860	85,490	132,800	120,700	42,210	9,330	4,310	550,620	129
1946	13,590	14,640	26,310	21,800	16,130	34,400	77,250	93,880	42,420	10,820	3,240	2,000	356,480	83
1947	5,820	23,930	26,150	15,240	16,580	25,290	42,660	73,780	26,350	5,520	2,350	1,530	265,200	62
1948	3,300	3,910	4,030	3,530	4,860	10,770	49,590	98,970	64,710	12,590	3,110	1,950	261,320	61
1949	1,860	2,030	3,460	4,770	6,580	15,200	58,400	83,030	34,050	5,560	2,510	1,420	218,870	51
1950	1,390	4,670	4,760	10,020	28,460	25,270	73,420	86,660	51,020	10,550	2,660	2,080	300,960	70
1951	3,250	79,820	76,080	27,840	23,570	33,500	46,490	72,020	41,040	12,000	3,440	2,240	421,290	99
1952	2,770	4,360	31,420	60,990	39,900	69,110	105,500	234,100	171,500	76,760	21,710	6,870	824,990	193
1953	4,400	6,830	13,930	25,550	15,600	21,040	51,510	57,200	79,460	24,900	5,020	2,690	308,130	72
1954	2,670	3,900	5,270	10,300	17,000	30,520	74,420	104,800	40,820	11,120	3,200	2,040	306,060	72
1955	1,760	4,950	8,270	13,180	26,000	22,870	35,550	80,210	65,430	12,540	3,460	1,840	276,060	65
1956	1,400	3,700	186,600	94,000	44,900	44,200	68,700	133,100	97,100	37,100	10,000	3,800	724,600	170
1957	4,310	4,100	4,310	6,780	15,490	21,330	30,880	87,060	97,590	16,110	4,160	2,940	295,060	69
1958	4,440	6,900	12,250	12,320	25,970	54,710	110,300	194,800	143,800	52,660	15,010	6,480	639,640	150
1959	4,280	4,660	4,390	6,780	16,210	25,810	35,820	33,230	16,080	3,360	1,800	2,350	154,770	36
1960	1,750	1,660	2,160	4,270	15,670	22,380	42,790	56,770	24,480	4,680	2,230	1,490	180,330	42
1961	1,910	5,160	6,340	4,280	5,470	10,640	25,110	33,050	16,190	2,920	3,970	1,720	116,760	27
1962	549	1,944	4,455	6,563	51,571	29,729	95,620	92,237	85,084	24,996	5,336	2,467	400,551	94
1963	3,505	2,652	2,682	29,344	83,777	27,567	62,712	122,366	99,508	40,922	10,025	6,115	491,175	115
1964	5,974	14,505	10,239	7,474	7,890	15,073	38,791	68,730	45,523	10,009	3,380	2,456	230,044	54
1965	2,247	9,124	40,947	44,641	26,507	28,076	66,182	100,490	105,060	41,786	17,187	5,790	488,037	114
1966	4,300	16,158	16,459	15,840	13,097	28,082	58,842	62,637	22,729	5,278	2,535	1,648	247,605	58
1967	1,648	9,576	211,288	35,727	37,712	67,310	94,510	186,084	190,808	138,778	36,342	14,870	1,024,653	240
1968	6,373	7,755	12,736	13,055	19,282	24,829	38,200	58,555	28,975	6,048	2,620	1,646	220,074	51
1969	4,048	7,754	11,141	183,908	120,200	97,467	148,253	282,796	238,982	129,665	36,548	10,566	1,271,328	297
1970	8,335	7,767	12,835	55,441	21,967	42,364	41,102	96,332	53,487	14,519	2,866	2,458	359,473	84
1971	2,535	8,470	14,628	19,534	18,000	27,610	40,874	66,989	68,106	18,738	5,562	2,077	293,123	69
1972	3,243	6,313	10,033	10,491	12,550	29,276	26,946	39,997	20,521	4,157	1,303	3,193	168,023	39
1973	2,916	6,859	12,024	35,953	37,046	56,302	72,632	198,094	146,368	33,741	10,114	3,741	615,790	144
1974	6,345	12,167	17,250	36,681	18,853	54,994	74,617	132,863	100,341	24,510	8,700	2,505	489,826	115
1975	4,205	6,480	7,962	8,704	15,196	35,082	32,276	125,084	115,749	23,994	4,963	3,884	383,579	90
1976	11,213	7,529	8,235	5,000	8,327	17,421	22,362	39,910	9,190	3,767	2,305	11,657	146,916	34
1977	6,700	3,511	3,019	4,860	4,840	6,790	17,941	21,690	19,478	2,606	1,605	601	93,641	22
1978	1,220	2,757	20,012	35,471	72,927	106,282	95,196	172,348	191,882	82,839	21,360	31,516	833,810	195
1979	8,341	7,252	10,116	18,333	25,730	46,352	61,471	135,178	68,175	22,425	9,178	3,616	416,167	97
1980	7,151	7,448	7,141	143,236	130,130	92,711	96,136	126,584	153,646	89,099	23,028	8,220	884,530	207
1981	5,649	5,482	8,769	8,957	16,753	25,450	51,139	71,564	38,902	10,487	3,469	1,781	248,402	58
1982	4,550	11,770	14,712	32,625	40,340	63,190	190,850	173,102	118,808	65,601	22,751	33,339	771,638	181
1983	34,695	51,521	86,740	95,073	119,054	172,703	99,696	202,682	284,412	162,216	68,524	24,689	1,402,005	328
1984	16,415	43,581	68,724	45,273	38,462	47,544	53,941	110,326	48,524	27,771	11,417	4,866	516,844	121
1985	7,734	15,402	15,037	17,790	21,271	28,856	73,622	90,412	43,897	9,969	3,197	5,197	332,384	78
1986	5,857	10,630	22,699	33,688	144,099	151,530	106,016	152,366	124,804	44,318	13,829	5,581	815,417	191
1987	9,400	6,000	5,600	7,500	13,900	20,800	45,400	48,700	23,800	7,500	1,500	1,503	191,603	45
1988	2,549	6,466	8,521	20,098	12,918	23,201	33,967	47,113	21,818	5,022	1,811	2,063	185,547	43
1989	1,825	5,066	7,244	7,761	11,855	34,279	61,276	52,184	23,715	4,808	1,710	2,900	214,623	50
1990	3,261	3,489	3,904	5,800	7,476	20,093	32,385	36,828	19,593	5,399	1,809	1,166	141,203	33
1991	1,073	1,656	2,206	3,287	2,471	42,268	40,102	70,408	67,925	14,557	4,140	2,146	252,239	59
1992	3,021	5,857	4,028	5,996	12,986	18,268	42,270	40,412	8,771	5,072	1,668	744	149,093	35
1993	5,421	5,615	6,990	40,769	32,861	66,923	82,230	149,112	109,402	38,416	7,482	3,888	549,109	128
1994	3,400	4,179	6,024	6,028	12,807	24,014	37,191	61,038	30,145	3,975	1,194	1,706	191,701	45
1995	6,028	5,546	7,728	43,262	31,597	119,883	84,245	161,532	209,830	146,511	37,042	12,790	865,994	203
1996	5,643	4,522	11,086	19,694	72,041	65,013	93,641	141,287	79,733	22,695	8,436	4,245	528,036	124
1997	3,564	29,516	66,382	235,340	69,845	64,674	74,050	123,796	63,198	21,471	7,997	3,713	763,546	179
1998	6,928	7,876	13,518	28,834	78,267	78,517	114,569	134,009	246,529	175,056	34,021	15,888	934,012	219
1999	10,300	11,258	12,919	16,693	23,403	22,695	39,448	77,138	35,536	9,541	3,743	3,324	265,998	62
2000	2,567	4,332	3,777	11,701	41,219	52,329	65,670	113,395	51,946	13,656	5,631	3,156	369,379	86
2001	6,081	6,595	5,068	7,442	13,268	31,260	52,190	101,625	23,917 --					
Avg	4,876	8,591	18,094	27,309	32,327	43,807	64,800	103,887	80,922	29,923	8,349	4,552	427,438	
Avg 1962-00	5,916	9,892	20,764	35,806	39,211	50,655	66,830	107,343	87,562	38,767	11,444	6,505	480,695	

Kaweah - Tulare Lakebed Flooding Assumption

Section 3

1922 - 1961 uses unimpaired flow relationship (performed on an "at least available" basis)
1962 - 1999 uses estimate of flooding based on reports

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	0	0	0	0	0	0	0	30	0	0	0	0	30
1923	0	0	0	0	0	0	0	0	0	0	0	0	0
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0	0	0	0	0	0
1926	0	0	0	0	0	0	0	0	0	0	0	0	0
1927	0	0	0	0	0	0	0	0	0	0	0	0	0
1928	0	0	0	0	0	0	0	0	0	0	0	0	0
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	30	0	0	0	0	0	30
1937	0	0	0	0	30	0	30	30	0	0	0	0	90
1938	0	0	0	0	0	30	30	30	0	0	0	0	90
1939	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	0	0	0	0	0	0	0	0	0	0	0	0	0
1941	0	0	0	0	0	0	0	30	0	0	0	0	30
1942	0	0	0	0	0	0	0	0	0	0	0	0	0
1943	0	0	0	0	0	60	30	30	0	0	0	0	120
1944	0	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	0	0	0	0	0	0	0	0	0
1946	0	0	0	0	0	0	0	0	0	0	0	0	0
1947	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	30	60	0	0	0	0	90
1953	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	30	0	0	0	0	0	0	0	0	0	30
1957	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	30	30	0	0	0	0	60
1959	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	16	0	0	0	0	0	0	0	0	0	16
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	66	66	66	66	66	0	0	0	330
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	26	0	0	0	0	26
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	49	27	0	0	0	0	0	0	76
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	26	35	0	0	0	0	61
1983	0	0	10	53	112	139	90	64	77	11	0	0	556
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	17	99	21	0	0	0	0	0	137
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	15	0	0	0	15
1996	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	101	93	0	0	0	0	0	0	0	194
1998	0	0	0	0	2	5	46	44	72	12	0	0	181
1999	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	0	0	1	2	5	5	5	6	3	0	0	0	28

SUCCESS DAM (CDEC-SCC)

FULL NATURAL RUNOFF - Acre-feet

(Synthetic through WY 1930)

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	WY Total	% Avg
1909	2,079	1,800	2,750	58,464	52,496	30,972	43,104	42,198	36,924	8,484	2,720	1,716	283,707	202
1910	1,871	5,720	23,766	31,878	14,245	28,246	29,082	15,606	3,490	1,080	515	317	155,816	111
1911	1,462	1,696	3,290	33,642	21,480	46,266	27,972	19,080	20,740	6,216	1,938	515	184,297	131
1912	1,584	2,083	2,785	3,449	3,020	5,246	4,950	10,816	7,356	954	235	177	42,655	30
1913	632	730	1,450	2,761	3,805	6,622	8,316	10,912	4,310	1,872	1,819	2,337	45,566	32
1914	829	2,751	3,690	45,297	20,220	29,870	20,160	19,440	10,356	4,644	1,050	466	158,773	113
1915	1,290	830	2,475	4,731	10,560	11,880	15,840	18,720	12,600	3,684	896	374	83,880	60
1916	713	809	3,810	59,283	41,888	71,280	60,960	37,700	22,270	7,080	2,839	1,594	310,225	221
1917	7,056	3,711	8,874	9,976	22,980	16,779	26,196	18,360	14,400	3,672	1,102	371	133,476	95
1918	821	792	1,685	1,903	3,945	15,745	13,500	6,270	6,600	900	210	352	52,723	38
1919	3,960	3,311	4,300	3,410	7,280	11,880	16,800	15,840	3,000	630	140	91	70,642	50
1920	675	792	4,300	3,355	3,750	15,040	20,100	24,200	10,080	2,520	700	308	85,820	61
1921	2,376	3,139	4,750	8,700	11,000	22,620	14,790	16,056	10,212	2,400	568	287	96,899	69
1922	678	593	6,550	10,034	15,960	14,523	15,150	40,300	14,160	3,732	1,266	506	123,451	88
1923	1,227	3,354	10,353	8,816	7,800	9,546	20,160	24,420	7,500	3,288	756	1,394	98,614	70
1924	1,756	1,572	1,945	2,382	2,695	3,199	5,830	3,982	435	64	60	53	23,972	17
1925	724	4,796	5,150	6,380	11,550	12,100	16,500	16,704	7,716	2,496	833	358	85,306	61
1926	1,719	2,045	3,165	2,624	6,396	8,256	19,110	11,408	1,832	191	144	93	56,984	41
1927	125	10,208	6,450	7,192	39,644	29,116	29,267	26,620	10,572	3,276	829	352	163,651	117
1928	993	8,536	4,425	4,976	5,450	15,510	11,730	5,775	1,608	171	140	61	59,375	42
1929	103	2,041	3,630	4,064	4,080	8,342	6,754	12,688	4,920	972	202	145	47,941	34
1930	125	381	1,100	2,959	6,708	10,208	13,500	10,240	5,050	698	151	91	51,210	36
1931	340	7,500	2,200	3,400	3,700	2,900	2,500	1,960	210	20	0	0	24,730	18
1932	0	120	13,250	9,200	29,300	21,500	19,650	29,040	13,510	2,350	170	40	138,130	98
1933	140	490	1,800	9,000	6,700	15,000	14,140	16,540	14,220	1,740	50	20	79,840	57
1934	60	580	4,000	4,900	3,500	4,900	1,790	270	290	10	0	0	20,300	14
1935	0	1,330	2,600	4,200	6,600	12,500	31,650	20,460	8,500	980	40	10	88,870	63
1936	290	820	1,900	3,800	53,000	26,500	43,210	27,530	10,860	2,320	290	80	170,600	122
1937	760	1,670	5,800	8,500	86,500	65,000	58,580	51,330	20,280	5,530	1,180	570	305,700	218
1938	900	1,830	27,500	11,200	34,500	105,000	61,720	67,590	31,420	8,740	2,830	1,620	354,850	253
1939	2,800	4,400	5,100	6,500	10,500	21,000	20,790	9,160	2,400	330	20	70	83,070	59
1940	890	820	1,800	42,500	58,000	40,000	36,570	21,070	7,300	1,230	170	250	210,600	150
1941	1,230	2,420	13,800	17,300	46,000	38,000	40,730	45,080	22,370	5,960	1,750	1,040	235,680	168
1942	1,870	3,100	9,800	18,000	13,000	20,000	26,720	24,930	14,480	2,760	580	360	135,600	97
1943	570	2,850	7,000	47,500	28,000	167,000	55,510	33,040	15,160	5,120	1,730	970	364,450	260
1944	1,700	3,100	4,600	7,400	11,500	20,000	15,610	24,220	10,830	2,480	480	170	102,090	73
1945	520	6,750	5,100	4,600	47,000	39,000	39,860	34,440	18,940	4,560	1,460	760	202,990	145
1946	2,050	4,200	13,000	13,300	8,500	15,500	18,860	13,020	4,510	820	100	50	93,910	67
1947	1,110	7,500	9,000	5,900	6,000	9,000	7,230	5,120	1,290	30	10	10	52,200	37
1948	280	1,450	2,100	1,450	2,350	5,800	23,860	19,070	6,920	680	40	10	64,010	46
1949	70	460	1,900	3,460	4,000	9,490	15,670	10,980	2,500	250	40	10	48,830	35
1950	10	1,400	2,500	5,610	14,890	9,070	15,340	8,830	4,090	170	10	0	61,920	44
1951	1,450	48,500	34,000	13,800	11,720	17,940	11,320	13,060	2,360	190	10	0	154,350	110
1952	1,980	13,170	18,760	40,390	25,960	60,690	58,930	58,480	28,170	8,420	3,460	1,710	320,120	228
1953	1,540	4,000	6,290	24,070	8,700	9,560	15,840	15,570	10,320	2,270	510	410	99,080	71
1954	780	2,370	3,590	7,750	10,030	16,640	25,570	16,340	4,970	650	120	0	88,810	63
1955	330	2,030	4,470	8,510	13,370	9,850	7,970	12,860	4,720	460	0	0	64,570	46
1956	70	1,220	56,600	45,500	21,300	16,000	22,320	31,700	11,000	2,600	660	460	209,430	149
1957	1,500	1,700	2,100	3,800	6,200	9,000	7,600	24,000	8,000	900	100	200	65,100	46
1958	1,400	2,600	6,400	8,500	17,500	46,200	63,800	48,000	18,400	7,000	1,800	1,500	223,100	159
1959	1,240	2,430	2,580	3,740	7,060	7,270	4,260	2,790	380	0	0	0	31,750	23
1960	0	390	1,090	2,550	11,550	10,720	9,320	10,390	1,960	110	20	10	48,110	34
1961	0	1,692	2,632	2,087	2,158	3,687	4,106	2,511	5,770	0	0	0	24,643	18
1962	0	303	1,553	2,648	23,477	13,603	23,828	13,206	6,282	938	141	256	86,235	61
1963	845	1,045	1,198	9,914	28,995	10,136	26,291	25,309	9,624	3,786	1,916	1,267	120,326	86
1964	2,091	5,270	3,872	3,858	3,398	7,438	14,604	13,218	5,314	657	282	430	60,432	43
1965	682	4,578	17,247	23,558	12,036	10,852	29,144	20,718	12,218	3,402	1,966	1,246	137,647	98
1966	877	4,308	6,032	6,869	6,476	8,493	8,079	4,296	1,212	458	0	123	47,223	34
1967	270	2,124	138,482	16,899	16,818	24,861	50,657	65,584	34,225	14,716	5,278	3,969	373,883	266
1968	2,741	4,503	6,909	7,529	10,689	12,492	10,812	7,561	2,890	938	16	182	67,262	48
1969	1,630	4,062	5,504	99,518	86,455	70,970	83,140	73,732	46,910	19,994	7,839	4,102	503,856	359
1970	4,554	4,754	7,470	34,124	13,284	24,098	12,056	12,938	5,935	1,991	791	357	122,352	87
1971	760	5,076	7,888	11,683	9,497	10,638	11,248	15,116	8,295	2,759	849	206	84,015	60
1972	1,029	2,588	6,329	5,326	5,764	5,816	3,917	2,807	833	71	22	256	34,758	25
1973	893	3,727	6,425	27,204	26,660	40,733	36,377	47,406	21,013	7,343	4,366	3,080	225,227	160
1974	2,848	5,338	9,094	23,863	9,560	26,851	35,608	22,213	11,185	5,433	3,560	1,119	156,672	112
1975	2,152	3,592	5,082	5,548	12,530	19,817	17,173	31,191	15,497	4,881	2,753	2,148	122,364	87
1976	3,610	4,390	4,608	3,320	4,616	8,220	6,518	4,358	1,188	500	149	942	42,419	30
1977	1,436	1,309	1,597	2,527	2,001	2,281	1,589	2,487	536	0	77	44	15,884	11
1978	149	547	8,144	16,265	48,401	62,669	46,636	41,527	29,542	10,278	3,660	4,782	272,600	194
1979	2,569	3,392	5,722	7,105	12,504	22,699	20,630	22,263	8,293	4,023	2,707	1,702	113,609	81
1980	2,095	3,225	3,495	75,420	72,991	53,213	37,072	35,891	26,617	11,907	4,988	2,773	329,687	235
1981	2,233	3,124	4,887	6,097	10,255	16,808	18,205	11,639	4,376	1,648	571	399	80,242	57
1982	1,748	2,965	5,518	16,417	19,619	34,037	78,029	39,805	17,604	6,912	3,243	4,366	230,263	164
1983	7,490	20,010	45,208	59,547	86,762	121,434	69,149	85,451	72,054	29,181	11,901	6,827	615,014	438
1984	7,680	19,830	42,950	25,570	19,600	22,190	18,470	17,000	7,150	3,250	1,510	1,340	186,540	133
1985	2,800	8,460	7,860	10,440	13,390	16,680	24,530	15,390	6,840	2,840	1,060	1,740	112,030	80
1986	2,091	5,407	9,564	12,359	67,171	73,177	34,392	22,505	11,310	4,124	2,711	2,335	247,146	176
1987	3,300	3,700	3,900	5,200	8,400	12,300	12,000	5,800	1,600	300	300	262	57,062	41
1988	720	2,656	4,028	11,399	5,302	6,647	6,793	6,002	1,974	175	69	718	46,483	33
1989	0	1,982	3,358	4,078	6,403	16,695	12,081	7,067	1,946	460	369	240	54,679	39
1990	662	1,097	1,523	3,103	3,884	8,146	5,264	3,997	2,089	40	0	0	29,805	21
1991	0	488	1,008	1,720	912	22,312	14,297	11,330	6,028	1,444	321	298	60,158	43
1992	486	1,654	1,734	2,650	6,817	6,889	6,496	2,676	264	781	655	165	31,267	22
1993	662	2,055	3,330	24,302	16,705	30,078	23,760	21,757	13,121	3,029	1,002	490	140,291	100
1994	313	1,381	2,947	3,227	7,414	9,140	7,702	10,288	2,077	377	351	345	45,562	32
1995	531	1,690	3,001	23,721	16,947	61,996	34,324	51,845	37,014	13,688	4,380	3,001	252,138	180
1996	2,464	2,805	4,441	11,135	38,188	44,560	28,431	22,596	8,107	2,945	1,843	1,111	168,626	120
1997	1,500	20,154	54,905	149,191	46,225	30,643	21,077	17,681	7,765	4,346	2,269	1,609	357,365	255
1998	4,303	5,385	7,839	23,830	77,910	64,847	86,889	70,089	68,841	33,317	11,449	6,579	461,278	329
1999	6,555	7,611	8,230	13,486	15,689	10,977	14,930	12,010	4,713	1,515	1,176	438	97,330	69
Average	1,488	4,079	9,306	16,432	19,778	25,532	24,319	22,016	11,481	3,650	1,355	918	140,353	

Tule - Tulare Lakebed Flooding Assumption

Section 3

1922 - 1961 uses unimpaired flow relationship (performed on an "at least available" basis)
1962 - 1999 uses estimate of flooding based on reports

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	0	0	0	0	0	0	0	0	0	0	0	0	0
1923	0	0	0	0	0	0	0	0	0	0	0	0	0
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0	0	0	0	0	0
1926	0	0	0	0	0	0	0	0	0	0	0	0	0
1927	0	0	0	0	0	0	0	0	0	0	0	0	0
1928	0	0	0	0	0	0	0	0	0	0	0	0	0
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	0	0	0	0	0
1937	0	0	0	0	30	30	0	0	0	0	0	0	60
1938	0	0	0	0	0	60	0	0	0	0	0	0	60
1939	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	0	0	0	0	0	0	0	0	0	0	0	0	0
1941	0	0	0	0	0	0	0	0	0	0	0	0	0
1942	0	0	0	0	0	0	0	0	0	0	0	0	0
1943	0	0	0	0	0	60	0	0	0	0	0	0	60
1944	0	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	0	0	0	0	0	0	0	0	0
1946	0	0	0	0	0	0	0	0	0	0	0	0	0
1947	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	30	0	0	0	0	0	0	30
1953	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	16	0	0	0	0	0	0	0	0	0	16
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	8	52	54	42	15	14	0	0	0	185
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	9	0	0	0	0	0	0	9
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	52	24	2	0	0	0	0	0	78
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	4	4	0	0	0	0	8
1983	0	0	0	23	62	93	37	39	41	0	0	0	295
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	49	0	0	0	0	0	0	49
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	5	0	0	0	5
1996	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	96	48	4	0	0	0	0	0	0	148
1998	0	0	0	0	5	40	62	33	35	14	0	0	189
1999	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	0	0	0	2	3	6	2	1	1	0	0	0	15

Appendix A

Section 4
Northern San Joaquin Valley/Other

San Joaquin Valley and Sacramento Valley Water Year Classifications
Simulated Vernalis Flow
Simulated San Joaquin River Excess at Vernalis above Threshold
Simulated Merced River Flow above Minimum Flow and Assumed Additional Requirements
VAMP Pulse Flow
Vernalis/VAMP Hydrology Extension
Merced Hydrology Extension
Cross Valley Canal Capacity

Files

Name	Size	Type	Last Modified
Cross Valley Capacity Calcs.xls	91KB	Microsoft Excel Worksheet	8/8/01 1:21 PM
SJRA and Northern Trib Water.123	446KB	Lotus 1-2-3 9 Workbook	4/21/02 10:38 AM

Chronological Sacramento and San Joaquin Valley Water Year Hydrologic Classification Indices

Department of Water Resources California Cooperative Snow Surveys

Section 4

Based on measured unimpaired runoff in [million acre-feet], subject to revision.

	40/30/30 Sacramento Valley					60/20/20 San Joaquin Valley							
	River Runoff [maf]		WY Index			River Runoff [maf]		WY Index				40/30/30	60/20/20
WY	Oct-Mar	Aprl-May	WY	Index	Type	Oct-Mar	Apr-Jul	WY	Index	Type		1=W, 5=C	1=W, 5=C
1901						3.49	5.58	9.39	4.60	W	1901		1
1902						1.12	3.81	5.08	3.40	AN	1902		2
1903						1.45	4.13	5.71	3.45	AN	1903		2
1904						1.96	5.37	7.64	4.31	W	1904		1
1905						1.82	3.36	5.30	3.24	AN	1905		2
1906	12.57	12.92	26.71	11.76	W	2.53	9.24	12.43	6.70	W	1906	1	1
1907	18.96	13.45	33.70	14.07	W	3.67	7.61	11.82	6.20	W	1907	1	1
1908	8.29	5.60	14.77	7.73	BN	0.98	2.17	3.32	2.40	D	1908	3	4
1909	20.61	8.98	30.68	12.10	W	2.85	5.91	8.97	4.59	W	1909	1	1
1910	13.12	6.11	20.12	9.38	W	2.87	3.62	6.64	3.65	AN	1910	1	2
1911	12.27	13.12	26.38	11.74	W	3.63	7.52	11.48	5.97	W	1911	1	1
1912	4.84	5.65	11.41	6.71	BN	0.54	2.57	3.21	2.55	BN	1912	3	3
1913	5.72	6.29	12.85	6.24	D	0.44	2.34	3.00	2.00	C	1913	4	5
1914	16.72	10.08	27.81	10.92	W	2.72	5.67	8.69	4.35	W	1914	1	1
1915	11.41	11.42	23.86	10.99	W	1.29	4.95	6.40	4.10	W	1915	1	1
1916	14.25	8.89	24.14	10.83	W	2.67	5.50	8.38	4.65	W	1916	1	1
1917	7.25	9.14	17.26	8.83	AN	1.66	4.84	6.66	4.13	W	1917	2	1
1918	5.27	4.89	10.99	6.19	D	1.07	3.40	4.59	3.08	BN	1918	4	3
1919	8.12	6.77	15.66	7.00	BN	1.06	2.99	4.09	2.62	BN	1919	3	3
1920	3.63	4.91	9.20	5.15	C	0.72	3.29	4.09	2.64	BN	1920	5	3
1921	15.47	7.52	23.80	9.20	AN	1.97	3.84	5.90	3.23	AN	1921	2	2
1922	6.63	10.57	17.98	8.97	AN	1.51	5.99	7.68	4.54	W	1922	2	1
1923	6.21	6.27	13.21	7.06	BN	1.39	3.95	5.51	3.55	AN	1923	3	2
1924	3.27	1.94	5.74	3.87	C	0.45	1.03	1.50	1.42	C	1924	5	5
1925	8.76	6.51	15.99	6.39	D	1.45	3.93	5.51	2.93	BN	1925	4	3
1926	6.37	4.79	11.76	5.75	D	0.89	2.56	3.49	2.30	D	1926	4	4
1927	14.34	8.75	23.83	9.52	W	1.80	4.56	6.50	3.56	AN	1927	1	2
1928	10.24	5.86	16.76	8.27	AN	1.69	2.64	4.37	2.63	BN	1928	2	3
1929	4.00	3.84	8.40	5.22	C	0.52	2.29	2.84	2.00	C	1929	5	5
1930	8.24	4.65	13.52	5.90	D	0.76	2.44	3.25	2.02	C	1930	4	5
1931	3.52	2.09	6.10	3.66	C	0.46	1.18	1.66	1.20	C	1931	5	5
1932	6.28	6.24	13.12	5.48	D	1.79	4.69	6.63	3.41	AN	1932	4	2
1933	3.73	4.66	8.94	4.63	C	0.49	2.77	3.34	2.44	D	1933	5	4
1934	5.68	2.45	8.63	4.07	C	0.98	1.26	2.28	1.44	C	1934	5	5
1935	6.27	9.69	16.59	6.98	BN	1.26	5.03	6.41	3.56	AN	1935	3	2
1936	10.32	6.41	17.35	7.75	BN	2.00	4.38	6.49	3.74	AN	1936	3	2
1937	5.50	7.24	13.33	6.87	BN	1.78	4.66	6.53	3.90	W	1937	3	1
1938	17.96	12.93	31.83	12.62	W	3.58	7.33	11.24	5.89	W	1938	1	1
1939	4.56	3.04	8.18	5.58	D	1.00	1.83	2.90	2.20	D	1939	4	4
1940	14.78	6.93	22.43	8.88	AN	2.49	4.04	6.59	3.36	AN	1940	2	2
1941	16.32	9.77	27.08	11.47	W	2.22	5.51	7.93	4.43	W	1941	1	1
1942	14.33	9.93	25.24	11.27	W	1.93	5.28	7.38	4.44	W	1942	1	1
1943	13.37	6.90	21.13	9.77	W	2.86	4.28	7.28	4.03	W	1943	1	1
1944	4.81	4.93	10.43	6.35	D	0.87	2.97	3.92	2.76	BN	1944	4	3
1945	8.42	5.92	15.06	6.80	BN	2.07	4.37	6.60	3.59	AN	1945	3	2
1946	10.89	5.97	17.62	7.70	BN	1.99	3.65	5.73	3.30	AN	1946	3	2
1947	5.90	3.83	10.39	5.61	D	1.26	2.12	3.42	2.18	D	1947	4	4
1948	5.39	9.55	15.75	7.12	BN	0.56	3.58	4.21	2.70	BN	1948	3	3
1949	5.73	5.59	11.97	6.09	D	0.62	3.12	3.79	2.53	BN	1949	4	3
1950	7.01	6.72	14.44	6.62	BN	1.02	3.57	4.65	2.85	BN	1950	3	3
1951	16.77	5.42	22.95	9.18	AN	4.35	2.83	7.25	3.14	AN	1951	2	2
1952	13.86	13.68	28.60	12.38	W	2.18	6.84	9.30	5.17	W	1952	1	1
1953	10.83	8.26	20.09	9.55	W	1.07	3.18	4.35	3.03	BN	1953	1	3
1954	9.74	6.81	17.43	8.51	AN	1.10	3.16	4.30	2.72	BN	1954	2	3
1955	5.19	5.07	10.98	6.14	D	0.78	2.67	3.50	2.30	D	1955	4	4
1956	20.32	8.60	29.89	11.38	W	4.14	5.29	9.67	4.46	W	1956	1	1
1957	7.72	6.29	14.89	7.83	AN	1.02	3.19	4.29	3.01	BN	1957	2	3
1958	16.37	12.24	29.71	12.16	W	1.67	6.40	8.36	4.77	W	1958	1	1
1959	7.40	3.84	12.05	6.75	BN	0.98	1.85	2.98	2.21	D	1959	3	4
1960	7.72	4.65	13.06	6.20	D	0.85	2.07	2.96	1.85	C	1960	4	5
1961	6.87	4.39	11.97	5.68	D	0.54	1.50	2.10	1.38	C	1961	4	5
1962	8.17	6.23	15.11	6.65	BN	1.26	4.24	5.61	3.07	BN	1962	3	3
1963	12.01	10.09	22.99	9.63	W	1.68	4.37	6.24	3.57	AN	1963	1	2
1964	5.90	4.37	10.92	6.41	D	0.93	2.14	3.14	2.19	D	1964	4	4
1965	16.59	8.13	25.64	10.15	W	3.23	4.55	8.15	3.81	W	1965	1	1
1966	7.42	4.84	12.95	7.16	BN	1.49	2.42	3.98	2.51	BN	1966	3	3
1967	12.14	11.01	24.06	10.20	W	2.46	7.09	9.98	5.25	W	1967	1	1
1968	8.66	4.12	13.64	7.24	BN	1.02	1.85	2.94	2.21	D	1968	3	4
1969	15.33	10.68	26.98	11.05	W	3.84	8.14	12.29	6.09	W	1969	1	1
1970	18.87	4.35	24.06	10.40	W	2.55	2.96	5.61	3.18	AN	1970	1	2
1971	12.71	8.90	22.57	10.37	W	1.56	3.23	4.91	2.89	BN	1971	1	3
1972	7.61	5.02	13.43	7.29	BN	1.25	2.22	3.57	2.16	D	1972	3	4
1973	12.80	6.38	20.05	8.58	AN	1.87	4.48	6.47	3.50	AN	1973	2	2
1974	21.69	9.78	32.50	12.99	W	2.43	4.53	7.12	3.90	W	1974	1	1
1975	9.24	8.95	19.23	9.35	W	1.37	4.65	6.18	3.85	W	1975	1	1
1976	4.63	2.75	8.22	5.29	C	0.78	1.07	1.97	1.57	C	1976	5	5
1977	2.49	1.93	5.12	3.11	C	0.22	0.80	1.05	0.84	C	1977	5	5
1978	14.90	8.12	23.92	8.65	AN	2.57	6.50	9.65	4.58	W	1978	2	1
1979	6.06	5.64	12.41	6.67	BN	1.87	3.99	5.98	3.67	AN	1979	3	2
1980	15.49	6.00	22.33	9.04	AN	3.74	5.41	9.47	4.73	W	1980	2	1
1981	6.81	3.63	11.10	6.21	D	0.85	2.29	3.22	2.44	D	1981	4	4
1982	20.56	11.94	33.53	12.81	W	3.78	7.00	11.41	5.45	W	1982	1	1
1983	22.75	13.66	37.65	15.29	W	5.42	8.73	15.01	7.22	W	1983	1	1
1984	15.98	5.52	22.35	10.00	W	3.51	3.48	7.13	3.69	AN	1984	1	2
1985	6.24	4.00	11.04	6.47	D	1.11	2.41	3.60	2.40	D	1985	4	4
1986	19.45	5.39	25.75	9.94	W	4.36	4.92	9.50	4.31	W	1986	1	1
1987	5.85	2.79	9.26	5.85	D	0.55	1.48	2.08	1.86	C	1987	4	5
1988	5.78	2.90	9.23	4.65	C	0.86	1.55	2.48	1.48	C	1988	5	5
1989	9.01	5.07	14.79	6.12	D	1.07	2.42	3.56	1.96	C	1989	4	5
1990	4.94	3.73	9.27	4.81	C	0.83	1.59	2.46	1.51	C	1990	5	5
1991	3.89	4.01	8.44	4.21	C	0.56	2.57	3.20	1.96	C	1991	5	5
1992	5.41	2.93	8.87	4.06	C	0.86	1.66	2.58	1.56	C	1992	5	5
1993	12.44	8.98	22.21	8.54	AN	2.49	5.65	8.38	4.20	W	1993	2	1
1994	4.55	2.73	7.80	5.02	C	0.66	1.80	2.54	2.05	C	1994	5	5
1995	19.78	13.59	34.49	12.88	W	3.67	8.01	12.31	5.95	W	1995	1	1
1996	13.05	8.37	22.29	10.26	W	2.57	4.51	7.22	4.12	W	1996	1	1
1997	20.23	4.39	25.42	10.82	W	5.75	3.59	9.51	4.13	W	1997	1	1
1998	17.65	12.54	31.39	13.31	W	2.83	7.11	10.43	5.66	W	1998	1	1
1999	12.97	7.26	21.19	9.80	W	1.90	3.85	5.91	3.59	AN	1999	1	2
2000	12.01	5.99	18.88	8.94	AN	1.98	3.78	5.90	3.38	AN	2000	2	2
2001					D					D	2001	5	5

Simulated Vernalis Flow - TAF

Section 4

May VAMP 157 Merced Condition - Before Millerton Baseline Adjustment

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	133	112	166	174	387	663	532	484	437	258	149	103	3599
1923	120	127	285	458	346	221	332	431	204	141	133	88	2884
1924	124	92	96	99	107	102	92	121	81	46	46	51	1057
1925	103	91	91	79	155	152	170	342	125	117	79	75	1580
1926	104	85	89	80	108	104	141	196	111	67	54	55	1196
1927	108	118	127	110	267	255	237	347	127	118	112	70	1995
1928	97	115	129	131	139	333	270	347	114	108	98	67	1949
1929	98	84	78	78	99	100	101	123	91	46	44	47	989
1930	95	78	74	76	88	105	99	122	82	43	43	46	952
1931	95	76	74	71	75	76	80	74	68	44	45	49	828
1932	98	81	199	217	426	296	204	273	94	88	84	78	2137
1933	109	79	81	99	108	122	89	196	78	70	50	51	1134
1934	93	72	82	80	104	92	84	117	67	40	42	47	922
1935	99	88	92	186	182	270	343	430	154	119	113	88	2163
1936	118	91	96	126	715	518	427	422	132	125	90	84	2942
1937	124	91	108	159	855	720	560	556	149	151	126	95	3693
1938	132	111	378	407	1214	2011	1356	1498	742	361	218	142	8572
1939	382	129	126	138	166	222	178	351	123	119	93	61	2090
1940	126	96	96	262	321	528	392	351	191	139	132	90	2723
1941	145	111	189	330	830	743	698	567	284	306	175	98	4476
1942	135	133	295	484	495	454	485	430	220	312	184	103	3730
1943	197	153	228	781	602	1088	510	492	202	164	152	104	4672
1944	139	118	124	123	172	215	203	431	155	150	101	80	2011
1945	130	119	118	114	363	523	413	430	160	156	151	99	2775
1946	128	132	351	284	286	302	294	430	188	146	141	91	2771
1947	128	117	130	119	146	113	121	196	97	55	55	57	1336
1948	109	89	82	73	79	111	174	274	126	116	78	75	1387
1949	111	84	85	79	93	162	143	197	118	89	73	72	1306
1950	111	87	82	100	152	144	135	272	114	109	72	71	1450
1951	113	224	480	723	545	332	241	431	160	119	110	74	3552
1952	132	103	166	364	477	842	746	936	460	330	202	117	4875
1953	371	124	160	388	271	194	226	430	136	129	121	77	2627
1954	127	96	95	103	128	159	166	274	129	122	113	74	1584
1955	113	91	99	112	108	102	121	197	110	64	58	58	1234
1956	114	88	584	1085	752	489	388	430	258	312	156	100	4756
1957	117	107	112	107	128	261	196	431	136	125	113	75	1907
1958	133	100	106	122	192	705	891	782	580	314	172	113	4209
1959	213	117	107	133	250	178	129	274	116	113	92	56	1778
1960	107	82	78	85	124	112	119	196	101	55	51	52	1164
1961	95	85	87	75	80	81	101	97	58	51	49	52	911
1962	101	82	84	74	336	276	203	351	109	82	67	68	1835
1963	110	81	80	112	181	196	260	430	155	126	113	85	1930
1964	113	102	102	102	96	102	105	196	101	53	51	53	1177
1965	111	107	208	497	437	343	442	431	204	142	131	99	3152
1966	117	158	340	284	265	210	138	342	118	113	92	71	2249
1967	123	98	172	191	207	576	925	1086	629	570	298	209	5084
1968	201	115	124	134	210	187	150	274	121	118	108	59	1800
1969	125	103	122	712	1677	1580	1457	1351	839	417	230	139	8754
1970	357	141	218	1065	537	451	270	430	173	135	131	91	3998
1971	140	113	146	144	192	207	187	432	136	129	120	77	2023
1972	113	92	105	104	128	90	113	193	99	52	53	54	1196
1973	113	94	94	128	299	502	347	430	136	132	123	86	2484
1974	134	100	124	455	267	429	517	430	203	145	136	98	3036
1975	140	105	118	118	308	562	473	430	213	217	136	119	2938
1976	145	111	112	103	110	108	110	197	104	70	50	54	1275
1977	193	128	104	74	74	77	89	115	58	42	40	47	1042
1978	104	84	97	206	403	840	922	837	224	195	180	217	4312
1979	104	115	108	315	526	552	393	430	132	127	118	87	3008
1980	134	107	113	758	1263	940	501	531	263	316	252	136	5315
1981	110	113	110	165	140	197	161	274	120	114	100	59	1665
1982	131	111	112	335	866	1104	1541	1016	571	330	250	207	6573
1983	551	534	1125	1525	2035	2638	1636	1555	1442	886	337	465	14730
1984	587	753	1256	934	558	387	231	431	176	151	143	95	5703
1985	132	115	117	109	128	130	129	194	116	106	59	60	1394
1986	124	110	111	104	1043	1579	707	565	396	201	149	118	5207
1987	120	105	100	99	114	121	118	196	106	68	54	55	1255
1988	99	88	82	78	76	80	97	123	77	42	46	53	940
1989	91	74	85	73	76	95	100	110	86	51	49	51	942
1990	93	83	77	73	75	79	94	95	53	48	43	49	863
1991	87	75	69	59	60	138	101	112	71	49	41	44	907
1992	82	74	69	65	125	109	76	69	38	43	37	43	831
Average	144	119	171	254	351	410	349	403	202	152	112	88	2754

Simulated San Joaquin River Excess at Vernalis Above Threshold **Section 4**

May VAMP 157 Merced Condition - Before Millerton Baseline Adjustment

Assumed Flow Threshold Above Which Flow Can Be Captured - CFS

	3000	3000	3000	3000	3000	3000	8000	8000	5000	3000	3000	3000	
WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	0	0	0	0	220	478	56	0	140	74	0	0	969
1923	0	0	100	273	180	36	0	0	0	0	0	0	589
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0	0	0	0	0	0
1926	0	0	0	0	0	0	0	0	0	0	0	0	0
1927	0	0	0	0	101	71	0	0	0	0	0	0	172
1928	0	0	0	0	0	149	0	0	0	0	0	0	149
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	15	32	259	112	0	0	0	0	0	0	418
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	1	15	85	0	0	0	0	0	0	102
1936	0	0	0	0	548	333	0	0	0	0	0	0	881
1937	0	0	0	0	688	536	84	64	0	0	0	0	1,371
1938	0	0	193	223	1,048	1,827	880	1,006	445	177	34	0	5,831
1939	198	0	0	0	0	37	0	0	0	0	0	0	235
1940	0	0	0	77	154	344	0	0	0	0	0	0	575
1941	0	0	4	146	664	559	222	75	0	121	0	0	1,791
1942	0	0	110	300	329	270	9	0	0	128	0	0	1,144
1943	13	0	43	596	435	903	34	0	0	0	0	0	2,024
1944	0	0	0	0	6	30	0	0	0	0	0	0	36
1945	0	0	0	0	196	339	0	0	0	0	0	0	535
1946	0	0	167	100	119	117	0	0	0	0	0	0	503
1947	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	45	295	539	378	148	0	0	0	0	0	0	1,405
1952	0	0	0	179	310	657	270	444	163	146	18	0	2,187
1953	187	0	0	203	105	9	0	0	0	0	0	0	505
1954	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	399	900	586	304	0	0	0	128	0	0	2,317
1957	0	0	0	0	0	76	0	0	0	0	0	0	76
1958	0	0	0	0	25	520	415	290	283	130	0	0	1,662
1959	28	0	0	0	83	0	0	0	0	0	0	0	112
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	170	91	0	0	0	0	0	0	261
1963	0	0	0	0	15	11	0	0	0	0	0	0	26
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	23	313	270	159	0	0	0	0	0	0	765
1966	0	0	155	100	99	26	0	0	0	0	0	0	380
1967	0	0	0	7	40	391	449	594	332	386	114	31	2,342
1968	16	0	0	0	43	2	0	0	0	0	0	0	61
1969	0	0	0	528	1,511	1,395	981	859	542	233	46	0	6,095
1970	173	0	33	880	371	266	0	0	0	0	0	0	1,723
1971	0	0	0	0	26	22	0	0	0	0	0	0	48
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	133	318	0	0	0	0	0	0	451
1974	0	0	0	271	100	244	41	0	0	0	0	0	656
1975	0	0	0	0	142	377	0	0	0	33	0	0	552
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	9	0	0	0	0	0	0	0	0	0	0	0	9
1978	0	0	0	22	236	656	446	345	0	11	0	39	1,755
1979	0	0	0	131	360	368	0	0	0	0	0	0	858
1980	0	0	0	574	1,096	756	25	39	0	132	68	0	2,688
1981	0	0	0	0	0	13	0	0	0	0	0	0	13
1982	0	0	0	150	699	919	1,065	524	274	146	66	29	3,871
1983	367	356	940	1,341	1,868	2,453	1,160	1,063	1,145	701	153	287	11,834
1984	403	575	1,072	749	391	202	0	0	0	0	0	0	3,392
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	877	1,394	231	73	99	17	0	0	2,690
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
Ave	20	14	50	122	210	254	90	76	48	36	7	5	930

Simulated Merced River Flow above Minimum Flow and Assume Additional Requirements after checking against Vernalis above Threshold

Section 4

May VAMP 157 Merced Condition - Before Millerton Baseline Adjustment - TAF

Only Periods of Excess Vernalis Flow Shown

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922					0	124	56		55	68			304
1923			35	54	43	26							158
1924													0
1925													0
1926													0
1927					0	0							0
1928						0							0
1929													0
1930													0
1931													0
1932			0	0	0	18							18
1933													0
1934													0
1935				0	0	52							52
1936					246	56							302
1937					209	85	39	41					373
1938			106	57	228	223	177	174	155	68	34		1,222
1939	0					0							0
1940				0	0	21							21
1941			4	62	135	114	69	65		68			519
1942			46	76	71	82	9			68			351
1943	0		27	132	81	131	27						399
1944					6	0							6
1945					59	47							106
1946			93	43	25	24							185
1947													0
1948													0
1949													0
1950													0
1951		0	110	79	61	0							250
1952				18	53	141	96	92	72	68	18		557
1953	0			42	15	0							57
1954													0
1955													0
1956			0	116	70	75				68			329
1957						0							0
1958					0	130	85	81	61	68			426
1959	0				27								27
1960													0
1961													0
1962					0	0							0
1963					0	11							11
1964													0
1965			0	44	52	47							142
1966			30	32	24	0							87
1967				0	0	136	90	87	67	99	86	31	596
1968	0				16	0							16
1969				0	182	211	166	162	141	68	46		977
1970	0		23	145	57	0							226
1971					0	0							0
1972													0
1973					0	10							10
1974				81	26	65	18						191
1975					98	81				33			211
1976													0
1977	0												0
1978				0	0	94	49	44		11		39	236
1979				79	97	52							228
1980				243	243	88	25	38		68	68		773
1981						0							0
1982				0	129	187	142	174	81	68	66	29	876
1983	11	83	128	178	205	275	215	213	193	217	86	116	1,922
1984	43	102	190	85	68	9							496
1985													0
1986					111	179	50	47	28	17			432
1987													0
1988													0
1989													0
1990													0
1991													0
1992													0
Average	1	3	11	22	37	39	18	17	12	15	6	3	184

Division Agreement - Pass of 50 , 23, 17, 20
Merced - Stanislaus - Exchange - Tuolumne
Total Volume Distribution
Cap of 110 TAF
10-01-00

May	Merced	Stanislaus	Exchange	Tuolumne	Total
1922	0.0	0.0	0.0	0.0	0.0
1923	55.0	20.9	9.0	18.0	102.9
1924	25.0	10.0	1.9	0.0	36.9
1925	31.7	10.0	5.0	10.0	56.7
1926	25.0	9.6	0.0	0.0	34.6
1927	25.0	8.7	0.0	0.0	33.7
1928	55.0	22.0	10.4	18.0	105.4
1929	4.9	0.0	0.0	0.0	4.9
1930	9.7	0.0	0.0	0.0	9.7
1931	0.0	0.0	0.0	0.0	0.0
1932	25.0	10.0	5.0	5.9	45.9
1933	31.0	10.0	5.0	10.0	56.0
1934	25.0	10.0	5.0	8.1	48.1
1935	27.5	10.0	5.0	10.0	52.5
1936	55.0	22.0	11.0	22.0	110.0
1937	0.0	0.0	0.0	0.0	0.0
1938	0.0	0.0	0.0	0.0	0.0
1939	55.0	22.0	11.0	22.0	110.0
1940	7.0	0.0	0.0	0.0	7.0
1941	0.0	0.0	0.0	0.0	0.0
1942	25.0	5.9	0.0	0.0	30.9
1943	0.0	0.0	0.0	0.0	0.0
1944	55.0	22.0	11.0	22.0	110.0
1945	45.0	18.0	7.3	14.6	84.9
1946	55.0	22.0	11.0	22.0	110.0
1947	36.5	13.6	5.0	10.0	65.1
1948	25.0	10.0	5.0	8.7	48.7
1949	16.6	0.0	0.0	0.0	16.6
1950	25.0	10.0	1.0	0.0	36.0
1951	28.9	10.0	5.0	10.0	53.9
1952	0.0	0.0	0.0	0.0	0.0
1953	55.0	18.9	9.0	18.0	100.9
1954	17.1	0.0	0.0	0.0	17.1
1955	25.0	10.0	3.2	0.0	38.2
1956	25.0	0.9	0.0	0.0	25.9
1957	46.9	18.0	9.0	18.0	91.9
1958	0.0	0.0	0.0	0.0	0.0
1959	48.5	18.0	9.0	18.0	93.5
1960	36.5	14.6	7.1	10.0	68.2
1961	0.0	0.0	0.0	0.0	0.0
1962	29.1	10.0	5.0	10.0	54.1
1963	55.0	22.0	10.0	18.0	105.0
1964	36.5	12.9	5.0	10.0	64.4
1965	45.0	17.0	7.3	14.6	83.9
1966	55.0	22.0	11.0	22.0	110.0
1967	0.0	0.0	0.0	0.0	0.0
1968	45.0	16.6	7.3	14.6	83.5
1969	0.0	0.0	0.0	0.0	0.0
1970	55.0	22.0	11.0	22.0	110.0
1971	55.0	22.0	11.0	22.0	110.0
1972	29.2	10.0	5.0	10.0	54.2
1973	36.5	14.6	7.3	11.5	69.9
1974	25.0	10.0	5.0	5.9	45.9
1975	25.0	8.9	0.0	0.0	33.9
1976	28.1	10.0	5.0	10.0	53.1
1977	25.0	10.0	1.8	0.0	36.8
1978	0.0	0.0	0.0	0.0	0.0
1979	41.4	14.6	7.3	14.6	77.9
1980	0.0	0.0	0.0	0.0	0.0
1981	45.0	14.6	7.3	14.6	81.5
1982	0.0	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0	0.0
1984	55.0	22.0	11.0	22.0	110.0
1985	4.4	0.0	0.0	0.0	4.4
1986	0.0	0.0	0.0	0.0	0.0
1987	25.0	10.0	5.0	2.7	42.7
1988	25.0	2.3	0.0	0.0	27.3
1989	0.0	0.0	0.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	0.0
1991	0.0	0.0	0.0	0.0	0.0
1992	0.0	0.0	0.0	0.0	0.0
Max	55	22	11	22	110
Ave	25	9	4	7	45

Flow at Vernalis Post 1992 Modeling Period
(cfs)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1993	849	956	981	4,119	3,037	2,702	3,421	3,609	2,341	1,509	1,998	2,771
1994	3,040	1,759	1,628	1,773	1,989	2,205	1,863	1,972	1,109	1,135	867	869
1995	1,369	1,288	1,295	4,598	6,564	14,609	19,935	22,183	14,013	9,879	3,924	4,735
1996	5,691	2,429	2,250	2,430	11,891	15,068	7,501	8,420	3,739	2,209	2,033	2,164
1997	2,796	2,783	10,633	31,993	32,289	13,689	4,397	4,659	2,901	1,890	1,697	1,954
1998	2,547	2,138	1,022	5,385	27,256	19,658	21,980	17,837	17,996	14,349	5,596	5,322
1999	5,714	3,675	4,104	4,257	10,811	8,501	6,134	5,800	3,163	2,210	1,937	1,983
2000	2,402	2,235	1,737	2,059	7,177	12,636	5,466	4,958	2,955	1,963	2,099	2,331
2001	2,772	2,437	2,220	2,441	3,121	3,317	3,003	3,715				

Assumed Flow Threshold Above Which Flow Can Be Captured - CFS

3000	3000	3000	3000	3000	3000	8000	8000	5000	3000	3000	3000

San Joaquin River Excess at Vernalis Above Threshold

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1993	0	0	0	1,119	37	0	0	0	0	0	0	0
1994	40	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	1,598	3,564	11,609	11,935	14,183	9,013	6,879	924	1,735
1996	2,691	0	0	0	8,891	12,068	0	420	0	0	0	0
1997	0	0	7,633	28,993	29,289	10,689	0	0	0	0	0	0
1998	0	0	0	2,385	24,256	16,658	13,980	9,837	12,996	11,349	2,596	2,322
1999	2,714	675	1,104	1,257	7,811	5,501	0	0	0	0	0	0
2000	0	0	0	0	4,177	9,636	0	0	0	0	0	0
2001	0	0	0	0	121	317	0	0	0	0	0	0

VAMP Determination Assumptions

1993 Tuol FERC and IOP would have made existing flow higher.
Assume single step to 4,450 cfs w/ suppl equal to difference to recorded flow. Likely overestimates VAMP suppl flow.
Use Division Agreement to split volume, assume Goodwin is at 1,500, Stan water provided by Merced/Tuol.

1994 Tuol FERC and IOP would have made existing flow higher.
Assume single step to 3,200 cfs w/ suppl equal to difference to recorded flow. Likely overestimates VAMP suppl flow.
Use Division Agreement to split volume.

1997 Use Division Agreement to split volume, assume Goodwin is at 1,500, Stan water provided by Merced/Tuol.
Assume additional water above 110 provided by Merced.

	SRR Index C	2-yr Sum		VAMP Target	Req/Act Water	VAMP Allocation Merced	Stanislaus	Exchange	Tuolumne	Total
1993	W	6	Single Step	4450	51,702	32,000	0	5,000	15,000	52,000
1994	C	6	Single Step	3200	75,509	39,500	14,600	7,300	14,600	76,000
1995	W	6	Single Step	NA						
1996	W	10	Double	NA						
1997	W	10	Double	7000	143,972	100,000	0	11,000	33,000	144,000
1998	W	10	Double	NA						
1999	AN	9	Double	Actual/7000	147,500	82,200	0	11,000	54,300	147,500
2000	AN	8	Double	Actual/5700	77,680	46,750	0	8,280	22,650	77,680
2001	D	6	Single Step	Actual/4450	78,650	42,120	14,730	7,740	14,060	78,650

Merced Hydrology Extension **Section 4**

Simulated Merced River Downstream Flows in excess of Minimum Requirements

Information based on draft simulation by Merced ID

Periods of simulated excess shown in shaded areas.

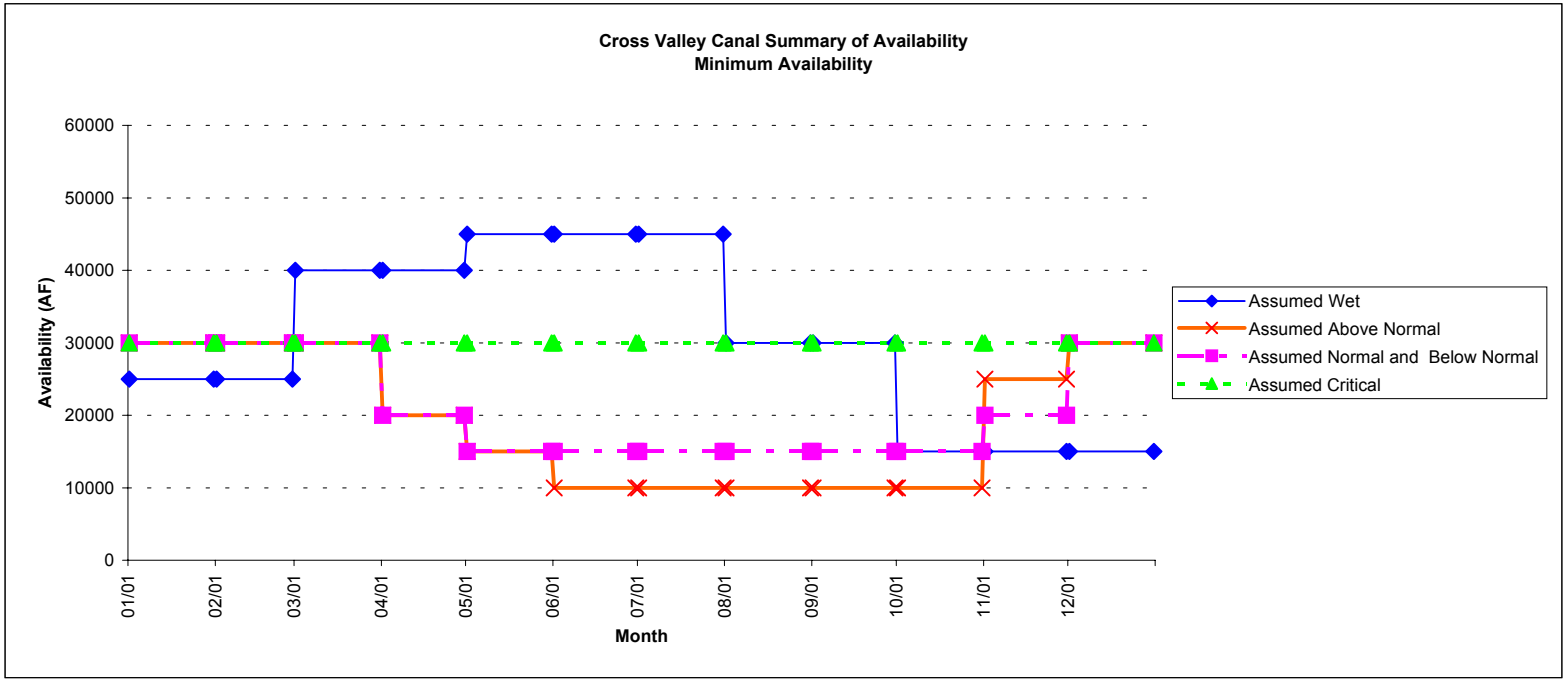
WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1993								vamp					<150
1994	150							vamp					<150
1995													<950
1996	150												<450
1997								vamp					<900
1998													<900
1999	150							vamp					<300

Adjusted Simulated Excess Flow above Minimum Requrements

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1993				20					80	50	50	50	250
1994													0
1995						170	70	180	300	140	85	85	1030
1996				50	170	60	42	100					422
1997			200	570	100	40							910
1998					220	100	70	60	300	140	85	85	1060
1999				30	100								130

Notes:

Merced simulation illustrated operation that held significant amounts of water into the fall, producing significant amounts of release during October in order to meet flood control storage requirements at the end of October. The SJRA modeling minimized the flood control dump during October by distributing the anticipated flood control release during the preceeding summer period. The 'adjusted' flow represents Steiner's distribution of excess flow in a manner that would be anticipated to occur if a SANJASM simulation was extended through 1999.



Assumed Available Capacity in the Cross Valley Canal (acre-feet)

Year Type/ Month	Assumed Wet	Assumed Above Normal	Assumed Normal Normal	Assumed Below Normal	Assumed Critical
Jan	25000	30000	30000	30000	30000
Feb	25000	30000	30000	30000	30000
Mar	40000	30000	30000	30000	30000
Apr	40000	20000	20000	20000	30000
May	45000	15000	15000	15000	30000
Jun	45000	10000	15000	15000	30000
Jul	45000	10000	15000	15000	30000
Aug	30000	10000	15000	15000	30000
Sep	30000	10000	15000	15000	30000
Oct	15000	10000	15000	15000	30000
Nov	15000	25000	20000	20000	30000
Dec	15000	30000	30000	30000	30000

Notes/Comments

Assumed available capacity in the Cross Valley Canal was estimated based on the following:

1. Review of historical use in years 1994-2000 for minimum available at either Tupman or PP6.
2. Year type based on DWR unimpaired runoff for the San Joaquin Valley.
3. Assumed "wet" year capacity derived from lower range of 4 years of available data.
4. Assumed "above normal" year capacity derived from lower range of 2 years of available data.
5. Assumed "critical" year capacity derived from 1 year of available data.
6. Assumed "normal" and "below normal" year capacity derived from assumed values for "above normal" and "dry" year capacity.
7. Overall effect is lowest capacity (and most existing use in cross valley canal) is in more normal years when there is water to move through conveyance, but not so much that it is not needed.

Appendix A

Section 5
Agricultural Water Requirement Determination

A5.1 AGRICULTURAL WATER REQUIREMENT DETERMINATION METHODOLOGY

The following describes the methodology and data used to estimate the consumptive water use for the irrigation and water districts that receive water from the Friant Division.

The net irrigation requirement for a unit area is the amount of water that must be supplied by irrigation to satisfy the evapotranspiration rate, the leaching, and the miscellaneous water requirements not provided by either water stored in the soil or precipitation that enters the soil (Jensen et al. 1990). In this analysis, the net irrigation requirement was estimated using the following equation (the miscellaneous water uses were considered insignificant):

$$NET_{irr} = ET_{crop} - PPT_{eff} - \Delta SW + LCH$$

where:

NET_{irr} = Net irrigation water requirement for the period considered (inches [in.])

ET_{crop} = Total water used in evapotranspiration (in.)

PPT_{eff} = Effective rainfall (in.)

ΔSW = Change in soil water that can be used during the period (in.)

LCH = Water required for leaching (in.)

A5.1.1 Evapotranspiration

The total water used by each crop in evapotranspiration, ET_{crop}, was expressed as the following equation:

$$ET_{crop} = k_c \cdot ET_o$$

where:

k_c = Crop coefficient

ET_o = Reference evapotranspiration (in.)

The term ET_{crop} is also referred to as the consumptive use. Crop coefficients were generally obtained from University of California Cooperative Extension Leaflets 21427, 21428, and 21454 (University of California 1989a, 1989b, 1994). Table 1 lists the source of the crop coefficients used for each crop, as well as adjustments, if any (Zander 2000). The daily crop coefficients corresponding to particular growth and development stages were calculated for each crop. The monthly k_c was then obtained by averaging the daily k_c values within each month. Table 2 presents the resulting monthly k_c values.

The average monthly reference evapotranspiration was obtained from stations maintained by the California Irrigation Management Information System (CIMIS). The ET_o data for each district were obtained from the nearest CIMIS station with at least 7 years of records. Rather than using CIMIS data from stations with shorter periods of records, normal-year ET_o data were used from the nearest location. The normal-year ET_o data were obtained from http://wwwdpla.water.ca.gov/cgi-bin/cimis/cimis/hq/main.pl#Normal. Table 3 contains the ET_o data for CIMIS stations in the vicinity of the Friant Division. The stations assumed to have representative ET_o data for Friant Division stations are shown in Table 4.

A5.1.2 Effective Rainfall

Effective precipitation is the sum of precipitation intercepted by living or dry vegetation, precipitation that stagnates on soil and evaporates, precipitation lost by evaporation during plant growth, and precipitation that contributes to leaching or facilitates other agricultural operations (Dastane 1974). Effective precipitation does not include precipitation lost to surface runoff, precipitation lost to deep percolation below the root zone, or moisture that remains in the soil after the crop harvest and that is not useful for the next crop (Dastane 1974).

For this analysis, effective precipitation was calculated based on a method developed by the U.S. Department of Agriculture Soil Conservation Service (USDA-SCS). This method uses the following relation (USDA-SCS 1970):

$$r_e = (0.70917 \cdot r_t^{0.82416} - 0.11556) \cdot (10^{0.02426.u}) \cdot f$$

where:

r_e = average effective monthly rainfall (in.)

r_t = average monthly rainfall (in.)

u = average monthly consumptive use (in.)

f = correction factor for application depth different from 3 in., where $f = (0.531747 + 0.295164 \cdot D - 0.057697 \cdot D^2 + 0.003804 \cdot D^3)$ where D is the net depth of application during irrigation (in.)

The allowable depletion is the amount of soil water that can be used by plants without suffering yield loss due to water stress (University of California 1993). To simplify the analysis, the allowable depletion for each water district was assumed to be 3 in. In the current analysis, the net depth of application during irrigation was approximated by the allowable depletion.

The monthly precipitation data were obtained from the National Weather Service (NWS) and are presented in Table 5. The NWS stations assumed to have representative precipitation data for Friant Division stations are shown in Table 4.

A5.1.3 Carryover Soil Moisture

The soil moisture at the beginning of the year was assumed to be equal to the allowable depletion (3 in.). The carryover soil moisture was calculated by adding the effective precipitation to the

previous month's soil moisture and subtracting the consumptive use. It was assumed that the carryover soil moisture could not be less than half the allowable depletion.

A5.1.4 Leaching

In this study, the leaching requirement was set to be 5 percent of the total amount of irrigation water.

A5.1.5 Irrigation Efficiency

Due to unavoidable losses, no field application of irrigation water can be 100 percent efficient. Thus, more water than is needed to satisfy net irrigation requirements must be applied. In this study, a 77 percent irrigation efficiency was assumed for all districts.

A5.1.6 Gross Irrigation Demand

By taking into account the irrigation efficiency, the gross field irrigation requirements (NET_{gross}) may be estimated as:

$$NET_{gross} = \alpha \cdot NET_{irr}$$

where α is the irrigation efficiency.

A5.2 RESULTS

Agricultural districts within the Friant Division were included in the water balance analysis. It was assumed that the crop mix and acreage planted in 1995 could be used to estimate the current irrigation water demand. The estimated crop mix and acreage for 2025 was used to estimate the future water demand. The acreage per district of each major crop is presented in Table 6 for 1995 and in Table 7 for 2025. This information was provided by the U.S. Bureau of Reclamation (Zander 2000). The gross irrigation requirements for each district are shown in Table 8 (and also Section 4, Table 4.4, of the main body of this Water Supply Study). The gross irrigation requirement in acre-feet/acre changes from 1995 to 2025 due to a change in cropping patterns. Note that Tables 6 and 7 have not been revised to reflect changes made in Section 4, Table 4-2, because acreages by crop were not revised by the WSOT. However, Table 8 has been modified to reflect the changes in total irrigated acreage.

A5.3 REFERENCES

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U.S. Department of Agriculture Soil Conservation Service (USDA-SCS). 1970. Irrigation Water Requirements. USDA-SCS Technical Release No. 21.

Zander, Joel. 2000. U.S. Bureau of Reclamation. Personal communication with Jeanne Hudson, Water Resources Engineer, URS Corporation. April 17.

Table 1
References for Crop Coefficients (kc values)

Crop Group Name	Location	kc Source	Notes
Alfalfa	San Joaquin Vly	UC Publication 3396	used a constant Kc averaged over entire year
Almonds	Central Vly	UC Leaflet 21428	used kc values for deciduous orchards, c associated with leafout date 2/26, but used a leafout date of 2/20 and assumed kc values cut in half from 7/20 to 8/20.
Barley	San Joaquin Vly	UC Leaflet 21454	used small grains planted 11/1 except used season end date of 5/1
Beans	San Joaquin Vly	UC Leaflet 21427	planted 5/1
Cereals, other (use barley)	San Joaquin Vly	UC Leaflet 21454	used small grains planted 11/1
Citrus	Central Vly	UC Leaflet 21428	assumed a constant Kc for entire year
Corn	San Joaquin Vly	UC Leaflet 21427	planted 4/1
Cotton	San Joaquin Vly	UC Leaflet 21427	used kc values and growth dates associated with a plant date of 4/16, but used a plant date of 4/10 and season end date of 10/1
Deciduous Orchard, c	Central Vly	UC Leaflet 21428	leafout date 3/1 (From UC Leaflet 21428, Deciduous Orchard, c refers to "peaches, apricots, pears, plums, almonds and pecans without a cover crop.")
Deciduous Orchard, d	Central Vly	UC Leaflet 21428	leafout date 3/1 (From UC Leaflet 21428, Deciduous Orchard, d refers to "apples, cherries, and walnuts without a cover crop.") "other nuts" were included with Deciduous Orchard, d.
Grain Sorghum (Milo)	San Joaquin Vly	UC Leaflet 21427	planted 5/1
Grapes (table)	San Joaquin Vly	UC Leaflet 21454	leafout date 3/15
Melons	San Joaquin Vly	UC Leaflet 21427	used plant date of 3/16, except used season end date of 6/30
Misc. Truck/Field Crops (High)	San Joaquin Vly	UC Leaflet 21427	used corn planted 4/1
Misc. Truck/Field Crops (Low)	Imperial Vly	UC Leaflet 21454	used lettuce planted 8/31
Misc. Truck/Field Crops (Med)			used avg. of misc. (High) and misc. (Low)
Nursery/Lettuce	Imperial Vly	UC Leaflet 21454	used lettuce planted 8/31
Olives	Central Vly	UC Leaflet 21428	leafout date 3/31
Pasture (Improved)	Statewide	UC Leaflet 21427	used constant kc shown for grazed pasture
Potatoes	San Joaquin Vly	UC Leaflet 21427	planted 3/1
Sugar Beets	San Joaquin Vly	UC Leaflet 21427	planted 3/16
Tomatoes (canning)	San Joaquin Vly	UC Leaflet 21427	planted 5/1
Tomatoes (fresh market)	San Joaquin Vly	UC Leaflet 21454	used tomatoes planted 3/23
Wheat	San Joaquin Vly	UC Leaflet 21454	used small grains planted 11/1 except used season end date of 6/1

Table 2
Monthly Crop Coefficients (Kc)

Month	Alfalfa Monthly Average Kc	Almonds Monthly Average Kc	Barley Monthly Average Kc	Beans Monthly Average Kc	Cereal (use Barley) Monthly Average Kc	Citrus Monthly Average Kc	Corn Monthly Average Kc	Cotton Monthly Average Kc	Deciduous Orchard, c Monthly Average Kc	Deciduous Orchard, d Monthly Average Kc	Grain Sorghum (Milo) Monthly Average Kc	Grapes (table) Monthly Average Kc
Jan	0.95	0.00	0.98	0.00	0.98	0.65	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.95	0.18	1.20	0.00	1.20	0.65	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.95	0.62	1.14	0.00	1.14	0.65	0.00	0.00	0.58	0.60	0.00	0.17
Apr	0.95	0.71	0.78	0.00	0.78	0.65	0.20	0.11	0.70	0.75	0.00	0.46
May	0.95	0.80	0.24	0.28	0.24	0.65	0.60	0.22	0.82	0.91	0.16	0.64
Jun	0.95	0.89	0.00	1.08	0.00	0.65	1.11	0.75	0.87	0.97	0.51	0.80
Jul	0.95	0.74	0.00	0.98	0.00	0.65	0.99	1.17	0.87	0.97	1.04	0.82
Aug	0.95	0.62	0.00	0.25	0.00	0.65	0.59	1.05	0.87	0.97	0.81	0.70
Sep	0.95	0.80	0.00	0.00	0.00	0.65	0.00	0.62	0.83	0.95	0.00	0.00
Oct	0.95	0.62	0.00	0.00	0.00	0.65	0.00	0.01	0.71	0.88	0.00	0.00
Nov	0.95	0.02	0.25	0.00	0.25	0.65	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.95	0.00	0.36	0.00	0.36	0.65	0.00	0.00	0.00	0.00	0.00	0.00

Month	Melons Monthly Average Kc	Misc. (High) (use Corn) Monthly Average Kc	Misc. (Low) (use 8/31 Lettuce) Monthly Average Kc	Misc. (Med) (use avg. of High and Low) Monthly Average Kc	Nursery/ Lettuce Monthly Average Kc	Olives Monthly Average Kc	Pasture (Improved) Monthly Average Kc	Potatoes Monthly Average Kc	Sugarbeets Monthly Average Kc	Tomatoes Monthly Average Kc	Tomatoes (fresh market) Monthly Average Kc	Wheat Monthly Average Kc
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.00	0.00	0.00	0.00	0.98
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.00	0.00	0.00	0.00	1.20
Mar	0.09	0.00	0.00	0.00	0.00	0.02	0.90	0.58	0.08	0.00	0.02	1.20
Apr	0.26	0.20	0.00	0.10	0.00	0.62	0.90	1.01	0.27	0.00	0.08	1.09
May	0.90	0.60	0.00	0.30	0.00	0.71	0.90	1.19	0.75	0.27	0.64	0.74
Jun	0.63	1.11	0.00	0.56	0.00	0.78	0.90	0.71	1.10	0.62	1.00	0.24
Jul	0.00	0.99	0.00	0.49	0.00	0.80	0.90	0.00	1.09	1.04	0.90	0.00
Aug	0.00	0.59	0.13	0.36	0.13	0.80	0.90	0.00	1.02	0.99	0.05	0.00
Sep	0.00	0.00	0.21	0.10	0.21	0.80	0.90	0.00	0.48	0.38	0.00	0.00
Oct	0.00	0.00	0.71	0.35	0.71	0.80	0.90	0.00	0.00	0.00	0.00	0.00
Nov	0.00	0.00	1.01	0.50	1.01	0.00	0.90	0.00	0.00	0.00	0.00	0.25
Dec	0.00	0.00	0.48	0.24	0.48	0.00	0.90	0.00	0.00	0.00	0.00	0.36

Table 3
Average Total Monthly Reference Evapotranspiration (inches)

ETo Station Name	Period of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Arvin-Edison	3/22/95 to 3/31/00	1.15	1.81	3.82	5.53	7.17	8.19	8.89	8.46	6.00	4.22	1.80	1.23
Belridge	10/9/98 to 3/31/00	1.08	2.05	3.98	5.52	7.66	8.25	9.18	8.09	6.69	4.42	2.02	1.46
Blackwells Corner	10/19/86 to 3/31/00	1.34	2.07	3.78	5.48	7.06	7.86	8.51	7.74	5.78	3.88	1.93	1.22
Famoso	4/9/97 to 3/31/00	1.08	1.72	3.33	5.12	7.17	7.77	8.42	7.56	5.62	3.85	1.65	1.21
Firebaugh/Telles	9/22/82 to 3/31/00	1.01	1.82	3.70	5.74	7.55	8.26	8.28	7.21	5.49	3.87	1.88	1.06
Five Points	6/7/82 to 3/31/00	1.32	2.06	3.98	6.23	8.06	8.70	8.91	8.18	6.34	4.56	2.41	1.38
Fresno State	10/3/88 to 3/31/00	0.84	1.63	3.25	5.23	6.96	7.97	8.65	7.59	5.42	3.60	1.69	0.86
Kettleman	11/19/82 to 3/31/00	1.19	2.10	4.02	6.05	7.67	8.57	9.02	8.09	6.04	4.35	2.14	1.13
Lindcove	5/31/89 to 3/31/00	0.89	1.55	3.03	4.75	6.47	7.56	8.08	7.21	5.17	3.44	1.60	0.87
Los Banos	6/28/88 to 3/31/00	0.88	1.69	3.45	5.54	7.20	8.17	8.60	7.45	5.43	3.79	1.85	0.94
Orange Cove	1/1/99 to 3/31/00	0.79	1.55	3.27	4.43	7.22	8.27	8.74	7.59	5.92	4.15	1.96	1.42
Parlier	5/23/83 to 3/31/00	0.98	1.88	3.55	5.26	6.94	7.72	8.11	7.06	5.14	3.43	1.64	0.92
Shafter/USDA	6/1/82 to 3/31/00	0.89	1.55	3.03	4.75	6.47	7.56	8.08	7.21	5.17	3.44	1.60	0.87
Stratford	10/29/82 to 3/31/00	0.97	2.00	3.87	6.14	8.02	8.76	8.85	7.86	5.97	4.21	2.05	0.99
Visalia/ICI Americas	1/5/83 to 3/31/00	0.93	1.76	3.31	5.20	6.94	7.67	7.81	6.92	5.02	3.31	1.55	0.88
Visalia	used Normal Year Eto	1.00	1.80	3.40	5.40	7.00	8.10	8.40	7.20	5.70	3.80	1.60	0.90
Arvin	used Normal Year Eto	1.20	1.80	3.50	4.70	6.60	7.40	8.10	7.30	5.30	3.40	1.60	1.00
Delano	used Normal Year Eto	0.90	1.80	3.40	4.70	6.60	7.70	8.50	7.30	5.40	3.40	1.40	0.70
Chowchilla	used Normal Year Eto	1.00	1.40	3.20	4.70	6.60	7.80	8.50	7.30	5.30	3.40	1.40	0.70
Madera	used Normal Year Eto	0.90	1.40	3.20	4.80	6.60	7.80	8.50	7.30	5.30	3.40	1.40	0.70
Los Banos (normal)	used Normal Year Eto	1.00	1.50	3.20	4.70	6.10	7.40	8.20	7.00	5.30	3.40	1.40	0.70

Table 4
Weather Stations with Representative Reference Evapotranspiration (ETo) and Precipitation

District Friant-Kern Canal Service Area	Weather Station with Representative ETo	Weather Station with Representative Precipitation
Arvin-Edison WSD	Arvin	Kern River PH 1
Delano-Earlimart ID	Delano	Delano
Exeter ID	Visalia/ICI Americas	Exeter Fauver Ranch
Fresno ID	Fresno State	Fresno Yosemite Intl
Garfield WD	Fresno State	Friant Government Camp
International WD	Fresno State	Friant Government Camp
Ivanhoe ID	Visalia/ICI Americas	Visalia
Lewis Creek WD	Visalia/ICI Americas	Lindsay
Lindmore ID	Visalia/ICI Americas	Lindsay
Lindsay-Strathmore ID	Visalia/ICI Americas	Lindsay
Lower Tule River ID	Visalia/ICI Americas	Porterville
Orange Cove ID	Visalia	Orange Cove
Porterville ID	Visalia/ICI Americas	Porterville
Saucelito ID	Visalia/ICI Americas	Porterville
Shafter-Wasco ID	Shafter/USDA	Wasco
Southern San Joaquin MUD	Shafter/USDA	Wasco
Stone Corral ID	Lindcove	Lemon Cove
Tea Pot Dome WD	Kettleman	Porterville
Terra Bella ID	Kettleman	Porterville
Tulare ID	Visalia/ICI Americas	Lindsay
Madera Canal Service Area		
Chowchilla WD	Chowchilla	Le Grand
Madera ID	Madera	Madera
Downstream San Joaquin River Service Area		
Gravelly Ford WD	Firebaugh/Telles	Mendota Dam
Cross Valley Canal Service Area		
Alpaugh ID	Kettleman	Angiola
Atwell Island WD	Kettleman	Delano
Hills Valley ID	Visalia	Orange Cove
Kern-Tulare WD	Delano	Delano
Pixley ID	Kettleman	Angiola
Rag Gulch WD	Famoso	Delano
Tri-Valley WD	Visalia	Orange Cove

Table 5
Average Total Monthly Precipitation (inches)

Precip. Station Name	Period of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Angiola	7/48 to 3/82	1.444	1.306	1.121	0.813	0.247	0.06	0.006	0.015	0.16	0.254	0.714	1.055
Bakersfield AP	10/37 to 10/98	1.026	1.167	1.199	0.66	0.223	0.083	0.012	0.046	0.119	0.297	0.63	0.788
Buttonwillow	7/48 to 10/98	1.057	1.083	1.065	0.523	0.234	0.06	0.022	0.023	0.167	0.257	0.593	0.626
Corcoran Irrig Dist	7/48 to 10/98	1.469	1.37	1.207	0.642	0.219	0.054	0.006	0.005	0.178	0.293	0.794	1.014
Delano	7/48 to 10/98	1.32	1.303	1.321	0.728	0.294	0.073	0.001	0.017	0.187	0.291	0.874	0.88
Exeter Fauver Ranch	7/48 to 9/51	1.83	1.263	1.453	0.873	0.247	0	0	0	0.44	0.377	1.377	1.283
Five Points 5 SSW	12/48 to 10/98	1.293	1.098	0.996	0.467	0.266	0.103	0.014	0.02	0.204	0.306	0.69	0.868
Fresno Yosemite Intl	7/48 to 10/98	2.143	1.87	1.99	0.987	0.368	0.15	0.009	0.016	0.187	0.495	1.233	1.575
Friant Government Camp	7/48 to 10/98	2.651	2.35	2.544	1.265	0.489	0.148	0.012	0.014	0.25	0.65	1.678	2.21
Hanford 1 S	12/27 to 10/98	1.521	1.524	1.478	0.709	0.231	0.072	0.01	0.011	0.14	0.357	0.812	1.277
Kern River PH 1	7/48 to 8/91	1.568	1.446	1.696	1.11	0.345	0.067	0.007	0.063	0.21	0.453	1.131	1.218
Kettleman Station	7/48 to 10/98	1.406	1.383	1.147	0.585	0.304	0.041	0.013	0.033	0.197	0.284	0.67	0.846
Le Grand	7/48 to 12/80	2.414	2.056	1.778	1.326	0.41	0.062	0.011	0.038	0.2	0.522	1.604	2.178
Lemon Cove	7/48 to 10/98	2.679	2.245	2.512	1.276	0.52	0.148	0.015	0.034	0.293	0.645	1.641	2.078
Lindsay	7/48 to 10/98	2.263	1.975	2.177	1.084	0.436	0.102	0.012	0.024	0.283	0.529	1.473	1.66
Madera	7/48 to 10/98	2.122	1.719	1.912	1.133	0.462	0.093	0.014	0.019	0.182	0.544	1.357	1.669
Mendota Dam	7/48 to 9/84	1.418	1.256	1.292	0.872	0.266	0.038	0.006	0.014	0.215	0.352	0.955	1.21
Orange Cove	6/31 to 11/90	2.408	2.14	1.959	1.192	0.39	0.095	0.011	0.007	0.159	0.622	1.199	2.046
Piedra	7/48 to 10/98	2.976	2.378	2.32	1.597	0.717	0.102	0.039	0.001	0.212	0.564	1.672	2.629
Porterville	7/48 to 10/98	2.113	1.799	2.003	1.054	0.398	0.084	0.015	0.016	0.279	0.543	1.295	1.559
Visalia	12/27 to 10/98	1.939	1.861	1.767	0.957	0.331	0.089	0.009	0.01	0.141	0.495	1.042	1.626
Wasco	7/48 to 10/98	1.231	1.3	1.312	0.675	0.245	0.105	0.015	0.021	0.14	0.281	0.683	0.821

Table 6
Water Year 1995 Acreage of Crops within Friant Unit

District Friant-Kern Canal Service Area	Alfalfa	Almonds	Barley	Beans	Cereals, other (use barley)	Citrus	Corn	Cotton	Deciduous Orchard, c	Deciduous Orchard, d	Grain Sorghum (Milo)	Grapes (table)	Melons
Arvin-Edison WSD	3,005		467		4,591	12,430		14,176	25,251	11,678	103		
Delano-Earlimart ID	2,104	5,615	156	1,397	87	1,114	362	3,918	1,094	2,770	55	25,626	60
Exeter ID	59				170	8,731		23	890	270		259	
Fresno ID	9,039	11,929	10	110	2,864	8,941	3,745	9,720	8,549	5,913		77,240	
Garfield WD		355			240	235				240		115	
International WD						627							
Ivanhoe ID	41					9,409			208	151		10	
Lewis Creek WD			16		20			60	10	3		116	
Lindmore ID	1,105		253	473	626	10,409	188	2,640	865	859	63	753	
Lindsay-Strathmore ID	31		5		405	9,147		47	96	327			6
Lower Tule River ID	22,738	958	2,354	641	5,088		25,254	26,788	2,855	2,713	40	2,745	60
Orange Cove ID	80	496		1	442	17,645	7	331	1,139	1,256		1,813	14
Porterville ID	709	116		827	942	553	1,160	1,426	2,225	2,574		969	41
Saucelito ID	1,000	1,353		1,764	725	94		3,648	787	1,757	1,178	3,868	
Shafter-Wasco ID	3,822	9,331		887		33		9,528	356	260	89	1,408	128
Southern San Joaquin MUD	3,906	13,476	810	676	232	3,623	368	8,027	255	2,026		11,170	
Stone Corral ID				180		3,021		475	498	557		239	
Tea Pot Dome WD						2,523			13	31		60	
Terra Bella ID						99							
Tulare ID	14,111	118	1,391	666	4,570		12,973	23,778	849	2,905		1,998	34
Madera Canal Service Area													
Chowchilla WD	11,900	14,957					7,931	16,520		979	210		
Madera ID	1,264	15,612	617		2,941	649	4,166	4,432	4,867	7,279		55,594	116
Downstream San Joaquin River Service Area													
Gravelly Ford WD	393	2,072					48	702	149	40		4,785	
Cross Valley Canal Service Area													
Alpaugh ID	1,583				945		160	2,377					
Atwell Island WD	774				278			2,992					
Hills Valley ID		60				1,607			16	20		494	
Kern-Tulare WD		530			70	6,589	55			994		4,127	
Pixley ID	12,566	2,766	2,198	1,057	2,088		9,306	18,107	289	166	1,230	4,180	318
Rag Gulch WD						1,176				49		3,508	
Tri-Valley WD						809							
Friant Unit (all above districts combined):	90,230	79,744	8,277	8,679	27,324	99,464	65,723	149,715	51,261	45,817	2,968	201,077	777

Table 6
Water Year 1995 Acreage of Crops within Friant Unit

District Friant-Kern Canal Service Area	Misc. Truck/Field Crops (High)	Misc. Truck/Field Crops (Low)	Misc. Truck/Field Crops (Med)	Nursery/ Lettuce	Olives	Pasture (Improved)	Potatoes	Sugar Beets	Tomatoes (canning)	Tomatoes (fresh market)	Wheat	Total Crop Acreage
Arvin-Edison WSD		15,673				24	15,302					102,700
Delano-Earlimart ID	564		225	17	144						210	45,518
Exeter ID			2		855	29						11,288
Fresno ID		9,144			205	11,998					140	159,547
Garfield WD		20				210						1,415
International WD												627
Ivanhoe ID					689	18						10,526
Lewis Creek WD					406							631
Lindmore ID				26	4,852			35			605	23,752
Lindsay-Strathmore ID				70	1,671				32		15	11,852
Lower Tule River ID		712	1,122		68	41		887	38		3,722	98,824
Orange Cove ID	10	12	9	10	711							23,976
Porterville ID		223	199	56	212			59	53		947	13,291
Saucelito ID			25		567				17		2,434	19,217
Shafter-Wasco ID		210	642			168	1,145	415			811	29,233
Southern San Joaquin MUD		158	57				90	231			947	46,052
Stone Corral ID					247	80						5,297
Tea Pot Dome WD				59	245	17						2,948
Terra Bella ID												99
Tulare ID			43	238				689			2,952	67,315
Madera Canal Service Area												
Chowchilla WD		20	40						362		3,214	56,133
Madera ID		385	3	499	739				10		664	99,837
Downstream San Joaquin River Service Area												
Gravelly Ford WD											253	8,442
Cross Valley Canal Service Area												
Alpaugh ID						156					160	5,381
Atwell Island WD								161				4,205
Hills Valley ID					120							2,317
Kern-Tulare WD					203						135	12,703
Pixley ID		15	39	381	120	241		156			6,196	61,419
Rag Gulch WD											175	4,908
Tri-Valley WD					27							836
Friant Unit (all above districts combined):	574	26,572	2,406	1,356	12,081	12,982	16,537	2,633	512	0	23,580	930,289

Table 7
Water Year 2025 Acreage of Crops within Friant Unit

District Friant-Kern Canal Service Area	Alfalfa	Almonds	Barley	Beans	Cereals, other (use barley)	Citrus	Corn	Cotton	Deciduous Orchard, c	Deciduous Orchard, d	Grain Sorghum (Milo)	Grapes (table)	Melons	Misc. Truck/Field Crops (High)
Arvin-Edison WSD	2,143	3,958			6,046	12,504	464	15,535	4,287	3,373		26,913	3,250	
Delano-Earlimart ID	2,717				261	1,175	672	2,193		10,996		31,757		
Exeter ID										700		200		
Fresno ID	7,849				7,999	12,000	5,060	12,514		23,672		77,231		
Garfield WD														
International WD														
Ivanhoe ID	41					9,421				373		10		
Lewis Creek WD														
Lindmore ID	1,130				625	10,562	569	2,791		1,642		968		
Lindsay-Strathmore ID	31		5		10			47		307			41	
Lower Tule River ID	20,635				11,805	88	45,396	19,097		7,131		2,810		
Orange Cove ID	110	460						320		2,910		2,020		60
Porterville ID	500	500		350	250		350	800		5,500		1,200		850
Saucelito ID	765			421		205	43	2,841		4,721		4,579		
Shafter-Wasco ID	4,141	10,435		921			90	8,200		488	302	1,466	144	
Southern San Joaquin MUD	4,281				1,297	4,041	1,094	7,469		16,672		12,925		
Stone Corral ID					90	3,086	10	540		1,157		200		
Tea Pot Dome WD									2,801					
Terra Bella ID		14			150					500				
Tulare ID	12,977	598		1,521			18,337	16,058		4,473		2,104		312
Madera Canal Service Area														
Chowchilla WD	12,000	16,000	275	272	2,136		13,000	14,000		5,000	239	5,507	160	
Madera ID	2,376				3,399		1,966	3,122		30,465		57,401		
Downstream San Joaquin River Service Area														
Gravelly Ford WD	37	2,023						530	149	40		5,272		
Cross Valley Canal Service Area														
Alpaugh ID	3,000		1,000					3,000						
Atwell Island WD	1,245				1,280			1,877						
Hills Valley ID			154			2,444				141		494		
Kern-Tulare WD	118	530	2,814							1,142		3,570		
Pixley ID	11,284							11,544		3,706		4,511		
Rag Gulch WD	436		28							55		3,894		
Tri-Valley WD						621				223				
Friant Unit (all above districts combined):	87,816	34,518	4,276	3,485	35,348	56,147	87,051	122,478	7,237	125,387	541	245,032	3,595	1,222

Table 7
Water Year 2025 Acreage of Crops within Friant Unit

District Friant-Kern Canal Service Area	Misc. Truck/Field Crops (Low)	Misc. Truck/Field Crops (Med)	Nursery/ Lettuce	Olives	Pasture (Improved)	Potatoes	Sugar Beets	Tomatoes (canning)	Tomatoes (fresh market)	Wheat	Total Crop Acreage
Arvin-Edison WSD	754	22,848	218		420	23,976		2,651			129,340
Delano-Earlimart ID	1,087				114						50,972
Exeter ID			100	11,670							12,670
Fresno ID		9,570			12,144						168,039
Garfield WD											
International WD											
Ivanhoe ID				669							10,514
Lewis Creek WD											
Lindmore ID	1,886	475		4,861			72				25,581
Lindsay-Strathmore ID				11,790	263			29		22	12,545
Lower Tule River ID		2,943			551		418				110,874
Orange Cove ID				18,800	275						24,955
Porterville ID		50	100	2,000	350		100	2	10	300	13,212
Saucelito ID										4,127	17,702
Shafter-Wasco ID		1,224	1,885		168	1,255	191		11	1,583	32,504
Southern San Joaquin MUD		545	438	57	10		216				49,045
Stone Corral ID					80						5,163
Tea Pot Dome WD		436		245							3,482
Terra Bella ID		475	10	10,491	500						12,140
Tulare ID			282		855		426	679		14,951	73,573
Madera Canal Service Area											
Chowchilla WD		583	17	594	1,036			500	40	1,217	72,576
Madera ID	930	1,123		2,817	4,059						107,658
Downstream San Joaquin River Service Area											
Gravelly Ford WD										417	8,468
Cross Valley Canal Service Area											
Alpaugh ID					500		300			200	8,000
Atwell Island WD		80									4,482
Hills Valley ID				120							3,353
Kern-Tulare WD		5		8,110						215	16,504
Pixley ID		34,750			1,624						67,419
Rag Gulch WD		160		1,097						135	5,805
Tri-Valley WD				27							871
Friant Unit (all above districts combined):	4,657	75,267	3,050	73,348	22,949	25,231	1,723	3,861	61	23,167	1,047,447

Table 8
Agricultural Water Requirements

District	Gross Irrigation Requirement (acre-ft/acre) 1995	2025	(acre-feet) 1995	2025
Friant-Kern Canal Service Area				
Arvin-Edison WSD	3.0	3.0	390,059	390,059
Delano-Earlimart ID	3.0	3.1	147,497	156,441
Exeter ID	3.1	3.4	35,281	37,412
Fresno ID	3.0	3.1	482,450	515,234
Garfield WD	3.1	ND	4,419	ND
International WD	3.0	ND	1,905	ND
Ivanhoe ID	3.1	3.1	32,380	32,430
Lewis Creek WD	3.0	ND	1,892	ND
Lindmore ID	3.0	2.8	71,036	72,898
Lindsay-Strathmore ID	2.9	3.4	34,682	42,381
Lower Tule River ID	3.0	2.9	297,263	322,476
Orange Cove ID	3.2	3.6	84,872	90,565
Porterville ID	3.0	3.5	39,269	45,702
Saucelito ID	2.7	2.9	51,842	50,728
Shafter-Wasco ID	3.2	3.0	93,759	97,894
Southern San Joaquin MUD	3.1	3.4	143,955	165,427
Stone Corral ID	3.0	3.1	16,072	15,904
Tea Pot Dome WD	3.5	4.0	10,464	14,072
Terra Bella ID	3.6	3.9	43,108	47,552
Tulare ID	3.0	2.9	199,047	212,081
Madera Canal Service Area			0	0
Chowchilla WD	3.3	3.3	187,368	235,931
Madera ID	2.8	3.1	282,625	333,389
Downstream San Joaquin River Service Area			0	0
Gravelly Ford WD	3.1	3.0	26,400	25,296
Cross Valley Canal Service Area			0	0
Alpaugh ID	3.7	4.1	19,819	32,799
Atwell Island WD	3.7	3.3	15,422	15,003
Hills Valley ID	3.1	3.0	7,153	10,174
Kern-Tulare WD	3.1	2.9	38,905	47,790
Pixley ID	3.5	3.1	213,124	206,007
Rag Gulch WD	2.8	3.0	13,657	17,248
Tri-Valley WD	3.2	3.5	2,651	3,065
Friant Unit (average or total for above districts):	3.1	3.2	2,988,377	3,235,956

Source: USBR 2000 and WSOT detailed comments, July 31, 2002.

ND = no data on crop acreage

Appendix B
Gaming Model

Appendix B

Gaming Model

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Gaming Model

Model Description

The process of Friant gaming involves using an interactive spreadsheet to route water to various uses and demands. The model requires the gamer to make decisions for where and how much water is to be routed, and then accounts for the decision by tracking its affect through the rest of the modeled system. The gamers' operation is compared to a baseline operation. Historical operations and delivery data from 1981 through 1994 are used as the background trace of operations for the model. All operational decisions are made by the gaming participants through interactive input to the model. Changes in operations made by the gaming participants are measured against the historical trace.

The Friant Gaming Model depicts the affected area and facilities shown in Figure 1. The model was constructed to illustrate various mechanisms that could offset the potential diversion supply impact resulting from an increased release of flows to the San Joaquin River from Millerton. These mechanisms include the downstream recapture of restoration flows, utilization of excess flows, or alternative management of existing supplies.

The imbalance between supplemental restoration flows to the San Joaquin River and water needed to maintain the baseline diversion supply manifests itself within Millerton storage. Imbedded in the model is a baseline trace of operations that currently represents recorded historical operations for the Friant Division, inclusive of historical canal diversions, Millerton storage, releases to the river, and all of the intricacies/anomalies that affected that record. As a gaming decision is made for releases to the river, the historical diversion to the canals is maintained and the change in river release (from that occurring in the baseline) equates to a change from the historically recorded Millerton storage. Without further action by the gamer, the changes in release and their affect on Millerton storage would trickle into subsequent months, potentially fully depleting Millerton storage.

The objective of the game could be the provision of assumed restoration flows while maintaining the baseline diversion supply. Accomplishing this objective could require the exercise of mechanisms that will in effect reduce the amount of baseline diversion supply that is needed from Millerton, and in subsequent effect return water to storage in Millerton. Success can be measured by the ability to assure an active Millerton storage level.

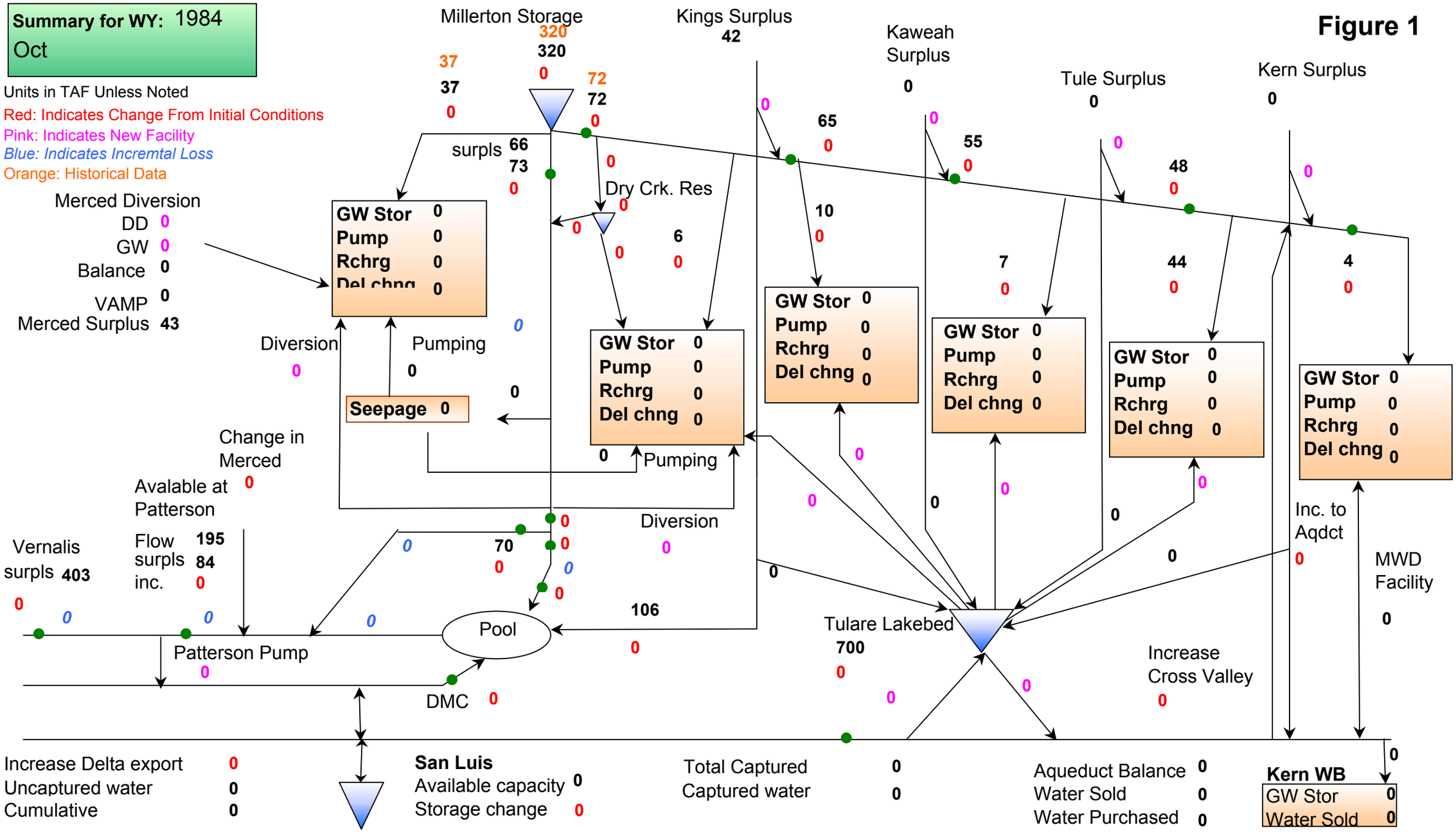
Mechanisms that are available to offset the diversions from Millerton generally derive their water supply from either 1) releases from Millerton to the San Joaquin River, and other flows tributary to the San Joaquin River and Delta, or 2) releases from the Tulare Lake Basin tributaries that have historically overflowed from the basin or have flooded the Tulare Lakebed. These flows can be either used directly (within the same month) to offset the Millerton diversion demands or be regulated through storage for subsequent diversion demand offset. Mechanically, the model returns storage to Millerton in a month that diversion demand is offset.

Regarding the re-capture/utilization of flows from the San Joaquin River, water can be diverted below Gravelly Ford for direct demand offset or for storage to a groundwater basin (for

Summary for WY: 1984
Oct

Units in TAF Unless Noted
Red: Indicates Change From Initial Conditions
Pink: Indicates New Facility
Blue: Indicates Incremtal Loss
Orange: Historical Data

Figure 1



subsequent direct demand offset). The incremental recharge due to the change in river flow is tracked, and is available for direct demand offset. The potential impact to Mendota Pool water users from changes in San Joaquin River flows (and Kings River overflows) is also tracked.

Below the Mendota Pool, incremental flows in the San Joaquin River are tracked along with assumed surplus flows from Merced River for potential diversion at a Patterson Pumping Facility. Remaining incremental flow and surplus flows below Patterson enter into the balance of flows that may still be available for diversion from the Delta. If diverted at Patterson or the Delta, flow is available to either provide direct diversion offset via conveyance through the California Aqueduct and Cross Valley Canal to the lower reach demands of the Friant-Kern Canal, or be regulated by San Luis Reservoir, Tulare Lakebed or groundwater storage basins for subsequent direct diversion offset.

Tulare Lake Basin tributary surplus flows can be either intercepted at their crossings of the Friant-Kern Canal and routed to storage opportunities, or be routed/stored in Tulare Lakebed for subsequent use. Millerton releases can be routed to Big Dry Creek Reservoir for storage, and subsequent release to the San Joaquin River or for direct demand offset.

Merced River surplus flows and controlled releases for VAMP can be routed into the Madera Canal service area for interaction with Millerton storage. A simplistic cumulative balance of changes in Merced River operations is maintained, and implied flow changes are tracked downstream.

Water balances are maintained at various locations, such as the cumulative incremental storage in groundwater basins and the “unutilized” balance of water within the California Aqueduct conveyance. The structure of the model and its many elements of conveyance, storage and demand lends itself to being potentially capable of surrogating many mechanisms not plainly identified by the schematic. For instance, conservation or water purchases could be addressed by modifying the baseline demand or by using one of the “groundwater” basins as a surrogate supply. Southern California reservoir storage could be surrogated by the California Aqueduct conveyance balance.

The model is essentially “unconstrained”. Gamers can make decisions and input volumes of water that could be infeasible or violate known hydrologic conditions, constraints or the physical characteristics of facilities. Within the model various hydrologic parameters such as available flow and storage balances are provided as guidance to the decision making process. Additional “cheat sheets” are also relied upon to provide guidance. The unconstrained nature of the model allows gamers to try-out “what-ifs” in terms of incremental changes to a baseline. Later analysis can determine if the incremental change is facilitated with existing facilities or requires incremental enhancements to facilities.

Model Structure

The Friant gaming process involved making changes to the models as ideas and questions arose throughout the gaming process. Included in electronic form is the latest version of the gaming model. This version of the model incorporates model accounting logic and decision opportunities that existed at the end of the gaming sessions, October 2, 2001. Also included is a separate spreadsheet that was developed to illustrate the Delta operation from EWA game 6A. This operation was used to estimate the windows of opportunity to export restoration flows from the Delta. The Delta information was preliminary at the time of gaming and was subsequently updated for the long–term simulation modeling.

The gaming model consists of a multi-sheet Excel workbook. Each worksheet serves a computational, conversion, data reporting or input function. Each sheet's purpose is listed below.

Worksheet Name	Worksheet description
Surplus	Graph charts displaying annual gaming results
Bal	
Chart1	
incr_q	
Millerton	
Pool	
Pow	
Stor	
Chart	Gaming model schematic (Displays a month of operation)
Model	Gaming Model (Main logic sheet)
graph data	Monthly data for year being gamed
Base	Initial gaming condition (Baseline data)
graph data base	Monthly data for year being gamed (Baseline data)
Dif	Monthly difference between model with gaming conditions and initial conditions (*model results* minus *baseline*)
graph data dif	Monthly data for year being gamed of *dif*
Convert	Conversion between 1,000 AF to cfs units
Lookup	Contains lookup data used for gaming model
Power	Contains data to calculate power usage
Daily	NOT Used - converts data from monthly to daily units

The Model Worksheet

This worksheet contains the equations and logic that perform the actual gaming exercise. The equations used to perform the model accounting are documented at the end of this document. The model worksheet is separated into the following sections:

- Millerton Reservoir
- San Joaquin River - Friant to Gravelly Ford
- SJR Bifurcation to Sack Dam
- Madera Canal
- Merced and SJR to Patterson
- Delta and CVP/SWP South of Delta
- Lakebed operation
- San Luis incremental operation
- Fraint-Kern Canal (Friant to Kings R.)
- Fraint-Kern Canal (Kings R. to Kaweah R.)
- Fraint-Kern Canal (Kaweah R. to Tule R.)
- Fraint-Kern Canal (Tule R. to Kern)
- Fraint-Kern Canal (Kern and South)
- Kern Water Bank
- Ground Water
- Summary and graph data
- Power Estimates

Millerton Reservoir

This portion of the model calculates Millerton storage by comparing reservoir inflow with canal and river releases and evaporation. River releases are determined by the gaming participants and directly input to the model. Releases to Madera and Friant-Kern canals are calculated by the model by meeting all the demands that are not met by project alternatives. For example, if groundwater pumping is increased by 50 TAF in the Friant service area then canal releases from Friant Dam will be decreased by 50 TAF.

Millerton Reservoir is the focal point of the gaming model, the storage in Millerton is used an indicator of the adequacy of the operation. Increases in Friant releases will result in lower Millerton storage while delivery to the Friant service area from alternative water supply sources will result in an increase in Millerton storage. If Millerton reservoir falls below acceptable levels, it is an indication that the increased burden on Millerton is greater than the water generated from the project alternatives. Conversely, if Millerton storage is higher than historical levels, then project alternatives may have generated more water than is necessary to satisfy restoration flows.

San Joaquin River - Friant to Gravelly Ford

This portion of the model maintains a mass balance, or water accounting, for the San Joaquin River from Friant to Gravelly Ford. There is a separate account for increased seepage due to increases or decreases in San Joaquin River flow. The incremental flow, model flow minus historical flow, is maintained in a separate account and is used to calculate the incremental seepage to ground water.

SJR Bifurcation to Sack Dam

This section of the model maintains a water budget for the San Joaquin River from Gravelly Ford to the Sack Dam. Changes in San Joaquin River flow, James Bypass flow, and Delta Mendota Canal (DMC) flow are all accounted to maintain a water budget. Incremental losses and seepage are also included in the accounting. A separate account is maintained for changes in DMC flow to estimate changes to the CVP water supply south of the Delta.

Madera Canal

Historical Madera Canal deliveries from Friant are used as the demand for this service area. The model decreases Madera Canal flow at Friant when alternative water supply sources are used to satisfy this demand, or increases Madera Canal flow to bank water to the groundwater basin. Alternative water supply sources for the Madera Canal service area include conjunctive use and Merced River surplus and VAMP releases.

Merced and SJR to Patterson

This section of the model includes Merced River releases for VAMP, reservoir spills from Exchequer and the operation of the San Joaquin River to Patterson. Merced River release for VAMP can be exchanged for Friant releases. Delivery of the Merced River VAMP water or reservoir spills can be made to the Madera Canal service area when capacity is available. A pumping facility at Patterson can be used to capture restoration and surplus flow from the San Joaquin River.

Delta and CVP/SWP South of Delta

An separate spreadsheet containing information from EWA Delta game 6A is used to estimate the capacity and timing of available pumping potential at the CVP/SWP export pumps. This capacity is at times used to recapture restoration and surplus flows. The model displays the total volume of recaptured water in the section. The gaming participants also input the destination of the recaptured water in this section.

Lakebed Operation

The operation of the Tulare Lakebed is input and accounted in this section of the model. Decisions on tributary flow to the Lakebed and releases from the Lakebed to the Aqueduct and Cross Valley Canal are input and the resulting storage is calculated by the model.

San Luis Incremental Operation

The baseline storage operation of San Luis Reservoir was extracted from the EWA Delta Game 6A. Recaptured restoration flows are allowed to be stored in the unused portion of San Luis Reservoir.

Friant-Kern Canal

Delivery operations of the Friant-Kern Canal are separated into 5 sections in the model:

- Friant to Kings R.
- Kings R. to Kaweah R.
- Kaweah R. to Tule R.
- Tule R. to Kern R.
- From Kern to South

Each Friant-Kern Canal section is addressed in a similar fashion. Friant-Kern Canal historical deliveries are used as demands in the model. When the operations of a canal section are changed, diversions from Friant Dam are correspondingly changed.

Water supply made available from various project alternatives may only be available for a portion of the Friant-Kern Canal service area depending on the geographic location of the water supply source. For example, water supply from the Tulare Basin tributaries is only available in canal locations that are downstream, or down-canal, from the intersection of the specific tributary and the canal. Delivery from the Cross Valley Canal can only be made to Friant water users that are south of the Kern River or in the lower reach of the Friant-Kern Canal between the Tule and Kern Rivers.

Kern County Bank

This section of the code accounts for recaptured water stored in and pumped from a ground water bank in Kern County.

Summary and Graph Data

This section contains data for graphing purposes.

Power Estimates

This section contains estimated power usage (preliminary and unchecked).

Model Files

Name	Size	Type	Last Modified
gaming_model.xls	6,832KB	Microsoft Excel Worksheet	10/2/01 7:43 AM

Interactive Model Logic

Row Number	Row Title	Initial Condition	Formulas and Data
7	**Millerton Reservoir**		
8	Inflow		74
9	Release to SJR		=4.8
10	Friant release to SJR (cfs)		=+C9/[Friant_game_100101.xls]convert!C1
11	Calculated required release		=MAX((+C41-C40-C39),C13)
12	Incremental flow below Friant		=+C9-[Friant_game_100101.xls]base!C9
13	Minimum Friant Release to SJR		=+C22-C23
14	Minimum Friant Release to SJR (cfs)		
15	Flow above minimum (surplus)		=+C9-C11
16	Madera Canal Release (taf)		=+C82
17	Friant-Kern Canal Release (taf)		=+C168+C169
18	Evaporation rate (inches)		4
19	Evaporation		=IF(B20>0,(-1.77*B20+455.4*(B20^0.5)-566.62*(B20^0.333333)+1.19)*C18/12/1000,0)
20	Millerton Storage	288	**=+B20+C8-C9-C16-C17-C19**
21	Maximum storage, flood rule		=520.5-85
22	Minimum River flow for restoration		0
23	Increase flow from Big Dry Creek Reservoir		0
24			
25	Historical Friant Kern Canal		117
26	Historical Madera Canal		33
27	Historical Millerton storage		206
28			
29	**San Joaquin River - Friant to Gravelly Ford**		
30	Incremental depletion	5%	=(-C12-C23)*$B30
31	Deep Percolation from River Flow (% of incremental loss)	80%	=-C30*$B31
32	Increase GW recharge north of River (Can reduce Madera Canal diversion)		=+C31/2
33	Increase GW recharge south of River (Can reduce Friant-Kern Canal diversion)		=+C31-C32
34	GW storage north of River	0	=+B34+C32-C35-C92+C60-C62
35	GW loss north of River (% of Recharge)	10%	=+C32*$B35
36	GW storage south of River	0	=+B36+C33-C37-C189+C61-C63
37	GW loss south of River	10%	=+C33*$B37
38	Total GW storage due to SJR recharge		=+C34+C36
39	Total GW recharge due to SJR recharge		=+C31+C59
40	Depletion, diversions (Friant to Gravelly Ford)		-5
41	Required flow at Gravelly Ford (taf)		=[Friant_game_100101.xls]convert!C1*C42
42	Required flow at Gravelly Ford (cfs)		0
43	Flow at Gravelly Ford		=+C9+C30+C40+C23
44	Diversion north of river for DD		0
45	Diversion north of river for GW		0
46	Total diversion to north of river		=+C45+C44
47	Diversion south of river for DD		0
48	Diversion south of river for GW		0
49	Total diversion to south of river		=+C48+C47
50	Flow below Gravelly Ford		=+C43-C46-C49
51	Incremental Flow		=+C12+C30+C23-C46-C49
52	Historical flow to Chowchilla bypass		0
53	Flow increment to Chowchilla bypass		0
54	Flow increment below bypass, inflow to pool		=+C51-C53
55	Flow increment below bypass, inflow to pool (cfs)		=+C54/[Friant_game_100101.xls]convert!C1
56			
57	**SJR Bifurcation to Sack Dam**		
58	Incremental losses (Gravelly Ford to Pool)	5%	=-C54*$B58
59	Deep Percolation from River Flow (% of incremental loss)	80%	=-C58*$B59
60	Increase GW recharge north of River (Can reduce Madera Canal diversion)		=+C59/2
61	Increase GW recharge south of River (Can reduce Friant-Kern Canal diversion)		=+C59-C60
62	GW loss north of River	10%	=+$B62*C60
63	GW loss south of River	10%	=+$B63*C61
64	Remaining SJR incremental flow		=+C54+C58
65	Remaining SJR incremental flow (cfs)		=+C64/[Friant_game_100101.xls]convert!C1
66	Tulare Lake basin overflow, James Bypass (base condition)		0
67	Tulare Lake basin overflow, James Bypass		=+C66+C206
68	San Joaquin River at Bifurcation (base condition)		0.1
69	Revised surplus plus incremental flow available to divert at pool		=+C66+C64+C68+C206
70	Surplus diverted under base (including Sack Dam diversion)		0
71	Ability to divert additional surplus (demand remaining)		61
72	Check if surplus is now less than surplus diverted under base		=MAX(+C70-C69,0)
73	Remaining surplus plus flow increment		=+C69-C70
74	Additional diversions of SJR flow		0
75	Change in DMC inflow		=-C74+C72+C137
76	Cumulative Pool offset		=+B76+C75-C137
77	Incremental losses (Pool to Merced)	0%	=-(+C64-C74)*$B77
78	Flow increment above Merced River		=+C64-C74+C77+C206
79	Flow increment above Merced River (cfs)		=+C78/[Friant_game_100101.xls]convert!C1
80			
81	**Madera Canal**		

82	Madera Canal at Head		=+C87
83	Madera Canal at Head (cfs)		=+C82/[Friant_game_100101.xls]convert!C$1
84	Base Canal Demand		33
85	Total Diversion (gw+canal)		33
86	Delivery change		=-C84+C85
87	Canal diversion		=(+C85-C93-C94-C92-C44)+C88
88	Canal diversion to GW		=+C319
89	GW storage	0	=+B89+C88+C95-C90-C93+C45
90	GW loss	10%	=+(C88+C95+C45)*$B90
91	GW recharge		=+C95+C88+C45
92	Increase GW pumping from SJR recharge		0
93	Increase GW pumping		=MIN(C318,C85)
94	Increase supply from Merced ID for DD		0
95	Increase supply from Merced ID for GW		0
96	Merced ID Balance		=+B96-C103-C94-C95
97			
98	**Merced and SJR to Patterson**		
99	Flow increment head of Chowchilla bypass		=+C53
100	Losses in Chowchilla bypass	0%	=-C99*$B100
101	SJR Incremental flow above Merced		=+C99+C100+C78
102	Merced Release for VAMP		0
103	Change in Merced River flow		0
104	SJR Incremental flow below Merced		=+C101+C103
105	SJR flow at Patterson (base)(with May VAMP 1981-1992)		41
106	Merced River available surplus		0
107	Losses (Merced River to Patterson)	10%	=-$B107*C104
108	Incremental flow available at patterson		=+C104+C107
109	SJR surplus at Vernalis (base)		0
110	SJR surplus at Vernalis		=+C109+C118
111	SJR Available surplus flood flow (Merced plus surplus at Pool)		=MIN(C109,C106+C73)
112	SJR Available surplus flood flow (Merced plus surplus at Pool) (cfs)		=+C111/[Friant_game_100101.xls]convert!C$1
113	**Available for recirculation/capture**		=+C104+C111+C107
114	Available for recirculation/capture (cfs)		=+C113/[Friant_game_100101.xls]convert!C$1
115	Available pumping capacity at Patterson		9999
116	Available Capacity at O'Neill (cfs)		1000
117	Diversion for recirculation		0
118	Incremental flow below Patterson		=+C104-C117+C107
119			
120	**Delta and CVP/SWP South of Delta**		
121			
122	Incremental losses (Patterson to Vernalis)	10%	=-$B122*C118
123	Incremental Flow in Delta (Vernalis)		=+C118+C122
124	Available Delta Water Supply		=+C123
125			
126	Available Capacity at O'Neill (cfs)		1000
127	Available Capacity at O'Neill		=+C126*[Friant_game_100101.xls]convert!C1
128	Uncaptured water		=+C124-C130
129	Uncaptured water (cumulative)		=+B129+C128
130	Increase Delta Export		0
131	Losses	3%	
132	Available flow for diversion		=(+C130+C117)-(+C130+C117)*($B131)+C74
133	Water Purchase		0
134	Water sold		0
135	Maximum potential demand for DD offset (Cross Valley and others)		=+C262/2+C291
136	Diversion for DD offset (to CVC)		0
137	Diversion for DD offset to Pool		0
138			
139	Remaining Available flow for diversion to storage		=+C132-C136-C137
140	Captured water diverted to Tulare Lakebed		0
141	Captured water diverted to CVC for GW		0
142	Captured water diverted to San Luis		0
143			
144	Remaining Available flow for diversion		=+C139-SUM(C140:C142)
145	Total to CVC		=+C141+C136+C153+C162+C164
146	Total capture/recapture		=+C136+C137+C140+C141+C142
147			
148	**Lakebed operation**		
149	Total flow to Lakebed (without tribs)		=+C140+C163
150	Available Tulare tribs flood flow		=+C203+C228+C258+C287
151	Tulare tributary flood flow to Lakebed		0
152	Release to Aqueduct		0
153	Release to cross valley canal		=+C304+C303
154	Total flow to Aqueduct		=+C153+C152
155	Tulare Lakebed Storage	0	=+B155+C151-C152-C157+C140+C163-C219-C250-C276-C305-C193
156	Evaporation rate (inches)		5
157	Evaporation		=MIN(B155,MAX(0,VLOOKUP(B155,[Friant_game_100101.xls]lookup!$L$4:$M$70,2)/1000*C156/12))
158			
159	**San Luis incremental operation**		

160	Incremental storage capacity		1135
161	San Luis Incremental storage	0	=+B161+C142-SUM(C162:C165)
162	Storage release to DD offset		0
163	Storage release to lakebed		0
164	Storage release to CVC GW		0
165	Spill or release to Aqueduct		0
166			
167	**Fraint-Kern Canal (Friant to Kings R.)**		
168	Friant-Kern Canal Release (taf)		=+C188+C194+C215+C220+C243+C251+C267+C296+C280-C170+C297+C171
169			
170	Diversion of trib. surplus into canal		=+C202+C227+C257+C286
171	Canal Diversion to Big Dry Creek Reservoir		0
172			
173	Big Dry Creek Reservoir Storage	0	=+B173+C171-C174-C178-C177
174	Big Dry Creek Reservoir Evaporation		=(+B173/50)*C$18/12
175	Big Dry Creek Reservoir Release to GW		0
176	Big Dry Creek Reservoir Release for direct diversion		0
177	Big Dry Creek Reservoir Release to SJR		=+C23
178	Total Dry Creek Reservoir release to demand center		=+C176+C175
179	Canal diversion to GW		=+C319
180			
181	GW storage	0	=-C182-C190+B181+C183
182	GW loss	10%	=+B182*C183
183	GW recharge		=+C179+C175+C48+C192
184	Base Canal Demand (Friant to Kings)		11
185	Total Diversion for Demand		=+C184
186	Delivery change		=-C184+C185
187	Friant-Kern Canal diversion for demand		=+C185-C190-C176-C47-C191
188	Total Friant-Kern Canal diversion (DD plus GW)		=+C187+C179
189	Increase GW pumping from SJR recharge		0
190	Increase GW pumping		=MIN(C318,C185)
191	Diversion from Tulare Lakebed to DD		0
192	Diversion from Tulare Lakebed to GW		0
193	Total from Lakebed		=+C192+C191
194	Canal Losses		0
195	Canal Flow above Kings River		=+C168+C169-C171-C179-C187+C180-C194
196			
197	**Fraint-Kern Canal (Kings R. to Kaweah R.)**		
198	Surplus Available from Kings River (flow to Lakebed)		0
199	Total surplus available (includes unused spills to Pool and Vernalis)		=MIN(C66,C66+C68-C70,C109)+C198
200	Canal Flow		=+C168+C169-C171-C179-C187
201	Canal Available capacity (5000 cfs)	5000	=$B201*[Friant_game_100101.xls]convert!C1-C200
202	Diversion of Kings River surplus		0
203	Kings surplus to Lakebed		=IF(C202>C198,0,C198-C202)+C205
204	Canal Flow downstream from Kings River		=+C202+C200
205	James bypass flow to Lakebed		0
206	Change in Kings river flow to James Bypass		=IF(C202>C198,-(C202-C198),0)-C205
207	Base Canal Demand (Kings to Kaweah)		16
208	Total Diversion		=+C207
209	Delivery Change		=-C207+C208
210	Friant-Kern Canal diversion for demand		=+C208-C216-C217
211	Canal diversion to GW		=+C319
212	Total GW recharge		=+C211+C218
213	GW storage	0	=+B213+C212-C216-C214
214	GW loss	10%	=+C212*$B214
215	Total Friant-Kern Canal diversion (DD plus GW)		=+C211+C210
216	Increase GW pumping		=MIN(C318,C208)
217	Diversion from Tulare Lakebed to DD		0
218	Diversion from Tulare Lakebed to GW		0
219	Total from Lakebed		=+C218+C217
220	Canal Losses		0
221	Canal Flow above Kaweah River		=+C204-C210-C211-C220
222			
223	**Fraint-Kern Canal (Kaweah R. to Tule R.)**		
224	Surplus available from Kaweah River		0
225	Canal Flow		=+C221
226	Available capacity	4000	=$B226*[Friant_game_100101.xls]convert!C1-C225
227	Diversion of Surplus		0
228	Kaweah River surplus to Lakebed		=+C224-C227
229			
230	Flow downstream from Kaweah River		=+C227+C225
231			
232	Canal Diversion to Yokohl Reservoir		0
233			
234	Yokohl Reservoir Storage	0	=+B234+C232-C235-C236
235	Yokohl Reservoir Evaporation		=(+B234/50)*C$18/12
236	Yokohl Reservoir Release into Canal		0
237			
238	Base Canal Demand		11

239	Total Diversion		=+C238
240	Delivery change		=-C238+C239
241	Friant-Kern Canal diversion for demand		=+C239-C247-C248
242	Canal diversion to GW		=+C319
243	Total Friant-Kern Canal diversion (DD plus GW)		=+C242+C241
244	Total GW recharge		=+C242+C249
245	GW storage	0	=+B245+C244-C247-C246
246	GW loss	10%	=+C244*$B246
247	Increase GW pumping		=MIN(C318,C239)
248	Diversion from Tulare Lakebed to DD		0
249	Diversion from Tulare Lakebed to GW		0
250	Total from Lakebed		=+C249+C248
251	Canal Losses		0
252	Flow above Tule River		=+C230-C232+C236-C241-C242-C251
253			
254	**Fraint-Kern Canal (Tule R. to Kern)**		
255	Surplus Available from Tule R.		0
256	Available capacity	4000	=$B256*[Friant_game_100101.xls]convert!C1-C252
257	Diversion of Surplus		0
258	Tule River Surplus to Lakebed		=+C255-C257
259			
260	Canal flow downstream from Tule River		=+C257+C252
261			
262	Base Canal Demand		56
263	Total Diversion		=+C262
264	Delivery change		=-C262+C263
265	Friant-Kern Canal diversion to demand		=+C263-C273-C274-C278
266	Canal diversion to GW		=+C319
267	Total Friant-Kern Canal diversion (DD plus GW)		=+C266+C265
268			
269	Recharge capacity		99
270	Delta water diversion to GW		=MIN(C269,C141-C299)
271	GW storage	0	=+B271-C273-C272+C277
272	GW loss	10%	=+$B272*C277
273	Increase GW pumping		=MIN(C318,C263)
274	Diversion from Tulare Lakebed to DD		0
275	Diversion from Tulare Lakebed to GW		0
276	Total from Lakebed		=+C275+C274
277	Total recharge		=+C266+C270+C275
278	Incremental increase direct diversion (Cross Valley and all others)		=MIN(C262,C136-C307)
279	Incremental increase diversion from Cross Valley (cfs)		=+C278/[Friant_game_100101.xls]convert!C1
280	Canal Losses		0
281	Flow above Kern River		=+C260-C265-C266-C280
282			
283	**Fraint-Kern Canal (Kern and South)**		
284	Surplus Available from Kern		0
285	Available capacity	2500	=$B285*[Friant_game_100101.xls]convert!C1-C281
286	Diversion of Surplus		0
287	Kern River Surplus to Lakebed		=+C284-C286
288			
289	Aqueduct to AE south Canal GW		0
290			
291	Base Canal Demand		23
292	Total Diversion		=+C291
293	Delivery change		=-C291+C292
294	Friant-Kern Canal diversion for demand		=+C292-C302-C303-C307-C162
295	Canal diversion to GW		=+C319
296	Total Friant-Kern Canal diversion (DD plus GW)		=+C295+C294
297	Increase Canal diversion to Aqueduct (thru cross valley or intertie)		0
298	Recharge capacity		8
299	Delta water diversion to GW		=MIN(C298-C295,C141)
300	GW storage	0	=+B300-C301-C302+C306
301	GW loss	10%	=+$B301*C306
302	Increase GW pumping		=MIN(C318,C292)
303	Diversion from Tulare Lakebed for DD		0
304	Diversion from Tulare Lakebed for GW		0
305	Total from Lakebed		=+C304+C303
306	Total recharge		=+C295+C299+C304+C164+C289
307	Delta Incremental increase direct diversion (Cross Valley and all others)		=MIN(C292,C136)
308	Delta Incremental increase diversion from Cross Valley (cfs)		=+C307/[Friant_game_100101.xls]convert!C1
309			
310	**Kern Water Bank**		
311	Aqueduct diversion to KWB		0
312	Water sold to KWB		0
313	Storage in KWB	0	=+B313+C311-C312-C314
314	Kern Water Bank to Aqueduct		0
315	Net change to Aqueduct		=-C314+C311
316			
317	**Ground Water**		

318	Pumping at all demands centers		0
319	Recharge at all demand centers		0
320			
321			
322	**Summary and graph data**		
323	Ground water storage		=+C89+C181+C213+C245+C271+C300+C38
324	Available Tulare Basin Surplus		=+C198+C224+C255+C284
325	rediversion		=-C136-C137
326	Total increased GW pumping		=-(+C93+C190+C216+C247+C273+C302)
327	Increase supply from Merced ID for DD		=-C94
328	Diversion from Tulare Lakebed to DD		=-(C248+C274+C303)
329	Big Dry Creek Reservoir Release for direct diversion		=-C176
330			
331	Balance		=-C12-SUM(C326:C329)+B331+C136+C137
332	Aqueduct Balance		=+C144+C152+C297+B332+C165-C311-C134+C314-C289+C133
333			
334			
335			
336			
337	**Power Estimates**		
338	**Millerton**		
339	Millerton elevation	0.87	=0.06503*B20-6.43193*B20^0.5+53.65131*B20^(1/3)+258.837
340	Friant-Kern Canal Generation	-472	=IF(C$339>495,(+C$339+$B340)*$B$339,0)*(MIN(C17,3000*[Friant_game_100101.xls]convert!C$1))
341	Madera Canal Generation	-448	=IF(C$339>482,(+C$339+$B341)*$B$339,0)*(MIN(C16,1200*[Friant_game_100101.xls]convert!C$1))
342	River Release	-309	=IF(C$339>347,(+C$339+$B342)*$B$339,0)*(MIN(C9,150*[Friant_game_100101.xls]convert!C$1))
343		-1.36	
344	Pump-out to Friant-Kern Canal	475	=IF(C$339<470,(+$B344-C$339)*$B$343,0)*C17
345	Pump-out to Madera Canal	451	=IF(C$339<446,(+$B345-C$339)*$B$343,0)*C16
346			
347	**Re-capture/Capture Pumping**		
348	Lower SJR to Adjacent Basins	-127	=(+C46+C49)*$B348
349	Patterson to O'Neill	-300	=+C117*$B349
350	Delta to O'Neill	-300	=+C130*$B350
351	O'Neill through CVC to FK Canal	-324	=(+C145-C153)*$B351
352	O'Neill to Tulare Lakebed	-150	=+C140*$B352
353			
354	**Tulare Lakebed Regulation Pumping**		
355	Tulare Lakebed Through CVC to FK Canal	-361	=+C153*$B355
356	Tulare Lakebed to Kings-Kaweah Demand	-127	=+C217*$B356
357	Tulare Lakebed to Kaweah-Tule Demand	-127	=+C248*$B357
358			
359	**San Luis Reservoir Pumping/Generation**		
360	Storage	901	901
361	Pumping		=VLOOKUP(B$360,[Friant_game_100101.xls]lookup!$Q$8:$S$17,2)*C142
362	Generation		=VLOOKUP(C$360,[Friant_game_100101.xls]lookup!$Q$8:$S$17,3)*SUM(C162:C165)
363			
364	**Groundwater Extraction**		
365	Madera Basin	-250	=+(C93+C92)*$B365
366	Friant-Kings Basin	-250	=(+C189+C190)*$B366
367	Kings-Kaweah Basin	-250	=+C216*$B367
368	Kaweah-Tule Basin	-250	=+C247*$B368
369	Tule-Kern Basin	-250	=+C273*$B369
370	Kern-South Basin	-250	=+C302*$B370
371			
372	**East-side Tributary Pump-in**		
373	Kings River	-34	=+C202*$B373
374	Kaweah River	-27	=+C227*$B374
375	Tule River	-29	=+C257*$B375
376	**Energy Summary**		
377	Energy Generation		\\\\
378	Energy Consumption		=+C344+C345+SUM(C348:C352)+SUM(C355:C357)+C361+SUM(C365:C370)+SUM(C373:C375)
379	Net Energy		=+C378+C377
380	Cumulative net energy		=+B380+C379

Appendix C
Long-Term Model Development/Documentation

Section 1. Baseline Operation Model
Section 2. Long-Term Operation Simulation Model

Appendix C

Section 1
Baseline Operation Model

Appendix C

Section 1
Baseline Operation Model

Model Purpose and Description

The basic operational requirement of the long-term modeling is to meet the demands for both restoration of the river and Friant-related water deliveries to Friant water users. Irrigation deliveries vary from year to year based on an annually variable water supply. The task of synthesizing a long-term depiction of water deliveries requires the development of a baseline operation model for the Friant Division that combines current operational objectives for water supply and flood control with water demands from the Friant water users. These demands have been developed for the hydrologic period 1922 through 1999. The long-term model includes delivery of water to Friant water users as a demand to be met with either Millerton Lake water supply or other mechanisms.

The baseline operation model used to simulate the current operation of the Friant Division is a spreadsheet tool. Input to the model for operations upstream of Millerton Lake is consistent with the "Base Plan" results described in *Evaluation of Potential Increases in Millerton Lake Water Supply Resulting from Changes in Upper San Joaquin River Basin Projects Operation, Phase 2* (Reclamation 2000). Flood control operations for Millerton Lake and the lower San Joaquin River are based on the rainflood space reservation requirements specified by the U.S. Army Corps of Engineers (USACE). The flood control operation during the snowmelt runoff period recognizes the competing objectives of water supply and flood control (the operation attempts to maximize water supply carry-over storage while minimizing the potential for downstream flooding). Minimum required releases below Friant Dam for riparian and prior-right users are modeled as a constant annual requirement of 116,700 acre-feet distributed in a monthly pattern typical of historical operations.

The best representation of water demands on Millerton Lake would result from a comprehensive analysis that considers the consumptive use requirements of the Friant water users together with all of their available water resources. However, that form of analysis is beyond the scope of this assignment. Instead, the water deliveries developed by the baseline model mimic historical operations.

A review of the historical record of water deliveries from the Friant Division was conducted. The record of those deliveries is contained in a database maintained by Reclamation. The protocol of the database attempts to categorize the different classifications of water deliveries made through the Friant Division. The review found several anomalies within the data, some of which could be explained by changing practices of classification (or institutional changes in classifications) and others that were apparently data entry errors. Although questionable or possibly misinterpreted data were a problem, the review provided significant insight regarding the relationship between water supply availability and water delivery patterns for the Friant Division.

Most salient to this analysis are the data concerning monthly deliveries from the Friant-Kern Canal and the Madera Canal as water supply availability changes during a year. The data and analysis allowed development of a water delivery function based on water supply availability at Millerton Lake that is responsive to both flood control requirements and other considerations

within the basin that affect the delivery of water from the Friant Division (such as water availability from tributaries within the Tulare Lake Basin). Analysis also provided a coarse division of water deliveries between Class 1, Class 2, and other water classifications. Added to the synthesized water deliveries are canal losses that were developed through a comparison of historical water deliveries and canal diversions.

The water delivery function is integral to the development of a baseline operation for the Friant Division, and the operation of an alternative is compared against the baseline. The total canal diversions of a synthesized baseline operation for the Friant Division is illustrated in Appendix D, Section 1. Also shown are the historical canal diversions for the Friant Division. Most comparable are synthetic and recorded diversions after 1961. Prior to 1961, Friant water user facilities were not completely built out, and many of the facilities in the Tulare Lake Basin were incomplete.

The synthetic diversions are reflective of historical recorded operations and are termed “Base X Demands” for the purpose of this analysis. Currently these baseline canal deliveries are an issue. Within the record of the Base X Demands are deliveries that include a combination of flood flow diversions, deliveries of flood flows to non-Reclamation lands (but allowed by law), and other delivery exceptions. In consideration of these exceptions within the context of the analysis of alternatives, a “Base Y Demand” scenario was also synthesized to establish a range for the baseline Friant water users demand. The difference between the two levels of demands is the simulation of deliveries during times of flood operations at Millerton Lake. In the Base X Demand synthesis, when Millerton Lake is releasing to the river in excess of minimum requirements, additional water representing the availability of flood flows to Friant water users is included. In the Base Y Demand synthesis, this additional water is not included. The difference between the two baseline diversion levels is illustrated in Appendix D, Section 1.

In addition to the synthetic canal diversions, other baseline hydrologic parameters are required for the long-term model. The two baseline demands result in two different operations for the lower San Joaquin River. These two operations differ in terms of frequency and magnitude of simulated flows that at times reach the San Joaquin River–Chowchilla Bypass bifurcation. The changes in Millerton Lake operation affect the results used from other studies depicting San Joaquin River and Delta operations. Therefore, adjustments to the CALSIM II, SANJASM, and STANMOD hydrology were incorporated into the long-term model.

Description of Spreadsheet Model

The Baseline Model is designed to produce an existing condition simulation of the Friant Division. Historical hydrologic and meteorological data from water year 1922 through 1999 are imposed on the model’s representation of existing facilities and operation criteria to produce a simulation of operations over the entire hydrologic period.

The Baseline Model spreadsheet is comprised of several worksheets. The worksheet names, with a brief description, are presented in the following table. The major components of the spreadsheet are described in additional detail.

Worksheet Name	Worksheet description
Formulas	Model documentation: Formulas in "base_model"
base_model	Main model worksheet, contains delivery logic, flood control logic, Millerton simulation, and time series data for San Joaquin and Tulare Basins
del_dat	Contains data for water delivery logic
fld_rel_pat	Contains monthly patterns for snowmelt release volumes
adjustable graphic	Bar chart for display of 3-year time-series of results
adjustable graphic data	Generates table-formatted data from time-series data
data_proj_model	Baseline model data interface to Long-term Operation Simulation Model
Lookup	Lookup table data
Convert	Conversion of units between cfs to 1,000 AF

The Baseline Model Worksheet

This worksheet contains the equations and logic that perform the actual baseline simulation of the Friant system. The equations used to perform the simulation are documented on a separate worksheet ("Formulas") in the Baseline Excel spreadsheet and are contained included at the end of this document. The baseline worksheet is separated into the following sections:

- Delivery Logic
- Flood Control Logic
    - Rain Flood Logic
    - Snowmelt Logic
- Delivery Adjustments
- Millerton Operation
- San Joaquin River Basin Data
- Tulare Basin Data

<u>Delivery Logic</u>

Annual water deliveries for the Friant service area are determined in March of each year and updated monthly through June. The allocation is estimated by summing the total water available from storage and inflow and subtracting requirements and losses. The remainder is the water available for delivery. The following equation is used to estimate water delivery at any point during allocation season:

Water available for delivery:

= Sum current month through September Millerton inflow
+ Beginning of month Millerton Storage
- Millerton target (end of September) carryover storage
- Average current month through September evaporation
- Minimum Friant release to SJR for current month through September
- Losses for current month through September

Water is allocated to Class 1 and Class 2 deliveries based on the annual volume of available water. If the annual volume is less than the full Class 1 contract amount, Class 1 is set to the annual volume of available water. If the annual volume is greater than the Class 1 contract amount, Class 1 is set to full contract amount and the remainder is allocated to Class 2, up to the full Class 2 contract amount.

The monthly delivery patterns are based on the total annual volume of delivery. There are lookup tables in the model on the "del_dat" worksheet that contain monthly delivery patterns. Four lookup tables are used to determine monthly patterns for total delivery to the Friant-Kern

and Madera canals and Class 1 delivery to the Friant-Kern and Madera canals. Monthly Class 2 delivery is the difference between total deliveries and Class 1 deliveries. Deliveries determined using this logic are based solely on water supply availability at Friant without consideration of wetness in the Friant service area and delivery of flood control releases. Adjustments for these factors are made elsewhere in the model.

Flood Control Logic

The Millerton flood control operation in the model is based on the U.S. Army Corps of Engineers flood control manual. The amount of rainflood space required depends on the time of year, and rainflood releases are made in order to maintain this required space. During the heaviest precipitation months of November through January, 170,000 acre-feet of reserved space is maintained. In all months with a rainflood space requirement, the first 85,000 acre-feet is provided in Millerton. The next 85,000 acre-feet of rainflood space (if required) is allowed to be made in Mammoth Pool.

The conditional flood control space necessary to be made available in Millerton was determined for each month between February and May. This was done by making a forecast of the quantity of water anticipated to be spilled by the end of June. This forecast required an estimate of the available water supply and project deliveries through the end of June. The water supply forecast used perfect foresight to predict exactly the amount of Millerton inflow that would occur. The projected deliveries through the end of June were forecasted during each month. Using the water supply forecast, the delivery forecast, the current storage, and the end of June full reservoir storage target (520,000 acre-feet), the projected volume of spill through the end of June is computed. The projected spill volume is then distributed on a release schedule which is consistent with historical reservoir flood control operation. Large projected spills are spread out over as many months as necessary to avoid flooding downstream on the San Joaquin River, while the release of small projected spill volumes is deferred until their release is necessary in May or June. The flood control release made for a given month is the greater of the computed rainflood release and the conditional space release.

Delivery Adjustments

There are two adjustments made to deliveries after initial allocations are made with the delivery logic. One is based on wetness in the Tulare Basin and the other is based on flood control releases from Friant. Deliveries from the Friant-Kern canal are reduced when there is abundant surplus in the Tulare Basin tributaries. This is a surrogate of the reduction in deliveries that occurs when Tulare Basin water users are receiving flood flows from their local tributary projects. Conversely, deliveries to both the Friant-Kern and Madera Canals are increased when spills from Friant can be delivered. The model assumes an increased demand for water when Friant is spilling. The demand for surplus is a user defined input to the model. The increased flood flow demand logic will not occur during months when the Tulare Basin tributary logic reduces deliveries.

Millerton Operation

This section of the spreadsheet determines the state of Millerton Reservoir occurs. Millerton storage is updated based on inflow, deliveries, river releases, and evaporation by using a simple mass balance.

San Joaquin River Basin Data

This section of the spreadsheet contains river flow data and demands from the USBR SANJASM model. These data are used in the project model to identify recapture and surplus flow diversion opportunities. Because the operation of Millerton in this model is different than the operation generated by the SANJASM model, adjustments are made in this section for incorporation into the long-term model.

Tulare Basin Data

Surpluses to the Tulare Lakebed from the Kings, Kaweah, and Tule Rivers are contained in this section. These data are used in the long-term model when addressing project alternatives. Refer to Appendix A for the determination of surplus flows.

Interface Data from Baseline Model Long-term Model ("data_proj_model" worksheet)

This worksheet contains data that is transferred from the Baseline Model to the long-term. This data includes the Baseline simulation of Millerton including canal deliveries, and hydrologic data for the San Joaquin and Tulare Lake Basins. The following are the data that are transferred from the Baseline Model to the long-term model:

- Millerton Inflow
- Total Friant Release to SJR
- Total Canal Diversion
- Friant-Kern Canal Delivery
  - Losses
  - Class 1
  - Class 2
  - Other
- Madera Canal Delivery
  - Losses
  - Class 1
  - Class 2
  - Other
- Minimum Release (Depletion and/or diversions, Friant to Gravelly Ford)
- Flow at Gravelly Ford
- Tulare Lake Basin Overflow, James Bypass
- Mendota Pool Demand
- Flow below Mendota Pool
- DMC Flow to Pool
- Merced VAMP (May only)
- Merced River Surplus (with Vernalis check)
- Modified Surplus at Vernalis
- Modified SJR Flow below Merced River
- Adjusted Millerton Inflow w/o Fine Gold CreekTAF
- Fine Gold Creek Monthly Inflow TAF
- Kings River Surplus to Lakebed
- Kaweah River Surplus to Lakebed
- Tule River Surplus to Lakebed
- Mammoth Pool Storage

Model Files

Two separate versions of the Baseline Model exist and are both included in Appendix D, Section 1. The two versions of the model are the same except the results reflect the different assumption for flood flow deliveries (Base X demands vs Base Y demands) to the Friant-Kern and Madera Canals.

Base X Condition Model Heading and Logic

SECTION HEADING	SUBSECTION HEADINGS		COLUMN HEADING	COLUMN LETTER	SPREADSHEET FORMULAS
			Water Year Index	A	1922.1
			Water Year	B	1922
			Month Water Year	C	10
			Month contract year	D	5
			Month	E	Jul
DELIVERY LOGIC	Calculations for Annual Water Supply Allocation	Annual Water Supply Forecast	March	F	=IF($C20=6,SUM($CC20:$CC26)+$CJ19-$CJ$1-del_dat!B$22-SUM($CG20:$CG26)-del_dat!B$21,0)
			April	G	=IF($C20=7,SUM($CC20:$CC25)+$CJ19-$CJ$1-del_dat!C$22-SUM($CG20:$CG25)-del_dat!C$21,0)
			May	H	=IF($C20=8,SUM($CC20:$CC24)+$CJ19-$CJ$1-del_dat!D$22-SUM($CG20:$CG24)-del_dat!D$21,0)
			June	I	=IF($C20=9,SUM($CC20:$CC23)+$CJ19-$CJ$1-del_dat!E$22-SUM($CG20:$CG23)-del_dat!E$21,0)
			July through February	J	=IF($C20=10,+I19,IF(OR($C20>10,$C20<6),J19,0))
			Total	K	=SUM(F20:J20)
		Annual Class 1 Allocation	March	L	=MIN(F20,del_dat!$M$4)
			April	M	=MAX(0,MIN(G20,del_dat!$M$4-$AR19))
			May	N	=MAX(0,MIN(H20,del_dat!$M$4-$AR19))
			June	O	=MAX(0,MIN(I20,del_dat!$M$4-$AR19))
			July through February	P	=MAX(0,IF($D20=5,+O19-AO19,IF($D20>5,P19-AO19,0)))
			Total	Q	=SUM(L20:P20)
		Annual Available Surplus and Class 2 Allocation	March	R	=IF(D20=1,+F20-L20-MAX(0,BH20),0)
			April	S	=IF(D20=2,MAX(0,+R19-MAX(BC19-BN19,0)-(MAX(0,BJ20)-MAX(0,BH19))),0)
			May	T	=IF(D20=3,MAX(0,+S19-MAX(BC19-BN19,0)-(MAX(0,BL20)-MAX(0,BJ19))),0)
			June	U	=IF(D20=4,MAX(0,+T19-MAX(BC19-BN19,0)),IF(D20>4,MAX(0,+U19-MAX(BC19-BN19,0)),0))
			Total Available surplus	V	=SUM(R20:U20)
			Annual Class 2 allocation	W	=MIN($V20,del_dat!$M$5)
	Annual Water Supply Allocation Summary	Friant-Kern Delivery	Total	X	=+Y20+Z20
			Class 1	Y	=(+Q20+AR19)*del_dat!$E$12/100
			Class 2	Z	=+W20*del_dat!$F$12/100
		Madera Delivery	Total	AA	=+AB20+AC20
			Class 1	AB	=(+Q20+AR19)*del_dat!$E$10/100
			Class 2	AC	=+W20*del_dat!$F$10/100
		Total	Total	AD	=+X20+AA20
			Class 1	AE	=+Y20+AB20
			Class 2	AF	=+Z20+AC20
	Monthly Allocation		Monthly delivery distribution pattern index	AG	=IF(C20=6,VLOOKUP(AD20,del_dat!$A$71:$M$86,1),AG19)
		Friant-Kern Delivery	Total	AH	=VLOOKUP(AD20,del_dat!$A$31:$M$46,$D20+1)/100*(X20)
			Class 1	AI	=VLOOKUP(AG20,del_dat!$A$71:$M$86,$D20+1)/100*Y20
			Class 2	AJ	=+AH20-AI20
		Madera Delivery	Total	AK	=VLOOKUP(AD20,del_dat!$A$51:$M$66,$D20+1)/100*AA20
			Class 1	AL	=VLOOKUP(AG20,del_dat!$A$90:$M$105,$D20+1)/100*AB20
			Class 2	AM	=+AK20-AL20
		Total	Total	AN	=+AH20+AK20
			Class 1	AO	=+AI20+AL20
			Class 2	AP	=+AJ20+AM20
		Monthly Cumulative delivery	Total	AQ	=IF(D20=1,AN20,IF(D20<12,AQ19+AN20,0))
			Class 1	AR	=IF($D20=1,AO20,IF($D20<12,AR19+AO20,0))
			Class 2	AS	=IF($D20=1,AP20,IF($D20<12,AS19+AP20,0))
		Final Forecasted Delivery	Madera Canal Release at head	AT	=HLOOKUP($D20,del_dat!$B$17:$M$20,4)+AK20
			Friant-Kern Canal Release at head	AU	=HLOOKUP($D20,del_dat!$B$17:$M$20,3)+AH20
			Total Canal Diversion	AV	=+AT20+AU20

FLOOD CONTROL LOGIC	Rainflood Release		Allowable Millerton Storage - Rainflood Space	AW	=VLOOKUP($C20,lookup!$A$5:$D$16,4,FALSE)
			Required Flood Control Space	AX	=$AW$1-AW20
			Mammoth Storage	AY	91
			Mammoth Credit	AZ	=IF(AX20>85,MIN($AY$1-AY20,AX20-85),0)
			Updated - Required Millerton Space	BA	=AX20-AZ20
			Updated - Maximum storage, flood rule	BB	=$AW$1-BA20
			Rainflood Release	BC	=MAX(0,(+CJ19+CC20-AV20-CI20)-BB20)
	Snowmelt Release		Estimated Mon-Jun Millerton Evap.	BD	=HLOOKUP(D20,del_dat!$B$17:$M$23,7)
			Lookup index	BE	0
		February Forecast	Forecast Feb-Jun Spill	BF	=IF(C20=5,SUM(CC20:CC24)-del_dat!$M$25-SUM(CG20:CG24)-BD20+CJ19-$AW$1,BF19)
			Feb - Jun Snowmelt Release	BG	=IF(AND(BF20>0,C20>4,C20<10),VLOOKUP(BF20,fld_rel_pat!$A$29:$M$44,C20-3,TRUE)*BF20/100,0)
		March Forecast	Forecast Mar-Jun Spill	BH	=IF(C20=6,SUM(CC20:CC23)-del_dat!$B$25-SUM(CG20:CG23)-BD20+CJ19-$AW$1,BH19)
			Mar - Jun Snowmelt Release	BI	=IF(AND(BH20>0,C20>5,C20<10),VLOOKUP(BH20,fld_rel_pat!$A$75:$L$90,C20-4,TRUE)*BH20/100,0)
		April Forecast	Forecast Apr-Jun Spill	BJ	=IF(C20=7,SUM(CC20:CC22)-del_dat!$C$25-SUM(CG20:CG22)-BD20+CJ19-$AW$1,BJ19)
			Apr-Jun Snowmelt Release	BK	=IF(AND(BJ20>0,C20>6,C20<10),VLOOKUP(BJ20,fld_rel_pat!$A$117:$L$128,C20-5,TRUE)*BJ20/100,0)
		May Forecast	Forecast May-Jun Spill	BL	=IF(C20=8,SUM(CC20:CC21)-del_dat!$D$25-SUM(CG20:CG21)-BD20+CJ19-$AW$1,BL19)
			May-Jun Snowmelt Release	BM	=IF(AND(BL20>0,C20>7,C20<10),VLOOKUP(BL20,fld_rel_pat!$A$152:$L$160,C20-6,TRUE)*BL20/100,0)
			Monthly Snowmelt Release	BN	=IF(AND(C20>4,C20<10),VLOOKUP(BE20,BE20:BM20,BE20,FALSE),0)
			Total Flood Control Release (rain + snowmelt)	BO	=IF(C20=9,BC20,MAX(BC20,BN20))
DELIVERY ADJUSTMENTS			Fresno R. Index for Wet month delivery reduction	BP	2
			Madera Adjustment (decrease in delivery based on wetness)	BQ	0
			Tule R. Index (used as wetness index for entire basin)	BR	4
			Friant-Kern Adjustment (decrease in delivery based on Tulare basin wetness)	BS	=IF(BR20>40,MIN((BR20-40),AU20),0)
			Madera Canal Release (Reduced for wet conditions)	BT	=AT20-BQ20
			Frinant-Kern Release (Reduced for wet conditions)	BU	=AU20-BS20
			Available Madera Canal Flood Water	BV	=IF(AND(C20>1,C20<5),0,IF(BO20>0,MAX(0,MIN($BZ$1*(BO20-CG20),$BV$1*convert!D20)),0))
			Available Friant-Kern Canal Flood Water	BW	=IF(BO20>0,MAX(0,MIN($CA$1*(BO20-CG20),$BW$1*convert!D20)),0)
			Available Madera Capacity	BX	=MAX(BX$1*convert!D20-AT20,0)
			Available Friant-Kern Capacity	BY	=MAX(BY$1*convert!D20-AU20,0)
			Additional Madera Delivery	BZ	=IF(BQ20=0,MIN(BV20,BX20),0)
			Additional Friant-Kern Delivery	CA	=IF(BS20=0,MIN(BW20+(BV20-BZ20),MIN(BY20,$BW$1*convert!D20)),0)

MILLERTON OPERATION		Maximum Release not to Exceed Dead Storage	CB	=+CJ19+CC20-(CD20+CE20)-CI20-$CJ$1
		Millerton Inflow	CC	306
		Madera Canal Release at head	CD	=BT20+BZ20
		Friant-Kern Canal Release at head	CE	=BU20+CA20
		Total Release to SJR	CF	=MIN(MAX(CB20,CG20),MAX((BO20-(BZ20+CA20)+(BQ20+BS20)),CG20))
		Minimum release (Depletion and/or diversions, Friant to Gravelly Ford)	CG	=VLOOKUP($C20,lookup!$A$5:$C$16,3,FALSE)
		Evaporation rate (inches)	CH	=VLOOKUP($C20,lookup!$A$5:$E$16,5,FALSE)
		Evaporation	CI	=IF(CJ19>0,(-1.77*CJ19+455.4*(CJ19^0.5)-566.62*(CJ19^0.333333)+1.19)*CH20/12/1000,0)
		Millerton Storage	CJ	=+CJ19+CC20-CF20-(CD20+CE20)-CI20
SAN JOAQUIN RIVER BASIN DATA		Flow at Gravelly Ford	CK	=+CF20-CG20
		Tulare Lake basin overflow, James Bypass	CL	0
		Total Flow Available for Diversion at Pool	CM	=+CL20+CK20
		Mendota Pool Demand	CN	127
		Flow below Mendota Pool	CO	=MAX(0,+CM20-CN20)
		DMC Flow to Pool	CP	=MAX(0,+CN20-CM20)
		Flow below Mendota Pool from SANJASM and extension	CQ	0
		Vernalis Flow from STANMOD SANJASM (node 125) and extension	CR	258
		Surplus at Vernalis from SANJASM and extension	CS	74
		Modification to SJR flow below pool to match SANJASM flow	CT	=+CO20-CQ20
		Modified Vernalis for use in Project Model	CU	=+CR20+CT20
		Modified Surplus at Vernalis for use in Project Model	CV	=+CS20+CT20
		Merced River Surplus (w/o Vernalis check)	CW	68
		Merced River Surplus (with Vernalis check)	CX	=MAX(0,MIN(CW20,CV20))
		SJR flow below Merced (from SANJASM, node 40) and extension	CY	109
		Modified SJR flow below Merced	CZ	=+CY20+CT20
		Merced VAMP (may only)	DA	0
		Exchequer Storage 1922-92	DB	910
		Adjusted Millerton w/o Finegold TAF	DC	305
		Finegold Monthly Inflow TAF	DD	1
TULARE BASIN DATA		Kings River surplus to Lakebed	DE	0
		Kaweah River surplus to Lakebed	DF	0
		Tule River Surplus to Lakebed	DG	0
		Kern River Surplus to Lakebed	DH	NA

Appendix C

Section 2
Long-term Operation Simulation Model

Appendix C

Section 2
Long-term Operation Simulation Model

Introductory Remark

The Long-term Operation Simulation Model was developed to answer specific questions regarding alternatives that could facilitate San Joaquin River restoration. The spreadsheet model was developed and refined to respond to the desires of the WSOT, and depicts the specific alternatives that evolved over the course of several months of gaming and long-term project modeling. The model was designed to evaluate a certain breadth of project alternatives in an efficient manner. The model is somewhat limited in its capacity to evaluate alternatives that include components that are not already incorporated in the model. Although the intent was to develop the model in a format that is easy to understand, at times the model code is streamlined for efficiency, with certain decisions "hardwired". The understanding of the model code, and use of the model by parties not intimately familiar with the evolution of the project alternatives may require additional assistance beyond this documentation.

Model Purpose and General Assumptions

The model simulates an operation of a bundle through 78 years of consecutive months of historically-based hydrology. Operational closure in the model occurs at Millerton Reservoir; i.e., the water balance between water demands (such as canal diversions and river releases) and water supply (such as reservoir inflow, capture and re-use supplies, and other components satisfying water demands) occurs at Millerton Reservoir. If the demands exceed supply, the reservoir loses storage. If the supply exceeds demands, the reservoir gains storage. Interacting with the balance are the various components of a bundle. Underlying the simulation is hydrology developed through several analyses including the reliance on recent CALSIM II, SANJASM and STANMOD results. The geographical scope and facilities included in the model are illustrated in Figure 1. The hydrology is described in Appendix A.

<u>Restoration Flow Assumptions</u>

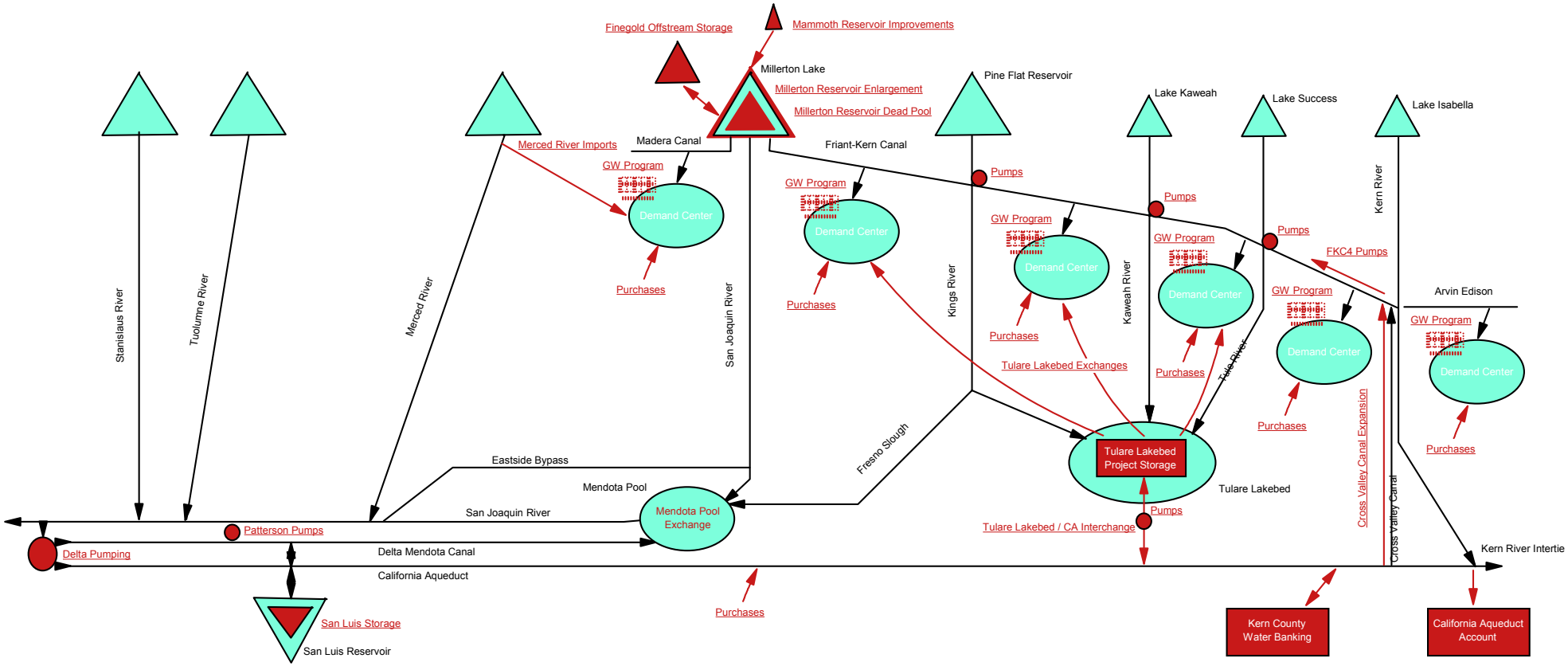
The Consulting Team was provided preliminary hydrographs concerning flows necessary for the restoration of the river. At the time the hydrographs were provided the estimates were explicitly qualified as being no more than a best guess as to what the restoration flow requirements may be upon completion of additional analyses, and their use is to be limited to the water supply modeling for the study.

The restoration hydrographs were provided in a format that allowed the development of average monthly flow requirements for various reaches of the lower river. Two different sets of hydrographs were prepared. One set indicates flow requirements for a channel that represents "existing" conditions. The other set estimates flow requirements for a channel that is "modified" with actions such as gravel augmentation, pit filling and channel resizing. The magnitude and volume of flow requirements are expected to be lower for a channel that has been modified for restoration purposes. The restoration hydrographs and supporting documentation are included as Attachment A.

Each set of hydrographs, coined "Existing Channel" for the existing channel scenario and "Modified Channel" for the modified channel scenario, were additionally refined to represent flow requirements by year type, triggered by wetness. Flow volumes and their distribution vary

Figure 1

Project Configurations
All Components



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DBSteiner 2/7/02

according to the wetness of the year. For this analysis, the year type classification is based on a ranking of unimpaired water year runoff at Friant for the 1909-2000 hydrologic record. A preliminary year type frequency distribution objective resulted in the wettest 20 percent of the years being classified as “Wet”, the driest 20 percent of the years being classified as “Dry”, and the intermediate 60 percent of the years being equally split between “Normal-Wet” and “Normal-Dry” classifications. Within the modeling, the year type classification is established during March and continues to apply through the following February. Table 1 provides the annual release requirement below Friant for each channel scenario. Attachment B documents the determination of the annual restoration flow-year type.

Table 1 - Modeled Flow Requirement below Friant

Year Type	Modified Channel * Acre-feet	Existing Channel * Acre-feet
Wet	573,000	890,000
Normal-Wet	500,000	591,000
Normal-Dry	458,000	491,000
Dry	348,000	361,000

* Includes 117,000 acre-feet for current downstream needs.

Costing Assumptions

Fixed and variable cost estimates are determined based on the components assumed to be within a bundle and the operation of those components. The long-term model is structured to facilitate alternative assumptions for the physical attributes of certain bundle facilities. These attributes become constraints within the modeling and also affect the determination of the cost of the component. For instance, the bundles assume the use of a pumping facility at the Kaweah River’s crossing of the Friant-Kern Canal. The size of the facility is assumed to be 1,000 cfs, and is priced accordingly. Alternatively, the facility could be assumed to be a different size within the model and the facility’s cost will be adjusted. The following is a summary of fixed and variable cost assumptions used in this analysis.

Fixed Capital and Maintenance Costs. Fixed capital and maintenance costs were developed for several facility components. A direct cost for a component is determined based on its size. A contingency and indirect cost factor of 1.99 is multiplied to the direct cost to arrive at the total capital cost of the component. The annual cost of the component is derived by adding the assumed annual maintenance cost (a percentage of the total capital cost) to the annualized recovery of the total capital cost. Component financing assumes a 30-year recovery period with 6 percent financing. Table 2 provides the fixed capital and maintenance cost assumptions currently used by the model. Most of the cost and financing variables can be modified by the modeler.

Power Costs/Revenues. Associated with many of the bundle components is the generation or consumption of energy. Estimates of net head and mechanical efficiencies were developed for the components and are provided in Table 3.

Table 2 - Fixed Capital and Maintenance Cost Assumptions

Component	Size	Capital Cost ($1,000)	Maintenance Cost Factor	Annual Cost ($1,000)
Millerton Pumps to Friant-Kern Canal	2,000 cfs	44,735	3.1 %	4,637
Millerton Pumps to Madera Canal	Included in FKC Cost			
Friant River Release Generator	450 cfs	18,358	1.0 %	1,517
Millerton Reservoir Enlargement	105,000 af	89,953	1.0 %	7,435
Cross Valley Canal Improvements	337 cfs	42,250	2.0 %	3,914
Friant-Kern Reverse Pumping	500 cfs	9,950	4.0 %	1,121
Tulare Lake Storage and Pumping	500 cfs/100,000 af	50,148	2.0 %	4,646
Patterson Pumping Plant	500 cfs	70,148	2.0 %	6,499
Kings River Pumping Plant	1,000 cfs	2,420	4.0 %	273
Kaweah River Pumping Plant	1,000 cfs	1,936	4.0 %	218
Tule River Pumping Plant	1,000 cfs	2,033	4.0 %	229
Merced River Intertie	100 cfs	41,338	2.5 %	4,037
Fine Gold Reservoir	400,000 af	420,288	1.0 %	34,736
Mammoth Pool Enlargement	30,000 af	18,806	1.0 %	1,554

Table 3 - Power Generation/Consumption Assumptions

Component	Tailwater Elev (ft)	Net Head (ft)	Efficiency (%)	kWh/AF
Friant-Kern Canal Generation *	470	Varies depending on Millerton Reservoir elevation	85	Varies depending on Millerton Reservoir elevation
Madera Canal Generation *	446		85	
Friant River Release	307		85	
Pumping to Friant-Kern Canal	470		70	
Pumping to Madera Canal	446		70	
Delta Pumping				300
O=Neill Pumping				60
Patterson Pumping		220	75	299
San Luis Reservoir P/G				Rating Table
Dos Amigos Pumping				150
Tulare Lake Pumping		180	80	229
Cross Valley Canal		132	80	168
Friant-Kern Reverse Pumping		20	80	25
Madera Canal Area GW Pumping		180	70	262
FKC 1 Area GW Pumping		130	70	189
FKC 2 Area GW Pumping		100	70	146
FKC 3 Area GW Pumping		120	70	175
FKC 4 Area GW Pumping		260	70	379
FKC 5 Area GW Pumping		410	70	597
Kern County Area GW Pumping		270	70	393
Kings River Crossing Pumpng		25	70	36
Kaweah River Crossing Pumpng		20	70	29
Tule River Crossing Pumping		21	70	31
Merced River Intertie Pumping		106	75	144
Fine Gold Pumping *			75	Varies by net reservoir head
Fine Gold Generation *			87	

* Analyzed but not included in bundle costs or revenues.

Existing institutional arrangements for the marketing of generation of power associated with Friant facilities are ignored within the model. Generation and power consumption associated with a bundle's operation are calculated for each project component. It is also assumed that, for simplicity of evaluation, all power consumed or generated is represented by a constant value during a year. Generation at the canals and from the existing river generator at Friant Dam is determined, but revenues from that generation are not credited to the project (a switch is included to either count the revenues or not). Fine Gold generation value or pumping cost is also switched on or off (currently the switch is off). The value of power assigned to generation and consumption is shown in Table 5.

Table 5 - Assumed Value of Power ($/MWh)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Cost of Consumption											
60	60	60	60	60	60	60	60	60	60	60	60
Revenue Value											
40	40	40	40	40	40	40	40	40	40	40	40

Wheeling Charges. Certain components utilized in the bundles may be assessed a wheeling charge for their use. Use of the Cross Valley Canal is assigned a wheeling charge of $13 per acre-foot of conveyed water. Any water conveyed through State and Federal West-side facilities is assigned a wheeling charge of approximately $49 per acre-foot. Energy costs for pumping are added to these wheeling charges.

Groundwater Put Charge. Groundwater banking and pumping is an integral component of each bundle. It is assumed that the utilization of existing groundwater systems or additional systems will be facilitated through contractual arrangements. Therefore, instead of a fixed annual cost being assigned to the inclusion of such facilities a put charge is assigned to water banked to a groundwater basin. The charge is assumed as $180 per acre-foot banked.

Water Purchases and Sales

Several types of water purchases are assumed within each bundle, and vary in their magnitude and frequency of use. One form of purchase, coined "Category 1" purchases, is functionally incorporated into the long-term model as an annually-constant purchase of water. This category of purchase is assumed to represent the purchase and use of an amount of reclaimed urban wastewater and reclaimed oil-well wastewater. This volume is assumed to be 20,000 acre-feet per year and is assigned a composite cost of $325 per acre-foot. This relatively small annual volume of purchase is distributed evenly over a year, and serves as a direct offset to baseline demands.

A second form of purchase coined "Category 2" is incorporated into the long-term model. This form of purchase can represent annual purchases (e.g., long-term contract purchases that are exercised annually) of water from either Eastside or Westside sources that are triggered in magnitude and frequency by year-type.

Currently, Category 2 purchases from the Eastside can represent two components of supply: (1) a component representing water conservation improvements that would amount to some value, e.g.,40,000 acre-feet per year; and, (2) a component of purchased supply that would amount to an average quantity over the entire study period, e.g., 80,000 acre-feet per year. This later component of water can be fashioned by year type in greater or lesser quantities (akin to an "option" purchase arrangement).

Both components of Category 2 purchases are assumed to have a source from entities that could provide water that would in effect directly offset Friant water user diversions from the

canals. The historical delivery pattern and geographical distribution of Class 1 and Class 2 water is used to distribute the offset of diversion requirements due to Category 2 purchases. Separate prices for the two components of water are input to the model. A single melded cost is determined for Category 2 water based on the volumes associated with each component. Costing of the second component of Category 2 water can include an annual “premium” payment and an “exercise” payment. Category 2 water can also be incorporated into the model as a “Westside” supply, and is managed identical to supplies that are recirculated. Volumes of Category 2 water from the Westside can be modeled by month and year type.

A third form of purchase is explicitly modeled within the bundles and coined “Category 3" purchases. This form of purchase represents short-term annual water that is acquired from East-side sources (e.g., water users capable of facilitating a reduction to Friant water users’ demand for surface water from the Friant Division). Functionally, these purchases reduce baseline demands.

The magnitude of the purchase is determined by the long-term model through an iterative process. The model first provides a result that identifies the volume of water necessary, if any, to maintain active storage throughout the year in Millerton Reservoir. An algorithm then determines the amount of water to be “acquired” in February to keep Millerton Reservoir from being lowered below dead storage at any time. The algorithm assumes water will become available during the year (February through September) on a irrigation/consumptive use pattern, assuming the consumption by several crops. The assumed crops are cotton, grain, alfalfa and corn, with an irrigation/consumptive use pattern shown in Table 6.

Table 6 - Assumed Irrigation/Consumptive Use Pattern for Category 3 Purchases (Cotton, Grain, Alfalfa and Corn Surrogate)

	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Irrig/CU (AF/Acre)	0.13	0.19	0.18	0.26	0.49	0.65	0.59	0.23
Percent by Month	4.9 %	7.2 %	6.6 %	9.5 %	17.9 %	23.8 %	21.7 %	8.5 %
Cumulative %	4.9 %	12.1 %	18.7 %	28.2 %	46.1 %	69.9 %	91.5 %	100.0 %

The amount of water acquired varies from year to year, and is assigned a price that varies by year type and by the volume acquired. The price function for this category of purchase is shown in Table 7.

Table 7 - Assumed Price Function for East-side Short-term Purchases (Category 3 Purchases)

	Friant Restoration Flow Year Type	
	Wet, Normal Wet & Normal Dry	Dry
Constant ($/AF)	165	321
Market Variable ($/TAF)	0.310	0.411
Price = $\text{Constant}_{\text{Year Type}}$ + ($\text{Market Variable}_{\text{Year Type}}$ x AF/1000)		

The Category 3 purchase algorithm and iterative model process is at times limited in its ability to balance purchases with Millerton Reservoir operations. This circumstance occurs because of the spreadsheet structure of the long-term model. At times when the iteration occurs another resource such as the groundwater operation may be triggered differently (banking or extraction) as the result of the purchase, and thus fault the original calculation of required purchases. Also, during certain sequences of winter and spring months there occur instances of water shortages that would not be appropriately met with such a purchase mechanism. The long-term model accommodates these intermittent water shortages as “residual” purchases when needed to maintain Millerton Reservoir storage no lower than dead storage. The price function assumed for residual purchases is a surrogate representing the cost of SWP entitlement water from the West-side of the San Joaquin Valley. The price is assumed to vary according to year-type,

representing fixed costs associated with the SWP being applied to reduced entitlements during drier conditions. Table 8 depicts the pricing assumed for residual purchases.

Table 8 - Assumed Price Function for Residual Purchases

	Sacramento Valley 40-30-30 Index				
	Wet	Above Normal	Below Normal	Dry	Critical
Price ($/AF)	134	155	191	262	311

Valuing Residual Storage

Groundwater banking and extraction is a key element of the bundles. The assumed availability of banking allows otherwise surplus Friant runoff to be stored and then utilized at a later time. Groundwater banking also is used to store surplus flows from the East-side tributaries, and provides regulation storage for recirculated restoration flows.

Typically the groundwater extraction side of a banking program is bounded by the amount of water that has been previously banked. The model can be constrained to only allow pumping from a positive balance, or can be allowed to be unconstrained through either indicating a large “negative” minimum storage or by initiating the model with a large “beginning” storage in each basin.

Circumstances can occur whereby the facilities develop water supplies that are not fully utilized by the end of the simulation period (i.e., “residual storage”). Residual storage manifests in both the groundwater basin operation and in the “California Aqueduct Account” operation. Positive balances in either of these operations are indications that more water is developed during the simulation period and stored in these mechanisms than the model has the means to use the water. Again, since these ending positive balances are accrued during the entire simulation period, the results can only be interpreted as an average annual value. Residual storage in the groundwater basin provides a credit to the net costs of a bundle. The credit currently is valued at the cost of the “groundwater put charge” ($180 per acre-foot). Other residual storage can be credited if a value is assumed for those supplies.

Model Structure and Worksheet Description

The long-term model workbook is comprised of several worksheets. The worksheets and a general description for each are listed below. Additional descriptions of several of the worksheets are also included.

Worksheet Name	Worksheet Description
Model Doc	Inventory and Description of worksheet within model
Formulas	Formulas for each cell in the model ("Model" worksheet)
Control	Contains parameters that control simulation options and bundle configuration
Model	Main simulation sheet
Cat 3 Purchase	Category 3 water purchase logic
Purchase Control	User input: volumes and cost of Cat 1 & Cat 2 purchases; value of Cat 3 and Residual purchases
Delivery	Baseline Distributions of deliveries for Madera and Friant-Kern Canals
Chrono Graph	Monthly chronological graphs for various project parameters
Pur Water Chart	Graphic of annual water purchase volumes
GW Chart	Graphic of annual Groundwater operation
Matrix & Export	Table formatted data based on user input. Summary of annual results. Matrix of monthly data for export to other programs.
Use_matrix	Lookup Table for triggering water supply assets based on Millerton Storage
Stor_matrix	Lookup Table for Triggering water puts to storage based on Millerton Storage
Annual Ranking Graphs	Graph worksheet providing graph of annual data sorted by unimpaired runoff at Friant.
EOSep Storage	Graph worksheet providing graph of a monthly parameter sorted by unimpaired runoff at Friant.
Econ Chart	Graphic of annual economic parameters
Pow & Fin Control	Financial, Power and Facility Fixed and Variable Cost Assumptions
Pow & Pur & Fin Annual Sum	Annual economic totals
Pow & Pur Monthly	Worksheet to calculate derivative monthly values from other monthly parameters
Misc Monthly	Additional monthly values derived from other model parameters.
Convert	Conversion of units between cfs to 1,000 AF, and times-series power cost data
Lookup	Lookup table data for reservoir storage and other parameters
Misc Annual	Miscellaneous annual sum values for output evaluation
Snw Flood Rel Logic	Patterns for Snowmelt Flood Release (not used)
Rest_q	Contains monthly time-series of restoration flows and bypass requirements
Delta	Data used to estimate available export pumping capacity based on CALSIM II simulation
Base_Data	Data passed from Baseline Model

The simulation of this system has many interdependent components. This circumstance has presented problems with circular arguments in the model logic, which is not easily addressed using spreadsheets. To avoid using Visual Basic code to perform the model simulation a "break" in the model logic is introduced. The "beak" is located between the section that simulates the Delta and the section that simulates the CVP/SWP south of Delta operations and subsequently the Friant-Kern Canal operation.

A manual iteration of Category 3 water purchases is also included in the model. This circumstance is described in the section describing the Millerton operation.

Control Worksheet

This worksheet controls the components and options used in the simulation. Either binary switches or facility capacities of proposed facilities are used to configure the model. Features controlled by this worksheet include:

- Water purchases
- Use of Tulare Basin Tributary Surplus Flow
- Merced River Conveyances
- Recapture of Restoration Flow
  - Mendota Pool
  - Patterson
  - Delta
- Groundwater Operation
- Use of San Luis Reservoir
- Cross Valley Canal Operation
- Millerton Reservoir Operation/Configuration
- Fine Gold Reservoir Operation
- Tulare Lakebed Operation
- San Joaquin River losses

Main Project Simulation Worksheet ("Model")

This worksheet contains the equations and logic that perform the actual simulation of project alternatives. The equations used to perform the simulation are documented in a separate worksheet ("Formulas") in the model and are included in Attachment C. The Model worksheet is separated into the following sections:

- Fine Gold Operation
- Millerton Reservoir Operation
- San Joaquin River - Friant to Gravelly Ford
- San Joaquin River - Gravelly Ford to Merced
- Merced River
- San Joaquin River - Merced River to Vernalis
- Delta and CVP/SWP South of Delta
- Aqueduct and South of Delta "West Side"
- San Luis Incremental Operation
- Tulare Lakebed Operation
- Madera Canal
- Friant-Kern Canal (Friant to Kings R.)
- Friant-Kern Canal (Kings R. to Kaweah R.)
- Friant-Kern Canal (Kaweah R. to Tule R.)
- Friant-Kern Canal (Tule R. to Kern)
- Friant-Kern Canal (From Kern to South)
- Kern County Bank
- Year Type and Triggers

<u>Fine Gold Operation</u>

The simulation of a proposed Fine Gold Reservoir is performed in this section of the worksheet. Parameters such as fill rate, release rate, maximum storage capacity, dead storage, and beginning storage that specify the physical makeup of Fine Gold are read from the "Control"

worksheet. Rules for filling and releasing water from Fine Gold Reservoir are indentified in the "Stor_matrix" and "Use_matrix" worksheets. Diversion to storage and releases from storage are triggered based beginning of month storage in Millerton Reservoir by use of lookup tables located in these worksheets.

Millerton Reservoir Operation

This section of the worksheet performs the simulation of Millerton Reservoir. Dead storage and size of the reservoir are determined from the "Control" worksheet. This simulation does not determine deliveries to the Friant water users. Diversions are determined in the Baseline simulation spreadsheet and aggregated to various canal reaches in the "Delivery" worksheet. Flood Control operation for rainflood releases are made in the project model, however pre-releases for snowmelt are not included.

Millerton storage is updated based on inflow, deliveries, river releases, and evaporation by using a simple mass balance. In many of the project alternatives, the increased burden on Millerton Storage is greater than operable storage. When this occurs the model introduces "makeup" water to prevent Millerton from falling below dead storage and allow the model to continue the simulation. The makeup water is considered to be a shortage and is labeled as "Residual Shortage Water" in the model. This shortage must be satisfied from an unspecified water source such as water purchases. There is a feature in the model that allows this shortage to be made up from Category 3 water purchases. Category 3 water purchases are simulated using an iterative modeling approach, which is performed manually by the model user. To perform this iteration the user must copy the values from the "Residual Shortage Water" column and paste it into a column in the "Cat 3 Purchase" worksheet. The resulting water purchase calculated in the "Cat 3 Purchase" worksheet must then be copied back to the simulation model in the column labeled "Cat 3 Purchase Water".

San Joaquin River - Friant to Gravelly Ford

This portion of the model accounts for the river depletions/accretions and diversions from Friant to Gravelly Ford. The model calculates the incremental depletion based on the changes in San Joaquin River flow when compared to the Baseline simulation. This increase in depletion is added to the Baseline depletion to calculate the flow at Gravelly Ford. Accounting of changes to groundwater from increased seepage is also accounted in this section of the model.

San Joaquin River - Gravelly Ford to Merced

All flow entering and leaving the San Joaquin River, including Mendota Pool, from Gravelly ford to the Merced River is accounted in this section of the model. Incremental depletions and groundwater seepage are accounted from Gravelly Ford to Mendota Pool. Changes in James bypass and Delta-Mendota Canal inflows are simulated and the incremental change in flow in the San Joaquin River at the confluence of the Merced is determined. Recapture of restoration flows is allowed by checking bypass flow requirements identified in the "Rest_q" worksheet and by turning on the option with a switch located in the "Control" worksheet.

Merced River

Increases in Merced River flow for VAMP and Merced River surplus from the Baseline model are used in this section to estimate the amount of water from the Merced River that might be available for delivery in the Madera Canal service area. The following data and binary switches are read from the "Control" worksheet to specify the use of Merced River water:

- Merced to Madera service area capacity (cfs)
- Replace Merced VAMP release with SJR restoration flow release
- Route Merced River Surplus to Madera Canal service area
- Fraction of Madera service area demand that can be met from Merced
- Use Merced River water to recharge GW in Madera service area.

San Joaquin River - Merced River to Vernalis

In this section of the model the incremental depletions are accounted using the same method that is used for each previously described reach of the San Joaquin River. A proposed pump station at Patterson is simulated by checking bypass flow requirements specified in the "Rest_q" worksheet and by specifying a pump station capacity in the "Control" worksheet. The incremental flow at Vernalis represents the change in Delta inflow resulting from the project.

Delta and CVP/SWP South of Delta

Recapture of restoration flows at CVP/SWP Delta export pumps is calculated in this section of the worksheet. A binary switch located in the "Control" worksheet is used to trigger use of CVP/SWP export pumps. Available export capacity is estimated using a separate spreadsheet (documented below) and imported to the "Delta" worksheet. Export of increased flow at Vernalis is limited by constraints of SWRCB D1641, CVPIA (b)(2), and EWA. The simulation of Delta operations has been extracted from the August, 2002 Joint USBR/DWR release of CALSIM II.

The logic "break" to prevent circular logic is located in the last column of this section. Values in this column must be copied to the first column in the next section to perform the model simulation. There is an indicator in the upper left corner of the model worksheet (Cell A7) to indicate whether this manual operation must be performed.

Aqueduct and South of Delta "West Side"

This section of the model takes the recaptured restoration flows and routes them to various locations based on priorities located in the "Control" worksheet. The first priority is always to deliver recaptured flow to offset direct Friant-Kern Canal deliveries by delivering recaptured water through the Cross Valley Canal. Once this opportunity has been fully exercised, water will be banked to San Luis storage, groundwater storage, Tulare Lakebed storage, Kern County Bank storage, or the Aqueduct Balance. Simulation of these facilities is described in later sections.

San Luis Incremental Operation

The storage operation of San Luis Reservoir was extracted from the August, 2002 Joint USBR/DWR release of CALSIM II. Recaptured restoration flows are allowed to be stored in the unused portion of San Luis Reservoir. Parameters located in the "Control" worksheet control whether or not to use San Luis Reservoir to store restoration flows.

Tulare Lakebed Operation

Only the portion of Tulare Lakebed storage that is defined as part of the Restoration Project is addressed in the model. Tulare Lakebed can be filled from surplus flows from the Tulare Lake Tributaries or by diversions from the California Aqueduct. Water in the Tulare Lakebed can be

disposed to the California Aqueduct or to the Friant-Kern Canal demand centers. The operation is controlled by the following parameters located in the “Control” worksheet:

- Maximum capacity
- Capacity from Aqueduct
- Capacity to Aqueduct
- Divert unused James bypass flow to Tulare Lakebed
- Capacities based on year type
    - Capacity to Friant-Kern (Friant-Kings) (TAF)
    - Capacity to Friant-Kern (Kings to Kaweah)
    - Capacity to Friant-Kern (Kaweah to Tule)
    - Capacity to Friant-Kern (Tule to Kern)
    - Capacity to Friant-Kern (Kern to South)

Madera Canal

Madera Canal deliveries, as determined in the Baseline model, are used as demands in the Project model. These demands are always satisfied in the project model. When water is delivered to the Madera Canal service area from alternative sources included in the project, diversions from Friant are decreased. Alternative sources include conveyances from Merced, ground water storage programs, and water purchases.

Groundwater pumping and recharge are triggered using lookup Tables located in the “Stor_matrix” and “Use_matrix” worksheets. Recharge and pumping are triggered based beginning of month storage in Millerton Reservoir by use of lookup tables.

Friant-Kern Canal

The Friant-Kern Canal is separated into 5 sections (also used as demand centers) in the model:

- Friant to Kings River
- Kings River to Kaweah River
- Kaweah River to Tule River
- Tule River to Kern River
- From Kern River to the South

Each Friant-Kern Canal section is simulated in a similar fashion. Friant-Kern Canal deliveries, as determined in the Baseline model, are used as demands in the Project model. These demands are always satisfied in the project model with either diversions from Friant or from Project components. When water is delivered to the Friant-Kern Canal service area, from alternative sources included in the project, deliveries from Friant Dam are decreased.

Water supply made available from various project components may only be available for a portion of the Friant-Kern Canal service area depending on the geographic location of the water supply source. For example, water supply intercepted from the Tulare Basin tributaries is only available in canal locations that are downstream, or down-canal, from the intersection of the tributary and the canal. Delivery from the Cross Valley Canal can only be made to Friant water users that are south of the Kern River or are located in the lower the reach of the Friant-Kern Canal between the Tule and Kern Rivers.

Groundwater pumping and recharge are triggered using lookup Tables located in the “Stor_matrix” and “Use_matrix” worksheets. Recharge and pumping are triggered based

beginning of month storage in Millerton Reservoir by use of lookup tables. Recharge for each reach can also be triggered based on availability of surplus flows from the Tulare Lake Basin Tributaries. For Canal reaches that can be served from the Cross Valley Canal, recharge can occur when recaptured water is in excess of demands and a priority is set for recharge.

Kern County Bank

Recaptured water can be stored in a water bank in the Kern County area based on the availability of recaptured water and the location priority for storing recaptured water. Releases from the Kern Bank are made when there is available capacity in the Cross Valley Canal and there is a demand in the lower reaches of the Friant-Kern Canal.

Year Type and Triggers

This section of the model contains water year classifications for the 60-20-20 Year-tye index and Friant Restoration year-types. The determination of triggers for recharge and groundwater pumping is located in this section. A trigger for using Tulare Lake Basin tributary surplus flow for recharge is also located in this section.

Delta Worksheet

This worksheet contains data from a separate spreadsheet that is used to estimate available Delta export capacity. This worksheet contains the data necessary to calculate allowable incremental exports allowed by increases in San Joaquin River flow to the Delta. This worksheet also includes a determination of the fraction of the month that either (b)(2) or EWA actions restrict Delta exports. This information is used to determine when restoration flow can be exported.

Cat 3 Purchase Worksheet

This worksheet synthesizes the water required to keep Millerton from falling below dead storage ("Residual Shortage Water" calculated in the model in the "Millerton Operation" section) into a schedule of Category 3 water purchases. Category 3 purchases are made available on an agricultural use pattern, therefore the time of the year that shortages occur influence the volume of water that must be purchased to eliminate shortages.

Worksheets for Output Processing

There are several worksheets in the spreadsheet model that are used to summarize and process the simulation results, these worksheets are:

- Matrix & Export
- Chrono Graph
- Pur Water Chart
- GW Chart
- Annual Ranking Graphs
- EOSep Storage
- Econ Chart
- Pow & Pur & Fin Annual Sum
- Pow & Pur Monthly
- Misc Monthly
- Misc Annual

Model Files

Delta Spreadsheet

This is a spreadsheet that is used to determine the capability of capturing restoration flows in the Delta at CVP and SWP export facilities. Data is extracted from the August, 2002 CALSIM II simulation that was jointly released by DWR and USBR. This simulation contains export reductions specified in SWRCB D1641, CVPIA (b)(2) export reductions, and EWA export reductions. The capability to export additional water from the Delta is estimated based on these regulatory constraints as simulated in the August, 2002 CALSIM II simulation.

Name	Size	Type	Last Modified
Delta(9-04-02).xls	2,386KB	Microsoft Excel Worksheet	9/9/02 11:48 AM

Project Model

Project Model 9-10-02.xls	31MB	Microsoft Excel Worksheet	9/29/02 1:38 PM

Attachment A

Draft San Joaquin River Restoration Hydrographs
(Revised 8/14/01 by Rob Thomson, 9/06/01 by Scott McBain)

The San Joaquin River Water Supply Oversight Team (WOST) has requested that the San Joaquin River Restoration Oversight Team (ROST) provide them with draft hydrographs of estimated restoration flows on the San Joaquin River. These hydrographs are intended to assist the WOST in their modeling of various water supply alternatives. The attached hydrographs have been developed by the ROST without any participation or feedback from JSA. Further, the ROST and JSA are still in the process of developing the quantitative objectives on which the final restoration study hydrographs will be based. Therefore, the attached preliminary hydrographs should be regarded as nothing more than the ROST's "best guess" as to what the actual restoration hydrographs will be and its use limited to the modeling exercises for the Water Supply study. Finally, these hydrographs are not intended to replace or guide the concurrent ROST/JSA modeling and gaming exercises presently underway that are directed at developing and comparing various restoration strategies, and developing the hydrograph(s) for each restoration strategy.

Flow for different water years and channel modification scenarios
Below and in the accompanying Excel spreadsheets, we present draft restoration hydrographs for two channel scenarios (existing channel and modified channel), and for the following four water year-types:

Water Year	Exceedence Probability
WET	0% to 20%
NORMAL-WET	20% to 50%
NORMAL-DRY	50% to 80%
DRY	80% to 100%

The two channel scenarios are assumed to have different water needs, as channel modification (gravel augmentation, pit filling, channel resizing) would reduce the flow magnitude and volume required to achieve restoration objectives. For the existing channel scenario, larger flow magnitudes and volumes are assumed to satisfy the restoration requirements of the river absent the various anticipated physical restoration actions (e.g., filling in gravel pits, reconfiguring channel depths, etc.) that the ROST believes may reduce the amounts of water necessary to achieve specific restoration objectives (e.g., seasonal water depth or temperature requirements). The magnitudes and volumes of restoration flow requirements are expected to be lower if physical restoration and channel modification actions occur.

Hydrograph development
Flow volumes are different for each water year classification, as the ROST has assumed that certain restoration objectives requiring high flow magnitudes and volumes would be achieved during wetter years when there is more water available in the Central Valley.

These objectives are listed below, and are later linked to specific hydrograph components:

WET

- Significant cobble/gravel bed mobilization
- Channel migration
- Significant riparian regeneration on floodplains
- Adequate flows and temperatures for smolt outmigration for all species
- Flow continuity in all reaches for native warm-water fish assemblages
- Adequate fish passage flows in all reaches throughout year
- Attractant pulse flows for adult Chinook salmon and winter-run steelhead

NORMAL-WET

- Marginal cobble/gravel bed mobilization
- Limited channel migration
- Limited riparian regeneration on floodplains
- Adequate flows and temperatures for smolt outmigration for all species
- Flow continuity in all reaches for native warm-water fish assemblages
- Adequate fish passage flows in all reaches throughout year
- Attractant pulse flows for adult Chinook salmon and winter-run steelhead

NORMAL-DRY

- Adequate flows and temperatures for smolt outmigration for all species
- Flow continuity in all reaches for native warm-water fish assemblages
- Adequate fish passage flows in all reaches throughout year
- Attractant pulse flows for adult Chinook salmon and winter-run steelhead

DRY

- Adequate flows and temperatures for smolt outmigration for all species
- Flow continuity in all reaches for native warm-water fish assemblages
- Marginal fish passage flows in all reaches throughout year
- Attractant pulse flows for adult Chinook salmon and winter-run steelhead

Information on the assumed magnitude, duration, timing, and frequency of specific flow releases is provided in the individual hydrographs. For all hydrographs, the ROST assumed that existing constraints, such as impaired channel capacity, are not limiting. The hydrographs in the Excel spreadsheets provide additional information of flows for each reach of the river, incorporating available information and assumptions on reach-specific losses and gains, and available information and assumptions on fish and habitat requirements in each reach. The two Excel files ("ROST hydro with existing channel.xls" and "ROST hydro with channel modification.xls") are organized such that flows for each water year are presented in different sheets and charts rather than combined on a single hydrograph for each year type. Notwithstanding the assumptions listed below, the draft hydrographs presented here have not been (and cannot yet be)

quantitatively informed by results of ongoing ROST/JSA modeling and gaming exercises, and the likely effects of the various restoration strategies on Friant flows required to achieve desired ecological and geomorphological goals.

Assumptions, Information and References

The draft hydrographs shown and described on the following pages and also in the attached Excel spreadsheets are based on the following assumptions, information and references:

1. The draft hydrographs have been developed to address most Restoration Plan goals, including restoration of ecological processes (e.g., riparian recruitment and maintenance, seasonal floodplain inundation), hydro-geomorphological processes (e.g., mobilization of gravel), and restoration and maintenance of self-sustaining, viable populations of chinook salmon and other native fishes (e.g., steelhead, splittail, native resident fishes). The actual reach-specific quantitative objectives for San Joaquin River restoration have not yet been developed and are thus not reflected in these hydrographs.
2. Flow releases are estimates, subject to modification based on modeling results, finalization of the quantitative objectives, and other new information regarding geomorphological, ecological, and/or biological requirements, effects of various restoration strategies, and a long-term adaptive management program. Flow timing, durations, and frequencies identified for fish restoration, riparian recruitment, resetting, and maintenance, and geomorphological processes are, at this time prior to completion of modeling and gaming exercises by JSA, our best estimates based on presently available information (and see #5 below), of the restoration flows that will be required.
3. Flows (cfs) in the hydrographs below are total Friant releases (i.e., flows include water released to satisfy downstream riparian water rights; the model used in water supply planning process [USAN] assumes an annual water rights release of approximately 121,000 acre feet). We recognize that, along the length of the river, these flows will attenuate, infiltrate, and/or may be diverted for consumption or recirculation. Therefore, in the Excel files, we incorporated available information on losses and gains for each reach, as well as information and our informed assumptions regarding fish and habitat needs in each reach to generate more detailed hydrographs. These assumptions of flow losses, gains, and habitat needs have been incorporated in developing hydrographs in each of the five reaches (measured at the upstream end of the reach), with an additional node at the intersection of Reach 4A and 4B to accommodate an assumed reversal in losing reach to gaining reach. These assumptions of flow gains and losses (and how they change with Friant releases) will be refined by JSA and incorporated into future restoration strategy hydrographs. No assumptions have been made regarding flood bypass operational rules, nor have VAMP flows and other tributary coordination been considered in the flow releases. The final restoration hydrograph(s), developed based on results of ROST and JSA modeling and gaming exercises, will need to incorporate even more detailed consideration of these factors and will refine the reach-by-reach hydrographs at multiple

downstream target locations (e.g., below Mendota Dam, Merced confluence, Delta).

4. In the Excel hydrographs, we have made preliminary recommendations for minimum flows in reaches that can be used to estimate how much water could be diverted at Mendota Pool and below the Merced River (i.e., Patterson) for consumptive uses or re-circulation. This may be useful to the WOST consultant for developing and evaluating various water supply scenarios. The releases shown in the Excel hydrographs provide for diversions at Patterson, but releases from Friant were developed for minimum flows in Reach 1, 2, and 3, thus no diversions from Mendota are assumed with these hydrographs. Larger Friant releases could greatly improve fishery conditions in Reach 1 and 2, and this additional water could then be diverted for other uses at Mendota provided the minimum flows to Reach 3 are maintained. This option is NOT included in the Excel charts, but could be considered in the future.
5. Flow levels and durations used at different times in the year in these draft hydrographs were based on information from a variety of sources including: Raines, 1992 (Draft Summary of Friant Fishery issues with Preliminary Instream Flow Recommendations); USFSW, 1994 (The Relationship Between Instream Flow, Adult Immigration, and Spawning Habitat Availability for Fall-run Chinook Salmon in the Upper San Joaquin River); Cain (Masters Thesis and other work); selected literature on life history characteristics of chinook salmon, steelhead, splittail, other native fishes presumed to be resident in the San Joaquin River, and requirements of riparian vegetation; JSA and Mussetter Engineering information in Phase 1 report; professional judgment; and other sources.
6. Flow levels in the draft hydrograph have <u>not</u> been informed by quantitative understanding of flow-temperature relationships or updated flow-depth relationships. Therefore, particularly for summer and fall periods in Reaches 1 and 2, flow levels may need to be modified to provide adequate habitat conditions for oversummering anadromous fishes and native resident fishes and, in the fall, adequate migration depths for anadromous fishes.
7. High magnitude geomorphic flows designed to mobilize cobbles and gravels could occur anytime during the winter and spring but have been timed to occur after March 1 to avoid scouring fall-run chinook salmon redds and to provide collateral benefits to Chinook salmon outmigration and riparian regeneration. With existing Reach 1 and 2 channel geometry and bed characteristics, we estimated that a 12,000 cfs peak flow is necessary to achieve the geomorphic objective of mobilizing gravel based on the following considerations: the pre-dam channel forming event (2 year recurrence interval) was approximately 12,000 cfs; the Mussetter model predicted that a magnitude of approximately 12,000 cfs was necessary to move the existing highly armored bed; and a gravel tracer study conducted by Cain (1997) measured slight movement of this armored bed material after a flow of 12,000 cfs. We realize that this flow threshold may pose flood control and levee problems in Reaches 1 and 2 (upstream of anticipated diversion at the bifurcation structure). This flow threshold could be lowered substantially with a large gravel augmentation program that would reduce the armored condition of the bed, reduce particle size, increase coarse sediment

supply, and thus reduce the flow threshold necessary to move the bed. The flow threshold necessary to mobilize the channelbed particles is dependent on the high flow energy slope, particle size, particle density, channel geometry, and flow depth. Channel modification efforts can reduce the particle size and narrow the channel width to reduce the flow threshold necessary to mobilize the bed surface compared to existing conditions. In order to maintain fish, channel, and riparian habitat, relevant literature indicates that moderate geomorphic flows should occur on average once every 1.5-2 years (contained in NORMAL-WET year hydrograph), and larger geomorphic flows that causes more significant channel movement, scour, and redeposition should occur on a less frequent basis (contained in WET year hydrograph).

8. Flows for riparian recruitment are targeted for WET water years, with the flow to begin between mid-April and mid-May to coincide with seed dispersal of target riparian species. This timing also corresponds to geomorphic and fall-run chinook salmon outmigration flows, such that multiple benefits are achieved with this flow release. Under the "with channel modification" scenario, a peak flow magnitude of 8,000 cfs is intended to clear or create seedbed surfaces for target riparian species on a given potential recruitment surface. This riparian recruitment surface is initially assumed to be inundated by flows near 3,000 cfs based on analysis of Fresno Metropolitan Flood Control District cross sections, previous conversations with a Friant Dam operator, discussion with Mussetter Engineering and Jones & Stokes staff, and analysis of aerial photographs during high flows. Flows recede quickly down to 3,000 cfs following the 8,000 cfs peak flow, then are very gradual such that riparian seedlings can germinate, initiate, and establish on the target inundation surface. Less water may be necessary to establish riparian vegetation on floodplain terraces in Reaches 2, 3, 4, and 5 due to finer grain texture (larger capillary fringe), creating potential future opportunities for diverting portions of the spring peak flow at the bifurcation structure, Mendota Pool, and/or Patterson. However, we initially assume that all flows are conveyed in the main channel through Reach 5 to decrease smolt stranding and increase smolt growth and outmigration success. The ramp down rate at flows lower than 3,000 cfs was roughly based on stage-discharge relationships depicted in JSA 1998 groundwater data results from the pilot project, and literature on root growth. The overall rate may be too abrupt for the establishment of seedlings, but we incorporated irrigation pulse flows into the ramp down to reduce the potential for root desiccation. According to Mike Scott (USGS), riparian recruitment and "resetting" flows should occur on average about once every 5-10 years; hence, these riparian recruitment flows are targeted for WET water years.

Annual Water Amounts

Table 1. Estimated additional flow releases from Friant Dam to satisfy restoration objectives with and without channel modification. These water amounts are calculated from the Excel files, and all values have been rounded to the nearest 1,000 acre feet.

Water Year	Exceedence Probability	Friant release: Channel modification (acre-feet)*	Friant release: Current channel (acre-feet)*
WET	0% to 20%	452,000	769,000
NORMAL-WET	20% to 50%	379,000	470,000
NORMAL-DRY	50% to 80%	337,000	370,000
DRY	80% to 100%	227,000	240,000
Weighted average		351,000	454,000

*Excludes 121,000 ac-ft releases for riparian water rights

For a "dry" year, i.e., the driest 20 percent of water years, in which flows are directed at providing minimal-adequate passage and environmental conditions for targeted fish species with a reduced number of seasonal flow pulses, the combined water rights, and restoration releases from Friant total 348,000 and 361,000 acre feet for the with- (Figure 1) and without (Figure 2) channel modification scenario, respectively. Excluding flow releases already required for riparian water rights (assumed to 121,000 acre feet annually, based on USAN model), the supplemental flow requirement for fish would be approximately 227,000 and 240,000 acre feet. These estimates, as well as the estimates for the following hydrographs, account for a small flow pulse for smolt outmigration.

For a "normal-dry" year, i.e., 30 percent of water year types below average, in which flows are directed at providing adequate passage and environmental conditions (which includes maintenance of riparian vegetation) for the targeted fish species, the combined water rights, and restoration releases from Friant total 458,000 and 491,000 acre feet for the with- (Figure 2) and without (Figure 3) channel modification scenario, respectively. Excluding flow releases already required for riparian water rights (assumed to 121,000 acre feet annually, based on USAN model), the supplemental flow requirement for fish would be approximately 337,000 and 370,000 acre feet.

For a "normal-wet" year, i.e., 30 percent of water year types above average, in which flows are directed at providing adequate passage and environmental conditions (which includes maintenance of riparian vegetation) for the targeted fish species, the combined water rights, and restoration releases from Friant total 500,000 and 591,000 acre feet for the with- (Figure 5) and without (Figure 6) channel modification scenario, respectively. Excluding flow releases already required for riparian water rights (assumed to 121,000 acre feet annually, based on USAN model), the supplemental flow requirement for fish would be approximately 379,000 and 470,000 acre feet. High flows that achieve geomorphic and riparian objectives are timed to coincide with the spring smolt outmigration pulse flow

In a "wet" year, i.e., the wettest 20 percent of years, in which additional flows are released to satisfy geomorphic and riparian recruitment and resetting conditions as well as passage and habitat requirements for targeted fish species, the combined water rights, fish, geomorphic, and riparian recruitment/resetting flows from Friant total 573,000 and 890,000 acre feet for the with- (Figure 7) and without (Figure 8) channel modification

scenario, respectively. Excluding water rights flow releases, the supplemental flow requirements would be approximately 452,000 –and 769,000 acre feet High flows that achieve geomorphic and riparian objectives are timed to coincide with the spring smolt outmigration pulse flow.

Notations and descriptions of draft Hydrograph Components
(figures in Excel files)

Note – The notations below describe the rationale for each of the major features on the hydrographs identified with letters.

Note – Pulse flows have been combined to use water more efficiently by satisfying multiple objectives to the greatest degree possible.

Note – Below, and in the Excel spreadsheets, preliminary suggestions on amounts of flow allowable for diversion at Patterson (below confluence with Merced River) are for instantaneous flows at the diversion site, not for the total of amounts of water released at Friant. Friant releases have been minimized to satisfy flow objectives in Reach 1, 2, and 3; thus, no diversions are recommended at Mendota Dam under these Friant releases. However, increasing Friant releases to improve conditions in Reach 1 and 2 (not included in this analysis) could theoretically be diverted at Mendota provided minimum flow targets are met in Reach 3. See the Excel spreadsheets for more detailed information on suggested allowable water diversion amounts at Patterson.

A: Attraction and passage (i.e., depth and temperature) flow for adult fall-run chinook salmon (FRCS). Timing of pulse based in observed peak fall-run chinook salmon migration during September-October and the greater likelihood of a rainstorm pulse later in the fall. Upper range flow values are based on Raines 1992 for normal year. Duration of attraction pulse (31 days) based on estimated travel time of 15-21 days, from Raines 1992.

Note – A substantial amount of this native San Joaquin River water should be allowed to flow to the Delta.

B: Winter base flow during FRCS spawning and incubation and possible late migrant chinook salmon. Requires adequate flows to provide suitable temperature, habitat and gravel availability in Reaches 1 and 2. Proposed base flow level assumes that temperatures are adequate, that there is flow continuity throughout the five reaches, and that depth is adequate for fish passage.

Note – Some of this flow may be available for diversion below Reach 2 (i.e., Mendota Pool) and/or below the Merced confluence (i.e., Patterson).

C: Pulse flow for outmigration of spring-run chinook salmon (SRCS) juveniles. Attraction and passage pulse flow for adult steelhead (SH).

Note – Some of this flow may be available for diversion at Patterson.

D: Pulse flow for outmigration of SRCS and initial flooding of river edge and floodplain habitat. Attraction and passage flow for adult steelhead. Attraction flows for adult splittail (ST). Does not occur in DRY water years.

Note – Flows above 3,000 cfs may be diverted below Patterson.

Note – Timing of pulses C and D based primarily on peak SRCS juvenile outmigration and, to a lesser extent, steelhead adult migration. Flow levels are roughly based on Raines 1992 and the expectation that water temperatures will generally be adequately low and therefore not limiting.

Note – A substantial fraction of the native San Joaquin River water in pulses C and D should reach Reaches 4 and 5 (for floodplain inundation) and then to be allowed to flow to the Delta (for attraction flows).

Note – In the "dry" year hydrograph, flow pulses C and D have been combined into a single pulse with a lower peak flow.

E and **F**: Prolonged pulse flow and ramp-down for FRCS smolt outmigration, attraction for adult ST and SRCS migration, river edge and floodplain habitat creation/enhancement for FRCS juveniles and ST spawning and rearing (minimum duration inundation for ST = 30 days), and riparian recruitment and resetting. Pulse flow E for WET and NORMAL-WET water years also accounts for geomorphological processes, i.e., gravel/bed mobilization in Reaches 1 and 2.

Timing – For optimal riparian recruitment this pulse should occur between mid-April through mid-June. The pulse flow for geomorphological processes should occur after March 1 and, for optimal timing, would coincide with the second FRCS outmigration pulse flow.

Frequency –We assume that reshaping this pulse for riparian recruitment flows will be required on average every 5 years (WET water years), with potentially some recruitment during NORMAL-WET water years for effective riparian recruitment. The pulse flow for geomorphological processes is not required to occur in NORMAL-DRY or DRY years unless there have been more than two dry years in a row, in which case a flow pulse greater than 6,000 cfs is required to occur in the third year.

Shape and duration – The receding limb of the pulse flow is rapid down to 3,000 cfs, then the receding limb is much slower to encourage riparian seedling germination, initiation, and establishment. For optimal riparian recruitment, the shape of this pulse (i.e., declining limb, F) may be modified in some years.

Note – Wetter years without restoration have higher geomorphic flow magnitudes to reflect impaired existing channel conditions, while wetter years with restoration show how channel improvements and gravel augmentation lowers flows for certain hydrograph components.

Note – A substantial fraction of the native San Joaquin River water should reach Reaches 4 and 5 (for floodplain inundation) and then to be allowed to flow to the Delta (for attraction flows and habitat creation and improvement). Initial recommendations are that only flows above 3,000 cfs can be diverted at Patterson.

Note – In the "dry" year hydrograph, flow pulses C and D have been combined into a single 40-day flow pulse.

G: Summer base flows for SRCS and SH holding in Reach 1, habitat (i.e., temperature) for native resident fishes in Reaches 1 and 2, maintenance of riparian vegetation in all Reaches, prioritizing vegetation in Reach 2. Flow levels based on assumed water rights losses (from USAN) and infiltration losses based on the minimum 5 cfs flow requirement in Reach 2 and CCID estimates in Reach 2 and 4A.

Note – These flows are most critical only in Reaches 1 and 2. It is likely that a certain percent of these flows may be diverted at either Mendota Pool or Patterson, as long as the minimum baseflows are maintained in each reach (see cells R1 and R2 in each Excel worksheet).

Figure 1. DRY Water year hydrographs for San Joaquin River reaches 1-5 WITH channel modification

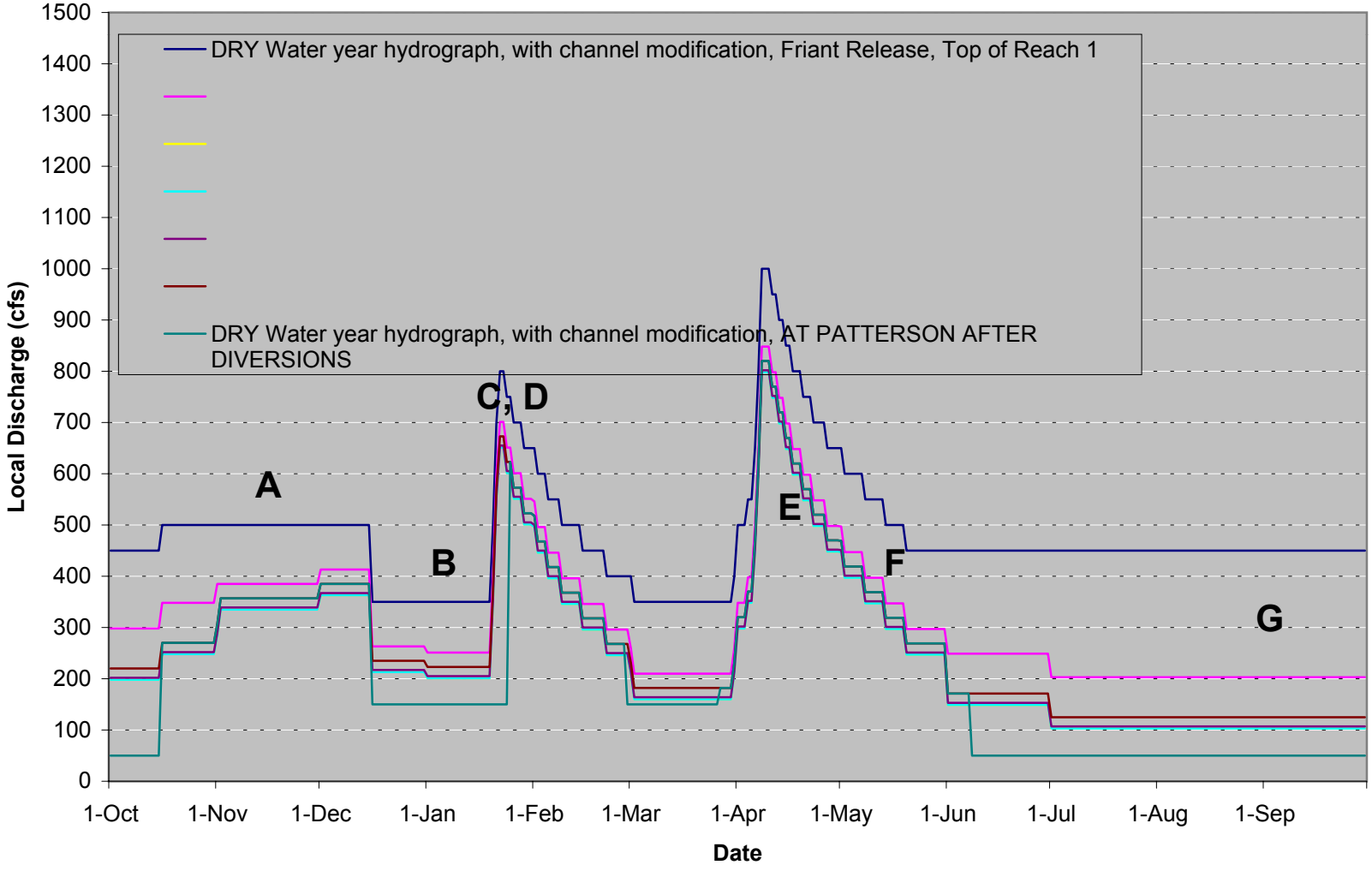


Figure 2. DRY Water year hydrographs for San Joaquin River reaches 1-5 WITHOUT channel modification

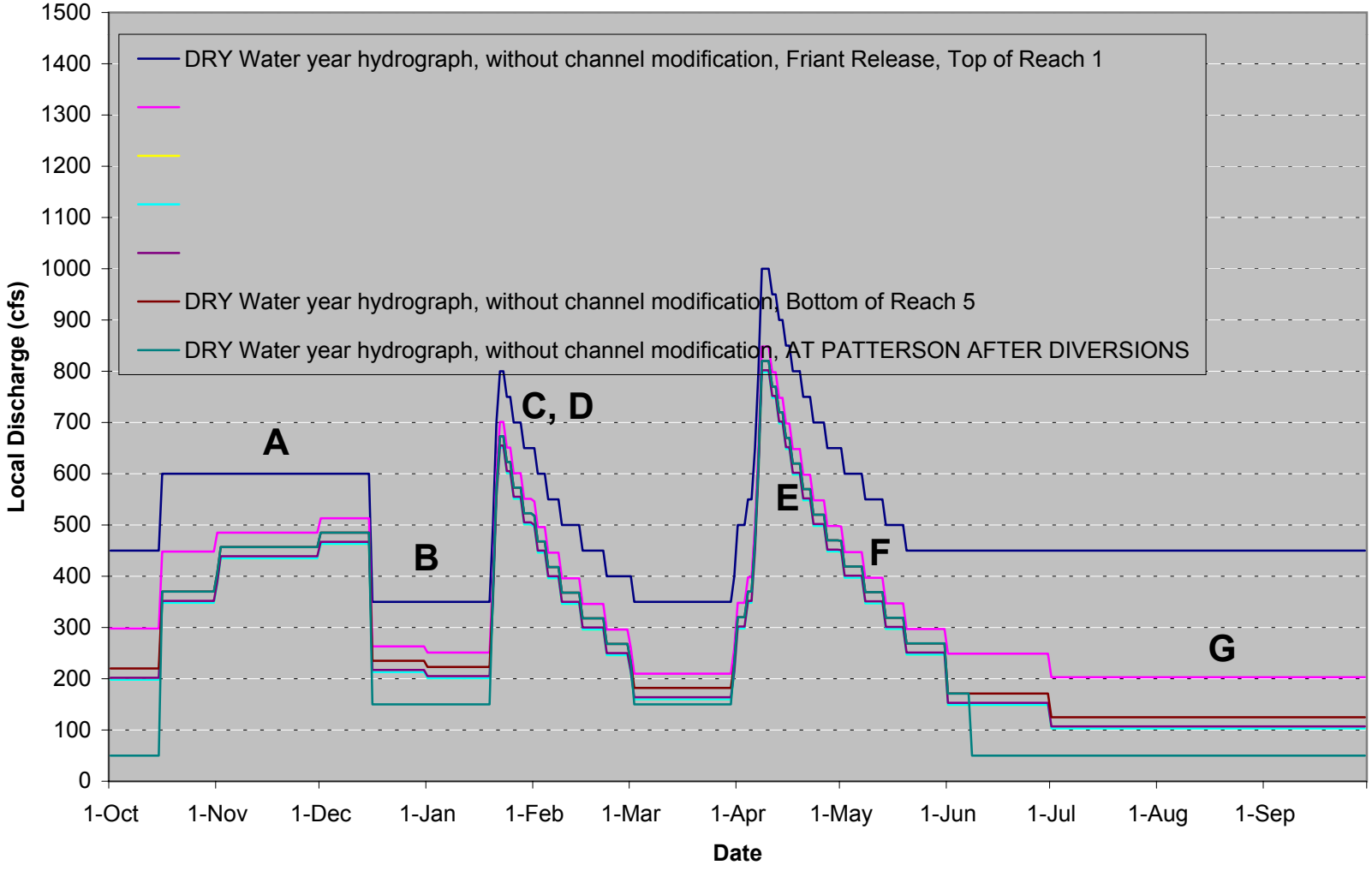


Figure 3. NORMAL-DRY Water year hydrographs for San Joaquin River reaches 1-5 WITH channel modification

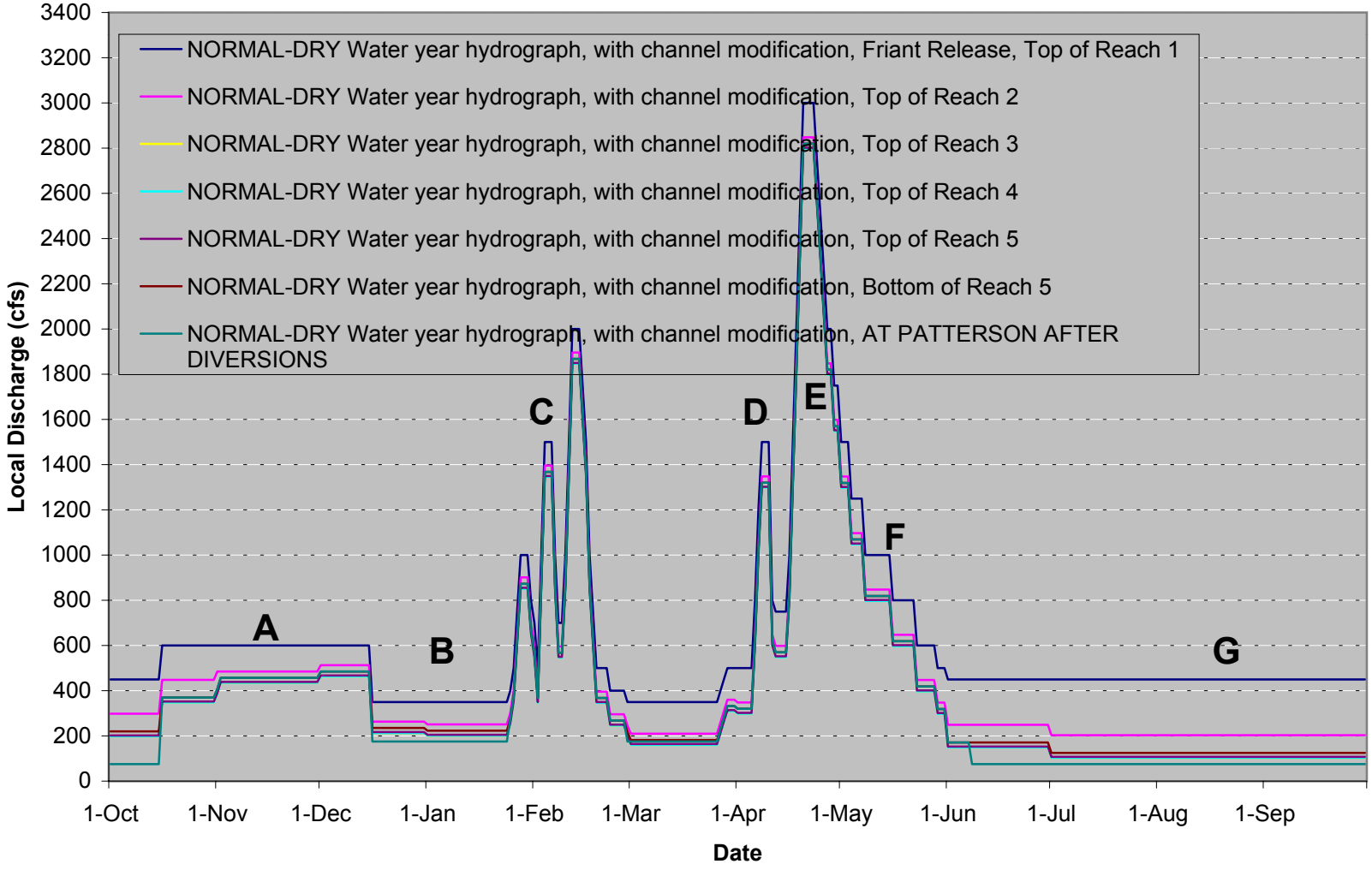


Figure 4. NORMAL-DRY Water year hydrographs for San Joaquin River reaches 1-5 WITHOUT channel modification

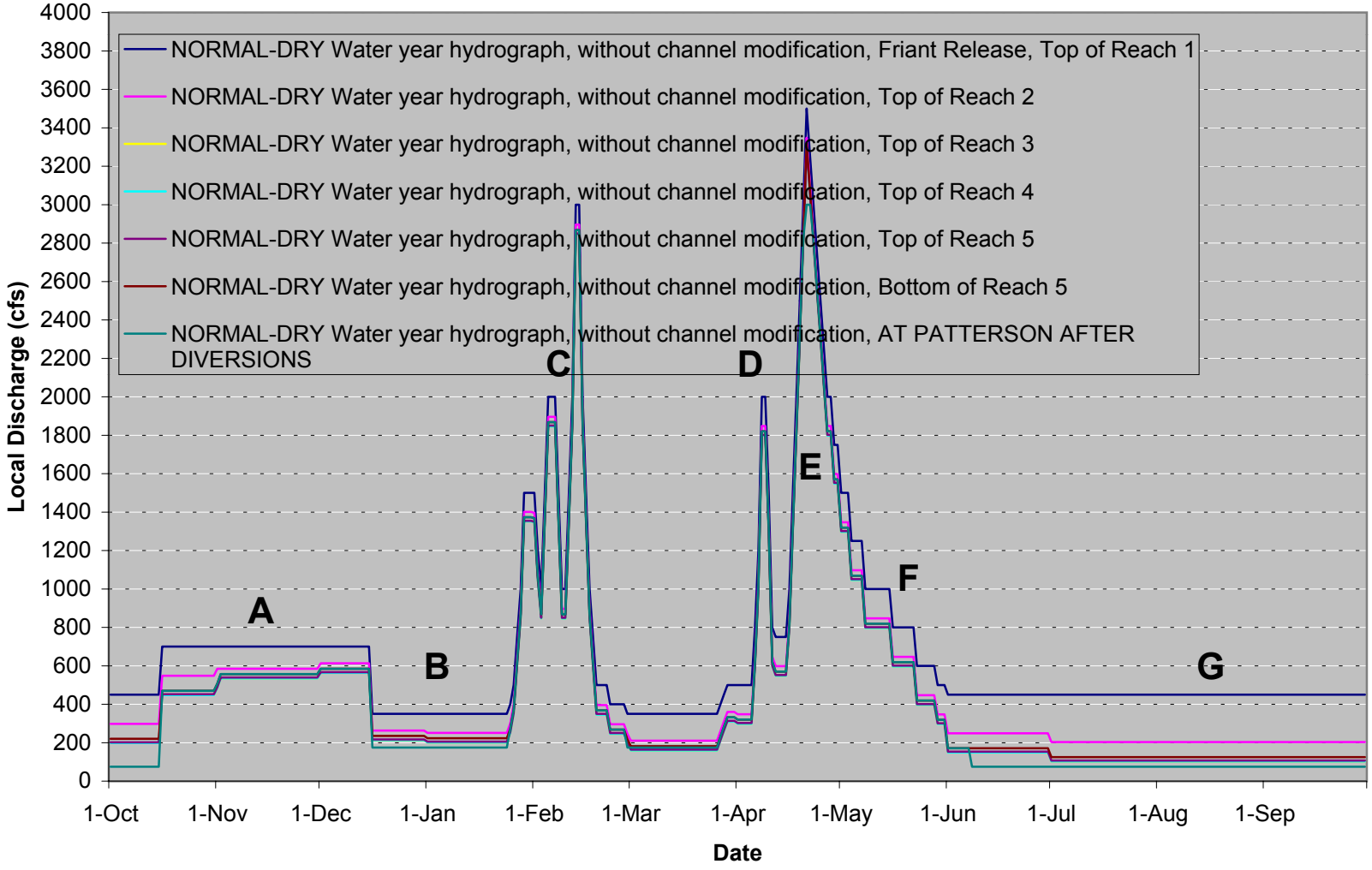


Figure 5. NORMAL-WET Water year hydrographs for San Joaquin River reaches 1-5 WITH channel modification

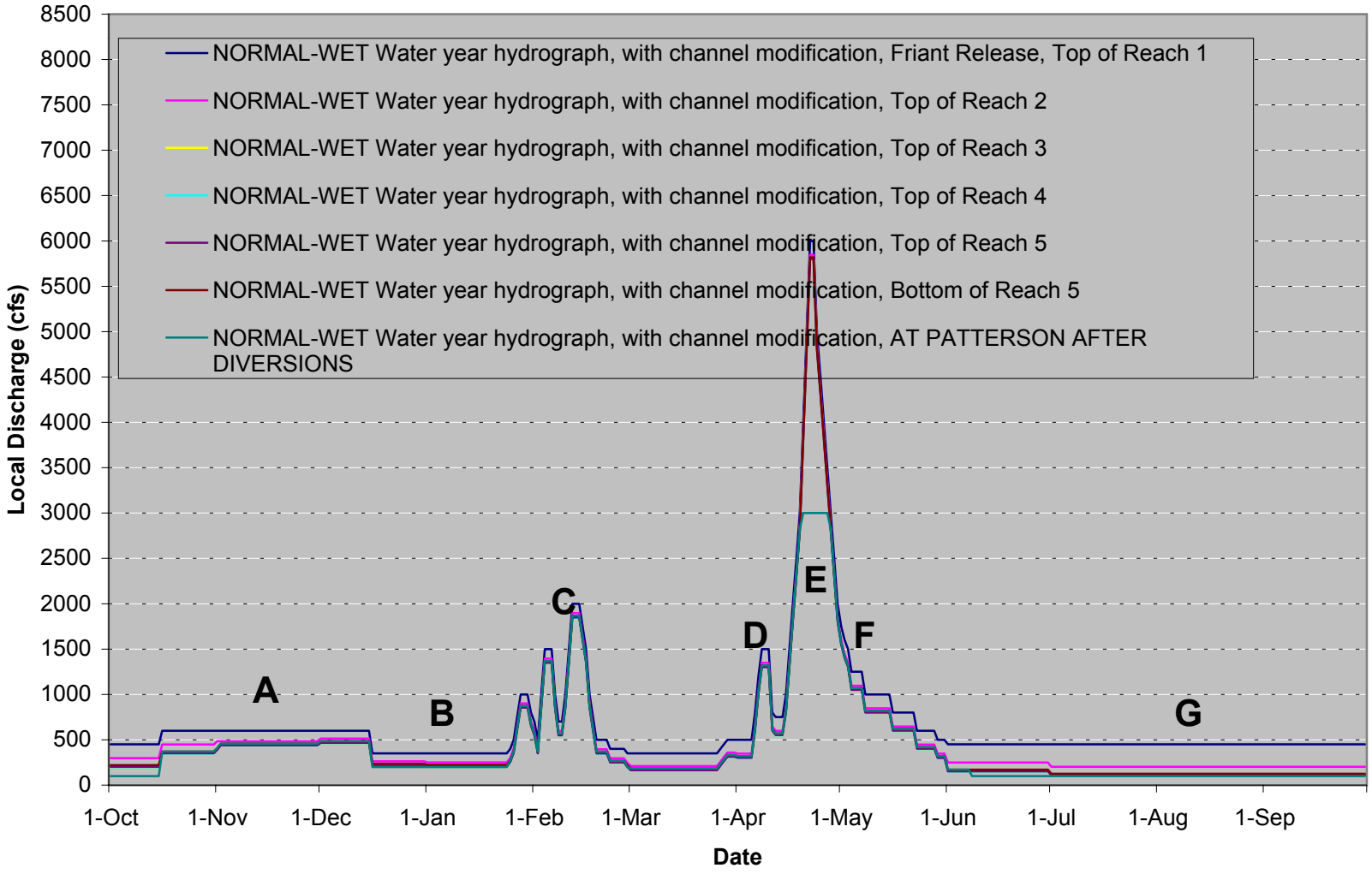


Figure 6. NORMAL-WET Water year hydrographs for San Joaquin River reaches 1-5 WITHOUT channel modification

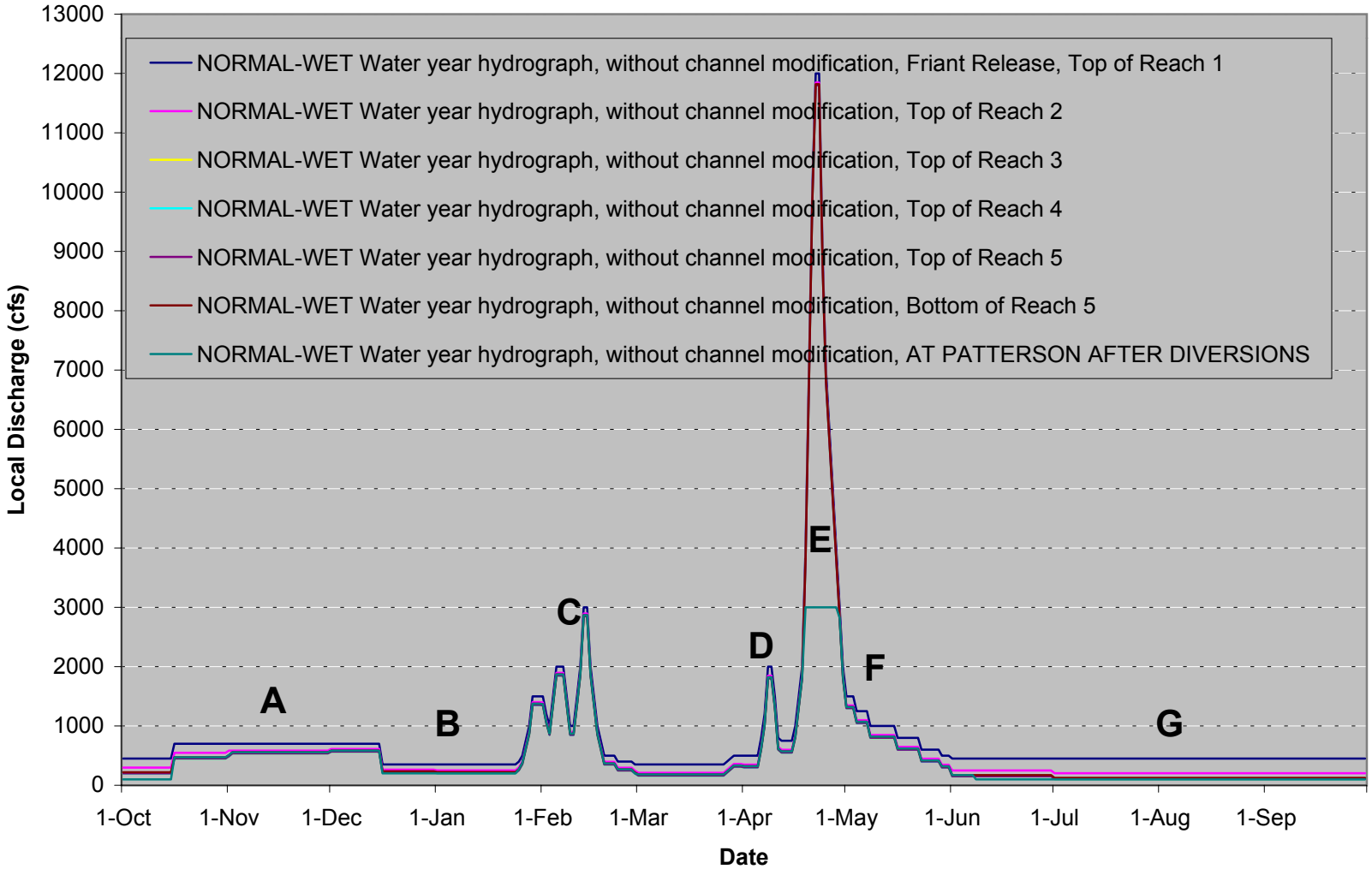


Figure 7. WET Water year hydrographs for San Joaquin River reaches 1-5 WITH channel modification

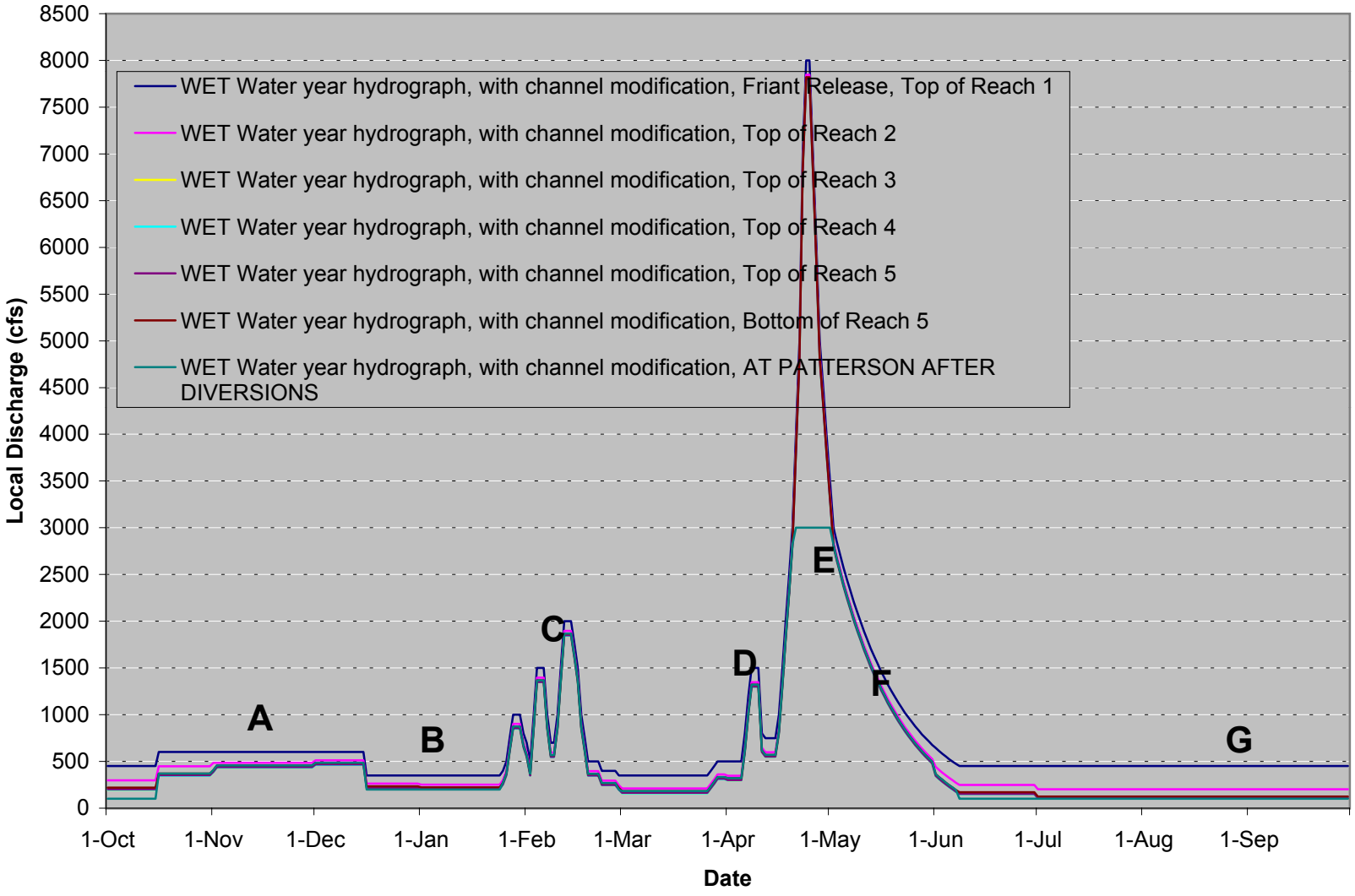
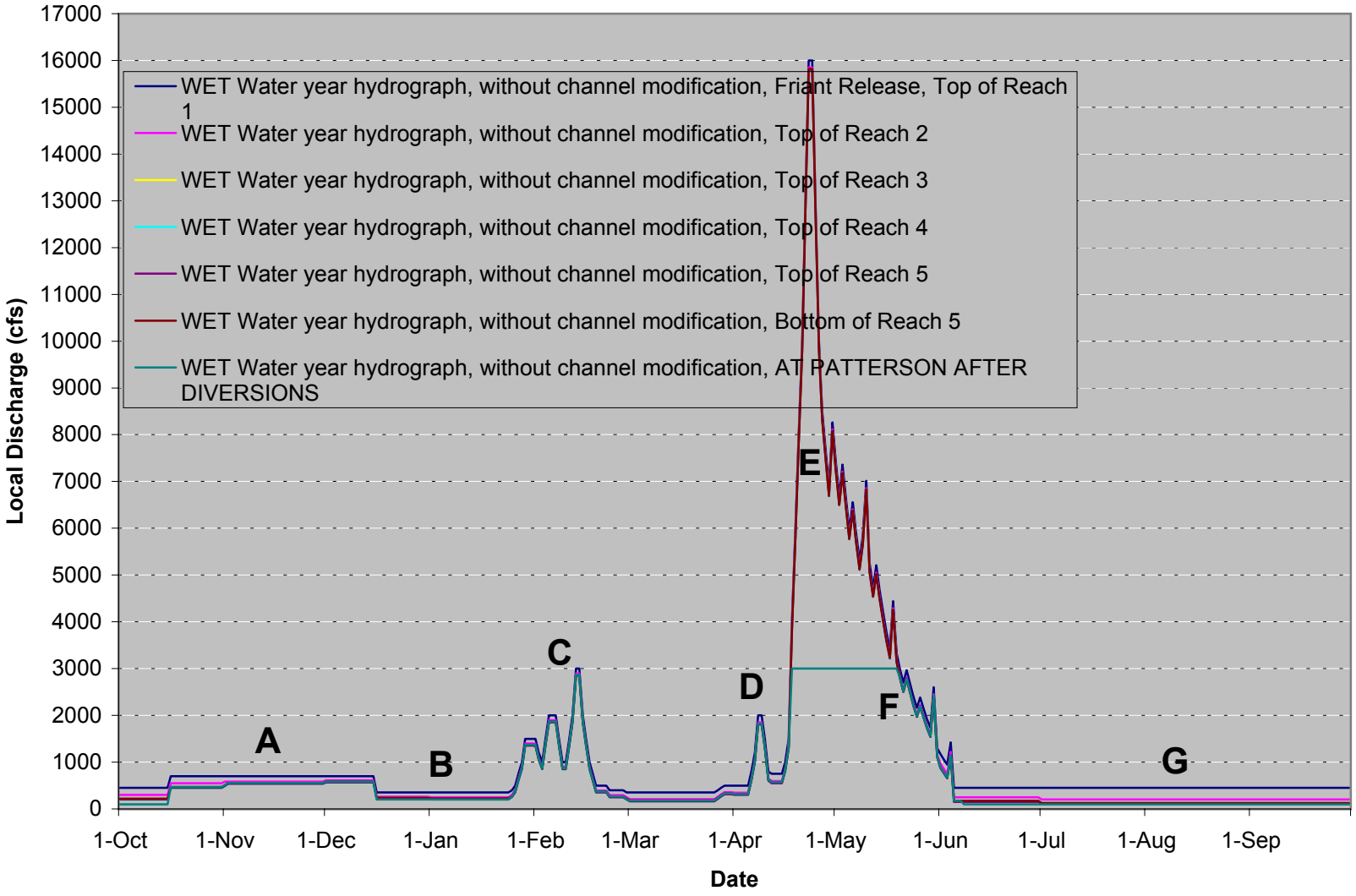


Figure 8. WET Water year hydrographs for San Joaquin River reaches 1-5 WITHOUT channel modification



Restoration Flows without Channel Modifications

Wet Year	Top of 1	Top of 2	Top of 3	Top of 4	Top of 4B	Top of 5	Bottm of 5	After Pater
Oct	35,604	26,258	20,109	20,109	18,387	20,355	21,461	17,891
Nov	41,654	34,810	31,736	31,736	30,070	31,974	33,045	33,045
Dec	31,934	26,585	23,510	23,510	21,789	23,756	24,863	23,752
Jan	30,843	24,756	21,682	21,682	19,960	21,928	23,034	21,939
Feb	67,042	61,266	58,489	58,489	56,934	58,712	59,711	59,676
Mar	22,711	14,103	11,028	11,028	9,307	11,274	12,381	12,381
Apr	284,825	275,780	272,805	272,805	271,138	273,043	274,114	103,618
May	261,405	251,997	248,923	248,923	247,201	249,169	250,276	164,271
Jun	32,324	20,364	14,413	14,413	12,747	14,651	15,722	12,483
Jul	27,670	12,482	6,333	6,333	4,612	6,579	7,686	6,149
Aug	27,670	12,482	6,333	6,333	4,612	6,579	7,686	6,149
Sep	26,777	12,080	6,129	6,129	4,463	6,367	7,438	5,951
Sum	890,459	772,963	721,491	721,491	701,220	724,387	737,419	467,306
Normal-Wet	Year							
Oct	35,604	26,258	20,109	20,109	18,387	20,355	21,461	17,891
Nov	41,654	34,810	31,736	31,736	30,070	31,974	33,045	33,045
Dec	31,934	26,585	23,510	23,510	21,789	23,756	24,863	23,752
Jan	30,843	24,756	21,682	21,682	19,960	21,928	23,034	21,939
Feb	67,042	61,266	58,489	58,489	56,934	58,712	59,711	59,676
Mar	22,711	14,103	11,028	11,028	9,307	11,274	12,381	12,381
Apr	196,962	187,917	184,942	184,942	183,275	185,180	186,251	98,580
May	55,935	46,527	43,453	43,453	41,731	43,698	44,805	44,805
Jun	26,777	14,817	8,866	8,866	7,200	9,104	10,175	6,936
Jul	27,670	12,482	6,333	6,333	4,612	6,579	7,686	6,149
Aug	27,670	12,482	6,333	6,333	4,612	6,579	7,686	6,149
Sep	26,777	12,080	6,129	6,129	4,463	6,367	7,438	5,951
Sum	591,579	474,082	422,610	422,610	402,339	425,506	438,538	337,255
Normal-Dry	Year							
Oct	35,604	26,258	20,109	20,109	18,387	20,355	21,461	17,147
Nov	41,654	34,810	31,736	31,736	30,070	31,974	33,045	33,045
Dec	31,934	26,585	23,510	23,510	21,789	23,756	24,863	22,959
Jan	30,843	24,756	21,682	21,682	19,960	21,928	23,034	20,749
Feb	67,042	61,266	58,489	58,489	56,934	58,712	59,711	59,626
Mar	22,711	14,103	11,028	11,028	9,307	11,274	12,381	12,020
Apr	96,299	87,254	84,279	84,279	82,613	84,517	85,588	84,814
May	55,935	46,527	43,453	43,453	41,731	43,698	44,805	44,805
Jun	26,777	14,817	8,866	8,866	7,200	9,104	10,175	5,796
Jul	27,670	12,482	6,333	6,333	4,612	6,579	7,686	4,612
Aug	27,670	12,482	6,333	6,333	4,612	6,579	7,686	4,612
Sep	26,777	12,080	6,129	6,129	4,463	6,367	7,438	4,463
Sum	490,916	373,420	321,948	321,948	301,676	324,844	337,875	314,649
Dry Year								
Oct	32,430	23,084	16,935	16,935	15,213	17,181	18,288	13,230
Nov	35,703	28,860	25,786	25,786	24,119	26,024	27,095	27,095
Dec	28,959	23,610	20,535	20,535	18,813	20,781	21,888	19,190
Jan	29,753	23,665	20,591	20,591	18,869	20,837	21,943	19,192
Feb	26,976	21,200	18,423	18,423	16,868	18,645	19,645	19,645
Mar	21,719	13,111	10,037	10,037	8,315	10,282	11,389	9,549
Apr	44,629	35,584	32,609	32,609	30,943	32,847	33,918	33,918
May	31,637	22,229	19,155	19,155	17,433	19,401	20,507	20,507
Jun	26,777	14,817	8,866	8,866	7,200	9,104	10,175	4,655
Jul	27,670	12,482	6,333	6,333	4,612	6,579	7,686	3,074
Aug	27,670	12,482	6,333	6,333	4,612	6,579	7,686	3,074
Sep	26,777	12,080	6,129	6,129	4,463	6,367	7,438	2,975
Sum	360,699	243,203	191,731	191,731	171,460	194,627	207,659	176,105

Restoration Flows with Channel Modifications

Wet Year	Top of 1	Top of 2	Top of 3	Top of 4	Top of 4B	Top of 5	Bottm of 5	After Pater
Oct	32,430	23,084	16,935	16,935	15,213	17,181	18,288	14,718
Nov	35,703	28,860	25,786	25,786	24,119	26,024	27,095	27,095
Dec	28,959	23,610	20,535	20,535	18,813	20,781	21,888	20,777
Jan	27,471	21,384	18,310	18,310	16,588	18,556	19,662	18,568
Feb	53,455	47,679	44,902	44,902	43,347	45,125	46,124	46,089
Mar	22,711	14,103	11,028	11,028	9,307	11,274	12,381	12,381
Apr	161,259	152,214	149,239	149,239	147,572	149,477	150,548	97,588
May	100,408	91,000	87,926	87,926	86,204	88,172	89,279	88,646
Jun	28,235	16,274	10,324	10,324	8,658	10,562	11,633	8,394
Jul	27,670	12,482	6,333	6,333	4,612	6,579	7,686	6,149
Aug	27,670	12,482	6,333	6,333	4,612	6,579	7,686	6,149
Sep	26,777	12,080	6,129	6,129	4,463	6,367	7,438	5,951
Sum	572,749	455,252	403,780	403,780	383,509	406,676	419,708	352,503

Normal-Wet	Year							
Oct	32,430	23,084	16,935	16,935	15,213	17,181	18,288	14,718
Nov	35,703	28,860	25,786	25,786	24,119	26,024	27,095	27,095
Dec	28,959	23,610	20,535	20,535	18,813	20,781	21,888	20,777
Jan	27,471	21,384	18,310	18,310	16,588	18,556	19,662	18,568
Feb	53,455	47,679	44,902	44,902	43,347	45,125	46,124	46,089
Mar	22,711	14,103	11,028	11,028	9,307	11,274	12,381	12,381
Apr	133,985	124,941	121,965	121,965	120,299	122,203	123,275	98,362
May	56,629	47,221	44,147	44,147	42,425	44,393	45,500	45,500
Jun	26,777	14,817	8,866	8,866	7,200	9,104	10,175	6,936
Jul	27,670	12,482	6,333	6,333	4,612	6,579	7,686	6,149
Aug	27,670	12,482	6,333	6,333	4,612	6,579	7,686	6,149
Sep	26,777	12,080	6,129	6,129	4,463	6,367	7,438	5,951
Sum	500,239	382,742	331,270	331,270	310,999	334,166	347,198	308,672

Normal-Dry	Year							
Oct	32,430	23,084	16,935	16,935	15,213	17,181	18,288	13,974
Nov	35,703	28,860	25,786	25,786	24,119	26,024	27,095	27,095
Dec	28,959	23,610	20,535	20,535	18,813	20,781	21,888	19,984
Jan	27,471	21,384	18,310	18,310	16,588	18,556	19,662	17,377
Feb	53,455	47,679	44,902	44,902	43,347	45,125	46,124	46,039
Mar	22,711	14,103	11,028	11,028	9,307	11,274	12,381	12,020
Apr	92,828	83,783	80,808	80,808	79,142	81,046	82,117	82,117
May	55,935	46,527	43,453	43,453	41,731	43,698	44,805	44,805
Jun	26,777	14,817	8,866	8,866	7,200	9,104	10,175	5,796
Jul	27,670	12,482	6,333	6,333	4,612	6,579	7,686	4,612
Aug	27,670	12,482	6,333	6,333	4,612	6,579	7,686	4,612
Sep	26,777	12,080	6,129	6,129	4,463	6,367	7,438	4,463
Sum	458,387	340,890	289,418	289,418	269,147	292,314	305,346	282,893

Dry Year								
Oct	29,257	19,910	13,762	13,762	12,040	14,007	15,114	10,056
Nov	29,753	22,909	19,835	19,835	18,169	20,073	21,144	21,144
Dec	25,984	20,634	17,560	17,560	15,838	17,806	18,913	16,215
Jan	29,753	23,665	20,591	20,591	18,869	20,837	21,943	14,898
Feb	26,976	21,200	18,423	18,423	16,868	18,645	19,645	19,411
Mar	21,719	13,111	10,037	10,037	8,315	10,282	11,389	9,640
Apr	44,629	35,584	32,609	32,609	30,943	32,847	33,918	33,918
May	31,637	22,229	19,155	19,155	17,433	19,401	20,507	20,507
Jun	26,777	14,817	8,866	8,866	7,200	9,104	10,175	4,655
Jul	27,670	12,482	6,333	6,333	4,612	6,579	7,686	3,074
Aug	27,670	12,482	6,333	6,333	4,612	6,579	7,686	3,074
Sep	26,777	12,080	6,129	6,129	4,463	6,367	7,438	2,975
Sum	348,600	231,104	179,632	179,632	159,360	182,528	195,559	159,569

Full Natural Flow for San Joaquin River at Friant

(CDEC) Acre-feet

Attachment B
Restoration Year Type Determination

SJF

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Apr-Jul	WY Total
1909	23,900	16,200	18,500	277,000	183,000	133,000	352,000	646,000	827,000	309,000	78,100	37,000	2,134,000	2,900,700
1910	25,000	49,600	220,000	188,200	86,400	190,000	378,300	479,400	238,500	98,200	37,700	50,200	1,194,400	2,041,500
1911	28,000	23,100	31,200	254,000	206,000	350,600	430,000	570,900	943,100	593,000	113,500	42,600	2,537,000	3,586,000
1912	29,300	25,000	20,300	28,300	25,600	58,200	80,700	261,100	370,700	92,300	34,100	18,300	804,800	1,043,900
1913	13,200	16,700	16,600	19,400	23,700	37,700	99,100	262,100	180,300	104,300	67,000	39,300	645,800	879,400
1914	11,700	18,400	25,600	276,800	151,100	238,100	388,300	605,900	607,800	386,900	130,600	42,200	1,988,900	2,883,400
1915	29,200	20,600	20,600	32,100	92,100	126,300	259,000	400,700	615,200	281,000	57,700	31,800	1,555,900	1,966,300
1916	14,200	13,400	30,900	182,600	144,500	341,200	479,000	581,400	582,400	282,300	77,500	31,100	1,925,100	2,760,500
1917	57,700	29,800	38,400	40,600	134,900	109,900	238,400	397,100	598,300	210,300	58,400	22,400	1,444,100	1,936,200
1918	12,700	11,700	12,500	12,700	33,700	157,500	192,900	341,400	515,400	109,600	28,800	37,900	1,159,300	1,466,800
1919	98,000	36,300	38,600	26,200	66,800	93,700	223,800	481,600	150,400	52,900	18,900	10,300	908,700	1,297,500
1920	12,700	10,300	26,000	21,300	26,200	105,300	171,800	455,600	349,800	99,600	30,100	13,800	1,076,800	1,322,500
1921	26,500	35,200	34,100	64,400	77,800	168,500	203,800	367,800	434,100	144,900	31,700	15,600	1,150,600	1,604,400
1922	10,700	9,900	59,000	66,200	98,600	104,500	205,100	684,800	757,800	265,800	68,700	24,000	1,913,500	2,355,100
1923	13,200	28,200	84,400	63,300	65,500	96,700	221,100	506,000	304,300	193,600	50,400	27,600	1,225,000	1,654,300
1924	27,900	16,000	14,200	14,000	21,200	25,700	94,600	164,000	34,900	16,500	9,200	5,900	310,000	444,100
1925	9,600	26,200	27,300	27,100	84,500	100,700	219,100	418,800	313,300	146,200	53,000	12,900	1,097,400	1,438,700
1926	19,800	16,400	21,300	16,500	57,000	96,300	347,000	378,400	146,100	43,400	12,300	6,900	914,900	1,161,400
1927	5,800	55,700	49,500	46,800	154,500	150,900	275,300	507,600	495,500	196,700	47,600	15,400	1,475,100	2,001,300
1928	20,100	68,600	32,800	33,400	48,100	149,900	188,900	373,000	175,500	44,000	13,700	5,700	781,400	1,153,700
1929	8,500	10,300	14,600	16,000	22,900	64,700	107,200	308,600	210,500	75,200	18,700	5,200	701,500	862,400
1930	5,000	6,200	8,300	18,200	35,600	80,000	165,100	213,500	243,600	60,800	16,900	5,900	683,000	859,100
1931	10,600	13,400	10,200	16,000	23,400	38,900	100,200	173,500	59,700	16,000	11,100	7,200	349,400	480,200
1932	5,900	8,400	71,800	58,900	167,700	156,600	238,100	491,500	543,600	238,800	51,400	14,700	1,512,000	2,047,400
1933	12,600	8,900	14,600	26,500	30,000	73,400	159,000	213,400	410,100	118,900	29,300	14,700	901,400	1,111,400
1934	6,800	10,300	38,100	46,800	50,300	109,400	166,100	146,200	68,900	27,300	13,400	7,900	408,500	691,500
1935	12,600	26,600	36,200	72,500	85,200	110,900	356,600	496,800	519,200	144,200	43,800	18,600	1,516,800	1,923,200
1936	13,600	15,800	16,400	38,300	195,900	163,500	348,600	510,000	347,700	150,500	42,100	10,900	1,356,800	1,853,300
1937	10,900	12,600	36,400	34,900	252,700	190,600	303,800	704,800	456,800	159,700	34,000	10,800	1,625,100	2,208,000
1938	9,800	12,300	210,700	70,900	207,300	433,800	434,200	795,000	912,700	431,200	127,900	42,600	2,573,100	3,688,400
1939	38,900	33,100	28,700	32,700	43,300	102,800	239,900	208,800	110,300	43,400	24,800	14,100	602,400	920,800
1940	34,800	14,200	11,400	134,100	139,800	210,000	290,000	558,600	362,900	96,600	21,200	7,000	1,308,100	1,880,600
1941	10,100	11,700	98,400	105,800	182,800	208,600	242,400	711,200	641,500	330,900	85,800	23,300	1,926,000	2,652,500
1942	21,500	30,300	96,000	113,100	102,600	128,500	298,500	465,500	632,600	284,000	64,700	16,700	1,680,600	2,254,000
1943	10,100	42,500	43,400	169,700	113,300	267,700	335,100	502,500	325,100	178,800	49,900	15,600	1,341,500	2,053,700
1944	10,500	15,100	19,800	31,200	55,400	111,600	140,800	408,200	279,500	142,600	35,000	15,700	971,100	1,265,400
1945	12,700	58,400	56,100	44,100	237,700	147,900	275,900	476,800	487,600	240,200	73,900	26,800	1,480,500	2,138,100
1946	59,100	65,600	118,300	78,980	53,800	125,800	310,400	463,900	279,900	117,800	36,900	19,100	1,172,000	1,729,580
1947	28,500	64,900	84,500	47,700	64,000	100,300	171,000	347,700	145,800	42,700	16,800	11,600	707,200	1,125,500
1948	22,800	18,200	15,400	18,900	20,200	42,600	164,600	390,600	372,600	107,900	26,000	15,000	1,035,700	1,214,800
1949	10,500	7,900	14,600	16,200	25,900	73,000	234,500	409,500	268,300	63,200	25,600	14,900	975,500	1,164,100
1950	9,800	16,100	17,200	43,200	90,100	89,600	280,100	379,000	262,900	87,000	21,700	13,800	1,009,000	1,310,500
1951	17,100	247,000	300,400	111,200	104,200	119,200	201,900	321,900	278,000	114,700	31,700	11,700	916,500	1,859,000
1952	12,300	20,400	83,400	133,000	98,700	176,700	385,200	819,900	640,800	335,300	101,400	33,000	2,181,200	2,840,100
1953	16,900	18,700	42,900	85,000	48,000	71,500	197,200	211,300	320,200	171,600	30,200	13,200	900,300	1,226,700
1954	9,400	16,600	16,600	33,400	65,400	127,200	278,400	439,500	217,600	80,400	20,200	9,100	1,015,900	1,313,800
1955	6,000	17,800	31,200	41,600	48,900	74,100	126,500	337,800	348,200	87,900	29,600	11,400	900,400	1,161,000
1956	6,100	13,200	460,500	271,200	140,800	169,500	278,300	568,000	613,800	317,800	86,500	34,400	1,777,900	2,960,100
1957	26,300	21,700	20,700	29,500	66,900	90,100	142,200	326,700	439,900	115,000	31,700	15,900	1,023,800	1,326,600
1958	16,400	18,500	43,300	42,600	112,500	181,400	362,600	795,500	622,300	287,500	107,900	40,500	2,067,900	2,631,000
1959	16,100	14,600	14,600	36,900	89,300	113,500	202,800	208,500	153,400	41,000	16,900	41,700	605,700	949,300
1960	18,200	9,400	9,500	17,900	54,800	86,100	177,800	240,400	147,500	42,600	16,800	7,600	608,300	828,600
1961	8,100	22,400	31,300	19,000	30,700	48,800	124,400	171,500	128,300	27,100	25,100	10,200	451,300	646,900
1962	9,900	14,900	23,000	23,300	184,800	109,800	380,900	396,700	505,300	203,000	51,800	20,200	1,485,900	1,923,600
1963	17,500	10,700	10,700	82,000	207,800	101,400	191,800	463,800	492,400	264,700	70,700	31,400	1,412,700	1,944,900
1964	25,500	64,300	36,300	31,300	30,300	52,100	126,500	256,600	200,300	59,700	28,700	10,600	643,100	922,200
1965	10,100	34,000	203,800	187,900	114,100	128,400	249,500	431,700	472,500	266,900	138,100	35,200	1,420,600	2,272,200
1966	17,700	100,900	65,900	62,400	55,600	125,700	276,500	361,800	147,700	50,600	25,000	8,800	836,600	1,298,600
1967	6,300	28,700	212,800	92,400	100,900	242,900	249,600	659,700	823,100	594,800	154,000	67,000	2,327,200	3,232,200
1968	26,900	22,900	34,300	36,900	75,400	82,900	146,100	231,100	131,200	43,800	22,100	8,500	552,200	862,100
1969	15,200	40,000	52,300	396,100	234,300	226,800	464,300	1,096,100	874,300	463,300	137,000	40,600	2,898,000	4,040,300
1970	32,600	31,700	47,100	159,400	83,300	136,900	146,000	375,800	278,500	106,600	36,700	11,000	906,900	1,445,600
1971	9,600	38,600	73,300	74,900	71,800	109,600	171,500	293,400	364,700	140,600	48,000	21,500	970,200	1,417,500
1972	13,300	25,500	57,500	41,300	50,000	138,400	124,000	268,200	213,300	47,000	15,800	44,700	652,500	1,039,000
1973	19,500	33,600	46,800	81,700	128,300	131,100	248,200	708,100	462,800	127,000	44,500	15,400	1,546,100	2,047,000
1974	21,000	87,600	81,800	137,500	66,200	209,700	267,200	596,600	482,000	161,700	59,500	19,700	1,507,500	2,190,500
1975	18,700	17,400	32,200	36,500	76,000	135,700	131,300	545,700	575,300	160,700	40,500	25,700	1,413,000	1,795,700
1976	48,500	32,800	23,800	18,400	37,600	59,100	81,600	173,500	60,200	34,700	23,700	35,300	350,000	629,200
1977	20,280	10,190	7,430	12,250	14,920	18,760	56,940	74,740	110,600	19,630	11,350	4,460	261,910	361,550
1978	5,520	9,400	80,420	158,540	195,870	325,840	346,130	697,300	825,800	462,460	149,000	145,600	2,331,690	3,401,880
1979	33,550	29,500	32,960	96,040	101,130	182,500	243,300	599,410	339,070	113,500	41,890	17,410	1,295,280	1,830,260
1980	23,750	29,120	33,530	326,840	282,470	215,780	314,700	527,540	642,080	426,460	113,410	37,000	1,910,780	2,972,680
1981	23,860	19,300	29,400	36,490	56,730	87,270	205,950	317,700	208,240	51,380	19,020	12,700	783,270	1,068,040
1982	18,750	70,400	64,900	119,240	198,780	231,450	612,930	725,350	584,620	371,470	148,370	169,790	2,294,370	3,316,050
1983	125,950	145,530	211,900	227,000	271,310	427,870	280,460	727,500	1,166,100	686,030	280,290	91,940	2,860,090	4,641,880
1984	53,060	148,770	226,650	126,400	107,450	162,490	203,010	489,030	266,160	162,280	67,460	36,090	1,120,480	2,048,850
1985	31,070	49,680	40,980	39,730	55,840	84,300	253,710	307,920	168,990	55,230	22,110	19,460	785,850	1,129,020
1986	23,900	38,300	67,700	93,400	472,400	426,200	361,400	624,300	593,400	222,200	76,400	31,800	1,801,300	3,031,400
1987	23,900	14,200	14,600	20,700	39,500	65,800	171,600	228,500	120,600	33,200	15,000	10,031	553,900	757,631
1988	16,260	24,276	25,360	59,390	48,340	91,370	152,680	219,540	141,930	48,574	22,830	11,592	562,724	862,142
1989	7,236	13,851	19,570	22,310	37,230	132,575	237,482	240,200	149,280	41,154	18,907	19,370	668,116	939,165
1990	23,030	22,088	16,729	24,927	33,583	85,112	172,691	165,351	122,158	54,021	14,339	8,487	514,221	742,516
1991	7,714	5,665	8,580	9,904	11,324	117,514	135,419	277,408	321,105	102,000	24,460	13,000	835,932	1,034,093
1992	12,347	19,244	17,655	20,970	67,534	76,810	208,878	237,788	75,575	46,206	16,965	8,550	568,447	808,522
1993	12,920	16,620	31,704	189,311	124,360	242,534	330,386	700,630	599,100	316,631	82,430	26,240	1,946,747	2,672,866
1994	19,395	17,090	21,176	23,209	41,890	75,434	149,690	257,843	159,005	35,700	14,466	11,550	602,238	826,448
1995	42,915	44,620	48,120	213,100	121,590	485,460	349,993	633,812	880,942	751,700	239,190	66,250	2,616,447	3,877,692
1996	23,697	15,070	50,192	70,240	229,481	222,164	333,373	588,600	412,003	184,085	55,413	18,454	1,518,061	2,202,772
1997	17,910	99,400	212,542	734,996	180,913	218,770	302,456	539,316	279,683	129,703	44,360	21,479	1,251,158	2,781,528
1998	17,927	24,485	35,665	101,550	210,410	232,083	288,075	445,675	886,311	686,382	159,130	72,148	2,306,443	3,159,841
1999	35,703	38,551	49,954	69,145	111,330	102,200	182,060	446,022	337,292	105,080	32,371	17,342	1,070,454	1,527,050
2000	11,717	12,242	15,723	79,939	154,753	164,400	279,620	529,817	350,834	90,848	37,230	14,817	1,251,119	1,741,940
2001	19,532	17,197	15,507	26,262	41,907	126,404	187,945	444,913	114,609				747,467	994,276

Years 1909 - 2000

Full Natural Flow for San Joaquin River at Friant - Sorted by Water Year Total

(CDEC) Acre-feet SJF

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Apr-Jul	WY Total	Count	Excd
1983	125,950	145,530	211,900	227,000	271,310	427,870	280,460	727,500	1,166,100	686,030	280,290	91,940	2,860,090	4,641,880	1	1.1
1969	15,200	40,000	52,300	396,100	234,300	226,800	464,300	1,096,100	874,300	463,300	137,000	40,600	2,898,000	4,040,300	2	2.2
1995	42,915	44,620	48,120	213,100	121,590	485,460	349,993	633,812	880,942	751,700	239,190	66,250	2,616,447	3,877,692	3	3.3
1938	9,800	12,300	210,700	70,900	207,300	433,800	434,200	795,000	912,700	431,200	127,900	42,600	2,573,100	3,688,400	4	4.3
1911	28,000	23,100	31,200	254,000	206,000	350,600	430,000	570,900	943,100	593,000	113,500	42,600	2,537,000	3,586,000	5	5.4
1978	5,520	9,400	80,420	158,540	195,870	325,840	346,130	697,300	825,800	462,460	149,000	145,600	2,331,690	3,401,880	6	6.5
1982	18,750	70,400	64,900	119,240	198,780	231,450	612,930	725,350	584,620	371,470	148,370	169,790	2,294,370	3,316,050	7	7.6
1967	6,300	28,700	212,800	92,400	100,900	242,900	249,600	659,700	823,100	594,800	154,000	67,000	2,327,200	3,232,200	8	8.7
1998	17,927	24,485	35,665	101,550	210,410	232,083	288,075	445,675	886,311	686,382	159,130	72,148	2,306,443	3,159,841	9	9.8
1986	23,900	38,300	67,700	93,400	472,400	426,200	361,400	624,300	593,400	222,200	76,400	31,800	1,801,300	3,031,400	10	10.9
1980	23,750	29,120	33,530	326,840	282,470	215,780	314,700	527,540	642,080	426,460	113,410	37,000	1,910,780	2,972,680	11	12.0
1956	6,100	13,200	460,500	271,200	140,800	169,500	278,300	568,000	613,800	317,800	86,500	34,400	1,777,900	2,960,100	12	13.0
1909	23,900	16,200	18,500	277,000	183,000	133,000	352,000	646,000	827,000	309,000	78,100	37,000	2,134,000	2,900,700	13	14.1
1914	11,700	18,400	25,600	276,800	151,100	238,100	388,300	605,900	607,800	386,900	130,600	42,200	1,988,900	2,883,400	14	15.2
1952	12,300	20,400	83,400	133,000	98,700	176,700	385,200	819,900	640,800	335,300	101,400	33,000	2,181,200	2,840,100	15	16.3
1997	17,910	99,400	212,542	734,996	180,913	218,770	302,456	539,316	279,683	129,703	44,360	21,479	1,251,158	2,781,528	16	17.4
1916	14,200	13,400	30,900	182,600	144,500	341,200	479,000	581,400	582,400	282,300	77,500	31,100	1,925,100	2,760,500	17	18.5
1993	12,920	16,620	31,704	189,311	124,360	242,534	330,386	700,630	599,100	316,631	82,430	26,240	1,946,747	2,672,866	18	19.6
1941	10,100	11,700	98,400	105,800	182,800	208,600	242,400	711,200	641,500	330,900	85,800	23,300	1,926,000	2,652,500	19	20.7
1958	16,400	18,500	43,300	42,600	112,500	181,400	362,600	795,500	622,300	287,500	107,900	40,500	2,067,900	2,631,000	20	21.7
1922	10,700	9,900	59,000	66,200	98,600	104,500	205,100	684,800	757,800	265,800	68,700	24,000	1,913,500	2,355,100	21	22.8
1965	10,100	34,000	203,800	187,900	114,100	128,400	249,500	431,700	472,500	266,900	138,100	35,200	1,420,600	2,272,200	22	23.9
1942	21,500	30,300	96,000	113,100	102,600	128,500	298,500	465,500	632,600	284,000	64,700	16,700	1,680,600	2,254,000	23	25.0
1937	10,900	12,600	36,400	34,900	252,700	190,600	303,800	704,800	456,800	159,700	34,000	10,800	1,625,100	2,208,000	24	26.1
1996	23,697	15,070	50,192	70,240	229,481	222,164	333,373	588,600	412,003	184,085	55,413	18,454	1,518,061	2,202,772	25	27.2
1974	21,000	87,600	81,800	137,500	66,200	209,700	267,200	596,600	482,000	161,700	59,500	19,700	1,507,500	2,190,500	26	28.3
1945	12,700	58,400	56,100	44,100	237,700	147,900	275,900	476,800	487,600	240,200	73,900	26,800	1,480,500	2,138,100	27	29.3
1943	10,100	42,500	43,400	169,700	113,300	267,700	335,100	502,500	325,100	178,800	49,900	15,600	1,341,500	2,053,700	28	30.4
1984	53,060	148,770	226,650	126,400	107,450	162,490	203,010	489,030	266,160	162,280	67,460	36,090	1,120,480	2,048,850	29	31.5
1932	5,900	8,400	71,800	58,900	167,700	156,600	238,100	491,500	543,600	238,800	51,400	14,700	1,512,000	2,047,400	30	32.6
1973	19,500	33,600	46,800	81,700	128,300	131,100	248,200	708,100	462,800	127,000	44,500	15,400	1,546,100	2,047,000	31	33.7
1910	25,000	49,600	220,000	188,200	86,400	190,000	378,300	479,400	238,500	98,200	37,700	50,200	1,194,400	2,041,500	32	34.8
1927	5,800	55,700	49,500	46,800	154,500	150,900	275,300	507,600	495,500	196,700	47,600	15,400	1,475,100	2,001,300	33	35.9
1915	29,200	20,600	20,600	32,100	92,100	126,300	259,000	400,700	615,200	281,000	57,700	31,800	1,555,900	1,966,300	34	37.0
1963	17,500	10,700	10,700	82,000	207,800	101,400	191,800	463,800	492,400	264,700	70,700	31,400	1,412,700	1,944,900	35	38.0
1917	57,700	29,800	38,400	40,600	134,900	109,900	238,400	397,100	598,300	210,300	58,400	22,400	1,444,100	1,936,200	36	39.1
1962	9,900	14,900	23,000	23,300	184,800	109,800	380,900	396,700	505,300	203,000	51,800	20,200	1,485,900	1,923,600	37	40.2
1935	12,600	26,600	36,200	72,500	85,200	110,900	356,600	496,800	519,200	144,200	43,800	18,600	1,516,800	1,923,200	38	41.3
1940	34,800	14,200	11,400	134,100	139,800	210,000	290,000	558,600	362,900	96,600	21,200	7,000	1,308,100	1,880,600	39	42.4
1951	17,100	247,000	300,400	111,200	104,200	119,200	201,900	321,900	278,000	114,700	31,700	11,700	916,500	1,859,000	40	43.5
1936	13,600	15,800	16,400	38,300	195,900	163,500	348,600	510,000	347,700	150,500	42,100	10,900	1,356,800	1,853,300	41	44.6
1979	33,550	29,500	32,960	96,040	101,130	182,500	243,300	599,410	339,070	113,500	41,890	17,410	1,295,280	1,830,260	42	45.7
1975	18,700	17,400	32,200	36,500	76,000	135,700	131,300	545,700	575,300	160,700	40,500	25,700	1,413,000	1,795,700	43	46.7
2000	11,717	12,242	15,723	79,939	154,753	164,400	279,620	529,817	350,834	90,848	37,230	14,817	1,251,119	1,741,940	44	47.8
1946	59,100	65,600	118,300	78,980	53,800	125,800	310,400	463,900	279,900	117,800	36,900	19,100	1,172,000	1,729,580	45	48.9
1923	13,200	28,200	84,400	63,300	65,500	96,700	221,100	506,000	304,300	193,600	50,400	27,600	1,225,000	1,654,300	46	50.0
1921	26,500	35,200	34,100	64,400	77,800	168,500	203,800	367,800	434,100	144,900	31,700	15,600	1,150,600	1,604,400	47	51.1
1999	35,703	38,551	49,954	69,145	111,330	102,200	182,060	446,022	337,292	105,080	32,371	17,342	1,070,454	1,527,050	48	52.2
1918	12,700	11,700	12,500	12,700	33,700	157,500	192,900	341,400	515,400	109,600	28,800	37,900	1,159,300	1,466,800	49	53.3
1970	32,600	31,700	47,100	159,400	83,300	136,900	146,000	375,800	278,500	106,600	36,700	11,000	906,900	1,445,600	50	54.3
1925	9,600	26,200	27,300	27,100	84,500	100,700	219,100	418,800	313,300	146,200	53,000	12,900	1,097,400	1,438,700	51	55.4
1971	9,600	38,600	73,300	74,900	71,800	109,600	171,500	293,400	364,700	140,600	48,000	21,500	970,200	1,417,500	52	56.5
1957	26,300	21,700	20,700	29,500	66,900	90,100	142,200	326,700	439,900	115,000	31,700	15,900	1,023,800	1,326,600	53	57.6
1920	12,700	10,300	26,000	21,300	26,200	105,300	171,800	455,600	349,800	99,600	30,100	13,800	1,076,800	1,322,500	54	58.7
1954	9,400	16,600	16,600	33,400	65,400	127,200	278,400	439,500	217,600	80,400	20,200	9,100	1,015,900	1,313,800	55	59.8
1950	9,800	16,100	17,200	43,200	90,100	89,600	280,100	379,000	262,900	87,000	21,700	13,800	1,009,000	1,310,500	56	60.9
1966	17,700	100,900	65,900	62,400	55,600	125,700	276,500	361,800	147,700	50,600	25,000	8,800	836,600	1,298,600	57	62.0
1919	98,000	36,300	38,600	26,200	66,800	93,700	223,800	481,600	150,400	52,900	18,900	10,300	908,700	1,297,500	58	63.0
1944	10,500	15,100	19,800	31,200	55,400	111,600	140,800	408,200	279,500	142,600	35,000	15,700	971,100	1,265,400	59	64.1
1953	16,900	18,700	42,900	85,000	48,000	71,500	197,200	211,300	320,200	171,600	30,200	13,200	900,300	1,226,700	60	65.2
1948	22,800	18,200	15,400	18,900	20,200	42,600	164,600	390,600	372,600	107,900	26,000	15,000	1,035,700	1,214,800	61	66.3
1949	10,500	7,900	14,600	16,200	25,900	73,000	234,500	409,500	268,300	63,200	25,600	14,900	975,500	1,164,100	62	67.4
1926	19,800	16,400	21,300	16,500	57,000	96,300	347,000	378,400	146,100	43,400	12,300	6,900	914,900	1,161,400	63	68.5
1955	6,000	17,800	31,200	41,600	48,900	74,100	126,500	337,800	348,200	87,900	29,600	11,400	900,400	1,161,000	64	69.6
1928	20,100	68,600	32,800	33,400	48,100	149,900	188,900	373,000	175,500	44,000	13,700	5,700	781,400	1,153,700	65	70.7
1985	31,070	49,680	40,980	39,730	55,840	84,300	253,710	307,920	168,990	55,230	22,110	19,460	785,850	1,129,020	66	71.7
1947	28,500	64,900	84,500	47,700	64,000	100,300	171,000	347,700	145,800	42,700	16,800	11,600	707,200	1,125,500	67	72.8
1933	12,600	8,900	14,600	26,500	30,000	73,400	159,000	213,400	410,100	118,900	29,300	14,700	901,400	1,111,400	68	73.9
1981	23,860	19,300	29,400	36,490	56,730	87,270	205,950	317,700	208,240	51,380	19,020	12,700	783,270	1,068,040	69	75.0
1912	29,300	25,000	20,300	28,300	25,600	58,200	80,700	261,100	370,700	92,300	34,100	18,300	804,800	1,043,900	70	76.1
1972	13,300	25,500	57,500	41,300	50,000	138,400	124,000	268,200	213,300	47,000	15,800	44,700	652,500	1,039,000	71	77.2
1991	7,714	5,665	8,580	9,904	11,324	117,514	135,419	277,408	321,105	102,000	24,460	13,000	835,932	1,034,093	72	78.3
1959	16,100	14,600	14,600	36,900	89,300	113,500	202,800	208,500	153,400	41,000	16,900	41,700	605,700	949,300	73	79.3
1989	7,236	13,851	19,570	22,310	37,230	132,575	237,482	240,200	149,280	41,154	18,907	19,370	668,116	939,165	74	80.4
1964	25,500	64,300	36,300	31,300	30,300	52,100	126,500	256,600	200,300	59,700	28,700	10,600	643,100	922,200	75	81.5
1939	38,900	33,100	28,700	32,700	43,300	102,800	239,900	208,800	110,300	43,400	24,800	14,100	602,400	920,800	76	82.6
1913	13,200	16,700	16,600	19,400	23,700	37,700	99,100	262,100	180,300	104,300	67,000	39,300	645,800	879,400	77	83.7
1929	8,500	10,300	14,600	16,000	22,900	64,700	107,200	308,600	210,500	75,200	18,700	5,200	701,500	862,400	78	84.8
1988	16,260	24,276	25,360	59,390	48,340	91,370	152,680	219,540	141,930	48,574	22,830	11,592	562,724	862,142	79	85.9
1968	26,900	22,900	34,300	36,900	75,400	82,900	146,100	231,100	131,200	43,800	22,100	8,500	552,200	862,100	80	87.0
1930	5,000	6,200	8,300	18,200	35,600	80,000	165,100	213,500	243,600	60,800	16,900	5,900	683,000	859,100	81	88.0
1960	18,200	9,400	9,500	17,900	54,800	86,100	177,800	240,400	147,500	42,600	16,800	7,600	608,300	828,600	82	89.1
1994	19,395	17,090	21,176	23,209	41,890	75,434	149,690	257,843	159,005	35,700	14,466	11,550	602,238	826,448	83	90.2
1992	12,347	19,244	17,655	20,970	67,534	76,810	208,878	237,788	75,575	46,206	16,965	8,550	568,447	808,522	84	91.3
1987	23,900	14,200	14,600	20,700	39,500	65,800	171,600	228,500	120,600	33,200	15,000	10,031	553,900	757,631	85	92.4
1990	23,030	22,088	16,729	24,927	33,583	85,112	172,691	165,351	122,158	54,021	14,339	8,487	514,221	742,516	86	93.5
1934	6,800	10,300	38,100	46,800	50,300	109,400	166,100	146,200	68,900	27,300	13,400	7,900	408,500	691,500	87	94.6
1961	8,100	22,400	31,300	19,000	30,700	48,800	124,400	171,500	128,300	27,100	25,100	10,200	451,300	646,900	88	95.7
1976	48,500	32,800	23,800	18,400	37,600	59,100	81,600	173,500	60,200	34,700	23,700	35,300	350,000	629,200	89	96.7
1931	10,600	13,400	10,200	16,000	23,400	38,900	100,200	173,500	59,700	16,000	11,100	7,200	349,400	480,200	90	97.8
1924	27,900	16,000	14,200	14,000	21,200	25,700	94,600	164,000	34,900	16,500	9,200	5,900	310,000	444,100	91	98.9
1977	20,280	10,190	7,430	12,250	14,920	18,760	56,940	74,740	110,600	19,630	11,350	4,460	261,910	361,550	92	*******

Years 1909 - 2000

San Joaquin River at Friant Restoration Flow Year Type

Water Year	Year Type	
1909	W	1
1910	NW	2
1911	W	1
1912	ND	3
1913	D	4
1914	W	1
1915	NW	2
1916	W	1
1917	NW	2
1918	ND	3
1919	ND	3
1920	ND	3
1921	ND	3
1922	NW	2
1923	ND	3
1924	D	4
1925	ND	3
1926	ND	3
1927	NW	2
1928	ND	3
1929	D	4
1930	D	4
1931	D	4
1932	NW	2
1933	ND	3
1934	D	4
1935	NW	2
1936	NW	2
1937	NW	2
1938	W	1
1939	D	4
1940	NW	2
1941	NW	2
1942	NW	2
1943	NW	2
1944	ND	3
1945	NW	2
1946	NW	2
1947	ND	3
1948	ND	3
1949	ND	3
1950	ND	3
1951	NW	2
1952	W	1
1953	ND	3
1954	ND	3
1955	ND	3
1956	W	1
1957	ND	3
1958	NW	2
1959	ND	3
1960	D	4
1961	D	4
1962	NW	2
1963	NW	2
1964	D	4
1965	NW	2
1966	ND	3
1967	W	1
1968	D	4
1969	W	1
1970	ND	3
1971	ND	3
1972	ND	3
1973	NW	2
1974	NW	2
1975	NW	2
1976	D	4
1977	D	4
1978	W	1
1979	NW	2
1980	W	1
1981	ND	3
1982	W	1
1983	W	1
1984	NW	2
1985	ND	3
1986	W	1
1987	D	4
1988	D	4
1989	D	4
1990	D	4
1991	ND	3
1992	D	4
1993	W	1
1994	D	4
1995	W	1
1996	NW	2
1997	W	1
1998	W	1
1999	ND	3
2000	NW	2

Attachment C - Spreadsheet Formulas

Main Heading	Sub - heading	Sub - heading	Worksheet Column	Formula
		Water year	A	1922.01
		Month Index	B	1
Fine Gold Operation		Fine Gold inflow	C	=+Base_Data'!Z11
		Fine Gold Storage Rule	D	=HLOOKUP(B11,Control'!$D$111:$O$113,3)
		Fine Gold Maximum Put based on trigger	E	=VLOOKUP($AD10,Stor_matrix'!$B$13:$AL$44,$B11*3)
		Fine Gold pump-in	F	=MAX(0,MIN(F$1*Convert'!D11,(+D11-J10-C11+I11),E11))
		Fine Gold Maximum Release based on trigger	G	=VLOOKUP($AD10,Use_matrix'!$B$13:$AL$44,$B11*3)
		Fine Gold Release	H	=MIN(J10-J$2+C11,MAX(0,MIN(H$1*Convert'!D11,J10-J$2,G11)+MAX(0,(J10+C11+F11-I11-J$1))))
		Fine Gold Evap.	I	=VLOOKUP(J10,Lookup'!$R$5:$S$14,2)*VLOOKUP($B11,Lookup'!$A$5:$F$16,6,FALSE)/12/1000
		Fine Gold Storage	J	=MIN(J$1,+J10+C11+F11-H11-I11)
Millerton Reservoir Operation		Millerton inflow without Fine Gold	K	=+Base_Data'!Y11
		Inflow	L	=+K11-F11+H11
		Total Canal Diversion	M	=+N11+O11
		Madera Canal Release (taf)	N	=+DX11-EG11-EH11+ED11-DY11-DZ11-EB11
		Friant-Kern Canal Release (taf)	O	=+EJ11
		Allowable Millerton Storage - Rainflood Space (taf)	P	=VLOOKUP($B11,Lookup'!$A$5:$E$16,5,FALSE)
		Required Flood Control Space (taf)	Q	=$P$1-P11
		Mammoth Credit (taf)	R	=IF(Q11>85,MIN($R$1-Base_Data'!AD11,Q11-85),0)
		Updated - Required Millerton Space (taf)	S	=Q11-R11
		Updated - Maximum storage, flood rule	T	=$P$1-S11
		Rainflood Release (taf)	U	=MAX(0,(AD10+L11-M11-Z11)-T11)
		Snowmelt Release (taf)	V	0
		Total Flood Control Release (taf)	W	=MAX(U11,V11)
		Required Friant Release with channel modification	X	=Rest_q'!F11
		Total Release to SJR	Y	=MAX(X11,W11)
		Evaporation	Z	=IF(AD10>0,(-1.77*AD10+455.4*(AD10^0.5)-566.62*(AD10^0.333333)+1.19)*VLOOKUP($B11,Lookup'!$A$5:$F$16,6,FALSE)/12/1000,0)
		1. Set to 0 for initial run 2. Copy "AC" to purchase_ matrix 3. Copy value from purch._ matrix BE Type3 Purchase Water	AA	0
		Category 3 Unused Purchase Water	AB	=+EC11+EQ11+FO11+GJ11+HE11+HW11
		Residual Shortage Water	AC	=-MIN(+AD10+L11-M11-Z11-Y11-AD$1,0)*AC$1
		Millerton Storage	AD	=+AD10+L11-M11-Z11-Y11+AC11
		Incremental flow below Friant	AE	=+Y11-Base_Data'!E11
G		Incremental depletion	AF	=AE11*AF$1

San Joaquin River - Friant to Gravelly Ford		Deep Percolation from River Flow (% of incremental loss)	AG	=AF11*AG$1
		Total GW storage due to SJR recharge	AH	=+AH10+AG11
		Depletion and/or diversions (Friant to Gravelly Ford)	AI	=VLOOKUP($B11,Lookup'!$A$5:$C$16,3,FALSE)
		Flow at Gravelly Ford	AJ	=+Y11-AF11-AI11
		Incremental Flow at Gravelly Ford	AK	=+AJ11-Base_Data'!P11
San Joaquin River - Gravelly Ford to Merced		Incremental losses (Gravelly Ford to Pool)	AL	=+AK11*AL$1
		Deep Percolation from River Flow (% of incremental loss)	AM	=AL11*AM$1
		Total GW storage due to SJR recharge	AN	=+AN10+AM11
		Remaining SJR incremental flow	AO	=+AK11-AL11
		SJR flow to Pool, including Chowchilla bypass	AP	=+AJ11-AL11
		Tulare Lake basin overflow, James Bypass (base condition)	AQ	=+Base_Data'!Q11
		Tulare Lake basin overflow, James Bypass	AR	=+AQ11+FI11
		Revised surplus plus incremental flow available to divert at pool	AS	=+AP11+AR11
		Required bypass flow	AT	=IF(AT$1'=0,X11-AI11-AF11-AL11,+Rest_q'!G11/1000)
		Available for diversion at pool	AU	=IF(AT$1=0,MAX(0,(AP11-AT11))+AR11,MAX(0,(AP11-AT11))*Rest_q'!H11+AR11)
		Pool Demand	AV	=+Base_Data'!R11
		DMC to Pool	AW	=MAX(0,+AV11-AU11)
		Change in DMC inflow	AX	=+AW11-Base_Data'!T11
		Credit to DMC	AY	=MIN(AX11,0)
		Impact to DMC	AZ	=MAX(AX11,0)
		Flow past pool	BA	=+AS11-(AV11-AW11)
		Incremental flow past pool	BB	=+BA11-Base_Data'!S11
		Incremental losses (Pool to Merced)	BC	=-(-BB11)*BC$1
		Flow increment above Merced River	BD	=BB11+BC11
Merced R		Merced Release for VAMP	BE	=+Base_Data'!U11
		Merced River available surplus (considering Vernalis surplus)	BF	=+Base_Data'!V11
		Change in Merced River flow from VAMP Exchange	BG	=-MAX(0,MIN(BE11,BD11))*BG$1
		Merced ID Account Balance for VAMP Exchange	BH	=+BH10-BG11-BI11

River		Diversion of Merced River VAMP	BI	=(EH11+EI11-BK11)
		Merced River water available to Madera service area	BJ	=(BF11*BF$1+BH10)
		Diversion of Merced River Surplus	BK	=+EH11+EI11-MIN(EH$1*Convert'!D14,BH10)
San Joaquin River - Merced River to Vernalis		SJR Incremental flow below Merced	BL	=+BD11+BG11-BK11
		SJR flow below Merced (base)	BM	=+Base_Data'!X11
		SJR flow below Merced	BN	=+BM11+BL11
		Incremental Losses (Merced River to Patterson)	BO	=-BO$1*BL11
		Incremental flow at patterson	BP	=+BL11+BO11
		SJR surplus at Vernalis (base)	BQ	=MAX(0,+Base_Data'!W11)
		Required bypass flow	BR	=+Rest_q'!G11/1000
		Available SJR flow at patterson, considering Restoration and surplus	BS	=MAX(0,MIN(((BM11+BP11-BR11)*Rest_q'!H11),MIN(BM11,BQ11)+BP11))
		Patterson Diversion for recirculation	BT	=MIN($BT$1*Convert'!D11*Rest_q'!H11,BS11)
		Incremental flow below Patterson	BU	=+BP11-BT11
		Incremental losses (Patterson to Vernalis)	BV	=-BV$1*BU11
		Incremental Flow in Delta (Vernalis)	BW	=+BU11+BV11
Delta and CVP/SWP South of Delta		Available CVP/SWP export capacity	BX	=MAX(0,MIN(Delta'!F11,(+BW11+Delta'!D11)*Delta'!E11)*Delta'!L11)
		Incremental water available for export	BY	=MAX(0,+BW11*Delta'!J11)
		Increase Delta Export	BZ	=MIN(BY11,BX11)*BZ$1
		Uncaptured water	CA	=+BW11-BZ11
		Copy From Total Captured or Recaptured Water (calculated)	CB	=+BZ11+BT11+(-AY11*AY$1)
Aqueduct and South		**Copy Values To** Total Captured or Recaptured Water (values)	CC	5
		Purchsed Water	CD	=HLOOKUP($B11,Purchase'!$B$65:$M$70,$IN11+1)*$CD$1
		Available flow for diversion (adjusted for losses)	CE	=(+CC11)-(+CC11*CE$1)+CD11
		BeginningCVC capacity	CF	=HLOOKUP(B11,Control'!$D$86:$O$92,IN11+2)+CF$1*Convert'!D11
		Maximum Demand for CVC offset	CG	=MIN(((+HR11-HS11-HT11-HV11)+MIN(GZ11-HA11-HB11-HD11,HP$1*Convert'!D11)),MAX(0,GS11-GV11))
		Recirc Diversion for DD offset (to CVC)	CH	=MIN(CE11:CG11)
		Remaining CVC capacity	CI	=+CF11-CH11
	Piority 1 Captured Water Storage	Remaining Recirc Available flow for diversion to storage	CJ	=+CE11-CH11
		CVC GW	CK	=MIN((MIN(MAX(0,($GS11+$GT11-$GV11)),$GT11,$HP$1*Convert'!$D11-$HL11+$HY$1)),+CJ11,$CI11)*CK$1
		Kern Co. Bnk	CL	=MIN(+CJ11,$DE$1)*CL$1
		San Luis	CM	=MIN((+$DF$1*+CJ11),$DI11)*CM$1
		TLB	CN	=MIN(($DG$1*Convert'!$D11),+CJ11,$DV$1-$DV10)*CN$1
		rem	CO	=CJ11-SUM(CK11:CN11)

of Delta "West Side"	Piority 2 Captured Water Storage	CVC GW	CP	=MIN((MIN(MAX(0,($GS11+$GT11-$GV11)),$GT11,$HP$1*Convert'!$D11-$HL11+$HY$1)),+CO11,$CI11)*CP$1
		Kern Co. Bnk	CQ	=MIN(CO11,$DE$1)*CQ$1
		San Luis	CR	=MIN((+$DF$1*CO11),$DI11)*CR$1
		TLB	CS	=MIN(($DG$1*Convert'!$D11),CO11,$DV$1-$DV10)*CS$1
	Piority 3 Captured Water Storage	rem	CT	=CO11-SUM(CP11:CS11)
		CVC GW	CU	=MIN((MIN(MAX(0,($GS11+$GT11-$GV11)),$GT11,$HP$1*Convert'!$D11-$HL11+$HY$1)),+CT11,$CI11)*CU$1
		Kern Co. Bnk	CV	=MIN(CT11,$DE$1)*CV$1
		San Luis	CW	=MIN((+$DF$1*CT11),$DI11)*CW$1
		TLB	CX	=MIN(($DG$1*Convert'!$D11),CT11,$DV$1-$DV10)*CX$1
	Piority 4 Captured Water Storage	rem	CY	=CT11-SUM(CU11:CX11)
		CVC GW	CZ	=MIN((MIN(MAX(0,($GS11+$GT11-$GV11)),$GT11,$HP$1*Convert'!$D11-$HL11+$HY$1)),+CY11,$CI11)*CZ$1
		Kern Co. Bnk	DA	=MIN(CY11,$DE$1)*DA$1
		San Luis	DB	=MIN((+$DF$1*CY11),$DI11)*DB$1
		TLB	DC	=MIN(($DG$1*Convert'!$D11),CY11,$DV$1-$DV10)*DC$1
	Final Diversion to Storage	Recirc Diversion to CVC for GW	DD	=+CK11+CP11+CU11+CZ11
		Recirc Diversion to Kern County Bank	DE	=+CL11+CQ11+CV11+DA11
		Recirc Diversion to San Luis	DF	=+CM11+CR11+CW11+DB11
		Recirc Diversion to Tulare Lakebed	DG	=+CN11+CS11+CX11+DC11
		Recirc Diversion to Aqueduct Balance	DH	=CY11-SUM(CZ11:DC11)
San Luis Incremental Operation		SL Incremental storage capacity	DI	=+Delta'!M11
		San Luis Incremental storage	DJ	=+DJ10+DF11-DM11-DN11
		Remaining CVC capacity	DK	=+DR11-DT11
		Remaining unmet CVC demand	DL	=+DS11-DT11
		SL Storage release to CVC DD offset	DM	=MIN(DJ10,DK11,DL11)
		SL Spill or release to Aqueduct	DN	=IF(DI11<DJ10,MAX(0,DJ10-DI11-DM11),0)
Tulare Lakebed Operation		Tulare Basin Tribs flood flow to TLB	DO	=+FG11+GD11+GY11+FH11
		Total Project diversion to Lakebed	DP	=MIN(DV$1-DV10,DG11+MIN(DO11,DO$1*Convert'!D11))
		TLB Pump to Aqueduct Account	DQ	0
		Remaining CVC capacity	DR	=+CI11
		Remaining unmet CVC demand	DS	=+CG11-CH11
		TLB Release to cross valley canal	DT	=+IC11+HK11
		Total TLB flow to Aqueduct	DU	=+DT11+DQ11
		Tulare Lakebed Project Storage	DV	=+DV10+DP11-DQ11-DW11-FU11-GP11-DT11-EW11
		TLB Evaporation	DW	=MIN(DV10,VLOOKUP(MAX(0,DV10),Lookup'!$I$5:$J$19,2)*VLOOKUP($B11,Lookup'!$L$5:$O$16,4)/12/1000)
Madera Canal		MC Base Canal Demand	DX	=+Delivery'!U11
		MC Type1 purchase water	DY	=MIN(DX11,HLOOKUP($B11,Purchase'!$B$3:$M$10,3))*$DY$1
		MC Type2 purchase water	DZ	=MIN(DX11-DY11,HLOOKUP($B11,Purchase'!$B$29:$M$34,$IS11+1))*$DZ$1
		MC Type2 unused purchase water	EA	=(HLOOKUP($B11,Purchase'!$B$29:$M$34,$IS11+1)-DZ11)*$DZ$1
		MC Type3 purchase water	EB	=MIN(DX11-DY11-DZ11,+AA11*$EB$1)
		MC Type3 unused purchase water	EC	=+AA11*$EB$1-EB11
		Madera Canal diversion to GW (induced recharge)	ED	=(+ED$1-EI11)*IQ11
		MC GW storage	EE	=+EE10+EF11-EG11-(EF11*EF$1)+EA11+EC11
		MC GW recharge	EF	=+EI11+ED11
		MC Increase GW pumping	EG	=MIN(EG$1,EG$2*(DX11-DY11-DZ11-EB11),EE10-EE$1)*$IP11

I		Increase supply from Merced ID for DD	EH	=MIN(+EH$1*Convert'!D11,DX11*EH$2,BJ11)
		Increase supply from Merced ID for GW recharge	EI	=(MIN(+EH$1*Convert'!D11,BJ11)-EH11)*$EI$1
Friant-Kern Canal (Friant to Kings R.)		Friant-Kern Canal Release (taf)	EJ	=+ER11+FP11+GK11+HF11+HX11-EK11+IH11
		Total Diversion of trib. surplus into FKC	EK	=+FD11+GA11+GV11
		Base Canal Demand (Friant to Kings)	EL	=+Delivery'!Z11
		Total FKC1 Type1 purchase water	EM	=MIN(EL11,HLOOKUP($B11,Purchase'!$B$3:$M$10,4))*$EM$1
		Total FKC1 Type2 purchase water	EN	=MIN(EL11-EM11,HLOOKUP($B11,Purchase'!$B$35:$M$40,$IS11+1))*$EN$1
		Total FKC1 Type2 unused purchase water	EO	=(HLOOKUP($B11,Purchase'!$B$35:$M$40,$IS11+1)-EN11)*$EN$1
		Total FKC1 Type3 purchase water	EP	=MIN(EL11-EM11-EN11,+AA11*$EP$1)
		Total FKC1 Type3 unused purchase water	EQ	=+AA11*$EP$1-EP11
		Total Friant-Kern Canal diversion (DD plus GW)	ER	=ES11+EL11-ET11-EW11-EM11-EN11-EP11
		FKC 1 Diversion to GW	ES	=+ES$1*$IQ11
		FKC 1 Increase GW pumping	ET	=MIN(ET$1,ET$2*(EL11-EM11-EN11-EP11)-EW11,EV10-EV$1)*$IP11
		FKC 1 Total GW recharge	EU	=+ES11
		FKC 1 GW storage	EV	=+EV10-(EU$1*EU11)-ET11+EU11+EO11+EQ11
		FKC 1 Diversion from Tulare Lakebed to DD	EW	=MIN(EL11,$DV10-$DW11,HLOOKUP($IN11,Control'!$D$122:$H$127,2))*IO11
		Canal Flow above Kings River	EX	=+EJ11-ER11
Friant-Kern Cana		Surplus Available from Kings River (flow to Lakebed)	EY	=+Base_Data'!AA11
		Total surplus available (includes unused spills to Pool and Vernalis)	EZ	=MAX(0,MIN(AQ11,BQ11))+EY11
		Potential canal use of surplus (base delivery)	FA	=(+FJ11-FK11-FL11-FN11)+($GE11-GF11-GG11-GI11)+($GZ11-HA11-HB11-HD11)+($HR11-HS11-HT11-HV11)
		Maximum potential use of surplus for GW recharge	FB	=+(+FQ$1+GL$1+HG$1+HY$1)
		Diversion of Surplus Kings for Aqueduct thru Kern intertie	FC	=MIN($IH$1,MAX(0,MIN(FD$1*Convert'!D11,EZ11)-(FB11+FA11)))
		Diversion of Kings River surplus	FD	=MIN(EZ11,(FA11+FB11),FD$1*Convert'!$D11)+FC11
		Canal Flow downstream from Kings River	FE	=+EX11+FD11
		Canal check (negative = violation)	FF	=+FF$1*Convert'!$D11-FE11
		Kings surplus to Lakebed	FG	=IF(FD11>EY11,0,EY11-FD11)

I (Kings R. to Kaweah R.)		James bypass flow to Lakebed (diversion to Lakebed)	FH	=MIN(EZ11,EZ11-FD11,DV$1-DV10+DW11)*FH$1
		Change in Kings river flow to James Bypass	FI	=IF(FD11>EY11,-(FD11-EY11),0)-FH11
		Base Canal Demand (Kings to Kaweah)	FJ	=+Delivery'!AE11
		Total FKC2 Type1 purchase water	FK	=MIN(FJ11,HLOOKUP($B11,Purchase'!$B$3:$M$10,5))*$FK$1
		Total FKC2 Type2 purchase water	FL	=MIN(FJ11-FK11,HLOOKUP($B11,Purchase'!$B$41:$M$46,$IS11+1))*$FL$1
		Total FKC2 Type2 unused purchase water	FM	=(HLOOKUP($B11,Purchase'!$B$41:$M$46,$IS11+1)-FL11)*$FL$1
		Total FKC2 Type3 purchase water	FN	=MIN(FJ11-FK11-FL11,+AA11*$FN$1)
		Total FKC2 Type3 unused purchase water	FO	=+AA11*$FN$1-FN11
		Total Friant-Kern Canal diversion (DD plus GW)	FP	=+FQ11+FJ11-FR11-FU11-FK11-FL11-FN11
		FKC 2 Canal diversion to GW	FQ	=MAX((MIN(FQ$1,MAX(0,(FD11-FA11)))),($IQ11*FQ$1))
		FKC 2 Increase GW pumping	FR	=MIN(FR$1,FR$2*(FJ11-FK11-FL11-FN11)-FU11,FT10-FT$1)*$IP11
		FKC 2 Total GW recharge	FS	=+FQ11
		FKC 2 GW storage	FT	=+FT10+FS11-FR11-(FS11*FS$1)+FM11+FO11
		FKC 2 Diversion from Tulare Lakebed to DD	FU	=MIN(FJ11,$DV10-$DW11-$EW11,HLOOKUP($IN11,Control'!$D$122:$H$127,3))*IO11
		Canal Flow above Kaweah River	FV	=+FE11-FP11
Friant-Kern Canal (Kaweah R		Surplus available from Kaweah River	FW	=+Base_Data'!AB11
		Potential canal use of surplus (base delivery)	FX	=MAX(0,(($GE11-GF11-GG11-GI11)+($GZ11-HA11-HB11-HD11)+($HR11-HS11-HT11-HV11))-($FD11-MIN($FD11,$FJ11+$FQ11)))
		Maximum potential use of surplus for GW recharge	FY	=MAX(0,+($GL$1+$HG$1+$HY$1)+MIN(0,(($GE11-GF11-GG11-GI11)+($GZ11-HA11-HB11-HD11)+($HR11-HS11-HT11-HV11))-($FD11-MIN($FD11,$FJ11+$FQ11))))
		Diversion of Surplus Kaweah for Aqueduct thru Kern intertie	FZ	=MIN($IH$1-$FC11,MAX(0,MIN(GA$1*Convert'!D11,FW11)-(FY11+FX11)))
		Diversion of Surplus Kaweah	GA	=MIN(FW11,(FX11+FY11),GA$1*Convert'!$D11)+FZ11
		Canal Flow downstream from Kaweah River	GB	=+GA11+FV11
		Canal check (negative = violation)	GC	=+GC$1*Convert'!$D11-GB11
		Kaweah River surplus to Lakebed	GD	=+FW11-GA11
		Base Canal Demand (Kaweah to Tule)	GE	=+Delivery'!AJ11
		Total FKC3 Type1 purchase water	GF	=MIN(GE11,HLOOKUP($B11,Purchase'!$B$3:$M$10,6))*$GF$1
		Total FKC3 Type2 purchase water	GG	=MIN(GE11-GF11,HLOOKUP($B11,Purchase'!$B$47:$M$52,$IS11+1))*$GG$1
		Total FKC3 Type2 unused purchase water	GH	=(HLOOKUP($B11,Purchase'!$B$47:$M$52,$IS11+1)-GG11)*$GG$1
		Total FKC3 Type3 purchase water	GI	=MIN(GE11-GF11-GG11,+AA11*$GI$1)

. to Tule R.)		Total FKC3 Type3 unused purchase water	GJ	=+AA11*$GI$1-GI11
		Total Friant-Kern Canal diversion (DD plus GW)	GK	=+GL11+GE11-GM11-GP11-GF11-GG11-GI11
		FKC 3 Canal diversion to GW	GL	=MAX((MAX(MIN(GL$1,(MAX(0,$FD11-$FA11)-$FQ11)+(MAX(0,$GA11-$FX11))),0)),($IQ11*GL$1))
		FKC 3 Increase GW pumping	GM	=MIN(GM$1,GM$2*(GE11-GF11-GG11-GI11)-GP11,GO10-GO$1)*$IP11
		FKC 3 Total GW recharge	GN	=+GL11
		FKC 3 GW storage	GO	=+GO10+GN11-GM11-(GN11*GN$1)+GH11+GJ11
		FKC 3 Diversion from Tulare Lakebed to DD	GP	=MIN(GE11,$DV10-$DW11-$EW11-$FU11,HLOOKUP($IN11,Control'!$D$122:$H$127,4))*IO11
		Canal Flow above Tule River	GQ	=+GB11-GK11
Friant-Kern Canal (Tule R. to Kern)		Surplus Available from Tule R.	GR	=+Base_Data'!AC11
		Potential canal use of surplus (base delivery)	GS	=MAX(0,(($GZ11-HA11-HB11-HD11)+($HR11-HS11-HT11-HV11))-($FD11+GA11-MIN($FD11+GA11,(MIN($FD11,$FJ11+$FQ11)+$GE11+$GL11))))
		Maximum potential use of surplus for GW recharge	GT	=MAX(0,(+HG$1+HY$1)+MIN(0,(($GZ11-HA11-HB11-HD11)+($HR11-HS11-HT11-HV11))-($FD11+GA11-MIN($FD11+GA11,(MIN($FD11,$FJ11+$FQ11)+$GE11+$GL11)))))
		Diversion of Surplus Tule for Aqueduct thru Kern intertie	GU	=MIN($IH$1-$FC11-FZ11,MAX(0,MIN(GV$1*Convert'!D11,GR11)-(GT11+GS11)))
		Diversion of Surplus Tule	GV	=MIN(GR11,(GS11+GT11),GV$1*Convert'!$D11)+GU11
		Canal flow downstream from Tule River	GW	=+GV11+GQ11
		Capacity check	GX	=+GX$1*Convert'!$D11-GW11
		Tule River Surplus to Lakebed	GY	=+GR11-GV11
		Base Canal Demand (Tule to Kern)	GZ	=+Delivery'!AO11
		Total FKC4 Type1 purchase water	HA	=MIN(GZ11,HLOOKUP($B11,Purchase'!$B$3:$M$10,7))*$HA$1
		Total FKC4 Type2 purchase water	HB	=MIN(GZ11-HA11,HLOOKUP($B11,Purchase'!$B$53:$M$58,$IS11+1))*$HB$1
		Total FKC4 Type2 unused purchase water	HC	=(HLOOKUP($B11,Purchase'!$B$53:$M$58,$IS11+1)-HB11)*$HB$1
		Total FKC4 Type3 purchase water	HD	=MIN(GZ11-HA11-HB11,AA11*$HD$1)
		Total FKC4 Type3 unused purchase water	HE	=+AA11*$HD$1-HD11
		Total Friant-Kern Canal diversion (DD plus GW)	HF	=+HG11+GZ11-HH11-HK11-HL11-HM11-HA11-HB11-HD11
		FKC 4 Canal diversion to GW	HG	=MAX((MAX(MIN(HG$1,(MAX(0,$FD11-$FA11-$FQ11-$GL11))+(MAX(0,$GA11-$FX11-$GL11))+(MAX(0,$GV11-$GS11))),0)),($IQ11*HG$1))
		FKC 4 Increase GW pumping	HH	=MIN(HH$1,HH$2*(GZ11-HA11-HB11-HD11),(GZ11-HA11-HB11-HD11)-HL11-HK11-HM11,HJ10-HJ$1)*$IP11
		FKC 4 Total GW recharge	HI	=+HG11+HO11
		FKC 4 GW storage	HJ	=+HJ10-HH11+HI11-(HI$1*HI11)+HC11+HE11
		FKC 4 Diversion from Tulare Lakebed to DD	HK	=MIN((GZ11-HA11-HB11-HD11)-HL11,$DV10-$DW11-$EW11-$FU11-$GP11-$IC11,HLOOKUP($IN11,Control'!$D$122:$H$127,5),HP$1*Convert'!D11-HL11,DR11-IC11)*IO11
		Delta Incremental Increase Direct Diversion to FKC 4	HL	=MIN((CH11)-IE11,HP$1*Convert'!D11,GZ11-HA11-HB11-HD11)
		San Luis Release for Direct Diversion to FKC 4	HM	=MIN(DM11-IF11,HP$1*Convert'!D11-HL11-HK11,GZ11-HA11-HB11-HD11-HL11-HK11)

)		Kern Bank to Direct Diversion to FKC 4	HN	=MIN(IM11-IG11,HP$1*Convert'!D11-HL11-HK11-HM11,GZ11-HA11-HB11-HD11-HL11-HK11-HM11)
		FKC 4 Delta water diversion to GW (through CVC)	HO	=DD11-ID11
		FKC 4 Total flow from CVC	HP	=+HO11+HL11+HM11+HK11+HN11
		Canal Flow above Kern River	HQ	=+GW11-HF11-HP11
Friant-Kern Canal (From Kern to South)		Base Canal Demand (South of Kern R.)	HR	=+Delivery'!AT11
		Total FKC5 Type1 purchase water	HS	=MIN(HR11,HLOOKUP($B11,Purchase'!$B$3:$M$10,8))*$HS$1
		Total FKC5 Type2 purchase water	HT	=MIN(HR11-HS11,HLOOKUP($B11,Purchase'!$B$59:$M$64,$IS11+1))*$HT$1
		Total FKC5 Type2 unused purchase water	HU	=(HLOOKUP($B11,Purchase'!$B$59:$M$64,$IS11+1)-HT11)*$HT$1
		Total FKC5 Type3 purchase water	HV	=MIN(HR11-HS11-HT11,AA11*$HV$1)
		Total FKC5 Type3 unused purchase water	HW	=+AA11*$HV$1-HV11
		Total FKC5 diversion (DD plus GW)	HX	=+HY11+HR11-HZ11-IC11-IE11-IF11-HS11-HT11-HV11
		FKC 5 Canal diversion to GW	HY	=MAX((MAX(MIN(HY$1,(MAX(0,$FD11-$FA11)+(MAX(0,$GA11-$FX11)+(MAX(0,$GV11-$GS11)-$FQ11-$GL11-$HG11)))),0)),($IQ11*HY$1))
		FKC 5 Increase GW pumping	HZ	=MIN(HZ$1,HZ$2*(HR11-HS11-HT11-HV11),(HR11-HS11-HT11-HV11)-IE11-IC11-IF11,IB10-IB$1)*$IP11
		FKC 5 Total recharge	IA	=+HY11+ID11
		FKC 5 GW storage	IB	=+IB10-HZ11+IA11-(IA$1*IA11)+HU11+HW11
		FKC 5 Diversion from Tulare Lakebed for DD	IC	=MIN(HR11-HS11-HT11-HV11-IE11,($DV10-$DW11-$EW11-$FU11-$GP11),HLOOKUP($IN11,Control'!$D$122:$H$127,6),DR11)*IO11
		FKC 5 Delta water diversion to GW (through CVC)	ID	=MIN(HY$1,MAX(0,GT11-HG$1),DD11)
		FKC 5 Delta Incremental Increase Direct Diversion	IE	=MIN(+CH11,HR11-HS11-HT11-HV11)
		San Luis Release for Direct Diversion to FKC 5	IF	=MIN(HR11-HS11-HT11-HV11-IE11-IC11,DM11)
		Kern Bank to Direct Diversion to FKC 5	IG	=MIN(HR11-HS11-HT11-HV11-IE11-IC11-IF11,IM11)
		FKC 5 Increase Canal release to Aqueduct (thru cross valley or intertie)	IH	=+FC11+FZ11+GU11
Kern county bank		Recirc diversion to KCB	II	=+DE11
		Storage in KCB	IJ	=+IJ10+II11-IM11
		Remaining CVC capacity	IK	=+DK11-DM11
		Remaining unmet CVC demand	IL	=+DL11-DM11
		Kern Bank to CVC for DD	IM	=MIN(IJ10,IK11,IL11,IM$1)
Year Type		40-30-30 Year Type	IN	2
		Trigger for use of Tulare Basin Surplus	IO	=IF(AND(SUM(Control'!$B$15:$B$17)>0,EZ11+FW11+GR11>0),0,1)
		Ground Water Pumping Trigger	IP	=VLOOKUP($AD10,Use_matrix'!$B$13:$AL$44,$B11*3-1)*IO11

and Triggers		Ground Water recharge Trigger	IQ	=IF(VLOOKUP($AD10,Stor_matrix'!$B$13:$AL$44,$B11*3-1)'=0,+IR11,1)
		Estimated Flood release indicator	IR	=IF(MAX(0,(AD10+L11-Base_Data'!F11-Z11-X11)-T11)>0,1,0)
		Friant Restoration flow year type	IS	2

Appendix D
Long-Term Model Results

Section 1. Baseline Modeling Results
Section 2. Long-Term Project Modeling Results

Appendix D

Section 1
Baseline Modeling Results

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Baseline Modeling Results

The task of synthesizing a long-term depiction of water deliveries and reservoir operations required the development of a baseline operation model for the Friant Division that would combine current operational objectives for water supply and flood control with water demands from the Friant water users. The delivery of water to Friant water users, as depicted for the hydologic period 1922 through 1999, is carried into the long-term model as a demand to be met with either Millerton Reservoir water supply or other mechanisms.

Two different baselines were developed for the Water Supply Plan analysis. One baseline is reflective of historical recorded operations and is referred to as “Base X” for the purpose of this analysis. The other baseline reduces the amount of water diversions to the canals. Currently at issue are the canal deliveries that serve as a basis of comparing alternatives. Within the record of historical diversions are flood flow diversions, deliveries of flood flows to non-Reclamation lands (allowable by law), and other delivery exceptions that are being questioned as an appropriate base upon which to evaluate the alternatives. In consideration of this debate within the context of the analysis of alternatives, “Base Y” was synthesized. The difference between the two baselines is the simulation of deliveries during times of flood operations at Millerton Reservoir. In the Base X synthesis, when Millerton Reservoir is releasing to the river in excess of minimum requirements, an additional water delivery from the canals occurs to represent the availability of flood flows to Friant water users. In the Base Y synthesis, these additional deliveries do not occur.

In addition to the synthetic canal diversions, other baseline hydrologic parameters are required for the long-term model. The two baseline simulations develop two different resultant operations for the lower San Joaquin River below Friant. These two operations are different in terms of the frequency and magnitude of simulated flows that at times reach the bifurcation of the San Joaquin River with the Chowchilla Bypass. Due to the linkage of the Millerton Reservoir operation with the results utilized from other studies depicting the San Joaquin River and Delta operations, the baseline simulations provided adjustments to the CALSIM II, SANJASM and STANMOD hydrology incorporated into the long-term model.

Listed below are selected results of the baseline modeling process. The baseline model(s) and supporting data summary and graphic files are included in electronic form.

<u>Baseline Modeling Results Tables and Figures</u>

Note: Between the time of performance of these studies and the publication of the final Water Supply Study the naming of the two baseline demand scenarios changed. The following listing of tables and figures is consistent with the revised names. However, the computer files and printed tables and figures contained in this appendix have not been revised to the new naming protocol. The revised reference to the “Base X” demand scenario corresponds to the old reference of “Baseline”. The revised reference to the “Base Y” demand scenario corresponds to the old reference of “Alternative Baseline”.

Table 1 Madera Canal - Historical Diversions
Table 2 Friant-Kern Canal - Historical Diversions
Table 3 Madera Canal - Modeled Base X Diversions
Table 4 Madera Canal - Difference between Modeled and Historical Diversions
Table 5 Friant-Kern Canal - Modeled Base X Diversions
Table 6 Friant-Kern Canal - Difference between Modeled and Historical Diversions
Table 7 Release to San Joaquin River - Base X
Table 8 Madera Canal - Modeled Base Y Diversions
Table 9 Friant-Kern Canal - Modeled Base Y Diversions
Table 10 Release to San Joaquin River - Base Y
Table 11 Annual Comparisons between Modeled and Historical Canal and River Flows
Table 12 Derived Friant-Kern Canal Class 1 Deliveries
Table 13 Derived Friant-Kern Canal Class 2 Deliveries
Table 14 Modeled Friant-Kern Canal Other Deliveries
Table 15 Friant-Kern Canal Delivery Adjustment
Table 16 Derived Madera Canal Class 1 Delivery
Table 17 Derived Madera Canal Class 2 Delivery
Table 18 Modeled Madera Canal Other Deliveries
Figure Set 1 Historical and Modeled Canal Diversions - Base X
Figure Set 2 Historical and Modeled Canal Diversions - Base Y
Figure Set 3 Modeled Canal Diversions - Base X and Base Y
Figure Set 4 Millerton Operations - Historical and Modeled Base X
Figure Set 5 Flows at Mendota Pool - Base X
Figure Set 6 Availability of Surplus Flows - Base X
Figure Set 7 Merced River and San Joaquin River - Base X
Figure Set 8 Millerton Operations - Base X and Base Y

Model and Data Files

base_model_12_19_01.xls
Base case model with results for “Base X” diversions

base_model_12_19_01_Alt_Base.xls
Base case model with results for “Base Y” diversions

Base Cases 12_24_01.123
Spreadsheet of results and graphics for baseline studies

BASE CASES 12_24_01.xls
Spreadsheet of baseline results (without graphics)

Table 1
Station name : Madera Cn A Friant Ca
Station number: 11249500 (1998-2000 CVOCO Report of Operations)
Acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	WY Tot	Contract Year (TAF)
1949	141	0	0	0	0	1,216	9,646	12,478	24,960	41,431	40,295	21,483	151,651	152
1950	0	0	0	0	0	190	3,134	12,290	23,820	36,645	25,307	16,935	118,322	118
1951	0	0	0	0	0	2,164	10,701	8,977	23,076	45,807	40,975	10,624	142,324	142
1952	0	69	0	52	48	0	1,325	14,059	33,654	47,233	53,703	29,265	179,408	181
1953	2,003	0	0	26	0	11,106	11,869	10,520	27,555	51,771	48,592	29,142	192,583	192
1954	873	0	50	63	204	3,685	17,863	23,508	40,822	53,973	51,071	19,670	211,785	211
1955	0	0	0	0	817	18,706	10,201	12,193	37,165	53,303	52,112	34,336	218,834	221
1956	0	0	0	0	2,694	10,475	15,447	15,348	45,095	59,614	56,768	33,390	238,831	236
1957	220	0	0	24	0	12,492	19,613	9,422	45,813	61,572	57,984	34,344	241,483	243
1958	1,937	0	0	0	26	4,322	6,248	27,511	51,688	63,849	59,291	28,882	243,754	250
1959	5,183	0	0	0	2,735	31,238	14,595	23,925	43,978	62,042	24,032	0	207,728	200
1960	66	0	60	0	0	19,460	6,371	67	42,282	58,460	17,038	0	143,804	144
1961	0	0	0	0	0	11,379	1,670	0	17,036	58,351	14,220	0	102,656	103
1962	99	0	0	42	0	8,253	30,221	29,598	52,634	66,665	62,833	26,410	276,756	278
1963	409	101	0	0	1,375	6,912	12,682	31,321	53,894	65,753	65,096	33,142	270,687	280
1964	9,975	361	0	0	1,162	28,872	0	6,010	49,806	75,571	50,196	5,748	227,701	223
1965	0	0	0	1,263	5,151	32,527	13,510	38,333	57,950	74,480	63,664	37,480	324,360	338
1966	11,670	0	0	0	8,372	31,056	15,695	7,821	47,951	72,140	29,362	0	224,067	229
1967	0	0	0	8,979	15,662	13,331	15,576	73,270	64,012	78,229	75,790	44,202	389,052	411
1968	24,251	7,349	0	0	14,761	8,850	0	8,356	43,435	38,420	22,461	1,740	169,623	145
1969	5,248	0	0	0	16,021	27,128	24,748	53,001	68,863	77,753	75,472	55,885	404,120	449
1970	20,509	5,885	3,011	6,909	30,030	16,636	37,956	41,086	54,758	56,659	24,135	891	298,465	258
1971	14,933	599	0	0	10,134	30,381	9,937	13,206	47,721	70,355	65,894	17,524	280,684	262
1972	931	0	0	0	5,659	39,067	143	1,944	39,539	48,606	17,056	0	152,944	149
1973	0	859	0	0	2,067	12,601	41,515	54,691	69,258	79,519	66,812	19,956	347,277	383
1974	20	0	0	29,108	9,031	21,309	37,958	59,376	72,061	79,241	71,152	16,074	395,329	367
1975	0	0	0	0	10,035	15,981	25,680	57,736	73,826	75,988	50,143	10,364	319,752	310
1976	0	0	0	0	0	0	0	0	13,408	47,691	33,255	0	94,355	94
1977	0	0	0	0	0	0	0	0	821	26,135	4,719	0	31,675	53
1978	0	0	0	0	21,237	50,383	63,046	74,520	75,988	78,130	51,335	22,378	437,017	457
1979	31,593	6,647	0	0	3,271	10,481	55,631	69,522	70,152	69,073	59,445	19,464	395,280	360
1980	1,090	0	0	0	5,113	67,266	74,837	77,257	75,492	71,545	70,851	40,208	483,659	510
1981	32,884	0	0	0	0	2,577	20,644	43,211	33,015	21,896	18,942	27,323	200,491	206
1982	0	0	0	11,334	27,448	25,551	52,840	77,555	75,294	76,424	68,167	41,836	456,449	472
1983	28,870	2,283	0	0	23,502	55,447	69,899	74,699	74,639	77,416	57,250	68,609	532,613	522
1984	36,881	0	0	0	7,508	46,838	34,186	31,694	31,244	63,192	50,528	38,410	340,482	318
1985	5,189	0	0	0	17,167	43,236	1,626	4,550	26,093	44,996	40,616	21,959	205,433	225
1986	5,342	0	0	0	36,590	60,229	70,970	76,206	75,849	78,666	66,949	42,223	513,022	506
1987	23,328	8,519	0	0	3,191	8,444	0	0	41,388	52,428	32,547	2,924	172,769	138
1988	0	0	0	0	0	0	99	8,450	42,893	60,459	10,374	0	122,275	122
1989	0	0	0	34	0	0	0	23,001	43,938	54,195	26,823	42	148,033	148
1990	0	0	0	0	0	0	0	347	22,338	56,391	31,220	1,460	111,756	112
1991	0	0	0	0	61	0	18	18,451	28,112	60,999	44,391	4,372	156,403	156
1992	0	0	0	0	0	0	0	23,362	49,925	47,394	6,079	0	126,760	127
1993	0	0	0	0	0	32,982	51,583	65,059	63,365	73,667	58,400	45,261	390,317	427
1994	32,282	4,840	0	0	0	0	0	14,523	34,687	43,972	43,702	7,908	181,915	148
1995	0	0	0	0	2,876	38,034	51,448	63,637	61,286	72,279	60,971	38,569	389,099	422
1996	27,435	5,839	0	0	2,656	39,765	41,239	60,770	61,338	54,614	43,099	26,638	363,394	387
1997	7,603	0	2,331	32,385	17,443	50,922	44,065	50,468	59,453	56,647	37,070	33,599	391,985	350
1998	17,966	0	0	0	0	33,450	51,660	58,134	61,909	68,954	34,039	29,201	355,314	404
1999	15,515	15,812	21,922	3,223	10,306	22,771	27,708	42,213	37,222	54,251	45,252	26,982	323,175	266
2000	9,361	0	0	0	0	9,082	35,572	46,914	52,277	55,433	37,732	22,376	268,748	
Ave 1961-00	9,085	1,477	682	2,332	7,696	22,544	25,359	37,007	50,622	62,114	44,701	20,779	284,397	285

Table 2
Station name : Friant-Kern Cn A Friant Ca
Station number: 11250000 (1998-2000 CVOCO Report of Operations)
Acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	WY Tot	Contract Year (TAF)
1949	0	0	0	0	0	1,260	1,281	0	454	16,132	23,594	0	42,721	43
1950	0	0	0	0	0	15,231	22,378	17,766	52,878	45,585	41,534	79	195,452	195
1951	0	0	0	0	0	23,502	37,393	11,830	66,029	107,666	86,086	35,870	368,376	396
1952	14,417	8,777	0	0	4,725	2,759	12,147	28,945	55,675	126,278	138,466	69,770	461,958	526
1953	73,070	17,461	0	202	1,101	56,437	54,300	40,124	99,278	163,736	160,362	74,586	740,656	691
1954	22,530	7,375	0	149	11,937	52,801	58,130	124,486	153,069	172,126	145,736	63,075	811,413	813
1955	25,464	6,232	0	153	11,840	87,016	77,176	64,015	134,680	166,890	156,915	74,334	804,713	950
1956	27,272	10,471	173	234	150,609	154,590	120,857	107,966	182,107	200,689	222,416	142,221	1,319,603	1,235
1957	49,960	31,159	0	1,002	22,287	92,387	78,150	63,232	211,130	180,502	152,150	108,396	990,356	1,012
1958	27,981	3,580	0	5,399	88,847	67,098	34,229	88,934	169,909	255,846	259,902	143,074	1,144,798	1,143
1959	62,823	18,377	0	0	42,780	149,302	71,011	57,107	143,195	132,734	96,765	35,435	809,530	769
1960	58,401	10,013	0	198	14,608	69,942	37,603	32,053	115,295	110,657	87,339	45,557	581,668	565
1961	22,532	2,805	720	0	40,299	51,190	26,472	23,435	74,786	80,272	80,974	38,107	441,592	428
1962	24,318	9,144	0	339	19,165	165,271	266,352	150,181	189,517	216,574	215,821	113,048	1,369,730	1,456
1963	54,151	22,471	0	1,083	61,072	74,280	163,549	221,472	243,919	237,909	260,356	173,116	1,513,378	1,593
1964	94,712	17,155	161	7,200	99,514	75,732	31,466	36,520	113,238	157,912	152,043	52,354	838,009	981
1965	28,622	284	0	82,351	250,242	218,371	77,027	187,453	206,657	213,569	206,881	159,400	1,630,857	1,555
1966	72,359	36,032	13,718	82,910	81,034	151,785	71,674	68,228	148,060	156,328	123,751	60,362	1,066,241	997
1967	36,081	12,292	0	15,592	152,833	148,485	100,972	58,501	138,948	242,203	266,840	240,021	1,412,769	1,599
1968	132,320	52,247	26,599	51,307	140,789	61,453	51,337	69,789	110,778	109,926	100,189	60,608	967,342	610
1969	17,845	2,015	2,825	1,250	21,545	14,365	52,787	122,878	159,930	237,405	260,057	189,563	1,082,463	1,351
1970	59,242	50,553	38,672	31,605	133,864	72,792	94,270	96,341	158,224	189,047	207,930	81,863	1,214,405	1,089
1971	35,456	14,979	0	12,133	125,655	106,732	72,477	51,849	123,154	233,736	218,185	97,917	1,092,273	1,055
1972	48,378	23,526	18,990	6,030	54,314	105,772	50,514	83,581	128,293	149,457	91,975	50,962	811,792	789
1973	21,164	1,402	0	0	105,992	103,079	158,482	221,597	214,754	210,610	203,329	130,455	1,370,862	1,497
1974	47,600	26,174	0	43,072	137,417	136,514	217,947	230,542	241,531	241,174	242,979	103,063	1,668,013	1,578
1975	48,940	15,559	0	9,416	90,190	80,867	152,928	243,098	226,040	232,486	173,695	118,812	1,392,030	1,365
1976	51,820	14,212	0	4,822	66,693	53,537	34,390	47,995	77,140	95,079	78,713	46,567	570,968	494
1977	17,466	11,919	0	3,370	27,761	9,685	8,420	5,381	35,560	54,866	60,366	29,249	264,043	286
1978	20,195	3,519	0	0	58,872	16,076	18,950	115,464	207,494	242,245	237,405	147,235	1,067,456	1,413
1979	189,816	81,111	0	0	157,268	143,629	201,563	187,917	230,891	221,599	182,351	84,459	1,680,604	1,369
1980	42,199	20,333	0	0	54,191	65,059	159,116	135,979	222,073	241,273	261,247	155,982	1,357,452	1,532
1981	117,055	43,574	22,431	24,827	83,779	44,823	51,513	80,808	133,093	205,233	116,729	57,180	981,046	990
1982	29,021	10,725	1,515	68,984	190,277	116,461	103,925	217,074	262,278	274,596	258,153	144,865	1,677,874	1,570
1983	105,842	39,904	10,044	19,789	16,606	2,295	35,374	54,925	170,026	236,374	176,710	128,451	996,340	1,102
1984	71,595	51,063	0	0	174,717	111,413	83,545	129,126	218,185	234,053	166,693	103,618	1,344,008	1,262
1985	79,718	22,675	0	149	112,341	79,989	81,292	104,887	149,834	140,709	89,704	57,892	919,190	851
1986	51,995	9,951	1,133	10,939	72,788	55,695	121,708	202,198	254,840	250,952	208,863	166,078	1,407,140	1,490
1987	78,898	36,849	25,462	18,453	70,277	30,179	66,999	54,338	89,597	115,519	89,930	57,958	734,458	670
1988	45,584	3,749	3,424	10,967	102,023	46,755	23,750	52,263	106,335	138,924	76,014	43,306	653,094	547
1989	29,076	5,744	0	0	24,699	36,492	73,552	62,115	126,329	181,808	94,361	45,127	679,303	700
1990	36,836	22,368	4,745	2,035	14,242	33,452	35,622	40,215	57,337	95,902	95,301	50,700	488,754	474
1991	36,246	10,288	0	0	18,895	315	17,685	69,466	128,372	181,550	124,266	64,004	651,087	667
1992	52,152	11,584	0	5,290	12,115	11,685	40,622	77,158	155,824	107,704	103,539	49,764	627,436	660
1993	34,051	3,880	0	11,883	64,317	178,951	231,990	260,592	269,518	301,591	244,347	104,273	1,705,393	1,726
1994	69,999	23,883	8,422	15,247	17,040	27,188	39,307	40,120	133,172	148,862	111,366	55,480	690,087	709
1995	24,384	6,317	186	7,069	115,771	119,210	83,686	138,468	251,111	275,826	264,579	162,330	1,448,937	1,601
1996	112,867	70,531	34,315	27,126	60,614	100,478	206,443	220,744	269,339	265,531	185,477	91,717	1,645,182	1,477
1997	63,518	9,808	1,069	61,068	1,480	108,283	162,230	137,655	224,294	234,351	155,149	108,597	1,267,503	1,330
1998	109,314	37,099	19,708	10,003	23,502	9,247	1,916	27,797	93,548	224,374	199,580	126,210	882,298	997
1999	95,717	20,525	56,958	33,025	108,458	60,602	69,460	145,728	201,682	224,354	164,968	72,909	1,254,386	1,034
2000	61,912	14,767	0	11,643	5,677	116,100	117,088	259,105	214,416	209,557	166,197	95,644	1,272,107	
Ave 1961-00	59,275	21,825	7,277	17,274	79,208	78,607	91,460	118,325	169,003	195,286	167,925	97,981	1,103,448	1,100

Table 3
Madera Canal Diversion (TAF)
Modeled Baseline

12-19-01	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	WY Total	M-F Tot	Apr-Jul Tot
1922	0	0	0	0	6	33	38	58	62	57	52	35	341	373	254
1923	21	3	0	0	14	25	27	47	48	59	45	21	310	283	220
1924	3	3	0	0	5	0	0	9	26	33	23	3	105	94	73
1925	0	0	0	0	0	0	0	21	61	76	53	8	219	219	158
1926	0	0	0	0	0	0	2	25	48	60	42	6	183	187	135
1927	0	0	0	0	4	24	32	50	58	64	49	23	304	313	232
1928	3	3	0	0	7	22	2	25	54	68	47	7	238	225	178
1929	0	0	0	0	0	0	0	12	36	45	31	5	129	129	93
1930	0	0	0	0	0	0	0	12	36	45	31	5	129	129	93
1931	0	0	0	0	0	0	0	7	18	23	16	2	66	67	48
1932	0	0	0	0	1	26	34	53	57	68	52	24	315	326	239
1933	3	3	0	0	6	0	0	20	59	74	51	8	224	212	159
1934	0	0	0	0	0	0	1	11	31	39	27	4	113	113	82
1935	0	0	0	0	0	23	31	49	55	61	46	22	287	303	219
1936	3	3	0	0	10	29	33	52	51	63	48	23	315	316	238
1937	3	3	0	0	11	29	33	55	61	68	52	25	340	340	257
1938	3	3	0	0	11	38	57	77	76	77	68	46	456	490	336
1939	28	5	0	0	18	0	1	15	40	50	34	5	196	148	124
1940	0	0	0	0	3	25	29	45	48	53	41	19	263	274	203
1941	2	2	0	0	10	35	39	60	65	63	53	36	365	385	272
1942	22	4	0	0	8	33	37	55	61	75	57	27	379	361	269
1943	3	3	0	0	10	30	34	54	53	66	50	24	327	323	247
1944	3	3	0	0	6	0	0	21	61	76	53	8	231	225	164
1945	0	0	0	0	6	26	35	55	58	70	53	25	328	335	250
1946	3	3	0	0	7	22	28	44	61	76	53	8	305	295	238
1947	0	0	0	0	3	2	0	23	48	60	41	6	183	180	136
1948	0	0	0	0	0	0	0	17	48	60	42	6	173	173	125
1949	0	0	0	0	0	0	0	19	55	69	48	7	198	198	143
1950	0	0	0	0	0	0	0	25	58	73	50	8	214	220	156
1951	0	0	0	0	6	20	23	36	41	51	39	18	234	238	177
1952	2	2	0	0	6	35	50	66	71	67	60	40	399	433	295
1953	24	4	0	0	16	0	0	20	59	74	51	8	256	212	169
1954	0	0	0	0	0	0	0	26	54	68	47	7	202	202	148
1955	0	0	0	0	0	0	0	19	57	71	49	8	204	210	147
1956	0	0	0	0	6	35	39	57	62	56	51	34	340	372	255
1957	21	3	0	0	14	21	23	37	42	53	40	19	273	249	190
1958	2	2	0	0	10	35	49	64	69	64	59	40	394	424	291
1959	24	4	0	0	16	0	0	15	45	56	39	6	205	161	132
1960	0	0	0	0	0	0	0	12	34	43	30	4	123	123	89
1961	0	0	0	0	0	0	0	9	25	32	22	3	91	91	66
1962	0	0	0	0	0	25	27	49	55	61	47	22	286	303	217
1963	3	3	0	0	11	27	30	53	57	68	52	24	328	323	246
1964	3	3	0	0	6	0	0	17	49	62	43	7	190	184	134
1965	0	0	0	0	6	28	31	52	60	70	53	25	325	332	247
1966	3	3	0	0	7	21	26	24	54	68	47	7	260	253	200
1967	0	0	0	0	6	43	61	77	76	77	64	44	448	489	340
1968	26	4	0	0	17	0	0	15	43	54	37	6	202	161	129
1969	0	0	0	0	6	39	57	77	76	77	67	45	444	488	332
1970	27	5	0	0	18	22	24	37	43	54	41	19	290	251	198
1971	2	2	0	0	7	20	23	36	42	52	39	18	241	239	180
1972	2	2	0	0	5	2	0	18	51	64	44	7	195	188	140
1973	0	0	0	0	2	29	32	50	58	64	49	23	307	319	235
1974	3	3	0	0	8	30	34	54	61	68	52	24	337	335	255
1975	3	3	0	0	6	24	32	50	55	64	48	23	308	308	231
1976	3	3	0	0	6	0	0	12	33	42	29	4	132	120	93
1977	0	0	0	0	0	0	0	5	12	16	11	1	45	51	33
1978	0	0	0	0	6	42	59	77	76	77	66	45	448	490	337
1979	27	4	0	0	17	28	32	51	53	62	48	22	344	312	243
1980	3	3	0	0	10	38	51	67	72	73	57	39	413	439	311
1981	23	4	0	0	15	0	0	20	54	68	47	7	238	202	157
1982	0	0	0	0	6	38	54	71	74	74	64	44	425	467	317
1983	33	4	0	0	11	48	65	77	76	77	72	49	512	515	354
1984	30	5	0	0	16	29	29	46	47	58	44	21	325	287	225
1985	3	3	0	0	7	0	4	22	50	63	43	7	202	195	146
1986	0	0	0	0	6	32	39	60	64	59	54	36	350	385	260
1987	22	4	0	0	15	0	0	11	32	40	28	4	156	115	98
1988	0	0	0	0	0	0	0	13	36	45	31	5	130	130	94
1989	0	0	0	0	0	0	0	14	39	49	34	5	141	141	102
1990	0	0	0	0	0	0	0	11	30	38	26	4	109	109	79
1991	0	0	0	0	0	0	0	14	41	52	36	5	148	148	107
1992	0	0	0	0	0	0	0	12	35	44	31	5	127	133	91
1993	0	0	0	0	6	34	39	60	65	61	54	37	356	391	265
1994	22	4	0	0	15	0	0	14	39	49	34	5	182	147	117
1995	0	0	0	0	6	48	65	77	76	77	70	48	467	519	349
1996	29	5	0	0	24	30	34	55	61	68	52	24	382	336	272
1997	3	3	0	0	6	29	33	52	49	59	45	21	300	305	228
1998	3	3	0	0	11	45	61	77	76	77	62	42	457	485	347
1999	25	4	0	0	16	23	25	40	47	54	41	19	294		205
Avg	6	2	0	0	7	17	21	38	52	60	46	18	267	267	195

Table 4
Madera Canal Diversion (TAF) Difference between Modeled and Historical (Model minus Historical)
Modeled Baseline

12-19-01	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	WY Total	M-F Tot	Apr-Jul Tot
1922															
1923															
1924															
1925															
1926															
1927															
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1955															
1956															
1957															
1958															
1959															
1960															
1961	0	0	0	0	0	-11	-2	9	8	-26	8	3		-12	
1962	-0	0	0	-0	0	17	-3	19	2	-6	-16	-4		25	
1963	3	3	0	0	10	20	17	22	3	2	-13	-9		43	
1964	-7	3	0	0	5	-29	0	11	-1	-14	-7	1		-39	
1965	0	0	0	-1	1	-5	17	14	2	-4	-11	-12		-6	
1966	-9	3	0	0	-1	-10	10	16	6	-4	18	7		24	
1967	0	0	0	-9	-10	30	45	4	12	-1	-12	-0		78	
1968	2	-3	0	0	2	-9	0	7	-0	16	15	4		16	
1969	-5	0	0	0	-10	12	32	24	7	-1	-8	-11		39	
1970	6	-1	-3	-7	-12	5	-14	-4	-12	-3	17	18		-7	
1971	-13	1	0	0	-3	-10	13	23	-6	-18	-27	0		-23	
1972	1	2	0	0	-1	-37	-0	16	11	15	27	7		39	
1973	0	-1	0	0	-0	16	-10	-5	-11	-16	-18	3		-64	
1974	3	3	0	-29	-1	9	-4	-5	-11	-11	-19	8		-32	
1975	3	3	0	0	-4	8	6	-8	-19	-12	-2	13		-2	
1976	3	3	0	0	6	0	0	12	20	-6	-4	4		26	
1977	0	0	0	0	0	0	0	5	11	-10	6	1		-2	
1978	0	0	0	0	-15	-8	-4	2	0	-1	15	23		33	
1979	-5	-3	0	0	14	18	-24	-19	-17	-7	-11	3		-48	
1980	2	3	0	0	5	-29	-24	-10	-3	1	-14	-1		-71	
1981	-10	4	0	0	15	-3	-21	-23	21	46	28	-20		-4	
1982	0	0	0	-11	-21	12	1	-7	-1	-2	-4	2		-5	
1983	4	2	0	0	-13	-7	-5	2	1	-0	15	-20		-7	
1984	-7	5	0	0	8	-18	-5	14	16	-5	-7	-17		-31	
1985	-2	3	0	0	-10	-43	2	17	24	18	2	-15		-30	
1986	-5	0	0	0	-31	-28	-32	-16	-12	-20	-13	-6		-121	
1987	-1	-5	0	0	12	-8	0	11	-9	-12	-5	1		-23	
1988	0	0	0	0	0	0	-0	5	-7	-15	21	5		8	
1989	0	0	0	-0	0	0	0	-9	-5	-5	7	5		-7	
1990	0	0	0	0	0	0	0	11	8	-18	-5	3		-3	
1991	0	0	0	0	-0	0	-0	-4	13	-9	-8	1		-8	
1992	0	0	0	0	0	0	0	-11	-15	-3	25	5		6	
1993	0	0	0	0	6	1	-13	-5	2	-13	-4	-8		-36	
1994	-10	-1	0	0	15	0	0	-1	4	5	-10	-3		-1	
1995	0	0	0	0	3	10	14	13	15	5	9	9		97	
1996	2	-1	0	0	21	-10	-7	-6	-0	13	9	-3		-51	
1997	-5	3	-2	-32	-11	-22	-11	2	-10	2	8	-13		-45	
1998	-15	3	0	0	11	12	9	19	14	8	28	13		81	
1999	9	-12	-22	-3	6	0	-3	-2	10	-0	-4	-8			
Avg	-1	0	-1	-2	-0	-3	-0	4	2	-3	1	-0		-4	

Table 5
Friant-Kern Canal Diversion (TAF)
Modeled Baseline

12-19-01	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	WY Total	M-F Tot	Apr-Jul Tot
1922	5	4	15	75	69	145	135	109	260	231	204	122	1374	1477	949
1923	82	30	27	27	105	67	109	182	171	203	172	99	1274	1128	837
1924	46	14	11	11	43	23	27	40	84	109	66	37	511	442	326
1925	28	12	1	1	14	55	90	117	144	170	145	83	860	912	590
1926	39	13	10	10	36	53	111	183	122	144	123	71	915	951	649
1927	34	11	8	8	83	66	172	208	253	216	183	105	1347	1355	998
1928	49	15	12	17	59	82	109	168	133	157	134	77	1012	961	708
1929	37	12	9	9	34	30	37	54	116	150	89	50	627	599	421
1930	38	15	1	1	18	30	37	54	115	149	89	50	597	597	403
1931	38	15	1	1	18	16	19	28	57	74	46	27	340	320	212
1932	20	9	1	1	22	69	180	214	216	226	192	110	1260	1348	927
1933	51	16	13	13	48	53	88	114	140	166	141	81	924	886	609
1934	38	12	9	9	35	27	44	48	100	130	78	44	574	535	384
1935	33	13	1	1	16	63	174	213	247	207	176	101	1245	1298	920
1936	47	15	12	12	31	128	106	225	185	213	181	104	1259	1229	888
1937	48	15	12	12	0	38	90	89	263	228	193	110	1098	1265	708
1938	51	16	13	61	113	3	58	114	231	286	231	152	1329	1415	805
1939	103	37	34	34	132	35	54	76	129	167	99	55	955	676	593
1940	42	16	1	0	2	104	168	207	214	187	158	91	1190	1264	882
1941	43	13	10	36	33	137	66	109	257	266	209	125	1304	1533	868
1942	84	30	27	100	123	144	194	171	256	235	203	119	1686	1616	1123
1943	81	29	26	19	139	0	97	230	187	222	188	108	1326	1168	875
1944	50	15	12	12	47	55	90	117	143	170	144	83	938	903	622
1945	39	13	10	10	29	70	185	226	218	232	197	113	1342	1546	960
1946	52	16	87	86	64	62	153	204	144	170	145	83	1266	1177	797
1947	39	13	29	62	73	75	82	162	121	144	122	71	993	869	657
1948	34	11	8	8	31	46	76	99	122	144	123	71	773	773	518
1949	34	11	8	8	31	51	84	109	134	159	135	78	842	851	568
1950	37	12	9	9	34	56	92	164	139	165	140	81	938	1138	650
1951	38	4	83	81	95	58	96	124	152	181	153	88	1153	1031	706
1952	42	13	10	10	104	43	52	105	259	249	218	137	1242	1366	812
1953	92	33	30	30	118	54	88	115	141	167	142	82	1092	894	683
1954	39	12	9	9	36	54	89	189	132	156	133	77	935	929	656
1955	36	12	9	9	33	52	86	111	137	163	138	80	866	914	582
1956	38	12	0	2	95	136	137	182	259	231	202	121	1415	1534	1040
1957	81	29	26	26	104	59	97	127	156	185	157	90	1137	1052	728
1958	42	13	10	10	106	57	46	113	255	231	215	135	1233	1353	808
1959	91	33	30	30	117	44	73	95	116	138	117	68	952	741	583
1960	33	11	8	8	30	29	36	53	112	144	86	48	598	580	404
1961	37	15	1	1	18	22	27	39	81	105	63	36	445	428	292
1962	28	12	1	1	13	67	109	215	247	208	177	101	1179	1321	859
1963	47	15	12	12	111	71	117	221	223	227	192	110	1358	1375	970
1964	51	16	54	48	45	47	78	101	124	147	125	72	908	924	542
1965	34	11	8	82	95	63	121	121	242	231	196	112	1316	1447	873
1966	52	81	86	78	64	73	146	166	132	156	133	77	1244	1100	737
1967	36	12	0	71	98	151	74	116	231	286	226	146	1447	1553	956
1968	98	35	32	32	126	43	71	91	112	133	113	66	952	680	576
1969	32	11	8	0	0	39	37	108	153	286	228	150	1052	1361	623
1970	101	36	33	62	128	71	99	128	158	187	159	91	1253	1042	771
1971	43	13	10	10	73	58	96	125	154	182	155	89	1008	973	688
1972	42	13	10	10	39	72	80	103	127	151	128	74	849	862	572
1973	35	12	9	9	62	62	171	141	254	216	183	105	1259	1372	906
1974	49	15	12	86	78	139	179	229	262	227	192	110	1578	1479	1114
1975	51	16	13	13	48	65	173	208	232	214	182	104	1319	1312	940
1976	49	15	12	12	46	28	34	51	107	139	83	46	622	556	405
1977	35	14	1	1	17	11	13	19	37	47	30	18	243	198	144
1978	14	7	1	1	0	52	76	140	231	286	226	149	1183	1561	785
1979	100	36	37	106	122	130	178	222	213	212	179	103	1638	1320	1077
1980	48	15	12	0	8	55	143	199	250	300	216	132	1378	1588	955
1981	89	32	29	29	114	51	84	118	132	156	133	77	1044	950	655
1982	36	12	9	43	99	143	38	206	248	255	227	146	1462	1569	989
1983	172	105	23	6	0	4	60	96	128	286	240	160	1280	1458	574
1984	119	110	31	104	120	113	133	184	169	200	170	98	1551	1251	919
1985	46	14	11	51	62	55	140	151	125	149	126	73	1003	886	682
1986	35	11	8	8	5	36	137	186	254	226	206	126	1238	1452	844
1987	85	31	28	28	109	28	33	49	104	135	81	45	756	542	458
1988	34	14	1	1	17	31	37	55	116	150	90	50	596	603	406
1989	38	15	1	1	19	33	40	59	127	164	98	54	649	654	442
1990	41	16	1	1	20	26	32	46	98	126	76	43	526	511	348
1991	33	13	1	1	16	35	43	63	135	175	104	58	677	697	467
1992	44	17	1	1	21	30	37	54	115	148	89	49	606	662	405
1993	38	15	1	1	85	147	137	188	257	243	207	127	1446	1587	1057
1994	85	31	28	28	109	33	40	59	127	164	98	54	856	795	532
1995	41	16	1	75	87	64	161	130	231	286	233	158	1483	1704	959
1996	106	38	35	60	202	61	185	232	263	227	193	110	1712	1360	1170
1997	51	16	0	0	22	137	179	224	192	201	171	98	1291	1289	955
1998	46	14	11	11	5	55	38	112	131	286	218	141	1068	1365	627
1999	95	34	38	95	122	63	102	145	199	189	160	92	1334		820
Avg	52	20	16	26	61	62	95	133	171	191	154	91	1071	1070	712

Table 6
Friant-Kern Canal Diversion (TAF) Difference between Modeled and Historical (Model minus Historical)
Modeled Baseline

12-19-01	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	WY Total	M-F Tot
1922														
1923														
1924														
1925														
1926														
1927														
1928														
1929														
1930														
1931														
1932														
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1941														
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1944														
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1946														
1947														
1948														
1949														
1950														
1951														
1952														
1953														
1954														
1955														
1956														
1957														
1958														
1959														
1960														
1961	14	12	0	1	-22	-29	1	16	6	25	-18	-2		-0
1962	4	3	1	1	-6	-98	-157	65	57	-9	-39	-12		-135
1963	-7	-7	12	11	50	-3	-47	-0	-21	-11	-68	-63		-218
1964	-44	-1	54	41	-55	-29	47	64	11	-11	-27	20		-57
1965	5	11	8	-0	-155	-155	44	-66	35	17	-11	-47		-108
1966	-20	45	72	-5	-17	-79	74	98	-16	-0	9	17		103
1967	-0	-0	0	55	-55	3	-27	57	92	44	-41	-94		-46
1968	-34	-17	5	-19	-15	-18	20	21	1	23	13	5		70
1969	14	9	5	-1	-22	25	-16	-15	-7	49	-32	-40		10
1970	42	-15	-6	30	-6	-2	5	32	-0	-2	-49	9		-47
1971	8	-2	10	-2	-53	-49	24	73	31	-52	-63	-9		-82
1972	-6	-11	-9	4	-15	-34	29	19	-1	2	36	23		73
1973	14	11	9	9	-44	-41	13	-81	39	5	-20	-25		-125
1974	1	-11	12	43	-59	2	-39	-2	20	-14	-51	7		-99
1975	2	0	13	4	-42	-16	20	-35	6	-18	8	-15		-53
1976	-3	1	12	7	-21	-26	-0	3	30	44	4	-1		62
1977	18	2	1	-2	-11	1	5	14	1	-8	-30	-11		-88
1978	-6	3	1	1	-59	36	57	25	24	44	-11	2		148
1979	-90	-45	37	106	-35	-14	-24	34	-18	-10	-3	19		-49
1980	6	-5	12	0	-46	-10	-16	63	28	59	-45	-24		56
1981	-28	-12	7	4	30	6	32	37	-1	-49	16	20		-40
1982	7	1	7	-26	-91	27	-66	-11	-14	-20	-31	1		-1
1983	66	65	13	-14	-17	2	25	41	-42	50	63	32		356
1984	47	59	31	104	-55	2	49	55	-49	-34	3	-6		-11
1985	-34	-9	11	51	-50	-25	59	46	-25	8	36	15		35
1986	-17	1	7	-3	-68	-20	15	-16	-1	-25	-3	-40		-38
1987	6	-6	3	10	39	-2	-34	-5	14	19	-9	-13		-128
1988	-12	10	-2	-10	-85	-16	13	3	10	11	14	7		56
1989	9	9	1	1	-6	-3	-34	-3	1	-18	4	9		-46
1990	4	-6	-4	-1	6	-7	-4	6	41	30	-19	-8		37
1991	-3	3	1	1	-3	35	25	-6	7	-7	-20	-6		30
1992	-8	5	1	-4	9	18	-4	-23	-41	40	-15	-1		2
1993	4	11	1	-11	21	-32	-95	-73	-13	-59	-37	23		-139
1994	15	7	20	13	92	6	1	19	-6	15	-13	-1		86
1995	17	10	1	68	-29	-55	77	-8	-20	10	-32	-4		103
1996	-7	-33	1	33	141	-39	-21	11	-6	-39	8	18		-117
1997	-13	6	-1	-61	21	29	17	86	-32	-33	16	-11		-41
1998	-63	-23	-9	1	-19	46	36	84	37	62	18	15		368
1999	-1	13	-19	62	14	2	33	-1	-3	-35	-5	19		
Avg	-2	2	8	13	-19	-14	4	16	4	3	-11	-4		-2

Table 7
Release to SJR (TAF)
Modeled Baseline

12-19-01	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	WY Total	M-F Tot	Apr-Jul Tot
1922	10	7	8	15	40	7	102	188	126	14	16	13	546	500	477
1923	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1924	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1925	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1926	10	7	7	5	5	7	9	31	13	14	16	13	137	137	79
1927	10	7	7	5	5	7	9	11	61	14	16	13	165	165	107
1928	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1929	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1930	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1931	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1932	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1933	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1934	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1935	10	7	7	5	5	7	12	11	14	14	16	13	121	186	63
1936	10	7	7	5	70	7	84	49	13	14	16	13	295	354	237
1937	10	7	7	5	129	115	184	204	73	14	16	13	777	879	719
1938	10	7	7	9	227	344	306	405	279	66	16	13	1689	1463	1627
1939	10	7	7	5	5	7	9	11	13	14	16	13	117	168	59
1940	10	7	7	5	56	7	9	63	13	14	16	13	220	321	162
1941	10	7	7	7	155	17	170	183	200	14	16	13	799	653	739
1942	10	7	7	11	5	7	13	11	102	14	16	13	216	272	152
1943	10	7	7	67	5	181	106	56	13	14	16	13	495	433	375
1944	10	7	7	5	5	7	9	11	13	14	16	13	117	298	59
1945	10	7	7	5	186	7	16	11	13	14	16	13	305	176	247
1946	10	7	42	22	5	7	9	54	13	14	16	13	212	165	102
1947	10	7	8	9	5	7	9	11	13	14	16	13	122	117	59
1948	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1949	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1950	10	7	7	5	5	7	9	11	13	14	16	13	117	487	59
1951	10	53	226	81	34	7	9	11	13	14	16	13	487	181	88
1952	10	7	7	49	25	199	205	207	195	14	16	13	947	883	845
1953	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1954	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1955	10	7	7	5	5	7	9	11	13	14	16	13	117	622	59
1956	10	7	206	281	35	13	29	85	181	14	16	13	890	385	357
1957	10	7	7	5	5	7	9	11	13	14	16	13	117	139	59
1958	10	7	7	5	27	183	211	200	110	14	16	13	803	781	745
1959	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1960	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1961	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1962	10	7	7	5	5	7	9	11	14	14	16	13	118	202	60
1963	10	7	7	5	89	7	9	11	13	14	16	13	201	123	143
1964	10	7	10	8	5	7	9	11	13	14	16	13	123	238	59
1965	10	7	7	91	40	7	9	11	13	14	16	13	238	136	94
1966	10	13	15	10	5	7	9	11	13	14	16	13	136	136	59
1967	10	7	9	10	17	114	200	207	83	228	16	13	914	895	849
1968	10	7	7	5	5	7	9	11	13	14	16	13	117	638	59
1969	10	7	7	197	334	281	315	465	411	98	16	13	2154	1635	1904
1970	10	7	7	7	5	7	9	11	13	14	16	13	119	117	59
1971	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1972	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1973	10	7	7	5	5	86	9	76	57	14	16	13	305	331	247
1974	10	7	7	31	5	14	9	75	42	14	16	13	243	217	159
1975	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1976	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1977	10	7	7	5	5	7	9	11	13	14	16	13	117	301	59
1978	10	7	7	5	189	202	189	271	171	97	16	13	1177	1012	1119
1979	10	7	7	24	5	7	14	35	13	14	16	13	165	528	88
1980	10	7	7	162	230	101	116	117	104	49	16	13	932	550	717
1981	10	7	7	5	5	7	9	11	13	14	16	13	117	240	59
1982	10	7	7	7	126	109	226	210	184	14	16	13	929	1682	869
1983	12	78	211	241	368	386	290	356	523	319	16	13	2813	2251	2242
1984	10	61	206	66	5	7	9	11	13	14	16	13	431	120	59
1985	10	7	7	8	5	7	9	11	13	14	16	13	120	456	59
1986	10	7	7	5	344	236	130	215	197	14	16	13	1194	855	1136
1987	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1988	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1989	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1990	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1991	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1992	10	7	7	5	5	7	9	11	13	14	16	13	117	140	59
1993	10	7	7	5	28	15	119	87	173	14	16	13	494	471	436
1994	10	7	7	5	5	7	9	11	13	14	16	13	117	242	59
1995	10	7	7	11	124	206	205	275	165	384	16	13	1423	1309	1359
1996	10	7	7	7	14	118	19	112	30	14	16	13	367	1285	307
1997	10	7	118	687	141	37	21	125	13	14	16	13	1202	475	351
1998	10	7	7	5	207	118	240	214	186	305	16	13	1328	1131	1270
1999	10	7	7	10	5	7	9	11	13	14	16	13	122		59
Avg	10	9	20	31	45	45	51	66	56	32	16	13	393	396	295

Table 8
Madera Canal Diversion (TAF)
Modeled Alternative Baseline

12-19-01	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	WY Total	M-F Tot	Apr-Jul Tot
1922	0	0	0	0	0	27	32	52	56	57	52	35	311	349	224
1923	21	3	0	0	14	25	27	43	48	59	45	21	306	279	216
1924	3	3	0	0	5	0	0	9	26	33	23	3	105	94	73
1925	0	0	0	0	0	0	0	21	61	76	53	8	219	219	158
1926	0	0	0	0	0	0	0	19	48	60	42	6	175	175	127
1927	0	0	0	0	0	24	26	45	52	64	49	23	283	295	211
1928	3	3	0	0	6	20	0	20	54	68	47	7	228	216	168
1929	0	0	0	0	0	0	0	12	36	45	31	5	129	129	93
1930	0	0	0	0	0	0	0	12	36	45	31	5	129	129	93
1931	0	0	0	0	0	0	0	7	18	23	16	2	66	66	48
1932	0	0	0	0	0	26	28	48	55	68	52	24	301	313	225
1933	3	3	0	0	6	0	0	20	59	74	51	8	224	212	159
1934	0	0	0	0	0	0	0	11	31	39	27	4	112	112	81
1935	0	0	0	0	0	23	25	43	49	61	46	22	269	280	201
1936	3	3	0	0	5	23	27	46	51	63	48	23	292	293	215
1937	3	3	0	0	6	23	27	49	55	68	52	25	311	311	228
1938	3	3	0	0	6	32	51	70	76	77	68	46	432	471	312
1939	28	5	0	0	18	0	0	14	40	50	34	5	194	143	122
1940	0	0	0	0	0	21	23	39	43	53	41	19	239	248	179
1941	2	2	0	0	5	29	34	54	59	60	53	36	334	358	241
1942	22	4	0	0	7	27	31	50	55	75	57	27	355	334	245
1943	3	3	0	0	6	24	28	48	53	66	50	24	305	305	225
1944	3	3	0	0	6	0	0	21	61	76	53	8	231	219	164
1945	0	0	0	0	0	26	29	49	56	70	53	25	308	319	230
1946	3	3	0	0	5	22	24	38	61	76	53	8	293	282	226
1947	0	0	0	0	0	0	0	18	48	60	41	6	173	173	126
1948	0	0	0	0	0	0	0	17	48	60	42	6	173	173	125
1949	0	0	0	0	0	0	0	19	55	69	48	7	198	198	143
1950	0	0	0	0	0	0	0	21	58	73	50	8	210	210	152
1951	0	0	0	0	0	20	23	36	41	51	39	18	228	232	171
1952	2	2	0	0	0	29	44	60	65	66	60	40	368	408	264
1953	24	4	0	0	16	0	0	20	59	74	51	8	256	212	169
1954	0	0	0	0	0	0	0	20	54	68	47	7	196	196	142
1955	0	0	0	0	0	0	0	19	57	71	49	8	204	204	147
1956	0	0	0	0	0	28	33	51	56	56	51	34	309	347	224
1957	21	3	0	0	14	21	23	37	42	53	40	19	273	244	190
1958	2	2	0	0	5	29	43	58	63	64	59	40	365	400	262
1959	24	4	0	0	16	0	0	15	45	56	39	6	205	161	132
1960	0	0	0	0	0	0	0	12	34	43	30	4	123	123	89
1961	0	0	0	0	0	0	0	9	25	32	22	3	91	91	66
1962	0	0	0	0	0	25	27	43	50	61	47	22	275	286	206
1963	3	3	0	0	5	27	30	48	55	68	52	24	315	316	233
1964	3	3	0	0	6	0	0	17	49	62	43	7	190	178	134
1965	0	0	0	0	0	28	31	50	56	70	53	25	313	324	235
1966	3	3	0	0	5	20	22	20	54	68	47	7	249	238	189
1967	0	0	0	0	0	37	55	70	76	77	64	44	423	470	315
1968	26	4	0	0	17	0	0	15	43	54	37	6	202	155	129
1969	0	0	0	0	0	33	51	70	76	77	67	45	419	469	307
1970	27	5	0	0	18	22	24	37	43	54	41	19	290	249	198
1971	2	2	0	0	5	20	23	36	42	52	39	18	239	239	178
1972	2	2	0	0	5	0	0	18	51	64	44	7	193	184	138
1973	0	0	0	0	0	23	26	45	52	64	49	23	282	293	210
1974	3	3	0	0	5	24	28	48	55	68	52	24	310	311	228
1975	3	3	0	0	6	24	26	45	51	64	48	23	293	293	216
1976	3	3	0	0	6	0	0	12	33	42	29	4	132	120	93
1977	0	0	0	0	0	0	0	5	12	16	11	1	45	45	33
1978	0	0	0	0	0	36	53	70	76	77	66	45	423	471	312
1979	27	4	0	0	17	22	26	45	50	62	48	22	323	286	222
1980	3	3	0	0	5	32	45	61	66	67	57	39	378	409	276
1981	23	4	0	0	15	0	0	19	54	68	47	7	237	195	156
1982	0	0	0	0	0	32	48	65	71	72	64	44	396	431	288
1983	26	4	0	0	5	42	59	70	76	77	71	49	479	493	329
1984	29	5	0	0	15	25	27	43	47	58	44	21	314	276	215
1985	3	3	0	0	5	0	0	18	50	63	43	7	192	181	136
1986	0	0	0	0	0	26	33	54	58	59	54	36	320	361	230
1987	22	4	0	0	15	0	0	11	32	40	28	4	156	115	98
1988	0	0	0	0	0	0	0	13	36	45	31	5	130	130	94
1989	0	0	0	0	0	0	0	14	39	49	34	5	141	141	102
1990	0	0	0	0	0	0	0	11	30	38	26	4	109	109	79
1991	0	0	0	0	0	0	0	14	41	52	36	5	148	148	107
1992	0	0	0	0	0	0	0	12	35	44	31	5	127	127	91
1993	0	0	0	0	0	28	33	54	59	60	54	37	325	366	234
1994	22	4	0	0	15	0	0	14	39	49	34	5	182	141	117
1995	0	0	0	0	0	42	59	70	76	77	70	48	442	495	324
1996	29	5	0	0	19	24	28	49	55	68	52	24	353	306	243
1997	3	3	0	0	0	23	27	46	47	59	45	21	274	279	202
1998	3	3	0	0	5	39	55	70	76	77	62	42	432	466	322
1999	25	4	0	0	16	23	25	39	44	54	41	19	290		201
Avg	6	2	0	0	5	15	18	35	51	60	46	18	255	255	183

Table 9
Friant-Kern Canal Diversion (TAF)
Modeled Alternative Baseline

12-19-01	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	WY Total	M-F Tot	Apr-Jul Tot
1922	5	4	1	1	2	71	64	109	189	231	204	122	1003	1261	666
1923	82	30	27	27	105	67	109	144	171	203	172	99	1236	1090	799
1924	46	14	11	11	43	23	27	40	84	109	66	37	511	442	326
1925	28	12	1	1	14	55	90	117	144	170	145	83	860	912	590
1926	39	13	10	10	36	53	87	110	122	144	123	71	818	802	552
1927	34	11	8	8	31	66	107	148	182	216	183	105	1099	1141	750
1928	49	15	12	12	46	56	90	115	133	157	134	77	896	863	597
1929	37	12	9	9	34	30	37	54	116	150	89	50	627	599	421
1930	38	15	1	1	18	30	37	54	115	149	89	50	597	597	403
1931	38	15	1	1	18	16	19	28	57	74	46	27	340	308	212
1932	20	9	1	1	10	69	112	155	191	226	192	110	1096	1196	763
1933	51	16	13	13	48	53	88	114	140	166	141	81	924	886	609
1934	38	12	9	9	35	27	33	48	100	130	78	44	563	524	373
1935	33	13	1	1	16	63	103	143	175	207	176	101	1032	1085	707
1936	47	15	12	12	31	64	106	151	180	213	181	104	1116	1086	745
1937	48	15	12	12	0	38	90	89	192	228	193	110	1027	1080	637
1938	51	16	13	13	47	3	58	114	160	212	231	152	1070	1270	594
1939	103	37	34	34	132	35	42	61	129	167	99	55	928	649	566
1940	42	16	1	0	2	60	96	133	157	187	158	91	943	991	635
1941	43	13	10	10	33	63	66	109	186	230	209	125	1097	1259	687
1942	84	30	27	27	103	71	122	107	184	235	203	119	1312	1295	822
1943	81	29	26	19	99	0	97	157	187	222	188	108	1213	1095	762
1944	50	15	12	12	47	55	90	117	143	170	144	83	938	903	622
1945	39	13	10	10	29	70	114	159	196	232	197	113	1182	1217	800
1946	52	16	13	12	43	62	100	130	144	170	145	83	970	939	649
1947	39	13	10	9	34	51	82	106	121	144	122	71	802	789	538
1948	34	11	8	8	31	46	76	99	122	144	123	71	773	773	518
1949	34	11	8	8	31	51	84	109	134	159	135	78	842	851	568
1950	37	12	9	9	34	56	92	119	139	165	140	81	893	879	605
1951	38	4	9	8	28	58	96	124	152	181	153	88	939	964	639
1952	42	13	10	10	37	43	52	105	188	236	218	137	1091	1282	661
1953	92	33	30	30	118	54	88	115	141	167	142	82	1092	894	683
1954	39	12	9	9	36	54	89	116	132	156	133	77	862	856	583
1955	36	12	9	9	33	52	86	111	137	163	138	80	866	847	582
1956	38	12	0	2	28	62	66	109	187	230	202	121	1057	1243	682
1957	81	29	26	26	104	59	97	127	156	185	157	90	1137	985	728
1958	42	13	10	10	39	57	46	113	184	231	215	135	1095	1282	670
1959	91	33	30	30	117	44	73	95	116	138	117	68	952	741	583
1960	33	11	8	8	30	29	36	53	112	144	86	48	598	580	404
1961	37	15	1	1	18	22	27	39	81	105	63	36	445	428	292
1962	28	12	1	1	13	67	109	143	176	208	177	101	1036	1111	716
1963	47	15	12	12	44	71	117	155	191	227	192	110	1193	1200	805
1964	51	16	13	12	45	47	78	101	124	147	125	72	831	783	542
1965	34	11	8	8	28	63	121	101	195	231	196	112	1108	1153	739
1966	52	16	12	12	42	57	93	114	132	156	133	77	896	850	594
1967	36	12	0	9	31	77	74	116	160	212	226	146	1099	1334	670
1968	98	35	32	32	126	43	71	91	112	133	113	66	952	680	576
1969	32	11	8	0	0	39	37	108	153	212	228	150	978	1258	549
1970	101	36	33	33	128	61	99	128	158	187	159	91	1214	999	761
1971	43	13	10	10	40	58	96	125	154	182	155	89	975	973	655
1972	42	13	10	10	39	50	80	103	127	151	128	74	827	810	550
1973	35	12	9	9	32	62	107	141	182	216	183	105	1093	1127	740
1974	49	15	12	12	43	65	112	155	191	227	192	110	1183	1193	793
1975	51	16	13	13	48	65	106	147	181	214	182	104	1140	1133	761
1976	49	15	12	12	46	28	34	51	107	139	83	46	622	556	405
1977	35	14	1	1	17	11	13	19	37	47	30	18	243	198	144
1978	14	7	1	1	0	52	76	140	160	212	226	149	1038	1339	640
1979	100	36	33	33	122	62	106	148	178	212	179	103	1312	1071	828
1980	48	15	12	0	8	55	72	125	178	226	216	132	1087	1297	664
1981	89	32	29	29	114	51	84	109	132	156	133	77	1035	840	646
1982	36	12	9	9	32	69	38	132	177	227	227	146	1114	1178	675
1983	99	34	23	6	0	4	60	96	128	212	229	160	1051	1207	500
1984	108	38	31	30	111	67	109	143	169	200	170	98	1274	1079	799
1985	46	14	11	11	41	54	88	108	125	149	126	73	846	790	565
1986	35	11	8	8	5	36	65	113	182	226	206	126	1021	1235	627
1987	85	31	28	28	109	28	33	49	104	135	81	45	756	542	458
1988	34	14	1	1	17	31	37	55	116	150	90	50	596	603	406
1989	38	15	1	1	19	33	40	59	127	164	98	54	649	654	442
1990	41	16	1	1	20	26	32	46	98	126	76	43	526	511	348
1991	33	13	1	1	16	35	43	63	135	175	104	58	677	697	467
1992	44	17	1	1	21	30	37	54	115	148	89	49	606	595	405
1993	38	15	1	1	18	73	66	114	186	230	207	127	1076	1284	687
1994	85	31	28	28	109	33	40	59	127	164	98	54	856	654	532
1995	41	16	1	1	20	64	90	130	160	212	233	158	1126	1396	676
1996	106	38	35	35	135	61	113	158	192	227	193	110	1403	1143	886
1997	51	16	0	0	22	63	108	150	170	201	171	98	1050	1048	714
1998	46	14	11	11	5	55	38	112	131	212	218	141	994	1214	553
1999	95	34	31	31	116	63	102	133	161	189	160	92	1207		764
Avg	51	18	12	11	45	49	76	107	148	182	153	91	943	943	606

Table 10
Release to SJR (TAF)
Modeled Alternative Baseline

12-19-01	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	WY Total	M-F Tot	Apr-Jul Tot
1922	10	7	22	89	112	86	180	194	203	14	16	13	946	740	789
1923	10	7	7	5	5	7	9	52	13	14	16	13	158	158	100
1924	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1925	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1926	10	7	7	5	5	7	35	110	13	14	16	13	242	299	184
1927	10	7	7	5	62	7	79	76	139	14	16	13	435	398	377
1928	10	7	7	10	20	34	29	69	13	14	16	13	242	222	179
1929	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1930	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1931	10	7	7	5	5	7	9	11	13	14	16	13	117	131	59
1932	10	7	7	5	19	7	83	75	41	14	16	13	297	283	239
1933	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1934	10	7	7	5	5	7	21	11	13	14	16	13	129	129	71
1935	10	7	7	5	5	7	89	87	91	14	16	13	351	421	293
1936	10	7	7	5	75	76	90	129	19	14	16	13	461	521	403
1937	10	7	7	5	135	121	190	210	150	14	16	13	878	1095	820
1938	10	7	7	57	300	350	312	411	350	139	16	13	1972	1625	1862
1939	10	7	7	5	5	7	21	27	13	14	16	13	145	198	87
1940	10	7	7	5	58	54	86	143	74	14	16	13	487	617	429
1941	10	7	7	32	161	97	175	189	277	54	16	13	1038	955	953
1942	10	7	7	83	27	85	91	81	180	14	16	13	614	620	478
1943	10	7	7	67	49	187	112	136	13	14	16	13	631	525	511
1944	10	7	7	5	5	7	9	11	13	14	16	13	117	304	59
1945	10	7	7	5	192	7	94	84	38	14	16	13	487	521	429
1946	10	7	116	95	27	7	67	134	13	14	16	13	519	419	262
1947	10	7	28	62	48	32	9	72	13	14	16	13	324	203	188
1948	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1949	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1950	10	7	7	5	5	7	9	60	13	14	16	13	166	754	108
1951	10	53	299	154	106	7	9	11	13	14	16	13	705	254	160
1952	10	7	7	49	98	205	211	214	272	29	16	13	1131	994	1029
1953	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1954	10	7	7	5	5	7	9	90	13	14	16	13	196	196	138
1955	10	7	7	5	5	7	9	11	13	14	16	13	117	694	59
1956	10	7	206	281	107	93	106	165	258	16	16	13	1278	701	745
1957	10	7	7	5	5	7	9	11	13	14	16	13	117	211	59
1958	10	7	7	5	99	190	217	206	187	14	16	13	971	877	913
1959	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1960	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1961	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1962	10	7	7	5	5	7	9	89	91	14	16	13	273	429	215
1963	10	7	7	5	161	7	9	82	47	14	16	13	378	304	320
1964	10	7	51	43	5	7	9	11	13	14	16	13	199	384	59
1965	10	7	7	165	112	7	9	33	64	14	16	13	457	439	239
1966	10	78	89	77	29	23	66	68	13	14	16	13	496	399	213
1967	10	7	9	71	89	194	206	213	155	302	16	13	1285	1133	1159
1968	10	7	7	5	5	7	9	11	13	14	16	13	117	644	59
1969	10	7	7	197	340	287	321	471	411	172	16	13	2252	1756	2002
1970	10	7	7	36	5	17	9	11	13	14	16	13	158	163	69
1971	10	7	7	5	41	7	9	11	13	14	16	13	153	117	95
1972	10	7	7	5	5	31	9	11	13	14	16	13	141	173	83
1973	10	7	7	5	37	93	78	81	135	14	16	13	496	602	438
1974	10	7	7	105	43	94	82	155	120	14	16	13	666	528	508
1975	10	7	7	5	5	7	82	77	69	14	16	13	312	312	254
1976	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1977	10	7	7	5	5	7	9	11	13	14	16	13	117	307	59
1978	10	7	7	5	195	208	195	277	243	170	16	13	1346	1253	1288
1979	10	7	11	98	5	80	91	115	50	14	16	13	510	800	355
1980	10	7	7	162	235	107	193	197	181	128	16	13	1256	869	1041
1981	10	7	7	5	5	7	9	20	13	14	16	13	126	356	68
1982	10	7	7	41	199	189	232	290	259	44	16	13	1307	2111	1213
1983	92	150	211	241	374	392	296	363	523	393	27	13	3075	2522	2341
1984	22	132	206	140	15	56	35	56	13	14	16	13	718	301	189
1985	10	7	7	47	27	8	65	58	13	14	16	13	285	565	185
1986	10	7	7	5	349	242	207	295	274	14	16	13	1439	1095	1381
1987	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1988	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1989	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1990	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1991	10	7	7	5	5	7	9	11	13	14	16	13	117	117	59
1992	10	7	7	5	5	7	9	11	13	14	16	13	117	212	59
1993	10	7	7	5	100	95	196	166	251	29	16	13	895	800	837
1994	10	7	7	5	5	7	9	11	13	14	16	13	117	388	59
1995	10	7	7	85	196	212	282	281	237	458	16	13	1804	1641	1666
1996	10	7	7	32	86	124	96	192	108	14	16	13	705	1532	620
1997	10	7	118	687	147	117	98	205	38	14	16	13	1470	743	619
1998	10	7	7	5	213	124	246	220	186	379	16	13	1426	1300	1368
1999	10	7	14	74	11	7	9	23	54	14	16	13	252		118
Avg	11	12	24	45	63	59	73	95	81	41	16	13	533	535	412

Table 11
Annual Comparisons between Modeled and Historical

		Baseline Demand and Operations (Contract Year) Diversion With Additional Delivery				Alternative Baseline Demand and Operations (Contract Year) Diversion w/o Additional Delivery ("Other")				Historical Data			
		MC Modeled	FKC Modeled	Total Canals Modeled	River Modeled	MC Modeled	FKC Modeled	Total Canals Modeled	River Modeled	MC Recorded	FK Recorded	Canals Recorded	River Recorded
1922		373	1477	1850	500	349	1261	1610	740				
1923		283	1128	1411	117	279	1090	1369	158				
1924		94	442	536	117	94	442	536	117				
1925		219	912	1131	117	219	912	1131	117				
1926		187	951	1138	137	175	802	977	299				
1927		313	1355	1668	165	295	1141	1436	398				
1928		225	961	1186	117	216	863	1079	222				
1929		129	599	728	117	129	599	728	117				
1930		129	597	726	117	129	597	726	117				
1931		67	320	387	117	66	308	374	131				
1932		326	1348	1674	117	313	1196	1509	283				
1933		212	886	1098	117	212	886	1098	117				
1934		113	535	648	117	112	524	636	129				
1935		303	1298	1601	186	280	1085	1365	421				
1936		316	1229	1545	354	293	1086	1379	521				
1937		340	1265	1605	879	311	1080	1391	1095				
1938		490	1415	1905	1463	471	1270	1741	1625				
1939		148	676	824	168	143	649	792	198				
1940		274	1264	1538	321	248	991	1239	617				
1941		385	1533	1918	653	358	1259	1617	955				503
1942		361	1616	1977	272	334	1295	1629	620				2261
1943		323	1168	1491	433	305	1095	1400	525				1803
1944		225	903	1128	298	219	903	1122	304				1210
1945		335	1546	1881	176	319	1217	1536	521				1992
1946		295	1177	1472	165	282	939	1221	419				1420
1947		180	869	1049	117	173	789	962	203				1064
1948		173	773	946	117	173	773	946	117				1026
1949		198	851	1049	117	198	851	1049	117	152	43	194	1033
1950		220	1138	1358	487	210	879	1089	754	118	195	314	1376
1951		238	1031	1269	181	232	964	1196	254	142	396	539	958
1952		433	1366	1799	883	408	1282	1690	994	181	526	707	1914
1953		212	894	1106	117	212	894	1106	117	192	691	883	357
1954		202	929	1131	117	196	856	1052	196	211	813	1,025	191
1955		210	914	1124	622	204	847	1051	694	221	950	1,170	719
1956		372	1534	1906	385	347	1243	1590	701	236	1,235	1,472	659
1957		249	1052	1301	139	244	985	1229	211	243	1,012	1,255	85
1958		424	1353	1777	781	400	1282	1682	877	250	1,143	1,393	1173
1959		161	741	902	117	161	741	902	117	200	769	969	82
1960		123	580	703	117	123	580	703	117	144	565	708	108
1961		91	428	519	117	91	428	519	117	103	428	531	90
1962		303	1321	1624	202	286	1111	1397	429	278	1,456	1,734	71
1963		323	1375	1698	123	316	1200	1516	304	280	1,593	1,874	79
1964		184	924	1108	238	178	783	961	384	223	981	1,203	73
1965		332	1447	1779	136	324	1153	1477	439	338	1,555	1,893	59
1966		253	1100	1353	136	238	850	1088	399	229	997	1,226	132
1967		489	1553	2042	895	470	1334	1804	1133	411	1,599	2,010	1202
1968		161	680	841	638	155	680	835	644	145	610	754	526
1969		488	1361	1849	1635	469	1258	1727	1756	449	1,351	1,800	1776
1970		251	1042	1293	117	249	999	1248	163	258	1,089	1,346	49
1971		239	973	1212	117	239	973	1212	117	262	1,055	1,317	48
1972		188	862	1050	117	184	810	994	173	149	789	938	127
1973		319	1372	1691	331	293	1127	1420	602	383	1,497	1,879	264
1974		335	1479	1814	217	311	1193	1504	528	367	1,578	1,945	98
1975		308	1312	1620	117	293	1133	1426	312	310	1,365	1,675	60
1976		120	556	676	117	120	556	676	117	94	494	588	88
1977		51	198	249	301	45	198	243	307	53	286	339	187
1978		490	1561	2051	1012	471	1339	1810	1253	457	1,413	1,870	1263
1979		312	1320	1632	528	286	1071	1357	800	360	1,369	1,729	387
1980		439	1588	2027	550	409	1297	1706	869	510	1,532	2,043	625
1981		202	950	1152	240	195	840	1035	356	206	990	1,196	68
1982		467	1569	2036	1682	431	1178	1609	2111	472	1,570	2,042	1599
1983		515	1458	1973	2251	493	1207	1700	2522	522	1,102	1,624	2867
1984		287	1251	1538	120	276	1079	1355	301	318	1,262	1,580	70
1985		195	886	1081	456	181	790	971	565	225	851	1,076	271
1986		385	1452	1837	855	361	1235	1596	1095	506	1,490	1,996	795
1987		115	542	657	117	115	542	657	117	138	670	808	75
1988		130	603	733	117	130	603	733	117	122	547	669	86
1989		141	654	795	117	141	654	795	117	148	700	848	96
1990		109	511	620	117	109	511	620	117	112	474	586	118
1991		148	697	845	117	148	697	845	117	156	667	823	106
1992		133	662	795	140	127	595	722	212	127	660	787	128
1993		391	1587	1978	471	366	1284	1650	800	427	1,726	2,153	332
1994		147	795	942	242	141	654	795	388	148	709	857	141
1995		519	1704	2223	1309	495	1396	1891	1641	422	1,601	2,023	1606
1996		336	1360	1696	1285	306	1143	1449	1532	387	1,477	1,864	1305
1997		305	1289	1594	475	279	1048	1327	743	350	1,330	1,680	405
1998		485	1365	1850	1131	466	1214	1680	1300	404	997	1,401	1513
1999										266	1,034	1,299	
Average	1961-98	281	1,100	1,381	497	268	952	1,220	658	286	1,102	1,387	494

Table 12
Derived
Friant-Kern Class 1 (TAF)

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	WY Total	M-F Tot	Apr-Jul Tot
1922	0	0	0	0	0	22	38	60	98	141	128	77	564	660	359
1923	40	13	7	7	29	26	42	65	100	139	125	73	666	661	401
1924	38	10	7	7	29	20	23	35	78	102	59	31	439	391	287
1925	23	8	0	0	12	34	57	77	103	138	113	65	630	660	421
1926	26	7	7	7	26	34	57	77	103	137	113	65	659	659	434
1927	26	7	7	7	26	26	42	65	100	139	125	73	643	662	398
1928	38	11	7	7	29	31	52	73	102	145	117	68	680	661	432
1929	26	7	7	7	26	27	33	49	110	143	82	44	561	548	388
1930	33	11	0	0	16	27	33	49	109	142	82	44	546	546	376
1931	33	11	0	0	16	13	15	23	51	67	39	21	289	257	185
1932	15	5	0	0	8	26	42	65	100	139	125	73	598	662	380
1933	38	11	7	7	29	34	57	77	103	138	113	65	679	660	438
1934	26	7	7	7	26	24	29	43	94	123	71	38	495	473	339
1935	28	9	0	0	14	28	47	69	101	149	121	71	637	661	408
1936	26	7	7	7	28	28	47	69	101	149	121	71	661	631	422
1937	26	7	7	7	-2	28	47	69	101	149	121	71	631	661	392
1938	26	7	7	7	28	0	28	52	96	146	136	82	615	644	350
1939	46	14	7	7	30	32	38	56	123	160	92	49	654	598	439
1940	37	12	0	-1	0	31	52	73	102	145	117	68	636	661	403
1941	26	7	7	7	26	20	33	56	98	143	132	79	634	661	376
1942	43	13	7	7	30	22	38	60	98	141	128	77	664	660	389
1943	40	13	7	7	29	-3	47	69	101	149	121	71	651	630	392
1944	26	7	7	7	28	34	57	77	103	138	113	65	662	660	437
1945	26	7	7	7	26	22	38	60	98	141	128	77	637	659	385
1946	40	12	7	7	29	28	47	69	101	149	121	71	681	661	423
1947	26	7	7	7	28	37	61	82	104	132	110	62	663	661	444
1948	26	7	7	7	26	40	66	86	106	125	106	59	661	661	449
1949	26	7	7	7	26	37	61	82	104	132	110	62	661	661	442
1950	26	7	7	7	26	34	57	77	103	138	113	65	660	653	435
1951	26	0	7	7	26	31	52	73	102	145	117	68	654	661	429
1952	26	7	7	7	26	20	33	56	98	143	132	79	634	661	376
1953	43	13	7	7	30	34	57	77	103	138	113	65	687	660	439
1954	26	7	7	7	26	34	57	77	103	138	113	65	660	660	435
1955	26	7	7	7	26	34	57	77	103	138	113	65	660	646	435
1956	26	7	-1	1	26	20	33	56	98	143	132	79	620	661	376
1957	43	13	7	7	30	31	52	73	102	145	117	68	688	661	433
1958	26	7	7	7	26	20	33	56	98	143	132	79	634	661	376
1959	43	13	7	7	30	40	66	86	106	125	106	59	688	661	453
1960	26	7	7	7	26	26	32	48	106	137	79	42	543	529	375
1961	32	11	0	0	16	19	23	34	75	98	56	30	394	377	265
1962	23	8	0	0	11	26	42	65	100	139	125	73	612	662	383
1963	38	11	7	7	29	22	38	60	98	141	128	77	656	659	388
1964	40	12	7	7	29	37	61	82	104	132	110	62	683	661	445
1965	26	7	7	7	26	20	33	56	98	143	132	79	634	661	376
1966	43	13	7	7	30	31	52	73	102	145	117	68	688	653	433
1967	26	7	-1	7	26	11	19	44	94	151	143	88	615	661	345
1968	50	16	7	7	31	40	66	86	106	125	106	59	699	625	454
1969	26	7	7	-1	-2	14	24	48	95	148	139	85	590	660	327
1970	48	15	7	7	30	28	47	69	101	149	121	71	693	661	424
1971	26	7	7	7	28	31	52	73	102	145	117	68	663	661	431
1972	26	7	7	7	26	37	61	82	104	132	110	62	661	661	442
1973	26	7	7	7	26	28	47	69	101	149	121	71	659	661	420
1974	26	7	7	7	28	28	47	69	101	149	121	71	661	661	422
1975	26	7	7	7	28	26	42	65	100	139	125	73	645	662	400
1976	38	11	7	7	29	25	30	46	101	132	76	40	542	505	363
1977	30	10	0	0	15	8	9	14	31	40	23	12	192	147	117
1978	9	3	0	0	-2	11	19	44	94	151	143	88	560	661	317
1979	50	16	7	7	31	28	47	69	101	149	121	71	697	631	425
1980	26	7	7	-1	6	17	28	52	96	146	136	82	602	661	345
1981	46	14	7	7	30	37	61	82	104	132	110	62	692	661	446
1982	26	7	7	7	26	17	28	52	96	146	136	82	630	627	365
1983	46	14	7	5	-2	1	5	30	90	159	154	96	605	657	283
1984	57	19	7	7	32	26	42	65	100	139	125	73	692	661	404
1985	38	10	7	7	29	34	57	77	103	138	113	65	678	637	438
1986	26	7	7	7	3	26	42	65	100	139	125	73	620	662	375
1987	38	11	7	7	29	25	29	44	98	128	74	39	529	491	353
1988	29	10	0	0	15	28	33	50	110	143	83	44	545	552	379
1989	33	11	0	0	17	30	36	54	121	157	91	48	598	603	415
1990	36	12	0	0	18	23	28	41	92	119	69	37	475	460	321
1991	28	9	0	0	14	32	39	58	129	168	97	52	626	646	440
1992	39	13	0	0	19	27	33	49	109	141	82	43	555	544	378
1993	33	11	0	0	16	22	38	60	98	141	128	77	624	660	375
1994	40	13	7	7	29	30	36	54	121	157	91	48	633	603	427
1995	36	12	0	0	18	3	5	30	90	159	154	96	603	659	305
1996	57	19	7	7	32	26	42	65	100	139	125	73	692	637	404
1997	38	11	-1	-1	20	28	47	69	101	149	121	71	653	636	414
1998	26	7	7	7	3	9	14	39	92	154	147	90	595	660	311
1999	52	17	7	7	32	28	47	69	101	149	121	71	701		426
Avg	32	10	5	5	22	26	41	61	100	139	112	65	618	619	389
Max	57	19	7	7	32	40	66	86	129	168	154	96	701	662	454
Min	9	0	-1	-1	-2	-3	5	14	31	40	23	12	192	147	117

Table 13
Derived
Friant-Kern Class 2 (TAF)

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	WY Total	M-F Tot	Apr-Jul Tot
1922	0	0	0	0	0	46	22	44	84	83	69	39	387	549	279
1923	37	13	19	19	74	38	63	74	65	57	40	19	518	379	371
1924	3	0	4	4	12	0	0	0	0	0	0	0	23	0	12
1925	0	0	0	0	0	18	29	35	35	25	25	12	179	201	142
1926	8	2	2	2	8	16	26	27	13	0	3	0	107	92	90
1927	2	1	1	1	2	37	61	78	76	70	51	26	406	428	324
1928	6	0	4	4	15	22	34	36	24	6	10	3	164	148	137
1929	5	1	1	1	5	0	0	0	0	0	0	0	13	0	5
1930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	40	66	85	85	81	60	31	448	483	357
1933	8	0	5	5	17	17	27	32	31	21	21	10	194	179	145
1934	7	2	2	2	7	0	0	0	0	0	0	0	20	0	7
1935	0	0	0	0	0	32	52	69	68	51	48	24	344	373	272
1936	16	4	4	4	1	32	55	77	73	57	53	27	403	403	295
1937	17	4	4	4	0	7	39	15	85	71	65	34	345	367	217
1938	20	5	5	5	16	0	25	57	58	59	88	65	403	575	215
1939	52	19	26	26	100	0	0	0	0	0	0	0	223	0	100
1940	0	0	0	0	0	26	40	55	49	35	34	17	256	280	205
1941	11	3	3	3	4	40	29	48	82	80	70	40	413	549	283
1942	36	13	20	20	71	46	81	42	80	87	68	37	601	587	407
1943	35	13	19	11	68	0	46	83	80	65	60	31	511	416	342
1944	19	5	5	5	17	18	29	35	35	25	25	12	230	194	159
1945	8	2	2	2	1	45	72	94	91	84	62	30	493	506	387
1946	7	0	5	4	12	31	49	56	37	14	17	7	239	228	199
1947	8	2	2	2	3	11	17	19	11	5	6	3	89	79	66
1948	2	1	1	1	2	4	6	8	10	12	10	6	63	65	42
1949	3	1	1	1	3	11	18	22	24	20	18	10	132	138	98
1950	6	1	1	1	6	19	32	37	30	20	21	10	184	177	144
1951	7	0	1	0	0	24	39	46	44	29	30	14	234	253	182
1952	10	3	3	2	9	20	15	43	84	86	79	52	406	570	257
1953	44	16	22	22	87	17	28	32	32	22	22	11	355	184	218
1954	7	2	2	2	7	18	29	34	23	11	13	5	153	146	122
1955	5	1	1	1	5	15	25	29	28	18	18	8	154	149	120
1956	6	2	0	0	0	40	29	47	84	79	63	36	386	534	279
1957	34	12	19	19	72	25	41	48	47	33	33	16	399	274	266
1958	11	3	3	3	11	34	9	52	80	81	76	50	413	570	267
1959	43	16	22	22	85	2	3	4	5	6	5	3	216	30	105
1960	1	0	0	0	1	0	0	0	0	0	0	0	2	0	1
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	38	62	73	70	63	45	22	373	398	306
1963	4	0	4	4	13	46	75	90	87	78	57	27	485	490	389
1964	6	0	5	5	14	7	12	14	14	8	8	4	97	73	69
1965	3	1	1	1	0	40	84	40	91	81	57	27	426	442	336
1966	4	-1	5	4	10	23	37	36	23	5	9	3	158	146	134
1967	5	1	0	1	3	63	51	68	60	54	75	52	433	622	299
1968	43	15	24	24	93	0	1	1	1	1	1	0	204	5	97
1969	0	0	0	0	0	22	9	56	52	57	82	59	337	549	196
1970	49	17	25	25	96	29	48	55	51	31	31	15	472	291	310
1971	12	3	3	3	10	24	40	47	45	31	31	15	264	264	197
1972	11	3	3	3	11	10	14	17	17	12	12	6	119	99	81
1973	4	1	1	1	4	30	57	67	75	60	55	29	384	416	293
1974	18	4	4	4	13	34	61	82	84	70	64	33	471	481	344
1975	20	5	5	5	18	37	60	77	75	69	50	25	446	421	336
1976	5	0	4	4	15	0	0	0	0	0	0	0	28	0	15
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	38	52	92	60	54	76	55	427	627	296
1979	45	16	25	25	89	31	55	74	71	55	51	26	563	388	375
1980	17	4	4	0	0	35	40	68	76	73	73	44	434	586	292
1981	39	14	21	21	82	11	19	22	21	17	16	9	292	127	172
1982	5	1	1	1	4	49	6	75	74	74	84	59	433	501	282
1983	48	16	16	0	0	0	52	61	32	46	68	58	397	501	191
1984	46	15	23	23	77	39	63	73	63	55	38	18	533	369	370
1985	2	0	4	4	10	17	27	25	16	4	7	2	118	104	99
1986	3	1	1	1	0	7	19	43	77	80	74	47	353	522	226
1987	42	15	20	20	78	0	0	0	0	0	0	0	175	0	78
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	48	24	49	81	82	72	44	400	572	284
1994	40	14	20	20	78	0	0	0	0	0	0	0	172	0	78
1995	0	0	0	0	0	58	81	95	64	46	72	56	472	686	344
1996	44	15	27	27	101	33	67	88	86	82	61	31	662	456	457
1997	8	0	0	0	0	32	57	76	63	45	43	21	345	363	273
1998	14	4	4	4	0	44	20	68	33	52	64	44	351	505	217
1999	38	13	23	23	83	32	51	59	54	33	33	16	458		312
Avg	14	4	6	6	21	21	31	40	42	36	34	20	274	274	191
Max	52	19	27	27	101	63	84	95	91	87	88	65	662	686	457
Min	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 14
Modeled
Friant-Kern Other (TAF)

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	WY Total	M-F Tot	Apr-Jul Tot
1922	0	0	14	74	67	74	71	0	71	0	0	0	371	216	283
1923	0	0	0	0	0	0	0	38	0	0	0	0	38	38	38
1924	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1926	0	0	0	0	0	0	24	74	0	0	0	0	98	150	98
1927	0	0	0	0	52	0	65	60	71	0	0	0	248	214	248
1928	0	0	0	5	13	26	18	54	0	0	0	0	116	98	111
1929	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0
1932	0	0	0	0	13	0	68	59	26	0	0	0	166	153	166
1933	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	11	0	0	0	0	0	11	11	11
1935	0	0	0	0	0	0	71	70	71	0	0	0	212	212	212
1936	0	0	0	0	0	64	0	74	5	0	0	0	143	143	143
1937	0	0	0	0	0	0	0	0	71	0	0	0	71	186	71
1938	0	0	0	48	67	0	0	0	71	74	0	0	260	145	212
1939	0	0	0	0	0	0	11	15	0	0	0	0	26	26	26
1940	0	0	0	0	0	44	71	74	57	0	0	0	246	271	246
1941	0	0	0	25	0	74	0	0	71	36	0	0	206	273	181
1942	0	0	0	72	20	73	71	64	71	0	0	0	371	319	299
1943	0	0	0	0	40	0	0	74	0	0	0	0	114	74	114
1944	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	0	0	71	67	23	0	0	0	161	330	161
1946	0	0	74	74	21	0	53	74	0	0	0	0	296	240	148
1947	0	0	20	53	40	24	0	57	0	0	0	0	194	81	121
1948	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	45	0	0	0	0	45	260	45
1951	0	0	74	74	67	0	0	0	0	0	0	0	215	67	67
1952	0	0	0	0	67	0	0	0	71	13	0	0	151	84	151
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	73	0	0	0	0	73	73	73
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	67	0
1956	0	0	0	0	67	74	71	74	71	2	0	0	359	292	359
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	67	0
1958	0	0	0	0	67	0	0	0	71	0	0	0	138	71	138
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	72	71	0	0	0	143	210	143
1963	0	0	0	0	67	0	0	66	32	0	0	0	165	175	165
1964	0	0	41	36	0	0	0	0	0	0	0	0	77	141	0
1965	0	0	0	74	67	0	0	20	47	0	0	0	208	294	134
1966	0	65	74	66	22	15	53	53	0	0	0	0	348	250	143
1967	0	0	0	62	67	74	0	0	71	74	0	0	348	219	286
1968	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	74	0	0	74	103	74
1970	0	0	0	29	0	10	0	0	0	0	0	0	39	43	10
1971	0	0	0	0	33	0	0	0	0	0	0	0	33	0	33
1972	0	0	0	0	0	23	0	0	0	0	0	0	23	53	23
1973	0	0	0	0	30	0	63	0	71	0	0	0	164	243	164
1974	0	0	0	74	35	74	67	74	71	0	0	0	395	286	321
1975	0	0	0	0	0	0	67	61	51	0	0	0	179	179	179
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	71	74	0	0	145	223	145
1979	0	0	4	74	0	67	71	74	35	0	0	0	325	247	247
1980	0	0	0	0	0	0	71	74	71	74	0	0	290	290	290
1981	0	0	0	0	0	0	0	9	0	0	0	0	9	110	9
1982	0	0	0	34	67	74	0	74	71	28	0	0	348	392	314
1983	74	71	0	0	0	0	0	0	0	74	10	0	229	249	74
1984	11	71	0	74	9	45	24	42	0	0	0	0	276	170	120
1985	0	0	0	39	20	1	52	44	0	0	0	0	156	97	117
1986	0	0	0	0	0	0	71	74	71	0	0	0	216	216	216
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	67	0
1993	0	0	0	0	67	74	71	74	71	13	0	0	370	303	370
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	141	0
1995	0	0	0	74	67	0	71	0	71	74	0	0	357	308	283
1996	0	0	0	25	67	0	71	74	71	0	0	0	308	216	283
1997	0	0	0	0	0	74	71	74	23	0	0	0	242	242	242
1998	0	0	0	0	0	0	0	0	0	74	0	0	74	151	74
1999	0	0	7	64	6	0	0	11	38	0	0	0	126		55
Avg	1	3	4	15	16	13	19	26	23	9	0	0	128	127	106
Max	74	71	74	74	67	74	71	74	71	74	10	0	395	392	370
Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 15
Modeled
Friant-Kern Adjustment (TAF)

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	WY Total	M-F Tot	Apr-Jul Tot
1922	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1923	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1924	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1926	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1927	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1928	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1929	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0
1936	0	0	0	0	13	0	3	0	0	0	0	0	16	48	16
1937	0	0	0	0	45	25	19	11	0	0	0	0	100	55	100
1938	0	0	0	0	0	65	22	28	0	0	0	0	115	115	115
1939	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0
1940	0	0	0	1	18	0	0	0	0	0	0	0	19	6	18
1941	0	0	0	0	6	0	1	5	0	0	0	0	12	6	12
1942	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0
1943	0	0	0	8	0	65	16	0	0	0	0	0	89	81	81
1944	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0
1945	0	0	0	0	7	0	0	0	0	0	0	0	7	0	7
1946	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1947	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0
1951	0	9	0	0	0	0	0	0	0	0	0	0	9	0	0
1952	0	0	0	0	0	21	19	18	0	0	0	0	58	58	58
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0
1956	0	0	9	6	0	0	0	0	0	0	0	0	15	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	6	24	8	0	0	0	0	38	38	38
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0
1967	0	0	9	0	0	0	11	26	0	0	0	0	46	37	37
1968	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0
1969	0	0	0	8	28	31	43	34	7	0	0	0	151	115	143
1970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	1	0	7	0	0	0	0	8	8	8
1974	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0
1978	0	0	0	0	7	23	7	2	0	0	0	0	39	32	39
1979	0	0	0	0	0	0	0	0	0	0	0	0	0	45	0
1980	0	0	0	12	33	13	0	0	0	0	0	0	58	13	46
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	38	0	0	0	0	0	38	107	38
1983	0	0	5	20	44	81	29	45	32	0	0	0	256	190	231
1984	0	0	3	0	0	0	0	0	0	0	0	0	3	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	27	0
1986	0	0	0	0	27	33	0	0	0	0	0	0	60	33	60
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	22	0	12	0	0	0	0	34	34	34
1996	0	0	0	0	0	5	0	0	0	0	0	0	5	36	5
1997	0	0	13	12	6	0	0	0	0	0	0	0	31	38	6
1998	0	0	0	0	38	25	47	30	29	0	0	0	169	131	169
1999	0	0	0	0	0	0	0	0	0	0	0	0	0		0
Avg	0	0	1	1	3	5	4	3	1	0	0	0	18	18	16
Max	0	9	13	20	45	81	47	45	32	0	0	0	256	190	231
Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 16
Derived
Madera Canal Class 1 (TAF)

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	WY Total	M-F Tot	Apr-Jul Tot
1922	0	0	0	0	0	0	0	0	31	42	42	21	136	140	73
1923	3	1	0	0	0	0	0	0	31	42	42	21	140	140	73
1924	3	1	0	0	0	0	0	7	23	29	20	3	86	82	59
1925	0	0	0	0	0	0	0	13	39	49	34	6	141	141	101
1926	0	0	0	0	0	0	0	13	39	49	34	6	141	141	101
1927	0	0	0	0	0	0	0	0	31	42	42	21	136	140	73
1928	3	1	0	0	0	0	0	13	39	49	34	6	145	141	101
1929	0	0	0	0	0	0	0	10	33	41	28	5	117	117	84
1930	0	0	0	0	0	0	0	10	33	41	28	5	117	117	84
1931	0	0	0	0	0	0	0	5	15	19	13	2	54	54	39
1932	0	0	0	0	0	0	0	0	31	42	42	21	136	140	73
1933	3	1	0	0	0	0	0	13	39	49	34	6	145	141	101
1934	0	0	0	0	0	0	0	9	28	35	24	4	100	100	72
1935	0	0	0	0	0	0	0	0	34	42	42	20	138	140	76
1936	1	1	0	0	0	0	0	0	34	42	42	20	140	140	76
1937	1	1	0	0	0	0	0	0	34	42	42	20	140	140	76
1938	1	1	0	0	0	0	0	0	25	42	42	21	132	140	67
1939	7	3	0	0	0	0	0	12	37	46	31	5	141	131	95
1940	0	0	0	0	0	0	0	13	39	49	34	6	141	141	101
1941	0	0	0	0	0	0	0	0	28	42	42	21	133	140	70
1942	4	3	0	0	0	0	0	0	31	42	42	21	143	140	73
1943	3	1	0	0	0	0	0	0	34	42	42	20	142	140	76
1944	1	1	0	0	0	0	0	13	39	49	34	6	143	141	101
1945	0	0	0	0	0	0	0	0	31	42	42	21	136	140	73
1946	3	1	0	0	0	0	0	0	34	42	42	8	130	126	76
1947	0	0	0	0	0	0	0	13	39	49	34	6	141	141	101
1948	0	0	0	0	0	0	0	13	39	49	34	6	141	141	101
1949	0	0	0	0	0	0	0	13	39	49	34	6	141	141	101
1950	0	0	0	0	0	0	0	13	39	49	34	6	141	141	101
1951	0	0	0	0	0	0	0	13	38	47	34	6	138	138	98
1952	0	0	0	0	0	0	0	0	28	42	42	21	133	140	70
1953	4	3	0	0	0	0	0	13	39	49	34	6	148	141	101
1954	0	0	0	0	0	0	0	13	39	49	34	6	141	141	101
1955	0	0	0	0	0	0	0	13	39	49	34	6	141	141	101
1956	0	0	0	0	0	0	0	0	28	42	42	21	133	140	70
1957	4	3	0	0	0	0	0	13	39	49	34	6	148	141	101
1958	0	0	0	0	0	0	0	0	28	42	42	21	133	140	70
1959	4	3	0	0	0	0	0	13	39	49	34	6	148	141	101
1960	0	0	0	0	0	0	0	10	31	39	27	4	111	111	80
1961	0	0	0	0	0	0	0	7	22	28	19	3	79	79	57
1962	0	0	0	0	0	0	0	0	31	42	42	21	136	140	73
1963	3	1	0	0	0	0	0	0	31	42	42	21	140	140	73
1964	3	1	0	0	0	0	0	13	39	49	34	6	145	141	101
1965	0	0	0	0	0	0	0	0	28	42	42	21	133	139	70
1966	3	3	0	0	0	0	0	13	39	49	34	6	147	141	101
1967	0	0	0	0	0	0	0	0	11	31	42	34	118	140	42
1968	14	4	0	0	4	0	0	13	39	49	34	6	163	141	105
1969	0	0	0	0	0	0	0	0	22	42	42	21	127	140	64
1970	10	3	0	0	0	0	0	0	34	42	38	19	146	135	76
1971	1	1	0	0	0	0	0	13	39	48	34	6	142	140	100
1972	0	0	0	0	0	0	0	13	39	49	34	6	141	141	101
1973	0	0	0	0	0	0	0	0	34	42	42	20	138	140	76
1974	1	1	0	0	0	0	0	0	34	42	42	20	140	140	76
1975	1	1	0	0	0	0	0	0	31	42	42	21	138	140	73
1976	3	1	0	0	0	0	0	10	30	38	26	4	112	108	78
1977	0	0	0	0	0	0	0	3	9	12	8	1	33	33	24
1978	0	0	0	0	0	0	0	0	11	31	42	34	118	140	42
1979	14	4	0	0	4	0	0	0	34	42	42	20	160	140	80
1980	1	1	0	0	0	0	0	0	25	42	42	21	132	140	67
1981	7	3	0	0	0	0	0	13	39	49	34	6	151	141	101
1982	0	0	0	0	0	0	0	0	25	42	42	21	130	140	67
1983	7	3	0	0	0	0	0	0	11	24	42	34	121	140	35
1984	21	4	0	0	4	0	0	0	31	42	41	21	164	139	77
1985	3	1	0	0	0	0	0	13	39	49	34	6	145	141	101
1986	0	0	0	0	0	0	0	0	31	42	42	21	136	140	73
1987	3	1	0	0	0	0	0	9	29	36	25	4	107	103	74
1988	0	0	0	0	0	0	0	11	33	41	28	5	118	118	85
1989	0	0	0	0	0	0	0	12	36	45	31	5	129	129	93
1990	0	0	0	0	0	0	0	9	27	34	23	4	97	97	70
1991	0	0	0	0	0	0	0	12	38	48	33	5	136	136	98
1992	0	0	0	0	0	0	0	10	32	40	28	5	115	115	82
1993	0	0	0	0	0	0	0	0	31	42	42	21	136	140	73
1994	3	1	0	0	0	0	0	12	36	45	31	5	133	129	93
1995	0	0	0	0	0	0	0	0	11	24	42	34	111	140	35
1996	21	4	0	0	4	0	0	0	31	42	42	21	165	140	77
1997	3	1	0	0	0	0	0	0	34	42	42	20	142	140	76
1998	1	1	0	0	0	0	0	0	11	24	42	34	113	140	35
1999	21	4	0	0	4	0	0	0	34	42	38	19	162		80
Avg	2	1	0	0	0	0	0	6	32	42	36	13	132	132	79
Max	21	4	0	0	4	0	0	13	39	49	42	34	165	141	105
Min	0	0	0	0	0	0	0	0	9	12	8	1	33	33	24

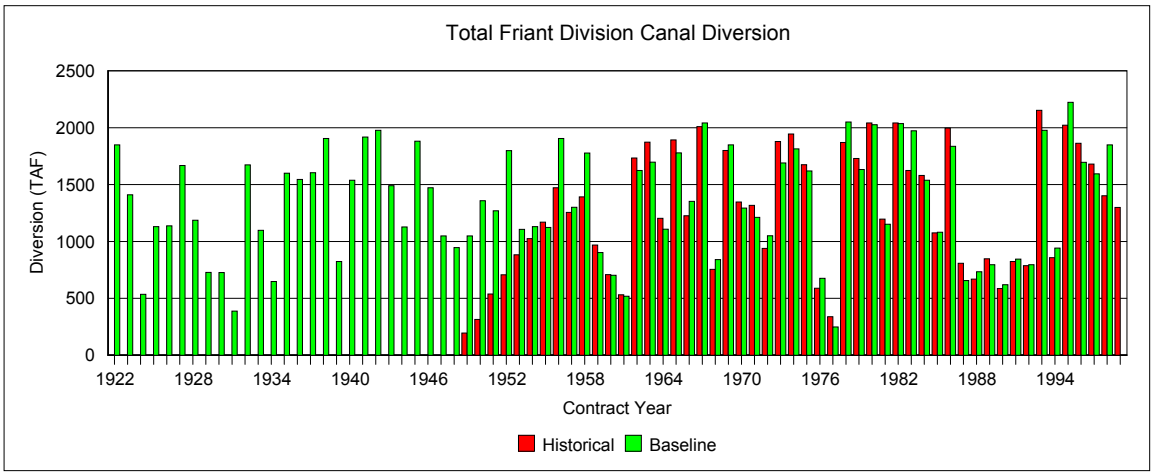
Table 17
Derived
Madera Canal Class 2 (TAF)

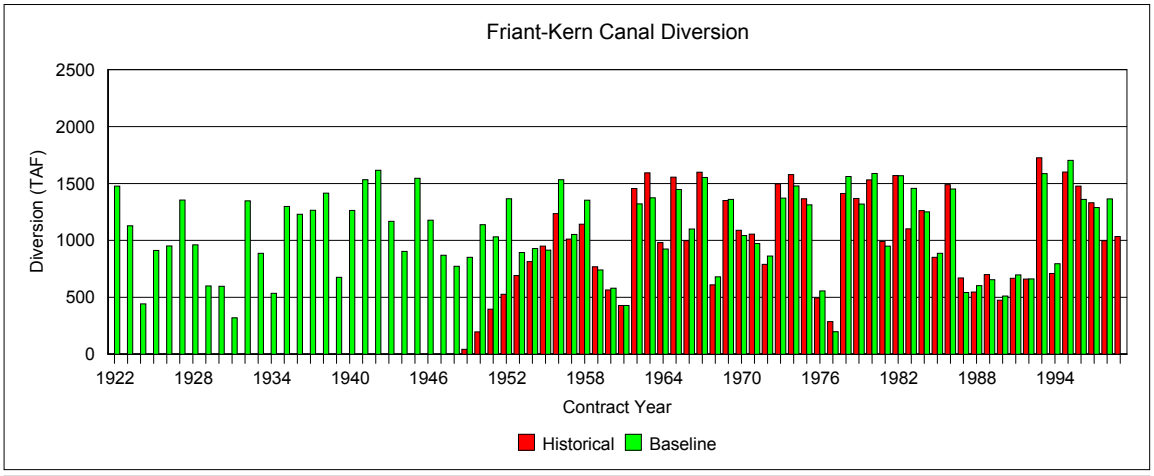
WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	WY Total	M-F Tot	Apr-Jul Tot
1922	0	0	0	0	0	27	32	50	22	11	7	14	163	197	142
1923	18	2	0	0	14	25	27	41	14	13	0	0	154	126	134
1924	0	1	0	0	5	0	0	0	0	0	0	0	6	0	5
1925	0	0	0	0	0	0	0	6	19	23	16	3	67	67	48
1926	0	0	0	0	0	0	0	4	6	7	5	1	23	23	17
1927	0	0	0	0	0	24	26	43	18	18	4	2	135	142	129
1928	0	1	0	0	6	20	0	5	12	15	10	2	71	64	58
1929	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	26	28	46	21	22	7	3	153	161	143
1933	0	2	0	0	6	0	0	5	16	21	14	2	66	58	48
1934	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	23	25	41	13	15	1	2	120	127	117
1936	1	1	0	0	5	23	27	44	14	17	3	3	138	139	130
1937	1	1	0	0	6	23	27	47	18	22	7	5	157	159	143
1938	2	2	0	0	6	32	51	68	48	31	23	25	288	319	236
1939	21	2	0	0	18	0	0	0	0	0	0	0	41	0	18
1940	0	0	0	0	0	21	23	25	1	0	4	13	87	96	70
1941	2	2	0	0	5	29	34	52	28	14	8	15	189	205	162
1942	17	1	0	0	7	27	31	48	21	29	12	6	199	183	163
1943	1	2	0	0	6	24	28	46	17	20	5	4	153	154	141
1944	2	2	0	0	6	0	0	6	19	23	16	3	77	67	54
1945	0	0	0	0	0	26	29	47	23	24	8	4	161	168	149
1946	0	2	0	0	5	22	24	36	24	30	8	0	151	144	141
1947	0	0	0	0	0	0	0	3	6	7	5	1	22	22	16
1948	0	0	0	0	0	0	0	2	6	7	5	1	21	21	15
1949	0	0	0	0	0	0	0	4	13	16	11	2	46	46	33
1950	0	0	0	0	0	0	0	7	16	20	14	2	59	59	43
1951	0	0	0	0	0	20	23	21	0	0	2	12	78	82	64
1952	2	2	0	0	0	29	44	58	34	20	15	19	223	256	185
1953	20	1	0	0	16	0	0	5	17	21	15	2	97	60	59
1954	0	0	0	0	0	0	0	6	12	15	10	2	45	45	33
1955	0	0	0	0	0	0	0	5	15	18	13	2	53	53	38
1956	0	0	0	0	0	28	33	49	25	10	6	13	164	195	145
1957	16	1	0	0	14	21	23	22	0	0	3	13	113	91	80
1958	2	2	0	0	5	29	43	56	32	18	14	19	220	248	183
1959	20	1	0	0	16	0	0	1	3	3	2	0	46	9	23
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	25	27	41	16	15	2	1	127	133	124
1963	0	1	0	0	5	27	30	46	21	22	7	3	162	164	151
1964	0	2	0	0	6	0	0	2	7	9	6	1	33	25	24
1965	0	0	0	0	0	28	31	48	25	24	8	4	168	173	156
1966	0	0	0	0	5	20	22	5	12	15	10	2	91	86	79
1967	0	0	0	0	0	37	55	68	62	43	19	10	294	319	265
1968	12	0	0	0	13	0	0	0	1	1	0	0	27	2	15
1969	0	0	0	0	0	33	51	68	51	31	21	24	279	316	234
1970	17	2	0	0	18	22	24	35	7	8	0	0	133	103	114
1971	1	1	0	0	5	20	23	22	0	0	3	13	88	90	70
1972	2	2	0	0	5	0	0	3	9	11	8	1	41	32	28
1973	0	0	0	0	0	23	26	43	15	18	4	3	132	139	125
1974	1	1	0	0	5	24	28	46	18	22	7	5	157	160	143
1975	2	2	0	0	6	24	26	43	17	17	3	2	142	139	133
1976	0	1	0	0	6	0	0	0	0	0	0	0	7	0	6
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	36	53	68	62	43	21	11	294	320	262
1979	13	0	0	0	13	22	26	43	14	16	3	3	153	134	134
1980	1	1	0	0	5	32	45	59	38	21	12	18	232	257	200
1981	16	1	0	0	15	0	0	4	12	15	10	2	75	43	46
1982	0	0	0	0	0	32	48	63	42	26	19	23	253	278	211
1983	19	1	0	0	5	42	59	68	62	50	26	15	347	342	286
1984	8	1	0	0	11	25	27	41	13	12	0	0	138	124	129
1985	0	1	0	0	5	0	0	4	8	10	7	1	36	30	27
1986	0	0	0	0	0	26	33	52	24	13	9	15	172	208	148
1987	19	2	0	0	15	0	0	0	0	0	0	0	36	0	15
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	28	33	52	25	14	9	16	177	213	152
1994	19	2	0	0	15	0	0	0	0	0	0	0	36	0	15
1995	0	0	0	0	0	42	59	68	62	50	25	15	321	345	281
1996	8	1	0	0	15	24	28	47	21	22	7	3	176	154	157
1997	0	2	0	0	0	23	27	44	11	13	0	1	121	126	118
1998	1	1	0	0	5	39	55	68	62	50	16	8	305	314	279
1999	4	0	0	0	12	23	25	37	8	8	0	0	117		113
Avg	3	1	0	0	4	15	18	27	16	14	7	5	111	111	95
Max	21	2	0	0	18	42	59	68	62	50	26	25	347	345	286
Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 18
Modeled
Madera Canal Other (TAF)

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	WY Total	M-F Tot	Apr-Jul Tot
1922	0	0	0	0	6	6	6	6	6	0	0	0	30	24	30
1923	0	0	0	0	0	0	0	3	0	0	0	0	3	3	3
1924	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1926	0	0	0	0	0	0	2	6	0	0	0	0	8	12	8
1927	0	0	0	0	4	0	5	5	6	0	0	0	20	17	20
1928	0	0	0	0	1	2	2	4	0	0	0	0	9	8	9
1929	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
1932	0	0	0	0	1	0	6	5	2	0	0	0	14	13	14
1933	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1
1935	0	0	0	0	0	0	6	6	6	0	0	0	18	22	18
1936	0	0	0	0	4	5	6	6	0	0	0	0	21	23	21
1937	0	0	0	0	6	6	6	6	6	0	0	0	30	30	30
1938	0	0	0	0	6	6	6	6	0	0	0	0	24	18	24
1939	0	0	0	0	0	0	1	1	0	0	0	0	2	5	2
1940	0	0	0	0	3	4	6	6	5	0	0	0	24	27	24
1941	0	0	0	0	6	6	6	6	6	3	0	0	33	29	33
1942	0	0	0	0	2	6	6	5	6	0	0	0	25	26	25
1943	0	0	0	0	3	6	6	6	0	0	0	0	21	18	21
1944	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
1945	0	0	0	0	6	0	6	6	2	0	0	0	20	16	20
1946	0	0	0	0	2	0	4	6	0	0	0	0	12	13	12
1947	0	0	0	0	3	2	0	5	0	0	0	0	10	7	10
1948	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	4	0	0	0	0	4	10	4
1951	0	0	0	0	6	0	0	0	0	0	0	0	6	6	6
1952	0	0	0	0	6	6	6	6	6	1	0	0	31	25	31
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	6	0	0	0	0	6	6	6
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
1956	0	0	0	0	6	6	6	6	6	0	0	0	30	24	30
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
1958	0	0	0	0	6	6	6	6	6	0	0	0	30	24	30
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	6	6	0	0	0	12	18	12
1963	0	0	0	0	6	0	0	5	3	0	0	0	14	8	14
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
1965	0	0	0	0	6	0	0	2	4	0	0	0	12	8	12
1966	0	0	0	0	2	1	4	4	0	0	0	0	11	15	11
1967	0	0	0	0	6	6	6	6	0	0	0	0	24	18	24
1968	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
1969	0	0	0	0	6	6	6	6	0	0	0	0	24	18	24
1970	0	0	0	0	0	1	0	0	0	0	0	0	1	4	1
1971	0	0	0	0	3	0	0	0	0	0	0	0	3	0	3
1972	0	0	0	0	0	2	0	0	0	0	0	0	2	4	2
1973	0	0	0	0	2	6	5	5	6	0	0	0	24	25	24
1974	0	0	0	0	3	6	6	6	6	0	0	0	27	24	27
1975	0	0	0	0	0	0	6	5	4	0	0	0	15	15	15
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
1978	0	0	0	0	6	6	6	6	0	0	0	0	24	18	24
1979	0	0	0	0	0	6	6	6	3	0	0	0	21	27	21
1980	0	0	0	0	6	6	6	6	6	6	0	0	36	30	36
1981	0	0	0	0	0	0	0	1	0	0	0	0	1	7	1
1982	0	0	0	0	6	6	6	6	4	2	0	0	30	36	30
1983	6	0	0	0	6	6	6	6	0	0	1	0	31	21	24
1984	1	0	0	0	1	4	2	3	0	0	0	0	11	11	10
1985	0	0	0	0	2	0	4	4	0	0	0	0	10	14	10
1986	0	0	0	0	6	6	6	6	6	0	0	0	30	24	30
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
1993	0	0	0	0	6	6	6	6	6	1	0	0	31	25	31
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
1995	0	0	0	0	6	6	6	6	0	0	0	0	24	24	24
1996	0	0	0	0	6	6	6	6	6	0	0	0	30	30	30
1997	0	0	0	0	6	6	6	6	2	0	0	0	26	26	26
1998	0	0	0	0	6	6	6	6	0	0	0	0	24	18	24
1999	0	0	0	0	0	0	0	1	3	0	0	0	4		4
Avg	0	0	0	0	2	2	3	3	2	0	0	0	12	12	12
Max	6	0	0	0	6	6	6	6	6	6	1	0	36	36	36
Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure Set 1


Total Friant Division Canal Diversion
Diversion (TAF)
2500
2000
1500
1000
500
0
1922
1928
1934
1940
1946
1952
1958
1964
1970
1976
1982
1988
1994
Contract Year
Historical
Baseline


Friant-Kern Canal Diversion
Diversion (TAF)
2500
2000
1500
1000
500
0
1922
1928
1934
1940
1946
1952
1958
1964
1970
1976
1982
1988
1994
Contract Year
Historical
Baseline

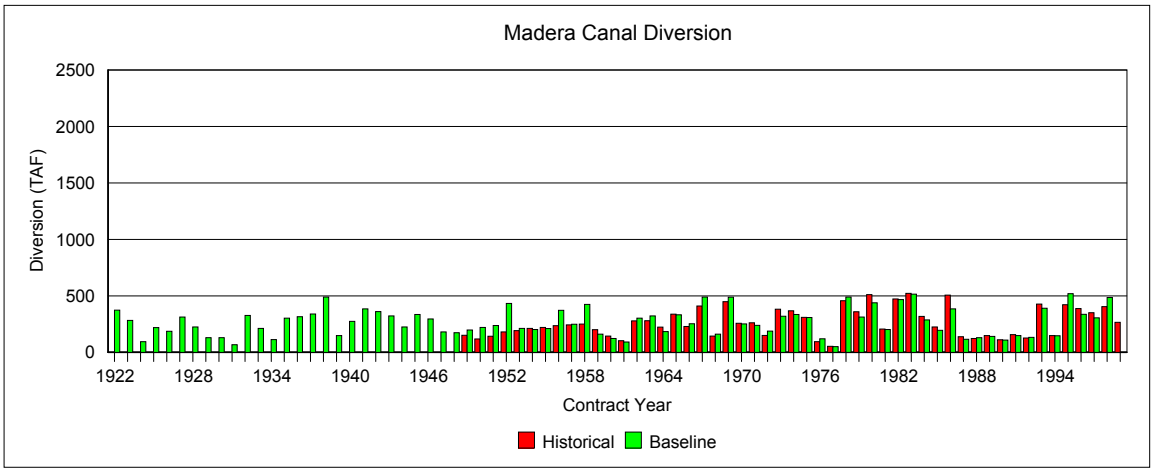
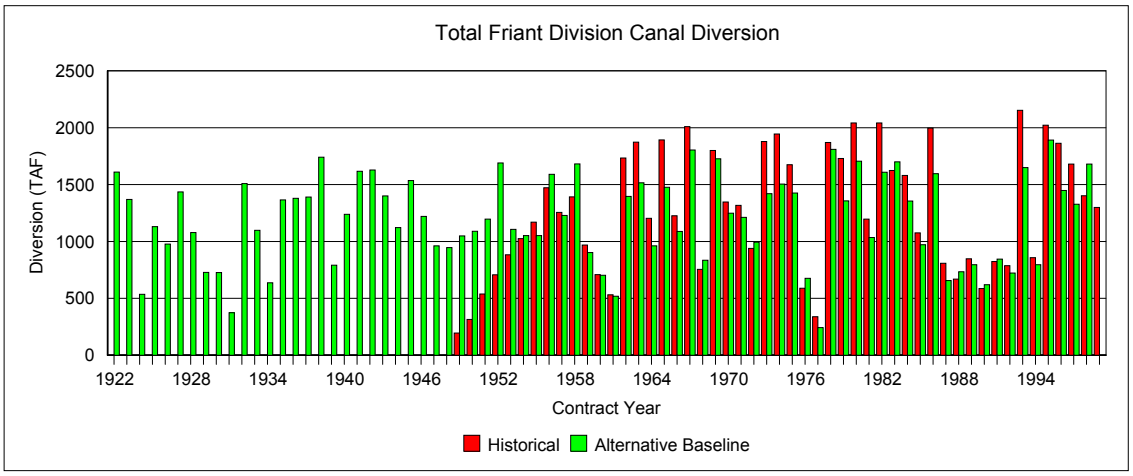
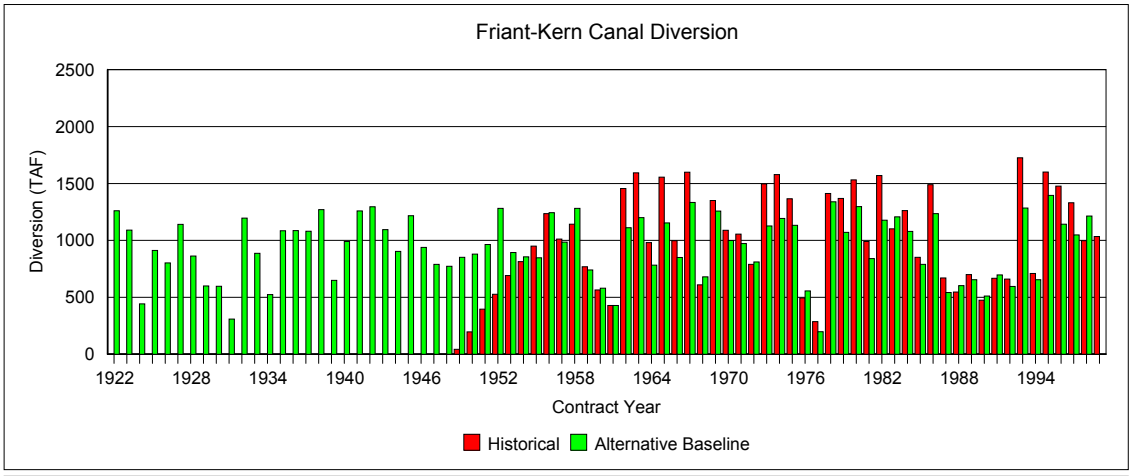

Madera Canal Diversion
Diversion (TAF)
2500
2000
1500
1000
500
0
1922
1928
1934
1940
1946
1952
1958
1964
1970
1976
1982
1988
1994
Contract Year
Historical
Baseline

Figure Set 2


Total Friant Division Canal Diversion
Diversion (TAF)
2500
2000
1500
1000
500
0
1922
1928
1934
1940
1946
1952
1958
1964
1970
1976
1982
1988
1994
Contract Year
Historical
Alternative Baseline


Friant-Kern Canal Diversion
Diversion (TAF)
2500
2000
1500
1000
500
0
1922
1928
1934
1940
1946
1952
1958
1964
1970
1976
1982
1988
1994
Contract Year
Historical
Alternative Baseline

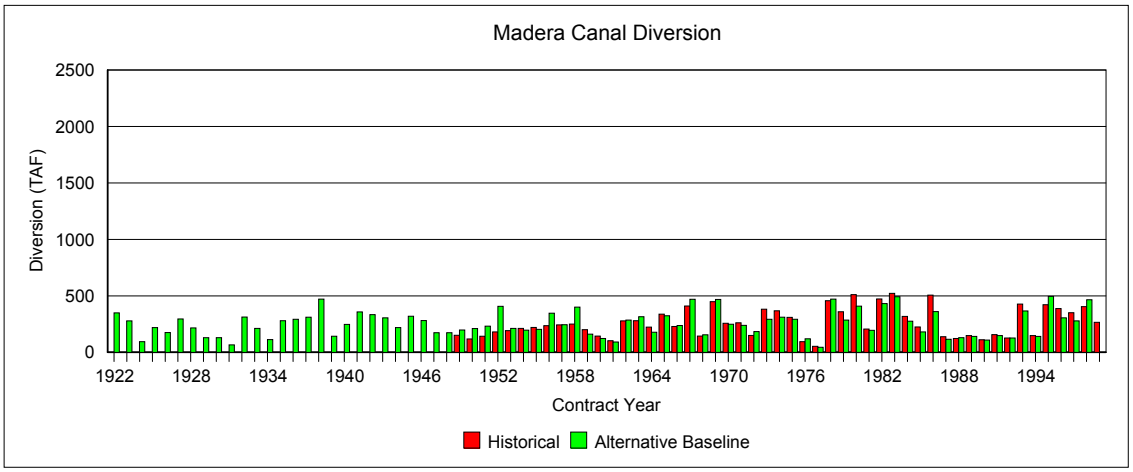
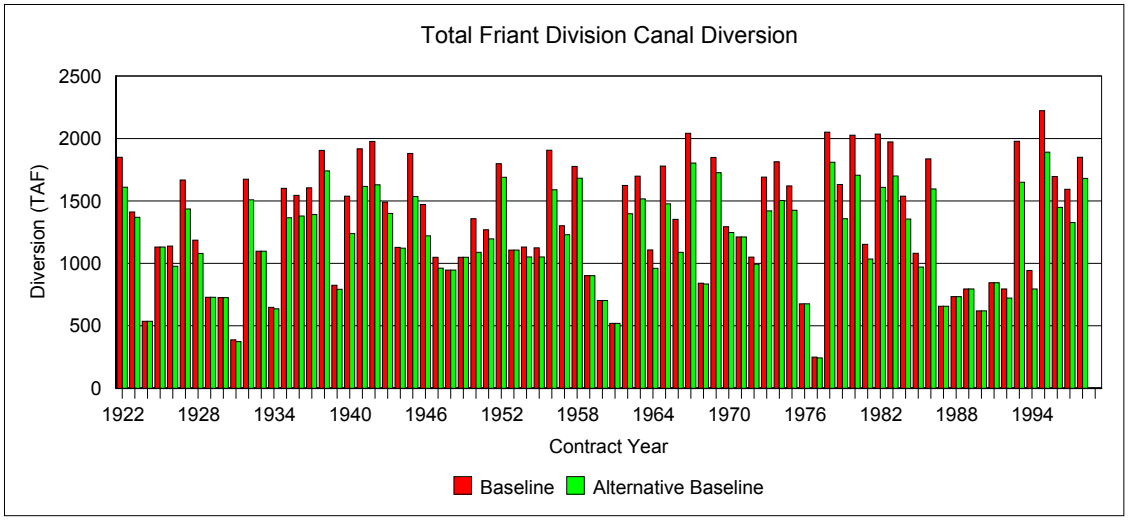
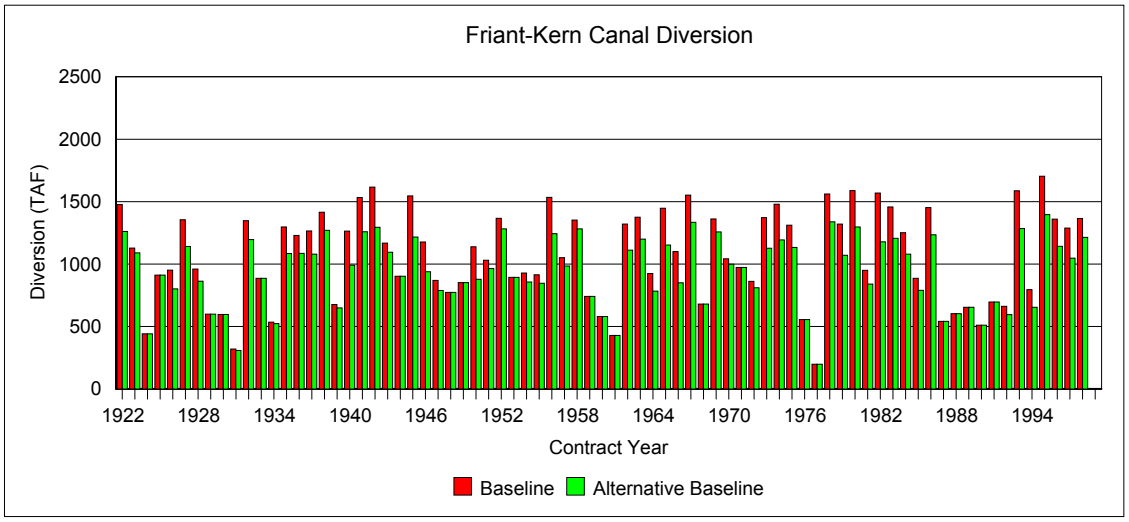

Madera Canal Diversion
Diversion (TAF)
2500
2000
1500
1000
500
0
1922
1928
1934
1940
1946
1952
1958
1964
1970
1976
1982
1988
1994
Contract Year
Historical
Alternative Baseline

Figure Set 3


Total Friant Division Canal Diversion
Diversion (TAF)
2500
2000
1500
1000
500
0
1922
1928
1934
1940
1946
1952
1958
1964
1970
1976
1982
1988
1994
Contract Year
Baseline
Alternative Baseline


Friant-Kern Canal Diversion
Diversion (TAF)
2500
2000
1500
1000
500
0
1922
1928
1934
1940
1946
1952
1958
1964
1970
1976
1982
1988
1994
Contract Year
Baseline
Alternative Baseline

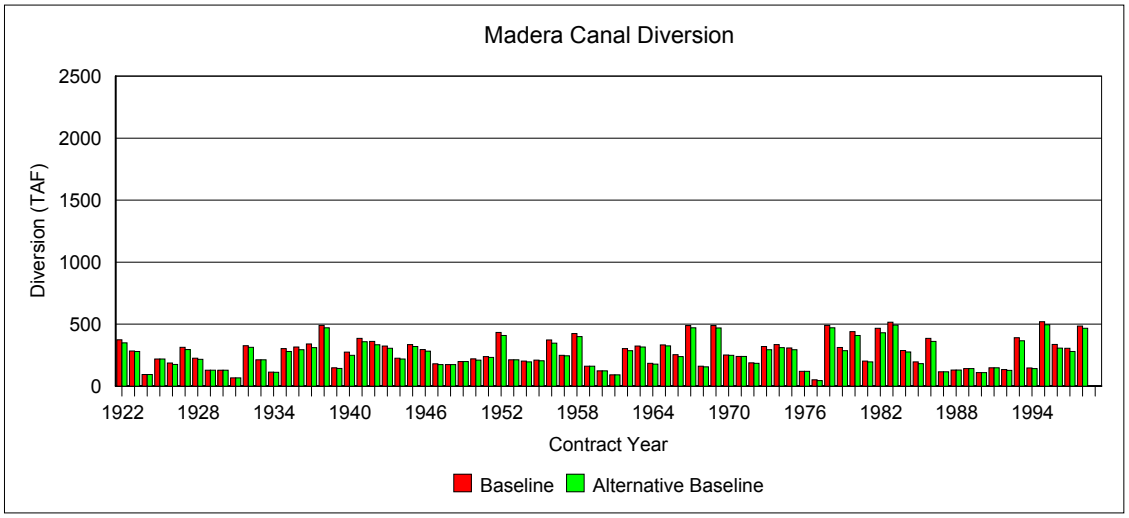
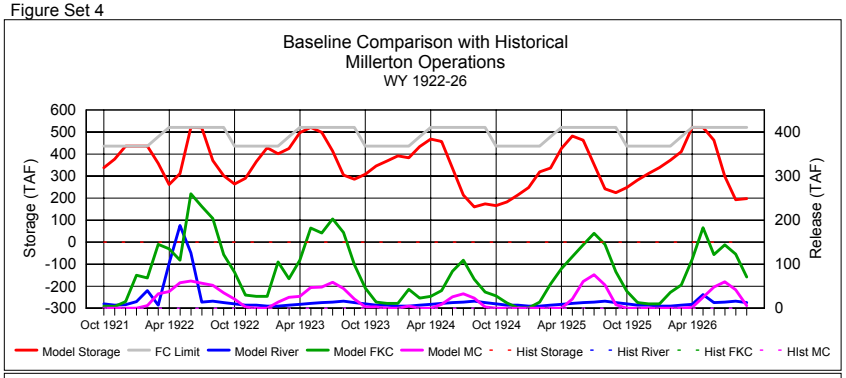
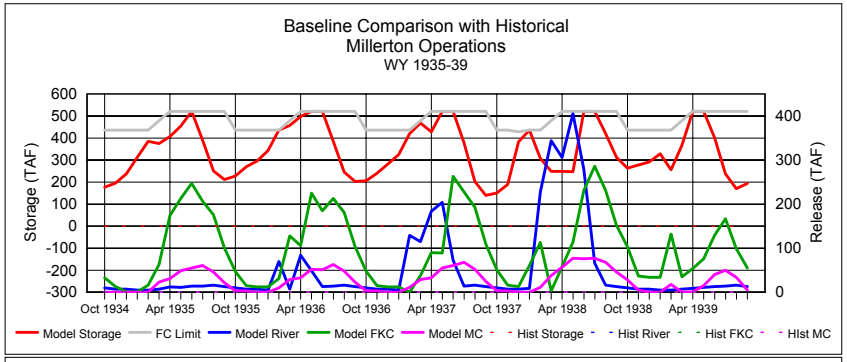
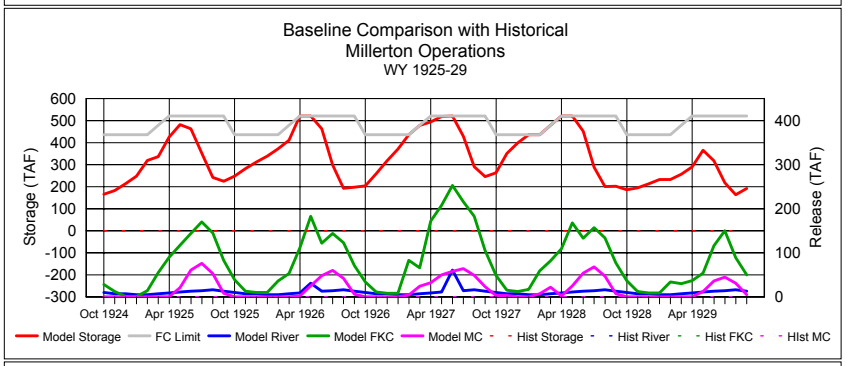
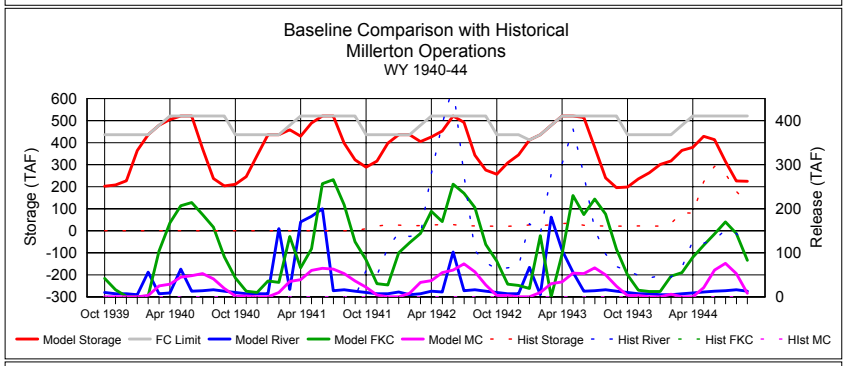

Madera Canal Diversion
Diversion (TAF)
2500
2000
1500
1000
500
0
1922
1928
1934
1940
1946
1952
1958
1964
1970
1976
1982
1988
1994
Contract Year
Baseline
Alternative Baseline

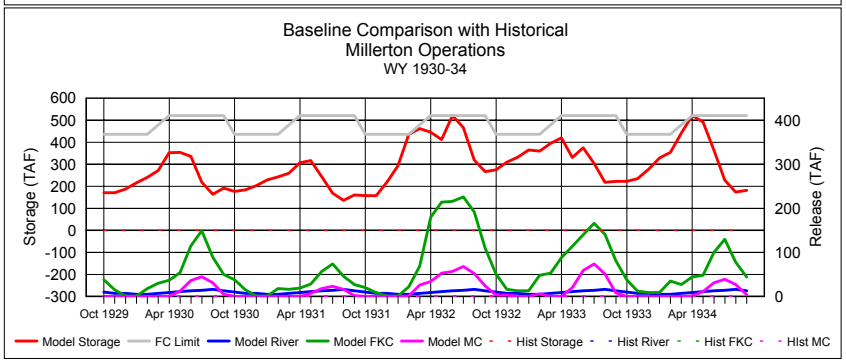
Figure Set 4


Baseline Comparison with Historical
Millerton Operations
WY 1922-26
Storage (TAF)
Release (TAF)
Oct 1921 Apr 1922 Oct 1922 Apr 1923 Oct 1923 Apr 1924 Oct 1924 Apr 1925 Oct 1925 Apr 1926
Model Storage FC Limit Model River Model FKC Model MC Hist Storage Hist River Hist FKC HIst MC


Baseline Comparison with Historical
Millerton Operations
WY 1935-39
Storage (TAF)
Release (TAF)
Oct 1934 Apr 1935 Oct 1935 Apr 1936 Oct 1936 Apr 1937 Oct 1937 Apr 1938 Oct 1938 Apr 1939
Model Storage FC Limit Model River Model FKC Model MC Hist Storage Hist River Hist FKC HIst MC


Baseline Comparison with Historical
Millerton Operations
WY 1925-29
Storage (TAF)
Release (TAF)
Oct 1924 Apr 1925 Oct 1925 Apr 1926 Oct 1926 Apr 1927 Oct 1927 Apr 1928 Oct 1928 Apr 1929
Model Storage FC Limit Model River Model FKC Model MC Hist Storage Hist River Hist FKC HIst MC


Baseline Comparison with Historical
Millerton Operations
WY 1940-44
Storage (TAF)
Release (TAF)
Oct 1939 Apr 1940 Oct 1940 Apr 1941 Oct 1941 Apr 1942 Oct 1942 Apr 1943 Oct 1943 Apr 1944
Model Storage FC Limit Model River Model FKC Model MC Hist Storage Hist River Hist FKC HIst MC


Baseline Comparison with Historical
Millerton Operations
WY 1930-34
Storage (TAF)
Release (TAF)
Oct 1929 Apr 1930 Oct 1930 Apr 1931 Oct 1931 Apr 1932 Oct 1932 Apr 1933 Oct 1933 Apr 1934
Model Storage FC Limit Model River Model FKC Model MC Hist Storage Hist River Hist FKC HIst MC

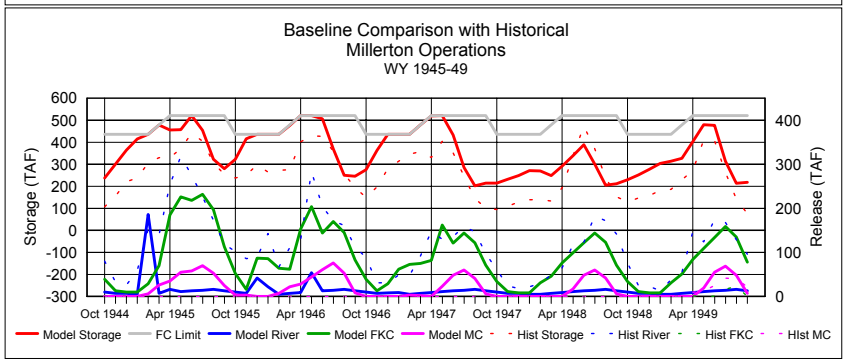
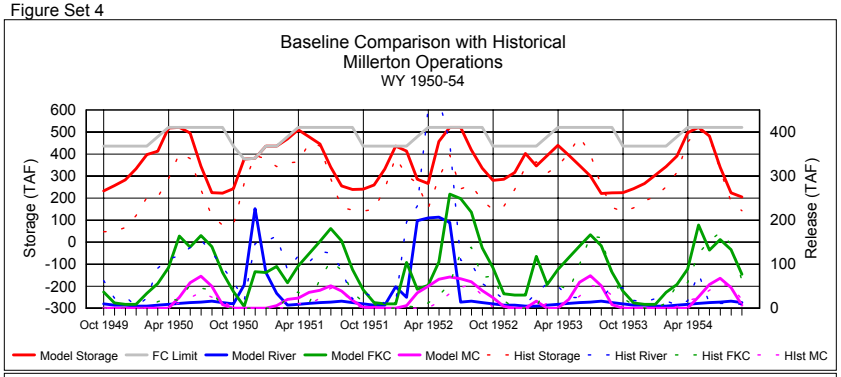
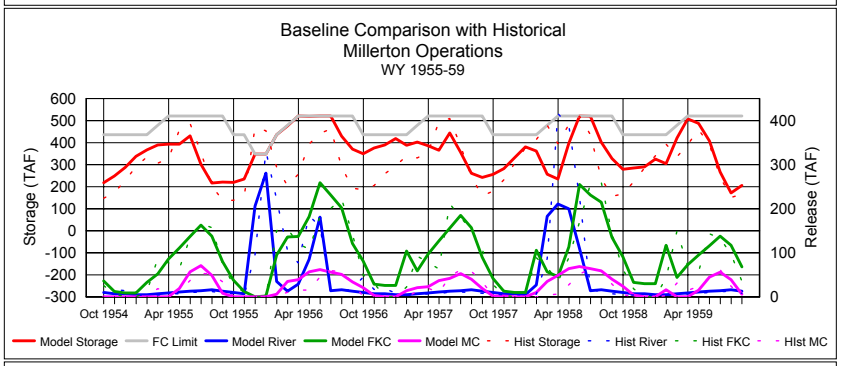
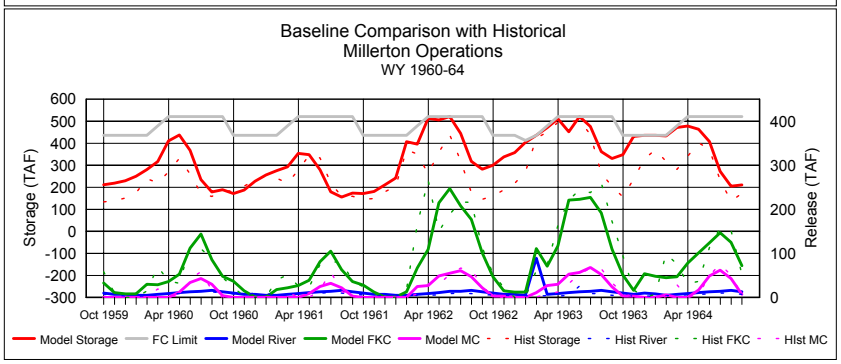
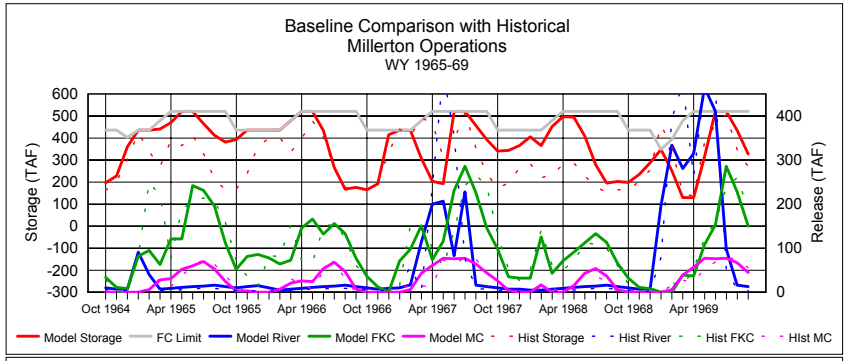

Baseline Comparison with Historical
Millerton Operations
WY 1945-49
Storage (TAF)
Release (TAF)
Oct 1944 Apr 1945 Oct 1945 Apr 1946 Oct 1946 Apr 1947 Oct 1947 Apr 1948 Oct 1948 Apr 1949
Model Storage FC Limit Model River Model FKC Model MC Hist Storage Hist River Hist FKC HIst MC

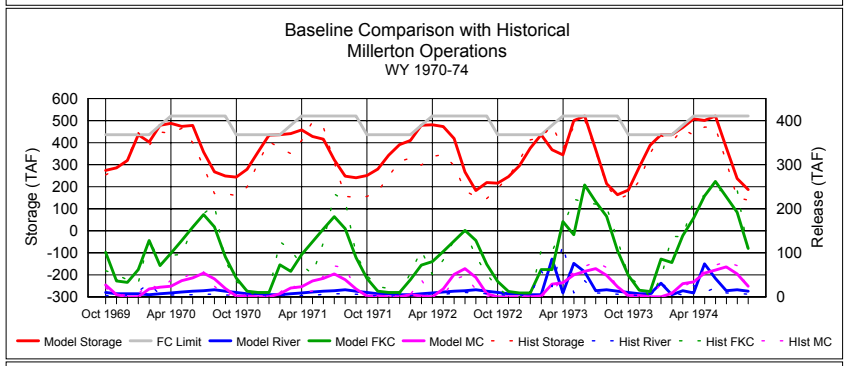
Figure Set 4


Baseline Comparison with Historical
Millerton Operations
WY 1950-54
Storage (TAF)
Release (TAF)
Oct 1949 Apr 1950 Oct 1950 Apr 1951 Oct 1951 Apr 1952 Oct 1952 Apr 1953 Oct 1953 Apr 1954
Model Storage FC Limit Model River Model FKC Model MC Hist Storage Hist River Hist FKC HIst MC


Baseline Comparison with Historical
Millerton Operations
WY 1955-59
Storage (TAF)
Release (TAF)
Oct 1954 Apr 1955 Oct 1955 Apr 1956 Oct 1956 Apr 1957 Oct 1957 Apr 1958 Oct 1958 Apr 1959
Model Storage FC Limit Model River Model FKC Model MC Hist Storage Hist River Hist FKC HIst MC


Baseline Comparison with Historical
Millerton Operations
WY 1960-64
Storage (TAF)
Release (TAF)
Oct 1959 Apr 1960 Oct 1960 Apr 1961 Oct 1961 Apr 1962 Oct 1962 Apr 1963 Oct 1963 Apr 1964
Model Storage FC Limit Model River Model FKC Model MC Hist Storage Hist River Hist FKC HIst MC


Baseline Comparison with Historical
Millerton Operations
WY 1965-69
Storage (TAF)
Release (TAF)
Oct 1964 Apr 1965 Oct 1965 Apr 1966 Oct 1966 Apr 1967 Oct 1967 Apr 1968 Oct 1968 Apr 1969
Model Storage FC Limit Model River Model FKC Model MC Hist Storage Hist River Hist FKC HIst MC


Baseline Comparison with Historical
Millerton Operations
WY 1970-74
Storage (TAF)
Release (TAF)
Oct 1969 Apr 1970 Oct 1970 Apr 1971 Oct 1971 Apr 1972 Oct 1972 Apr 1973 Oct 1973 Apr 1974
Model Storage FC Limit Model River Model FKC Model MC Hist Storage Hist River Hist FKC HIst MC

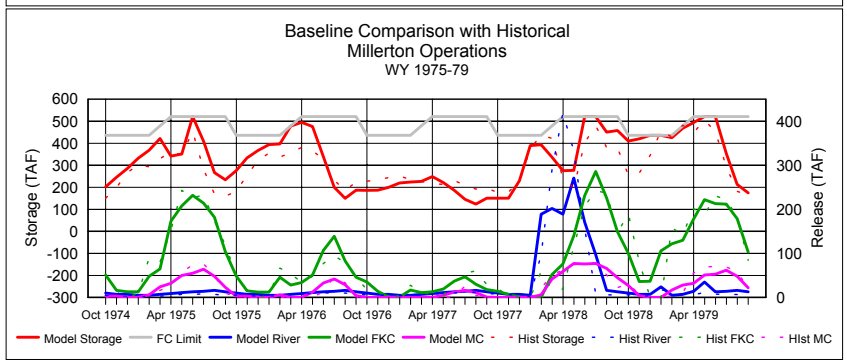
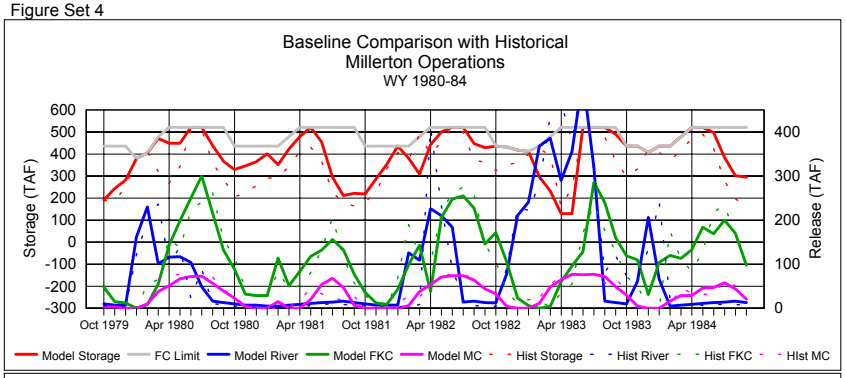
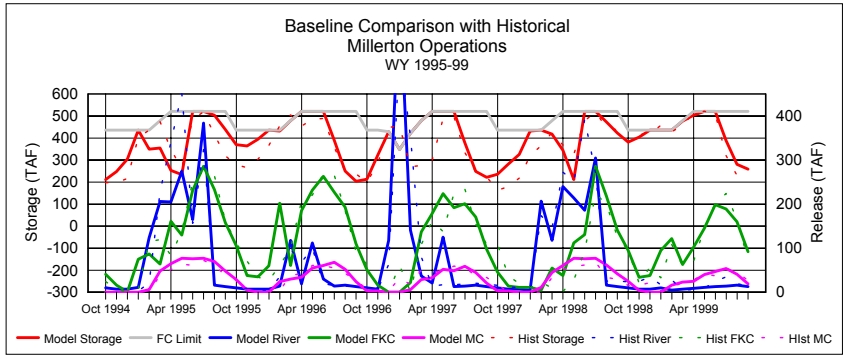
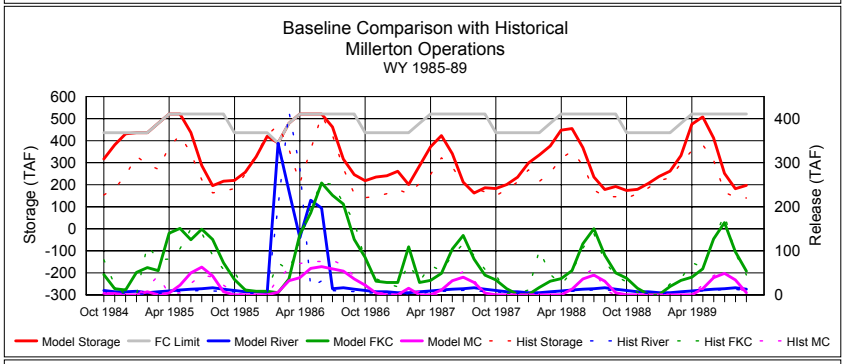

Baseline Comparison with Historical
Millerton Operations
WY 1975-79
Storage (TAF)
Release (TAF)
Oct 1974 Apr 1975 Oct 1975 Apr 1976 Oct 1976 Apr 1977 Oct 1977 Apr 1978 Oct 1978 Apr 1979
Model Storage FC Limit Model River Model FKC Model MC Hist Storage Hist River Hist FKC HIst MC

Figure Set 4


Baseline Comparison with Historical
Millerton Operations
WY 1980-84
Storage (TAF)
Release (TAF)
600
500
400
300
200
100
0
-100
-200
-300
400
300
200
100
0
Oct 1979
Apr 1980
Oct 1980
Apr 1981
Oct 1981
Apr 1982
Oct 1982
Apr 1983
Oct 1983
Apr 1984
Model Storage
FC Limit
Model River
Model FKC
Model MC
Hist Storage
Hist River
Hist FKC
HIst MC


Baseline Comparison with Historical
Millerton Operations
WY 1995-99
Storage (TAF)
Release (TAF)
600
500
400
300
200
100
0
-100
-200
-300
400
300
200
100
0
Oct 1994
Apr 1995
Oct 1995
Apr 1996
Oct 1996
Apr 1997
Oct 1997
Apr 1998
Oct 1998
Apr 1999
Model Storage
FC Limit
Model River
Model FKC
Model MC
Hist Storage
Hist River
Hist FKC
HIst MC


Baseline Comparison with Historical
Millerton Operations
WY 1985-89
Storage (TAF)
Release (TAF)
600
500
400
300
200
100
0
-100
-200
-300
400
300
200
100
0
Oct 1984
Apr 1985
Oct 1985
Apr 1986
Oct 1986
Apr 1987
Oct 1987
Apr 1988
Oct 1988
Apr 1989
Model Storage
FC Limit
Model River
Model FKC
Model MC
Hist Storage
Hist River
Hist FKC
HIst MC

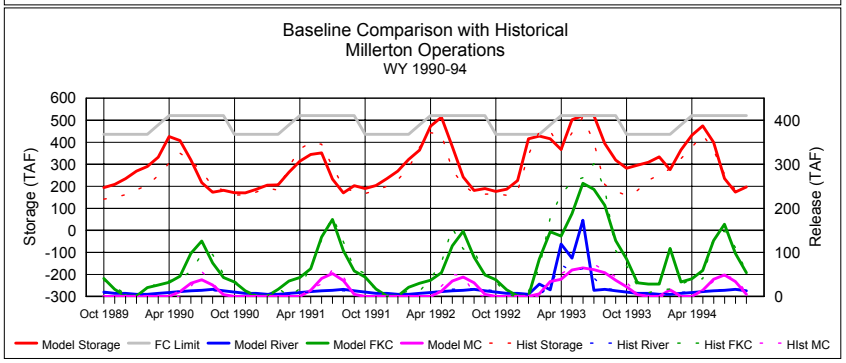
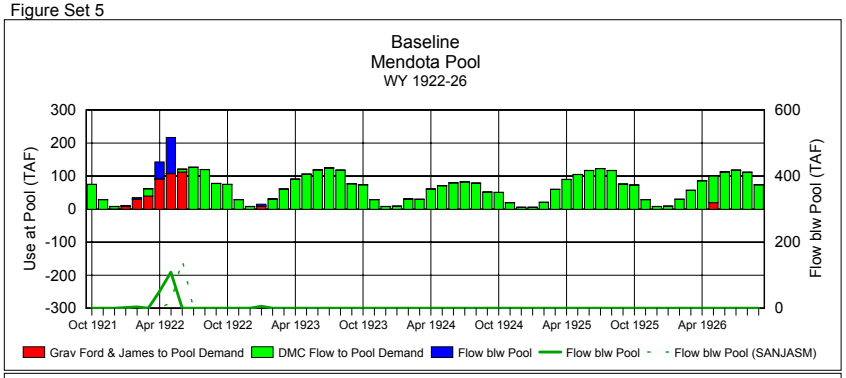
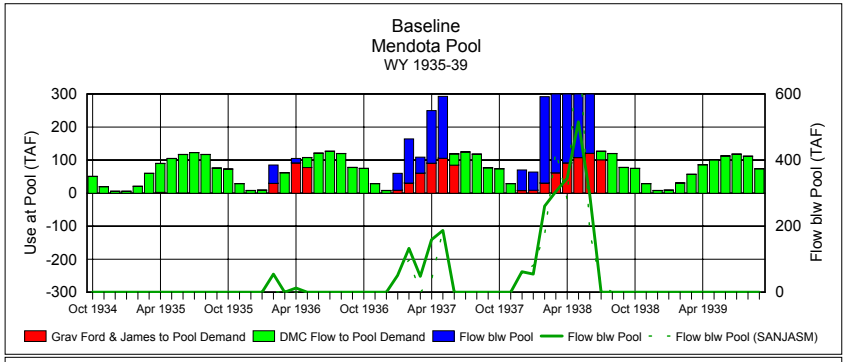
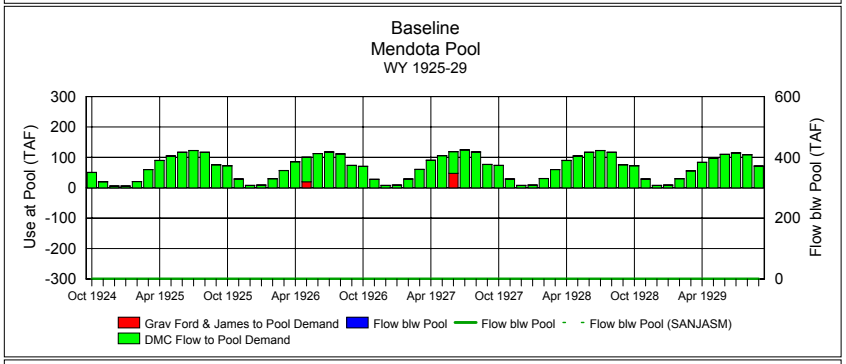
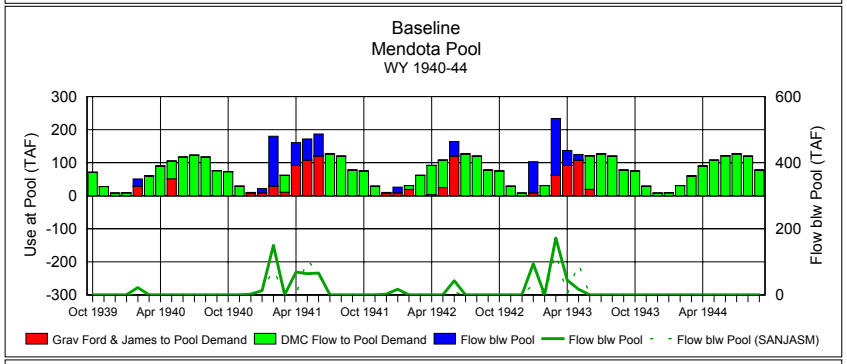

Baseline Comparison with Historical
Millerton Operations
WY 1990-94
Storage (TAF)
Release (TAF)
600
500
400
300
200
100
0
-100
-200
-300
400
300
200
100
0
Oct 1989
Apr 1990
Oct 1990
Apr 1991
Oct 1991
Apr 1992
Oct 1992
Apr 1993
Oct 1993
Apr 1994
Model Storage
FC Limit
Model River
Model FKC
Model MC
Hist Storage
Hist River
Hist FKC
HIst MC

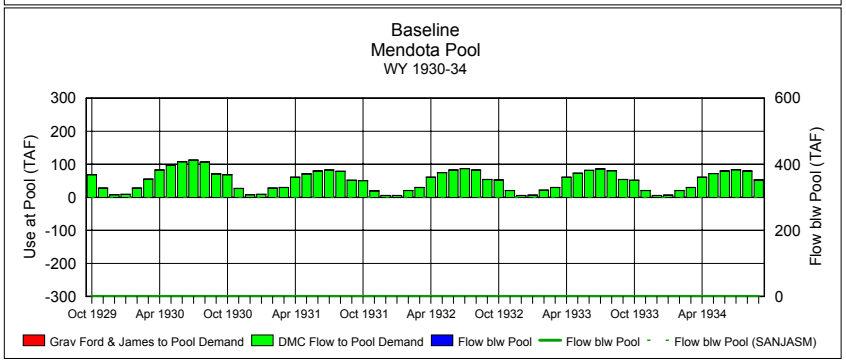
Figure Set 5


Baseline
Mendota Pool
WY 1922-26
Use at Pool (TAF)
Flow blw Pool (TAF)
Oct 1921
Apr 1922
Oct 1922
Apr 1923
Oct 1923
Apr 1924
Oct 1924
Apr 1925
Oct 1925
Apr 1926
Grav Ford & James to Pool Demand
DMC Flow to Pool Demand
Flow blw Pool
Flow blw Pool
Flow blw Pool (SANJASM)


Baseline
Mendota Pool
WY 1935-39
Use at Pool (TAF)
Flow blw Pool (TAF)
Oct 1934
Apr 1935
Oct 1935
Apr 1936
Oct 1936
Apr 1937
Oct 1937
Apr 1938
Oct 1938
Apr 1939
Grav Ford & James to Pool Demand
DMC Flow to Pool Demand
Flow blw Pool
Flow blw Pool
Flow blw Pool (SANJASM)


Baseline
Mendota Pool
WY 1925-29
Use at Pool (TAF)
Flow blw Pool (TAF)
Oct 1924
Apr 1925
Oct 1925
Apr 1926
Oct 1926
Apr 1927
Oct 1927
Apr 1928
Oct 1928
Apr 1929
Grav Ford & James to Pool Demand
Flow blw Pool
Flow blw Pool
Flow blw Pool (SANJASM)
DMC Flow to Pool Demand


Baseline
Mendota Pool
WY 1940-44
Use at Pool (TAF)
Flow blw Pool (TAF)
Oct 1939
Apr 1940
Oct 1940
Apr 1941
Oct 1941
Apr 1942
Oct 1942
Apr 1943
Oct 1943
Apr 1944
Grav Ford & James to Pool Demand
DMC Flow to Pool Demand
Flow blw Pool
Flow blw Pool
Flow blw Pool (SANJASM)


Baseline
Mendota Pool
WY 1930-34
Use at Pool (TAF)
Flow blw Pool (TAF)
Oct 1929
Apr 1930
Oct 1930
Apr 1931
Oct 1931
Apr 1932
Oct 1932
Apr 1933
Oct 1933
Apr 1934
Grav Ford & James to Pool Demand
DMC Flow to Pool Demand
Flow blw Pool
Flow blw Pool
Flow blw Pool (SANJASM)

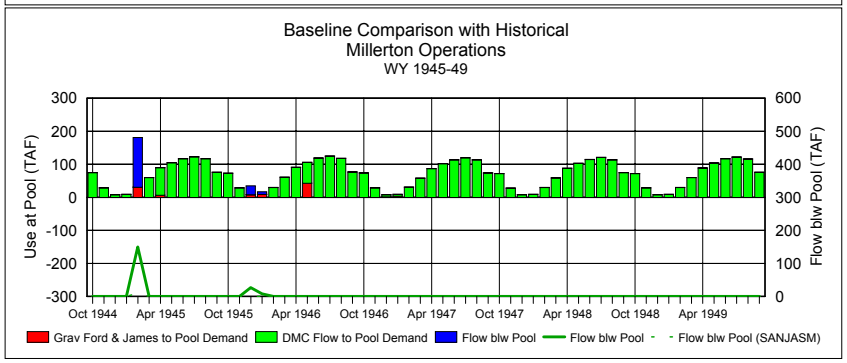
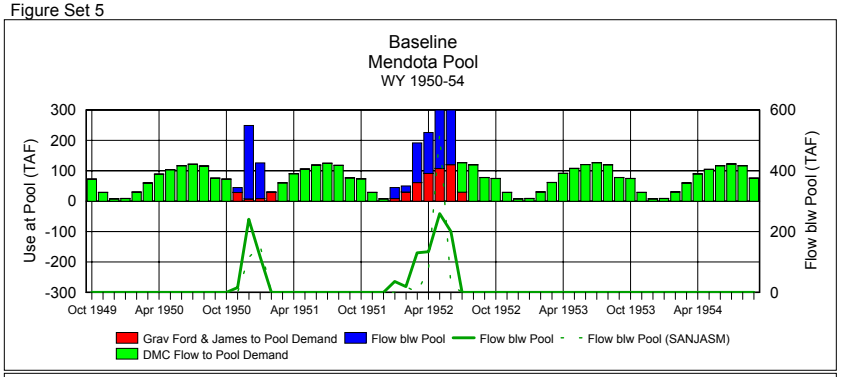
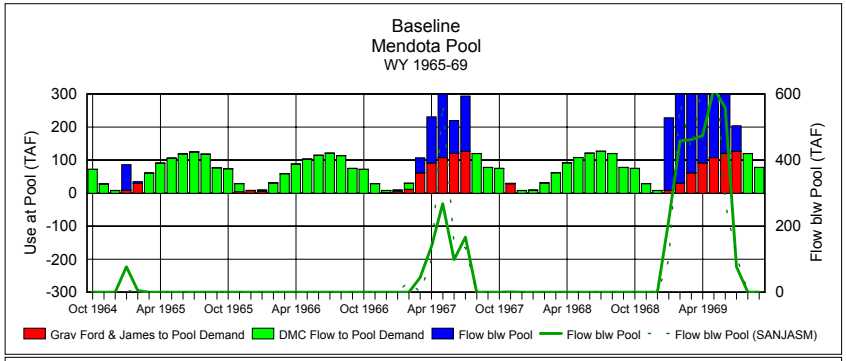
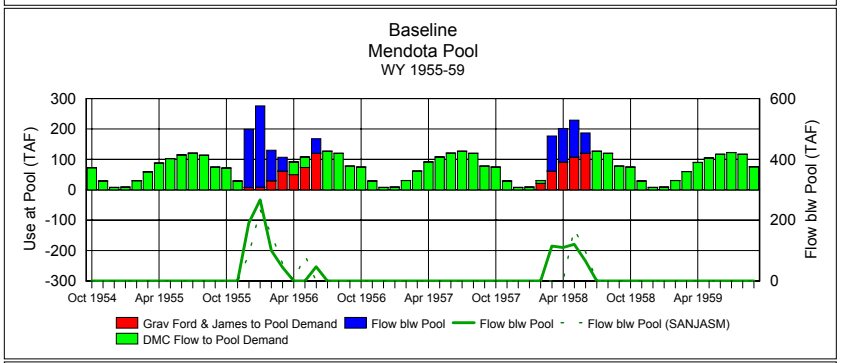
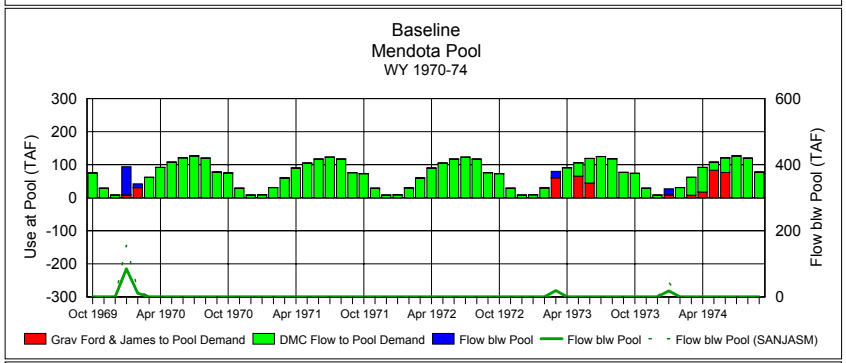

Baseline Comparison with Historical
Millerton Operations
WY 1945-49
Use at Pool (TAF)
Flow blw Pool (TAF)
Oct 1944
Apr 1945
Oct 1945
Apr 1946
Oct 1946
Apr 1947
Oct 1947
Apr 1948
Oct 1948
Apr 1949
Grav Ford & James to Pool Demand
DMC Flow to Pool Demand
Flow blw Pool
Flow blw Pool
Flow blw Pool (SANJASM)

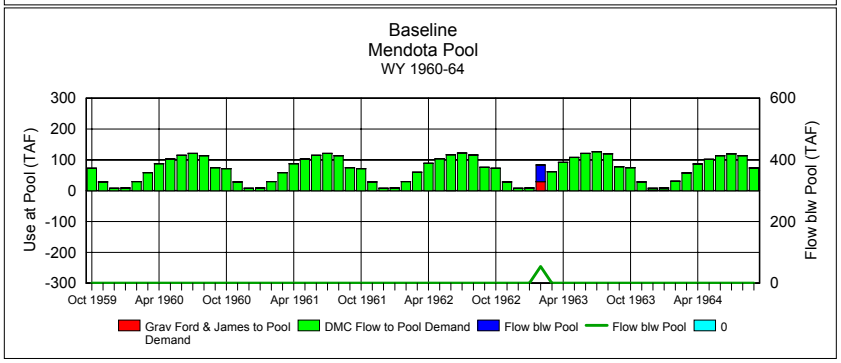
Figure Set 5


Baseline
Mendota Pool
WY 1950-54
Use at Pool (TAF)
Flow blw Pool (TAF)
Oct 1949 Apr 1950 Oct 1950 Apr 1951 Oct 1951 Apr 1952 Oct 1952 Apr 1953 Oct 1953 Apr 1954
Grav Ford & James to Pool Demand
Flow blw Pool
Flow blw Pool
Flow blw Pool (SANJASM)
DMC Flow to Pool Demand


Baseline
Mendota Pool
WY 1965-69
Use at Pool (TAF)
Flow blw Pool (TAF)
Oct 1964 Apr 1965 Oct 1965 Apr 1966 Oct 1966 Apr 1967 Oct 1967 Apr 1968 Oct 1968 Apr 1969
Grav Ford & James to Pool Demand
DMC Flow to Pool Demand
Flow blw Pool
Flow blw Pool
Flow blw Pool (SANJASM)


Baseline
Mendota Pool
WY 1955-59
Use at Pool (TAF)
Flow blw Pool (TAF)
Oct 1954 Apr 1955 Oct 1955 Apr 1956 Oct 1956 Apr 1957 Oct 1957 Apr 1958 Oct 1958 Apr 1959
Grav Ford & James to Pool Demand
Flow blw Pool
Flow blw Pool
Flow blw Pool (SANJASM)
DMC Flow to Pool Demand


Baseline
Mendota Pool
WY 1970-74
Use at Pool (TAF)
Flow blw Pool (TAF)
Oct 1969 Apr 1970 Oct 1970 Apr 1971 Oct 1971 Apr 1972 Oct 1972 Apr 1973 Oct 1973 Apr 1974
Grav Ford & James to Pool Demand
DMC Flow to Pool Demand
Flow blw Pool
Flow blw Pool
Flow blw Pool (SANJASM)


Baseline
Mendota Pool
WY 1960-64
Use at Pool (TAF)
Flow blw Pool (TAF)
Oct 1959 Apr 1960 Oct 1960 Apr 1961 Oct 1961 Apr 1962 Oct 1962 Apr 1963 Oct 1963 Apr 1964
Grav Ford & James to Pool Demand
DMC Flow to Pool Demand
Flow blw Pool
Flow blw Pool
0

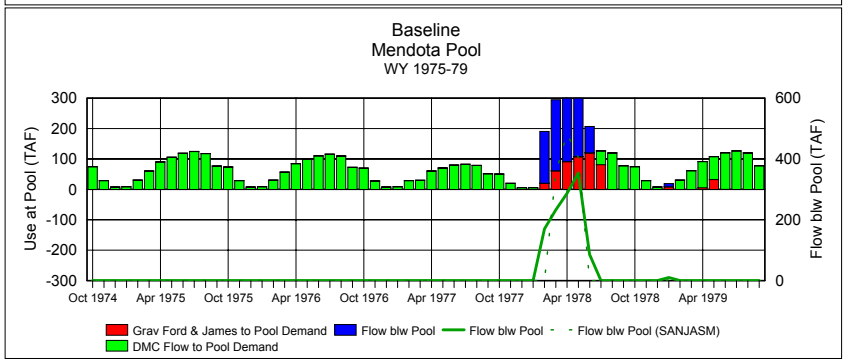
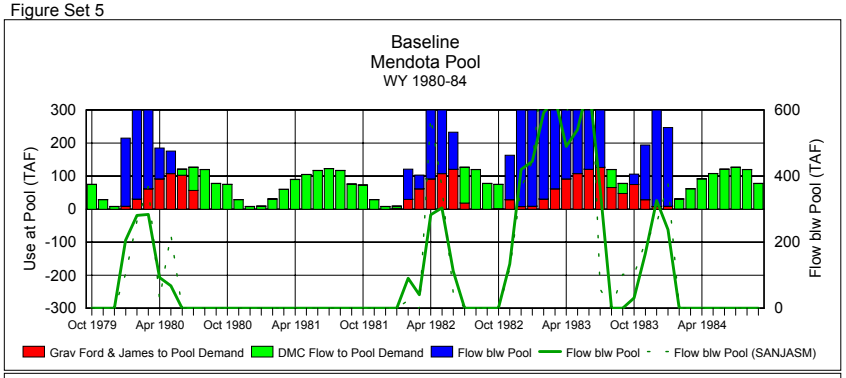
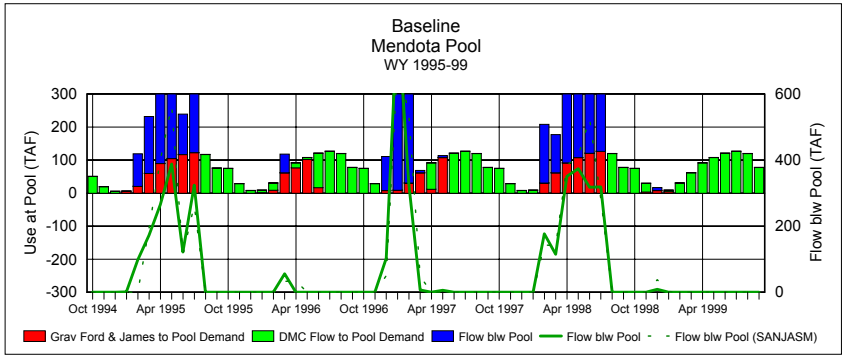
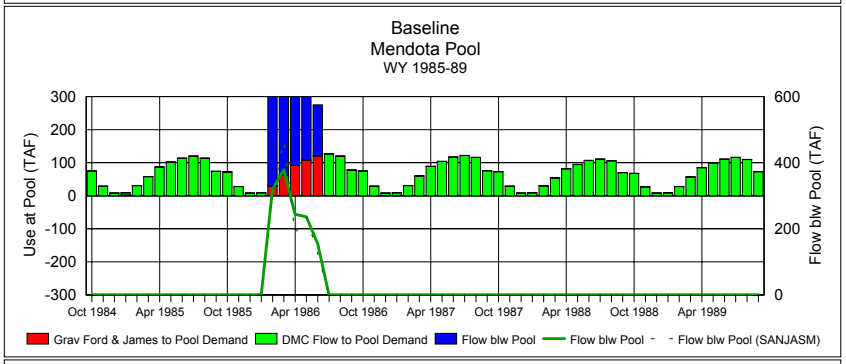

Baseline
Mendota Pool
WY 1975-79
Use at Pool (TAF)
Flow blw Pool (TAF)
Oct 1974 Apr 1975 Oct 1975 Apr 1976 Oct 1976 Apr 1977 Oct 1977 Apr 1978 Oct 1978 Apr 1979
Grav Ford & James to Pool Demand
Flow blw Pool
Flow blw Pool
Flow blw Pool (SANJASM)
DMC Flow to Pool Demand

Figure Set 5


Baseline
Mendota Pool
WY 1980-84
Use at Pool (TAF)
Flow blw Pool (TAF)
300
200
100
0
-100
-200
-300
600
400
200
0
Oct 1979
Apr 1980
Oct 1980
Apr 1981
Oct 1981
Apr 1982
Oct 1982
Apr 1983
Oct 1983
Apr 1984
Grav Ford & James to Pool Demand
DMC Flow to Pool Demand
Flow blw Pool
Flow blw Pool
Flow blw Pool (SANJASM)


Baseline
Mendota Pool
WY 1995-99
Use at Pool (TAF)
Flow blw Pool (TAF)
300
200
100
0
-100
-200
-300
600
400
200
0
Oct 1994
Apr 1995
Oct 1995
Apr 1996
Oct 1996
Apr 1997
Oct 1997
Apr 1998
Oct 1998
Apr 1999
Grav Ford & James to Pool Demand
DMC Flow to Pool Demand
Flow blw Pool
Flow blw Pool
Flow blw Pool (SANJASM)


Baseline
Mendota Pool
WY 1985-89
Use at Pool (TAF)
Flow blw Pool (TAF)
300
200
100
0
-100
-200
-300
600
400
200
0
Oct 1984
Apr 1985
Oct 1985
Apr 1986
Oct 1986
Apr 1987
Oct 1987
Apr 1988
Oct 1988
Apr 1989
Grav Ford & James to Pool Demand
DMC Flow to Pool Demand
Flow blw Pool
Flow blw Pool
Flow blw Pool (SANJASM)

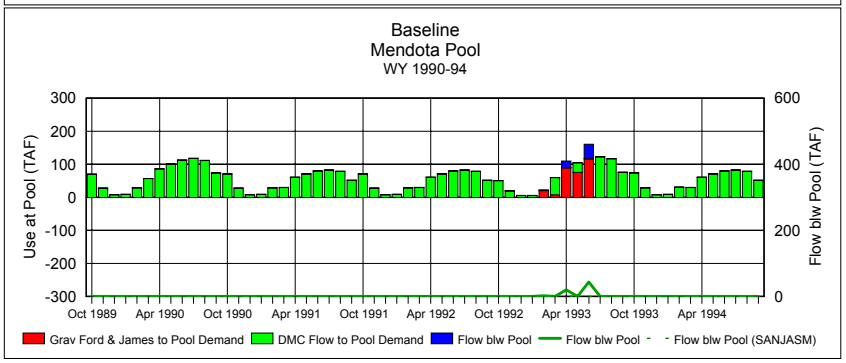
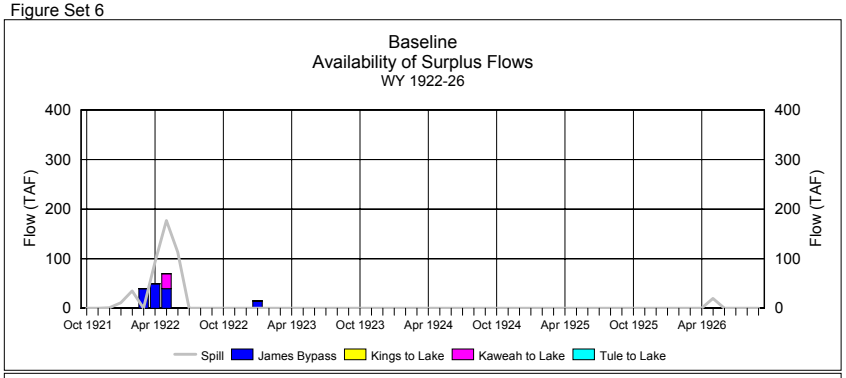
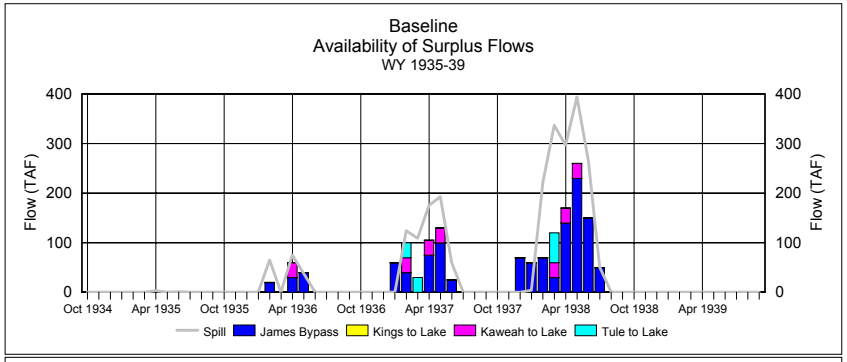
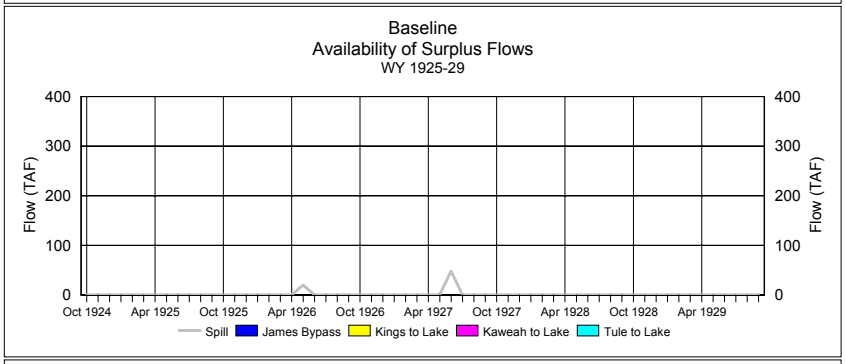
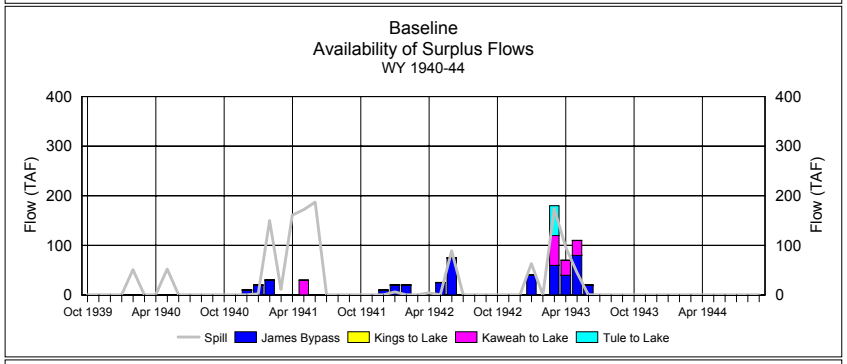

Baseline
Mendota Pool
WY 1990-94
Use at Pool (TAF)
Flow blw Pool (TAF)
300
200
100
0
-100
-200
-300
600
400
200
0
Oct 1989
Apr 1990
Oct 1990
Apr 1991
Oct 1991
Apr 1992
Oct 1992
Apr 1993
Oct 1993
Apr 1994
Grav Ford & James to Pool Demand
DMC Flow to Pool Demand
Flow blw Pool
Flow blw Pool
Flow blw Pool (SANJASM)

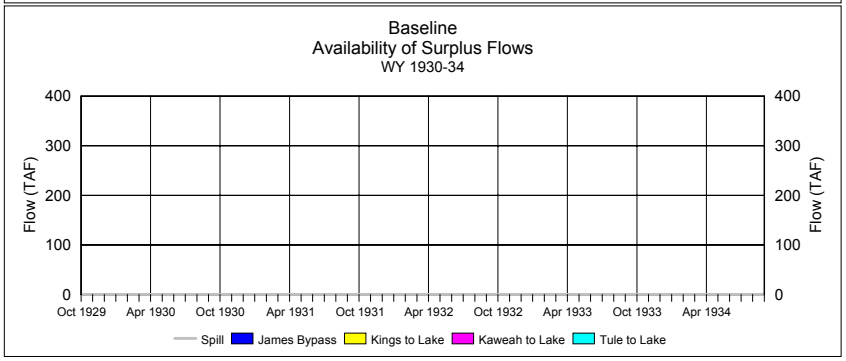
Figure Set 6


Baseline
Availability of Surplus Flows
WY 1922-26
Flow (TAF)
400
300
200
100
0
Oct 1921
Apr 1922
Oct 1922
Apr 1923
Oct 1923
Apr 1924
Oct 1924
Apr 1925
Oct 1925
Apr 1926
Spill
James Bypass
Kings to Lake
Kaweah to Lake
Tule to Lake


Baseline
Availability of Surplus Flows
WY 1935-39
Flow (TAF)
400
300
200
100
0
Oct 1934
Apr 1935
Oct 1935
Apr 1936
Oct 1936
Apr 1937
Oct 1937
Apr 1938
Oct 1938
Apr 1939
Spill
James Bypass
Kings to Lake
Kaweah to Lake
Tule to Lake


Baseline
Availability of Surplus Flows
WY 1925-29
Flow (TAF)
400
300
200
100
0
Oct 1924
Apr 1925
Oct 1925
Apr 1926
Oct 1926
Apr 1927
Oct 1927
Apr 1928
Oct 1928
Apr 1929
Spill
James Bypass
Kings to Lake
Kaweah to Lake
Tule to Lake


Baseline
Availability of Surplus Flows
WY 1940-44
Flow (TAF)
400
300
200
100
0
Oct 1939
Apr 1940
Oct 1940
Apr 1941
Oct 1941
Apr 1942
Oct 1942
Apr 1943
Oct 1943
Apr 1944
Spill
James Bypass
Kings to Lake
Kaweah to Lake
Tule to Lake


Baseline
Availability of Surplus Flows
WY 1930-34
Flow (TAF)
400
300
200
100
0
Oct 1929
Apr 1930
Oct 1930
Apr 1931
Oct 1931
Apr 1932
Oct 1932
Apr 1933
Oct 1933
Apr 1934
Spill
James Bypass
Kings to Lake
Kaweah to Lake
Tule to Lake

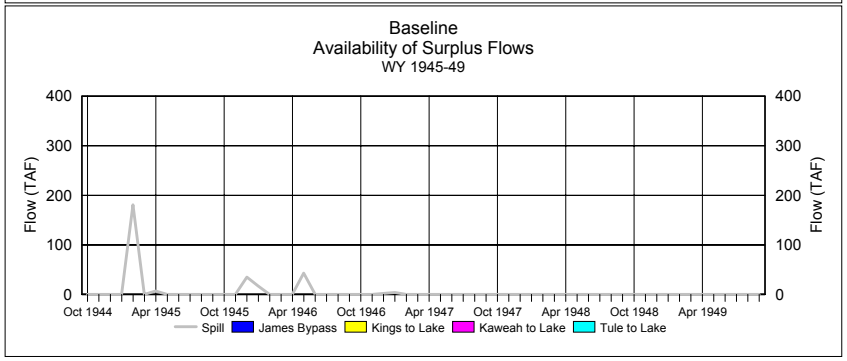
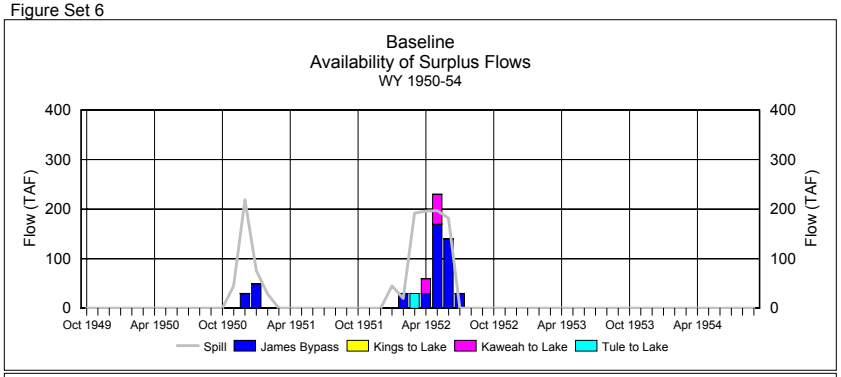
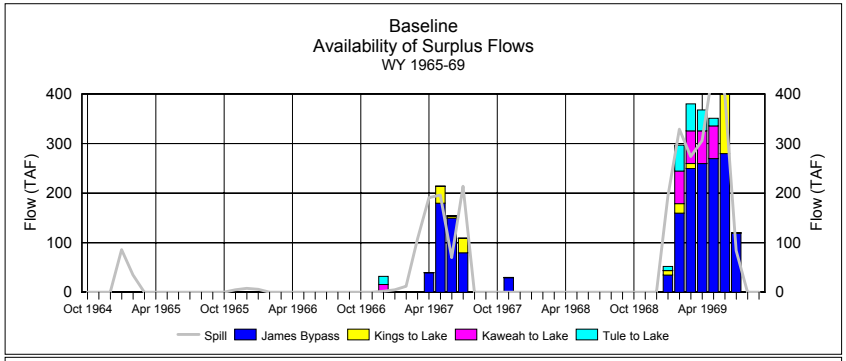
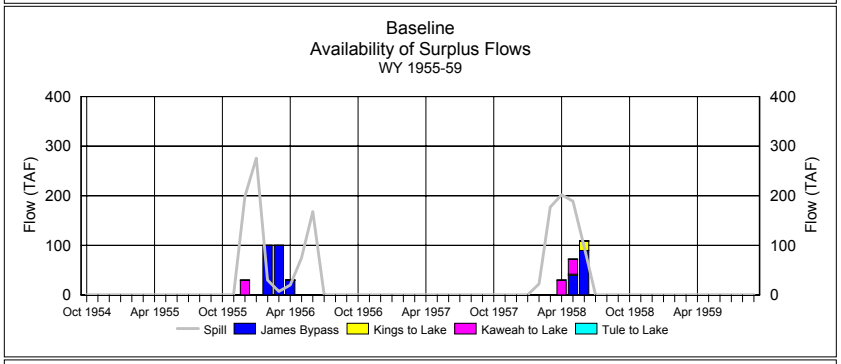
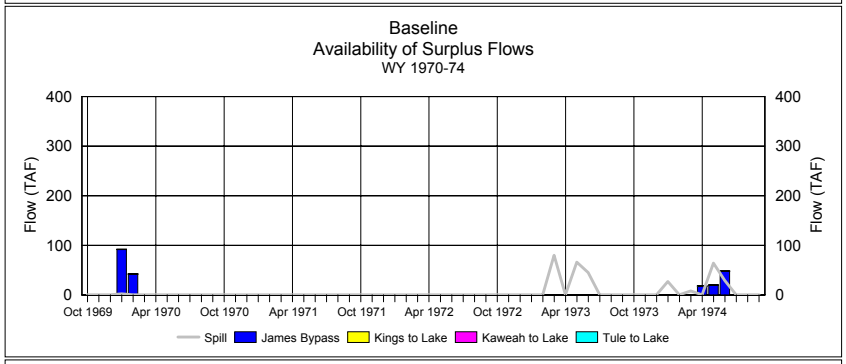

Baseline
Availability of Surplus Flows
WY 1945-49
Flow (TAF)
400
300
200
100
0
Oct 1944
Apr 1945
Oct 1945
Apr 1946
Oct 1946
Apr 1947
Oct 1947
Apr 1948
Oct 1948
Apr 1949
Spill
James Bypass
Kings to Lake
Kaweah to Lake
Tule to Lake

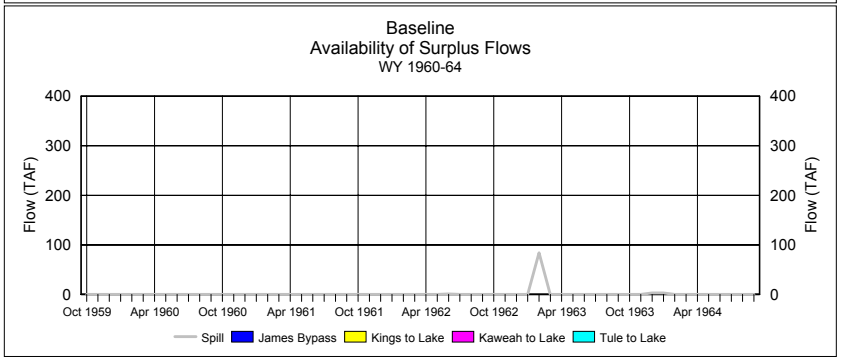
Figure Set 6


Baseline
Availability of Surplus Flows
WY 1950-54
Flow (TAF)
400
300
200
100
0
Oct 1949
Apr 1950
Oct 1950
Apr 1951
Oct 1951
Apr 1952
Oct 1952
Apr 1953
Oct 1953
Apr 1954
Spill
James Bypass
Kings to Lake
Kaweah to Lake
Tule to Lake


Baseline
Availability of Surplus Flows
WY 1965-69
Flow (TAF)
400
300
200
100
0
Oct 1964
Apr 1965
Oct 1965
Apr 1966
Oct 1966
Apr 1967
Oct 1967
Apr 1968
Oct 1968
Apr 1969
Spill
James Bypass
Kings to Lake
Kaweah to Lake
Tule to Lake


Baseline
Availability of Surplus Flows
WY 1955-59
Flow (TAF)
400
300
200
100
0
Oct 1954
Apr 1955
Oct 1955
Apr 1956
Oct 1956
Apr 1957
Oct 1957
Apr 1958
Oct 1958
Apr 1959
Spill
James Bypass
Kings to Lake
Kaweah to Lake
Tule to Lake


Baseline
Availability of Surplus Flows
WY 1970-74
Flow (TAF)
400
300
200
100
0
Oct 1969
Apr 1970
Oct 1970
Apr 1971
Oct 1971
Apr 1972
Oct 1972
Apr 1973
Oct 1973
Apr 1974
Spill
James Bypass
Kings to Lake
Kaweah to Lake
Tule to Lake


Baseline
Availability of Surplus Flows
WY 1960-64
Flow (TAF)
400
300
200
100
0
Oct 1959
Apr 1960
Oct 1960
Apr 1961
Oct 1961
Apr 1962
Oct 1962
Apr 1963
Oct 1963
Apr 1964
Spill
James Bypass
Kings to Lake
Kaweah to Lake
Tule to Lake

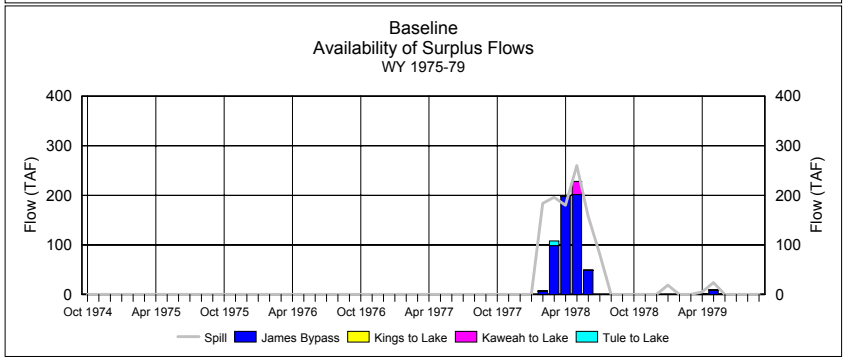
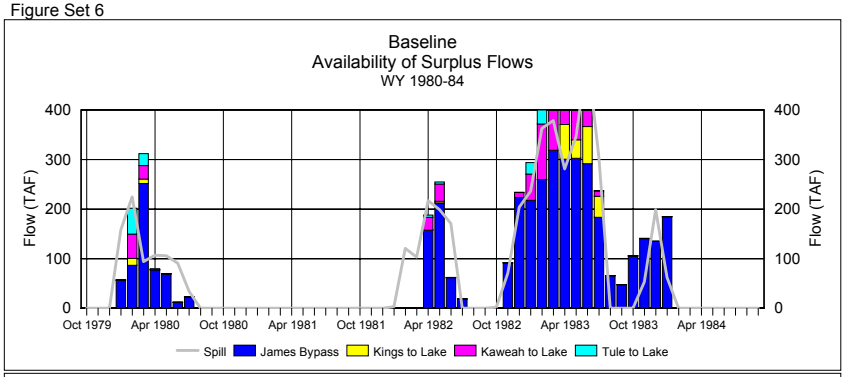
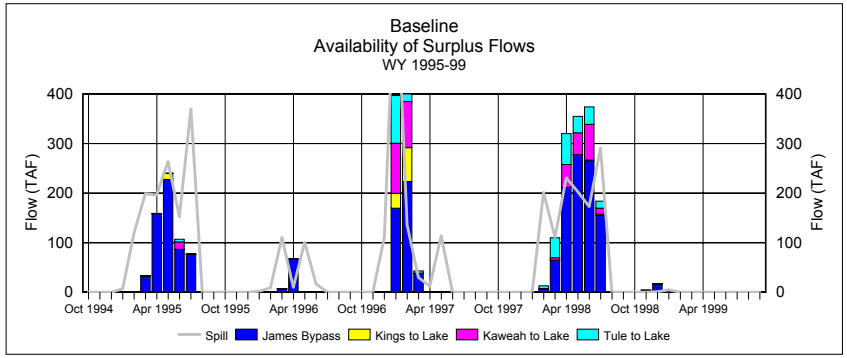
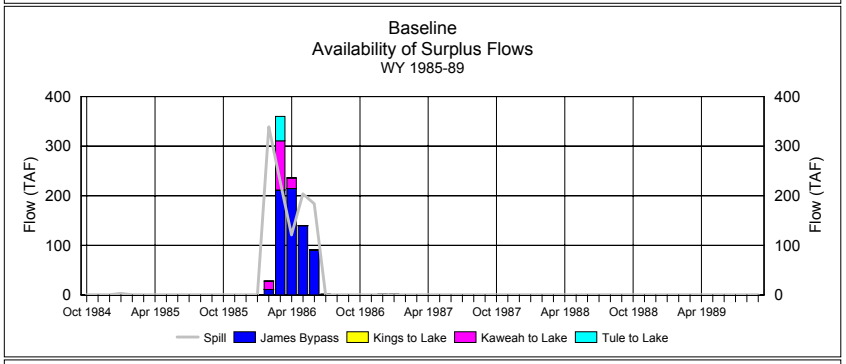

Baseline
Availability of Surplus Flows
WY 1975-79
Flow (TAF)
400
300
200
100
0
Oct 1974
Apr 1975
Oct 1975
Apr 1976
Oct 1976
Apr 1977
Oct 1977
Apr 1978
Oct 1978
Apr 1979
Spill
James Bypass
Kings to Lake
Kaweah to Lake
Tule to Lake

Figure Set 6


Baseline
Availability of Surplus Flows
WY 1980-84
Flow (TAF)
400
300
200
100
0
Oct 1979
Apr 1980
Oct 1980
Apr 1981
Oct 1981
Apr 1982
Oct 1982
Apr 1983
Oct 1983
Apr 1984
Spill
James Bypass
Kings to Lake
Kaweah to Lake
Tule to Lake


Baseline
Availability of Surplus Flows
WY 1995-99
Flow (TAF)
400
300
200
100
0
Oct 1994
Apr 1995
Oct 1995
Apr 1996
Oct 1996
Apr 1997
Oct 1997
Apr 1998
Oct 1998
Apr 1999
Spill
James Bypass
Kings to Lake
Kaweah to Lake
Tule to Lake


Baseline
Availability of Surplus Flows
WY 1985-89
Flow (TAF)
400
300
200
100
0
Oct 1984
Apr 1985
Oct 1985
Apr 1986
Oct 1986
Apr 1987
Oct 1987
Apr 1988
Oct 1988
Apr 1989
Spill
James Bypass
Kings to Lake
Kaweah to Lake
Tule to Lake

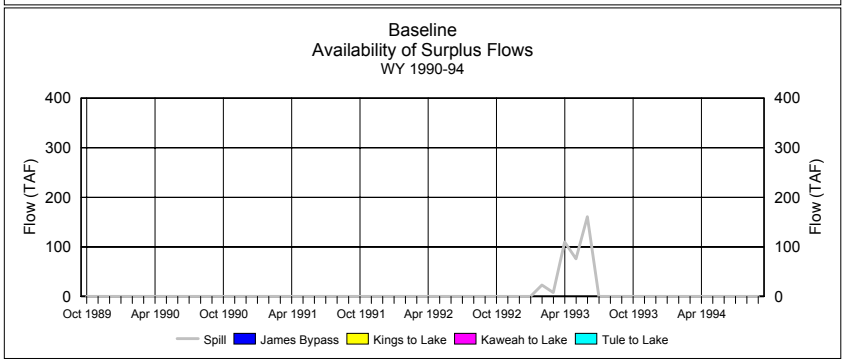
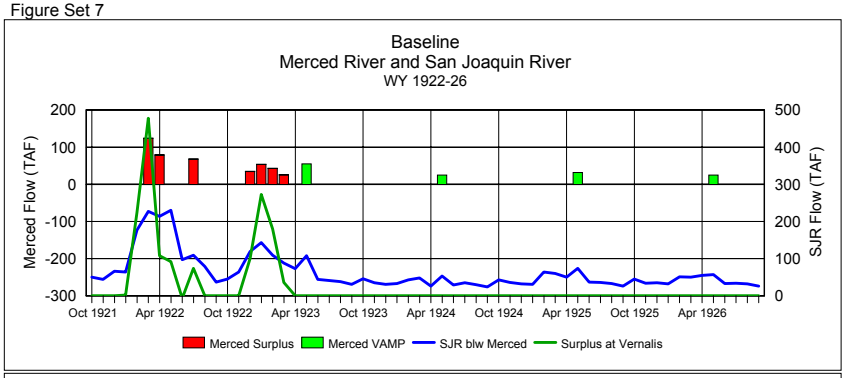
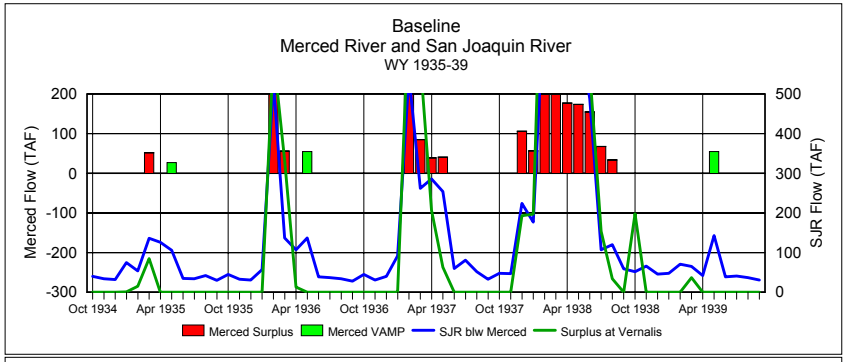
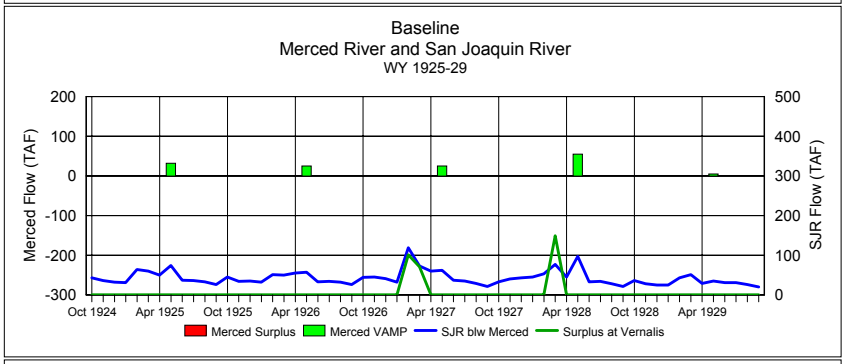
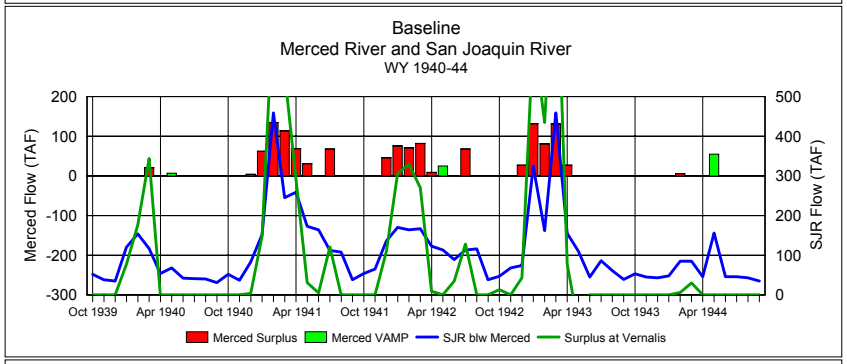

Baseline
Availability of Surplus Flows
WY 1990-94
Flow (TAF)
400
300
200
100
0
Oct 1989
Apr 1990
Oct 1990
Apr 1991
Oct 1991
Apr 1992
Oct 1992
Apr 1993
Oct 1993
Apr 1994
Spill
James Bypass
Kings to Lake
Kaweah to Lake
Tule to Lake

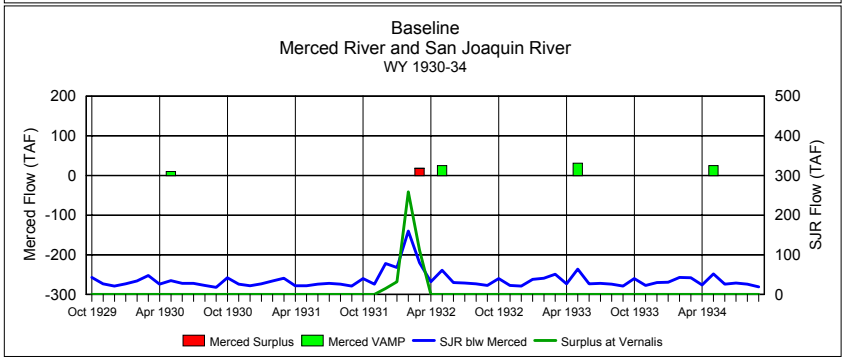
Figure Set 7


Baseline
Merced River and San Joaquin River
WY 1922-26
Merced Flow (TAF)
SJR Flow (TAF)
Oct 1921 Apr 1922 Oct 1922 Apr 1923 Oct 1923 Apr 1924 Oct 1924 Apr 1925 Oct 1925 Apr 1926
Merced Surplus
Merced VAMP
SJR blw Merced
Surplus at Vernalis


Baseline
Merced River and San Joaquin River
WY 1935-39
Merced Flow (TAF)
SJR Flow (TAF)
Oct 1934 Apr 1935 Oct 1935 Apr 1936 Oct 1936 Apr 1937 Oct 1937 Apr 1938 Oct 1938 Apr 1939
Merced Surplus
Merced VAMP
SJR blw Merced
Surplus at Vernalis


Baseline
Merced River and San Joaquin River
WY 1925-29
Merced Flow (TAF)
SJR Flow (TAF)
Oct 1924 Apr 1925 Oct 1925 Apr 1926 Oct 1926 Apr 1927 Oct 1927 Apr 1928 Oct 1928 Apr 1929
Merced Surplus
Merced VAMP
SJR blw Merced
Surplus at Vernalis


Baseline
Merced River and San Joaquin River
WY 1940-44
Merced Flow (TAF)
SJR Flow (TAF)
Oct 1939 Apr 1940 Oct 1940 Apr 1941 Oct 1941 Apr 1942 Oct 1942 Apr 1943 Oct 1943 Apr 1944
Merced Surplus
Merced VAMP
SJR blw Merced
Surplus at Vernalis


Baseline
Merced River and San Joaquin River
WY 1930-34
Merced Flow (TAF)
SJR Flow (TAF)
Oct 1929 Apr 1930 Oct 1930 Apr 1931 Oct 1931 Apr 1932 Oct 1932 Apr 1933 Oct 1933 Apr 1934
Merced Surplus
Merced VAMP
SJR blw Merced
Surplus at Vernalis

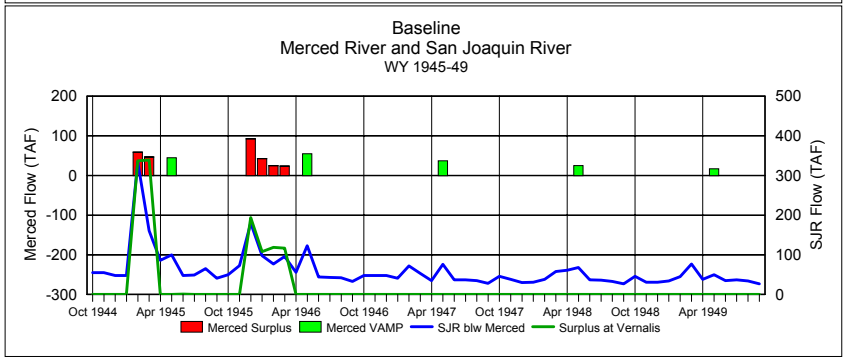
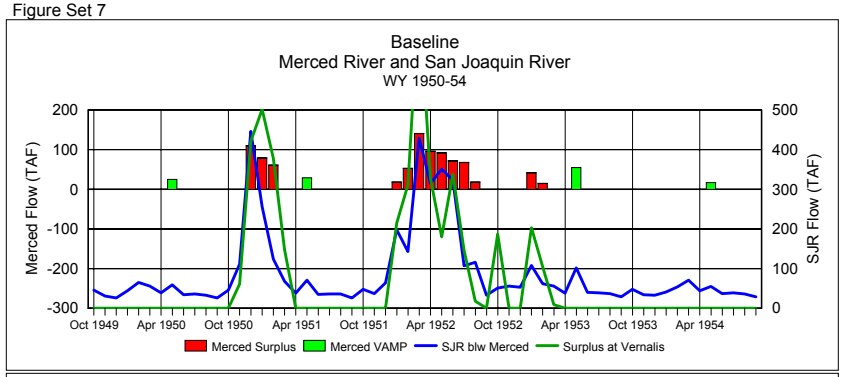
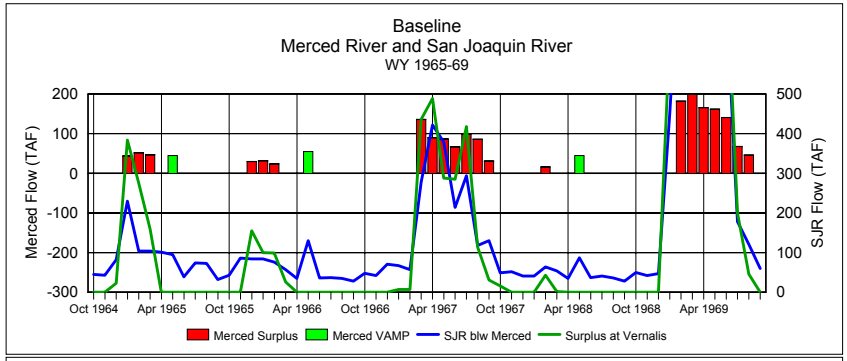
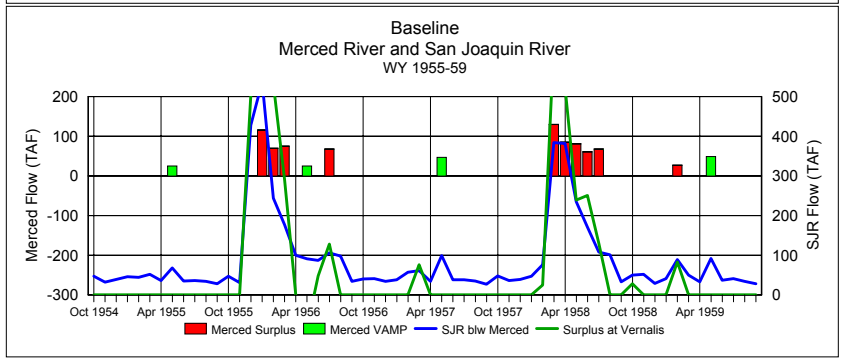
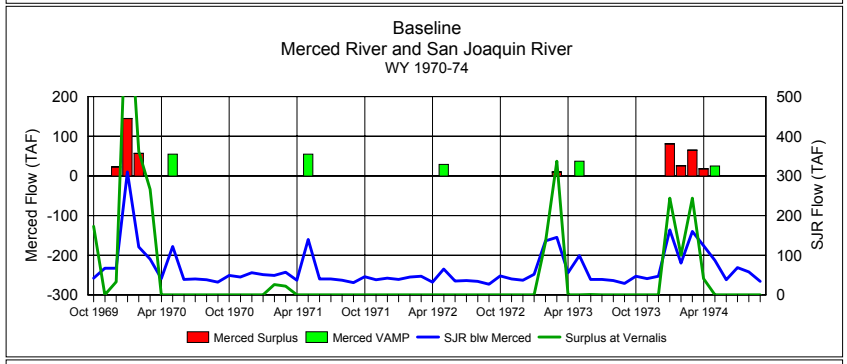

Baseline
Merced River and San Joaquin River
WY 1945-49
Merced Flow (TAF)
SJR Flow (TAF)
Oct 1944 Apr 1945 Oct 1945 Apr 1946 Oct 1946 Apr 1947 Oct 1947 Apr 1948 Oct 1948 Apr 1949
Merced Surplus
Merced VAMP
SJR blw Merced
Surplus at Vernalis

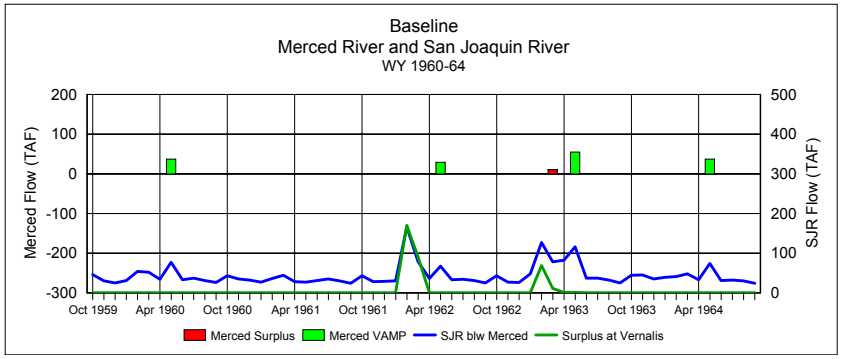
Figure Set 7


Baseline
Merced River and San Joaquin River
WY 1950-54
Merced Flow (TAF)
SJR Flow (TAF)
Oct 1949 Apr 1950 Oct 1950 Apr 1951 Oct 1951 Apr 1952 Oct 1952 Apr 1953 Oct 1953 Apr 1954
Merced Surplus
Merced VAMP
SJR blw Merced
Surplus at Vernalis


Baseline
Merced River and San Joaquin River
WY 1965-69
Merced Flow (TAF)
SJR Flow (TAF)
Oct 1964 Apr 1965 Oct 1965 Apr 1966 Oct 1966 Apr 1967 Oct 1967 Apr 1968 Oct 1968 Apr 1969
Merced Surplus
Merced VAMP
SJR blw Merced
Surplus at Vernalis


Baseline
Merced River and San Joaquin River
WY 1955-59
Merced Flow (TAF)
SJR Flow (TAF)
Oct 1954 Apr 1955 Oct 1955 Apr 1956 Oct 1956 Apr 1957 Oct 1957 Apr 1958 Oct 1958 Apr 1959
Merced Surplus
Merced VAMP
SJR blw Merced
Surplus at Vernalis


Baseline
Merced River and San Joaquin River
WY 1970-74
Merced Flow (TAF)
SJR Flow (TAF)
Oct 1969 Apr 1970 Oct 1970 Apr 1971 Oct 1971 Apr 1972 Oct 1972 Apr 1973 Oct 1973 Apr 1974
Merced Surplus
Merced VAMP
SJR blw Merced
Surplus at Vernalis


Baseline
Merced River and San Joaquin River
WY 1960-64
Merced Flow (TAF)
SJR Flow (TAF)
Oct 1959 Apr 1960 Oct 1960 Apr 1961 Oct 1961 Apr 1962 Oct 1962 Apr 1963 Oct 1963 Apr 1964
Merced Surplus
Merced VAMP
SJR blw Merced
Surplus at Vernalis

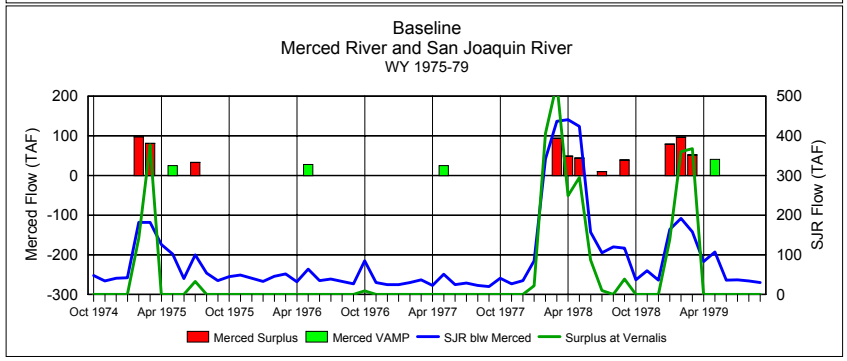
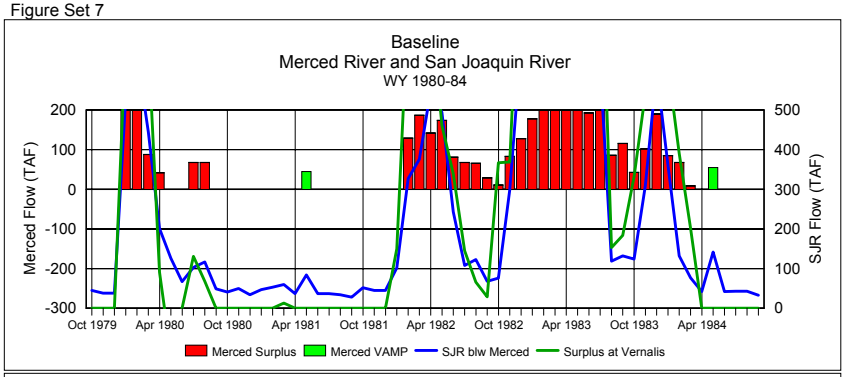
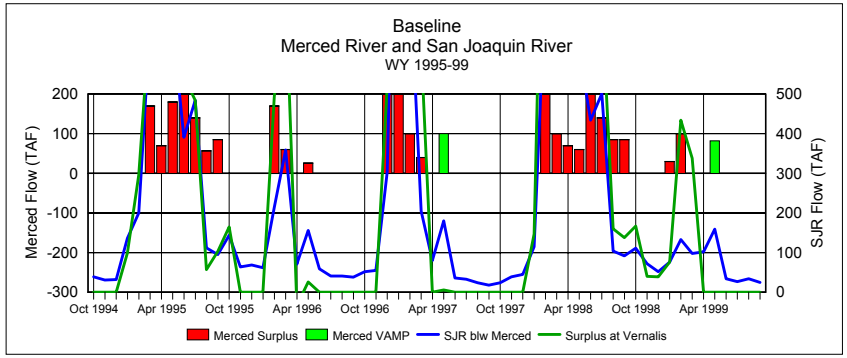
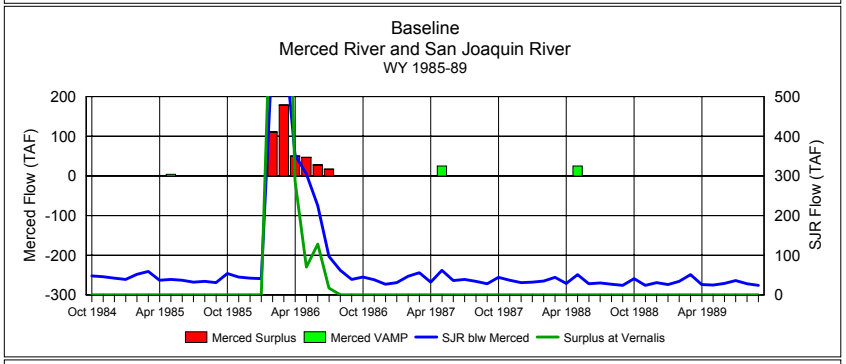

Baseline
Merced River and San Joaquin River
WY 1975-79
Merced Flow (TAF)
SJR Flow (TAF)
Oct 1974 Apr 1975 Oct 1975 Apr 1976 Oct 1976 Apr 1977 Oct 1977 Apr 1978 Oct 1978 Apr 1979
Merced Surplus
Merced VAMP
SJR blw Merced
Surplus at Vernalis

Figure Set 7


Baseline
Merced River and San Joaquin River
WY 1980-84
Merced Flow (TAF)
SJR Flow (TAF)
200
100
0
-100
-200
-300
500
400
300
200
100
0
Oct 1979
Apr 1980
Oct 1980
Apr 1981
Oct 1981
Apr 1982
Oct 1982
Apr 1983
Oct 1983
Apr 1984
Merced Surplus
Merced VAMP
SJR blw Merced
Surplus at Vernalis


Baseline
Merced River and San Joaquin River
WY 1995-99
Merced Flow (TAF)
SJR Flow (TAF)
200
100
0
-100
-200
-300
500
400
300
200
100
0
Oct 1994
Apr 1995
Oct 1995
Apr 1996
Oct 1996
Apr 1997
Oct 1997
Apr 1998
Oct 1998
Apr 1999
Merced Surplus
Merced VAMP
SJR blw Merced
Surplus at Vernalis


Baseline
Merced River and San Joaquin River
WY 1985-89
Merced Flow (TAF)
SJR Flow (TAF)
200
100
0
-100
-200
-300
500
400
300
200
100
0
Oct 1984
Apr 1985
Oct 1985
Apr 1986
Oct 1986
Apr 1987
Oct 1987
Apr 1988
Oct 1988
Apr 1989
Merced Surplus
Merced VAMP
SJR blw Merced
Surplus at Vernalis

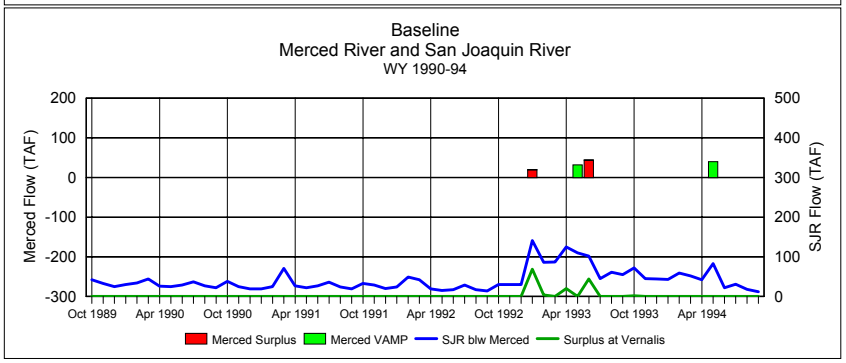
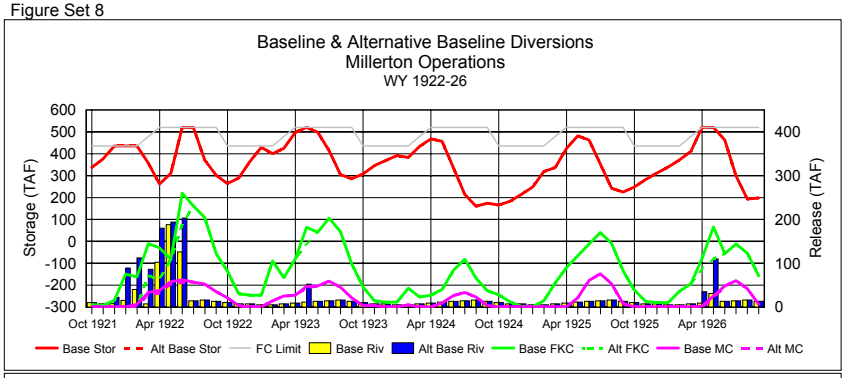
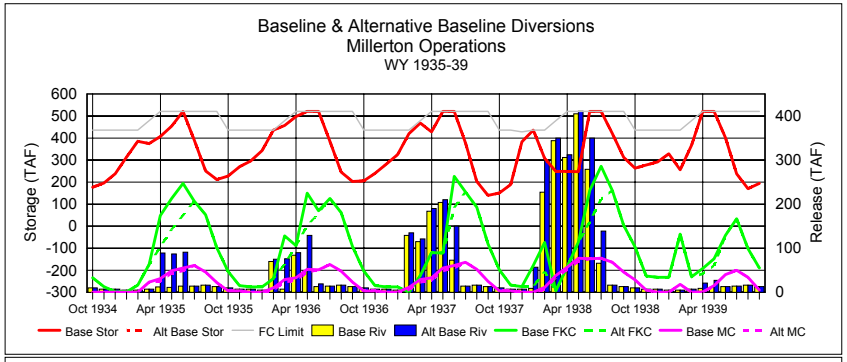
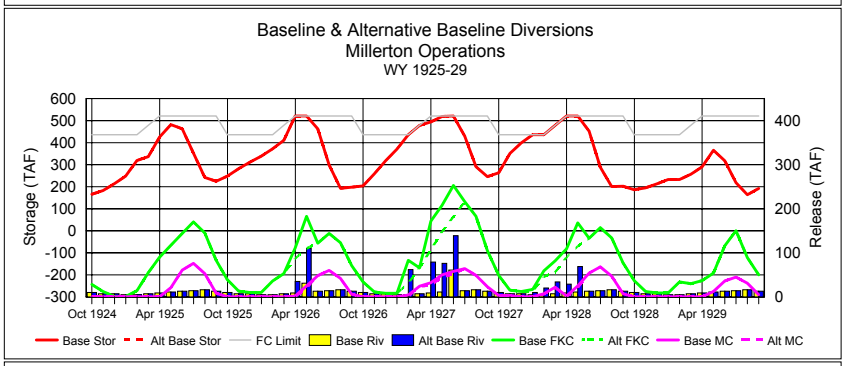
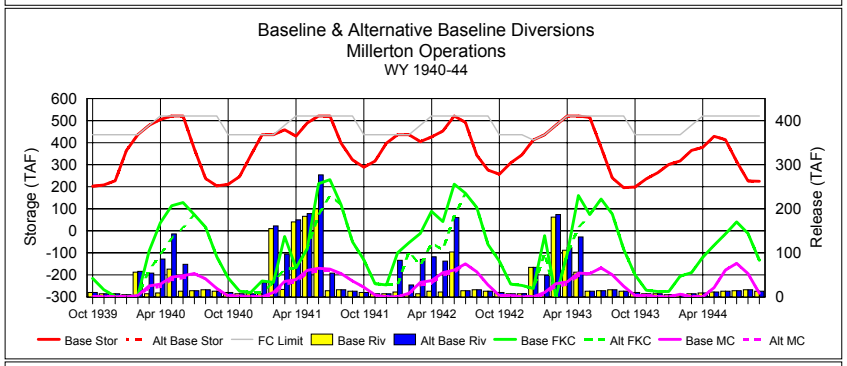

Baseline
Merced River and San Joaquin River
WY 1990-94
Merced Flow (TAF)
SJR Flow (TAF)
200
100
0
-100
-200
-300
500
400
300
200
100
0
Oct 1989
Apr 1990
Oct 1990
Apr 1991
Oct 1991
Apr 1992
Oct 1992
Apr 1993
Oct 1993
Apr 1994
Merced Surplus
Merced VAMP
SJR blw Merced
Surplus at Vernalis

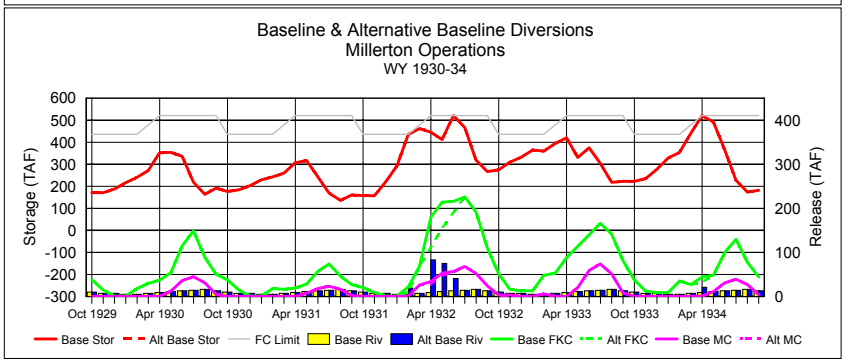
Figure Set 8


Baseline & Alternative Baseline Diversions
Millerton Operations
WY 1922-26
Storage (TAF)
Release (TAF)
Oct 1921
Apr 1922
Oct 1922
Apr 1923
Oct 1923
Apr 1924
Oct 1924
Apr 1925
Oct 1925
Apr 1926
Base Stor
Alt Base Stor
FC Limit
Base Riv
Alt Base Riv
Base FKC
Alt FKC
Base MC
Alt MC


Baseline & Alternative Baseline Diversions
Millerton Operations
WY 1935-39
Storage (TAF)
Release (TAF)
Oct 1934
Apr 1935
Oct 1935
Apr 1936
Oct 1936
Apr 1937
Oct 1937
Apr 1938
Oct 1938
Apr 1939
Base Stor
Alt Base Stor
FC Limit
Base Riv
Alt Base Riv
Base FKC
Alt FKC
Base MC
Alt MC


Baseline & Alternative Baseline Diversions
Millerton Operations
WY 1925-29
Storage (TAF)
Release (TAF)
Oct 1924
Apr 1925
Oct 1925
Apr 1926
Oct 1926
Apr 1927
Oct 1927
Apr 1928
Oct 1928
Apr 1929
Base Stor
Alt Base Stor
FC Limit
Base Riv
Alt Base Riv
Base FKC
Alt FKC
Base MC
Alt MC


Baseline & Alternative Baseline Diversions
Millerton Operations
WY 1940-44
Storage (TAF)
Release (TAF)
Oct 1939
Apr 1940
Oct 1940
Apr 1941
Oct 1941
Apr 1942
Oct 1942
Apr 1943
Oct 1943
Apr 1944
Base Stor
Alt Base Stor
FC Limit
Base Riv
Alt Base Riv
Base FKC
Alt FKC
Base MC
Alt MC


Baseline & Alternative Baseline Diversions
Millerton Operations
WY 1930-34
Storage (TAF)
Release (TAF)
Oct 1929
Apr 1930
Oct 1930
Apr 1931
Oct 1931
Apr 1932
Oct 1932
Apr 1933
Oct 1933
Apr 1934
Base Stor
Alt Base Stor
FC Limit
Base Riv
Alt Base Riv
Base FKC
Alt FKC
Base MC
Alt MC

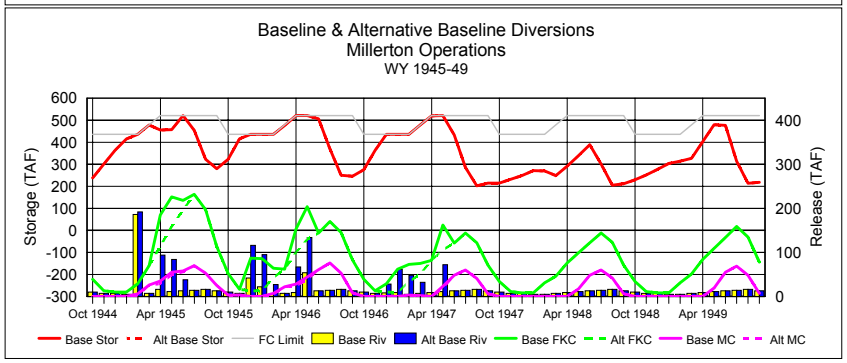
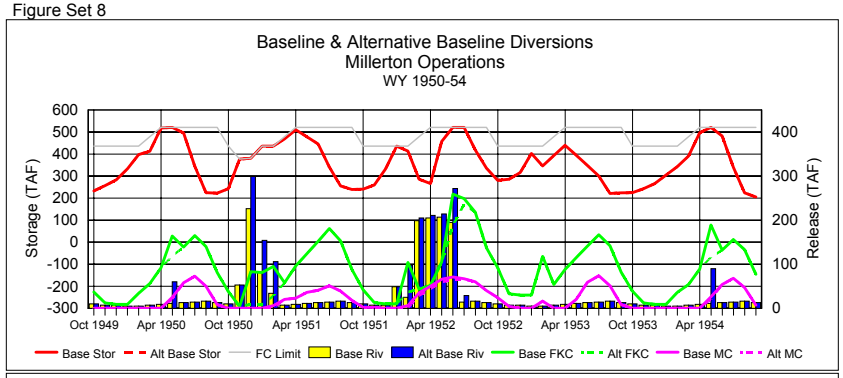
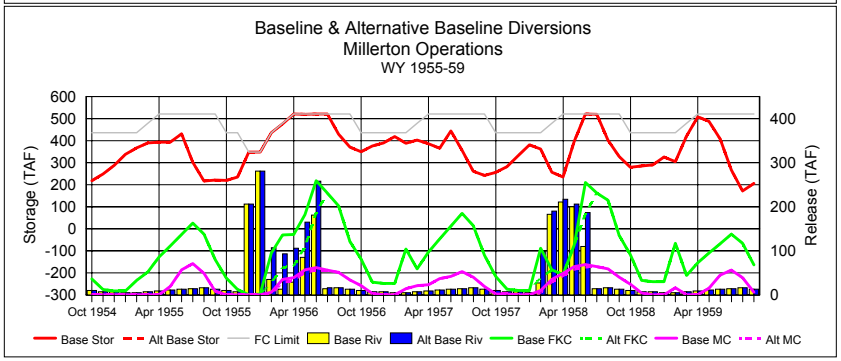
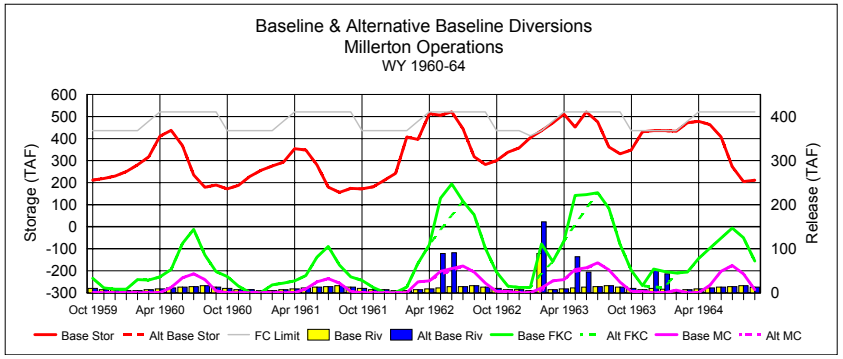
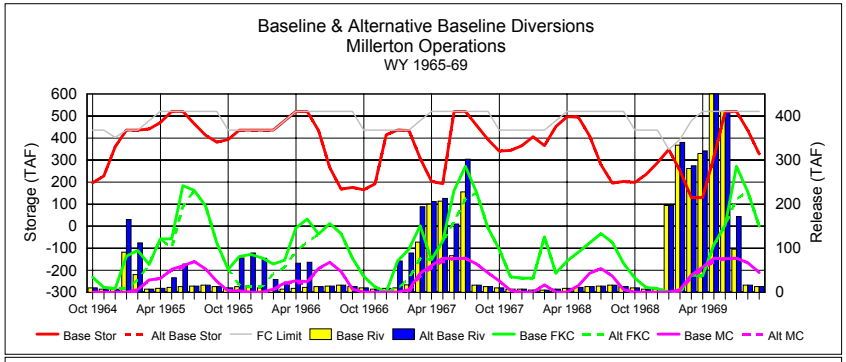

Baseline & Alternative Baseline Diversions
Millerton Operations
WY 1945-49
Storage (TAF)
Release (TAF)
Oct 1944
Apr 1945
Oct 1945
Apr 1946
Oct 1946
Apr 1947
Oct 1947
Apr 1948
Oct 1948
Apr 1949
Base Stor
Alt Base Stor
FC Limit
Base Riv
Alt Base Riv
Base FKC
Alt FKC
Base MC
Alt MC

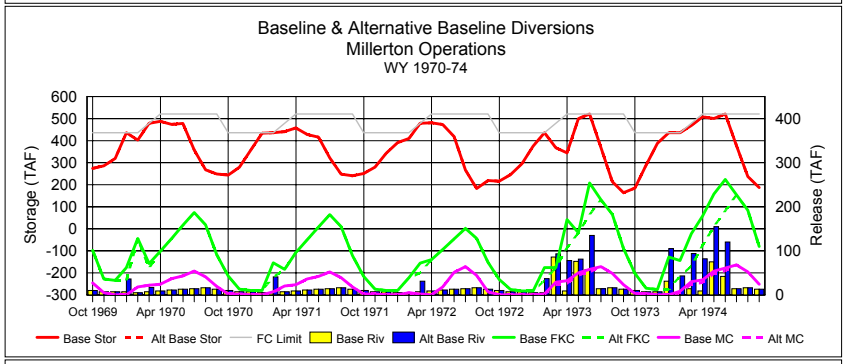
Figure Set 8


Baseline & Alternative Baseline Diversions
Millerton Operations
WY 1950-54
Storage (TAF)
Release (TAF)
Oct 1949 Apr 1950 Oct 1950 Apr 1951 Oct 1951 Apr 1952 Oct 1952 Apr 1953 Oct 1953 Apr 1954
Base Stor Alt Base Stor FC Limit Base Riv Alt Base Riv Base FKC Alt FKC Base MC Alt MC


Baseline & Alternative Baseline Diversions
Millerton Operations
WY 1955-59
Storage (TAF)
Release (TAF)
Oct 1954 Apr 1955 Oct 1955 Apr 1956 Oct 1956 Apr 1957 Oct 1957 Apr 1958 Oct 1958 Apr 1959
Base Stor Alt Base Stor FC Limit Base Riv Alt Base Riv Base FKC Alt FKC Base MC Alt MC


Baseline & Alternative Baseline Diversions
Millerton Operations
WY 1960-64
Storage (TAF)
Release (TAF)
Oct 1959 Apr 1960 Oct 1960 Apr 1961 Oct 1961 Apr 1962 Oct 1962 Apr 1963 Oct 1963 Apr 1964
Base Stor Alt Base Stor FC Limit Base Riv Alt Base Riv Base FKC Alt FKC Base MC Alt MC


Baseline & Alternative Baseline Diversions
Millerton Operations
WY 1965-69
Storage (TAF)
Release (TAF)
Oct 1964 Apr 1965 Oct 1965 Apr 1966 Oct 1966 Apr 1967 Oct 1967 Apr 1968 Oct 1968 Apr 1969
Base Stor Alt Base Stor FC Limit Base Riv Alt Base Riv Base FKC Alt FKC Base MC Alt MC


Baseline & Alternative Baseline Diversions
Millerton Operations
WY 1970-74
Storage (TAF)
Release (TAF)
Oct 1969 Apr 1970 Oct 1970 Apr 1971 Oct 1971 Apr 1972 Oct 1972 Apr 1973 Oct 1973 Apr 1974
Base Stor Alt Base Stor FC Limit Base Riv Alt Base Riv Base FKC Alt FKC Base MC Alt MC

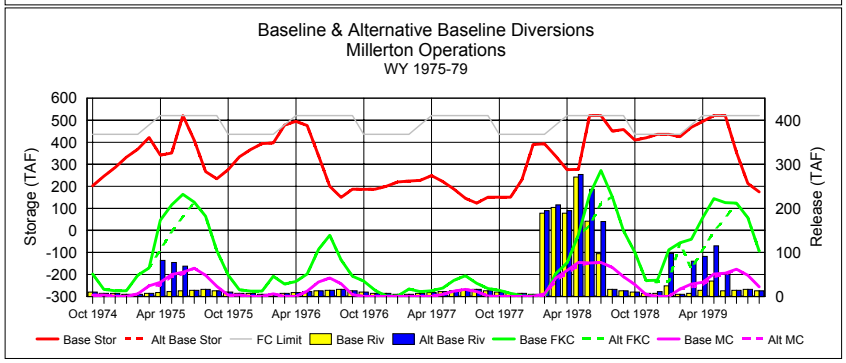
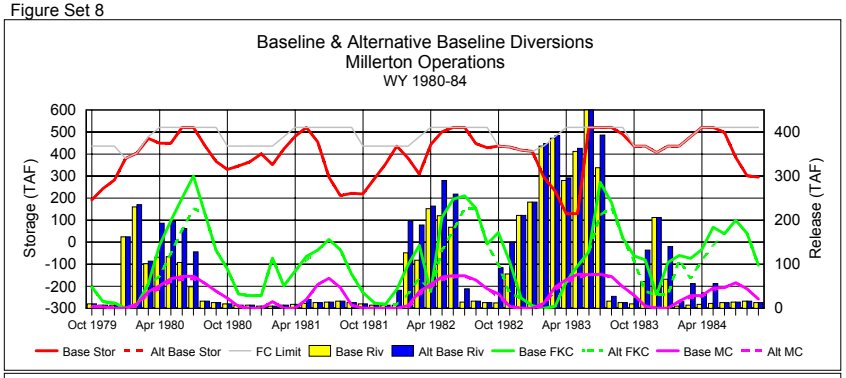
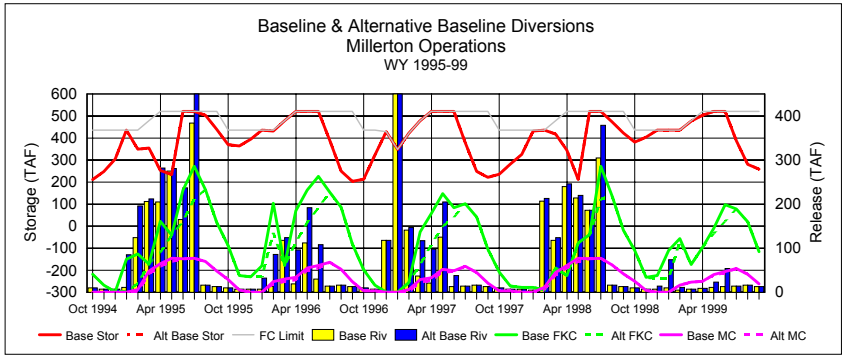
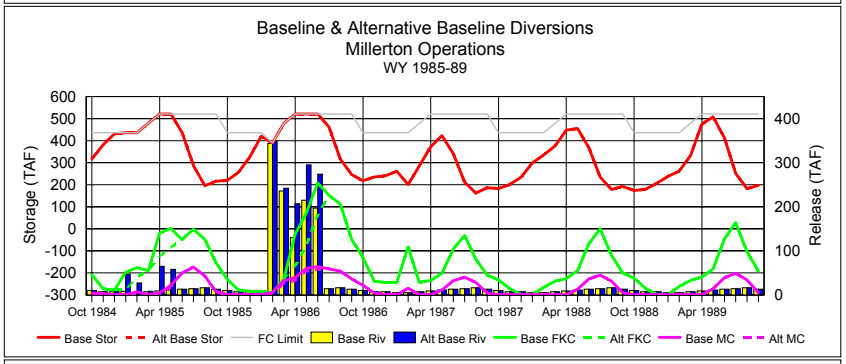
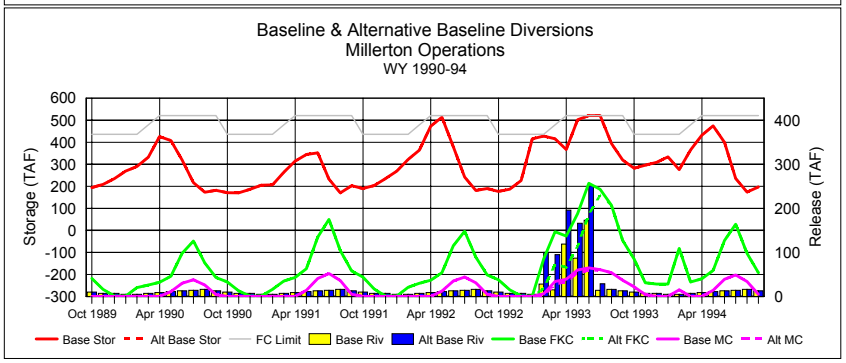

Baseline & Alternative Baseline Diversions
Millerton Operations
WY 1975-79
Storage (TAF)
Release (TAF)
Oct 1974 Apr 1975 Oct 1975 Apr 1976 Oct 1976 Apr 1977 Oct 1977 Apr 1978 Oct 1978 Apr 1979
Base Stor Alt Base Stor FC Limit Base Riv Alt Base Riv Base FKC Alt FKC Base MC Alt MC

Figure Set 8


Baseline & Alternative Baseline Diversions
Millerton Operations
WY 1980-84
Storage (TAF)
Release (TAF)
Oct 1979
Apr 1980
Oct 1980
Apr 1981
Oct 1981
Apr 1982
Oct 1982
Apr 1983
Oct 1983
Apr 1984
Base Stor
Alt Base Stor
FC Limit
Base Riv
Alt Base Riv
Base FKC
Alt FKC
Base MC
Alt MC


Baseline & Alternative Baseline Diversions
Millerton Operations
WY 1995-99
Storage (TAF)
Release (TAF)
Oct 1994
Apr 1995
Oct 1995
Apr 1996
Oct 1996
Apr 1997
Oct 1997
Apr 1998
Oct 1998
Apr 1999
Base Stor
Alt Base Stor
FC Limit
Base Riv
Alt Base Riv
Base FKC
Alt FKC
Base MC
Alt MC


Baseline & Alternative Baseline Diversions
Millerton Operations
WY 1985-89
Storage (TAF)
Release (TAF)
Oct 1984
Apr 1985
Oct 1985
Apr 1986
Oct 1986
Apr 1987
Oct 1987
Apr 1988
Oct 1988
Apr 1989
Base Stor
Alt Base Stor
FC Limit
Base Riv
Alt Base Riv
Base FKC
Alt FKC
Base MC
Alt MC


Baseline & Alternative Baseline Diversions
Millerton Operations
WY 1990-94
Storage (TAF)
Release (TAF)
Oct 1989
Apr 1990
Oct 1990
Apr 1991
Oct 1991
Apr 1992
Oct 1992
Apr 1993
Oct 1993
Apr 1994
Base Stor
Alt Base Stor
FC Limit
Base Riv
Alt Base Riv
Base FKC
Alt FKC
Base MC
Alt MC

Appendix D

Section 2
Long-term Project Modeling Results

Appendix D

Section 2
Long-term Project Modeling Results

The Long-term Project Model is used to model the performance of each bundle. The analysis is performed using a spreadsheet model that depicts the physical and operational system envisioned by a “bundle.” Performance is measured in terms of the mechanisms needed to develop restoration water, and in terms of general costs for the bundles that are assumed fixed or variable. Bundle facilities and operations are modeled over a 78-year sequence of years, providing a depiction of system performance through floods, droughts and other combinations of years. The model is described in Appendix C.

Five distinctly different bundle configurations are evaluated. The components included in the bundles range from water purchases to surface water storage facilities, and can include the use of storage and conveyance facilities of various entities. Each bundle is evaluated four different times in consideration of the two different restoration flow hydrographs and the two different baseline delivery scenarios. Additional configuration sensitivity analyses are also performed for each bundle.

Each bundle is evaluated using essentially the same prototype spreadsheet model. Configuration assumptions and the underlying hydrology (baseline and restoration flow assumptions) change among the bundles and their subset scenarios. Each model scenario was preserved as its own version of the model, with its own unique name. The long-term project models and supporting data summary are included in electronic form (listed below).

Several minor revisions occurred to the model during the completion of the studies. Most of these revisions involved graphic or data summary reporting. However, the formulation of Category 2 purchases evolved after several bundle studies were completed. Only Bundle A contains Category 2 purchases. Within that set of studies (models) only those models that include the phrase “REVISED” include the current assumptions for Category 2 purchases. None of the other bundle groups include Category 2 purchases, and their associated models were not revised. A revised version of the model that includes all of the revisions made during the simulations is included in Appendix C.

Graphical depictions of various hydrologic parameters are key to understanding the simulated operation of the bundles. The model contains a worksheet titled “Chrono Graphs” that manages the monthly data developed in the simulation. Two sets of graphs for the entire 78-year, 12-month simulation can be user defined. Ten additional graphs are available to illustrate the simulation. The parameters within a graph are grouped logically to assist result interpretation. These ten graphs and their reported parameters are listed below. An example of the group of ten graphs can be viewed from a file titled “\ Appendices \ Appendix D \ September Project Studies \ PDF Files Project \ Model 9-10-02 (Config E_Case X_Modified).pdf”

Figure 1 Millerton Lake Operations

- Millerton Lake Minimum Storage
- Millerton Lake Maximum Storage (including flood control)
- Simulated Millerton Lake Storage
- Baseline Millerton Lake Storage
- Simulated Friant-Kern Canal Diversion
- Simulated Madera Canal Diversion
- Baseline Friant-Kern Canal Diversion
- Baseline Madera Canal Diversion
- Simulated Release to the San Joaquin River
- Baseline Release to the San Joaquin River

Figure 2 Millerton Storage, Eastside Groundwater Operation and Spills

- Millerton Lake Spills
- Total Eastside Groundwater Pumping
- Total Eastside Groundwater Recharge
- Total Purchases other than Residual Purchases
- Residual Purchases
- Millerton Lake Minimum Storage
- Millerton Lake Maximum Storage (including flood control)
- Simulated Millerton Lake Storage
- Eastside Groundwater Storage

Figure 3 Purchases

- Category 1 Purchases (unused)
- Category 1 Purchases
- Category 2 Westside Purchases
- Category 2 Eastside Purchases (stored)
- Category 2 Eastside Purchases
- Category 3 Purchases
- Category 3 Purchases (stored)
- Residual Purchases

Figure 4 Aqueduct Balance and other Storage

- San Luis Restoration Project Storage
- Tulare Lakebed Restoration Project Storage
- Restoration Project Storage in the Kern County Bank
- Eastside Tributary Storage in Aqueduct Balance
- Recirculation Stored in Aqueduct Balance
- San Luis Spill Stored in Aqueduct Balance
- Tulare Lakebed Diversion Stored in Aqueduct Balance
- Aqueduct Balance

Figure 5 Recirculation Operation

- Credit to DMC from Mendota Pool
- Patterson Recirculation Diversion
- Delta Recirculation Diversion
- Incremental Release Uncaptured at Delta
- Captured Water Used for Direct Delivery
- Recirculated Water Stored in San Luis Reservoir
- Recirculated Water Stored in Eastside Groundwater
- Recirculated Water Stored in Kern County Bank
- Recirculated Water Stored in Tulare Lakebed
- Cross Valley Canal Available Capacity

Figure 6 Tulare Lakebed and San Luis Reservoir Operation

- Restoration Project Storage in San Luis Reservoir
- Restoration Project Storage in Tulare Lakebed
- Recirculated Water Diverted to Storage in San Luis Reservoir
- Recirculated Water Diverted to Storage in Tulare Lakebed
- Eastside Project Diversions to Tulare Lakebed
- Eastside Non-project Diversion to Tulare Lakebed
- San Luis Reservoir Release to Direct Deliveries
- San Luis Reservoir Spills to Aqueduct Balance
- Total Tulare Lakebed Deliveries to the Eastside

Figure 7 Eastside Groundwater Operations

- Total Eastside Groundwater Pumping
- Total Eastside Groundwater Recharge
- Category 2 and Category 3 Purchases Stored in Groundwater
- Madera Canal Area Incremental Groundwater Storage
- FKC 1 Area Incremental Groundwater Storage
- FKC 2 Area Incremental Groundwater Storage
- FKC 3 Area Incremental Groundwater Storage
- FKC 4 Area Incremental Groundwater Storage
- FKC 5 Area Incremental Groundwater Storage

Figure 8 Fine Gold Reservoir, Millerton Lake and Groundwater Operation

- Fine Gold Pumping
- Fine Gold Release
- Total Eastside Groundwater Pumping
- Total Eastside Groundwater Recharge
- Fine Gold Reservoir Storage
- Millerton Lake Minimum Storage
- Millerton Lake Maximum Storage (including flood control)
- Simulated Millerton Lake Storage

Figure 9 Mendota Pool Operation

- Credit to DMC from Mendota Pool
- Patterson Recirculation Diversion
- Delta Recirculation Diversion
- Incremental Release Uncaptured at Delta
- Potential Impact to DMC

Figure 10 Merced - Madera Canal Operations

- Supply from Merced Used for Direct Delivery
- Supply from Merced Used for Groundwater Storage
- Diversion of Merced River Surplus Flows
- Diversion of Merced River VAMP Flows
- Merced River VAMP Storage Account

Summary of Project Model Results

Table Set 1 - Average Annual Attributes

Bundle A
Bundle B & Bundle C
Bundle D & Bundle E

Table Set 2 - Bundle Cost Components

Model Files

Bundle A

Name	Size	Last Modified
Project Model 9-10-02 (Config A_Case X_Existing)REVISED.xls	30MB	9/17/2002 1:54 PM
Project Model 9-10-02 (Config A_Case X_Modified)REVISED.xls	30MB	9/18/2002 9:06 PM
Project Model 9-10-02 (Config A_Case X_Modified_Delta + Patterson).xls	30MB	9/11/2002 5:23 PM
Project Model 9-10-02 (Config A_Case X_Modified_Delta)REVISED.xls	30MB	9/17/2002 1:35 PM
Project Model 9-10-02 (Config A_Case X_Modified_Merced).xls	30MB	9/12/2002 8:11 AM
Project Model 9-10-02 (Config A_Case X_Modified_No East-side).xls	30MB	9/12/2002 9:24 AM
Project Model 9-10-02 (Config A_Case X_Modified_Patterson).xls	29MB	9/11/2002 9:49 PM
Project Model 9-10-02 (Config A_Case Y_Existing)REVISED.xls	30MB	9/18/2002 9:47 PM
Project Model 9-10-02 (Config A_Case Y_Modified)REVISED.xls	30MB	9/17/2002 2:10 PM

Bundle B

Name	Size	Last Modified
Project Model 9-10-02 (Config B_Case X_Existing).xls	30MB	9/15/2002 4:24 PM
Project Model 9-10-02 (Config B_Case X_Modified).xls	30MB	9/19/2002 12:52 PM
Project Model 9-10-02 (Config B_Case X_Modified_Merced).xls	30MB	9/16/2002 7:28 AM
Project Model 9-10-02 (Config B_Case X_Modified_No ES Trib).xls	30MB	9/16/2002 7:24 AM
Project Model 9-10-02 (Config B_Case X_Modified_Patterson).xls	30MB	9/15/2002 7:00 PM
Project Model 9-10-02 (Config B_Case Y_Existing).xls	30MB	9/19/2002 2:12 PM
Project Model 9-10-02 (Config B_Case Y_Modified).xls	30MB	9/15/2002 6:07 PM

Bundle C

Name	Size	Last Modified
Project Model 9-10-02 (Config C_Case X_Existing).xls	30MB	9/19/2002 10:19 PM
Project Model 9-10-02 (Config C_Case X_Modified).xls	30MB	9/16/2002 9:16 AM
Project Model 9-10-02 (Config C_Case X_Modified_No ES Trib).xls	30MB	9/16/2002 12:12 PM
Project Model 9-10-02 (Config C_Case X_Modified_Patterson).xls	30MB	9/16/2002 11:35 AM
Project Model 9-10-02 (Config C_Case Y_Existing).xls	30MB	9/19/2002 11:05 PM
Project Model 9-10-02 (Config C_Case Y_Modified).xls	30MB	9/16/2002 10:48 AM

Bundle D

Name	Size	Last Modified
Project Model 9-10-02 (Config D_Case X_Existing).xls	30MB	9/16/2002 2:47 PM
Project Model 9-10-02 (Config D_Case X_Modified).xls	30MB	9/20/2002 10:26 AM
Project Model 9-10-02 (Config D_Case X_Modified_No ES Trib).xls	30MB	9/16/2002 4:09 PM
Project Model 9-10-02 (Config D_Case X_Modified_Patterson).xls	30MB	9/16/2002 3:58 PM
Project Model 9-10-02 (Config D_Case Y_Existing).xls	30MB	9/20/2002 11:34 AM
Project Model 9-10-02 (Config D_Case Y_Modified).xls	30MB	9/16/2002 3:19 PM

Bundle E

Name	Size	Last Modified
Project Model 9-10-02 (Config E_Case X_Existing).xls	30MB	9/17/2002 2:14 PM
Project Model 9-10-02 (Config E_Case X_Modified).xls	30MB	9/20/2002 3:29 PM
Project Model 9-10-02 (Config E_Case X_Modified_No ES Trib).xls	30MB	9/17/2002 10:55 AM
Project Model 9-10-02 (Config E_Case X_Modified_Patterson).xls	30MB	9/17/2002 10:44 AM
Project Model 9-10-02 (Config E_Case Y_Existing).xls	30MB	9/20/2002 4:01 PM
Project Model 9-10-02 (Config E_Case Y_Modified).xls	30MB	9/17/2002 2:16 PM

Summary Data File

Name	Size	Last Modified
Summary September.xls	117KB	9/30/02 8:36 AM

Table Set 1 - Average Annual Attributes

Bundle Components	A	A	A	A	A	A	A	A	A
Cross Valley Canal Existing Capacity	x	x	x	x	x	x	x	x	x
Aqueduct Balance	x	x	x	x	x	x	x	x	x
Kern East-to-West (1000cfs)	x	x	x	x	x	x	x	x	x
Groundwater Storage (ES: 8in-5out; Kern Basin: 10in-8out)	x	x	x	x	x	x	x	x	x
Mendota Pool Recirculation	x	x	x	x	x	x	x	x	x
Friant-Kern Reach 4 Pump-back	x	x	x	x	x	x	x	x	x
Eastside Tributary Pump-in (1000cfs)	x	x	x	x	x	x	x	x	
San Luis Reservoir (Available Capacity)	x	x	x	x	x	x	x	x	x
Delta Recirculation					x		x		
Dead Storage (down to 40 TAF)									
Tulare Lake Reservoir (100 TAF)									
Millerton Reservoir Enlargement (105 TAF)									
Mammoth Pool Enlargement (30 TAF)									
Finegold Reservoir (400 TAF, 30 TAF dead pool)									
Patterson Pump (500 cfs) + CVC Improvement (500 cfs firm)						(w/o CVC)	x		
Merced Intertie (100 cfs)								x	
	Bundle A - Purchases with Groundwater, Eastside and Mendota Pool Recirculation								
	Base X		Base Y		Configuration Sensitivity				
Parameter (All values average annual 1,000 acre-feet or $1,000, except storage values representing end of study period residual)	Bundle A Case X Modified Channel	Bundle A Case X Existing Channel	Bundle A Case Y Modified Channel	Bundle A Case Y Existing Channel	Bundle A Case X Modified Channel w/ Delta	Bundle A Case X Modified Channel w/ Patterson	Bundle A Case X Modified Channel w/ Delta & Patterson	Bundle A Case X Modified Channel with Merced	Bundle A Case X Modified Channel w/o East-side Tributary Surplus
Total Purchase Directly Used	167	202	141	149	106	97	58	141	165
Cat 1 Unused	1	1	1	1	1	1	1	1	1
Levelized GW Storage Residual	34	17	82	56	38	39	44	34	23
Levelized Aqueduct Balance	16	16	16	16	18	20	19	16	0
Total Release to SJR	648	704	711	750	655	664	665	654	584
Required Friant Release, including 117,000 existing	466	562	466	562	466	466	466	466	466
Average Annual Spil	182	142	245	188	189	198	200	189	118
Total ES GW Pumping	62	64	53	60	60	63	63	62	57
Total ES GW Recharge	90	75	131	111	96	100	106	93	75
Fine Gold Pump-in	0	0	0	0	0	0	0	0	0
Fine Gold Release, including local runo	28	28	28	28	28	28	28	28	28
Residual Shortage Water	3	9	1	3	1	2	2	4	4
Total Cat 1 Directly Used	19	19	19	19	19	19	19	19	19
Total Cat 1 Unused	1	1	1	1	1	1	1	1	1
Total ES Cat 2 Directly Used	120	120	120	120	65	39	0	91	91
Total ES Cat 2 Stored	4	4	4	4	1	1	0	2	2
Cat 2 WS Purchase	0	0	0	0	0	0	0	0	0
Total Cat 3 Directly Used	24	53	1	7	21	37	37	28	52
Total Cat 3 Stored	2	2	0	1	1	1	1	2	3
Total Captured Water for Recirculation	41	44	39	41	121	143	189	41	41
Uncaptured Water at Delta	164	207	143	177	88	77	32	137	151
Patterson Diversion for Recirculation	0	0	0	0	0	102	102	0	0
Delta Diversion for Recirculation	0	0	0	0	80	0	46	0	0
Credit to DMC	-41	-44	-39	-41	-41	-41	-41	-41	-41
Potential Impact to DMC (Westside Supply)	49	50	97	101	48	46	46	49	37
Incremental Flow Past Pool	181	230	159	196	186	193	194	187	168
Tulare Basin Tribs Flood Flow to TLB	17	17	17	17	17	17	17	17	51
Total Project Diversion to Lakebed	0	0	0	0	0	0	0	0	0
TLB Release to CVC	0	0	0	0	0	0	0	0	0
Total TLB to ES	0	0	0	0	0	0	0	0	0
Non-project Trib Flow to TLB	17	17	17	17	17	17	17	17	51
Project Trib Flow to TLB	0	0	0	0	0	0	0	0	0
Diversion of Merced River VAMP	0	0	0	0	0	0	0	19	0
Diversion of Merced River Surplus	0	0	0	0	0	0	0	14	0
Increased Supply from Merced ID for DD	0	0	0	0	0	0	0	25	0
Increased Supply from Merced ID for GW Recharge	0	0	0	0	0	0	0	8	0
Total CVC	39	42	37	40	114	134	179	39	40
Beginning (available)CVC Capacity	304	304	304	304	304	304	548	304	304
Fixed Costs	-3358	-3358	-3358	-3358	-3358	-9857	-13771	-7394	-2638
GW Put Charge	-16280	-13513	-23567	-19955	-17529	-18175	-19209	-16680	-13514
Wheeling Costs	-225	-241	-210	-224	-678	-709	-968	-225	-221
Pumping	-2943	-3139	-2554	-2839	-5698	-6555	-8229	-3233	-2692
Gen	1906	1935	2008	2027	2140	2211	2261	1883	1850
Cat 1 Purchases	-6500	-6500	-6500	-6500	-6500	-6500	-6500	-6500	-6500
Cat 2 ES Purchases (Variable)	-27264	-27264	-27264	-27264	-16561	-13000	0	-24222	-24222
Cat 2 ES Fixed Charge (Premium)	-2714	-2714	-2714	-2714	-678	0	0	-631	-631
Cat 2 WS Purchases	0	0	0	0	0	0	0	0	0
Cat 3 ES Purchases	-6141	-13302	-156	-2002	-5172	-10241	-9816	-7541	-13802
Residual Purchase	-760	-1932	-194	-674	-271	-457	-475	-867	-807
Average Cat 1 Purch Cost ($/AF)	-325	-325	-325	-325	-325	-325	-325	-325	-325
Average Cat 2 ES Purch Cost ($/AF) (incl premium)	-242	-242	-242	-242	-260	-325	0	-268	-268
Average Cat 2 WS Purch Cost ($/AF)	0	0	0	0	0	0	0	0	0
Average Cat 3 Purch Cost ($/AF)	-240	-240	-185	-254	-238	-267	-260	-254	-253
Average Residual Purch Cost ($/AF)	-234	-207	-262	-268	-227	-239	-253	-235	-221
Credit for GW Balance (x Put Chrg)	6192	3065	14838	10050	6887	6993	7886	6186	4083
Credit for Aqueduct Balance (x)	0	0	0	0	0	0	0	0	0
Credit for River Spill (x)	0	0	0	0	0	0	0	0	0
Total Annual Net Cost w/o Credits	-64279	-70026	-64507	-63501	-54306	-63283	-56707	-65409	-63178
Total Annual Net Cost w/ Credits	-58087	-66961	-49669	-53451	-47418	-56289	-48821	-59223	-59096

Table Set 1 - Average Annual Attributes

Bundle Components	**B**	**B**	**B**	**B**	**B**	**B**	**B**	**C**	**C**	**C**	**C**	**C**	**C**
Cross Valley Canal Existing Capacity	x	x	x	x	x	x	x	x	x	x	x	x	x
Aqueduct Balance	x	x	x	x	x	x	x	x	x	x	x	x	x
Kern East-to-West (1000cfs)	x	x	x	x	x	x	x	x	x	x	x	x	x
Groundwater Storage (ES: 8in-5out; Kern Basin: 10in-8out)	x	x	x	x	x	x	x	x	x	x	x	x	x
Mendota Pool Recirculation	x	x	x	x	x	x	x	x	x	x	x	x	x
Friant-Kern Reach 4 Pump-back	x	x	x	x	x	x	x	x	x	x	x	x	x
Eastside Tributary Pump-in (1000cfs)	x	x	x	x	x	x		x	x	x	x	x	
San Luis Reservoir (Available Capacity)	x	x	x	x	x	x	x	x	x	x	x	x	x
Delta Recirculation	x	x	x	x	x	x	x	x	x	x	x	x	x
Dead Storage (down to 40 TAF)	x	x	x	x	x	x	x						
Tulare Lake Reservoir (100 TAF)								x	x	x	x	x	x
Millerton Reservoir Enlargement (105 TAF)													
Mammoth Pool Enlargement (30 TAF)													
Finegold Reservoir (400 TAF, 30 TAF dead pool)													
Patterson Pump (500 cfs) + CVC Improvement (500 cfs firm)					x							x	
Merced Intertie (100 cfs)						x							
	Bundle B - Minimum Pool and Delta Recirculation							Bundle C - Tulare Lakebed					
	Base X		Base Y		Configuration Sensitivity			Base X		Base Y		Config Sensitivity	
Parameter (All values average annual 1,000 acre-feet or $1,000, except storage values representing end of study period residual)	Bundle B Case X Modified Channel	Bundle B Case X Existing Channel	Bundle B Case Y Modified Channel	Bundle B- Case Y Existing Channel	Bundle B Case X Modified Channel with Patterson	Bundle B Case X Modified Channel w/ Merced	Bundle B Case X Modified Channel w/o East-side Tributary Surplus	Bundle C Case X Modified Channel	Bundle C Case X Existing Channel	Bundle C Case Y Modified Channel	Bundle C Case Y Existing Channel	Bundle C Case X Modified Channel with Patterson	Bundle C Case X Modified Channel w/o East-side Tributary Surplus
Total Purchase Directly Used	68	97	32	42	41	55	76	87	113	51	54	54	98
Cat 1 Unused	1	1	1	1	1	1	1	1	1	1	1	1	1
Levelized GW Storage Residual	23	11	66	41	39	30	20	38	22	80	50	51	30
Levelized Aqueduct Balance	18	21	18	22	20	18	3	18	20	18	21	19	2
Total Release to SJR	636	691	689	736	655	643	575	647	703	703	747	664	584
Required Friant Release, including 117,000 existing	466	562	466	562	466	466	466	466	562	466	562	466	466
Average Annual Spil	170	129	223	174	189	177	109	181	141	237	185	198	118
Total ES GW Pumping	52	55	45	50	53	55	49	52	57	48	65	60	53
Total ES GW Recharge	74	62	111	90	91	84	66	88	76	127	114	110	80
Fine Gold Pump-in	0	0	0	0	0	0	0	0	0	0	0	0	0
Fine Gold Release, including local runo	28	28	28	28	28	28	28	28	28	28	28	28	28
Residual Shortage Water	1	2	1	3	0	1	1	4	6	3	3	3	5
Total Cat 1 Directly Used	19	19	19	19	19	19	19	19	19	19	19	19	19
Total Cat 1 Unused	1	1	1	1	1	1	1	1	1	1	1	1	1
Total ES Cat 2 Directly Used	0	0	0	0	0	0	0	0	0	0	0	0	0
Total ES Cat 2 Stored	0	0	0	0	0	0	0	0	0	0	0	0	0
Cat 2 WS Purchase	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Cat 3 Directly Used	49	76	12	20	22	35	56	64	87	29	32	31	74
Total Cat 3 Stored	2	3	1	1	1	1	2	2	3	1	1	1	3
Total Captured Water for Recirculation	121	137	113	127	189	116	123	121	136	113	127	189	123
Uncaptured Water at Delta	74	104	52	79	24	54	62	66	97	45	70	13	70
Patterson Diversion for Recirculation	0	0	0	0	102	0	0	0	0	0	0	102	0
Delta Diversion for Recirculation	80	93	74	86	46	75	81	80	93	74	86	46	81
Credit to DMC	-41	-44	-39	-41	-41	-41	-41	-41	-44	-39	-41	-41	-41
Potential Impact to DMC (Westside Supply)	49	51	97	101	46	50	37	57	58	105	108	53	36
Incremental Flow Past Pool	171	219	140	183	185	177	159	162	211	132	172	173	167
Tulare Basin Tribs Flood Flow to TLB	17	17	17	17	17	17	51	44	44	44	45	44	51
Total Project Diversion to Lakebed	0	0	0	0	0	0	0	24	26	25	26	24	1
TLB Release to CVC	0	0	0	0	0	0	0	7	8	7	8	7	0
Total TLB to ES	0	0	0	0	0	0	0	10	11	10	11	10	1
Non-project Trib Flow to TLB	17	17	17	17	17	17	51	21	21	21	21	21	51
Project Trib Flow to TLB	0	0	0	0	0	0	0	23	23	24	24	23	0
Diversion of Merced River VAMP	0	0	0	0	0	19	0	0	0	0	0	0	0
Diversion of Merced River Surplus	0	0	0	0	0	14	0	0	0	0	0	0	0
Increased Supply from Merced ID for DD	0	0	0	0	0	25	0	0	0	0	0	0	0
Increased Supply from Merced ID for GW Recharge	0	0	0	0	0	8	0	0	0	0	0	0	0
Total CVC	114	126	106	117	178	110	117	120	133	113	124	185	116
Beginning (available)CVC Capacity	304	304	304	304	548	304	304	304	304	304	304	548	304
Fixed Costs	-7995	-7995	-7995	-7995	-18408	-12031	-7275	-8004	-8004	-8004	-8004	-18417	-7284
GW Put Charge	-13477	-11478	-20087	-16416	-16563	-15213	-12180	-15929	-13777	-22834	-20544	-19855	-14402
Wheeling Costs	-678	-756	-615	-689	-968	-662	-685	-678	-756	-615	-689	-968	-685
Pumping	-5837	-6572	-5204	-5858	-8170	-5998	-5665	-5642	-6333	-5241	-6208	-8363	-5372
Gen	1902	1979	1945	2037	2111	1911	1884	2082	2203	2128	2250	2256	2071
Cat 1 Purchases	-6500	-6500	-6500	-6500	-6500	-6500	-6500	-6500	-6500	-6500	-6500	-6500	-6500
Cat 2 ES Purchases (Variable)	0	0	0	0	0	0	0	0	0	0	0	0	0
Cat 2 ES Fixed Charge (Premium)	0	0	0	0	0	0	0	0	0	0	0	0	0
Cat 2 WS Purchases	0	0	0	0	0	0	0	0	0	0	0	0	0
Cat 3 ES Purchases	-14663	-22335	-4017	-6225	-6047	-10600	-16694	-17487	-24852	-8628	-9485	-8239	-21149
Residual Purchase	-152	-494	-215	-621	-139	-182	-249	-908	-1307	-657	-731	-812	-953
Average Cat 1 Purch Cost ($/AF)	-325	-325	-325	-325	-325	-325	-325	-325	-325	-325	-325	-325	-325
Average Cat 2 ES Purch Cost ($/AF) (incl premium)	0	0	0	0	0	0	0	0	0	0	0	0	0
Average Cat 2 WS Purch Cost ($/AF)	0	0	0	0	0	0	0	0	0	0	0	0	0
Average Cat 3 Purch Cost ($/AF)	-289	-284	-312	-292	-268	-293	-285	-266	-275	-282	-282	-255	-275
Average Residual Purch Cost ($/AF)	-254	-226	-243	-230	-294	-270	-253	-236	-204	-248	-246	-235	-204
Credit for GW Balance (x Put Chrg)	4213	1921	11955	7351	6975	5356	3535	6825	3954	14338	9063	9211	5426
Credit for Aqueduct Balance (x)	0	0	0	0	0	0	0	0	0	0	0	0	0
Credit for River Spill (x)	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Annual Net Cost w/o Credits	-47400	-54151	-42689	-42267	-54685	-49275	-47364	-53065	-59326	-50351	-49910	-60899	-54275
Total Annual Net Cost w/ Credits	-43187	-52229	-30734	-34916	-47710	-43919	-43829	-46240	-55372	-36012	-40847	-51688	-48849

Table Set 1 - Average Annual Attributes

Bundle Components	D	D	D	D	D	D	E	E	E	E	E	E
Cross Valley Canal Existing Capacity	x	x	x	x	x	x	x	x	x	x	x	x
Aqueduct Balance	x	x	x	x	x	x	x	x	x	x	x	x
Kern East-to-West (1000cfs)	x	x	x	x	x	x	x	x	x	x	x	x
Groundwater Storage (ES: 8in-5out; Kern Basin: 10in-8out)	x	x	x	x	x	x	x	x	x	x	x	x
Mendota Pool Recirculation	x	x	x	x	x	x	x	x	x	x	x	x
Friant-Kern Reach 4 Pump-back	x	x	x	x	x	x	x	x	x	x	x	x
Eastside Tributary Pump-in (1000cfs)	x	x	x	x	x		x	x	x	x	x	
San Luis Reservoir (Available Capacity)	x	x	x	x	x	x	x	x	x	x	x	x
Delta Recirculation	x	x	x	x	x	x	x	x	x	x	x	x
Dead Storage (down to 40 TAF)												
Tulare Lake Reservoir (100 TAF)												
Millerton Reservoir Enlargement (105 TAF)	x	x	x	x	x	x	x	x	x	x	x	x
Mammoth Pool Enlargement (30 TAF)	x	x	x	x	x	x	x	x	x	x	x	x
Finegold Reservoir (400 TAF, 30 TAF dead pool)							x	x	x	x	x	x
Patterson Pump (500 cfs) + CVC Improvement (500 cfs firm)					x						x	
Merced Intertie (100 cfs)												
	Bundle D - Enlarged Millerton & Mammoth						Bundle E - Enlarged Millerton & Mammoth, Fine Gold					
	Base X		Base Y		Config Sensitivity		Base X		Base Y		Config Sensitivity	
Parameter (All values average annual 1,000 acre-feet or $1,000, except storage values representing end of study period residual)	Bundle D Case X Modified Channel	Bundle D Case X Existing Channel	Bundle D Case Y Modified Channel	Bundle D Case Y Existing Channel	Bundle D Case X Modified Channel with Patterson	Bundle D Case X Modified Channel w/o East-side Tributary Surplus	Bundle E Case X Modified Channel	Bundle E Case X Existing Channel	Bundle E Case Y Modified Channel	Bundle E Case Y Existing Channel	Bundle E Case X Modified Channel with Patterson	Bundle E Case X Modified Channel w/o East-side Tributary Surplus
Total Purchase Directly Used	70	99	33	43	44	77	62	88	29	38	41	70
Cat 1 Unused	1	1	1	1	1	1	1	1	1	1	1	1
Levelized GW Storage Residual	27	14	66	42	44	21	22	11	60	37	39	16
Levelized Aqueduct Balance	18	21	18	22	20	3	18	21	18	21	20	3
Total Release to SJR	629	683	685	729	647	570	614	667	674	718	638	556
Required Friant Release, including 117,000 existing	466	562	466	562	466	466	466	562	466	562	466	466
Average Annual Spil	163	121	219	167	182	104	148	105	208	156	172	90
Total ES GW Pumping	43	47	38	44	40	40	29	33	18	26	21	27
Total ES GW Recharge	68	59	104	86	84	58	50	41	77	62	60	41
Fine Gold Pump-in	0	0	0	0	0	0	32	33	39	38	31	31
Fine Gold Release, including local runo	28	28	28	28	28	28	51	52	55	56	48	49
Residual Shortage Water	1	4	1	2	1	1	1	3	1	1	1	1
Total Cat 1 Directly Used	19	19	19	19	19	19	19	19	19	19	19	19
Total Cat 1 Unused	1	1	1	1	1	1	1	1	1	1	1	1
Total ES Cat 2 Directly Used	0	0	0	0	0	0	0	0	0	0	0	0
Total ES Cat 2 Stored	0	0	0	0	0	0	0	0	0	0	0	0
Cat 2 WS Purchase	0	0	0	0	0	0	0	0	0	0	0	0
Total Cat 3 Directly Used	50	76	13	22	24	57	42	66	10	18	21	49
Total Cat 3 Stored	2	3	1	1	1	2	2	3	1	1	1	2
Total Captured Water for Recirculation	121	136	113	127	189	123	121	136	113	127	190	123
Uncaptured Water at Delta	69	99	49	75	18	60	58	87	41	68	11	49
Patterson Diversion for Recirculation	0	0	0	0	102	0	0	0	0	0	102	0
Delta Diversion for Recirculation	80	93	74	86	46	81	80	93	75	86	46	81
Credit to DMC	-41	-44	-39	-41	-41	-41	-41	-44	-39	-41	-41	-41
Potential Impact to DMC (Westside Supply)	50	51	98	103	47	38	52	52	99	104	48	39
Incremental Flow Past Pool	166	213	136	179	179	156	153	199	128	170	170	145
Tulare Basin Tribs Flood Flow to TLB	17	17	17	17	17	51	17	17	17	17	17	51
Total Project Diversion to Lakebed	0	0	0	0	0	0	0	0	0	0	0	0
TLB Release to CVC	0	0	0	0	0	0	0	0	0	0	0	0
Total TLB to ES	0	0	0	0	0	0	0	0	0	0	0	0
Non-project Trib Flow to TLB	17	17	17	17	17	51	17	17	17	17	17	51
Project Trib Flow to TLB	0	0	0	0	0	0	0	0	0	0	0	0
Diversion of Merced River VAMP	0	0	0	0	0	0	0	0	0	0	0	0
Diversion of Merced River Surplus	0	0	0	0	0	0	0	0	0	0	0	0
Increased Supply from Merced ID for DD	0	0	0	0	0	0	0	0	0	0	0	0
Increased Supply from Merced ID for GW Recharge	0	0	0	0	0	0	0	0	0	0	0	0
Total CVC	114	126	106	117	178	117	114	126	107	117	179	116
Beginning (available)CVC Capacity	304	304	304	304	548	304	304	304	304	304	548	304
Fixed Costs	-12347	-12347	-12347	-12347	-22760	-11627	-47083	-47083	-47083	-47083	-57496	-46363
GW Put Charge	-12465	-10851	-18832	-15639	-15190	-10740	-9225	-7627	-14093	-11406	-10905	-7528
Wheeling Costs	-678	-750	-616	-689	-968	-679	-678	-750	-618	-689	-968	-679
Pumping	-5249	-5922	-4765	-5401	-7569	-5052	-4876	-5505	-4254	-4913	-7104	-4663
Gen	2212	2313	2273	2383	2386	2192	2243	2337	2329	2443	2441	2225
Cat 1 Purchases	-6500	-6500	-6500	-6500	-6500	-6500	-6500	-6500	-6500	-6500	-6500	-6500
Cat 2 ES Purchases (Variable)	0	0	0	0	0	0	0	0	0	0	0	0
Cat 2 ES Fixed Charge (Premium)	0	0	0	0	0	0	0	0	0	0	0	0
Cat 2 WS Purchases	0	0	0	0	0	0	0	0	0	0	0	0
Cat 3 ES Purchases	-14884	-22458	-4297	-6923	-6493	-16882	-12728	-20101	-3120	-5752	-5741	-15141
Residual Purchase	-274	-803	-165	-425	-289	-285	-216	-646	-151	-194	-252	-203
Average Cat 1 Purch Cost ($/AF)	-325	-325	-325	-325	-325	-325	-325	-325	-325	-325	-325	-325
Average Cat 2 ES Purch Cost ($/AF) (incl premium)	0	0	0	0	0	0	0	0	0	0	0	0
Average Cat 2 WS Purch Cost ($/AF)	0	0	0	0	0	0	0	0	0	0	0	0
Average Cat 3 Purch Cost ($/AF)	-288	-285	-302	-296	-267	-285	-294	-294	-302	-305	-272	-294
Average Residual Purch Cost ($/AF)	-207	-204	-279	-269	-274	-228	-280	-203	-281	-284	-217	-187
Credit for GW Balance (x Put Chrg)	4798	2592	11963	7642	7995	3719	4013	1907	10787	6612	7053	2867
Credit for Aqueduct Balance (x)	0	0	0	0	0	0	0	0	0	0	0	0
Credit for River Spill (x)	0	0	0	0	0	0	0	0	0	0	0	0
Total Annual Net Cost w/o Credits	-50184	-57317	-45248	-45540	-57384	-49573	-79064	-85875	-73489	-74095	-86525	-78853
Total Annual Net Cost w/ Credits	-45386	-54724	-33284	-37898	-49389	-45853	-75050	-83968	-62702	-67484	-79472	-75986

Table Set 2 - Bundle Cost Components

Bundle Configuration	Millerton Reservoir					
All values in $1,000	Canal Gen	River Gen (in excess of exist plant)	Canal Pumping	River Generator	Minimum Pool Pumps	Millerton Enlrg Incl Mammoth
Bundle A - Case X_Modified	0	1,873	0	-1,517	0	0
Bundle A - Case X_Existing	0	1,897	0	-1,517	0	0
Bundle A - Case Y_Modified	0	1,979	0	-1,517	0	0
Bundle A - Case Y_Existing	0	1,992	0	-1,517	0	0
Bundle A - Case X_Modified w/ Delta Recirculation	0	1,887	0	-1,517	0	0
Bundle A - Case X_Modified w/ Patterson Recirculation	0	1,880	0	-1,517	0	0
Bundle A - Case X_Modified w/ Delta Recirculation & Patterson	0	1,890	0	-1,517	0	0
Bundle A - Case X_Modified with Merced	0	1,851	0	-1,517	0	0
Bundle A - Case X_Modified_w/o East-side Tributary Surplus	0	1,818	0	-1,517	0	0
Bundle B - Case X_Modified	0	1,651	-285	-1,517	-4,637	0
Bundle B - Case X_Existing	0	1,642	-387	-1,517	-4,637	0
Bundle B - Case Y_Modified	0	1,699	-245	-1,517	-4,637	0
Bundle B - Case Y_Existing	0	1,708	-287	-1,517	-4,637	0
Bundle B - Case X_Modified with Patterson	0	1,737	-175	-1,517	-4,637	0
Bundle B - Case X_Modified w/ Merced	0	1,664	-278	-1,517	-4,637	0
Bundle B - Case X_Modified w/o East-side Tributary Surplus	0	1,631	-301	-1,517	-4,637	0
Bundle C - Case X_Modified	0	1,832	0	-1,517	0	0
Bundle C - Case X_Existing	0	1,867	0	-1,517	0	0
Bundle C - Case Y_Modified	0	1,880	0	-1,517	0	0
Bundle C - Case Y_Existing	0	1,921	0	-1,517	0	0
Bundle C - Case X_Modified with Patterson	0	1,883	0	-1,517	0	0
Bundle C - Case X_Modified w/o East-side Tributary Surplus	0	1,817	0	-1,517	0	0
Bundle D - Case X_Modified	0	1,960	0	-1,517	0	-8,989
Bundle D - Case X_Existing	0	1,976	0	-1,517	0	-8,989
Bundle D - Case Y_Modified	0	2,026	0	-1,517	0	-8,989
Bundle D - Case Y_Existing	0	2,054	0	-1,517	0	-8,989
Bundle D - Case X_Modified with Patterson	0	2,011	0	-1,517	0	-8,989
Bundle D - Case X_Modified w/o East-side Tributary Surplus	0	1,939	0	-1,517	0	-8,989
Bundle E - Case X_Modified	0	1,991	0	-1,517	0	-8,989
Bundle E - Case X_Existing	0	2,001	0	-1,517	0	-8,989
Bundle E - Case Y_Modified	0	2,085	0	-1,517	0	-8,989
Bundle E - Case Y_Existing	0	2,112	0	-1,517	0	-8,989
Bundle E - Case X_Modified with Patterson	0	2,068	0	-1,517	0	-8,989
Bundle E - Case X_Modified w/o East-side Tributary Surplus	0	1,971	0	-1,517	0	-8,989

Table Set 2 - Bundle Cost Components

Bundle Configuration	Recirculation								Groundwater and other Regulation				
All values in $1,000	Patterson Pump	TLB Pump	CVC Improve	FKC4 Pump	Total Recirc Pumping	FKC4 Pumping	Total Westside Wheeling Charge	CVC Wheeling Charge	TLB Pumping	San Luis Pumping	San Luis Gen	Total GW Pumping	Total GW Put Charge
Bundle A - Case X_Modified	0	0	0	-1,121	-837	-29	-179	-46	0	-53	33	-1,838	-16,280
Bundle A - Case X_Existing	0	0	0	-1,121	-888	-32	-191	-50	0	-61	38	-1,972	-13,513
Bundle A - Case Y_Modified	0	0	0	-1,121	-789	-28	-166	-43	0	-51	30	-1,493	-23,567
Bundle A - Case Y_Existing	0	0	0	-1,121	-836	-31	-178	-46	0	-59	35	-1,721	-19,955
Bundle A - Case X_Modified w/ Delta Recirculation	0	0	0	-1,121	-3,326	-82	-544	-134	0	-390	253	-1,713	-17,529
Bundle A - Case X_Modified w/ Patterson Recirculation	-6,499	0	0	-1,121	-3,954	-84	-564	-146	0	-573	331	-1,756	-18,175
Bundle A - Case X_Modified w/ Delta Recirculation & Patterson	-6,499	0	-3,914	-1,121	-5,572	-121	-776	-192	0	-619	371	-1,730	-19,209
Bundle A - Case X_Modified with Merced	0	0	0	-1,121	-839	-26	-179	-46	0	-52	32	-1,847	-16,680
Bundle A - Case X_Modified_w/o East-side Tributary Surplus	0	0	0	-1,121	-840	-28	-175	-46	0	-52	32	-1,772	-13,514
Bundle B - Case X_Modified	0	0	0	-1,121	-3,318	-80	-544	-134	0	-389	252	-1,578	-13,477
Bundle B - Case X_Existing	0	0	0	-1,121	-3,669	-90	-611	-145	0	-530	336	-1,709	-11,478
Bundle B - Case Y_Modified	0	0	0	-1,121	-3,067	-78	-492	-124	0	-381	247	-1,240	-20,087
Bundle B - Case Y_Existing	0	0	0	-1,121	-3,373	-88	-555	-134	0	-513	329	-1,405	-16,416
Bundle B - Case X_Modified with Patterson	-6,499	0	-3,914	-1,121	-5,566	-120	-776	-192	0	-618	374	-1,503	-16,563
Bundle B - Case X_Modified w/ Merced	0	0	0	-1,121	-3,152	-78	-531	-131	0	-380	247	-1,641	-15,213
Bundle B - Case X_Modified w/o East-side Tributary Surplus	0	0	0	-1,121	-3,382	-83	-549	-136	0	-390	253	-1,509	-12,180
Bundle C - Case X_Modified	0	-4,646	0	-1,121	-3,318	-82	-544	-134	-194	-389	251	-1,473	-15,929
Bundle C - Case X_Existing	0	-4,646	0	-1,121	-3,658	-91	-611	-145	-212	-530	336	-1,655	-13,777
Bundle C - Case Y_Modified	0	-4,646	0	-1,121	-3,064	-81	-492	-124	-192	-382	248	-1,328	-22,834
Bundle C - Case Y_Existing	0	-4,646	0	-1,121	-3,370	-90	-555	-134	-209	-514	330	-1,833	-20,544
Bundle C - Case X_Modified with Patterson	-6,499	-4,646	-3,914	-1,121	-5,565	-125	-776	-192	-198	-618	372	-1,670	-19,855
Bundle C - Case X_Modified w/o East-side Tributary Surplus	0	-4,646	0	-1,121	-3,380	-84	-549	-136	-15	-391	254	-1,502	-14,402
Bundle D - Case X_Modified	0	0	0	-1,121	-3,318	-80	-544	-134	0	-389	252	-1,275	-12,465
Bundle D - Case X_Existing	0	0	0	-1,121	-3,665	-90	-606	-144	0	-530	337	-1,449	-10,851
Bundle D - Case Y_Modified	0	0	0	-1,121	-3,065	-79	-492	-124	0	-382	248	-1,047	-18,832
Bundle D - Case Y_Existing	0	0	0	-1,121	-3,374	-89	-555	-134	0	-513	330	-1,232	-15,639
Bundle D - Case X_Modified with Patterson	-6,499	0	-3,914	-1,121	-5,562	-121	-776	-192	0	-622	375	-1,078	-15,190
Bundle D - Case X_Modified w/o East-side Tributary Surplus	0	0	0	-1,121	-3,380	-84	-544	-134	0	-390	254	-1,198	-10,740
Bundle E - Case X_Modified	0	0	0	-1,121	-3,317	-80	-544	-134	0	-389	252	-904	-9,225
Bundle E - Case X_Existing	0	0	0	-1,121	-3,661	-90	-606	-144	0	-530	336	-1,037	-7,627
Bundle E - Case Y_Modified	0	0	0	-1,121	-3,085	-79	-494	-124	0	-378	244	-519	-14,093
Bundle E - Case Y_Existing	0	0	0	-1,121	-3,373	-90	-556	-134	0	-518	330	-738	-11,406
Bundle E - Case X_Modified with Patterson	-6,499	0	-3,914	-1,121	-5,580	-124	-776	-192	0	-623	373	-590	-10,905
Bundle E - Case X_Modified w/o East-side Tributary Surplus	0	0	0	-1,121	-3,378	-83	-544	-134	0	-390	254	-812	-7,528

Table Set 2 - Bundle Cost Components

Bundle Configuration	ES Trib				Merced Intertie		Fine Gold		
All values in $1,000	Kings Pump	Kaweah Pump	Tule Pump	Total Trib River Pumping	Intertie Convey	Intertie Pumping	Fine Gold Facilities	Fine Gold Pumping	Fine Gold Gen
Bundle A - Case X_Modified	-273	-218	-229	-186	0	0	0	0	0
Bundle A - Case X_Existing	-273	-218	-229	-186	0	0	0	0	0
Bundle A - Case Y_Modified	-273	-218	-229	-193	0	0	0	0	0
Bundle A - Case Y_Existing	-273	-218	-229	-193	0	0	0	0	0
Bundle A - Case X_Modified w/ Delta Recirculation	-273	-218	-229	-186	0	0	0	0	0
Bundle A - Case X_Modified w/ Patterson Recirculation	-273	-218	-229	-186	0	0	0	0	0
Bundle A - Case X_Modified w/ Delta Recirculation & Patterson	-273	-218	-229	-187	0	0	0	0	0
Bundle A - Case X_Modified with Merced	-273	-218	-229	-186	-4,037	-282	0	0	0
Bundle A - Case X_Modified_w/o East-side Tributary Surplus	0	0	0	0	0	0	0	0	0
Bundle B - Case X_Modified	-273	-218	-229	-187	0	0	0	0	0
Bundle B - Case X_Existing	-273	-218	-229	-187	0	0	0	0	0
Bundle B - Case Y_Modified	-273	-218	-229	-193	0	0	0	0	0
Bundle B - Case Y_Existing	-273	-218	-229	-193	0	0	0	0	0
Bundle B - Case X_Modified with Patterson	-273	-218	-229	-187	0	0	0	0	0
Bundle B - Case X_Modified w/ Merced	-273	-218	-229	-187	-4,037	-282	0	0	0
Bundle B - Case X_Modified w/o East-side Tributary Surplus	0	0	0	0	0	0	0	0	0
Bundle C - Case X_Modified	-273	-218	-229	-187	0	0	0	0	0
Bundle C - Case X_Existing	-273	-218	-229	-187	0	0	0	0	0
Bundle C - Case Y_Modified	-273	-218	-229	-193	0	0	0	0	0
Bundle C - Case Y_Existing	-273	-218	-229	-193	0	0	0	0	0
Bundle C - Case X_Modified with Patterson	-273	-218	-229	-187	0	0	0	0	0
Bundle C - Case X_Modified w/o East-side Tributary Surplus	0	0	0	0	0	0	0	0	0
Bundle D - Case X_Modified	-273	-218	-229	-187	0	0	0	0	0
Bundle D - Case X_Existing	-273	-218	-229	-187	0	0	0	0	0
Bundle D - Case Y_Modified	-273	-218	-229	-193	0	0	0	0	0
Bundle D - Case Y_Existing	-273	-218	-229	-193	0	0	0	0	0
Bundle D - Case X_Modified with Patterson	-273	-218	-229	-187	0	0	0	0	0
Bundle D - Case X_Modified w/o East-side Tributary Surplus	0	0	0	0	0	0	0	0	0
Bundle E - Case X_Modified	-273	-218	-229	-187	0	0	-34,736	0	0
Bundle E - Case X_Existing	-273	-218	-229	-187	0	0	-34,736	0	0
Bundle E - Case Y_Modified	-273	-218	-229	-193	0	0	-34,736	0	0
Bundle E - Case Y_Existing	-273	-218	-229	-193	0	0	-34,736	0	0
Bundle E - Case X_Modified with Patterson	-273	-218	-229	-187	0	0	-34,736	0	0
Bundle E - Case X_Modified w/o East-side Tributary Surplus	0	0	0	0	0	0	-34,736	0	0

Table Set 2 - Bundle Cost Components

Bundle Configuration	Summary of Fixed and Variable						Purchases						
All values in $1,000	Fixed Costs	GW Put Charge	Wheeling Costs	Pumping	Generation	Annual Net Cost W/O Purchase	Cat 1 Purchases	Cat 2 ES Purchases (Variable)	Cat 2 ES Fixed Chrg	Cat 2 WS Purchases	Cat 3 ES Purchases	Residual Purchases	Total Purchases
Bundle A - Case X_Modified	-3,358	-16,280	-225	-2,943	1,906	-20,901	-6,500	-27,264	-2,714	0	-6,141	-760	-43,378
Bundle A - Case X_Existing	-3,358	-13,513	-241	-3,139	1,935	-18,315	-6,500	-27,264	-2,714	0	-13,302	-1,932	-51,711
Bundle A - Case Y_Modified	-3,358	-23,567	-210	-2,554	2,008	-27,680	-6,500	-27,264	-2,714	0	-156	-194	-36,827
Bundle A - Case Y_Existing	-3,358	-19,955	-224	-2,839	2,027	-24,348	-6,500	-27,264	-2,714	0	-2,002	-674	-39,153
Bundle A - Case X_Modified w/ Delta Recirculation	-3,358	-17,529	-678	-5,698	2,140	-25,124	-6,500	-16,561	-678	0	-5,172	-271	-29,182
Bundle A - Case X_Modified w/ Patterson Recirculation	-9,857	-18,175	-709	-6,555	2,211	-33,085	-6,500	-13,000	0	0	-10,241	-457	-30,198
Bundle A - Case X_Modified w/ Delta Recirculation & Patterson	-13,771	-19,209	-968	-8,229	2,261	-39,916	-6,500	0	0	0	-9,816	-475	-16,791
Bundle A - Case X_Modified with Merced	-7,394	-16,680	-225	-3,233	1,883	-25,649	-6,500	-24,222	-631	0	-7,541	-867	-39,760
Bundle A - Case X_Modified_w/o East-side Tributary Surplus	-2,638	-13,514	-221	-2,692	1,850	-17,216	-6,500	-24,222	-631	0	-13,802	-807	-45,962
Bundle B - Case X_Modified	-7,995	-13,477	-678	-5,837	1,902	-26,084	-6,500	0	0	0	-14,663	-152	-21,316
Bundle B - Case X_Existing	-7,995	-11,478	-756	-6,572	1,979	-24,822	-6,500	0	0	0	-22,335	-494	-29,329
Bundle B - Case Y_Modified	-7,995	-20,087	-615	-5,204	1,945	-31,956	-6,500	0	0	0	-4,017	-215	-10,733
Bundle B - Case Y_Existing	-7,995	-16,416	-689	-5,858	2,037	-28,921	-6,500	0	0	0	-6,225	-621	-13,346
Bundle B - Case X_Modified with Patterson	-18,408	-16,563	-968	-8,170	2,111	-41,998	-6,500	0	0	0	-6,047	-139	-12,687
Bundle B - Case X_Modified w/ Merced	-12,031	-15,213	-662	-5,998	1,911	-31,993	-6,500	0	0	0	-10,600	-182	-17,282
Bundle B - Case X_Modified w/o East-side Tributary Surplus	-7,275	-12,180	-685	-5,665	1,884	-23,921	-6,500	0	0	0	-16,694	-249	-23,443
Bundle C - Case X_Modified	-8,004	-15,929	-678	-5,642	2,082	-28,171	-6,500	0	0	0	-17,487	-908	-24,894
Bundle C - Case X_Existing	-8,004	-13,777	-756	-6,333	2,203	-26,667	-6,500	0	0	0	-24,852	-1,307	-32,659
Bundle C - Case Y_Modified	-8,004	-22,834	-615	-5,241	2,128	-34,565	-6,500	0	0	0	-8,628	-657	-15,785
Bundle C - Case Y_Existing	-8,004	-20,544	-689	-6,208	2,250	-33,195	-6,500	0	0	0	-9,485	-731	-16,716
Bundle C - Case X_Modified with Patterson	-18,417	-19,855	-968	-8,363	2,256	-45,348	-6,500	0	0	0	-8,239	-812	-15,550
Bundle C - Case X_Modified w/o East-side Tributary Surplus	-7,284	-14,402	-685	-5,372	2,071	-25,672	-6,500	0	0	0	-21,149	-953	-28,603
Bundle D - Case X_Modified	-12,347	-12,465	-678	-5,249	2,212	-28,526	-6,500	0	0	0	-14,884	-274	-21,658
Bundle D - Case X_Existing	-12,347	-10,851	-750	-5,922	2,313	-27,556	-6,500	0	0	0	-22,458	-803	-29,761
Bundle D - Case Y_Modified	-12,347	-18,832	-616	-4,765	2,273	-34,286	-6,500	0	0	0	-4,297	-165	-10,962
Bundle D - Case Y_Existing	-12,347	-15,639	-689	-5,401	2,383	-31,692	-6,500	0	0	0	-6,923	-425	-13,848
Bundle D - Case X_Modified with Patterson	-22,760	-15,190	-968	-7,569	2,386	-44,102	-6,500	0	0	0	-6,493	-289	-13,282
Bundle D - Case X_Modified w/o East-side Tributary Surplus	-11,627	-10,740	-679	-5,052	2,192	-25,906	-6,500	0	0	0	-16,882	-285	-23,667
Bundle E - Case X_Modified	-47,083	-9,225	-678	-4,876	2,243	-59,620	-6,500	0	0	0	-12,728	-216	-19,444
Bundle E - Case X_Existing	-47,083	-7,627	-750	-5,505	2,337	-58,628	-6,500	0	0	0	-20,101	-646	-27,247
Bundle E - Case Y_Modified	-47,083	-14,093	-618	-4,254	2,329	-63,718	-6,500	0	0	0	-3,120	-151	-9,771
Bundle E - Case Y_Existing	-47,083	-11,406	-689	-4,913	2,443	-61,649	-6,500	0	0	0	-5,752	-194	-12,446
Bundle E - Case X_Modified with Patterson	-57,496	-10,905	-968	-7,104	2,441	-74,032	-6,500	0	0	0	-5,741	-252	-12,493
Bundle E - Case X_Modified w/o East-side Tributary Surplus	-46,363	-7,528	-679	-4,663	2,225	-57,009	-6,500	0	0	0	-15,141	-203	-21,844

Table Set 2 - Bundle Cost Components

Bundle Configuration	Total		
All values in $1,000	Total Annual Net Cost w/o Credits	Credits	Total Annual Net Cost with Credits
Bundle A - Case X_Modified	-64,279	6,192	-58,087
Bundle A - Case X_Existing	-70,026	3,065	-66,961
Bundle A - Case Y_Modified	-64,507	14,838	-49,669
Bundle A - Case Y_Existing	-63,501	10,050	-53,451
Bundle A - Case X_Modified w/ Delta Recirculation	-54,306	6,887	-47,419
Bundle A - Case X_Modified w/ Patterson Recirculation	-63,283	6,993	-56,290
Bundle A - Case X_Modified w/ Delta Recirculation & Patterson	-56,707	7,886	-48,821
Bundle A - Case X_Modified with Merced	-65,409	6,186	-59,223
Bundle A - Case X_Modified_w/o East-side Tributary Surplus	-63,178	4,083	-59,095
Bundle B - Case X_Modified	-47,400	4,213	-43,187
Bundle B - Case X_Existing	-54,151	1,921	-52,230
Bundle B - Case Y_Modified	-42,689	11,955	-30,734
Bundle B - Case Y_Existing	-42,267	7,351	-34,916
Bundle B - Case X_Modified with Patterson	-54,685	6,975	-47,710
Bundle B - Case X_Modified w/ Merced	-49,275	5,356	-43,919
Bundle B - Case X_Modified w/o East-side Tributary Surplus	-47,364	3,535	-43,829
Bundle C - Case X_Modified	-53,065	6,825	-46,240
Bundle C - Case X_Existing	-59,326	3,954	-55,372
Bundle C - Case Y_Modified	-50,351	14,338	-36,013
Bundle C - Case Y_Existing	-49,910	9,063	-40,847
Bundle C - Case X_Modified with Patterson	-60,899	9,211	-51,688
Bundle C - Case X_Modified w/o East-side Tributary Surplus	-54,275	5,426	-48,849
Bundle D - Case X_Modified	-50,184	4,798	-45,386
Bundle D - Case X_Existing	-57,317	2,592	-54,725
Bundle D - Case Y_Modified	-45,248	11,963	-33,285
Bundle D - Case Y_Existing	-45,540	7,642	-37,898
Bundle D - Case X_Modified with Patterson	-57,384	7,995	-49,389
Bundle D - Case X_Modified w/o East-side Tributary Surplus	-49,573	3,719	-45,854
Bundle E - Case X_Modified	-79,064	4,013	-75,051
Bundle E - Case X_Existing	-85,875	1,907	-83,968
Bundle E - Case Y_Modified	-73,489	10,787	-62,702
Bundle E - Case Y_Existing	-74,095	6,612	-67,483
Bundle E - Case X_Modified with Patterson	-86,525	7,053	-79,472
Bundle E - Case X_Modified w/o East-side Tributary Surplus	-78,853	2,867	-75,986

Appendix E
Water Purchases and Sales

Section 1. Oil Field Water
Section 2. Municipal/Industrial Wastewater and Urban Water Conservation
Section 3. Supply Curves for Water Purchases

Appendix E

Section 1
Oil Field Water

E1.1 INTRODUCTION

Oil field water is a potential source of reclaimed water that could be used for irrigation purposes. The reclaimed water would be blended with higher-quality water for irrigation of crops. Over 490 oil fields in the San Joaquin Valley may have the potential to produce oil field water for irrigation use, but only a very small percentage of these (18 fields, or 3.7 percent) have sufficient water in their oil wells for practical consideration as a supply source.

E1.2 ASSUMPTIONS AND METHODOLOGY

In this analysis, oil-field water volume and water quality data were collected from the 18 oil fields in the San Joaquin Valley that produced more than 500 acre-feet of water per year. Water data from the most recent annual report (1999) of the California Department of Conservation, Division of Oil, Gas, and Geothermal Reserves was used. If fields had been active prior to 1999 but were not producing more than 500 acre-feet of water in 1999, they were not included in this analysis. Water yields and water quality data were compared for those 18 fields. To further the analysis, additional research included the following assumptions and methodology:

- Water quality issues were researched because the driving force in recovering water from oil wells is the water quality. Quality is best on the east side of the Central Valley, in newer wells.
- Access to conveyance facilities was identified by using oil-field maps and DeLorme Southern California Atlas maps to identify fields that are closest to major water conveyance facilities, roads, and any other identifying items such as towns, power plants, and pumping stations.
- Costs associated with water conveyance were determined because the method used to transport water from oil wells to end users determines the cost of the reclaimed water.

E1.3 STUDY RESULTS

E1.3.1 Yield and Quality

Oil field water is typically available at a relatively constant rate, 365 days per year. A greater volume of oil field water exists on the west side of the San Joaquin Valley, but the water quality is better on the east side. About 167,000 acre-feet of oil field water is extracted each year in the San Joaquin Valley, of which approximately 100,000 acre-feet are on the west side (Vorster 2001).

Of the six counties in the San Joaquin Valley (Fresno, Kern, Kings, Madera, Merced, and Stanislaus), oil-field water in quantities greater than 500 acre-feet per year is found only in Kern and Fresno counties. A total of 18 fields in those two counties produce an average of 9,000 acre-feet per year of oil field water, with one field producing over 53,000 acre-feet per year (California Department of Conservation 2000a). See Table E1-1 for a summary of water yield for the 18 fields.

Table E1-1 Summary of Oil Fields in the San Joaquin Valley with Oil Well Water Greater than 500 Acre-Feet per Year

			Water Quality by Oil Field													
			Summary of Salinity, NaCl (ppm)			Summary of TDS (ppm)			Summary of Rw (ohm/m) 77°F			Summary of Conveyances, Roads, and Other Facilities				
Oil Field Name	Water (bbl)	Water (AF)	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Water Bodies/Conveyances	Roads	Cities/Towns/Other	Major Operators and Water Volume (>1mm barrels)	Comments
Ant Hill	3,882,891	501	4,600	1,600	3,100	4,700	3,500	4,100	2.05	1.20	1.63	Poso Creek, Kern River, Arvin-Edison Canal, California Aqueduct	Edison Highway, Comanche Dr		Stockdale Oil & Gas - 3,882,891	0.5 TAF potentially available.
Belridge North	10,673,786	1,376	40,000	8,400	22,600	42,000	10,100	25,650	8.00	0.15	1.85	Aqueduct	Highway 33	NE of Carneros Pumping Stn, N of unnamed pumping stns	Aera - 7,783,058; Crutcher-Tufts - 2,247,070	
Belridge South	225,093,373	29,014	40,000	10,700	26,500	40,000	13,900	29,600	0.73	0.16	0.35		Highway 33, Standard Rd, Lost Hills Rd,	Missouri Triangle, South Bellridge; E of Middlewater Pumping Stn, SE of Carneros Pumping Stn	Aera - 214,087,633; Crutcher-Tufts - 1,969,080; ExxonMobil - 6,329,938; Nuevo Energy - 2,192,601	
Buena Vista	8,174,061	1,054	40,100	10,100	28,914	40,317	27,430	32,749	0.27	0.16	0.21		Highways 119 and 33	Valley Acres, Dustin Acres; in Naval Petroleum Reserve No. 2?	Crimson Res Mgmt - 2,008,973; Nuevo Energy - 1,655,379; Vintage Petroleum - 3,803,705	
Cymric	79,891,533	10,298	25,700	1,700	15,548	25,967	4,844	17,629	1.90	0.26	0.56		Cymric Rd, Lost Hills Rd, Franco Western Rd, Highway 33	Monument Junction	Aera - 23,128,099; Chevron - 36,163,112; Nuevo Energy - 19,816,187	100,000 barrels/day (4,700 AF/year) disposed of by Valley Waste. Water quality precludes recovering remaining water.
Edison	5,492,650	708	17,800	70	3,774	17,810	532	4,172	10.80	0.36	4.53	East Side Canal, Poso Creek, Kern River, Arvin-Edison Canal, California Aqueduct	Panama Rd, DiGiorgio Rd, Vineland Rd, Eidson Rd, Malaga Dr, Commanche Dr, Tejon Highway, Sunset Blvd, Bear Mtn Blvd, Sycamore Rd, Edison Highway, Muller Rd	Buena Vista	Kenneth H. Hunter Trust - 1,830,376; Naftex Operating Co - 2,156,104	9,000 barrels/day disposed of by Valley Waste, pumped at cost of $.10/barrel ($775.80/AF, 423 AF/year). Potentially, .3 TAF available per year but TDS averages high.
Elk Hills	33,559,146	4,326	24,300	3,596	16,190	37,300	4,560	26,155	1.50	0.20	0.39	California Aqueduct	Elk Hills Rd, Skyline Rd, 30S Rd, 28S Rd, South Access Rd, Highway 119-Taft Highway, Tupman Rd, N flank Rd	Asphalto, in Naval Petroleum Reserve No.1?	Occidental of Elk Hills - 33,559,146	
Fruitvale	5,050,723	651	7,700	150	2,255	10,800	900	3,991	7.30	0.54	2.54	Calloway Canal, Friant-Kern Canal	7th Std Rd, Highway 58, Fruitvale Ave, Highway 99, Rosedale Highway, Jewetta Ave, Calloway Rd	powerplant	San Joaquin Fac Mgmt - 3,807,545	0.7 TAF potentially available.
Kern Front	36,533,101	4,709	200	80	140	1,100	500	800	12.00	9.00	10.50	Poso Creek	Highway 65, James Rd, Oilfields Rd, Woody Rd, Lerdo Highway		Bellaire Oil - 1,949,639; Oxy USA - 30,044,604; Stockdale Oil & Gas - 4,202,424	1.5 TAF going to Cawelo ID via Valley Waste. Gravity-fed canals and treatment ponds, cost of $.01-.02/barrel ($77.58-$155.16/AF). Potentially 3.2 TAF available.
Kern River	411,578,184	53,052	4,540	100	1,813	5,382	500	2,294	13.00	1.00	6.83	Beardsley Canal, Kern River, Kern Island Canal	Bakersfield-Glennville Rd, Granite Rd, Petrol Rd, Manor St	Bakersfield	Chevron - 51,018,573; Bellaire Oil - 1,949,639; DAI Oildale - 1,341,335; Texaco Expl - 358,575,211	23 TAF going to Cawelo ID; have plans to double that - if 46 TAF gone, potentially 7 TAF available.
Lost Hills	42,099,994	5,427	27,000	10,000	17,778	38,000	15,500	28,780	0.36	0.04	0.20	California Aqueduct	Lost Hills Rd, Holloway Rd, G.P. Rd, Highway 46		Aera - 16,937,475; Chevron - 20,577,423; Seneca Res - 3,982,786	
McKittrick	10,263,297	1,323	24,500	1,200	10,980	28,200	2,000	14,479	3.30	0.24	0.95		Highways 33 and 58, Reward Rd		Aera - 6,688,586; Chevron - 1,802,091; Texaco - 1,716,747	Valley Waste disposes some of the oil well water.
Midway-Sunset	205,939,567	26,545	37,000	50	16,895	38,000	1,650	19,395	5.50	0.17	0.90	California Aqueduct, Buena Vista Creek	Highway 166, Western Minerals Rd, Short Rd, Highways 33 and 119, Airport Rd, Gardner Field Rd, S Lake Rd, Middil Rd, Midway Rd, Mocal Rd, Highway 58, Shale Rd	Maricopa, Taft, Taft Heights, South Taft, Derby Acres, Fellows; near San Luis Obispo Co.	Aera - 92,140,221; Berry Petroleum - 14,211,578; Chevron - 14,722,299; Holmes Western Oil - 1,954,689; McFarland Energy - 3,063,347; Nuevo Energy - 8,861,192; Seneca Res - 4,064,525; Texaco - 56,443,172; Texaco Expl - 4,953,985	150,000 to 200,000 barrels/day (7,000 to 9,400 AF/year) disposed of by Valley Waste. Possible to reclaim some with better water quality?
Mount Poso	27,798,988	3,583	1,700	150	677	1,500	550	1,057	3,300.00	3.40	555.12	Poso Creek	Highways 65 and 155, Granite Rd, Famoso Woody Rd, Bakersfield-Glennville Rd	south of Jasmin Field, almost to Tulare Co.	Cimarron Oil - 1,392,188; Schaefer Oil - 9,551,885 (99.4% water); Stocker Res - 11,280,184	3.6 TAF potentially available.
Poso Creek	11,115,569	1,433	1,839	60	482	2,060	220	1,035	27.00	2.80	10.17	Poso Creek	Highway 65, James Rd, Oilfields Rd, Woody Rd, Lerdo Highway		E&B Nat Res Mgmt Corp - 8,336,465; Nevada Titan Energy - 1,886,155	1.4 TAF potentially available.
Round Mountain	40,734,348	5,251	2,500	750	1,494	2,700	1,400	1,900	4.60	2.20	3.35	Poso Creek, Kern River, Arvin-Edison Canal, California Aqueduct	Round Mountain Rd, Eastmont Rd		MacPherson Oil - 40,669,482 (98.6% water)	5.3 TAF potentially available.
Yowlumne	13,323,663	1,717	12,600	12,000	12,300	15,000	14,000	14,500				California Aqueduct	Highway 166-Maricopa Highway	small, unnamed reservoirs, gravel pits; north of Los Lobos Oil Field	Aera - 13,323,663	
Coalinga (Fresno Co.)	89,440,478	11,529	2,600	1,600	2,100	9,400	3,300	6,300	1.46	1.01	1.24	Warthan Creek	Highway 33, Palmer Ave, Monterrey Ave, Oil City Rd, Shell Rd, Highway 33/198, Derrick Ave, Jayne Ave, Lucille Ave, I-5	pumping stn, Coalinga No. 2 Substn, airport, small unnamed reservoirs	Aera - 36,048,306; Chevron - 53,314,054	

Information from:
California Oil and Gas Fields, Volume I, Central California, Publication No. TR11, California Department of Conservation, Division of Oil, Gas, and Geothermal Resources, Sacramento, 1998.
California Department of Conservation, Division of Oil, Gas, and Geothermal Resources, Maps. Publication No. PR1S, October 2000.
DeLorme, 1998. Southern and Central California Atlas and Gazetteer. Yarmouth, Maine.

= fields with average TDS of 2,294 ppm or less, indicating fields with potentially clean water for reclamation.

According to the Central Valley Regional Water Quality Control Board (Patterson, 2001), reclaimed water must meet the following criteria for irrigation:

- 1,000 micromhos/cm – EC
- 200 milligrams per liter (mg/L) – chlorides
- 1 mg/L – boron

Oil field water has levels of salt and boron that can damage sensitive crops if not diluted. In general, the water quality of oil field water is better on the east side of the valley. Salt levels northeast of Bakersfield are 1,000 to 1,500 parts per million (ppm) Total Dissolved Solids (TDS). Boron levels in the same area are typically 0.8 to 1.0 ppm and are the controlling water quality constituent that governs blending ratios. Districts applying the water to permanent crops typically blend to maintain boron concentrations below 0.5 ppm but allow short-term spikes of up to 0.8 ppm. Other areas in Kern County may have significantly higher levels of salts and boron.

Of the 18 oil fields in the San Joaquin Valley that produce more than 500 acre-feet per year of oil field water, average salinity ranges from 128 to 28,914 ppm. Only two fields (Edison and Kern Front) have an average salinity of less than 200 ppm and would meet the salinity criteria listed above without treatment.

The 18 oil fields have an average TDS of 13,033 ppm. The Kern River fields vary but have an average TDS of 2,294 ppm or less. Water currently reclaimed from these Kern fields is limited to water with lower TDS than this average. Water with higher TDS that is potentially available would require additional treatment in order to be usable. Acceptability criteria will need to be more thoroughly evaluated in addressed in a subsequent phase of the FWUA and NRDC Coalition restoration planning process. Assuming the Kern River field average as an upper limit of acceptability, there are five fields altogether that have an average TDS of 2,294 ppm TDS or less and could potentially be used as a source of irrigation water, although the water would likely have to be blended with other sources to reduce the salinity. The five fields with relatively low average TDS in their oil field water (Kern Front, Mount Poso, Poso Creek, Round Mountain, and Kern River) range in water productivity from 1,433 acre-feet per year (Poso Creek) to 53,052 acre-feet per year (Kern River) (California Department of Conservation 1998). See Table E1-1 for a summary of water quality for the 18 fields.

The water available for use in the Water Supply Plan cannot be water that is already purchased from oil wells. As shown on Table E1-1, some of the available water from the five abovementioned fields is currently being purchased or is in the planning stages to be purchased. The total of the potentially available amounts is approximately 22,000 acre-feet. However, to account for unknown water quality and conveyance issues, the amount of water potentially available from oil field water has been limited to 10,000 acre-feet per year in the model. The assumed amount will need to be verified in a subsequent phase of the FWUA and NRDC Coalition restoration planning process.

E1.3.2 Conveyance and Costs

The location of oil fields in relation to existing conveyance facilities or roads will affect the accessibility and cost of reclaiming oil field water. Several of the 18 fields are near canals or

aqueducts that could potentially serve as conveyance facilities for reclaimed oil field water if the water quality met the standards. In addition, most of the wells have numerous roads crossing through or near the fields (California Department of Conservation 2000b; DeLorme 1998). Table E1-1 summarizes the conveyances and roads that are in the vicinity of the 18 fields.

The arrangements for the purchase or disposal of oil field water appear diverse. Oil field water conveyance pipelines that have been built have cost several million dollars. For example, Valley Waste Disposal is a cooperative that conveys well water from Kern Front oil fields to the Cowelo Irrigation District. The disposal cooperative built channels, pipelines, and ponds to transport and treat the oil field water. The system is gravity fed and does not require pumping to move the water from the oil wells to the irrigation district. Typically the cost of the oil field water ranges from approximately $76 to $155 per acre-foot but could cost as much as $755 per acre-foot at other fields if pumping is required (Bright 2001).

One water agency charges an oil company $34 per acre-foot to take the water into its system. Another agency purchases the water from the oil company at $10 per acre-foot. More typically, according to the Central Valley Regional Board, oil field water is generally either reinjected into wells or left to drain into sumps (Gray 2001). The cost for these treatments is not prohibitive and may be as little as $78 per acre-foot (Bright 2001). To estimate the cost to reclaim oil field water for this plan, it was assumed that the average net cost to develop, treat, and deliver water for use was $400 per acre-foot. This estimate is based on a midpoint value (between $76 and $755) that was comparable to other water deliveries. At this rate, it would be reasonable to treat 10,000 acre-feet per year, approximately half the amount of Category 1 water used in the hydrologic model.

E1.3.3 Implementation Issues

Oil field water typically has high water temperatures compared with other surface and groundwater sources. Temperatures of oil field water northwest of Bakersfield average 141 degrees Fahrenheit year-round. The high temperatures can lead to algal blooms in reservoirs and canals that receive oil field water.

Periodically, crude oil can be accidentally discharged into the agricultural water agency's pipelines. This requires contingency planning and quick responses from hazardous materials cleanup crews.

In some areas, farmers and the environmental community may resist the use of oil field water for crop irrigation. Current use of oil field water offsets the need for surface water diversions or groundwater pumping. Specific use of this opportunity to create restoration flows would require institutional arrangements to create a crediting system to account for the offset.

E1.4 CONCLUSIONS

- Only a small percentage of oil fields in the San Joaquin Valley have a practicable supply of water (18 out of 493 produce more than 500 acre-feet per year).
- Based on the average TDS of the Kern River field, which is currently used as a source of oil field water, five fields (approximately one-third of the identified 18 oil fields) could meet or better that water quality criteria.

- Cost to reclaim oil field water averages $400 per acre-foot, and the supply averages only approximately 10,000 acre-feet per year.

E1.5 REFERENCES

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Appendix E

Section 2
Municipal/Industrial Wastewater and Urban Water Conservation

E2.1 MUNICIPAL/INDUSTRIAL WASTEWATER TREATMENT

E2.1.1 Description

Numerous wastewater treatment facilities are located throughout the San Joaquin Valley, and the effluent from these wastewater treatment plants may be a potential water supply for this project. This water may be applied to non-human consumption crops, applied to land for groundwater recharge, or released to surface water to the river systems and used downstream.

The purpose of this study is to evaluate potential new water supplies from this source. Water is considered new water if it is not currently used for other purposes and would not have to be replaced if used for this project. Wastewater effluent that currently is treated and disposed is not considered in this analysis because it is currently being used for irrigation or groundwater recharge. However, the unused treatment capacity at existing wastewater treatment facilities is potentially a new supply if the ultimate disposal of that water would result in a consumptive use of that water (such as evaporation). Treated wastewater could be incorporated into the water supply for this project in lieu of a consumptive use type of disposal.

The potential supply of new water at a wastewater treatment facility is calculated by subtracting current inflow to a treatment plant from the design capacity. The assumption in this analysis is that the community will continue to grow following the growth projections in the community general plan and use the available capacity at the treatment plant.

This analysis was designed to provide an overview of the potential magnitude of this water supply. The ultimate supply would be a function of the location of the treated wastewater, negotiations regarding sale of the supply, the quality of the supply, and the eventual use of the water.

E2.1.2 Process of Interviewing Wastewater Treatment Personnel

The magnitude of this potential supply was estimated by first identifying the amount of unused treatment capacity in the San Joaquin Valley. Wastewater treatment facility personnel from Merced to Bakersfield were contacted and asked to supply data about treatment plant design capacity, capacity used, level of treatment, current effluent disposal practices, and future plans of expansion. A copy of the list of questions asked can be found in Attachment A.

E2.1.3 Results of Interview Process

Information for 21 different wastewater treatment facilities was acquired for this analysis (Table E2-1). Table E2-1 lists current uses of effluent, where the effluent is used, and future disposal plans. The results show that the facilities contacted have a total remaining capacity of 135 thousand acre-feet per year (TAF/yr). The majority of the facilities have a secondary level of treatment and land disposal of the effluent. Several facilities have primary treatment or a combination of primary and secondary level treatment. Table E2-2 lists all facilities by underlying groundwater basin. Several of the treatment plants, including Coalinga, Delano, Madera, Mendota, and Tulare, are looking for land to discharge anticipated future effluent volumes.

Table E2-1
Wastewater Treatment Facilities Contacted for This Analysis

Wastewater Treatment Facility	Current Effluent Discharge	Place of Discharge	Plans for Expanding Capacity	EIR Prepared for Expansion	Need Discharge Point?
Bakersfield	AG	5,100 acres municipal land and 4,700 private	No	NA	No
Ceres	PEP, SWD	On site	Yes	Not needed	No
Coalinga	AG	Private and public land	Yes	No	Yes
Delano	AG	Private and public land	Yes	Yes	Yes
Dinuba	PEP	On site	Yes	Yes	No
Fresno	PEP, SWD	PEP - On site; SWD - into canal that drains into SJR	No	NA	No
Hanford	AG	6,500 acres around Hanford	Yes	Yes	No
Lindsay	PEP	On site	No	NA	No
Los Banos	PEP, AG	On site	Unknown	NA	No
Madera	PEP, AG	On site	Yes	No	Yes
Mendota	PEP, SWD	PEP - On site; SWD - onto land owned by city	No	No	Yes
Merced	SWD	Into canal that drains into the SJR	Yes	Not needed	No
Modesto	AG, SWD	AG - 2,500 acres owned by city; SWD - into SJR	No	NA	No
Porterville	PEP, AG	PEP - On site; AG - reclamation area adjacent to airport and on airport	No	NA	No
Sanger	PEP, AG	On site	No	NA	No
Selma-Kingsburg-Fowler	PEP, AG	PEP - On site; AG - No. of facility on district property	No	NA	No
Taft – ECO Resources Inc.	AG, SWD	AG - 64 acres owned by city; SWD - 80 acres of land owned by city and Department of Energy	Yes	Negative Declaration	No
Tracy	SWD	SWD - Into Old River	No	NA	No
Tulare (Domestic)	AG	AG - land located southwest of City	Yes	Yes	Yes
Tulare (Industrial)	AG	AG - land located southwest of 1875 South West St.	Yes	Yes	Yes
Turlock	AG (seasonally), SWD	AG - Unknown; SWD - into SJR	Yes	Unknown	
Visalia	PEP, AG, SWD	PEP - On site; AG - on site; SWD - into irrigation ditches	Yes	Negative Declaration	No

AG = Agricultural use
NA = Not applicable
PEP = Percolation evaporation ponds
SJR = San Joaquin River
SWD = Surface water delivery

Table E2-2
Wastewater Treatment Facility Capacity

Groundwater Basin	City	Design Capacity (TAF/yr)	Average Inflow (TAF/yr)	Remaining Capacity (TAF/yr)	Level of Treatment
Subbasin 10	Los Banos	5.5	3.6	1.9	Primary
Subbasin 11	Ceres	2.8	3.1	0.0	Primary & Secondary
	Modesto	78.4	31.7	46.7	Secondary
	Tracy	10.1	7.6	2.5	Secondary
	Turlock	22.4	11.2	11.2	Secondary
Subbasin 13	Madera	7.8	5.4	2.5	Secondary
	Merced	11.2	8.2	3.0	Secondary
Subbasin 14	Coalinga	1.5	1.0	0.4	50% Primary 50% Secondary
Subbasin 15	Hanford	6.2	5.4	0.8	Secondary
	Mendota	1.4	1.2	0.2	Secondary
Subbasin 16	Fresno	89.6	78.4	11.2	Secondary
Subbasin 17	Dinuba	3.5	2.2	1.3	Secondary
	Sanger	2.6	2.0	0.6	Secondary
	Selma-Kingsburg-Fowler	9.0	3.4	5.6	Secondary
Subbasin 18	Lindsay	5.6	1.2	4.4	Secondary
	Porterville	9.0	5.2	3.8	Secondary
	Tulare (Domestic)	6.7	3.6	3.1	Secondary
	Tulare (Industrial)	4.9	5.7	0.0	Secondary
	Visalia	17.9	4.7	13.3	Secondary
Subbasin 20	Delano	4.9	4.9	0.0	Secondary
Subbasin 21	Bakersfield	45.9	32.5	13.4	Secondary
	Taft	1.3	1.3	0.0	Secondary
	Total	**348.2**	**223.5**	**125.8**	

TAF/yr = thousand acre-feet per year

E2.1.3.1 Yield

Most wastewater treatment plants in the San Joaquin Valley that were inventoried for this study have an unused capacity. As the population grows this available capacity will be used, resulting in additional effluent. This effluent could be available for release into the San Joaquin River system or for the exchange of surface water currently being used by an irrigator. Irrigation use of this new effluent would have the same limitations as the currently used effluent; it would be limited to use on non-human consumption crops. Wastewater generated in these facilities could be exchanged for surface water and used for irrigation or released to the San Joaquin River.

This effluent would be derived from expanded municipal and industrial water use in the communities of the San Joaquin Valley. Because the ultimate buildout of the treatment plants is addressed in the local general plans and environmental documents for the treatment plants, it is assumed that the source(s) of the water needed to accommodate expected growth is available. The new urban water supply may come from an existing groundwater or surface water supply, and therefore the resulting wastewater effluent may not be new water.

According to the data collected in Table E2-2, a total wastewater treatment plant capacity of 126 TAF/yr remains. The treatment plants with the largest available capacity are Modesto, Bakersfield, Fresno, and the communities around Visalia. In large communities such as Bakersfield, the effluent supply is under contract for use by outside parties. This supply will not be available in the future. In the Fresno area, the wastewater is extensively reused irrigation and percolation to groundwater. The remaining effluent capacity is not considered new water.

Relative to the groundwater basins, the largest remaining wastewater treatment plant is in an area that overlies groundwater Subbasins 11, 16, 18, and 21. Based on recent analyses conducted for long-term water contract renewal environmental documents, the subbasins in the southern San Joaquin Valley are projected to have a future unmet water demand (Table E2-3).

Table E2-3
Unmet Water Demand for Friant Unit Contractors in the San Joaquin Valley

Groundwater Subbasin	Unmet Water Need (acre-feet/yr)
13	171,235
16	9,885
17	31,752
18	253,271
20	33,593
21	57,648

Source: USBR 2000

This projected unmet water demand represents an alternative, or competing, use for the wastewater effluent that would be generated as communities in the valley build out. Therefore, when developing this source of water, it must be assured that this is a new source of water and does not represent a net loss of water to a groundwater subbasin.

E2.1.3.2 Cost

The cost of municipal wastewater depends on prices negotiated with the treatment plant operator, the length of pipeline needed to convey the effluent to the place of use, the level of treatment, and any storage needs. The current regional cost for wastewater treatment is $200-500 per acre-foot. This cost does not separate treatment and disposal costs.

E2.1.3.3 Implementation Issues

The implementation of this water supply is affected by several issues that could limit its use. These issues are summarized below.

- Currently, the use of effluent to irrigate crops is limited to non-human consumption crops. Future available water may have similar constraints in the absence of advanced treatment. Advanced treatment may make the water too expensive to use on some crops.
- Discharge of wastewater into the river is constrained by limitations established by the Regional Water Quality Control Board (RWQCB), and any new discharges would require RWQCB approval. Surface water discharge may also require a higher level of treatment.
- Currently, most wastewater facilities discharge effluent on-site at the treatment facility. Off-site discharge would require a National Pollution Discharge Elimination System (NPDES) permit. All new facilities would have to acquire necessary permits to discharge water off-site. To acquire permits, facilities may require upgrading of facilities, which could become costly.
- The quality of water would also be a consideration to farmers. For example, secondary-level treatment may be used for non-human consumption crops, but some farmers may reject the effluent because of the constituents in effluent, such as salts.

E2.1.3.4 Timing of Supply

Effluent would have to be banked until the time of year that it is needed to fully realize the quantities described above. Depending on location of source, facilities to bank water may or may not be needed. Development of groundwater banks or percolation ponds can be accomplished in 0-5 years.

E2.1.4 Conclusions

Treated wastewater is an uncertain water supply for this project. The available volume and timing of the supply must be explored in greater detail before this supply can be considered firm. In addition, this supply should be considered in lieu of disposal methods such as evaporation that have a high consumptive use. Also, contracting, conveyance, and regulatory issues must be determined. The primary issues associated with wastewater effluent use are listed below.

- Effluent currently available in the San Joaquin Valley is being used for non-human consumption crops or recharging groundwater.
- Effluent could be available as a water source in the future as communities grow and utilize current unused capacities. However, if the source water supply that is developed to serve this

growth was previously used for agriculture, the reclaimed wastewater may not represent a new supply.

- Currently there are several facilities that are looking to purchase land for effluent discharge. This water may be a source that can be purchased.
- There is 126 TAF/yr potentially available from reclaimed wastewater. However, not all of these sources are available because of existing contracts for the effluent or because the source may not be new water. Because of the limitation of needing a supply that is new water and the uncertainty of future disposal options and commitments, this supply is currently considered unavailable.
- Purchasing reclaimed water for groundwater banking may be an effective means of holding the water until it can be sold or exchanged with water users.

E2.2 WATER CONSERVATION

To estimate the potential water supply from conservation measures, three levels of detail were considered. The valleywide level was considered in California Department of Water Resources (DWR) Bulletin 160-98 (DWR 1998), while studies by CALFED and the U.S. Bureau of Reclamation (USBR) looked at the subbasin and district level, respectively.

E2.2.1 Bulletin 160-98

In Bulletin 160-98, DWR estimated that in the San Joaquin River Region there is a potential to develop 2 TAF/yr by canal lining and piping. An estimated 17 TAF/yr is available in the Tulare Lake Basin through maximizing conservation measures. These potential savings are based on a valleywide water budget and therefore include the reuse of water that was initially applied for irrigation. This approach acknowledges the multiple uses of water in the valley. The conclusion is that valleywide, only a minor amount of new water is available through conservation.

E2.2.2 CALFED Water Use Efficiency Program

CALFED also analyzed the potential agricultural water savings in the west side and east side of the San Joaquin Valley and the Tulare Lake basins. In its analysis, CALFED acknowledged the reuse of seepage and percolated water but recognized that conservation measures that would result in reduced application would help water quality and would alter the timing when water was available. The analysis also recognized that long-term conservation would affect groundwater levels and the farmers that rely on that supply.

The CALFED estimates of agricultural conservation presented in the draft Water Supply Plan are undergoing revision by CALFED. The CALFED estimates of conservation savings focus on defining quantifiable objectives for various conservation measures. Two primary conservation objectives recently revised by CALFED include decrease flows to salt sinks and decrease nonproductive evapotranspiration. Recent estimates of reduction of losses to salt sinks in groundwater subbasins 13 and 15-21 indicate that conserving flows to salt sinks would yield only minor amounts of water (less than 1,000 acre-feet per subarea). The potential conservation savings through reducing unwanted ET was estimated by CALFED by assuming that

traditionally irrigated orchards, vines, and vegetable crops could be irrigated with micro irrigation systems. The potential savings were estimated by CALFED to be 17,300 acre-feet annually (CALFED 2000).

CALFED also examined urban water conservation in the San Joaquin and Tulare Lake basins. The urban conservation potential was assessed as the total potential loss and the total irrecoverable loss (Table E2-4). The irrecoverable loss is a subset of the total loss. The CALFED analysis estimates that 9-18 TAF is potentially available through conservation of irrecoverable losses on the east side of the Valley.

Table E2-4
CALFED Estimated Urban Water Consumption

	Source	Eastside (TAF)	Tulare Lake (TAF)
Conservation Potential of Projected Losses	Table 5-14	185-225	135-175
Conservation Potential of Irrecoverable Loss	Table 5-15	9-18	45-75

Note: Irrecoverable loss is part of the total projected loss.
TAF = Thousand acre-feet

E2.2.3 U.S. Bureau of Reclamation Water Conservation Plans

The USBR required Central Valley Project water districts develop water conservation plans pursuant to the Central Valley Project Improvement Act. ENTRIX reviewed the most recent plans to assess the amount of water potentially available for conservation (Table E2-6). The conservation potential associated with conveyance facilities, farm application, and losses to saline sinks is evaluated in the plans.

Table E2-5
Losses Determined in District Water Conservation Plans

	Canal Seepage (acre-feet)	Canal Evaporation (acre-feet)	Canal Spillage (acre-feet)	Total Conveyance (acre-feet)	Deep Percolation (acre-feet)	Saline Sink (acre-feet)
Total	331,649	19,775	65,999	563,884	702,397	5,076

Conservable water such as canal seepage and deep percolation of irrigation water remains in the water system and is used by other water users. Conserving this amount of water does not necessarily generate new water. However, it does allow additional flexibility in water use as explained above.

Water Lost to Groundwater Basin. The district conservation plans indicated that in the valley there is about 331,600 acre-feet of canal seepage, 66,000 acre-feet of canal spill, and 702,400 acre-feet of farm percolation. These volumes of water infiltrate to surface water sources or to the groundwater basin. However, the water remains part of the total valleywide water supply and is typically used by other parties. Reduction in these amounts may assist in increasing the flexibility of the water supply, but this is not considered new water.

Seepage loss from irrigation facilities can be recovered through piping of the water. The seepage from natural channels, such as rivers and creeks, cannot reasonably be recovered. The losses

vary between individual districts (Table E2-6). Also, not all of the district results are directly comparable because of differences between methods of accounting for losses.

Water Lost to Nonusable Locations. The district conservation plans indicated that in the valley there is about 19,800 acre-feet of canal evaporation and 5,100 acre-feet of seepage to a saline sink (Table E2-7). This volume of water could be recovered through conservation measures and would be new water.

Table E2-6
Conservation Data from Individual District Water Conservation Plans

Irrigation District Name	Year of Data	Canal Seepage (acre-feet)	Canal Evaporation (acre-feet)	Canal Spillage (acre-feet)	Total Conveyance Loss (acre-feet)	Deep Percolation (acre-feet)	Saline Sink (acre-feet)
Arvin - Edison WSD	2001	0	4,903	2,338	7,241	89,860	
Atwell Island ID	1996	0	0	0	0	0	2,323
Banta-Carbona ID	1998	86	82	0	168	1,604	0
Broadview WD	1997/ 1998	360	0	0	360	2,596	0
Central California ID	1993	NE	NE	NE	140,812	0	0
Chowchilla ID	1999/ 1996	44,164	2,000	11,255	57,419	63,782	0
Columbia Canal Co.	1993	2,720	680	138	3,538	30,300	0
Delano – Earlimont ID	1996	2,918	0	11,255	14,173	44,403	0
Exeter ID	1998	92	8	0	100	3,600	0
Firebaugh Canal WD	1993	NE	NE	NE	7,577	647	0
Fresno ID	1996	97,015	0	12,812	109,827	48,360	0
Gravely Ford Dist.	1989	0	0	0	0	2,878	0
Hills Valley ID	1996	0	0	0	0	1,644	0
Ivanhoe ID	1996	0	0	0	0	1,498	0
James ID	1999	9,534	978	450	7,128	0	0
Kern - Tulare	1996	595	361	0	956	8,451	0
Lindmore ID	1996	200	0	0	200	25,015	0
Lindsay - Strathmore ID	1996	490	0	0	490	1,433	0
Lindsay ID	1996	490	0	0	490	1,433	0
Lower Tule ID	1996	40,926	0	0	40,926	56,801	0
Madera ID (Open Canal)	1996	21,658	2,283	14,263	38,204	27,095	0

Table E2-6
Conservation Data from Individual District Water Conservation Plans

Irrigation District Name	Year of Data	Canal Seepage (acre-feet)	Canal Evaporation (acre-feet)	Canal Spillage (acre-feet)	Total Conveyance Loss (acre-feet)	Deep Percolation (acre-feet)	Saline Sink (acre-feet)
Madera ID (Rivers & Creeks)	1996	37,701	3,355	5,179	46,235	"	0
Mercy Springs WD	2001	1	27	0	28	150	103
Orange Cove ID	1995	2,614	0	0	2,614	31,345	0
Pacheco WD	1989	974	261	0	1,235	3,994	0
Panoche WD	1997	3,818	548	0	4,366	481	2,650
Patterson WD	1994	639	86	5,334	6,059	6,289	0
Pixley ID	1996	18,583	0	0	18,583	68,962	0
Plain View Wd	1989	0	0	0	0	3,266	0
Porterville ID	1996	0	0	0	0	9,396	0
Rag - Gulch ID	1996	247	0	0	247	6,121	0
San Luis Canal Co.	1993	18,534	4,191	0	22,725	16,434	0
San Luis Unit	1998	NE	NE	NE	1,906	7,357	0
Saucelito ID	1996	0	0	0	0	11,880	0
Shafter - Wasco ID	1996	0	0	0	0	34,764	0
Southern San Joaquin MUD	1996	0	0	0	0	41,302	0
Stone Coral	1996	0	0	0	0	32,047	0
Tea Pot Dome Water District	1996	7	5	0	12	476	0
Terra Bella ID	1996	0	0	0	0	0	0
Tri - Valley ID	1996	0	0	0	0	638	0
Tulare ID	1996	26,968	0	2,975	29,943	16,000	0
West Side ID	1998	315	7	0	322	95	0

NE = Not Estimated

Table E2-7
Targeted Benefits as Determined by CALFED

Ground-water Basin	Basin Name	TB	CALFED Targeted Benefit	Achievable AG Potential (TAF/yr)
10	Valley Floor West of San Joaquin River	106	Decrease flows to salt sinks	49-111
		107	Decrease nonproductive ET	7.5
11	Eastern San Joaquin Valley above Tuolumne River	127	Decrease nonproductive ET	8.2
12	Eastern Valley Floor between Merced and Tuolumne River	144	Decrease nonproductive ET	8.2
13	Eastern Valley Floor between San Joaquin River and Merced River	157	Decrease nonproductive ET	17.4
14	Westlands Area	163	Decrease flows to salt sinks	TBD
		164	Decrease nonproductive ET	8.9
15	Mid-Valley Area	167	Decrease flows to salt sinks	<1.0
		168	Decrease nonproductive ET	6.1
16	Fresno Area	176	Decrease nonproductive ET	7.3
17	Kings River Area	179	Decrease flows to salt sinks	TBD
		180	Decrease nonproductive ET	14.2
18	Kaweah River and Tule River Areas	183	Decrease flows to salt sinks	<1.0
		184	Decrease nonproductive ET	13.2
19	Western Kern County	188	Decrease flows to salt sinks	<1.0
		189	Decrease nonproductive ET	4.5
20	Eastern Kern County	193	Decrease nonproductive ET	8.1
21	Kern River Area	196	Decrease flows to salt sinks	<1.0
		197	Decrease nonproductive ET	6.4
	Total		Decrease nonproductive ET	110
	Total		Decrease flows to salt sinks	53-115

AG = Agricultural use
ET = Evapotranspiration
TAF/yr = Thousand acre-feet per year

E2.2.4 Water Needs Assessments

This information is covered in Section 4 of this Study.

E2.2.5 Cost

CALFED estimated costs for conserving the irrecoverable loss to be $110-700 per acre-foot in the eastside San Joaquin Valley and $150-950 per acre-foot in the Tulare Lake basin. The costs for conserving the applied water are $55-70 per acre-foot and $75-95 per acre-foot in the eastside San Joaquin Valley and Tulare Lake Basin, respectively. CALFED recognized that conservation may have an indirect water supply cost to water users that use the seepage from current irrigation.

E2.2.6 Conclusions

Three different analyses have identified the potential for water savings through conservation measures. The analyses looked at conservation from the valleywide, groundwater subbasins, and district-level perspectives. The volume of new water that flows to saline sinks is small (about 5,000 acre-feet annually, Table E2-5) from the USBR assessments and about 7,000 acre-feet from the CALFED assessment (CALFED 2002). Conservation measures that address conveyance seepage, canal evaporation, or on-farm loss have the potential of yielding larger quantities of water. CALFED acknowledged that a long-term reduction in these losses would have an impact on the groundwater supply, forcing groundwater users to seek other supplies. Furthermore, this reduction may exacerbate the groundwater overdraft that is present in much of the valley. Based on the water needs assessments (USBR 2000a and 2000b), about one-half of the total conserved water could be used to meet the remaining unmet water demand in the valley. The water available from reduction in evaporation or seepage to saline sinks in the valley and the Tulare Lake Basin could also be used to offset the unmet demand.

Based on review of these data, the Water Supply Oversight Team estimated that about 40,000 acre-feet would be available by agricultural conservation measures. This amount can be derived from the amount of water lost to salt sinks, canal evaporation, and canal seepage or spills.

The Water Supply Oversight Team estimated the potential urban conservation to be 10 TAF from the available data. This amount is considered to be the lower end of the volume of irrecoverable losses.

The cost of the water will range up to about $900 per acre-foot for a program to recover the percolation to saline sinks. Conveying this water to the eventual point of use is an additional cost. The cost of a program designed to conserve applied water and then store it in the groundwater for later recovery is unknown. The initial cost for conserving applied water is $55-95 per acre-foot for the eastside and Tulare Lake basins.

E2.3 REFERENCES

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Attachment A

Phone Log for Interviewing
Wastewater Treatment Plant Operators

Person Contacted:_____ Date:_____

Position: _____ Time: _____

Affiliation:_____ Location:_____

Address:_____ Phone #:_____

Notes:

_____
_____
_____
_____
_____

1) What is the current design capacity of your plant(s)?

2) What is your incoming inflow?

3) What is your current discharge?

4) What is your level of treatment?

5) What is the effluent currently being used for? How (sprinkler, flood irrigation etc.)

6) Where is the effluent currently being used?

7) Do you any have future plans for expansion? Do you have an EIR for these plans?

8) Who else in the area is producing more than 5mgd?

Appendix E

Section 3
Supply Curves for Water Purchases

TO: Water Supply Oversight Team

FROM: Stephen Hatchett, Duane Paul, Harry Seely, Michael Hanemann, and Susan Hootkins

DATE: January 4, 2002; revised September 23 and October 7, 2002

SUBJECT: Supply Curves for Water Purchases

The Water Supply Plan for restoration of the San Joaquin River is investigating a number of mechanisms for providing restoration flow. Purchases of water from willing sellers constitute a major activity in Water Supply Alternative Bundle A, and they will be used in a more limited role in other alternatives. The purpose of this memorandum is to describe the approach the consultant team is using to estimate the potential availability and cost of water market purchases, and to present results of the analysis in the form of supply curves of water from market purchases.

Three sources of information are used to create estimates of water supply from market transactions. The first source is a database of water sales compiled by Northwest Economic Associates, covering temporary and permanent transactions in the Central Valley since 1990. The second source of information is an analysis of potential water supplies from land fallowing prepared for CALFED as part of an economic analysis of potential new water supply and demand management activities to meet California's future demand (CALFED, 1999).

The third source provides expertise and opinions about the California water market from knowledgeable experts through a small number of telephone interviews. The interviews have assisted in identifying issues, limitations, and possible future directions in the water market. They did not provide specific examples of costs and prices of water sales that were not already included in the database.

Water Sale Transactions Database

Approach

NEA developed a database on water transactions for California, Arizona, and Colorado. Data for this report were restricted to water transfers originating in or destined for the San Joaquin Valley. The data are for transfers for the period from 1990 through mid 2001, encompassing drought and non-drought years. Each transaction was classified based on the original and final uses of the water, and agriculture was the source for all water transferred. Data sources included Water Strategist, Water Intelligence Monthly (both of which are compiled and published by Stratecon in Claremont, California), and newspapers and journals.

Several steps were required to reorganize the database for its use in developing supply curves. First, lease and permanent transactions were separated. Then lease transactions were

ranked on the basis of price, from lowest to highest, for dry years and non-dry years. To facilitate development of a "supply" curve representation of the data, the cumulative volume of water involved in the leases for each of the year types was calculated. Finally, the information was graphed to show the relationship between price per acre-foot (AF) and cumulative volume. Permanent sales were graphed in the same manner. A linear relationship was fit to each of the graphs.

A more rigorous analysis was undertaken to show how the price of water in lease transactions has changed over time and how the price of water varies according to water source and year type. Results indicate that over time, with all factors held constant, lease prices have increased by approximately $8 per AF per year. In addition, lease prices were found to be higher by $30 to $40 per AF (depending upon volume) in dry years than in non-dry years. Furthermore, results suggest that prices for leases of groundwater are about $35 per AF greater than for surface water. The reason for this is unclear: the higher selling price could be driven by the cost of pumping the groundwater, or it could be related to other factors such as location or reliability.

Price Escalation

Prior to creating supply curves shown below, all prices were escalated to 2001 dollars using the Implicit GDP Price Deflator. This simply adjusts for differences in the "purchasing power" of dollars spent for water in earlier years. It is uncertain whether future water prices will rise faster or slower than the general rate of inflation in the economy. Price rises can be cost-driven (resulting from changes in the underlying costs of producing a commodity for sale – in this case water) or demand-driven (caused by buyers competing and bidding up the price of a commodity).

Assessing demand-driven price increases is a primary goal of this task: to assess the effect of additional San Joaquin River Restoration demands on the market for water. As more water is demanded in the market, higher-cost suppliers (potential sellers) become willing to sell if they can get a higher price. Thus the overall market price for water would be raised independent of (or in addition to) the underlying inflation rate. Note that it is also possible for the supply side of the water market to adjust over time in ways that reduce prices. As water transactions become more common, transaction costs can decline. Also, as potential sellers observe a well-functioning market that preserves their property rights, they may lower their reservation price (the minimum price at which they are willing to sell).

The following analysis presents all water price estimates in constant 2001 dollars. Demand-driven increases in price are "built into" the analysis. Other cost-driven price increases that might change the shape or position of the supply curve are beyond the scope of this task.

Results from Transactions Database

The transactions database covers water years from 1990 through 2001. The large majority of transactions represent 1-year or other short term leases. Just over 100 transactions are included in the database, and thirteen of those represent permanent sales of a water entitlement. Eleven of the thirteen are permanent transfers of State Water Project entitlement to other SWP contractors, per the Monterey Agreement of 1995. Such transfers would not

have been made to non-SWP buyers. As a result, little usable information on permanent sales is available from the database to provide guidance for this project.

Therefore, the supply analysis here focuses on short-term lease transfers of water for two water year types:

- An average/wet water year, including 1993, and 1995-2000.
- A dry/critical water year, including 1990, 1991, 1992, 1994, and 2001.

Only results for the two years with the largest number of transactions are shown: 2000 and 2001. Because the water market in California has developed gradually over time, using the two most recent years is likely to provide the best indicator of future conditions.

Figures E3-1 and E3-2 show results for these two years. The graphs are created by ranking the transactions in order from lowest to highest cost and plotting price versus cumulative quantity. Estimated coefficients of a linear supply curve fit to the data points are shown in each figure.

These supply curves assume that each transaction observed in the database is an observation of the marginal willingness of suppliers to sell water. The price associated with each point on the curve, or increment of supply, represents the minimum offer necessary to induce the seller to sell that increment of water. If a buyer is in a position to control a market, the buyer will try to price-discriminate – essentially to buy each increment of water at or near its minimum price. In markets that function reasonably well and openly, a market-clearing price is more likely to predominate, and all buyers will pay the going rate for water regardless of its source or the seller's minimum acceptable price.

Note that these curves represent supply and price to **all** buyers in the market, not just potential purchases for San Joaquin River restoration. In order to estimate cost of water purchases for restoration, other purchasers of water (competitive bidders) should also be considered. For example, the size of the market for water purchases from the Central Valley in 2001 was over 400,000 acre-feet (see Figure E3-2). Although purchases for San Joaquin River restoration could displace (outbid) some of that activity, it is likely that much of the restoration purchases would be in addition to the existing market. In order to estimate the potential costs and quantities of water available beyond what has been observed, we use results from the 1999 CALFED study described below.

Estimates of Hypothetical Land Fallowing Transactions

Approach

Land fallowing is included here as a potential source of water for San Joaquin River restoration. Such transactions are assumed to transfer water from existing agricultural uses by reducing the consumptive use by irrigated crops.

Costs and available quantities of water from land fallowing vary by location and time. Key components of the cost at source include:

- The marginal value (MV) of water in agricultural use, defined as the net income a farmer can generate by using another increment of water in irrigated crop production
- Additional incentive above the MV needed to induce a sale and compensate the farmer for the costs and inconvenience of changing operations
- Potential compensation paid for direct and third-party impacts to water users, local governments, and others

Additional permitting, transactions, and transport costs are not included in the cost at the source. For purposes of this analysis, conveyance and exchange costs are estimated separately and described below.

The MV and quantity of water available from land fallowing were estimated using the Central Valley Production and Transfer Model (CVPTM), as described in the PEIS for CVPIA (Reclamation, 1997). CVPTM simulates decisions that Central Valley farmers make to maximize profits subject to resource, technical, and market constraints. CVPTM was used to estimate the MV of water used for irrigated crop production and, hence, the minimum price that agriculture will accept to sell different amounts of water available from land fallowing. CVPTM was used to estimate the MV per acre-foot of applied water. These estimates, and all water quantity estimates, are converted to equivalent values of consumptive use in the analysis. The California water code, SWRCB regulations, and CVPIA water transfer guidelines all attempt to assure that only "real" water is transferred. Although such rules are difficult in practice to monitor and enforce, the CVPTM analysis has assumed that only consumptive use is transferable. It is important to remember this assumption when comparing the costs of water from hypothetical land fallowing with the actual sales from the Transactions Database; the Database presents the quantity and cost of water actually sold, but in most cases does not specify how the water was generated (i.e., from re-operations, conservation, land fallowing, or other method).

Some market incentive payment above the MV of water will be necessary to induce existing users to fallow land and sell water. The incentive payment would provide profit and compensation for costs of implementing associated changes in farm and water operations. The magnitude of the needed incentive payment, is uncertain and varies for different circumstances. Based on discussions with representatives from potential urban buyers and potential agricultural sellers, and considering the experience of the 1991 Drought Water Bank, the market incentive payment during dry years (the percentage by which the price paid must exceed the MV of water to induce land fallowing and the sale of the water) was estimated to be 100 percent for the CALFED study.

Costs to compensate local water purveyors for costs of water sold and additional compensatory costs for third-party economic impact claims are not explicitly included (although they could be considered part of the incentive payment). Much uncertainty remains about the legal status of compensatory claims of third-party impact and how such claims would be verified and paid.

Land fallowing options were assessed for several regions in the Central Valley to capture regional variation. Costs and quantities are divided into ranges that show the increasing cost

of water as more land is fallowed. Implementation details were not specified for the 1999 CALFED study. Land fallowing programs can be implemented as fee title purchase of land or water, long-term leases, option agreements, short-term rotational leases, or annual agreements. Costs of water generated may differ depending on the implementation approach. For example, fee title purchase of land allows the seller to avoid all costs associated with the land, including taxes, management, maintenance, etc., and this may create a lower front-end cost. However, the buyer must then absorb those annual costs, so the total cost of a fee title purchase may not be lower.

Costs of land fallowing options were strongly influenced by the baseline assumptions used in the CALFED study. The Bay-Delta Accord and CVPIA dedicated water were assumed as part of the baseline. These have been estimated to reduce agricultural water supply by about 1 million acre-feet in a dry condition (CALFED, 1998). An additional 710 TAF of water was assumed to be acquired for instream flow and other environmental purposes through the CVPIA Water Acquisition Program and EWA. These programs effectively compete for water, raising the cost of water available for San Joaquin River Restoration.

Crop shifting is an idea related to land fallowing that was also considered. Under this concept, agriculture could shift water and land out of low revenue, high water-using crops into high revenue crops, thereby making more money with less water. However, farmers generally look for opportunities to produce high revenue crops simply to earn profit. Market factors such as demand elasticity and available processing and marketing contracts restrict farmers from increasing the high revenue crops faster than the growth in demand will support. In other words, if crop shifting were profitable and feasible (considering soil suitability, knowledge, and risk), farmers would have done it already. When a grower voluntarily fallows land to sell water, an effective crop shift from low to high revenue crops usually occurs. Similarly, if a district decided to sell water through a fallowing program, there would likely be flexibility on which growers would choose to participate. Therefore one would expect that participating growers would choose lower-value/higher water use crops to be fallowed. Crops fallowed, as predicted by CVPTM, were predominantly forage and other field crops, not vegetables, orchards, and vines. Therefore a change in crop mix was achieved without an absolute increase in production of high revenue crops.

Price Escalation

The same approach is used as was described for the Transaction Database prices. See the discussion above.

Results of Land Fallowing Analysis

Results for the two water year types are displayed in Figures E3-3 and E3-4. These estimates show water prices at the source: they do not include conveyance costs. Only results for the Eastside San Joaquin and Eastside Tulare regions are shown, although estimates for all Central Valley regions were made. The graphs are created by ranking the transactions in order from lowest to highest cost and plotting price versus cumulative quantity. Estimated coefficients of a linear supply curve fit to the data points are shown in each figure.

Interpretation of these curves is the same as described above for the transactions database curves. The baseline level of water market activity was already high, as outlined above, so the estimates of water costs from this study represent market activity beyond what has been observed in the transactions database.

Conveyance and Exchange Costs

Both sources of water transactions data report prices at the source (supplier). In order to generate a supply curve of transactions for San Joaquin River restoration, prices and quantities must be converted to their equivalents at Friant Dam. Conveyance and/or exchange costs are estimated for representative locations within each potential seller group and region.

Table E3-1 (attached) summarizes the conveyance cost estimates developed for this memorandum. Estimates are based largely on information provided by water project operators. The most likely path for transfers from the Sacramento Valley, Westside regions, and eastside San Joaquin region is assumed to be via exchange through State or Federal Delta pumping facilities, down the California Aqueduct, and through the Cross Valley Canal. Transfer costs and conveyance costs are shown for four major reaches of this assumed path.

The conveyance costs do not include transactions costs (such as for CEQA/NEPA compliance or legal fees) and local purveyor costs that might result from shifts in location or source of delivery caused by the exchange. Conveyance losses through the Delta are highly dependent on the water year type and month of physical transfer through the Delta. Capacity constraints may limit water transfers at a number of points in the system. These constraints would also apply to conveyance of other potential supplies, and therefore must be assessed as part of the overall bundles of water supplies. In particular, the Cross Valley Canal is the only significant facility available to convey water from outside to inside the Friant service area. The canal itself has limited capacity. Furthermore, without major structural improvements to both the Cross Valley Canal and the Friant-Kern Canal, it can deliver water to only limited portion of the Friant service area.

Storage and Other Costs

The supply curves developed below should be viewed as the schedules of costs and quantities of water available from the potential sellers. Although the estimates include conveyance costs to reach Friant Dam, this does not mean the water will necessarily be available at the time it is needed for release. The supply curves include water that would have been used for another purpose, and the purchase of that water implies that the buyer must use it on a similar delivery pattern (adjusted for conveyance delays) as the seller, *unless the buyer has existing storage capacity or can purchase it.*

Storage capacity is valuable for shifting water between years and within a year. Traditionally storage is used to convert a supply pattern based on hydrology (precipitation and runoff) to a pattern of demand. In the case of water transferred from an existing use, for example land

fallowing or water conservation, the existing pattern of use can be viewed (roughly) as the hydrology. Therefore, storage may be required if the buyer's use pattern is different than the seller's.

The most obvious and available storage opportunity for San Joaquin River restoration would be to use Millerton Reservoir to re-operate any water purchased through transfers or exchanges. Other opportunities could include:

- Develop other surface storage sites.
- Use groundwater basins for direct storage.
- Use groundwater basins for in-lieu storage.
- Purchase storage from the seller or from a third party.

The need for storage in excess of what Millerton can provide requires hydrologic and operations analysis, especially when water purchases are combined with other water supply options. Ideally, the analysis should identify the cost of storage separately from the "commodity" cost of the water. Some of the water prices in the Transactions Database likely include a storage value and some do not. None of the hypothetical land fallowing transactions include a storage component. Again, this does not matter if the buyer and seller have a similar use pattern or if the buyer has available storage capacity.

Other costs or benefits may be associated with re-operation of Friant Dam for San Joaquin River restoration. A potentially significant one is the change in the pattern and quantity of power generation. The amount of water flowing through generating turbines, the reservoir head (elevation), and the timing of the releases can affect the quantity and value of power produced. Costs or benefits of changes in power production are not estimated in this task.

Combined Supply Curves

Supply curves are created for two water year categories: average/wet and dry/critical. Data from the two water price studies are combined with conveyance costs to create the supply curves, shown in Figures E3-5 and E3-6. The initial portions of each curve, at the lower price ranges, include predominantly observations from the transactions database. Land fallowing transactions from the 1999 CALFED study are used to extrapolate costs and quantities beyond levels observed in recent years.

As described above, land fallowing transactions were assumed to sell only the consumptive use portion of applied water. In addition to the value of water for crop irrigation, an additional incentive payment, or markup, was added. In the CALFED study, a 100% dry year markup was added to cover local costs and profit to the seller. Based on the transactions data described above, it appears that a 50% markup is reasonably consistent with the high end of water transaction prices observed in the most recent dry year, 2001. In average and wet years, a 50% markup on the cost of fallowing land also appears to be consistent with the high cost transactions in the database.

Each of the figures indicates the approximate point at which the curve shifts from observed transactions to hypothetical transactions. This point also can be viewed as the approximate "starting point" for additional market purchases for San Joaquin River restoration, if it is assumed that all existing transactions would continue to occur. (That assumption is not necessarily true – the restoration program may be able to bid some of that water away from other buyers. For purposes of this analysis, a reasonable assumption is that water prices would begin near the upper end of the existing market.) Therefore, costs for purchasing restoration flow would start at the lines shown on the charts. Initial purchases would be approximately $160 per acre-foot for average/wet year leases, and over $300 per acre-foot for dry/critical year purchases.

Cost-Based Water Purchases

As described above, the water purchase supply curves show estimated market prices for different levels of overall water market volume. The estimated purchase price at any point on the supply curve consists of several components: the actual cost to the seller of providing the water (i.e., the net return foregone by not using the water for irrigation); an assumed 50% markup (profit) over cost as an incentive to sell; conveyance costs; and additional profit to low-cost sellers when higher-cost sellers set the going market price.

The 50% incentive is based on the price received by the seller and is estimated before adding on conveyance costs and before any adjustments for conveyance losses. Therefore it is not a fixed percent of the final cost per AF received (it generally ranges between 15-30% of the final cost per AF received). It is reasonable to estimate that about 20% of the final cost per AF received reflects the incentive payment.

The supply curves also show what the purchase costs would be if each increment (or "block of water") were purchased at its marginal cost rather than at the market-clearing price. For example, Figure C-1 in this appendix indicates that if total water purchases were about 230,000 AF in an average condition (100,000 AF for San Joaquin restoration and 130,000 AF in other transactions unrelated to the restoration program), the market price for the water acquired would be about $200 per AF received. However, the first, say, 10,000 AF block of water actually could be made available at $160 per AF, with additional 10,000 AF blocks rising in cost.

Therefore, the absolute minimum possible price to pay for each increment of water purchased can be approximated as follows:

- Select the appropriate starting point on the supply curve, representing an estimate of aggregate market transaction in the absence of the restoration program.
- Use the supply curve to estimate the marginal cost of incremental blocks of water purchased beyond the starting point. 10,000 AF increments might be reasonable.
- Reduce the price estimated from the supply curve by 20% to offset the assumed incentive payment described above.

- Add up the cost estimated in this fashion over the needed number of incremental blocks of water necessary.

Note that the cost estimate derived in this way would be very optimistic from a buyer's perspective: market forces tend to result in buyers paying more than the minimum price needed to cover a seller's cost. For this reason the water price estimates used to develop cost estimates of bundles in Section 6 have been assumed to be market-based.

Options Purchases

Options contracts are an approach that would allow the program to secure adequate supplies in all year types without the high annual cost of permanent or long-term purchases. There is, however, very little relevant information about actual options contracts for water on which to base a cost estimate appropriate for the San Joaquin Valley. So, we have developed an assumed price structure that is consistent with how options are generally priced relative to permanent long-term purchases and relative to pure spot market purchases. We use the following assumptions to estimate the Option Premium (the amount per AF paid every year regardless of whether water is taken) and the Exercise Price (the additional amount paid per AF when water is actually taken). General rules we use are:

- A 10 to 1 ratio of exercise price to premium is assumed. (Note that the premium could be a lump-sum payment up front. Some sellers might prefer this but it makes little difference to our analysis - the lump-sum payment could be financed).
- An effective price paid per AF (including both premiums and exercise price) is less than what would be required for pure spot market purchase, but greater than the price for a long-term purchase.
- Options pricing is also affected by overall demand - the higher the amount secured under option, the higher the price paid. We assume here that the price rises with quantity at the same rate estimated for the average year purchases in the price analysis described above.

Using these assumptions to set bounds for the analysis still leaves a range of possible prices. As an additional guide, we note that California Department of Water Resources' recent drought water option price offer of $10/AF premium plus $65/AF Exercise Price was not successful; therefore we should start our price curve higher than that. The following estimate is used for options pricing, but should be viewed as a reasonable estimate rather than a set of values estimated from actual transactions or uniquely derived by an algorithm.

- Assume that the starting prices for dry year options are: $12/AF premium and $120/AF exercise price.
- Assume that the exercise price rises according to the same formula as average year purchases derived above: 120 + 0.31*(TAF of options purchased).

- Assume that the premium rises accordingly to stay at one tenth of the exercise price.

Conclusions and Caveats

As indicated above, the analysis is based primarily on data on the actual water sale transactions that occurred in 2000 and 2001, and on information on hypothetical land fallowing transactions resulting from an economic analysis of farming in the Central Valley based on the CVPTM. These two sources were supplemented by telephone interviews with knowledgeable experts.

Our conclusion is that, if purchases of water from willing sellers under Water Supply Alternative Bundle A were to occur through options contracts in amounts ranging up to about 160,000 AF annually, the premium price would be estimated at about $17/AFand the exercise price would be estimated at about $170/AF. Assuming that the options are exercised in the 50 percent drier year types, the effective price paid for water when it is taken (including 2 years of premium paid for each year of the water taken) is $170 plus 2x$17, or about $204/AF. Additional spot market purchases might be needed in particularly dry years, and could be priced at a much higher effective price..

We stress again that these are estimates resulting from the assumptions and analysis described above. Also, a water purchase program of this size would represent a substantial increase in the volume of transactions that have historically occurred. For example, the State's drought water bank in 1991 purchased around 380,000 acre-feet of water from land fallowing contracts. Recent water market transactions in the Central Valley have totaled similar amounts (exact quantities are not known). A water purchase program will also compete for water with other environmental purchase programs, and with urban and agricultural buyers. Price estimates have attempted to account for this competition, as discussed above, but the logistics of negotiating and transporting a large aggregate volume of water transfers would be challenging.

Several additional caveats should be noted. First, the existing experience with water markets has shown that sometimes water becomes available for short term lease at substantially lower prices than those estimated above. However, this occurs opportunistically and at short notice, and there is no guarantee that Friant Water Users Authority would be able to secure these supplies instead of other interested buyers. Second, water markets in California will undoubtedly evolve over the next five to ten years beyond what has been observed in 2000 and 2001. On the one hand, more sellers are likely to enter the market, thereby increasing supply and potentially lowering prices; on the other hand, more buyers may enter the market, thereby increasing demand and raising prices. It is not possible at this time to forecast the effect of the changes that may occur as the market expands. Third, while the CVPTM analysis is based on an economic analysis of potential land fallowing and crop switching by farmers who sell the water saved thereby, the evidence suggests that this has played a limited role in the short-term lease transactions actually occurring in 2000 and 2001. In many cases, the source of supply was reduced diversion resulting from such things as conjunctive use, improved water district operations, or increased tailwater recovery. These are not included in

the CVPTM analysis. Although initial quantities of water provided through these means can be relatively low cost, larger quantities would require implementing increasingly expensive programs, with similar or even greater costs than the land fallowing assessed using the CVPTM.

The last caveat concerns the relevance of our results for predictions of long-term leases and permanent sales. Two points should be noted. First, if there is adequate storage – either in conventional above-ground reservoirs or in aquifers through conjunctive use and groundwater banking – then it may be possible to secure a reliable long-term water supply through market transactions based on opportunistic purchases and short-term leases. As noted above, we have limited information regarding the availability and price of reservoir storage, and information on the opportunities and costs associated with groundwater banking are being developed independently of this analysis. Second, the supply of water for long-term lease, option, or permanent sale depends partly on factors that are not incorporated in our analysis. The low profitability of water used for crop production relative to the market price in a water market transaction, which is the basis for the CVPTM analysis, is clearly likely to be a necessary condition for a seller to put water up for sale. However, it may not be a sufficient condition, especially with respect to the permanent sale or long-term lease of water. The decision to engage in those types of transaction may be triggered by a change in the management strategy of the farm owner, or perhaps even a change in the ownership of the farm. Both of these become more likely as time passes, implying that an increasing fraction of the water that is currently sold under short-term lease might instead be put up for long-term lease, option, or permanent sale. It is not possible at this time to forecast the rate at which this change could occur.

References

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CALFED. 1998. Phase II Interim Report. CALFED Bay-Delta Program. Sacramento, CA.

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Stratecon. Various dates, Water Strategist. Claremont, California.

Stratecon. Various dates, Water Intelligence Monthly. Claremont, California.

Table E3-1
Conveyance Cost Estimates by Source Region and Supplier Category

	Supply Area	Supplier	Reach A		Reach B		Reach C		Reach D		Total	
			Loss Factor	Cost/af	Loss Factor	Cost/af	Loss Factor	Cost/af	Loss Factor	Cost/af	Loss Factor	Cost/af
1	Sacramento Valley and Delta	All water users	1.538	$20.88	1.014	$33.26	1.004	$18.29	1.000	$0.00	1.567	$72.43
2a	San Joaquin East	Friant Unit contractors	1.000	$0.00	1.000	$0.00	1.000	$0.00	1.000	$0.00	1.000	$0.00
2b	San Joaquin East	Non-Friant water users	1.538	$20.88	1.014	$33.26	1.004	$18.29	1.000	$0.00	1.567	$72.43
3a	San Joaquin West	Exchange contractors	1.000	$0.00	1.014	$33.26	1.004	$18.29	1.000	$0.00	1.019	$51.55
3b	San Joaquin West	Delta Mendota contractors	1.000	$0.00	1.014	$33.26	1.004	$18.29	1.000	$0.00	1.019	$51.55
4a	Tulare East	Friant Unit contractors	1.000	$0.00	1.000	$0.00	1.000	$0.00	1.000	$0.00	1.000	$0.00
4b	Tulare East	Cross Valley contractors	1.000	$0.00	1.000	$0.00	1.004	$18.29	1.000	$0.00	1.004	$18.29
4c	Tulare East	State project contractors	1.000	$0.00	1.000	$0.00	1.004	$18.29	1.004	$16.83	1.008	$35.12
4d	Tulare East	Other water users	1.000	$0.00	1.000	$0.00	1.000	$0.00	1.004	$16.83	1.004	$16.83
5	Tulare West	All water users	1.000	$0.00	1.014	$33.26	1.004	$18.29	1.000	$0.00	1.019	$51.55
6a	Kern County	Friant Unit contractors	1.000	$0.00	1.000	$0.00	1.000	$0.00	1.000	$0.00	1.000	$0.00
6b	Kern County	Cross Valley contractors	1.000	$0.00	1.000	$0.00	1.004	$18.29	1.000	$0.00	1.004	$18.29
6c	Kern County	Other water users	1.000	$0.00	1.000	$0.00	1.004	$18.29	1.000	$0.00	1.004	$18.29

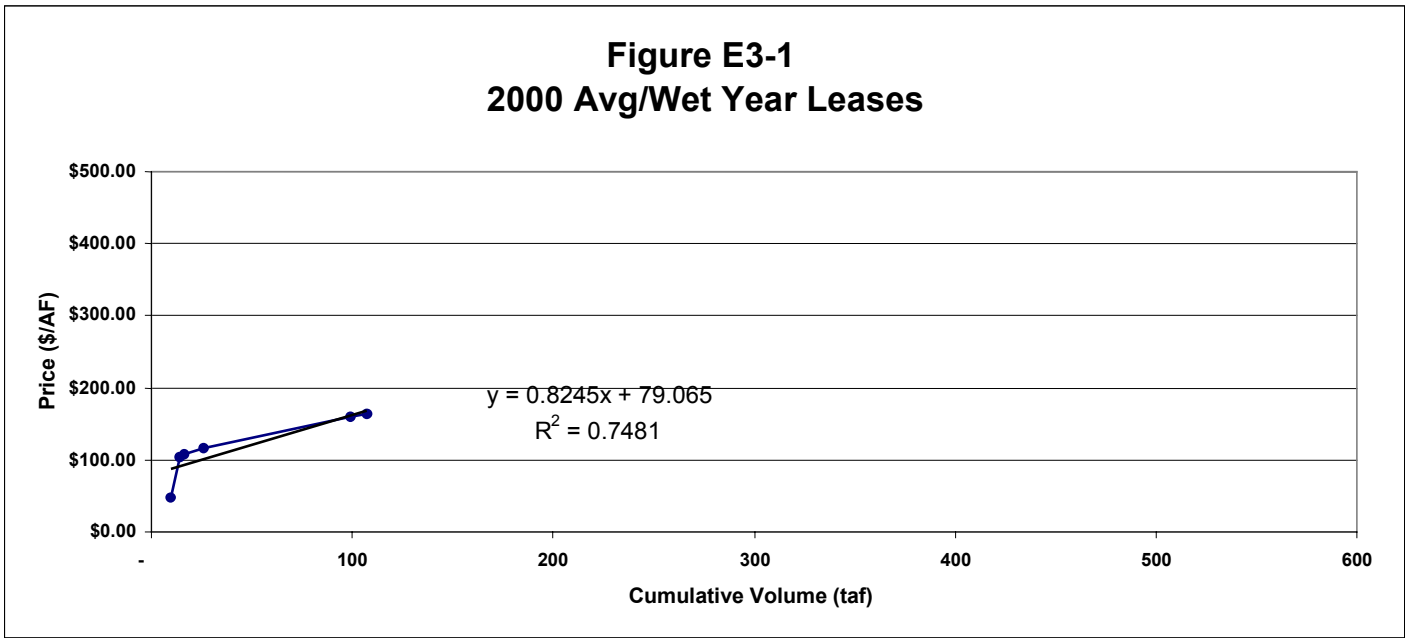
Figure E3-1
2000 Avg/Wet Year Leases
$500.00
$400.00
$300.00
$200.00
$100.00
$0.00
Price ($/AF)
y = 0.8245x + 79.065
R2 = 0.7481
-
100
200
300
400
500
600
Cumulative Volume (taf)

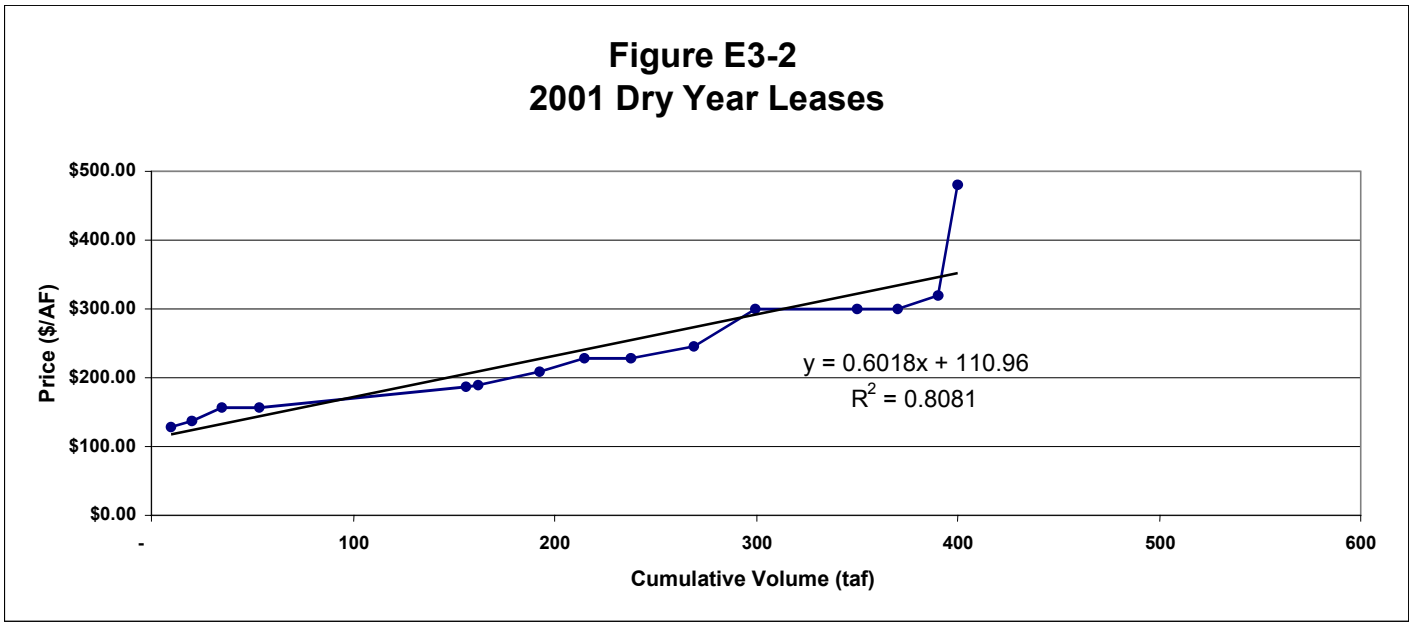
Figure E3-2
2001 Dry Year Leases
$500.00
$400.00
$300.00
$200.00
$100.00
$0.00
Price ($/AF)
y = 0.6018x + 110.96
R2 = 0.8081
-
100
200
300
400
500
600
Cumulative Volume (taf)

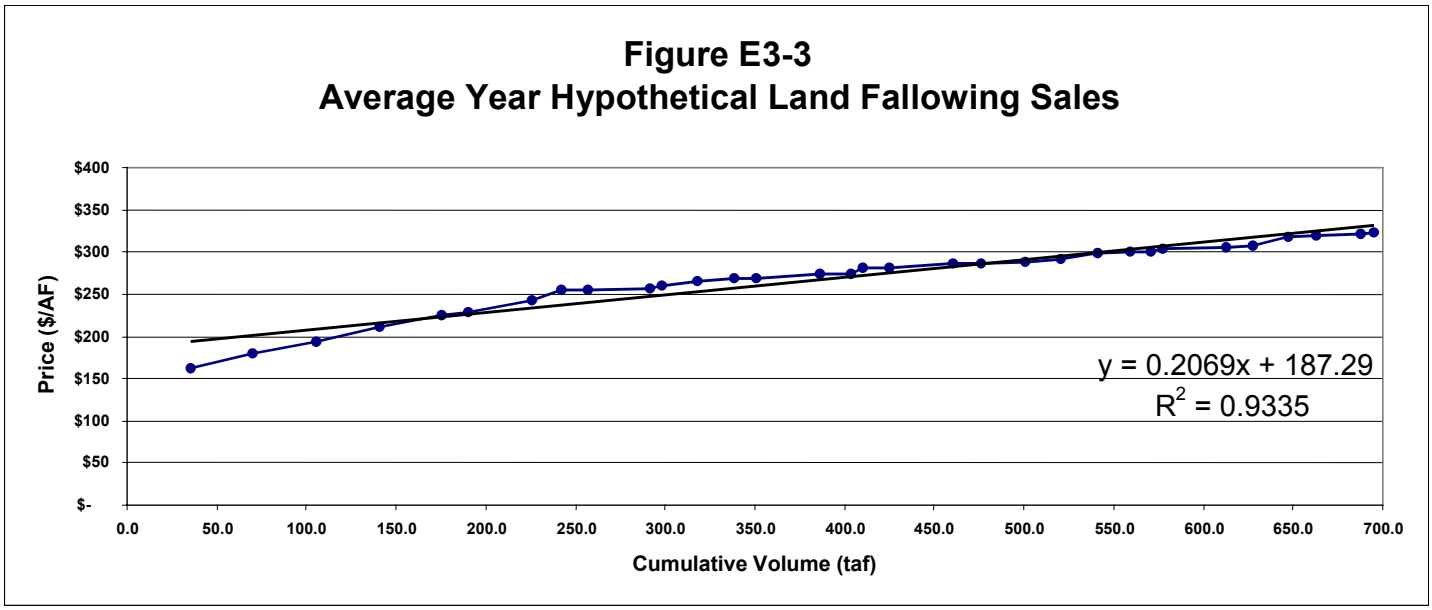
Figure E3-3
Average Year Hypothetical Land Fallowing Sales
Price ($/AF)
$400
$350
$300
$250
$200
$150
$100
$50
$-
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
Cumulative Volume (taf)
y = 0.2069x + 187.29
R2 = 0.9335

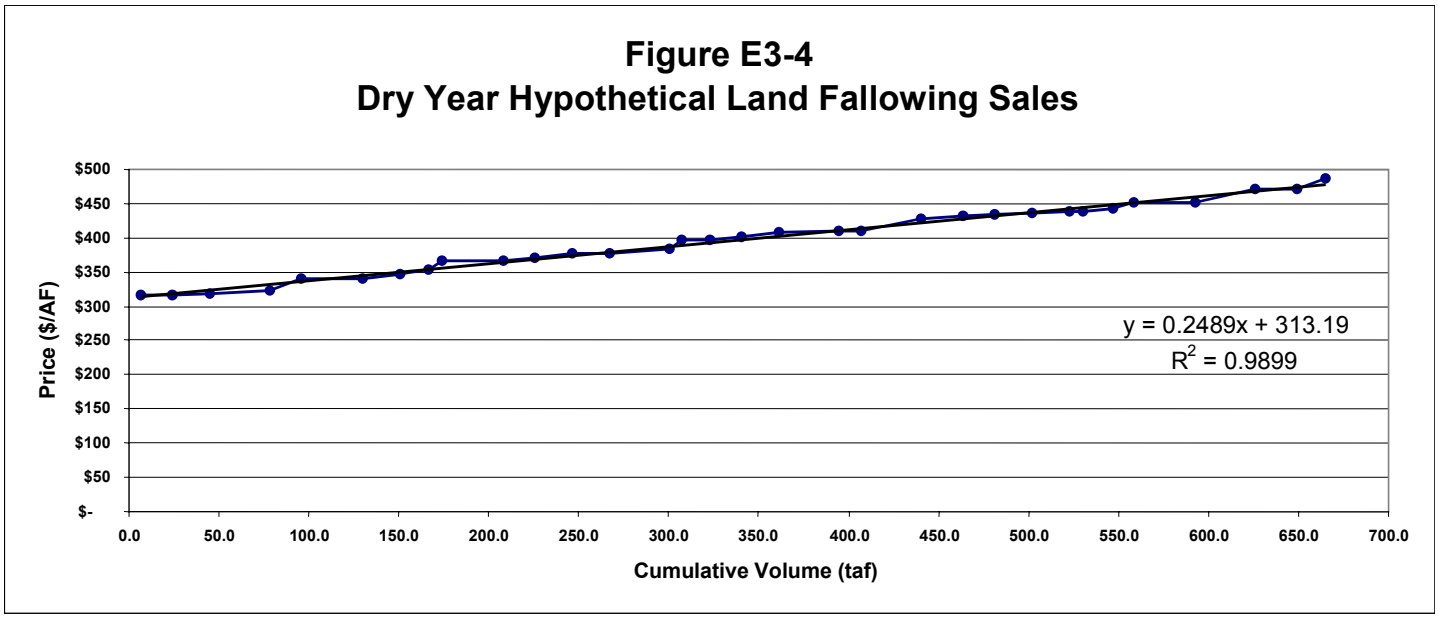
Figure E3-4
Dry Year Hypothetical Land Fallowing Sales
Price ($/AF)
$500
$450
$400
$350
$300
$250
$200
$150
$100
$50
$-
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
Cumulative Volume (taf)
y = 0.2489x + 313.19
R2 = 0.9899

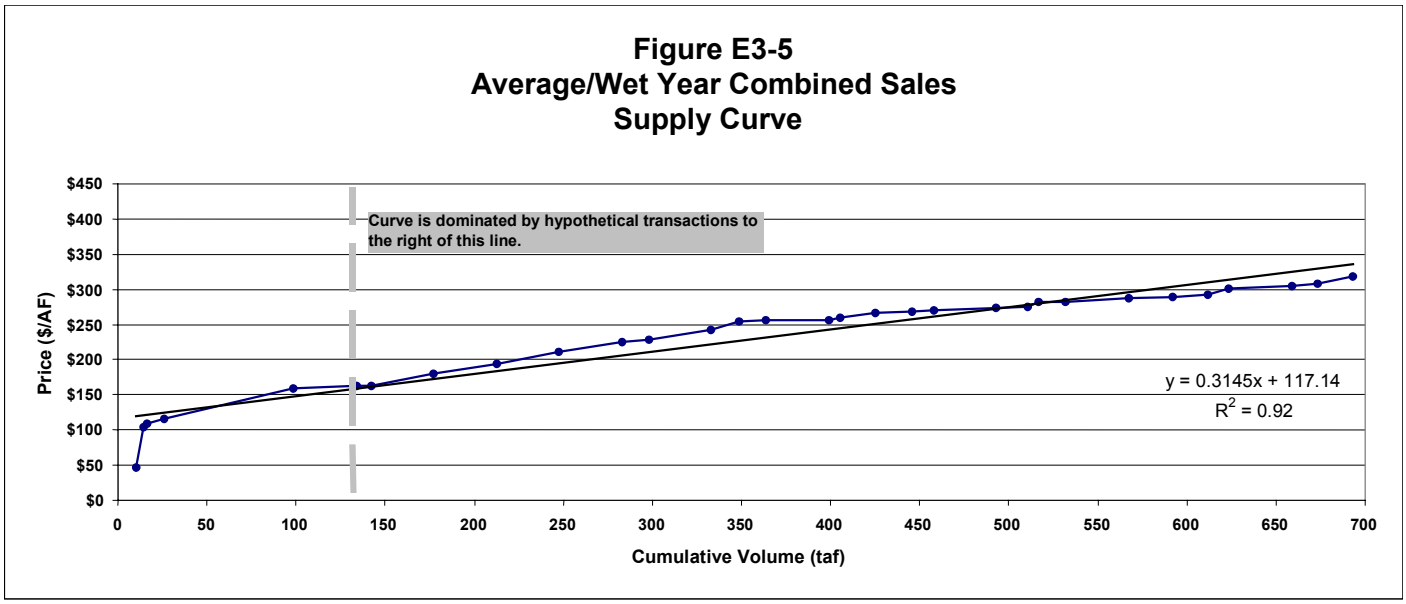
Figure E3-5
Average/Wet Year Combined Sales
Supply Curve
Curve is dominated by hypothetical transactions to the right of this line.
y = 0.3145x + 117.14
R2 = 0.92
Price ($/AF)
Cumulative Volume (taf)
$0
$50
$100
$150
$200
$250
$300
$350
$400
$450
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700

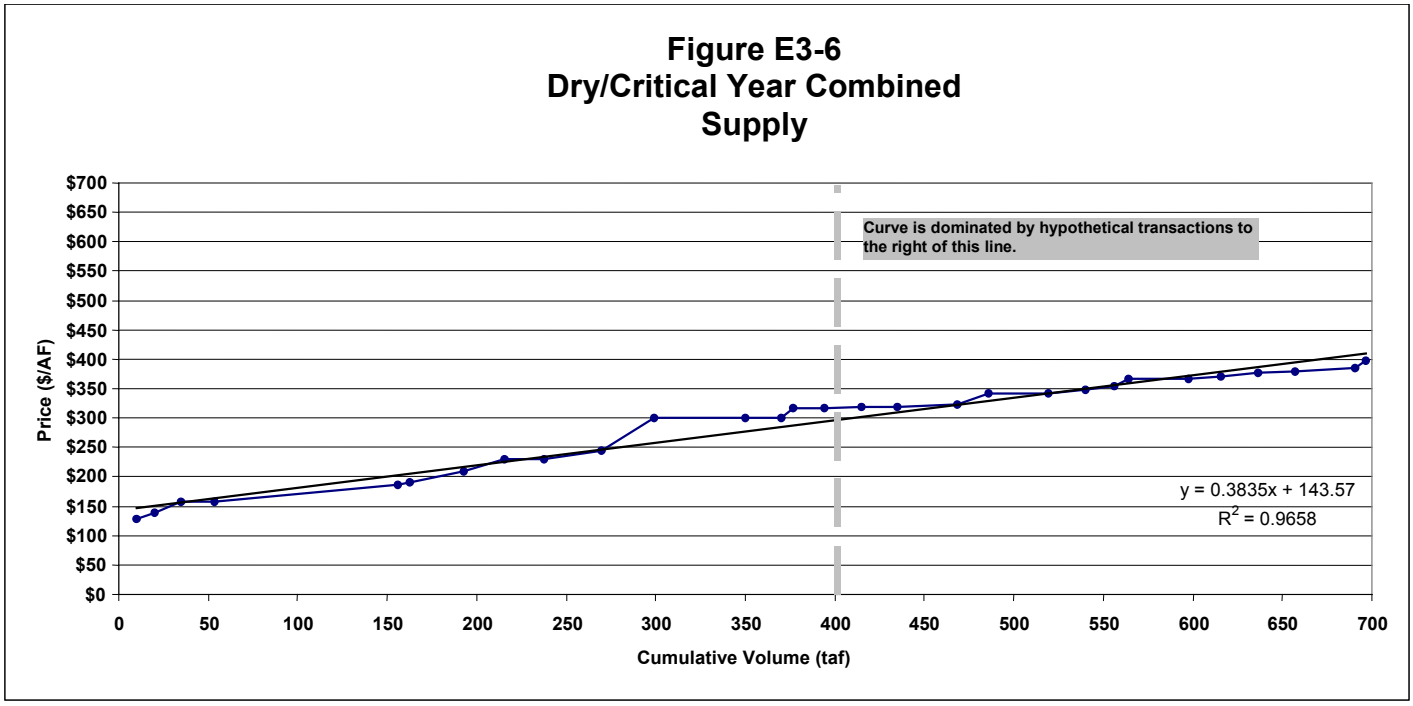
Figure E3-6
Dry/Critical Year Combined
Supply
Curve is dominated by hypothetical transactions to the right of this line.
y = 0.3835x + 143.57
R2 = 0.9658
Price ($/AF)
Cumulative Volume (taf)
$0
$50
$100
$150
$200
$250
$300
$350
$400
$450
$500
$550
$600
$650
$700
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700

Appendix F
Fixed Cost Estimates

The Water Supply Study (Study) includes fixed and variable costs for each component included in any of the bundles considered in the Study. These costs have been included in the model as one means of comparing alternatives. For the purpose of this study, fixed costs include all costs associated with the capital recovery of new component development and any operation and maintenance costs that apply regardless of the amount of use. Variable costs are those costs that depend on the amount of use. For example, the costs associated with capital recovery of initial construction costs of a component are considered fixed costs. Conveyance charges and water purchases are considered variable costs and are discussed elsewhere.

F.1 BASIC ASSUMPTIONS

Basic assumptions regarding the development of estimated construction costs include:

- The cost estimates for San Joaquin River streambed modifications are not included; the associated work is not yet defined.
- The costs estimated for the various components are based on a pre-feasibility level of design and are therefore very preliminary in nature.
- No engineering site work or engineering calculations have been performed. Because of possible geotechnical or other engineering limitations, it may not be feasible to construct certain components as assumed.
- Only cursory environmental review has been performed. There may be significant extraordinary environmental mitigation costs associated with implementation of various components.
- Cost estimates do not include a specific allowance for the mitigation costs associated with negative impacts to recreation.
- In general, the cost estimates have been developed for a specific capacity. Within limits in the model, the costs have been applied for smaller and larger capacities based on the calculated unit costs (cubic feet per second or acre-foot). In future studies this assumption will need to be verified for those components with variable capacity that merit additional consideration.

F.2 DIRECT CONSTRUCTION COSTS

The estimated direct construction cost for each component involving new construction is based on preliminary quantity estimates and unit prices for similar facilities. As stated above, the estimates are based on extremely limited engineering and environmental review. Therefore, it is not possible at this time to define confidence limits on the reliability of the estimates. A short description of the basis for the direct construction costs for each of the major components follows.

- Millerton Pumps to Friant-Kern and Madera Canals: The capital cost estimate was originally prepared for Theme 1, as included in Technical Memorandum No. 5 (URS 2001a). This estimate was broken down into 12 line items, including trashrack modifications, new manifold and discharge lines, pumps, barges, and electrical work. The most significant cost was for a fleet of barge-mounted 600 horsepower (hp) pumps. A quotation was obtained for Flygt submersible pumps from SHAPE Incorporated of Pleasanton, California.

- Friant River Release Generator: New turbine generator capacity was established to utilize flow up to that exceeded between 20 percent and 30 percent of the time, or 450 cfs. Capital costs for the new powerhouse are based on the 1982 cost per cfs capacity to construct the existing River Outlet Powerhouse inflated to 2002 prices.
- Millerton Lake Enlargement: The capital cost estimate was originally prepared as part of the long list of alternatives included in Technical Memorandum No. 4 (URS 2000d). Cost components included in the estimate are cubic yards of concrete for the raise, an allowance for spillway and outlet improvements, land costs for an increased reservoir area, and costs for a new earthfill saddle dam. The most significant cost is that associated with concrete for raising the existing structure. In the present estimate, concrete unit costs are corrected from $150/cubic yard (cy) for mass concrete to $300/cy because much of the raise cannot be placed as mass concrete.
- Cross Valley Canal Improvements: The capital costs are based on the rough estimates for the work provided by Mr. Jon Parnell in a telephone conversation on 15 November 2000. Mr. Parnell, manager of the Cross Valley Canal, has been investigating costs to upgrade the capacity by increasing the capacity of various lift stations and raising the liner.
- Friant-Kern Reverse Pumping: The capital costs are based on a rough estimate to develop a bi-directional intertie between the Friant-Kern Canal and the Cross Valley Canal as provided by Mr. Jon Parnell in a telephone conversation on 15 November 2000. Mr. Parnell, manager of the Cross Valley Canal, has been investigating costs for this feature. URS assumed that three lift stations would be necessary to lift the water past three check structures totaling about 21 feet of lift.
- Tulare Lake Storage and Pumping: The capital costs are based on storing a maximum of 100,000 acre-feet on approximately 25,000 acres of land. The major costs include land acquisition, three new pump stations (to convey stored water from the reservoir to the existing Blakeley Canal, from Blakeley Canal to the Tulare Lake Basin Water Storage District (TLBWSD) Lateral A, and from TLBWSD Lateral A to the California Aqueduct), and approximately one mile of new or upgraded pipeline to connect the canals. Land is assumed to cost $2,500/acre. However, it is assumed that the net cost is only about 25 percent of this amount once a return from utilizing the land for agriculture during periods when not needed for storage is considered. The pipeline costs are based on an 8-foot-diameter, 5/16-inch-thick, 5,200-foot-long steel pipe with an installed cost of $2.00/lb.
- Patterson Pump-in: The capital cost estimate was originally prepared based on 400 cfs capacity and prorated for 500 cfs. Major costs included are the pump station itself (complete with fish screens) and the conveyance from the pump station on the San Joaquin River to the Delta-Mendota Canal. Pump station costs are based on a lift of 200 feet (including losses), resulting in a requirement of 16,650 hp for 500 cfs. Unit cost per horsepower is estimated at $300. Fish screens at the recently installed Sutter Mutual facility cost approximately $10,000/cfs including pumps (Daryl Hayes CH2M Hill). An 8-foot-diameter, ½-inch-thick, 21,500-foot-long steel pipeline with an installed cost of $2.00/lb is assumed for the 400 cfs capacity option originally considered.
- Kings, Kaweah, and Tule River Pumping Plants (Eastside pump-in): The capital costs for the three pump stations are assumed to be $300/hp for lifts of 25 feet, 20 feet, and 21 feet

respectively at the three sites based on U.S. Geological Survey topographic maps at the location of the Friant-Kern Canal crossing.

- Merced River Intertie: The capital cost estimate is based on a combination of Alternatives 2 and 4 from work performed by others (Tolladay, Fremming, and Parson 2000). This combination would deliver water from the Merced River as far as Berenda Reservoir.
- Fine Gold Reservoir: The capital cost estimate was originally prepared as part of the long list of alternatives included in Technical Memorandum No. 4 (URS 2000d). Cost components included in the estimate are dam embankment costs and land acquisition costs for the raise and an allowance for road relocation costs. The most significant cost is that associated with the embankment of 16,600,000 cubic yards at $11.77/cy. In the present estimate, an allowance of $10,000,000 is included for road relocation. As outlined in the report, the outlet facility sizing is dependent on its use as a pump storage facility. It has been assumed that the cost to develop the size needed for pump storage will be offset by the pump storage benefits.
- Mammoth Pool Enlargement: The capital cost estimate was originally prepared as part of the long list of alternatives included in Technical Memorandum No. 4 (URS 2000d). The cost components included in the estimate are costs for spillway gates, dam embankment costs, and land acquisition costs. An allowance of $4,000,000 is included for spillway gates. Also included in the estimate are 400,000 cubic yards of new embankment at $20/cy.

F.3 MULTIPLIER ON DIRECT CONSTRUCTION COSTS

The direct cost construction costs described above have been multiplied by a cost factor of 1.99 to arrive at the total capital cost of each component. This cost factor is made up of the following elements:

- 1.20: Allowance for items necessary for the project but not yet identified given the preliminary nature of the component concept
- 1.12: Allowance for environmental mitigation, including environmental studies
- 1.10: Allowance for engineering design
- 1.09: Allowance for construction management services
- 1.03: Allowance for owner's administrative, legal, and financing costs
- 1.20: Allowance for contingencies

The resultant total multiplier is 1.20x1.12x1.10x1.09x1.03x1.20=1.99.

It is understood that the actual costs for the various elements making up the overall multiplier will vary from those assumed in the allowance depending on the nature of the component. For example, engineering costs will likely go up for small capital projects, whereas environmental mitigation costs might go down. However, a detailed review and evaluation of each of these elements for each component is not warranted at this very preliminary stage of project development. Such refinement can be considered in a future phase once the project configurations are better defined and additional engineering work is completed.

F.4 CONVERSION OF CAPITAL COST TO ANNUAL COST

Total capital costs have been calculated by applying the multiplier to the estimated direct construction costs. An annual project cost has been determined by applying a capital recovery factor of 0.07265. This factor is based on financing over a 30-year capital recovery period at 6 percent interest. In this preliminary evaluation of alternatives, there has been no consideration for staging construction over a number of years. Rather, it has been assumed that all capital needed for a facility would be expended at the onset of the evaluation period and that the annual costs (capital recovery, operation, and maintenance) apply immediately. This approach is consistent with the long-term model, which assumes components (including cost and benefits) are available for use at the start of the evaluation period.

F.5 MAINTENANCE COST FACTORS

Maintenance and fixed operating costs have been estimated by assuming that a percentage of the capital costs apply each year to a component. These maintenance cost factors vary depending on the assumed useful life of the facility (replacement costs) and the amount of effort the facility might take to operate and maintain. The following maintenance cost factors have been included in the estimate:

- 1 percent: New or Expanded Reservoirs. A relatively low maintenance cost factor is assumed because a small percentage of the high initial capital costs provide sufficient funds to operate the project, and because the service life of the project is expected to be greater than 50 years.
- 1 percent: Friant River Release Generator. A relatively low maintenance cost factor is assumed because there is an operating staff for the existing three powerhouses at Friant Dam, and the incremental effort to operate and maintain a fourth generator would be relatively low.
- 2–2.5 percent: Permanent Conveyance Improvements. Depending on the size and complexity of the facility, factors between 2 percent and 2.5 percent were included in the original estimates for new canal and pumping facilities developed for Technical Memoranda 4 and 5 (URS 2000d, 2000a). The absolute sums of money included for the various components (i.e., $1,400,000 per year for the Paterson Pumping Plant) seem reasonable to employ an operating staff and provide a reserve for repair and replacement of equipment.
- 3.1 percent: Millerton Pumps to Friant-Kern and Madera Canals. A relatively high maintenance cost factor is assumed because of the large crew necessary to deploy and then operate and maintain approximately 40 two-pump barge systems floating in Millerton Lake for several months a year.
- 4 percent: Eastside Tributary Pumps. A relatively high maintenance cost factor is assumed because of the relatively low capital cost of the facility. Each pumping plant would have an operating and maintenance budget of approximately $80,000/year.