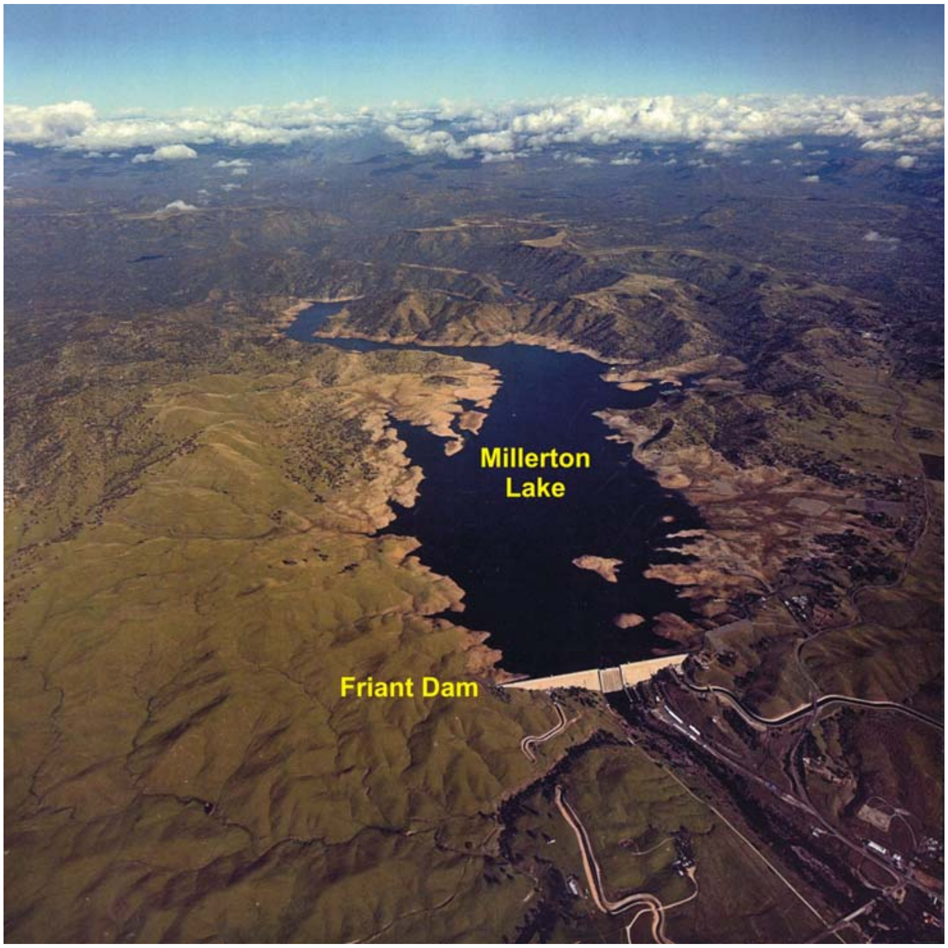
Upper San Joaquin River Basin Storage Investigation



Friant Dam Enlargement

Surface Storage Option Technical Appendix to the Phase 1 Investigation Report

A Joint Study by:

Bureau of Reclamation
Mid-Pacific Region

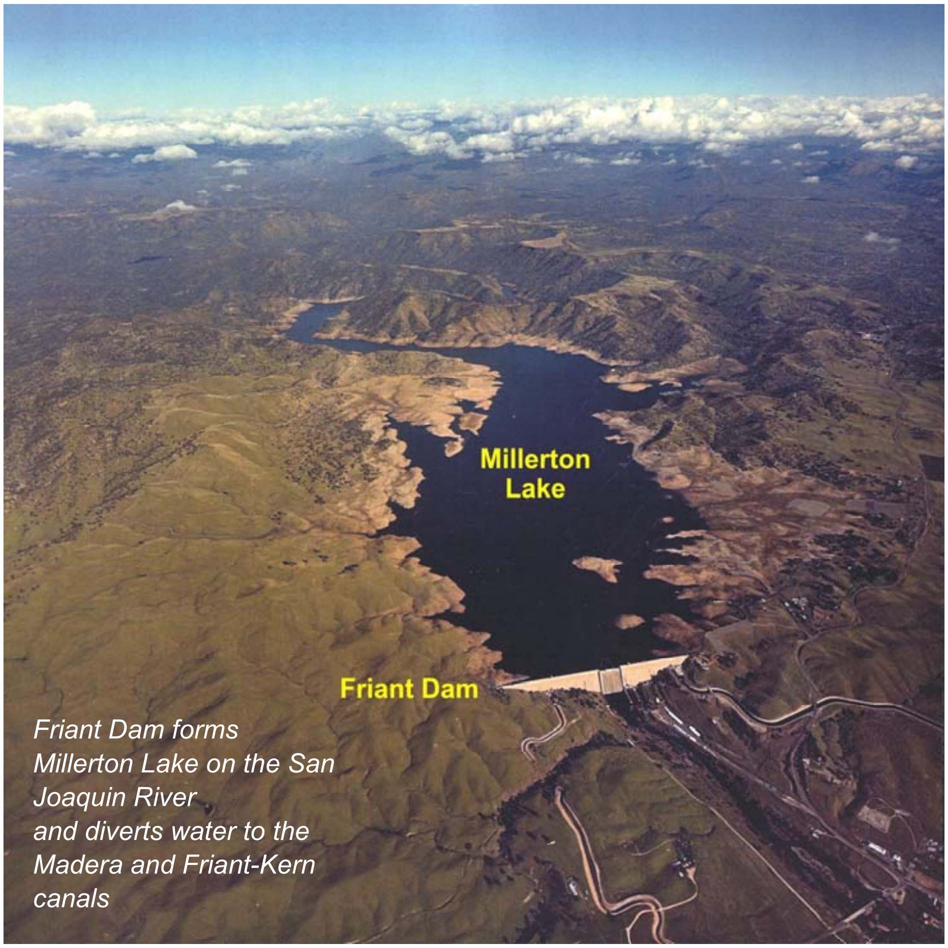
California Department
of Water Resources

In Coordination with:

The California Bay-Delta Authority

October 2003

Upper San Joaquin River Basin Storage Investigation



Friant Dam Enlargement

Surface Storage Option Technical Appendix to the Phase 1 Investigation Report

A Joint Study by:

Bureau of Reclamation
Mid-Pacific Region

California Department of Water Resources

In Coordination with:

The California Bay-Delta Authority

Prepared by:

MWH

October 2003

SURFACE WATER STORAGE OPTION
TECHNICAL MEMORANDUM

FRIANT DAM ENLARGEMENT

UPPER SAN JOAQUIN RIVER BASIN STORAGE INVESTIGATION

TABLE OF CONTENTS

Chapter **Page**

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Acronyms and Abbreviations

BRM	bedrock mortar
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CNPS	California Native Plant Society
Corps	United States Army Corps of Engineers
elevation	number of feet above mean sea level
FERC	Federal Energy Regulatory Commission
HEP	Habitat Evaluation Procedure
HMR	hydrometeorological report
Investigation	Upper San Joaquin River Basin Storage Investigation
NEPA	National Environmental Policy Act
PG&E	Pacific Gas and Electric
PMF	probable maximum flood
PMP	probable maximum precipitation
RCC	roller-compacted concrete
Reclamation	Bureau of Reclamation
RM	river mile
ROD	Record of Decision
SRA	State Recreation Area
TAF	thousand acre-feet
TCP	Traditional Cultural Place
TM	Technical Memorandum
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

THIS PAGE LEFT BLANK INTENTIONALLY

EXECUTIVE SUMMARY

A prefeasibility review of raising Friant Dam and enlarging Millerton Lake was completed as part of the Upper San Joaquin River Basin Storage Investigation (Investigation). Friant Dam is a 319-foot high concrete gravity dam on the San Joaquin River about 20 miles northeast of Fresno. Millerton Lake, the reservoir formed by Friant Dam, has a storage capacity of approximately 520 thousand acre-feet (TAF). Friant Dam and Millerton Lake provide water supply, flood control, hydropower generation, and recreation benefits to the region.

Options considered for increasing storage include 25-, 60-, and 140-foot raises of Friant Dam. A 25-foot raise would increase the storage capacity by 132 TAF, and would involve raising the dam crest, modifying the spillway and spillway chute, and constructing a dike approximately 3,000 feet long across a low ridge saddle at the southwest margin of the existing reservoir. Higher raises also would entail raising the dam crest and modifying the spillway. However, a 60-foot raise, which would increase storage capacity by 340 TAF, would require approximately 8,500 linear feet of new dike. A 140-foot raise, which would result in approximately 870 TAF of additional storage capacity, would require new dikes approximately 9,500 feet in total length and exceeding 100 feet high in some locations.

An enlarged Millerton Lake would provide opportunities to store larger volumes of San Joaquin River water. Stored water would continue to be diverted to the Friant-Kern and Madera canals and/or released to the San Joaquin River.

A dam raise could be accomplished with an overlay of conventional or roller-compacted concrete on the downstream face of the dam. The saddle dam, or dike, on the southwest rim of the reservoir (i.e., left side, looking downstream) would be constructed with earthfill. Safety considerations would be paramount in its design. Availability of materials from local sources does not appear to be a limiting factor. Appurtenant dam structures and facilities would be modified, reconstructed, or relocated to maintain existing operational characteristics.

Estimated field costs for dam raises considered in Phase 1 of the Investigation are listed in Table ES-1. Additional study will be needed to determine costs of reservoir clearing, environmental mitigation, relocation or acquisition of existing facilities, and acquisition of lands, easements, and rights-of-way. Costs of investigations, designs, construction management, administration, and interest during construction are not included in field costs.

Millerton Lake is a popular recreation location that supports a variety of boating and other day-use activities. Facilities on both sides of the reservoir would be affected by a dam raise. Many private residences near the reservoir lie at or above 610 feet above mean sea level (elevation 610), or more than 25 feet above the current maximum reservoir level of elevation 578. Raising the lake level would affect several houses, and infrastructure that supports residential development. Raise options would also affect upstream power generation.

TABLE ES-1.
SUMMARY OF CONSTRUCTION FIELD COSTS

Dam Raise (feet)	Normal Maximum Water Surface Elevation (feet above mean sea level)	Total New Storage (TAF)	Field Cost ($ Million)
25	603	132	100
60	638	340	**250**
140	718	870	**640**

Key:
TAF – thousand acre-feet

Enlarging Millerton Lake would affect fish spawning habitat in the upper portion of the lake and upstream in the San Joaquin River. Other impacts to habitat and wildlife would vary relative to the extent of inundation. Environmental mitigation has yet to be determined. Impacts to existing land uses, structures, and facilities appear mitigable, but mitigation likely would result in significant cost. The option of raising Friant Dam to enlarge Millerton Lake was retained for further consideration in the Investigation.

CHAPTER 1. INTRODUCTION

The Bureau of Reclamation, in cooperation with the California Department of Water Resources, is completing the Upper San Joaquin River Basin Storage Investigation (Investigation) consistent with the CALFED Bay Delta Program Record of Decision (ROD), August 2000. The Investigation will consider opportunities to develop water supplies to contribute to water quality improvements and restoration in the San Joaquin River, and to enhance conjunctive management and exchanges to provide high-quality water to urban areas. The ROD indicated that the Investigation should consider enlarging Friant Dam or developing an equivalent storage program to meet Investigation objectives.

The Investigation identified several potential surface storage sites to be initially considered through prefeasibility-level studies of engineering and environmental issues. This Technical Memorandum (TM), which was prepared as a technical appendix to the Phase I Investigation Report, presents findings from a prefeasibility-level review of the potential enlargement of Friant Dam and Millerton Lake.

STORAGE OPTION SUMMARY

Friant Dam and Millerton Lake are located on the San Joaquin River on the border between Fresno and Madera counties, near the community of Friant, about 20 miles northeast of Fresno, as shown in Figure 1-1. Millerton Lake and vicinity are shown in Figure 1-2. This TM considers three options for enlarging Millerton Lake: raising Friant Dam by 25, 60, or 140 feet, to increase reservoir storage capacity by 132, 340, or 870 thousand acre-feet (TAF), respectively.

SUMMARY OF PREVIOUS INVESTIGATIONS

In 1997, Reclamation considered the feasibility of raising Friant Dam by 60 feet or 140 feet to provide additional storage capacity in Millerton Lake.

POTENTIAL IMPROVEMENTS

As in the1997 Reclamation study, the current approach for raising the existing concrete gravity dam would be accomplished by an overlay on the downstream face of the dam and extending the top of the dam vertically, with either conventional mass concrete or roller-compacted concrete (RCC). The spillway for the raised structure would be configured to be similar to the existing spillway. Two Obermeyer gates would be removed and reinstalled at the top of the raised dam, and the remaining drum gate would be replaced with a third Obermeyer gate. Extensive modification or replacement of the existing canal outlet works, river outlet works, and powerplant would be necessary. These structures would be redesigned to be similar to the current configuration.

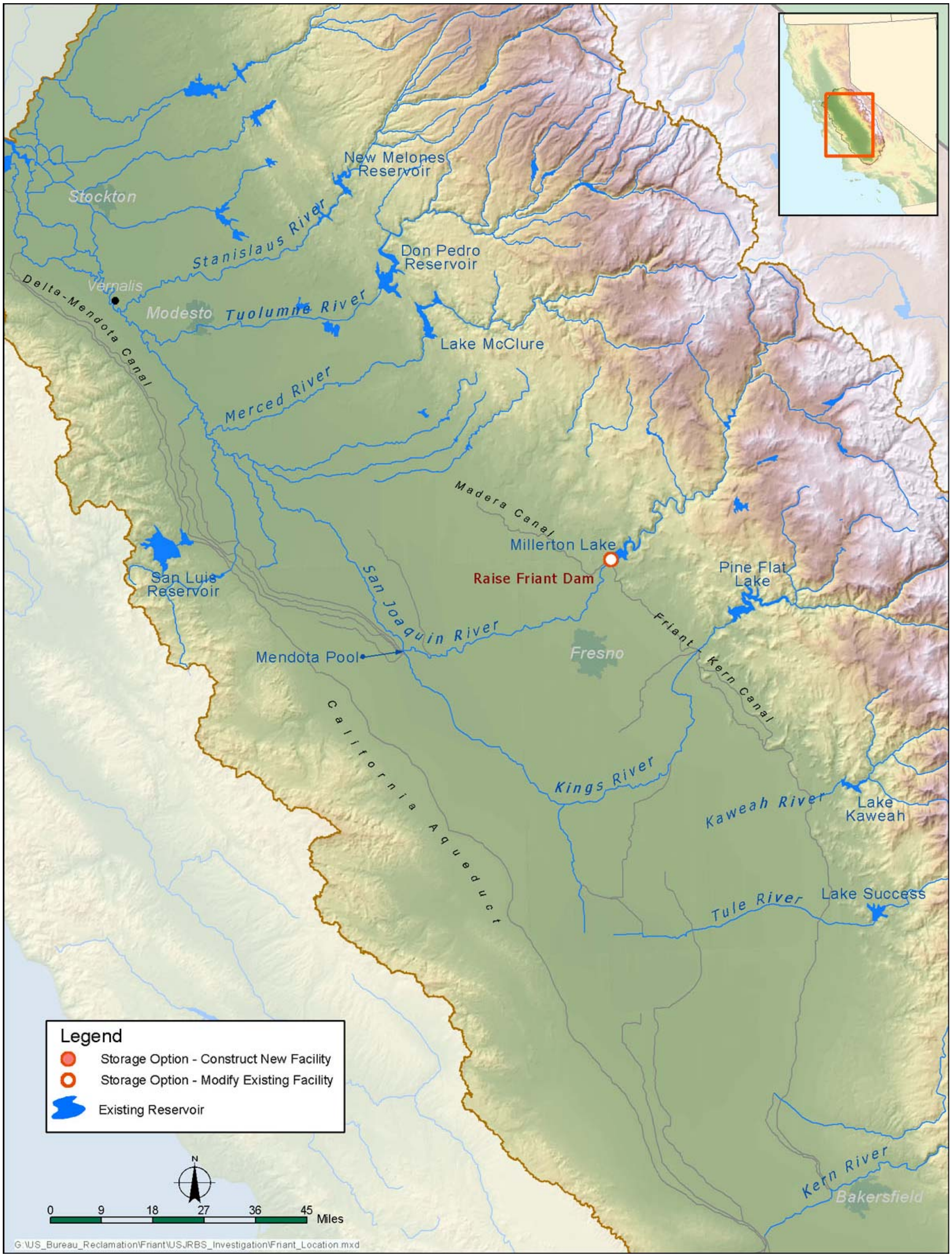


FIGURE 1-1. FRIANT DAM AND MILLERTON LAKE LOCATION MAP

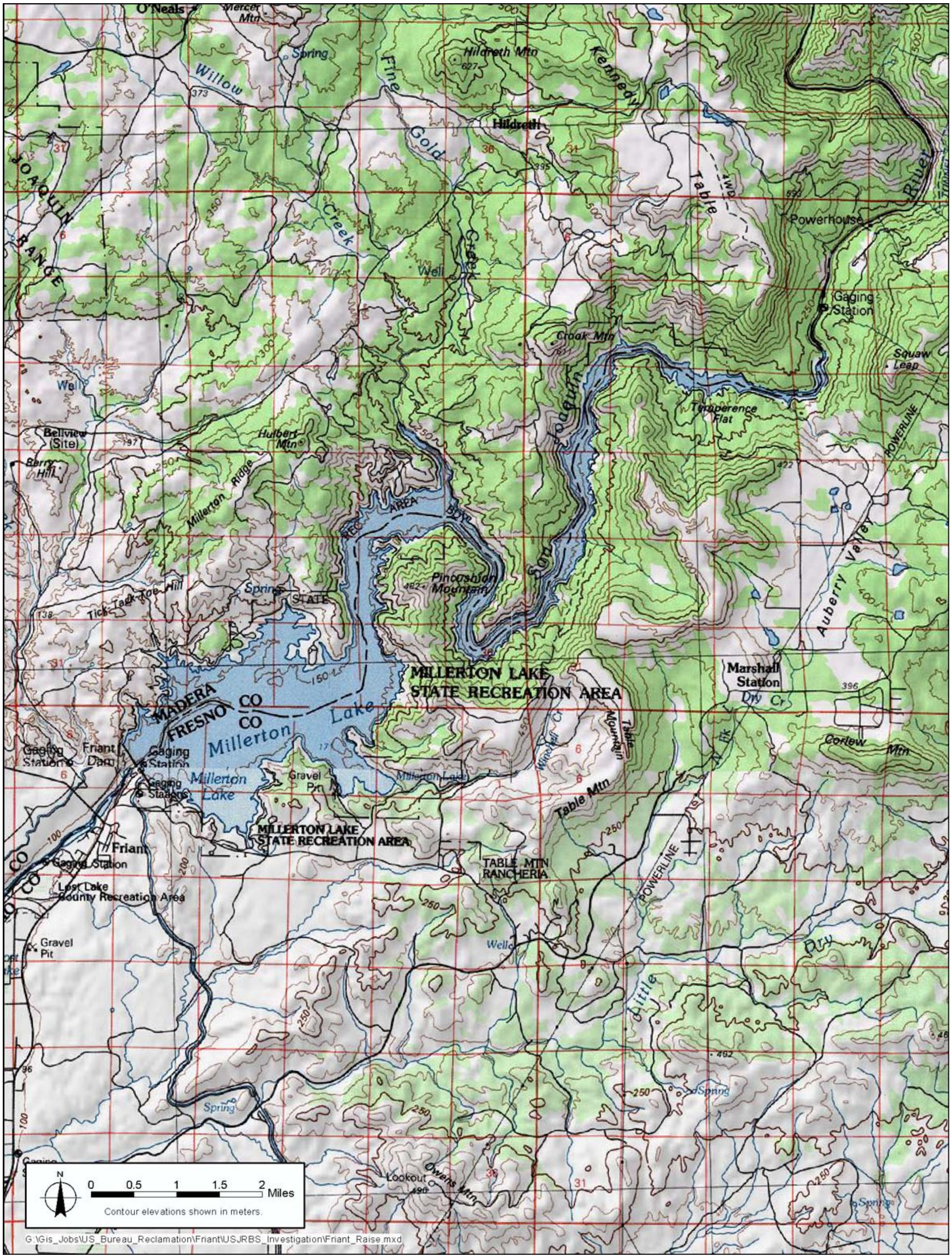


FIGURE 1-2. MILLERTON LAKE AREA MAP

An embankment or RCC saddle dam would be necessary to close off a low area along the left side of the reservoir. The height and length of the saddle dam would depend on the scale of the corresponding raise of Friant Dam. For the 25-foot raise option, the saddle dam would have a maximum height of 30 feet and crest length of 4,500 feet; a 60-foot raise would require approximately 8,500 linear feet of new dike; and a 140-foot raise would require new dikes approximately 9,500 feet in total length, exceeding 100 feet high in some locations. Figure 1-3 illustrates the largest potential enlargement option, the 140-foot dam raise.

The modified dam would use as much of the existing facilities as possible. However, as mentioned above, the existing drum gate would be replaced with a new Obermeyer gate. Outlet works, canal gates and valves may also need to be replaced to accommodate higher heads. The current analysis assumes that major changes to the existing powerplant are not necessary; however, future evaluations should consider turbine replacements to accommodate higher heads.

APPROACH AND METHODOLOGY

This TM was prepared from a brief review of the 1997 study, and engineering, geology, and environmental field visits in 2002.

Engineering and Geology

During the engineering and geology field visits in June and August 2002, the existing dam, abutments of an enlarged dam, potentially impacted areas, possible borrow areas, and site access were visually examined (see Appendix A). Surface geologic mapping and evaluations for possible construction materials were performed by Reclamation in July 2002 (2002a).

The seismotectonic evaluation conducted by Reclamation for this study (2002b) was based on readily available information and is considered appropriate for prefeasibility-level designs. Detailed, site-specific seismotectonic investigations were not conducted, nor was remotely sensed imagery evaluated for the seismotectonic analysis. More detailed, site-specific studies would be required for higher-level designs.

For prefeasibility studies, designs and analyses are typically quite general. Design layouts, sections, and dimensions for this study have been assumed based on standard practice and experience with similar facilities. Extensive efforts to optimize the design have not been made, and only limited value engineering techniques were used at this level of study.

Cost Estimation

Estimates of field construction costs are based on prefeasibility-level designs and contain provisions for uncertainties. Estimates were prepared for different sizes of dam and reservoir enlargement. Field costs for construction were estimated at 2003 price levels and include direct costs to modify or construct dams and appurtenant features. Cost estimates are presented in Chapter 3 with detailed worksheets in Appendix C.

Costs of relocation or acquisition of existing facilities, reservoir clearing, lands, easements, rights-of-way, environmental mitigation, investigations, designs, construction management, administration, and interest during construction are not included in the estimated field costs.

Environmental Review

During the environmental reconnaissance of the dam and reservoir area in May 2002, specialists in botany, wildlife, aquatic biology, recreational resources, and cultural resources visually assessed existing environmental resources (Appendix B). Additional research was conducted, making use of prior studies and available literature, the California Natural Diversity Database, topographic maps, and aerial photographs. This information was used to determine the extent to which potential environmental impacts might constrain the storage options under consideration. Where evident, opportunities for improving environmental resources or mitigating adverse effects were also noted. Surveys and consultations with external resource management or environmental agencies were not conducted.

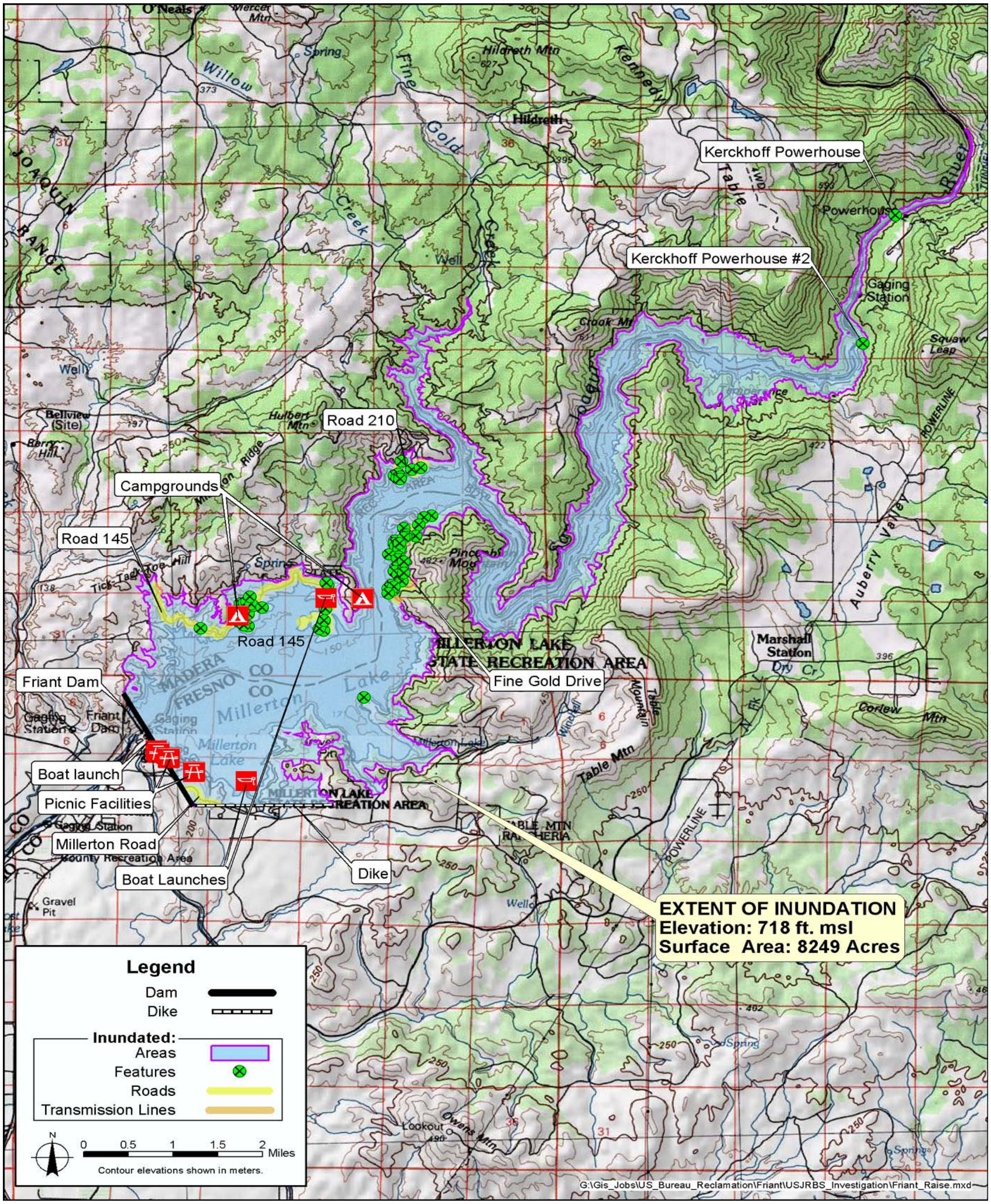


FIGURE 1-3. POTENTIAL STRUCTURES AND POTENTIALLY INUNDATED FACILITIES

CHAPTER 2. PHYSICAL SETTING

This chapter describes the physical setting of a potential Friant Dam enlargement, including topography, geology and seismicity, hydrology, existing facilities, and the environment.

TOPOGRAPHIC SETTING

Regional topography consists of the nearly level floor of the San Joaquin Valley rising abruptly to moderately steep, northwest-trending foothills with rounded canyons. Elevations in the immediate area range from about 310 feet above mean sea level (elevation 310) at Friant dam to over elevation 2,100 at the upper end of the reservoir.

Farther east, the terrain steepens and the canyons become more incised. The canyons have been cut by southwest- to west-flowing rivers and associated large tributaries. The San Joaquin River is the main river in the area. The topography of the San Joaquin River basin rises to over elevation 12,000 in the upper watershed, located in the Sierra Nevada.

Friant Dam is located in a section of river that passes through a narrow, southwest-trending bedrock slot in a relatively broad valley at the edge of the San Joaquin Valley. Outside the immediate canyon slot, the right abutment slope rises at a 5:1 horizontal to vertical ratio to about elevation 700. The left abutment slope rises at a lesser inclination, undulating over a broad area along the southern rim of the reservoir, which also rises to slightly over elevation 700. In the upper portions of the reservoir, several adjacent and nearby mountains are found along with flat-topped buttes.

Available Topographic Mapping

Aerial photography for topographic mapping was obtained on 28 August 2001, using LIDAR technology. Base maps were created with a model that produced topography with 10-foot contour intervals. Additional maps are being produced with 2-foot contour intervals.

Available Aerial Photography

In addition to the above, oblique aerial photographs of the sites were taken during flights made on 26 November 2001. The aerial photos of the sites are available from Reclamation.

GEOLOGIC AND SEISMIC SETTING

The site is located along the western border of the central portion of the Sierra Nevada Geomorphic Province at its boundary with the eastern edge of the Great Valley Geomorphic Province of California. Friant Dam is founded on metamorphic rocks consisting of quartz biotite schist, intruded by aplite and pegmatite dikes and by inclusions of dioritic rocks. The contact of these metamorphic rocks with the Sierra Nevada batholith lies just east of Friant Dam in Millerton Lake. The Sierra Nevada batholith is comprised of primarily intrusive rocks, including granite and granodiorite, with some metamorphosed granite such as granite gneiss. Intrusive Sierra Nevada batholith rocks underlie most of Millerton Lake and Friant Dam, Kerckhoff Dam, and the potential Temperance Flat and Fine Gold dam sites. Occasional remnants of lava flows and layered tuff are present in the Millerton Lake area at the highest elevations.

The central Sierra Nevada has a complex history of uplift and erosion. The predominant uplift tilted the western flank of the Sierra Nevada to the west. At the western border, rocks of the Sierra Nevada are overtopped by alluvium and sedimentary rocks of the Great Valley Province. The metamorphic rocks in the Friant Dam area dip steeply downstream to the west, and strike northwesterly. Erosion has resulted in thin alluvial cover.

Friant Dam and the three dikes constructed in association with it are founded on metamorphic rock consisting of hard quartz biotite schist, transected by many varying granitic (probably dioritic) dikes. These dikes are mostly aphanitic, but include pegmatitic and porphyritic varieties. Most are less than a few feet thick and locally include a few thin veins of quartz. The parent rock of the schist was derived from marine sediments, and the deformations and physical and chemical alteration that produced the schist principally occurred during emplacement of the Sierra Nevada Batholith. The granite dikes at the site are probably associated with the intrusion. The rock immediately upstream of the dam is the granodiorite of the batholith.

The potential for reactive aggregate was a concern to engineers during construction of Friant Dam. Chemical activity between high-alkali cement and certain components of some concrete aggregate such as chert resulted in expansion within the concrete and subsequent cracking. Low-alkali Portland-type cement with a pumicite pozzolan additive was used for most of the dam concrete, but in the early stages of construction, some high-alkali cement was used. Deterioration of concrete due to alkali aggregate reaction is the most serious problem identified for the dam and spillway.

Site Geotechnical Conditions

Schist exposed in the river channel immediately downstream of the dam is fresh while weathering is progressively more intense on the valley slopes, ultimately forming an intensely weathered zone 40 to 50 feet thick at the elevation of the dam crest. From descriptions provided on logs of boring during foundation excavation, rock at or below the final foundation surface is moderately to slightly weathered. Due to the weathering profile of the near-surface bedrock, the dam design incorporated a floating target for the final foundation surface. An average thickness of 32 feet of material was removed to achieve a satisfactory foundation. However, the depth of excavation in the area of a fault zone on the left abutment locally approached 70 feet.

Foliation (schistosity) is pervasive at the site and is the primary structural feature of the schist. The attitude of this foliation varies locally, but is fairly uniform within the area of the dam foundation, striking N65 - 75°W (subparallel to the dam axis) and dipping 55° - 85° SW (downstream). The schist readily cleaves along foliation in more weathered intervals of rock.

However, this tendency is proportional to the degree of weathering and is absent in fresh rock. Although minor shearing is widespread at the site, only a few faults are specifically documented in the record of construction. Construction drawings and written records of the work indicate discrete sets of joints, "flat seams," steeply dipping faults, and other discontinuities occur within the area of the dam foundation.

A number of trenches and shafts were excavated during dam construction along flat seams and portions of faults. These excavations were backfilled with concrete. An extensive and effective foundation grouting program was performed during construction.

No known adverse geologic/geotechnical conditions exist at the site that will require special consideration for design and/or construction. The foundation bedrock is considered competent for the existing dam, any of the options for raising the dam, appurtenant structures, and the embankment saddle dam.

Seismic Hazard Analysis

Overall, potential seismic hazard at the site is low. No known through-going faults have been identified in the vicinity of Friant Dam and Millerton Lake. While minor shearing is widespread within the dam site, only a few faults are specifically documented in the record of construction. None are considered active.

Preliminary earthquake loading analysis for this prefeasibility-level evaluation considered two types of potential earthquake sources: fault sources and areal/background sources (Reclamation, 2002b).

Twenty-two potential fault sources for the site were identified, including those faults associated with the San Andreas fault, seven western Great Valley faults, seven eastern Sierra Nevada faults, the White Wolf fault of the southern San Joaquin Valley, and six faults of the Sierra Nevada Foothills fault system. No major through-going or shear zones have been identified in this area of the Sierra Nevada, and historic seismicity rates are low.

The areal/background seismic source considered was the South Sierran Source Block , the region surrounding the site. This region possesses relatively uniform seismotectonic characteristics.

Probabilistic seismic hazard analysis performed shows that the peak horizontal accelerations to be expected at the site are 0.13g with a 2,500-year return period, 0.17g with a 5,000-year return period, and 0.23g with a 10,000-year return period.

HYDROLOGIC SETTING

Friant Dam and Millerton Lake have a drainage area of 1,638 square miles. Relevant environmental aspects of the immediate drainage area are described in a later section of this chapter.

Rainfall

Rainfall for the 1988 Reclamation Probable Maximum Flood (PMF) study for Friant Dam came from Hydrometeorological Report (HMR) 36 (USWB, 1969). The values were checked with the recently released HMR 58 (Corrigan et al., 1998) and were found to be very close for all durations. It was concluded that revision of the PMF study was not required as a result of changes in Probable Maximum Precipitation (PMP).

The PMP design storm distribution was the standard Reclamation PMP design storm for which the peak increment of rainfall occurs at the 2/3 point of the storm (hour 48 for a 72-hour storm), and decreasing incremental values of precipitation are alternated about the peak increment.

The entire basin was divided into six subbasins; different PMP amounts were calculated for each subbasin using a “successive-subtraction” technique that preserved the volume of the PMP over the entire basin but allowed for a storm-centering effect over the subbasins near the middle of the entire drainage basin.

Runoff and Flood Data

In calculating PMF, constant loss rates were considered that reflected the assumption that a significant portion of the basin would be covered with snow. Excess precipitation, after subtracting the constant loss, was converted to runoff by standard Reclamation unit hydrograph techniques. In addition to the rainfall runoff, runoff representing a 100-year snowmelt condition was also added to the PMF hydrograph.

Erosion and recharge are not typically considered when developing a PMF hydrograph. The prefeasibility-level PMF hydrograph for this dam site represents a maximum condition for clear water runoff with no consideration given to sediment flows or to groundwater recharge.

The current PMF for Friant Dam was derived from HMR 36, and is dated 7 October 1988. This PMF has a peak discharge of 574,000 cfs and a 15-day volume of 2,454 TAF. The PMF study included peak discharges for several frequency floods (Reclamation, 2002d). It is recognized that the Corps has prepared revised hydrologic data following a severe flood event in January 1997. More recent information will be incorporated as necessary to support flood benefits in future phases of the study.

EXISTING FACILITIES

The existing Friant Dam, owned and operated by Reclamation, is a concrete gravity structure with a structural height of 319 feet, crest length of 3,448 feet, crest width of 20 feet, and maximum base width of 267 feet. Three small dikes, to close low areas along the reservoir rim, are located in the Millerton State Recreation Area (SRA) on the left side of the existing reservoir. (Throughout this report, left and right are referenced to an orientation looking downstream.)

The spillway consists of an ogee overflow section, chute, and stilling basin at the center of the dam. The spillway is controlled by one 18-foot-high by 100-foot-wide drum gate, and two comparably sized Obermeyer gates. Madera Canal and outlets are located on the right abutment; Friant-Kern Canal and outlets are located on the left abutment. A river outlet works is located to the left of the spillway within the lower portion of the dam.

Millerton Lake SRA facilities, including a boat ramp, marina, camping and day-use facilities, are located along the left side of the reservoir. There are additional recreation facilities on the right side. Private residences are located at or above elevation 610, or more than 25 feet above the current maximum reservoir levels.

The dam serves the dual purposes of storage for irrigation and flood control. Millerton Lake has a gross storage capacity of 520.5 TAF at elevation 578, the top of active conservation storage.

HYDROPOWER FACILITIES

Three powerhouses, owned and operated by the Friant Power Authority, are located on the downstream side of Friant Dam. A powerhouse on each canal generates hydroelectricity as water is released to the Friant-Kern and Madera canals for delivery. A third powerhouse located at the base of the dam adjacent to the spillway generates hydroelectricity as water is released to the San Joaquin River. The combined installed capacity of the three powerhouses is about 30 megawatts (MW).

Two Pacific Gas and Electric (PG&E) powerhouses, Kerckhoff Powerhouse and Kerckhoff No. 2 Powerhouse, are located within a mile of the upstream end of Millerton Lake. Water feeding the powerhouses is diverted at Kerckhoff Dam and conveyed through tunnels and penstocks. Kerckhoff Powerhouse, commissioned in 1920 and located about a mile upstream of the extreme end of Millerton Lake, has a generation capacity just under 50 MW and generated an average of nearly 50 gigawatt-hours (GWh) per year from 1994 through 2002. Kerckhoff No. 2 Powerhouse, by contract, is a relatively modern facility, commissioned in 1983 with a capacity of 96 MW. It discharges directly to Millerton Lake and generated more than 500 GWh/yr, on average, from 1994 through 2002. Additional details regarding these powerhouses are provided in the Temperance Flat Reservoir TM.

ENVIRONMENTAL SETTING

This section describes the environmental setting for botany, wildlife, aquatic biology and water quality, recreation, cultural resources, land use, and mineral resources in the vicinity of Friant Dam and Millerton Lake. The geographic extent of this discussion is limited to areas that could be affected by raising Friant Dam.

Botany

Annual grassland and oak woodland habitats occur in the vicinity of the dam and around much of the reservoir area. Six special-status botanic species occur in the general area, including San Joaquin Valley Orcutt grass (Federally listed as threatened and State-listed as endangered), succulent owl's-clover (Federally listed as threatened and State-listed as endangered), Bogg's Lake hedge-hyssop (State-listed as endangered), Hartweg's pseudobahia (Federally listed and State-listed as endangered), tree anemone (State-listed as endangered), and Madera linanthus (California Native Plant Society [CNPS] List 1B). The first three of these are vernal pool species. Hartweg's pseudobahia is a grassland species.

Several populations of Madera linanthus occur along the shoreline of Millerton Lake. Although Madera linanthus is on CNPS List 1B, it has no other State or Federal status. Surveys would be needed to determine the presence or absence of vernal pools and associated species within the vicinity of Millerton Lake, as well as for tree anemone and Hartweg's pseudobahia.

Wildlife

Millerton Lake is surrounded by foothill pine–oak woodland habitat with pockets of grassland, wetland, and riparian habitats associated with hillside seeps and tributary streams. Stands of shoreline riparian habitat are few and very limited, probably due to reservoir fluctuations. The site hosts a diverse wildlife community, both resident and seasonal. Several sensitive species of wildlife are known to exist in the general area, including the California tiger salamander and western spadefoot toad. Fairy shrimp occur in vernal pools that could be located near the lake. Western pond turtles occur in Fine Gold Creek, a tributary to the reservoir. Foothill yellow-legged frogs and tri-colored blackbirds are also likely to occur in the area. Southern bald eagles may use the area for nesting and foraging during winter months.

Aquatic Biology and Water Quality

The downstream portion of Millerton Lake is open and wide, with gently sloping shorelines and several shallow bays, while much of the upper reservoir is narrow and steep-sided. During the May 2002 field visit of the environmental team, the reservoir level was near maximum pool elevation, inundating shoreline vegetation in some areas. Photographs suggest that little to none of the inundated vegetation reaches the water's edge when water elevation drops in late summer. Terminal portions of embayments in the downstream end of the reservoir are particularly shallow and well-vegetated. Such protected areas may provide the best spawning and nursery habitat for important game fish species such as largemouth bass (*Micropterus salmoides*) and spotted bass (*M. punctulatus*). In the upstream end of the reservoir, protected shallow water habitat is found primarily in the Temperance Flat area.

The 9-mile reach of the San Joaquin River between Millerton Lake and Kerckhoff Dam, a portion of which would be inundated if this measure were implemented, has a bedrock channel with a shallow gradient and many long narrow pools. The Kerckhoff Project powerhouses are located in the lower portion of the reach. Because the Kerckhoff Project bypasses water from this reach, stream flow usually results from Federal Energy Regulatory Commission (FERC) mandated flow releases for instream habitat: 15 cubic feet per second (cfs) in dry water years and 25 cfs in normal water years (PG&E, 1999). Summer water temperatures often exceed 75 degrees Fahrenheit, which is too warm for cold-water fish species. The reach supports several warm-water fish species. Flow released from the powerhouses into Millerton Lake is typically colder than water in the river because it is sheltered from the sun and travels more quickly from Kerckhoff Reservoir to the powerhouses via tunnels.

No water quality data were identified for Millerton Lake, but water quality data for Kerckhoff Reservoir are available (PG&E, 1986b). Because much of the inflow to Millerton Lake arrives from Kerckhoff Reservoir via diversion tunnels or the 9-mile reach of the San Joaquin River, water quality of Millerton Lake is probably excellent. All water quality parameters measured meet Basin Plan standards of the Central Valley Regional Water Quality Control Board.

Millerton Lake becomes thermally stratified during summer months and supports a two-stage fishery: cold-water species reside in deep water and warm-water species inhabit surface waters and areas near shore.

Many fish species inhabit Millerton Lake, most of which are introduced game species or forage species (USFWS, 1983). Principal game species are largemouth bass, smallmouth bass (*M. dolomieui*), spotted bass, bluegill sunfish (*Lepomis macrochirus*) and striped bass (*Morone saxatilits*). The principal forage species is threadfin shad (*Dorosoma pretense*).

Cold-water game species, including rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*), also inhabit Millerton Lake. American shad (*Alosa sappdissima*), an anadromous Atlantic Ocean species successfully introduced to the Sacramento and San Joaquin rivers, was accidentally planted in Millerton Lake in the mid-1950s and is the only landlocked population of American shad known to exist. American shad spawn in the San Joaquin River upstream of Millerton Lake and in the upper portion of the reservoir. Striped bass also spawn upstream in the river. Stocking of striped bass was suspended in 1987, but some natural reproduction occurs.

Native warm-water species in Millerton Lake include Sacramento sucker (*Catostomus occidentalis*), Sacramento pikeminnow (*Ptychocheilus grandis*), Sacramento blackfish (*Orthodon microlepidotus*), hitch (*Lavinia exilicauda*), and hardhead (*Mylopharodon conocephalus*). Hardhead, which has been classified as a State of California Species of Special Concern and a United States Forest Service (USFS) Sensitive Species, also inhabits the San Joaquin River upstream of Millerton Lake. Another State Species of Special Concern, Kern Brook lamprey (*Lamperta hubbsi*), may also occur in the area.

Recreation

Millerton Lake is a major low-elevation recreation destination, providing a variety of recreation opportunities, including fishing, swimming, boating, and water skiing. Several developed recreation facilities are present along the reservoir margins, including boat launching areas, developed campgrounds and day use areas, and recreation residences. The primary launching area is located on the south side of the reservoir near Friant Dam. This launch area is accessible by paved road and includes large paved parking areas and several boat ramps. Smaller, less heavily used boat launches are located elsewhere on the lake. Paved and unpaved roads provide access to the lake's shoreline. The area upstream of Big Bend, at about river mile (RM) 274.5, is relatively remote and accessible only by boat or unpaved roads. Dispersed use occurs along the entire shoreline and along the San Joaquin River upstream of Millerton Lake.

Whitewater boating occurs on the San Joaquin River upstream of Millerton Lake, between Kerckhoff Reservoir and Kerckhoff No. 2 Powerhouse. This run is 11 miles long and is generally referred to by boaters as the Patterson Bend Run. According to Holbek and Stanley (1988), the first 6 miles are mostly flat or Class II with an occasional Class III or IV rapid. The next 5 miles are much more difficult, Class V on the International Scale of Difficulty. In general, the run is navigable at flows ranging from 1,500 to 5,000 cfs, but expert boaters probably run it at higher flows. These flows are usually only available during late winter and spring when flows in the San Joaquin exceed the capacity of Kerckhoff No. 2 Powerhouse. Summer flows between Kerckhoff Dam and Kerckhoff No. 2 Powerhouse are typically well below the range considered navigable.

Cultural Resources

The San Joaquin River was a very important resource for the Native American people who lived along its reaches. Most settlements were located on low mounds along major waterways (Wallace, 1978). The Western Mono people fished for salmon and other river fish, and deer hunting was important. Western Mono hamlets were located along major streams, including the San Joaquin, Kings, and Kaweah rivers.

The Millerton Lake area is at the approximate border between traditional territories of the Foothill Yokuts and Western Mono or Monache people. There is some uncertainty in the literature regarding specific boundaries between the groups, or even what some groups were called. Some overlapping of boundaries would be expected because in much of native California, Native American territories were but loosely maintained, and people frequently traveled into adjacent territories to trade and to exploit resources thought of as common property for all residents of a region (Gayton, 1948). During the mid-20th century, when human remains from several Indian cemeteries that were to be inundated by Millerton Lake were removed by Reclamation for reinterment, it was discovered that descendants were from several different Yokuts groups. Some remains were taken to a cemetery at Table Mountain Rancheria, while others were buried at the Picayune Indian Cemetery near Coarsegold (Witte, 1941).

Northfork Mono people now live primarily at North Fork Rancheria, and the Posgisa Mono are at Big Sandy Rancheria in Auberry. Yokuts people live at Table Mountain Rancheria, in Friant.

Several archaeological surveys and excavations have been undertaken within the area that could be affected by raising Friant Dam. A recent records search by Reclamation archaeologists indicates 47 archaeological sites within, adjacent to, or outside but close by the existing pool (Welch, 2002). The sites are mostly prehistoric, including habitation sites with housepits, sweathouses, and human burials; a lithic quarry site; bedrock mortars (BRMs); rock rings; and lithic scatters. Some sites along Millerton Lake are as much as 2,000 years old (Moratto, 1984). Excavation of site CA-Mad-98 in the late 1980s revealed that the site was largely intact despite nearly 50 years of inundation (Rivers, 1988).

Various historic sites are present in the Millerton Lake area, mostly associated with early settlement or mining. American fur trappers entered the San Joaquin River drainage as early as 1827, and mining began on the river in 1850. In 1851, Fort Miller was established, and in 1852, a mining supply town called Rootville was established. This later became Millerton, named after nearby Fort Miller. Millerton became County Seat in 1856 and held this status until 1874 when the County Seat was moved to Fresno. Fort Miller was decommissioned in 1866 and became part of a cattle ranch. Friant Dam was constructed in the early 1940s. One property of historic interest is a former State of California courthouse. This structure was relocated from an original site within present-day Millerton Lake to its current location when Friant Dam was constructed. Because it was relocated, the courthouse is not eligible for recognition as an historic structure.

Land Use

Housing is present in four distinct areas around Millerton Lake. The most southwestern location is along Millerton Road between Friant Dam and the Millerton SRA. Many of these homes are within 50 vertical feet of the existing maximum water level of Millerton Lake. A second area is along Sky Harbor Drive, on the left side of the reservoir in Fresno County. Many of the homes in this area are developed on steep slopes with elevations as low as 20 feet above the maximum level of Millerton Lake. This area also contains several undeveloped lots. A third area, Hidden Lakes Estates, is in Madera County near the confluence of Fine Gold Creek. Some homes in this area are near the lake level and others are built on the hillside. The fourth area is in Temperance Flat, where two houses accessible by Wellbarn Road are present. Many of the homes around Millerton Lake appear to be used year-round while others may be seasonal residences. The three larger housing areas are accessed by roads that meander through hilly terrain along or near Millerton Lake.

Mineral Resources

There is evidence of former gold mining activities near RM 279 and in the Temperance Flat area. Literature review indicates that past mining activities at the Sullivan and Patterson mines were limited to mechanical processing.

THIS PAGE LEFT BLANK INTENTIONALLY

CHAPTER 3. STORAGE STRUCTURES AND APPURTENANT FEATURES

This chapter describes storage structures and appurtenant features for potentially enlarging Friant Dam and Millerton Lake, and associated constructibility issues, costs, and systems operations.

STORAGE STRUCTURES

The existing dam can likely be raised most economically with an RCC overlay. The saddle dam would be an earthfill structure.

The concrete dam raise would be accomplished by providing an overlay on the downstream face of the existing dam and extending the top of the dam vertically to the new crest elevation using RCC. A cross section illustrating typical details for a 25-foot dam raise using RCC is shown in Figure 3-1.

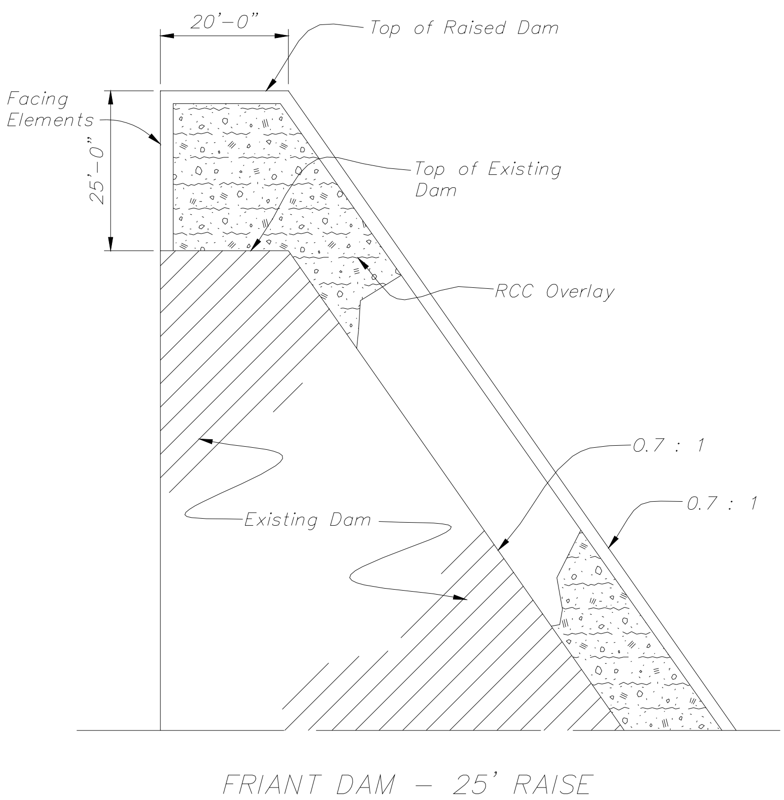


FIGURE 3-1. RCC OVERLAY CROSS SECTION

Facing elements would be included along both the upstream and downstream faces of the overlay. The facing elements would be constructed of conventional concrete to provide a more durable surface on the exposed faces of the dam. A conventional concrete cap would be included along the dam crest, and the spillway crest, guide walls, and stilling basin would be constructed using conventional concrete. The saddle dam would be a zoned earthfill dam consisting of a central core, filters, drainage elements, slope protection, and riprap.

RESERVOIR AREA AND STORAGE

Curves showing additional storage volume and total reservoir area vs. elevation are shown in Figure 3-2, which extends the existing elevation relationships of Millerton Lake up to a 140-foot raise. Reservoir area and total capacity data for Millerton Lake with the Friant Dam enlargement are summarized in Table 3-1.

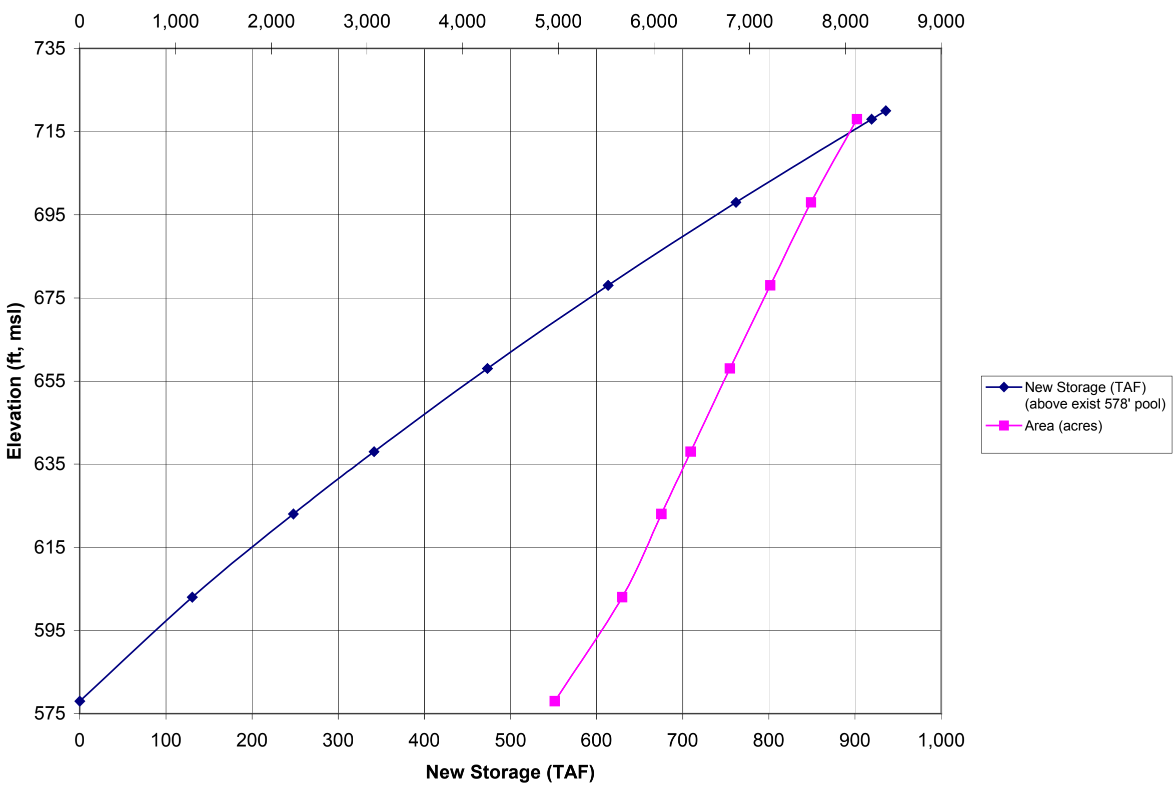


FIGURE 3-2. ELEVATION VS. STORAGE AND AREA RELATIONSHIPS

TABLE 3-1.
RESERVOIR AREA AND CAPACITY

Option	Area (Acres)	Total Capacity (TAF)	Increased Storage (TAF)
Existing	4,897	520	0
25-foot raise	5,500	652	132
60-foot raise	5,777	860	340
140-foot raise	7,694	1,390	870
Key: TAF – thousand acre-feet			

APPURTENANT FEATURES

This section describes major appurtenant features that would be associated with enlarging Friant Dam and Millerton Lake.

Conveyance

The existing outlet facilities satisfy current needs; therefore, additional facilities were not included in this estimate. If additional releases are required to satisfy future needs, new or expanded outlets may be required. Emergency evacuation of the reservoir is also satisfactory for the existing dam, but would need to be evaluated if this option were selected for further study.

The existing dam can accommodate about 30 percent of the current PMF volume before overtopping occurs. An abbreviated assessment of the overtopping parameters resulted in the determination that a breach of the concrete dam was not likely. Furthermore, it was determined that overtopping and breaching of the existing saddle dikes would not result in loss of life. Current studies do not include provisions for increasing spillway capacity. However, if this option is carried forward, the opportunity or need for providing additional spillway capacity should be considered.

Pumping Plants

Pumping plants would not be required.

CONSTRUCTIBILITY

This section discusses issues of concern related to constructing the dam, reservoir, and appurtenant features.

Land, Rights-of-Way, and Easements

Land acquisition for constructing the facilities is not considered an issue, since the lands required are either Reclamation or other public lands. Land in private ownership, including numerous residential sites around Millerton Lake, would have to be acquired for the new reservoir areas associated with raising Friant Dam more than 20 feet. Raises of less than 20 feet may require land acquisition of portions of private parcels, but may not affect structures.

Rights-of-way for constructing the dam raise and appurtenant facilities would be on or through existing Reclamation and/or other public lands.

Two hydroelectric powerhouses are located on the left abutment of Friant Dam: one on the Friant-Kern Canal and one for the river outlet. A third powerhouse is located on the Madera Canal outlet on the right abutment of the dam. Overhead power lines originate from these powerhouses.

Access

Principal access to the site for construction is via paved roads. Additional roads for construction site access and haul roads from local borrow areas would be required.

Borrow Sources and Materials

Concrete aggregate could be processed from bedrock outcrops in the reservoir area. This same processed material would provide filter material and riprap for the dike. Additional concrete aggregate and other processed materials may be available in limited quantities from alluvial deposits along the San Joaquin River floodplain downstream from the existing dam. Haul distances would be 2 to 3 miles to the dam and 2 miles or less to the saddle dam.

Pervious and semipervious materials could be acquired near the saddle dam by processing the granite colluvial soil; processing would remove oversize materials.

Impervious material for the core of the dike can be found on agricultural land within 1 to 2 miles of the dike. Because the fine-grained deposits are approximately 4 feet thick, a large surface area would have to be mined.

Processed sands and gravels could be supplied by commercial sources and/or crushing and processing quarried rock in the reservoir area.

Foundations

Foundations for any of the options would be in sound granitic rock, as described in the geology section. No special foundation considerations are known for the site at this time. Foundation preparation would be typical for each option.

Power Source

High voltage power is available from the existing Friant Dam. Lower voltage service (e.g., 110 volts [v] or 220 v) is also available at the dam.

Staging and Lay-Down Areas

Construction use/staging/lay-down areas would likely be located downstream of the dam on existing Reclamation property.

Contractor Availability and Resources

All options would involve heavy construction typical for the western United States. For the high dam options, several contractors might need to form a consortium due to the size of the construction.

Construction Schedule and Seasonal Constraints

The climate of central California around Friant Dam is mild with no snow. The coldest month is January with average daily high and low temperatures of 55° F and 36°F, respectively. The wet season is December through March with an average monthly rainfall of about 2.5 inches. Options considered in this report are immune to these climate conditions and year-round construction is assumed.

The construction period for the 25-foot raise option is estimated to be 2 to 3 years. The 60-foot raise has an estimated 2- to 4-year construction period, and the 140-foot raise would have a 3- to 6-year construction period.

Flood Routing During Construction

Detailed studies were not performed to evaluate diversion during construction. However, the existing spillway has a capacity of about 83,000 cfs, and the outlet works has a capacity of about 17,000 cfs. A 25-year diversion flood has a peak discharge capacity of about 65,000 cfs. For purposes of this study, it was assumed that the existing spillways would remain operational until the last 25 feet of dam raise. The final raise would be scheduled during the normally low flow periods of the year, and when the modified outlet works would be available. These assumptions would need to be verified during final designs.

Environmental Impacts During Construction

Environmental impacts during construction could be easily mitigated with proper planning and implementation of best management practices. The work site is remote to urbanization; therefore, noise and visual impacts would be minimal. The access road would require re-routing and could be restricted to the general public, except those property owners with lands upstream and American Indians requiring access to their tribal lands.

Truck traffic for importing materials and excavation equipment would discharge exhaust to the local air basin. Air quality issues could be mitigated by dust control measures for both the spillway excavation and berm construction.

Importing construction materials from distant sources would cause traffic impacts, but with proper planning and coordination with Caltrans, major impacts could be easily mitigated. All construction equipment should have spark arresters and fire control equipment should be keep readily accessible during construction. Construction water would have to be controlled and provisions for runoff and erosion control would need to be developed and implemented. A spill control plan would be needed to control any construction-related fuels, lubricants, and other materials.

A cultural survey should be conducted to identify any ancestral American Indian or historic artifacts and construction activities would be restricted in those areas. The presence of bald eagles, which have been sighted in the region, could affect the types of construction activities that would be permitted during some time periods.

Permits

It is probable that Federal and non-Federal sponsors would be involved in the work. Given the probable duality of sponsorship, and potential environmental and cultural impacts identified, at a minimum, certain permits could be required from the permitting agencies listed in Table 3-2.

TABLE 3-2. POSSIBLE REQUIRED PERMITS

Permit	Permitting Agency
Permit to Construct	DSOD, Fresno County
Encroachment	Caltrans, Fresno County
Air Quality	CARB, Fresno County
Low/No Threat NPDES	RWQCB
Waste Discharge	RWQCB
401 Certification	SWRCB
Blasting	Fresno County
Streambed Alteration	CDFG
Fire/Burn	CDF, Fresno County

Key:

CARB	California Air Resources Board
CDF	California Department of Forestry
CDFG	California Department of Fish and Game
DSOD	Department of Safety of Dams
NPDES	National Pollutant Discharge Elimination System
RWQCB	Regional Water Quality Control Board
SWRCB	State Water Resources Control Board

In addition, the following agencies could be involved in reviewing permit conditions:

- Bureau of Indian Affairs
- Bureau of Land Management
- State Historic Preservation Office
- Advisory Council on Historic Preservation
- United States Fish and Wildlife Service (USFWS)

In obtaining these permits, several plans would need to be prepared and submitted to the responsible agencies for review and approval:

- Construction Plan and Summary Documents
- Quality Control Inspection Plan
- Highway Notification Plan
- Blasting Plan
- Noise Monitoring Plan
- Water Quality Monitoring Plan
- Noxious Weed Control Plan
- Bat Protection Plan
- Management Plan for Avoidance and Protection of Historic and Cultural Properties
- Storm Water Pollution Prevention Plan
- Spill Prevention/Containment Plan
- Visual Quality Control Plan
- Dust Control and Air Quality Plan

Another important regulatory requirement involves compensation /mitigation for habitat loss. In October 1998, USFWS issued a draft Coordination Act Report and Habitat Evaluation Procedure (HEP Analysis). The HEP Analysis delineates how compensation for adversely affected baseline habitat and wildlife conditions is to be determined.

In addition, if power generation is included in a project or is modified for an existing project, FERC may become involved in the permitting process.

COSTS

Field costs for constructing each option were estimated at 2003 price levels. Table 3-3 summarizes these costs for the raise options considered.

Construction Costs

For each option, field costs represent the estimated direct costs to modify the dam and appurtenant features, plus allowances for mobilization (5 percent), unlisted items (15 percent), and contingencies (25 percent). Additional study would be needed to determine costs of reservoir clearing, environmental mitigation, relocation or acquisition of existing facilities, and acquisition of lands, easements, and rights-of-way. Costs of investigations, designs, construction management, administration, and interest during construction are not included in field costs. Details of the estimates are shown on worksheets in Appendix C.

TABLE 3-3.
SUMMARY OF CONSTRUCTION FIELD COSTS

Dam Raise (feet)	Normal Maximum Water Surface Elevation (feet above mean sea level)	Total New Storage (TAF)	Field Cost ($ Million)
25	603	132	100
60	638	340	**250**
140	718	870	**640**

Key:
TAF – thousand acre-feet

Operation and Maintenance Costs

Operation and maintenance costs have not yet been estimated for options considered in this TM. Reclamation will estimate operations, maintenance, and replacement costs by applying representative figures based on a review of other similar work and agency guidance.

SYSTEMS OPERATION

Systems operation studies of reservoir yield for potential alternative uses are presented in the Phase 1 Hydrologic Modeling TM.

CHAPTER 4. HYDROELECTRIC POWER OPTIONS

This chapter describes existing hydropower facilities, potential for increased generation and pumped storage, and power transmission.

HYDROPOWER FACILITIES

The existing powerhouses below Friant Dam are owned and operated by the Friant Power Authority. Cost estimates assume that the existing powerhouses would be modified, reconstructed, or relocated without any upgrades. Further study would be warranted to evaluate the feasibility of upgrading the existing plants for increased heads.

The existing Kerckhoff powerhouses, briefly described in Chapter 2, could be inundated by enlarging Millerton Lake, along with portions of associated access roads and transmission lines. Figure 4-1 shows the relationship of the Kerckhoff powerhouses to a potential 140-foot raise. A 25-foot raise would inundate Kerckhoff No. 2 Powerhouse and affect the tailwater of Kerckhoff Powerhouse (labeled Kerckhoff #1 in Figure 4-1). A raise of approximately 60 feet or greater would inundate Kerckhoff Powerhouse.

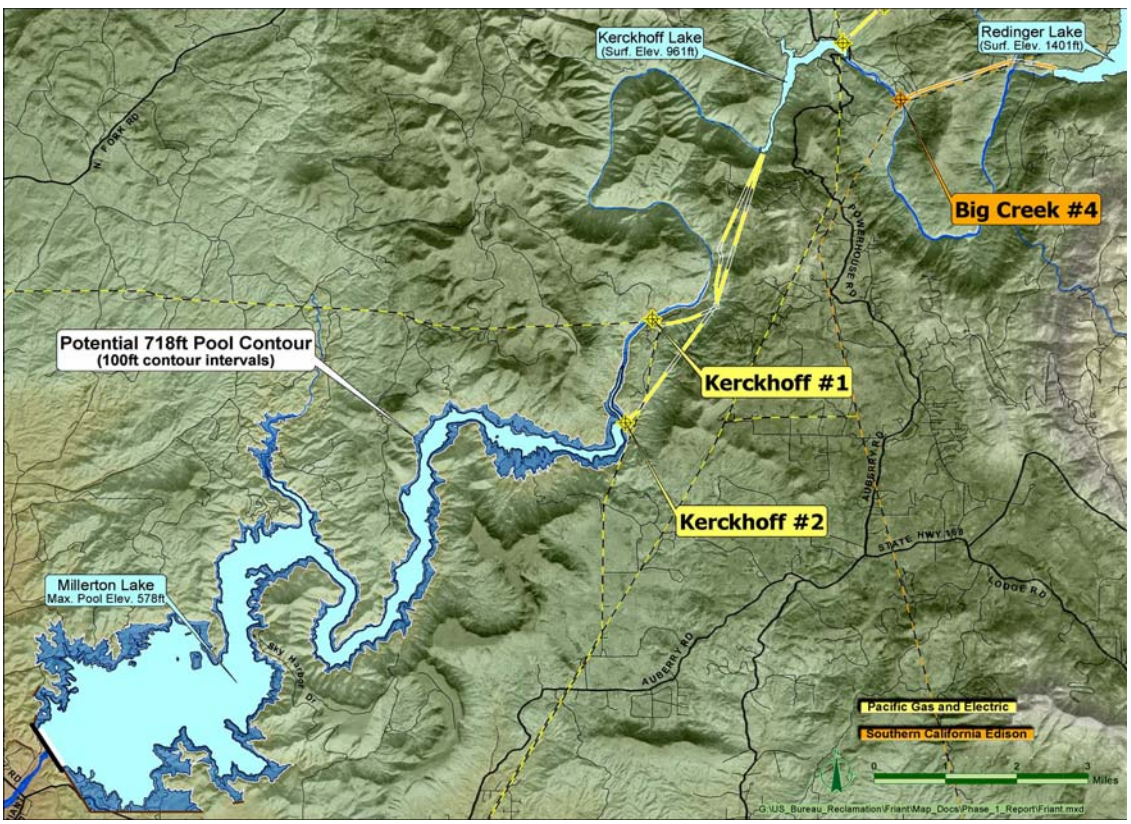


FIGURE 4-1. LOCATION OF KERCKHOFF POWERHOUSES

POTENTIAL INCREASED GENERATION

Enlarging Millerton Lake would increase the head at the Friant Dam powerhouses and allow some water that would otherwise be spilled to be released through the powerhouses. The amount of increased generation would depend on the scale of the enlargement and the operations of the enlarged reservoir. It is unlikely, however, that the increased generation at Friant Dam could completely replace lost generation from the Kerckhoff powerhouses. Even if Kerckhoff facilities could be relocated further upstream, it would be a costly endeavor and would reduce the head available for generation by the Kerckhoff hydroelectric project.

Once the range of potential raises to Friant Dam is refined, the potential increased generation at the Friant powerhouses and the potential to modify the Kerckhoff Project would be evaluated.

PUMPED STORAGE CONSIDERATIONS

Pumped storage was not considered for Friant Dam enlargement. However, the potential to use Millerton Lake as the lower reservoir in a potential pumped storage scheme is discussed in both the Fine Gold Reservoir and Temperance Flat Reservoir TMs.

TRANSMISSION

Relocated powerhouses at Friant Dam would be reconnected to the existing power grid.

CHAPTER 5. ENVIRONMENTAL CONSIDERATIONS

This chapter describes existing environmental resources at the site and qualitatively describes potential effects of reservoir enlargement, indicating the extent to which expected or potential environmental effects might pose a constraint to the development of surface storage. Where evident, opportunities for improving environmental resources or mitigating adverse effects have been noted. Analysis focused on botany, terrestrial wildlife, aquatic biology, water quality, recreational resources, cultural resources, and existing land uses. Mining and other known past activities that might affect site conditions are also briefly discussed, along with the potential presence of hazardous or toxic materials. Temporary construction-related disruptions and impacts are discussed in Chapter 3.

Identification of constraints was conducted at a preliminary, prefeasibility level of planning, consistent with the current phase of the Investigation. Criteria considered were based, in part, on criteria commonly used to evaluate environmental impacts of projects under the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). Application of criteria that may be used for NEPA or CEQA evaluation does not imply that the analysis was conducted at a level necessary to support an Environmental Impact Statement or Environmental Impact Report. Considerations included presence of special status species (e.g., Federally or State-listed endangered species); species of concern or sensitive habitats; relative amounts of affected riparian or wetland habitat; effects on native or game fish; conflict with established recreational uses or land uses; presence of nationally registered historic places, sacred Native American sites, or Traditional Cultural Places (TCPs); permanent disruption or division of established communities; and loss of energy production facilities.

BOTANY

Special-status botanic species occur in the area, including species listed as endangered or threatened (State and/or Federal listings). One listed species, tree anemone, may be present in the watershed, and several populations of Madera linanthus occur along the shoreline of Millerton Lake. (This species is on CNPS List 1B, but has no other State or Federal status.) Three special status species occur in vernal pools.

Constraints

Some wetland and riparian habitat would be affected by enlarging Millerton Lake. The likelihood of special-status species posing a constraint is low: a 25-foot raise of the dam is unlikely to affect tree anemone, although Madera linanthus would probably be impacted by a raise of Friant Dam. Overall, enlarging Millerton Lake would be expected to have a low degree of impact on special habitats and species.

Vernal pools would not likely be affected if the dam were raised up to 140 feet except perhaps in an area on the south side of the lake along Millerton Road. Surveys would be needed to determine the presence or absence of vernal pools and vernal pool special-status species.

Opportunities

Mitigation obligations do not appear extensive for botanic resources; however, there may be few readily available opportunities at this site for habitat improvement.

WILDLIFE

The site hosts a diverse wildlife community, both resident and seasonal. Several sensitive species of wildlife are known to exist in the vicinity, including the California tiger salamander, western spadefoot toad, and fairy shrimp in vernal pools possibly located near the lake. Western pond turtles occur in Fine Gold Creek, a tributary to the reservoir. Foothill yellow-legged frogs and tri-colored blackbirds are also likely to occur in the area. Southern bald eagles may use the area for nesting and foraging during winter months.

Constraints

Most of the sensitive species potentially present at the site are not listed as threatened or endangered by State or Federal agencies. However, the extent of habitat loss and the combined numbers of species that would be affected would increase in magnitude as larger reservoir sizes are considered, and could result in design or operational constraints.

AQUATIC BIOLOGY AND WATER QUALITY

The downstream end of Millerton Lake is open and wide, with gently sloping shorelines and several shallow bays, while much of the upper reservoir is narrow and steep-sided. Little or no inundated vegetation may reach the water’s edge when water elevation drops in late summer.

Terminal portions of embayments in the downstream end of the reservoir are particularly shallow and well vegetated. Such protected areas may provide the best spawning and nursery habitat for game fish species. In the upstream end of the reservoir, protected shallow water habitat is found primarily in the Temperance Flat area.

Millerton Lake becomes thermally stratified during summer months and supports a two-stage fishery. Cold-water species reside in deep water and warm-water species inhabit surface waters and areas near shore. A large number of fish species inhabit Millerton Lake, most of which are introduced game or forage species (USFWS, 1983). Principal game species are largemouth, smallmouth, spotted, and striped bass, and bluegill sunfish. The principal forage species is threadfin shad. Other cold-water game species include rainbow and brown trout. A landlocked population of American shad, an anadromous Atlantic Ocean species, is present in Millerton Lake and spawns in the upper portion of the reservoir, and also spawns, with striped bass, in the San Joaquin River upstream of the lake. Hardhead, which has been classified as a State of California Species of Special Concern and a USFS Sensitive Species, inhabits the San Joaquin River upstream of the existing lake. Another State Species of Special Concern, Kern Brook lamprey (*Lamperta hubbsi*), may also occur in the area.

The 9-mile reach of the San Joaquin River between Millerton Lake and Kerckhoff Dam has a bedrock channel with little gradient and many long narrow pools. The Kerckhoff Project powerhouses are situated in the lower portion of the reach. Because the Kerckhoff Project bypasses water from this reach, stream flow usually results from FERC-mandated flow releases for in-stream habitat. Summer water temperatures often exceed 75 degrees Fahrenheit, which is too warm for cold-water fish species. The reach supports a number of warm-water fish species. Flow released from the powerhouses into Millerton Lake is typically colder than that in the river because it is sheltered from the sun and travels quickly from Kerckhoff Reservoir to the powerhouses via tunnels.

Because much of the inflow to Millerton Lake arrives from Kerckhoff Reservoir, via diversion tunnels or the 9-mile reach of the San Joaquin River, water quality of Millerton Lake is probably excellent.

Constraints

Principal constraints on fish resources associated with raising Friant Dam would be increases in seasonal water level fluctuations, reductions in surface area of shallow water habitat, and inundation of a portion of the San Joaquin River upstream of the reservoir.

An increase in the maximum pool elevation of Millerton Lake would probably result in greater seasonal water level fluctuations. Presumably, greater enlargements would be associated with greater water level fluctuations, although operations studies would be needed to characterize the fluctuations.

Seasonal water level fluctuations can have a number of adverse effects on fish. Rapidly changing water levels can result in habitat instability, particularly for shallow water species. Water level fluctuations can adversely affect nearshore spawning species, such as largemouth bass, that spawn in the spring, when reservoir levels rise with snowmelt capture. Rising water levels result in increased water depth of largemouth bass nests, exposing them to water temperatures that may be too cold for the developing eggs. Spotted bass, introduced into Millerton Lake because they spawn in deeper, colder water than largemouth bass, and are better able to withstand rising water levels, would probably be less affected than largemouth bass by the increase in reservoir maximum pool.

Water level fluctuations also inhibit development of shoreline vegetation. Shoreline vegetation provides cover and feeding substrates for many warm-water game species in the reservoir. The vegetation also stabilizes shoreline sediments, reducing erosion and sedimentation. Because of the effects on vegetation, increases in water level fluctuations could adversely affect most fish species in the reservoir. Operations studies and an analysis of reservoir bathymetry is needed to determine the magnitude and direction of change in availability of shoreline habitat.

Increasing the reservoir elevation could change the availability of shallow water habitat; however, additional mapping and operational studies are required before this affect can be quantified. Shallow water habitat is beneficial to many reservoir fish species. This habitat is highly productive, because bottom nutrients and surface sunlight, both required for plankton growth, occur together in shallow water. Shallow water habitat tends to be warmer than deep-water habitat and thus promotes more rapid growth of the warm-water game species. A reduction in shallow water habitat would likely affect most fish adversely, while an increase would be beneficial. Although a higher water level would cause the total length of shoreline to increase, the surface area of shallow water habitat would not necessarily be enhanced. Raising the reservoir water level would increase shallow water habitat in some areas but reduce it in other areas, depending on the bathymetry. Quantification of shallow water area is further complicated because surface area of a given depth changes rapidly with seasonal water level fluctuations. A detailed analysis based on bathymetry would be needed to determine effects of different water levels on surface area of shallow water habitat.

Increasing the maximum pool of Millerton Lake to elevation 718 would result in inundation of 3 miles of the San Joaquin River upstream of Millerton Lake. This reach of the river is a spawning area for the American shad and striped bass populations. Shad also spawn in the upstream portion of Millerton Lake below Temperance Flat, which is the most riverine portion of the reservoir and has turbulent flows (PG&E, 1990). Spawning begins in May when water temperatures exceed 52 degrees Fahrenheit and usually ends by early July. Studies by PG&E have shown that American shad need uninterrupted, steady discharges from the Kerckhoff powerhouses to stimulate spawning. Powerhouses would have to be moved or protected with dikes to avoid their being inundated when the reservoir level was raised.

Increasing the maximum pool to elevation 718 would probably result in an upstream shift in American shad spawning area, particularly if the powerhouses were moved upstream. Because 3 miles of the river would be inundated, the upstream shift in spawning area could also be about 3 miles. Lesser increases in maximum pool elevation would result in more moderate upstream shifts in spawning locations. However, the ability of the population to shift spawning locations would depend on new flow conditions in the reservoir and river. Because operation of the Kerckhoff Project greatly affects flow conditions, operation of the project would have to be coordinated with the Friant Dam raise to ensure that suitable flows are maintained in spawning areas. Currently, when the reservoir is at or near full pool, suitable flow conditions may not exist in the upstream portion of the reservoir for shad spawning unless the reservoir receives high inflows from the river (USFWS, 1991). This suggests that flow conditions would not be suitable with increased reservoir elevations unless the powerhouses were operated differently or moved upstream. Adequate assessment of the effect of increasing maximum pool elevation on American shad spawning will require complex analyses, including hydraulic modeling.

No water quality constraints associated with increasing the maximum pool elevation of Millerton Lake have been identified. Increasing reservoir depth would likely lead to more stable thermal stratification and a larger pool of cold water.

Opportunities

Raising the maximum pool of Millerton Lake to elevation 718 would result in a substantial increase in total volume of fish habitat. The habitat type that would be most enhanced is deep, cold-water habitat used by species such as trout and salmon. Lesser raises in dam height would result in more moderate increases in total fish habitat. If cold-water habitat were sufficiently enlarged, stocking the reservoir with salmon and other cold-water species should be considered.

Increasing the maximum pool elevation might increase or reduce available shallow water habitat, depending on the reservoir's bathymetry. Adverse effects on American shad and striped bass spawning habitat of raising the reservoir level could likely be mitigated by establishing suitable flow conditions in the newly created upstream end of the reservoir and in the San Joaquin River above the reservoir. Establishing suitable flow conditions would probably require moving the Kerckhoff powerhouses upstream on the river and perhaps increasing flow releases from Kerckhoff Reservoir into the bypassed reach of the river.

If existing nearshore vegetation in Millerton Lake were not removed prior to raising the maximum pool, this vegetation would be inundated, thus providing a short-term increase in nutrient levels in the reservoir and enhancing habitat structure in the nearshore areas. Both effects would benefit fish production.

RECREATION

Millerton Lake is a major low-elevation recreation destination, providing a variety of recreation opportunities including fishing, swimming, boating, and water skiing. Several developed recreation facilities are present along the reservoir margins, including boat launching areas, developed campgrounds and day use areas, and recreation residences. Dispersed use occurs along the entire shoreline and along the San Joaquin River upstream of Millerton Lake. Whitewater boating occurs on the San Joaquin River upstream of Millerton Lake, between Kerckhoff Reservoir and Kerckhoff No. 2 Powerhouse.

Constraints

Raising the water surface elevation of Millerton Lake to elevation 718 would inundate all existing developed recreation facilities, including the primary boat launch area near the main dam, smaller boat launches on the north and south sides of the lake, Winchell Cove Campground, and day use areas. In addition, portions of the primary access roads would be submerged (see Figure 1-3). Submerging existing facilities and access roads would be considered a significant impact. Raising the water surface to elevation 718 would submerge the lower portion of Patterson Bend Run. This would reduce the boating run from about 11 to 9 miles, leaving most of the run intact.

Enlarging the reservoir would not substantially affect other dispersed use opportunities such as hiking, biking, camping, horseback riding, or off-highway vehicle use. These opportunities would continue to be available, regardless of the size of the reservoir, although trails and access facilities might need to be relocated.

Opportunities

Significant constraints associated with submerging existing developed recreation facilities could be reduced to less-than-significant levels by replacing the facilities. Enlarging Millerton Lake would increase the water surface area available for boating, fishing, and water skiing, and would increase the shoreline available for camping, picnicking, swimming, wading, and fishing. The enlarged reservoir would probably draw more visitors to the area, thereby creating demand for new facilities. Any new recreation facilities should be designed to accommodate future use levels.

Constraints associated with submerging the lower portion of Patterson Bend Run could be avoided by managing the water surface elevation so the run is not submerged when boating flows are present in the river. Providing better boating access could also mitigate minor impacts. Currently, boaters must paddle across Kerckhoff Reservoir and portage the dam to put in. The take-out is located at the PG&E Kerckhoff No. 2 Powerhouse. It might be possible to construct a new, more accessible take-out upstream of the inundation area.

CULTURAL RESOURCES

The Millerton Lake area is at the approximate border between traditional territories of the Foothill Yokuts and Western Mono or Monache people. A recent records search identified archaeological sites within, adjacent to, or outside but close by the existing reservoir area (Welch 2002). These sites include habitation sites with housepits, sweathouses, and human burials; a lithic quarry site; BRMs; rock rings; and lithic scatters. Some sites along Millerton Lake are as much as 2,000 years old (Moratto, 1984). In addition, various historic sites are present in the Millerton Lake area, mostly associated with mining or early settlement, including a former State of California courthouse.

Constraints

In light of the fact that numerous cultural resources are known to be present, it is possible that additional sites exist that have not yet been recorded. Inundation of archaeological sites (prehistoric or historic) can result in loss of important scientific data. As many as 47 known archaeological sites (possibly more) might be adversely affected by raising Friant Dam with the maximum raise of 140 feet; smaller raises presumably would affect fewer sites. No Native American sacred sites or TCPs are known to occur, but Northfork Mono and Yokuts concerns are expected.

An historic State of California courthouse would be inundated by dam raises greater than about 20 feet, but it is not eligible for the National Registry of Historic Places (NRHP). Available information does not indicate whether other known properties are eligible for the NRHP, but there is a strong probability that such properties exist.

Opportunities

Inundation damage to archaeological sites can be mitigated with scientific data recovery programs. Reservoir projects also provide an opportunity for public interpretation of the past. Potential impact to archaeological sites from ancillary facilities, such as roads, power lines, or other structures, may be avoidable through design or facility placement.

LAND USE

Many of the houses around Millerton Lake would be inundated or partially affected by raising the lake level. An initial inventory based on aerial photography only suggests that over 150 structures would be inundated if Millerton Lake level is raised 140 feet. The number of structures that would be affected from lower raises is not well understood, because the locations and elevations of building foundations and important infrastructure such as wells and septic systems have not been determined.

Most houses around Millerton Lake are accessed by roads that meander through hilly terrain along or near Millerton Lake. Portions of these roads are at elevations that would be inundated. Roads that would be affected by enlargement of the reservoir include Millerton Road, Road 145 on the northwestern shoreline to the peninsula in the lake, low spots of Fine Gold Drive, and a number of other private access roads.

As mentioned in Chapter 4, Kerckhoff Powerhouse, Kerckhoff No.2 Powerhouse and associated access roads and transmission lines could be inundated by raising Millerton Lake. A 25 foot raise would inundate Kerckhoff No. 2 Powerhouse and affect the tailwater of Kerckhoff Powerhouse. A raise of approximately 60 feet or greater would inundate Kerckhoff Powerhouse.

Constraints

Numerous houses may be within the inundation line, especially on the eastern side of the lake. Because of the potentially large number of houses and their proximity to the lake, their removal would be considered a significant constraint. However, additional research is needed to determine the extent to which removal of houses would constrain the reservoir size. A definitive determination of the number of houses that would be affected at various elevations is needed before a more precise assessment of impacts can be made.

Portions of public and private access roads, the Kerckhoff powerhouses, and associated access road and transmission lines would be inundated if Friant Dam were raised. The potential loss of energy generation capabilities at the Kerckhoff powerhouses could constrain the size of dam raise that would be justified. The potential presence of any contaminants at homes or facilities that would be inundated would need to be addressed in future stages of planning.

MINERAL RESOURCES

Several former gold mining sites in the Temperance Flat area could be affected by raising the level of Millerton Lake by 140 feet. As described in the Temperance Flat TM, past mining activity in the area raises the potential for the presence of mine tailings that might contain hazardous or toxic compounds. There is concern that inundation of abandoned mines or mine tailings could result in mobilization of metals or other potentially harmful chemicals into the water of an expanded reservoir. For example, if mercury was used in the gold extraction process, it could be present at mine sites in the area. Water quality might also be affected by acidic conditions from mining residuals.

Constraints

Preliminary review suggests these mines and the tailing piles do not likely contain hazardous or toxic compounds. A records search revealed that past mining activities were limited to mechanical processing at the Sullivan and Patterson mines. Therefore, it is unlikely that hazardous compounds sometimes used in the gold extraction process would be present. Soil samples collected at the mining sites during a field visit showed no observable free mercury. In addition, no arsenic or copper were seen at the mines. Contamination from metals is therefore unlikely. No sulfide minerals were seen at the mines, and tests for pH performed on standing water present in the Sullivan Mine tunnels indicated that the water was slightly basic (7.8). The potential for acid drainage is therefore low. Additional testing of material in the spoil piles would be needed to confirm the absence of hazardous and toxic materials.

It is likely that mine entrances that are submerged by raising the level of Millerton Lake would also be exposed regularly as the lake level is drawn down. The entrances to the mines would need to be sealed. Similarly, if mines are made more accessible by raising the lake level closer to the elevation of the mine entrance, potential safety hazards would need to be considered.

Opportunities

Development of a reservoir would also present an opportunity for interpretive displays of former mining activities. Remaining artifacts and equipment could be preserved.

CHAPTER 6. FINDINGS AND CONCLUSIONS

This TM describes a prefeasibility review of the potential enlargement of Friant Dam and Millerton Lake. An enlarged Millerton Lake would provide opportunities to store larger volumes of San Joaquin River water. Stored water would continue to be diverted to the Friant-Kern and Madera canals, and/or released to the San Joaquin River.

Options considered for increasing storage included 25-, 60-, and 140-foot raises of Friant Dam. A 25-foot raise would increase the storage capacity of Millerton Lake by 132 TAF, and would involve raising the dam crest, modifying the spillway and spillway chute, and constructing a dike approximately 3,000 feet long across a low ridge saddle at the southwest margin of the existing reservoir. Higher raises also would entail raising the dam crest and modifying the spillway. However, a 60-foot raise, which would increase storage capacity by 340 TAF, would require approximately 8,500 linear feet of new dike. A 140-foot raise, which would result in approximately 870 TAF of additional storage capacity, would require new dikes approximately 9,500 feet in total length and exceeding 100 feet high in some locations.

A dam raise could be accomplished with an overlay of conventional or RCC on the downstream face of the dam. The saddle dam, or dike, on the southwest rim of the reservoir would be constructed with earthfill. Safety considerations would be paramount in design. Availability of materials from local sources does not appear to be a limiting factor. Appurtenant dam structures and facilities would be modified, reconstructed, or relocated to maintain existing operational characteristics.

Millerton Lake is a popular recreation location that supports a variety of boating and other day-use activities. Facilities on both sides of the reservoir would be affected by a dam raise. Many private residences near the reservoir lie at or above elevation 610, or more than 25 feet above the current maximum reservoir level of elevation 578. Raising the lake level would affect several houses, and infrastructure that supports residential development. Raise options would also affect upstream power generation.

Enlarging Millerton Lake would affect fish spawning habitat in the upper portion of the lake and upstream in the San Joaquin River. Other impacts to habitat and wildlife would vary relative to the extent of inundation. Environmental mitigation has yet to be determined. Impacts to existing land uses, structures, and facilities appear mitigable, but mitigation likely would result in significant cost. The option of raising Friant Dam to enlarge Millerton Lake was retained for further consideration in the Investigation.

THIS PAGE LEFT BLANK INTENTIONALLY

CHAPTER 7. LIST OF PREPARERS

NAME	ROLE
Reclamation	
Jason Phillips	Project Manager
Chuck Howard	Regional Geologist
Joel Sturm	Engineering Geologist
Clarence Duster	Civil Engineer
Mark Pabst	Civil Engineer
Steve Higinbotham	Civil Engineer
MWH	
William Swanson	Project Manager
Stephen Osgood	Planner
David Rogers	Engineering Team Leader
James Herbert	Engineering Geologist
Willam Moler	Engineering Geologist
Michael Preszler	Civil Engineer, Hydrologist
Irina Torrey	Environmental Team Leader
Sara Hamm	Environmental Coordination
Philip Unger	Aquatic Biology
David Stevens	Wildlife Biology
Sandra Perry	Recreational Resources
Stephanie Murphy	Wildlife Biology
Barry Anderson	Botany
David White	Cultural Resources
James Darke	GIS Analyst
Steve Irving	GIS Technician
Emily McAlister	Technical Editor
Michelle Irwin	Document Coordinator

ACKNOWLEDGEMENTS

Overall coordination was provided by the Mid-Pacific Region of Reclamation. Coordination with other agencies and consultants was furnished by the Regional Office of Reclamation. Additionally, the Regional Office obtained aerial photography and topographic base maps; the Mid-Pacific Region produced the base model of site topography.

The Reclamation South Central Area Office provided support for information related to existing Reclamation facilities, and also coordinated field trips, and arranged site access with other agencies for field trips.

Geologic support and follow-up field reconnaissance was performed by the Mid-Pacific Region and Technical Service Center geology staff. The Mid-Pacific Region coordinated surface geologic mapping of the site and the initial borrow area investigations.

The Technical Service Center provided the seismotectonic evaluation for all the Upper San Joaquin River Basin Storage Investigation sites. Other Technical Service Center groups providing support for this report include the following:

- Geotechnical Engineering Group
- Engineering Geology Group
- Estimating Group
- Waterways and Concrete Dams
- Hydraulic Equipment Group
- Seismotectonics and Geophysics Group
- Flood Hydrology Group

CHAPTER 8. REFERENCES

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

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

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

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

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

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

California Public Utilities Commission (CPUC). 2000. Draft Environmental Impact Report for the Pacific Gas and Electric Company's Proposed Divestiture of Hydroelectric Facilities. Sacramento.

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

Corrigan, P., D.D. Fenn, D.R. Kluck, and J.L. Vogel. 1998. Probable Maximum Precipitation for California: Calculation Procedures. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service. Silver Spring, Maryland. Hydrometeorological Report 58 (Supercedes Hydrometeorological Report No. 36).

Davis, James T. 1961. Trade Routes and Economic Exchange among the Indians of California, Berkeley: University of California Archaeological Survey Reports 54.

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

Gayton, Anna H. 1948. Yokuts and Western Mono Ethnography, Vol. 2, Northern Foothill Yokuts and Western Mono. Berkeley: University of California Anthropological Records 10(1-2).

Gifford, Edward W. 1932. The Northfork Mono. Berkeley: University of California Publications in American Archaeology and Ethnology 31(2).

Heizer, Robert F. (ed.). 1978. Handbook of North American Indians, vol. 8, California. Washington, DC: Smithsonian Institution.

Heizer, Robert F., and Adan E. Treganza. 1944. Mines and Quarries of the Indians of California. California Journal of Mines and Geology 40:291-359.

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

Holbek, Lars, and Chuck Stanley. 1988. A Guide to the Best Whitewater in the State of California.

Latta, Frank F., 1949, Handbook of Yokuts Indians. Oildale, California: Bear State Books.

Levy, Richard. 1978. Eastern Miwok. In Robert F. Heizer, ed., Handbook of North American Indians, vol. 8, California. Washington DC: Smithsonian Institution. pp. 398-413.

Moratto, Michael. 1984. California Archaeology. San Diego: Academic Press.

Moyle, P.B., R.M. Yoshiyama, J.E. Williams, and E.D. Wikramanayake. 1995. Fish Species of Special Concern in California. Department of Wildlife and Fisheries, University of California, Davis.

Moyle, Peter B. 1976. Inland Fishes of California. Berkeley: University of California Press.

MWH. 2002. Technical Memorandum, Environmental Constraints and Criteria for Application. February.

Pacific Gas and Electric Company (PG&E). 1986a. Crane Valley Project Application for New License. Report E4 Historical and Archaeological Resources. Filed with the Federal Energy Regulatory Commission. San Francisco.

PG&E. 1986b. Application for License. Crane Valley Project (FERC Project No. 1354), Report E3: Fish, Wildlife, and Botanical Resources. April.

PG&E. 1990. Study of American shad at Millerton Lake, Kerckhoff Project (FERC No. 96-015), Report 026.11-90.7. Prepared by Stephen Ahern and Steve Cannata, Technical and Ecological Services. November.

PG&E. 1992. Full Pool Water Surface Velocity Study at Millerton Lake, Kerckhoff Project (FERC No. 96-015), Report 02611-92.4. Prepared by Stephen Ahern, Technical and Ecological Services. December.

PG&E. 1999. Proponents Environmental Assessment for Application No. 99-09-053, Volume 7. October 29.

PG&E. n.d. Kerckhoff Project, Exhibit W. Filed with the Federal Energy Regulatory Commission. San Francisco.

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

Reclamation. 1966. A Feasibility of Water Supply Development. United States Department of the Interior, Bureau of Reclamation, East Side Division CVP. June.

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

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

Reclamation. 1976. Design of Gravity Dams. United States Department of the Interior, Bureau of Reclamation. Denver, Colorado.

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

Reclamation. 1997. Friant Dam Enlargement Study, TM No. FR-8130-TM-97-2. United States Department of the Interior, Bureau of Reclamation, Technical Service Center. Denver, Colorado. October.

Reclamation. 2002a. Appraisal Geologic Study, Storage Options in the Millerton Lake Watershed, Upper San Joaquin River Basin Storage Investigation (DRAFT). United States Department of the Interior, Bureau of Reclamation, Mid-Pacific Region. Sacramento, California. August.

Reclamation. 2002b. Appraisal-Level Probabilistic Ground Motion Evaluation for the Upper San Joaquin River Basin Investigation, Central Valley Project. DRAFT. United States Department of the Interior, Bureau of Reclamation, Technical Service Center. Denver, Colorado. August.

Reclamation. 2002c. Upper San Joaquin River Basin Storage Investigation, Field Trip Logs from June 12, 2002. United States Department of the Interior, Mid-Pacific Region, Sacramento, California, August.

Reclamation. 2002d. Appraisal Level PMF Hydrograph and Peak Flow Frequency Estimates for Fine Gold Dam Site. United States Department of the Interior, Technical Service Center, Denver, Colorado. August 20.

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

Rivers, Betty. 1988. Ethnography of the Millerton Lake Area. In Philip Hines, CA-MAD-98: Excavation of a Prehistoric Village Site at Millerton Lake State Recreation Area, California Department of Parks and Recreation. Reprinted in Steidl, Steidl, and Lindahl, 1995, An Archaeological Reconnaissance Survey at Millerton Lake, Appendix B.

Rivers, Betty. 1995. A History of Mining in the Millerton Lake Area. In Steidl, Steidl and Lindahl, An Archaeological Reconnaissance Survey at Millerton Lake, Appendix D.

Roop, W. G. 1981. The Archaeology of Vernal Pools: An Example from Placer County. Manuscript Report, Novato: Archaeological Resource Service.

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

Sierra Nevada Ecosystem Project (SNEP). 1996. Potential aquatic diversity management areas in the Sierra Nevada. In Sierra Nevada Ecosystem Project: Final report to Congress, Volume III, Chapter 9. Davis: University of California.

Spier, Leslie. 1978a. Monache, In Robert F. Heizer, ed., Handbook of North American Indians, vol. 8, California. Washington, DC: Smithsonian Institution. pp. 426-436.

Spier, Leslie. 1978b. Foothill Yokuts. In Robert F. Heizer, ed., Handbook of North American Indians, vol. 8, California. Washington, DC: Smithsonian Institution. pp. 471-484.

Stammerjohan, George R. 1979. Historical Sketch of Millerton Lake SRA. In Millerton Lake State Recreation Area Inventory of Features, California Department of Parks and Recreation. Reprinted in Steidl, Steidl, and Lindahl, 1995, An Archaeological Reconnaissance Survey at Millerton Lake, Appendix C.

Steidl, Leslie, Bruce Steidl, and Kathleen Lindahl. 1995. An Archaeological Reconnaissance Survey at Millerton Lake (RMP 95 PCA 12320-378004). Prepared for California Department of Parks and Recreation, Bakersfield, California: Southern San Joaquin Valley Information Center, MA-365.

Steward, Julian H. 1929. Petroglyphs of California and Adjoining States, University of California Publications in American Archaeology and Ethnology 24(2):47-238.

TCR/ACRS. 1984. Cultural Resources Overview of the Southern Sierra Nevada: An Ethnographic, Linguistic, Archaeological and Historical Study of the Sierra National Forest, Sequoia National Forest, and Bakersfield District of the Bureau of Land Management. Submitted to USDA Forest Service, Bishop, California, by Theodoratus Cultural Research and Archaeological Consulting and Research Services.

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

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

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

USFWS. 1983. Appraisal Report, Enlarged Friant Dam and Millerton Lake Alternative, Enlarging Shasta Lake Investigation. Prepared for U.S. Bureau of Reclamation and California Department of Fish and Game. November.

USFWS. 1991. Kerckhoff Project, Fresno and Madera Counties, California, FERC No. 96 – American Shad Spawning Report. Letter from Wayne White, Sacramento Field Office, USFWS, to David Landes, Hydro Generation, PG&E Co. January 25.

USFWS. 1998. Draft Coordination Act Report and Habitat Evaluation Procedure. October.

United States Weather Bureau (USWB). 1969. Hydrometeorological Report Number 36, Interim Report Probable Maximum Precipitation in California, Revised. U.S. Department of Commerce, Washington, D.C.

Varner, Dudley M. 1977. Archaeological Investigations for the Kerckhoff Hydroelectric Project, Bakersfield CA: Southern San Joaquin Valley Information Center.

Varner, Dudley M. 1983. Applied Archaeology on the San Joaquin River: The Kerckhoff Hydroelectric Project, Bakersfield CA: Southern San Joaquin Valley Information Center.

Varner, Dudley M., and R. Bernal. 1976. Archaeological Investigations at Kerckhoff Reservoir, Bakersfield CA: Southern San Joaquin Valley Information Center.

Wallace, William J. 1978. Northern Valley Yokuts. In Robert F. Heizer, ed., Handbook of North American Indians, vol. 8, California. Washington, DC: Smithsonian Institution. pp. 462-470.

Welch, Patrick. 2002. Personal Communication with David White, Bureau of Reclamation, Sacramento, California.

White, David R. M. 1996. Report on Interviews for an Overview of Contemporary Native American Issues Pertaining to the Sequoia National Forest, in Fresno, Tulare, and Kern Counties, California. Santa Fe, New Mexico: Applied Cultural Dynamics.

White, David R. M. 2000. Ethnographic Profile of Native American Peoples Associated with the Pacific Gas and Electric Company's Proposed Divestiture of Hydroelectric Generating Facilities, Report prepared for Resource Insights, Sacramento, California, and Aspen Environmental Group, Agoura Hills, California.

Witte, G. H. 1941. History of Indians Buried in Friant Dam Reservoir Area and Their Removal for Reinterment, April 1940-October 1941, Friant, California. United States Department of the Interior, Bureau of Reclamation.

THIS PAGE LEFT BLANK INTENTIONALLY