Upper San Joaquin River Basin Storage Investigation

Temperance Flat Reservoir

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

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San Joaquin River looking downstream towards Millerton Lake

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MWH

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Surface Water Storage Option
Technical Memorandum

TEMPERANCE FLAT RESERVOIR
UPPER SAN JOAQUIN RIVER BASIN STORAGE INVESTIGATION

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ACRONYMS AND ABBREVIATIONS

BLM	Bureau of Land Management
BRM	bedrock mortar
CDFG	California Department of Fish and Game
CDMG	California Division of Mines and Geology
CDPR	California Department of Parks and Recreation
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CFRD	concrete-face rockfill dam
CFRF	concrete-face rockfill
cfs	cubic foot per second
CNDDB	California Natural Diversity Database
CNPS	California Native Plant Society
Corps	United States Army Corps of Engineers
DWR	California Department of Water Resources
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
elevation	elevation in feet above mean sea level
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
GWh/yr	gigawatt-hours per year
HEP	Habitat Evaluation Procedure
HMR	hydrometeorological report
hp	horsepower
Investigation	Upper San Joaquin River Basin Storage Investigation
kV	kilovolt
kW	kilowatt
LRMP	Land and Resource Management Plan
MW	megawatt

MWh	megawatt-hour
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NRHP	National Register of Historic Places
PG&E	Pacific Gas and Electric
PHA	peak horizontal acceleration
PMF	probable maximum flood
PMP	probable maximum precipitation
RCC	roller-compacted concrete
Reclamation	Bureau of Reclamation
RM	river mile
RNA	Research Natural Area
ROD	Record of Decision
rpm	revolution per minute
RWQCB	Regional Water Quality Control Board
SCE	South California Edison
SNF	Sierra National Forest
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
v	volt
WHR	Wildlife Habitat Relationships

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EXECUTIVE SUMMARY

A prefeasibility review of a potential new reservoir in the Temperance Flat area was completed as part of the Upper San Joaquin River Basin Storage Investigation (Investigation). Temperance Flat Reservoir would be a new surface water storage facility on the San Joaquin River, above Friant Dam and below Kerckhoff Dam. Water would be released from Temperance Flat Reservoir to Millerton Lake for canal diversion and/or release to the San Joaquin River. Operating criteria for the two reservoirs could be influenced by hydropower generation, ecosystem needs in the reservoirs, recreation opportunities, and flood control requirements.

Potential dam sites are being considered at three locations: river mile (RM) 274, RM 279, and RM 286 on the San Joaquin River. Reservoir sizes evaluated in this Technical Memorandum range from 460 thousand acre-feet to 2.8 million acre-feet in gross storage capacity. A portion of the storage capacity would replace existing Millerton Lake, Kerckhoff Lake, or Redinger Lake storage space. Several types of dam designs at each site have been considered. Estimated field construction costs range from $330 million to $1.4 billion and are listed in Table ES-1.

The San Joaquin River watershed above Millerton Lake is highly developed for hydropower generation. All reservoir options considered would impact existing hydropower projects and provide opportunities for hydroelectric energy generation. Depending on the location and height of the dam, Temperance Flat Reservoir has the potential to affect up to five powerhouses and two dams upstream of Millerton Lake. On the basis of preliminary estimates, new power generation associated with all options would be less than power generation lost due to construction of Temperance Flat Reservoir. Estimates of annual energy generation potential for Temperance Flat storage options are summarized in Table ES-2, along with an estimate of energy generation that would be impacted by each option.

Developing a reservoir in the Temperance Flat area would cause adverse environmental effects to aquatic and terrestrial wildlife, botanic, recreational, and cultural resources, and could affect land uses in the vicinity of the reservoir. Reservoir options at all three potential dam sites could affect special status, native, and game fish species. Aquatic life that would be affected by reservoir options at the RM 274 and RM 279 dam sites includes hardhead, American shad, and several types of bass. These fish reside in the upper portion of Millerton Lake, which would be within the new reservoir area for these dam sites. Reservoir options at RM 286 would affect fisheries in the reaches above and below Kerckhoff Lake and in Kerckhoff Lake. While a new reservoir could inundate riverine native fish habitat and/or spawning habitat for striped bass and shad, it would also expand lacustrine habitat that could benefit cold-water game species, and might create additional shallow water habitat beneficial to many species. It would also provide an opportunity to regulate flows so as to enhance conditions in Millerton Lake and/or the reach of the San Joaquin River above Millerton Lake that provides spawning habitat.

Wildlife species of concern that potentially would be affected by Temperance Flat Reservoir include the valley elderberry longhorn beetle, the California tiger salamander, the western pond turtle, and the foothill yellow-legged frog. Eagle, osprey, and waterfowl could benefit from a new reservoir.

Foothill woodlands and grasslands would be inundated by all reservoir options considered. Species for which mitigation would likely be required include tree anemone and Mariposa pussypaws.

TABLE ES-1. ESTIMATED CONSTRUCTION FIELD COSTS

Gross Pool Elevation (feet above mean sea level)	Gross Storage[1] (TAF)	Net Storage[2] (TAF)	Dam Type	Estimated Field Construction Cost[3] ($Millions)
RM 274 Dam Site				
800	531	462	CFRF	490
1,100	2,187	2,114	CFRF	800
RM 279 Dam Site				
900	460	444	RCC	410
			CFRF	430
1,100	1,263	1,243	RCC	750
			CFRF	730
1,300	2,775	2,736	RCC	1,400
			CFRF	1,200
RM 286 Dam Site				
1,200	465	457	Arch	330
			RCC	340
			CFRF	430
1,400	1,403	1,364	Arch	630
			RCC	560
			CFRF	590

Key:
Arch – thin concrete arch dam
CFRF – concrete-faced rockfill dam
RCC – roller-compacted concrete dam
RM – river mile
TAF – thousand acre-feet

Notes:
1. Total storage capacity of new reservoir.
2. Accounts for existing storage capacities of Millerton, Kerckhoff, and Redinger lakes.
3. Field cost represents the direct cost to construct the dam, spillway, powerhouse, and outlet works. Other costs are not included, such as lands, relocations, ancillary facilities, environmental mitigation, investigations, designs, construction management, administration, and interest during construction.

Recreational resources could be affected in portions of the Millerton Lake State Recreation Area, the San Joaquin River Gorge Management Area, and the Sierra National Forest (SNF). Recreational resources affected depend on the reservoir option. The RM 274 and RM 279 options would inundate portions of the Millerton Lake State Recreation Area, but the RM 286 options would not. All options would affect some portion of the Patterson Bend or Horseshoe Bend whitewater boating runs. However, a new reservoir could provide new flat-water recreation opportunities, improve access to recreational resources, and provide new recreational support facilities.

Prehistoric archaeological sites exist within the potentially inundated areas, as do homesteads and sites where mining occurred historically. Past mining sites have been identified but have yet to be assessed for their potential historic significance. While a new reservoir could inundate existing cultural resources, its development could create opportunities to expand knowledge of historic or prehistoric resources and enhance public interpretation of the past.

TABLE ES-2. TEMPERANCE FLAT ENERGY GENERATION AND IMPACT

Dam Site	Net Storage[1] (TAF)	Average Annual New Energy Generation[2] (GWh/yr)	Average Annual Energy Generation Potentially Affected[3] (GWh/yr)
RM 274	725	160 – 210	579
	1,350	210 – 270	579
RM 279	725	330 – 380	579
	1,350	400 – 450	1,125
RM 286	725	630 – 680	1,125[4]
	1,350	690 – 740	1,125[4]

Key:
GWh/yr – gigawatt-hours per year
RM – river mile
TAF – thousand acre-feet
Notes:
1. Hydropower analyses were made for storage capacities that generally correspond to elevations at which existing powerhouses would be affected.
2. Estimated annual energy generation was based on single-purpose analyses for restoration flow and water quality releases to the San Joaquin River. Operations were not optimized for power generation. Increased generation at Friant powerhouses, potential for pumped storage, and potential generation from relocated impacted facilities are not included.
3. Average annual energy generation from impacted powerhouses for 1994 through 2002, as reported in FERC annual reports for the Kerckhoff and Big Creek projects. Direct comparison of generalized generation estimates to actual historical generation is indicative in magnitude only for the prefeasibility-level analysis described in this document.
4. The RM 286 option would not inundate Kerckhoff or Kerckhoff No. 2 powerhouses. Potentially affected generation includes total generation at Kerckhoff powerhouses. Further evaluation will identify potential modifications to existing Kerckhoff facilities as part of the RM 286 option.

Existing land uses could be affected. Some of the options under consideration would inundate portions of the Backbone Creek Research Natural Area, which is protected under the SNF Long Range Management Plan, and the San Joaquin River Gorge Management Area, which is managed for recreation and wildlife habitat values by the Bureau of Land Management.

None of the Temperance Flat Reservoir options would physically divide an established community. However, individual private homes, private hydropower facilities and public facilities, including roads, bridges, and trails, could be inundated. The RM 274 and RM 279 options would inundate the San Joaquin River Trail footbridge at Kerckhoff Powerhouse. Several of the reservoir options would submerge the bridge that crosses Kerckhoff Lake at Powerhouse Road (Road 222).

No engineering or environmental issues were identified that would preclude further consideration of a reservoir in the Temperance Flat area. However, all three potential dam locations would pose construction challenges related to site access or placement of cofferdams. Mitigation measures would need to be developed to reduce the significance of potential environmental impacts.

Temperance Flat Reservoir has been retained for further consideration in the Feasibility Study. Future work will include additional engineering, hydropower, and environmental evaluations of operations and impacts on existing resources.

CHAPTER 1. INTRODUCTION

The Bureau of Reclamation, in cooperation with the California Department of Water Resources (DWR), 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 improved water quality in and restoration of the San Joaquin River and to enhance conjunctive management and exchanges to provide high-quality water delivered 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. Those potential storage sites were screened for suitability for continued study. A description of the screening process and results is included in the Phase 1 Investigation Report. A potential new reservoir in the vicinity of Temperance Flat was one of the potential storage options selected for additional study and consideration.

This Technical Memorandum (TM), prepared as a technical appendix to the Phase I Investigation Report, presents findings from technical studies conducted to date on a potential new dam and reservoir in the Temperance Flat area. It considers potential dam sites upstream of Friant Dam and below Kerckhoff Dam, and expands on and updates the March 2003 draft version of the TM. This TM will be updated again in the future as the Investigation continues. Potential water supply yields from Temperance Flat Reservoir and other storage options are not included in this TM, but are discussed in the Phase 1 Report.

STORAGE OPTIONS SUMMARY

Temperance Flat is a small, bowl-shaped basin in the upper reaches of Millerton Lake, approximately 13 river miles upstream of Friant Dam at about river mile (RM) 281 of the San Joaquin River. Temperance Flat is located on the border between Madera and Fresno counties, northeast of Auberry Valley and the community of Marshall Station, about 30 miles northeast of Fresno. For purposes of this TM, the entire area along the San Joaquin River above its confluence with Fine Gold Creek and below Kerckhoff Lake is referred to as the Temperance Flat area. The general site location is shown in Figure 1-1.

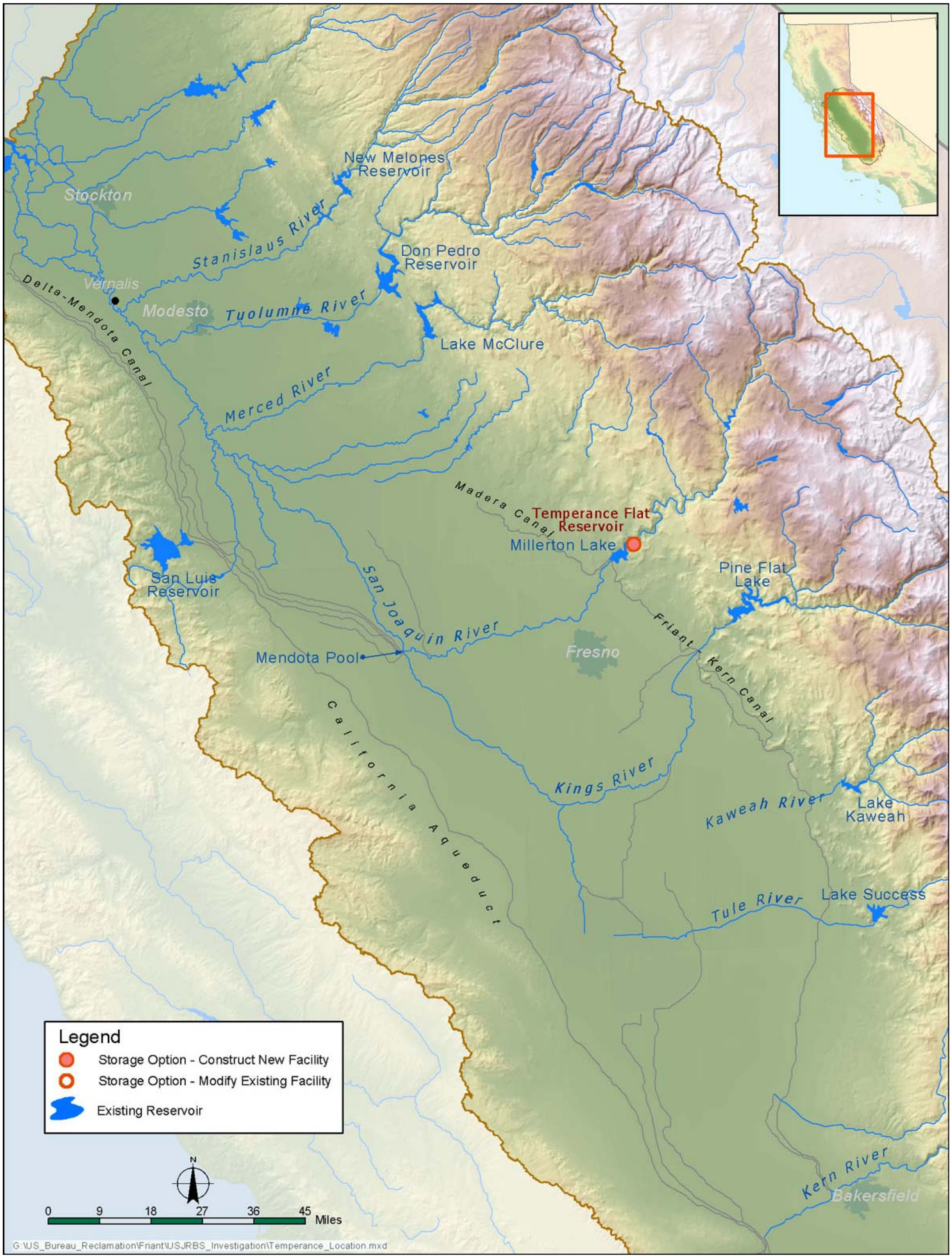

FIGURE 1-1. TEMPERANCE FLAT SITE LOCATION

Options for creating a new reservoir in the Temperance Flat area have been developed for three potential dam sites, as discussed above. These sites are all within 7 river miles of Temperance Flat, at approximately RM 274, RM 279, and RM 286, of the San Joaquin River. Locations of the potential dam sites are shown in Figure 1-2. The RM 274 site is in a narrow portion of upper Millerton Lake, approximately 7 river miles upstream of Friant Dam and just above the confluence with Fine Gold Creek. The RM 279 site is located about 5 miles farther upstream. Temperance Flat is about 2 river miles upstream of RM 279 and would be inundated by a reservoir created by a dam at either RM 274 or RM 279. RM 286 is about 5 miles farther upstream from Temperance Flat, in a narrow portion of the San Joaquin River canyon.

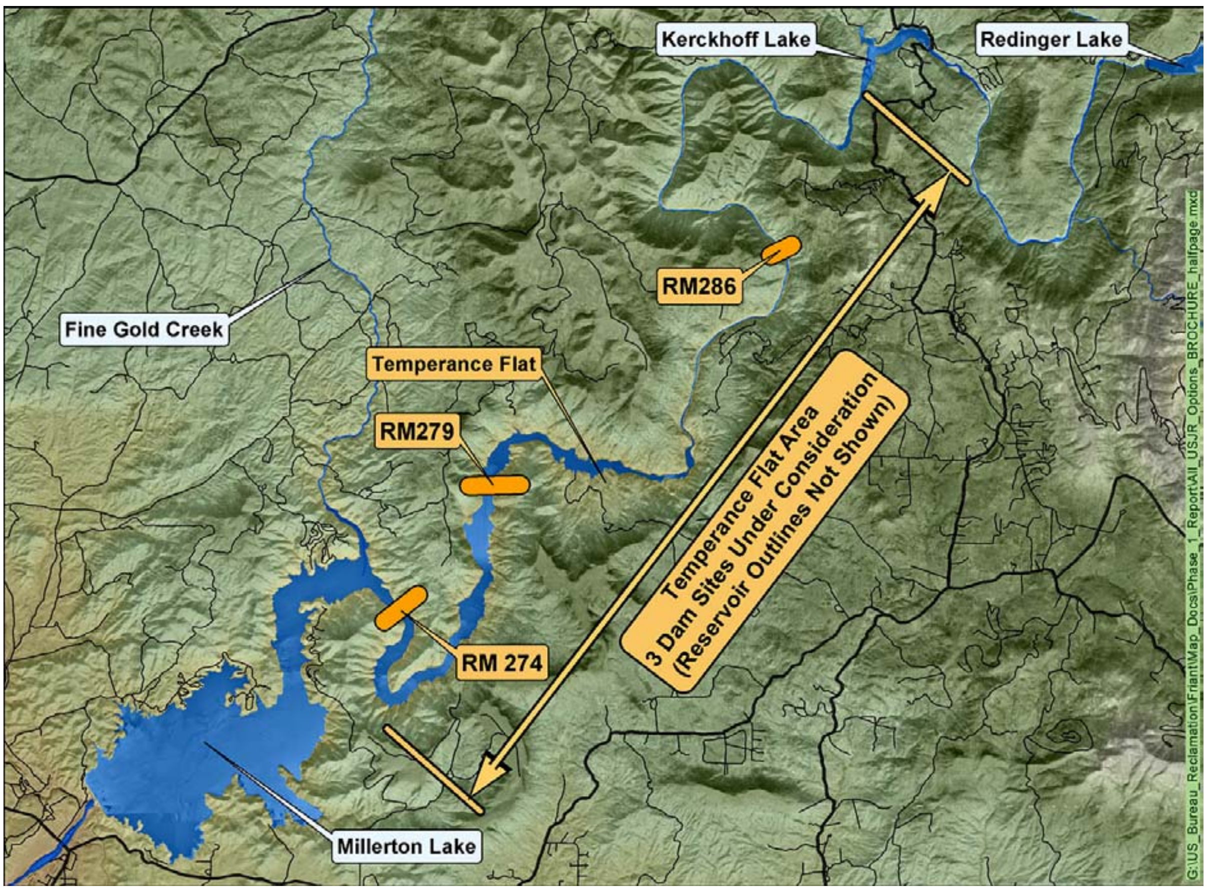

FIGURE 1-2. TEMPERANCE FLAT AREA POTENTIAL DAM SITES

A new reservoir in the Temperance Flat area would capture the flow of the San Joaquin River downstream of Kerckhoff Lake before it enters Millerton Lake. Water would be released from Temperance Flat Reservoir to Millerton Lake for canal diversion and/or release to the San Joaquin River. Operating criteria for the two reservoirs could be influenced by ecosystem needs in the reservoirs, recreation opportunities, hydropower generation, and flood control requirements.

SUMMARY OF PREVIOUS INVESTIGATIONS

In March 1930, Hyde Forbes, an engineering geologist, issued a geological report on three potential dam sites on the San Joaquin River for the DWR Department of Public Works. The report evaluated geologic conditions at the Friant, Fort Miller, and Temperance Flat (RM 274) sites. (Fort Miller is just downstream of the confluence of Fine Gold Creek with the San Joaquin River.) The geologic study contributed to planning efforts that led to construction of Friant Dam.

From a water storage perspective, the RM 274 site was considered superior to both the Friant and Fort Miller sites. Ultimately, the Friant site was selected because constructing a dam at RM 274 would have required extending canals around or through the current Millerton Lake area, or constructing a second dam at Friant for diverting water to the canals.

A prior version of this Temperance Flat TM was produced in March 2003.

POTENTIAL IMPROVEMENTS

A potential reservoir in the Temperance Flat area would consist of a new dam across the San Joaquin River, plus appurtenant features (e.g., spillway, outlet works, potential powerhouse). While constructing only one dam within the Temperance Flat area is contemplated, a range of potential dam sites, types, and sizes have been considered. Reservoir sizes considered in this TM range from 460 thousand acre-feet (TAF) to about 2.8 million acre-feet in gross storage capacity. An overview of facilities that might be constructed at each of the potential dam sites is presented below. Details of dam construction and appurtenant features are discussed in Chapter 3. Preliminary design layouts at all three dam sites are included in Appendix D along with detailed dam cross sections.

At all three potential dam sites, permanent features that would be constructed include the main dam, a powerhouse to allow generation of electricity, and an uncontrolled spillway to pass flood flows. Both upstream and downstream cofferdams would be required for river diversion and, in the case of the RM 274 and RM 279 dam sites, to keep Millerton Lake out of the construction zone. In all cases, the upstream cofferdam would be higher than the downstream cofferdam.

RM 274 Options

Two dam crest elevations are considered in this TM for the RM 274 site: 800 feet and 1,100 feet above mean sea level (elevations 800 and 1,100). The streambed at this site is at elevation 385, which would result in dam heights for the two selected dam crests of elevations 415 and 715, respectively, and gross storage capacities of approximately 530 TAF and 2,190 TAF, respectively (see Figure 1-3).

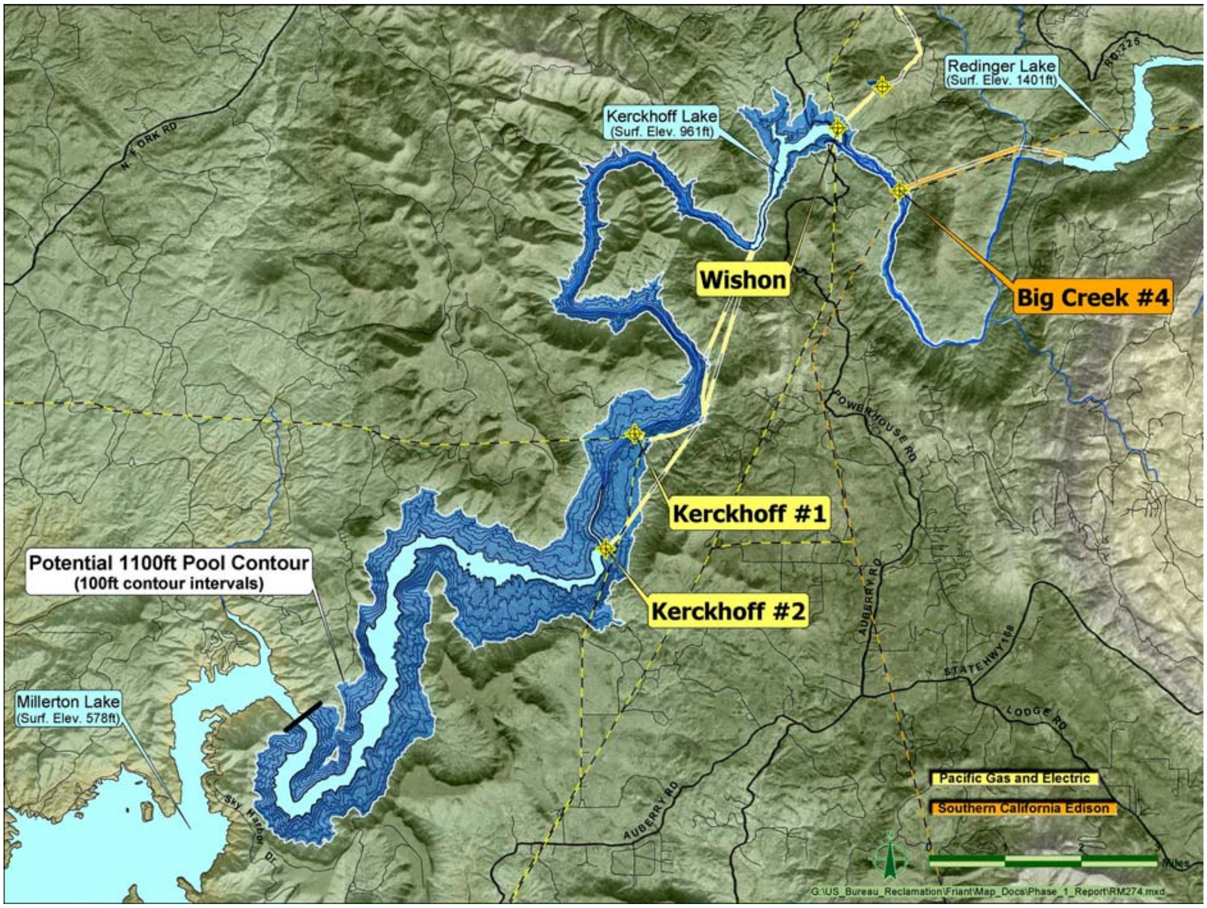

FIGURE 1-3. POTENTIAL TEMPERANCE FLAT RM 274 RESERVOIR

Possible dam types suited to this site include a roller-compacted concrete (RCC) or concrete-face rockfill (CFRF) gravity dam, or a thin arch dam. Preliminary designs and cost estimates were produced for the CFRF dam type. The RCC and arch dam types were not evaluated in this TM for RM 274, but could be considered in future studies.

Cofferdams and diversion tunnels would be required. Since the location of this dam is in the upper reach of Millerton Lake (with a depth of up to 175 feet), the upstream cofferdam would be about 250 feet high and the downstream cofferdam 195 feet high. The left abutment diversion tunnel would be converted to the outlet works.

RM 279 Options

For the RM 279 site, dam crests at elevations 900, 1,100, and 1,300 are considered in this TM. The streambed elevation at this site is elevation 460, which would result in dam heights of 440, 640, and 840 feet respectively, and gross storage capacities of approximately 460 TAF, 1,260 TAF, and 2,775 TAF, respectively (see Figure 1-4).

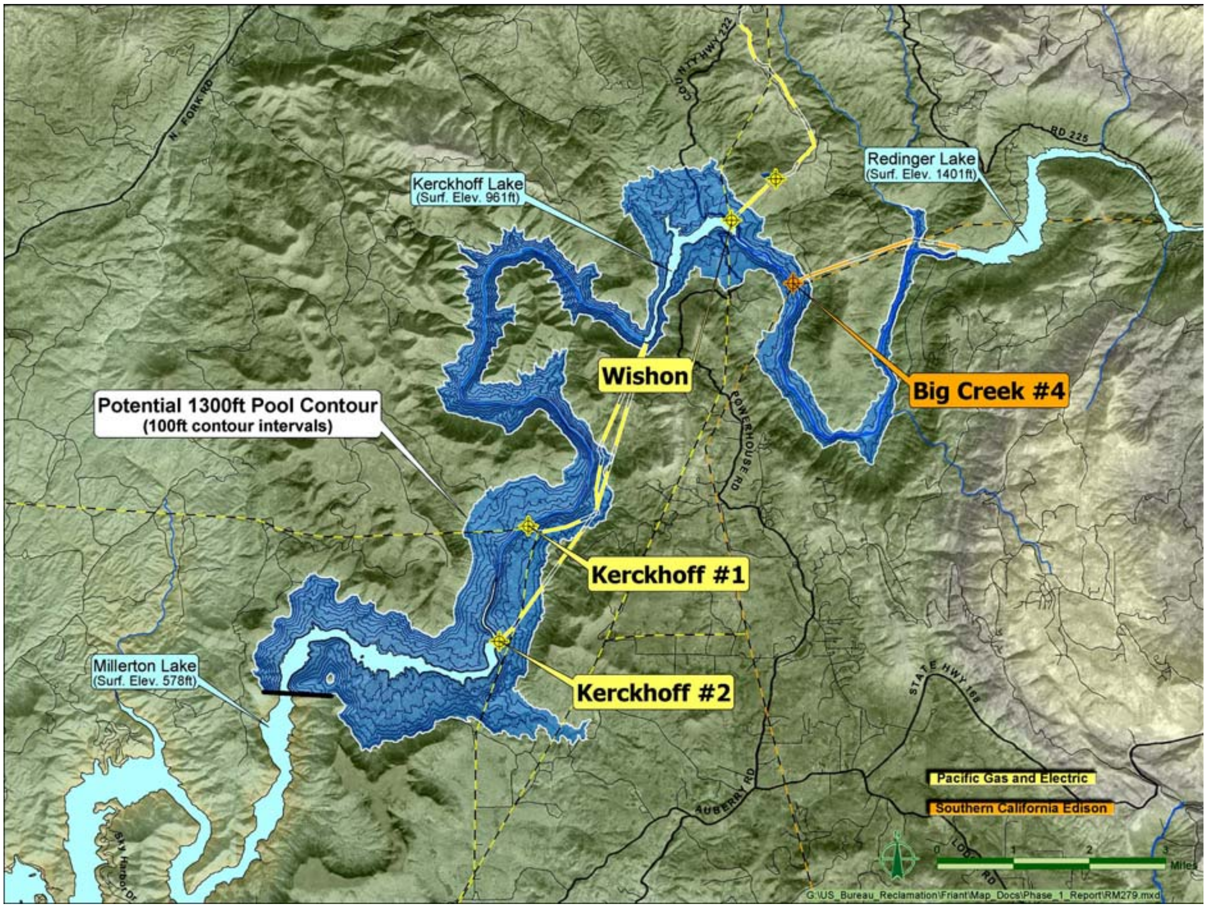

FIGURE 1-4. POTENTIAL TEMPERANCE FLAT RM 279 RESERVOIR

Possible dam types suited to this site include an RCC or CFRF gravity dam. A concrete thin arch dam was not evaluated in this TM, but could be considered in future studies for cost comparisons with the gravity dams.

Since the location of this dam is in the upper reach of Millerton Lake, an upstream cofferdam would need to be approximately 175 feet high and the downstream cofferdam about 120 feet high. The left abutment diversion tunnel would be converted to the outlet works.

RM 286 Options

Two dam crest elevations are considered in this TM: 1,200 and 1,400. The streambed is at elevation 740 for this site, resulting in dam heights for the two selected dam crests of 460 feet and 660 feet respectively, and approximate gross storage capacities of 465 TAF and 1,400 TAF, respectively (see Figure 1-5).

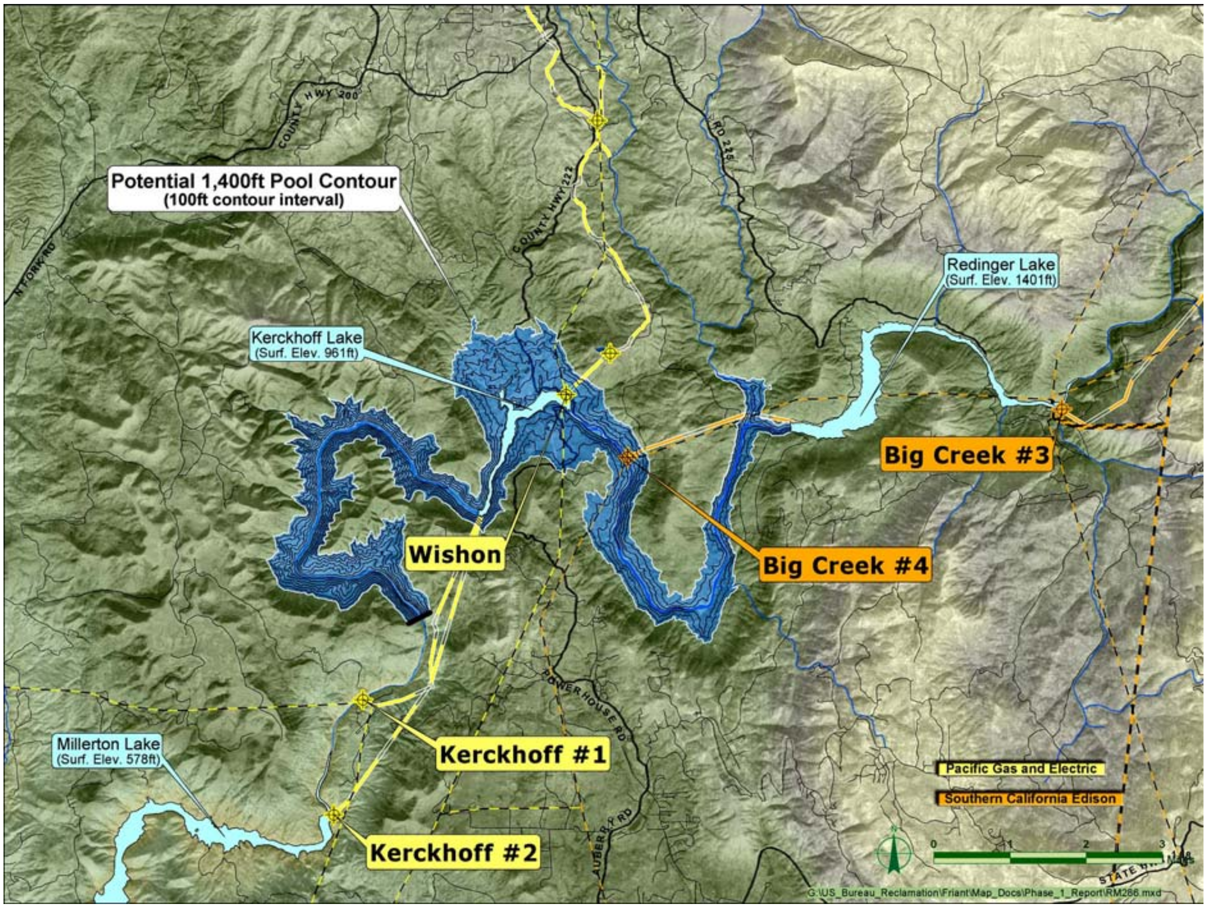

FIGURE 1-5. POTENTIAL TEMPERANCE FLAT RM 286 RESERVOIR

Possible dam types suited to this site include RCC, CFRF, or concrete arch dams. Preliminary designs and cost estimates were prepared for all three dam types at RM 286.

Required upstream and downstream cofferdams would be about 110 feet and 30 feet high, respectively. It might be possible to use the existing Kerckhoff Dam upstream to store some of the diversion floodwater and reduce the size of the upstream cofferdam at the site, but this concept was not evaluated for this TM. The right abutment diversion tunnel would be converted to the outlet works.

APPROACH AND METHODOLOGY

This TM was prepared from information developed following a brief review of relevant documents and several field reconnaissance excursions.

Engineering and Geology

Reconnaissance trips were made by Reclamation engineers and geologists to the RM 274 site on 14 May 2003; to the RM 279 site on 12 June 2002; and to the RM 286 site on 14 May 2003 (Appendix A). During field visits, abutments at the potential dam alignments, possible borrow areas, and site access points were visually examined. Reclamation performed surface geologic investigations and evaluations of possible construction materials in July 2002 (Reclamation, 2002a).

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

Options presented in this report are technically viable structures based on available information. Only standard structure types, consistent with current engineering principles and practices, were considered. Assumptions used for developing the designs are discussed in Chapter 3.

For prefeasibility-level studies, designs and analyses are typically quite general. Design layouts, sections, and dimensions for this study were prepared based on standard practice and experience with similar facilities. Extensive efforts to optimize designs were not conducted, and only limited value engineering techniques were used.

Cost Estimation

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

Costs of road and bridge construction, 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.

Hydropower Analysis

Hydropower specialists conducted a field reconnaissance trip to the Temperance Flat area in June 2003, viewing the potential dam sites and all existing hydropower facilities in the area to which they were provided access (Appendix A). Characteristics of existing facilities and information on past generation were obtained from Pacific Gas & Electric (PG&E) personnel and from Federal Energy Regulatory Commission (FERC) public records.

Preliminary estimates of potential energy generation at each of the candidate dam sites were produced using a spreadsheet approach based on output from the CALSIM hydrologic water balance model. To simplify the analysis, reservoir storage volumes associated with threshold impacts to power generation facilities. Assumptions were made regarding turbine and generator efficiencies, turbine restrictions on minimum and maximum heads and flows for generation, and head losses in water passages. Preliminary estimates were made of energy generated on an annual basis. Results reflect assumptions made at this level of study, and therefore only give a preliminary indication of possible energy generation output.

Environmental Review

Environmental field reconnaissance trips of the potential dam and reservoir areas were made on 29 May 2002 and 17-19 June 2003 (Appendix B). During field trips, specialists in botany, wildlife, aquatic biology, recreational resources, and cultural resources visually assessed existing environmental resources. In May 2002, resources were reviewed that could be affected by a dam at RM 274 or RM 279 and a reservoir up to elevation 1,100. In June 2003, the review extended to resources that could be affected by reservoir options at RM 274 up to elevation 1,100; options at RM 279 up to elevation 1,300; and options at RM 286 up to elevation 1,600.

Additional research was based on prior studies and available literature, topographic maps, aerial photographs, and conversations with other researchers familiar with the area. Natural resource databases were consulted, such as Wildlife Habitat Relationships and the California Natural Diversity Database (CNDDB) Rare Find 2, and relevant plans were examined relating to land use (e.g. the Sierra National Forest Land and Resource Management Plan and county general plans).

This information was used, along with prior knowledge of the area of the sites, to preliminarily identify the extent to which potential environmental impacts could constrain the storage options under consideration. Where evident, opportunities for improving environmental resources or mitigating adverse effects were also noted. No intensive surveys or official consultations with external resource management or environmental agencies were conducted. Field surveys and consultations with resource management and regulatory agencies would be needed to fully identify environmental impacts and mitigation requirements.

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CHAPTER 2. PHYSICAL SETTING

This chapter describes elements of the potential dam and reservoir settings, 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. 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 10,000 in the upper watershed, located in the Sierra Nevada.

Details of the topography at each of the three potential dam sites are presented in Chapter 3.

Available Topographic Mapping

Aerial photography for topographic mapping was conducted on 8 August 2001 using LIDAR technology. Base maps were created with a model, producing topography mapped in 10-foot contour intervals. Additional maps are being produced with 2-foot contour intervals.

Available Aerial Photography

Oblique aerial photographs of the sites were taken during flights made on 26 November 2001. The aerial photographs are available from the Mid-Pacific Regional Office of Reclamation.

GEOLOGIC AND SEISMIC SETTING

The Temperance Flat area is located along the western border of the central portion of the Sierra Nevada Province at its boundary with the eastern edge of the Great Valley 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 the dam in Millerton Lake. The Sierra Nevada batholith is comprised of primarily intrusive rocks, including granite and granodiorite, with some metamorphosed granite and granite gneiss. Intrusive Sierra Nevada batholith rocks underlie most of Millerton Lake and the Temperance Flat area 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 greatest 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. Metamorphic rocks in the Friant Dam area dip steeply downstream to the west, and strike northwesterly. Erosion has resulted in thin colluvial cover (Reclamation 2002a).

Geotechnical Conditions

No known adverse geotechnical conditions that would require special consideration for design and/or construction exist at any of the three sites. The foundation bedrock is considered competent for any of the dam types considered and for the potential appurtenant structures. There are no known faults at the RM 274, RM 279, or RM 286 sites or in the immediate vicinity. Details of observed geologic conditions at each of the potential dam sites are presented in Chapter 3.

Seismic Hazard Analysis

Overall, potential seismic hazard potential at the site is low. A preliminary, prefeasibility-level earthquake loading analysis considered two types of potential earthquake sources: fault sources and aerial/background sources (Reclamation, 2002b).

Twenty-two fault sources were identified and used to develop mean peak horizontal acceleration (PHA) hazard curves. Fault sources include those 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. Additionally, background, or random seismicity attributes were also developed by examining the South Sierran Source Block, the region surrounding the potential sites. This region possesses relatively uniform seismotectonic characteristics.

The mean PHA was calculated for these data and found to be the controlling source of potential earthquakes. Summary PHAs for select return periods are given in Table 2-1.

TABLE 2-1. SEISMIC ACCELERATIONS

Return Period	2,500 years	5,000 years	10,000 years
Peak Horizontal Acceleration	0.13 g	0.17 g	0.23 g

HYDROLOGIC SETTING

The drainage area above the RM 274 dam site is about 1,200 square miles. The terrain is generally mountainous with steep slopes and moderate to heavy forest cover. Elevations range from about elevation 400 at the RM 274 dam site to elevation 10,000 and above along the eastern basin boundary.

Rainfall

Rainfall estimates used for the potential Temperance Flat area dam sites are the same as those used for the 1988 Reclamation Friant Dam probable maximum flood (PMF) study.

The source of rainfall data used in the 1988 Reclamation PMF study for Friant Dam was Hydrometeorological Report (HMR) 36 (USWB, 1969). Values were checked with the more recent HMR 58 (Corrigan et al., 1998) and were found to be very close for all durations. It was concluded at that time that no new PMF study was required for Friant Dam based on 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 alternate about the peak increment.

The basin was divided into six subbasins with different PMP amounts for each subbasin. PMP amounts were formed by 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. For each of the RM 274, RM 279, and RM 286 sites, the most downstream subbasin was reduced in size to account for the difference in drainage area between the Friant Dam drainage basin and drainage basins associated with the Temperance Flat area dam site.

Runoff and Flood Data

Constant loss rates were considered that reflect the assumptions that a significant portion of the basin would be covered with snow. Excess precipitation, after subtracting constant loss rates, 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.

Prefeasibility-level PMF hydrographs were thus developed for the Temperance Flat area (Reclamation, 2002d). The resulting hydrographs represent a maximum runoff condition with no consideration given to sediment flows or to groundwater recharge.

Since the drainage basin is very large, only the general storm PMF hydrograph with a snowmelt base was considered. The PMF hydrograph has a peak of 561,200 cubic feet per second (cfs) and a 25-day volume of 2,521,700 acre-feet.

Results of the flood studies are suitable for prefeasibility-level designs, but should be reviewed and updated as necessary before final designs are developed.

EXISTING FACILITIES

This section describes existing facilities above RM 274 that could be affected by Temperance Flat Reservoir, proceeding from downstream to upstream. Table 2-2 lists approximate locations of facilities on the San Joaquin River above Millerton Lake, listed by river mile; approximate elevations are also given.

TABLE 2-2. APPROXIMATE LOCATIONS OF EXISTING FACILITIES ON SAN JOAQUIN RIVER ABOVE MILLERTON LAKE

Approximate Location (river mile)	Approximate Elevation (feet above mean sea level)	Feature
282.7	580	Kerckhoff No. 2 Powerhouse
283.6	578	Upstream limit of Millerton Lake
284.2	620	BLM footbridge
284.5	636	Kerckhoff Powerhouse
292.5	889	Base of Kerckhoff Dam
292.5	971	Kerckhoff Dam crest
294.7	1,000	Wishon Powerhouse
295.0	980	Bridge at Powerhouse Road
295.8	1,000	Big Creek No. 4 Powerhouse
301.0	1,210	Channel crossing @ Willow Creek
301.7	1,220	Base of Redinger Dam
301.7	1,401	Redinger Dam crest
305.6	1,410	Bridge at Italian Bar, Big Creek No. 3 Powerhouse
307.0	1,600	Residences, Chawanakee

The RM 274 potential dam site is situated close to Millerton Lake State Recreation Area (SRA) and just beyond the end of Fine Gold Drive, which provides access to a portion of the SRA and to residential properties near the shore of the lake. There are no other existing facilities or structures located at the RM 274 dam site. Evidence of past mining was observed, however, on the right abutments at the dam site.

No facilities or structures are present at the RM 279 site. Evidence of past mining, however, was observed on both the left and right abutments. The Sullivan Mine, no longer active, is located at Temperance Flat, upstream of the RM 274 and RM 279 dam sites, on the Fresno County side of the river (left side, looking downstream). Also at Temperance Flat are two residences, outbuildings, and structures associated with the Sullivan Mine. Kerckhoff Powerhouse (also referred to as Kerckhoff No. 1 Powerhouse) and Kerckhoff No. 2 Powerhouse are located upstream of RM 274, RM 279, and Temperance Flat, but below RM 286.

No facilities or structures are located at the RM 286 dam site. Kerckhoff dam and lake lie upstream of RM 286. The PG&E Wishon Powerhouse and Southern California Edison (SCE) Big Creek No. 4 Powerhouse discharge to Kerckhoff Lake. A bridge at Powerhouse Road spans the upper reach of Kerckhoff Lake. Farther upstream, and a short distance below Redinger Lake Dam, an improved road crossing traverses the channel of Willow Creek Redinger Lake and Dam are upstream of Kerckhoff Lake. A bridge at Italian Bar Road crosses Redinger Lake upstream of Redinger Dam. Big Creek No. 3 Powerhouse discharges to Redinger Lake, and the Chawanakee community is located adjacent to SCE Big Creek No. 3 Powerhouse.

UPSTREAM HYDROPOWER FACILITIES

PG&E and SCE own several hydropower generation facilities upstream of Millerton Lake, as shown in Figure 2-1. Both the PG&E and SCE systems consist of a series of diversion dams and reservoirs that provide water through tunnels to downstream powerhouses. A summary of generation capacity and dates of installation for PG&E and SCE power facilities above Millerton Lake to the edge of Redinger Lake are listed in Table 2-3. This table also summarizes annual reported energy generation from these facilities from 1994 through 2002. As indicated by minimum and maximum values, annual energy generation varies widely. Each of the potentially affected powerhouses has unique characteristics related to installed generation capacity, head, flow rates, equipment type, equipment age, and efficiency.

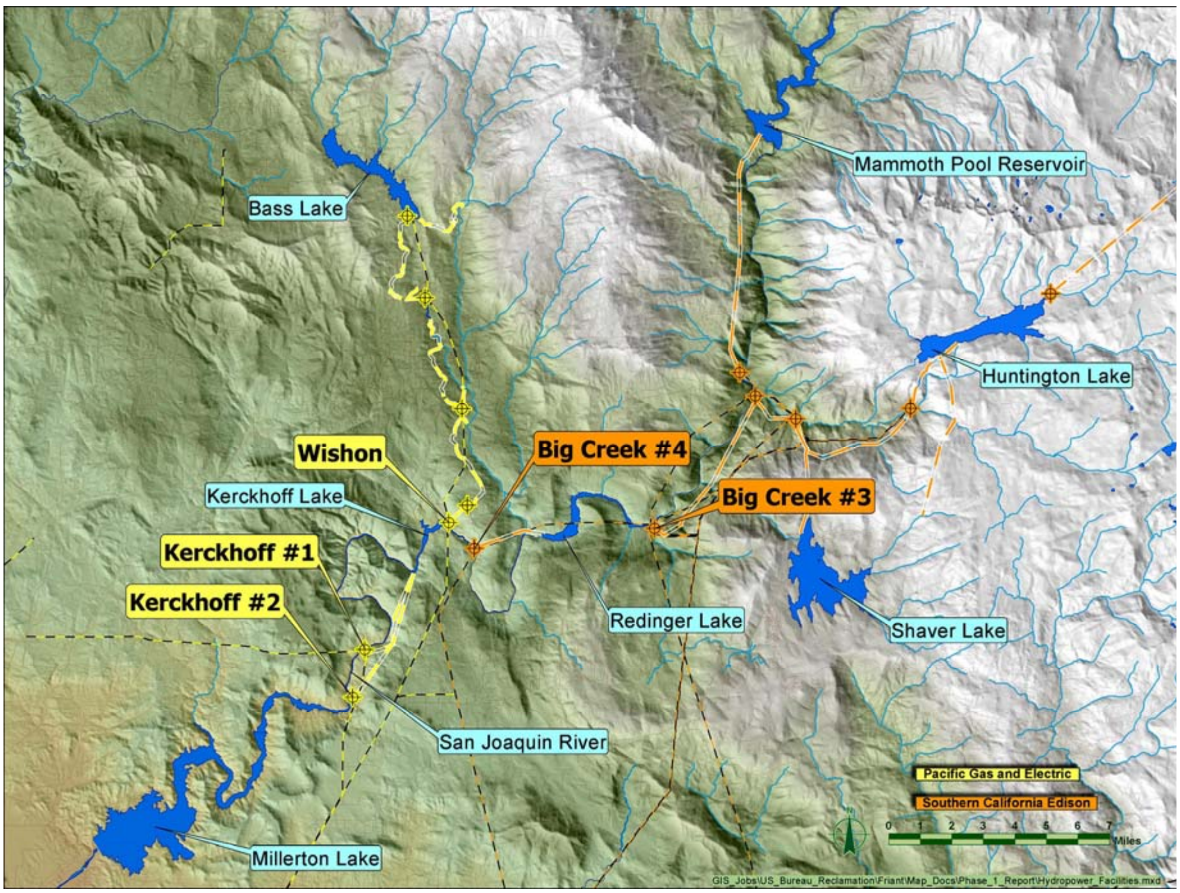


FIGURE 2-1. HYDROPOWER FACILITIES UPSTREAM OF MILLERTON LAKE

**TABLE 2-3.
HYDROELECTRIC GENERATION ABOVE MILLERTON LAKE**

	Pacific Gas & Electric			Southern California Edison	
	Wishon	**Kerckhoff**	**Kerckhoff No. 2**	**Big Creek No. 3**	**Big Creek No. 4**
FERC Proj. No.	1354	96	96	120	2017
Number of Units	4	3	1	7	2
Capacity (MW)	20	38	155	175	100
Year Commissioned	1919	1920	1983	1923	1952
Reported Annual Generation, Exclusive of Plant Use[1] (MWh)					
1994	27,904	10,348	275,752	567,399	294,398
1995	113,411	115,930	803,490	1,195,652	623,186
1996	93,551	52,273	696,653	1,050,192	608,066
1997	45,475	72,350	695,775	898,483	589,812
1998	117,762	75,657	735,830	1,094,868	613,169
1999	73,369	31,959	410,567	539,673	435,868
2000	73,642	37,632	482,279	837,543	448,810
2001	47,942	10,768	316,602	570,805	301,216
2002	54,588	19,639	368,396	717,201	352,915
Min. 1994-2002	27,904	10,348	275,752	539,673	294,398
Max. 1994-2002	117,762	115,930	803,490	1,195,652	623,186
Avg. 1994-2002	71,960	47,395	531,705	830,202	474,160

Key:
FERC – Federal Energy Regulatory Commission
MW – megawatt
MWh – megawatt – hour

Note:
1. Data source - annual FERC licensee reports.

PG&E Kerckhoff Hydroelectric Project

Existing PG&E facilities located within the potential inundation area of a Temperance Flat Reservoir include the following, proceeding upstream:

- Kerckhoff No. 2 Powerhouse
- Kerckhoff Powerhouse
- Kerckhoff Dam and Lake
- Wishon Powerhouse

Kerckhoff No. 2 Powerhouse

The Kerckhoff No. 2 Powerhouse is approximately 200 feet underground in a circular, rock chamber measuring 85 feet in diameter and 124 feet high. It houses a single, vertical Francis-type turbine/generator assembly. The powerhouse operates at a normal maximum gross head of 421 feet and has a normal operating capacity of 155 megawatts (MW). Turbine speed is 180 revolutions per minute (rpm); the turbine has a butterfly type shut-off valve.

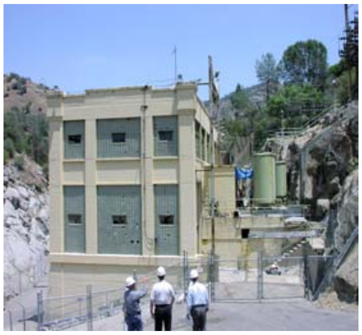
As with the Kerckhoff Powerhouse, most of the interior of the Kerckhoff No. 2 Powerhouse is unlined and very little spalling of rock appears to have occurred, an indication of the soundness of the surrounding rock formation.

Vehicles may access the powerhouse from Smalley Road through an unlined tunnel southwest of the switchyard. A roll-up door, which restricts access to the powerhouse to authorized personnel only, is located at the portal to the tunnel. The powerhouse may also be accessed through a vertical shaft located in the switchyard. The project was commissioned in 1983.

Water is conveyed from the intake in Lake Kerckhoff to the Kerckhoff No. 2 Powerhouse by means of a tunnel and penstock. The tunnel is approximately 21,632 feet long and has both lined and unlined sections. A surge chamber is located at the end of the tunnel near the intake for the penstock and consists of an unlined, tapered vertical shaft. An approximately 1,013-foot-long concrete- and steel-lined penstock conveys water from the tunnel to the powerhouse. The penstock has a 20-foot-diameter, 481-foot-long concrete-lined section, an 18-foot-diameter, 338-foot-long concrete-lined section, and a 15-foot-diameter, 194-foot-long steel-lined section that enters the powerhouse chamber. The penstock has a total flow capacity of 5,100 cfs.

Adjacent to the switchyard is an adit used during construction of the tunnel for Kerckhoff No. 2. This adit was plugged following project completion in 1983 and has not been used since. A tailings pile generated during tunnel construction is located downstream of the Kerckhoff Powerhouse outlet works. It extends a distance of approximately 1,000 feet along the left side of the river, on the uppermost perimeter of Lake Millerton. The tailings pile appears to have been placed as an engineered fill, sloping at about 1½:1 (horizontal to vertical), with concrete-lined drainage benches. The tailings appear to consist solely of granitic rock fragments and rock flour.

Kerckhoff Powerhouse



Kerckhoff Powerhouse, sometimes referred to as Kerckhoff No. 1 Powerhouse, is a reinforced concrete, tri-level building approximately 46 feet by 99 feet inside. It houses three vertical, Francis-type turbines directly coupled to generators with a total capacity of 38 MW. The normal maximum gross head is 350 feet and the turbine speed is 360 rpm; each turbine has a butterfly type shut-off valve generation voltage is 6,600 volts (v). The project was commissioned in 1920.

In the lower sections of the powerhouse, bedrock has been exposed in wall sections. These sections appeared very stable with little or no spalling, which attests to the high quality of the rock.

Water supply to Kerckhoff Powerhouse is conveyed by an approximately 16,943-foot-long unlined tunnel leading to three penstocks, which range from 913 to 945 feet in length and allow for a normal maximum gross head of 350 feet. A surge chamber is located at the end of the tunnel but upstream from the penstock gate valve. Two adits used during construction are located along the tunnel. The adits were plugged on completion of tunnel construction and have not been opened or used since. Three 115 kilovolt (kV) transmission lines serve Kerckhoff and Kerckhoff No. 2 powerhouses.

Kerckhoff Lake and Dam

Kerckhoff Dam, Kerckhoff Powerhouse, and Kerckhoff No. 2 Powerhouse are all included in FERC Project Number 96, which was originally licensed in 1922.

Kerckhoff Dam impounds Kerckhoff Lake, which serves as the forebay for both Kerckhoff and Kerckhoff No. 2 powerhouses. The dam is a concrete arch type, approximately 114 feet in height. The top of the dam is at elevation 994.50. The spillway crest is at elevation 971.34 and the normal maximum water surface is at elevation 985.00. The reservoir has a usable capacity of 4,252 acre-feet.

Separate intakes and water conveyance systems are provided for the Kerckhoff and Kerckhoff No. 2 powerhouses. Both intakes are located on the south bank of Kerckhoff Lake near the dam. For Kerckhoff Powerhouse, the intake structure is constructed of concrete and is equipped with two steel, slide gates. The intake for Kerckhoff No. 2 Powerhouse is a concrete-lined box structure located upstream of the Kerckhoff Powerhouse intake. Kerckhoff Lake has limited storage capabilities, which allow the powerhouses to provide peak generating loads during periods of high electrical demand.

Wishon Powerhouse

The A.G. Wishon Powerhouse was commissioned in 1919 as part of the Crane Valley Hydroelectric Generating Facility, FERC Project Number 1354.

The Wishon Powerhouse is located on the shore of Kerckhoff Lake. The powerhouse is a reinforced concrete and steel-framed, bi-level building, approximately 75 feet by 150 feet in size. It houses four generating units consisting of horizontal single-overhung impulse turbines connected to generators with a total capacity of 20 MW. Generation voltage is 2,300 v. Water from the turbines discharges into Kerckhoff Lake.

The water supply for the Wishon Powerhouse comes from Corrine Lake, located approximately 0.5 miles northeast of the powerhouse. Two penstocks, located east of the Wishon Powerhouse on a steep slope, convey water between Corrine Lake and the powerhouse. The penstocks are approximately 4,300 feet long. The diameter of the top half of the penstocks ranges from 40 to 44 inches. The diameter of the lower half of the penstocks ranges from 34 to 36 inches. The penstocks have a total flow capacity of 235 cfs.

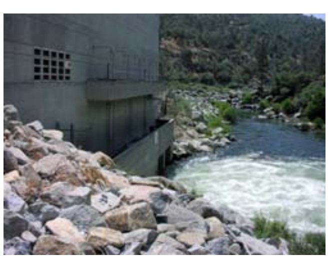
Transmission lines at the project include a 70 kV line from the San Joaquin No. 3 complex and a 70 kV line to the Coppermine substation.

SCE Big Creek Project

Existing SCE facilities potentially affected by a Temperance Flat Reservoir include the following:

- Big Creek No. 4 Powerhouse
- Redinger Dam
- Big Creek No. 3 Powerhouse

Big Creek No. 4 Powerhouse



The Big Creek No. 4 Project was constructed between the years 1949 and 1952 as FERC Project No. 2017, with a licensed capacity of 98,822 kilowatts (kW). Water is supplied to Big Creek No. 4 by a tunnel and penstock from the Redinger Lake Dam. Just upstream from the junction of the tunnel with the penstock is a surge chamber.

The powerhouse structure is 91 feet by 135 feet and is constructed of reinforced concrete. The powerhouse has five floors, including a draft tube floor, turbine floor, generator floor, storage floor, and erection floor. Normal tailwater level is at elevation 986.5.

The powerhouse contains two Francis-type, vertical shaft, hydraulic reaction turbines. Each turbine is rated at 66,000 horsepower (hp), with a design head of 383 feet and speed 257 rpm.

Also, each turbine is equipped with a 120-inch turbine butterfly shut-off valve. Each main turbine is directly connected to a vertical-shaft, totally enclosed generator. The Unit No. 1 generator was manufactured by Allis Chalmers while the Unit No. 2 generator was manufactured by General Electric. Each generator is rated at 50 MW. Generation voltage is 11.5 kV.

Station electrical service is supplied by a small, 450 hp horizontal, Francis-type water turbine with a design head of 383 feet and speed of 1,200 rpm. This turbine is connected to a 300 kW generator. Water is supplied to this small turbine from a 14-inch penstock that branches off the Unit No. 1 main turbine penstock, upstream of its butterfly-type turbine shut-off valve.

Two 220 kV transmission lines convey energy from the project: one proceeds to the Big Creek No. 3 Powerhouse and the other travels in the direction of Springville.

Redinger Lake and Dam

The dam at Redinger Lake (also known as Big Creek Dam No. 7) and intake structure are located about 6.3 river miles upstream of the Big Creek No. 4 Powerhouse. The dam is a concrete gravity dam, 250 feet high, and contains a maximum capacity of 35,000 TAF. The top of the dam, at elevation 1,413.5, is 875 feet long. The spillway has a crest elevation of 1,373 feet and is equipped with three 40-foot wide by 30-foot high radial gates. These gates are located approximately in the middle section of the dam crest. Normal maximum operating water level is elevation 1,403.

The intake to the power tunnel leading to the Big Creek No. 4 Powerhouse is located on the face of the dam to the right (looking downstream) of the spillway gates. This intake has full-height trash racks. The intake is divided into two rectangular openings, which can be closed by two wheel gates that are cable-suspended, electric-hoist-operated, and 8 feet by 17 feet and 8 inches. The outlet makes a transition to a 115-foot long, 17-foot diameter, welded steel pipe within and just beyond the dam section; thence, the pipe leads to the unlined power tunnel.

A turbine generator unit installed at the dam recovers energy from water released through the dam for instream flow purposes. The turbine is a Francis type horizontal shaft, hydraulic reaction turbine rated at 500 hp with a design head of 222 feet and speed of 1,200 rpm. This turbine is connected to a 350 kW generator, which feeds into the local 12 kV distribution system.

Big Creek No. 3 Powerhouse

Construction of the Big Creek No. 3 Project commenced in 1923 as FERC Project No. 120. The powerhouse has a licensed capacity of 174.45 MW.

Water is supplied to Big Creek No. 3 by tunnel and penstock from Big Creek Dam No. 6. Dam No. 6 Reservoir's normal maximum operating water level is at elevation 2,230. At normal maximum operating water levels, the gross head available at the Big Creek No. 3 powerhouse is 827 feet.

The powerhouse structure is constructed of reinforced concrete and contains seven turbine-generator units. Flow from the turbines discharges directly into Redinger Lake.

For the Big Creek No. 3 facility, annual power generation in 1995 was 567,399 MWh and in 1997 was 898,483 MWh.

ENVIRONMENTAL SETTING

Aspects of the environmental setting for the potential Temperance Flat Dam and Reservoir sites discussed below include botany, wildlife, aquatic biology and water quality, recreation, cultural resources, land use, and mineral resources.

Botany

Foothill woodlands dominate the area that would be affected by all three reservoir options under consideration. The predominant vegetation includes foothill pine (*Pinus sabiniana*), blue oak (*Quercus douglasii*), and interior live oak (*Q. wislizeni*).

Most of the San Joaquin River between Millerton Lake and the upper end of Redinger Lake lies in a steep canyon. Riparian vegetation is mostly sparse or absent, generally occurring as a narrow discontinuous band along the river. Riparian vegetation is somewhat better developed at the upper ends of the existing reservoirs, although water level fluctuations preclude its development in much of the area below the high water line. Riparian vegetation is more common in some of the tributaries, especially at their confluence with the San Joaquin River (Stebbins, 2003). Fish Creek, Willow Creek, and other larger tributaries possess some riparian canopy.

Vernal pools do not occur along this stretch of the San Joaquin River. However, surrounding the canyon are several large basalt tables known to have vernal pools well above elevation 1,600, along with associated special status plants and animals.

Five special status plant species, discussed in greater detail below, are known to occur in the San Joaquin River drainage system. Two of these are threatened species: tree-anemone (*Carpenteria californica*), a State-listed threatened species known to occur in 11 locations, and Mariposa pussypaws (*Calyptridium pulchellum*), a Federally listed threatened species known to occur in 7 locations.

Three other special status species occur in the region, but none have either State or Federal listing status. Two are on List 1B of the California Native Plant Society (CNPS) Inventory: Madera linanthus (*Linanthus serrulatus*) and orange lupine (*Lupinus citrinus* var. *citrinus*). Both are annual species; orange lupine is restricted to a special habitat. Oval-leaved viburnum (*Viburnum ellipticum*) is on List 2 of the CNPS. Oval-leaved viburnum is rare in California, but occurs more commonly in Oregon and Washington.

The United States Forest Service (USFS) maintains a list of special status species occurring within the boundaries of each of the National Forests in California (USFS, n.d.[a]). Each of the species discussed below occurs on the list for the Sierra National Forest (SNF). However, other species on the SNF list are not discussed here because they were not included in the CNDDB report for the area. Some of the other species on the SNF list could occur within the area studied.

Tree Anemone

Tree anemone (*Carpenteria californica*), a State-listed threatened species, is an erect evergreen shrub between 3 and 12 feet tall with large white flowers that resemble camellias. According to USFS, *Carpenteria californica* is a California shrub with a natural range of 50 square miles (USFS, 1970). Although Neal (n.d.) reports that the tree anemone occurs between elevation 975 and 9,800, the Rare Find database gives elevations of known locations as being between 1,120 and 4,400.

In 1994, the tree anemone was proposed for Federal listing as a threatened species. The United States Fish and Wildlife Service (USFWS) withdrew this proposal in September 1998, maintaining that the listing was unnecessary. In the September 1998 notice, USFWS indicated that approximately 30 percent of the known individuals were on private land and about 70 percent were on Federal land. In addition, several of the largest populations were in preserves managed by various agencies and environmental organizations.

Of the 11 known locations for this species, 3 stands are growing at or below elevation 1,600. According to Neal (n.d.), most stands occur in small drainages in foothill woodlands, although upper elevation stands occur in mixed conifer forest. No other locations have been recorded with the CNDDB (Bittman, 2003).

One of the largest populations of tree anemone occurs along Backbone Creek near its confluence with the San Joaquin River, within the Backbone Creek Research Natural Area (RNA) (Clines, 2003; Stebbins, 2003; Safford, 2003). In 1971, USFS established the 430-acre Backbone Creek RNA within the SNF because the RNA has significant potential for botanical and ecological research of the tree anemone, and for protection of the plant. Backbone Creek enters the San Joaquin River from the south, at the apex of Horseshoe Bend, between Kerckhoff and Redinger lakes, at an approximate elevation of 1,120.

Surveys for tree anemone have occurred mostly along roads and other access points, particularly on the south side of the river (Stebbins, 2003), outside USFS land. The river below Kerckhoff supports suitable habitat, but is very difficult to access, and few studies have been done in this area (Stebbins, 2003). Clines (2003) believes it is unlikely that large new populations would be discovered, but suggests that smaller, undocumented populations could be present in the area that would be affected by Temperance Flat Reservoir.

Mariposa Pussypaws

Mariposa pussypaws is a prostrate annual plant that grows in otherwise barren sand around decomposing granite domes, generally between elevations 1,450 and 3,600 in Madera, Mariposa, and Fresno counties. All populations within the study corridor along the San Joaquin River occur above elevation 2,000. Clines (2003) stated that several new populations have been found in the SNF, but none are within the study corridor. The river gorge between Millerton and Kerckhoff lakes supports little, if any, suitable habitat for Mariposa pussypaws due to the steep terrain and lack of granite domes (Stebbins, 2003). However, suitable conditions could occur above Kerckhoff Lake in relatively flat open areas.

Orange Lupine

Orange lupine is an annual member of the pea family that grows in barren areas around decomposing granite domes, where it is sometimes found with Mariposa pussypaws. It generally occurs between elevations 1,250 and 5,800 in Madera and Fresno counties. Most of the 66 known locations are above elevation 1,600. Like Mariposa pussypaws, suitable habitat for this species is probably very rare in the river gorge between Millerton and Kerckhoff lakes; more suitable habitat could exist above Kerckhoff Lake.

Madera Linanthus

Madera linanthus is a low annual plant that grows between elevations 250 and 5,000. It prefers decomposed granite soil in open foothill woodlands and lower mountain coniferous forests from Madera and Mariposa counties south to Kern County. Many of the known locations for this species are from dated historical records. Several populations are recorded along the shores of Millerton Lake; one known population occurs near Big Bend. Suitable conditions for this species probably exist in other parts of the study area as well. Clines (2003) conducted surveys for this species on USFS land but found only the common *Linanthus montanus*.

Oval-Leaved Viburnum

Oval-leaved viburnum is a shrub between 3 and 12 feet tall. This shrub is on CNPS List 2, meaning that it is rare in California but more common elsewhere. Although it grows at relatively low elevations in the Coast Range, known populations of oval-leaved viburnum in the Sierra Nevada drainage all occur above elevation 3,000. The likelihood of this species being present within the area studied is not clear, but suitable conditions are likely to exist. Clines (2003) suggested that if oval-leaved viburnum is present, it does not occur in large numbers.

Blue Elderberry

Blue elderberry (*Sambucus mexicanus*) is a shrub often associated with riparian habitat, but it also grows in and around rock outcrops in the foothills where individuals may obtain some subsurface water from shallow bedrock. Although not rare, this species is the sole habitat for the valley elderberry longhorn beetle, a Federally listed threatened insect. Stebbins (2003) has suggested that elderberries are much more common in the San Joaquin River gorge than might be expected.

Wildlife

The Temperance Flat area is a relatively rich wildlife region of the Sierran foothills, although the area has been altered by human activities such as mining, hydroelectric developments, river impoundments, cattle grazing, fire suppression, residential development, and establishment of non-native wildlife species.

Wildlife is associated with the habitats it occupies. The region is dominated by foothill pine–blue oak woodlands with open perennial grasslands. Forest canopy varies considerably by slope and aspect, while the shrub and ground cover layer is greatly affected by land uses such as cattle grazing. Much of the area could provide important deer winter ranges and bear habitat.

Fifteen species of special concern are recorded as occurring in the area, including one species listed by the Federal government as endangered (vernal pool tadpole shrimp); three species Federally listed as threatened (southern bald eagle, vernal pool fairy shrimp, valley elderberry longhorn beetle); three species listed by the State of California as endangered (southern bald eagle, great gray owl, willow flycatcher); and two listed by the State of California as threatened (Sierra red fox, vernal pool fairy shrimp). Eight species are California Species of Special Concern (California tiger salamander, western spadefoot toad, foothill yellow-legged frog, tri-colored blackbird, California mastiff bat, western pond turtle, prairie falcon, mid-valley fairy shrimp). However, since vernal pools are not known to occur near the upper San Joaquin River below elevation 1,600, the vernal pool shrimp species would not be expected to be found within the potential reservoir areas.

Aquatic Biology and Water Quality

This section describes existing aquatic biology and water quality conditions in each of the water bodies potentially affected by the options considered. Resources are described for Millerton Lake, the reach of the San Joaquin River upstream of Millerton Lake to Kerckhoff Dam, Kerckhoff Lake, the San Joaquin River between Kerckhoff Lake and Redinger Dam (Horseshoe Bend reach), and/or Redinger Lake.

Upper Millerton Lake

The river valley containing Millerton Lake upstream of RM 274 and RM 279 is mostly narrow and steep-sided. During the May 2002 and June 2003 field visits, the water level in Millerton Lake was near maximum pool elevation, inundating shoreline vegetation in some areas. While this is a typical storage condition in May and June, little of this vegetation probably reaches the water’s edge when the water elevation drops during late summer. Temperance Flat is the only substantial area in upper Millerton Lake with a gently sloping shoreline, shallow water, and well-developed shoreline vegetation. It is likely that this area provides good spawning and nursery habitat for important game fish species such as largemouth bass (*Micropterus salmoides*) and spotted bass (*M. punctulatus*).

Of the large number of fish species that inhabit Millerton Lake, most are introduced game species or forage species (USFWS, 1983a). The reservoir becomes thermally stratified during summer months and therefore supports a two-stage fishery with cold-water species residing in deep water and warm-water species inhabiting surface waters and areas near shore. The principal warm-water 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 the reservoir. Stocking of striped bass was suspended in 1987, but some natural reproduction occurs.

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 portion of the reservoir upstream of Temperance Flat, which is the most riverine portion of the reservoir with turbulent flows (PG&E, 1990).

Several native species also reside in Millerton Lake, including Sacramento sucker (*Catostomus occidentalis*), Sacramento pikeminnow (*Ptychocheilus grandis*), Sacramento blackfish (*Orthodon microlepidotus*), hitch (*Lavinia exilicauda*), and hardhead (*Mylopharodon conocephalus*). Hardhead is classified by the State of California as a Species of Special Concern and by USFS as a Sensitive Species.

Water quality information is not readily available for Millerton Lake, but water quality data are available for Kerckhoff Lake (PG&E, 1986a), from which Millerton Lake receives most of its inflow. All water quality parameters that have been measured meet the Basin Plan standards of the Central Valley Regional Water Quality Control Board (RWQCB). Therefore, the water quality of Millerton Lake can also be expected to be good.

San Joaquin River – Millerton Lake to Kerckhoff Dam

The 9-mile reach of the San Joaquin River between Millerton Lake and Kerckhoff Dam lies in a steep and narrow canyon that is particularly steep in the upper portion, known as the Patterson Bend reach. The river channel is bedrock-controlled with little gradient and many long narrow pools. Average channel gradient in the reach is relatively low, at about 33 feet per mile. The Kerckhoff Project powerhouses are located in the lower part of this reach. Water is directed at Kerckhoff Dam via tunnels to downstream powerhouses and thus bypasses the reach, resulting in low flow. Stream flow in the reach usually results from FERC-mandated flow releases for instream habitat: 15 cfs in dry water years and 25 cfs in normal water years (PG&E, 1999). Because of the low flows, summer temperatures increase sharply from Kerckhoff Dam to the powerhouses, often exceeding 75 degrees Fahrenheit, which is too warm for cold-water fish species.

Downstream of the powerhouses, the water is typically colder than that in the river because the released water has been sheltered from the sun as it travels quickly from Kerckhoff Lake to the powerhouses via tunnels. Because of the potential for rapid warming in the river downstream of Kerckhoff Dam, additional releases might be required to prevent summer water temperatures in the river from exceeding about 81 degrees Fahrenheit.

As noted previously, this reach contains spawning habitat for American shad. The Kerckhoff Project is required to increase flow downstream of Kerckhoff Powerhouse from May 15 through June 30 to enhance spawning conditions for American shad.

Fish species in the Millerton Lake to Kerckhoff Dam reach of the San Joaquin River include hardhead, which, as noted above, is classified as a State of California Species of Special Concern and a USFS Sensitive Species, and Kern brook lamprey, which is also a California Species of Special Concern. A petition was recently submitted to list the Kern brook lamprey under the Endangered Species Act (ESA). However, the presence of this species is based on an uncertain identification of larval lampreys collected in the reach (Moyle et al., 1995). Striped bass also spawn in the river upstream of the lake. The reach is too warm for cold-water species, but contains populations of exotic game fish species, such as smallmouth bass and green sunfish, and of the native species Sacramento pikeminnow and Sacramento sucker. In addition to fish, beds of the large freshwater clam, *Margaritifera spp.,* are found on the river bottom in this reach.

Kerckhoff Lake

Kerckhoff Lake is a narrow, 2.5-mile-long reservoir with a capacity of about 4 TAF. The upper portion is shallow with a well-vegetated shoreline due to deposition of silt, which probably provides good fish habitat. The lower portion is in a steep-walled canyon with a shoreline consisting mostly of bedrock and with little useful habitat for fish.

Water quality data are available for Kerckhoff Lake (PG&E, 1986a); all water quality parameters that have been measured meet the Basin Plan standards of the Central Valley RWQCB. Water temperatures in Kerckhoff Lake rarely exceed 68 degrees Fahrenheit, which is suitable for cold-water fish species. It is possible that sediments accumulating in the reservoir near the Kerckhoff Powerhouse intakes, which are at the base of Kerckhoff Dam, could contain toxic materials.

Kerckhoff Lake has many of the same fish species as the reach of the San Joaquin River downstream, including the native species hardhead, Sacramento pikeminnows, and Sacramento suckers. The reservoir has an additional native species, threespined stickleback (*Gasterosteus aculeatus*), and an introduced smelt, wagasaki (*Hypomesus nipponensis*). The reservoir does not contain American shad or striped bass, and because of its relatively cold water temperatures, it has no warm-water game species.

San Joaquin River – Kerckhoff Lake to Redinger Dam

The reach of the San Joaquin River from Big Creek No. 4 Powerhouse at Kerckhoff Lake to Redinger Dam, known as the Horseshoe Bend reach, runs through a steep-sided canyon similar to the canyon below Kerckhoff Lake. The river channel has a low gradient and is bedrock-controlled, forming a series of long, deep pools and runs separated by rockfall debris. Average gradient is about 35 feet per mile, similar to that in the Kerckhoff Reservoir to Millerton Reservoir reach. Much of the natural flow of the San Joaquin River is diverted at Redinger Dam to Big Creek No. 4 Powerhouse. The FERC-mandated minimum flow for most of the reach is 20 cfs. Except in years of high summer flows, summer water temperatures rise quickly in the river downstream of Redinger Dam. Temperatures in the lower portion of the reach might rise to 70 degrees Fahrenheit or more for much of the summer; this temperature is too warm for cold-water species such as trout, but suitable for native cool-water species such as hardhead, Sacramento pikeminnow, and Sacramento sucker (SCE, 1997).

Willow Creek, a major tributary, joins the river about a half-mile downstream of Redinger Dam. Willow Creek is a major source to the reach of fine sediments and warm water. Lower Willow Creek has very low surface flow, which helps keep exotic fish species in upper Willow Creek and Bass Lake from invading Horseshoe Bend.

The fish fauna of Horseshoe Bend are mostly native species, with hardhead the most abundant. The California Department of Fish and Game (CDFG) currently designates the Horseshoe Bend reach a Central Valley Drainage Hardhead/Pikeminnow Stream. Sacramento sucker, Sacramento pikeminnow, rainbow trout, and two sculpin species are also abundant (SCE, 1997).

Redinger Lake

Redinger Lake is 5.25 miles long and less than 2,000 feet wide with a capacity of 35 TAF. The basin's steep topography results in little shallow water habitat and no significant coves. The reservoir volume is small relative to the amount of inflow from the San Joaquin River and the Big Creek No. 3 Powerhouse, resulting in a high flushing rate. The high flushing rate, cold-water temperatures, low levels of nutrients, and small amount of shallow water habitat result in low reservoir fish production. According to past studies (SCE, 1997), Redinger Lake thermally stratifies in low but not high inflow years, while dissolved oxygen concentration is generally high and pH is slightly acidic at all depths. The fish fauna of Redinger Lake primarily consist of native species. Hardhead, Sacramento sucker, and Sacramento pikeminnow are the most abundant fish species in the reservoir (SCE, 1997).

Recreation

For discussion of recreation resources, Millerton Lake is best considered in two sections: a wide lake below the riverine confluence with Fine Gold Creek, and a narrow section above the confluence, beginning at about RM 274.

Downstream of Fine Gold Creek, Millerton Lake is moderately developed and is surrounded by numerous large private residences and developed recreation areas. Paved roads provide access to both the north and south sides of the lake. Upstream of RM 274, Millerton Lake is relatively undeveloped and is accessible only by boat or a few mostly unpaved roads. Upstream of RM 274, developed shoreline recreation areas are limited to the Hewitt Valley Environmental Camp and Temperance Flat Boat-In Camp, located on the north side of the lake between RM 280 and RM 281. In addition, a toilet facility is located at Temperance Flat, at about RM 281. Several trails and four-wheel drive roads traverse both the north and south sides of the lake and provide access for dispersed activities such as fishing, hiking, horseback riding, and hunting.

The Millerton Lake SRA adjoins large tracts of public land managed by BLM. The majority of non-water oriented recreation use in the area occurs within the boundaries of the BLM San Joaquin River Gorge Management Area, formerly known as the Squaw Leap Management Area. BLM has constructed and/or restored several buildings within the San Joaquin River Gorge Management Area, including a Native American village and presentation centers. These buildings are used as part of a program that draws school-aged children to learn about the natural and cultural resources of the area.

Smalley Road, a paved road, provides the main access to the San Joaquin River Gorge Management Area and to the PG&E Kerckhoff and Kerckhoff No. 2 powerhouses. It also provides access to a small footbridge, which crosses the San Joaquin River just downstream of Kerckhoff Powerhouse. Several unpaved roads and trails diverge from Smalley Road and provide access for hunting, fishing, mountain biking, hiking, and equestrian use. Off-road vehicle use is not allowed within the boundaries of the San Joaquin River Gorge Management Area.

There are no developed recreation facilities along the San Joaquin River between Kerckhoff Powerhouse and Kerckhoff Lake. A four-wheel drive road provides river access at about RM 287 and another four-wheel drive road provides access to the river at about RM 290. The absence of roads and developed facilities limits recreation use, but both warm- and cold-water fish species draw fishermen, particularly where four-wheel drive roads or trails provide river access. Whitewater boating also occurs along the San Joaquin River between Kerckhoff Lake and the Kerckhoff No. 2 Powerhouse. This run is generally referred to as the Patterson Bend run and is rated Class V on the International Scale of Difficulty.

Most of Kerckhoff Lake is situated on or bordered by SNF land managed by USFS. PG&E has developed recreation facilities at Kerckhoff Lake, including a car-top boat launch, a day-use area, and a campground at Smalley Cove, on the north side of the lake. PG&E also constructed a parking area at the BLM San Joaquin River Gorge Management Area. According to PG&E, these facilities are used primarily for picnicking, fishing, hunting, and primitive camping. As indicated in Table 2-4, use of these facilities is relatively light. The facilities receive heaviest use in April and May with lighter use between June and September (PG&E, 1999).

TABLE 2-4. RECREATION USE AT KERCKHOFF LAKE

Name	Type of Facility	Number of Units	Visits in 1996
Smalley Cove	Campground	5	16
Smalley Cove	Day use, picnic tables	5	267
Dispersed Use	Access areas	not applicable	538

The SCE Big Creek No. 4 Powerhouse is located just upstream of Kerckhoff Lake, and discharges water conveyed from Redinger Lake. There are no developed recreation facilities between the Big Creek No. 4 Powerhouse and Redinger Lake. A primitive trail, referred to as the Horseshoe Bend trail, traverses the north side of the San Joaquin River, providing access to upland areas for horseback riding, hunting, and hiking. An unpaved road provides river access where Willow Creek enters the San Joaquin River, about one-half mile downstream of Redinger Dam (Big Creek Dam No. 7). The river between Redinger Dam and Kerckhoff Lake is used for whitewater boating. This run is generally referred to as the Horseshoe Bend run and is considered Class III on the International Scale of Difficulty.

Redinger Lake is surrounded by SNF land managed by USFS, although the reservoir is owned and operated by SCE as part of its Big Creek No. 4 Hydroelectric Project. There are two developed public recreation areas at Redinger Lake. One is located on the north shore about 2,000 feet upstream from the dam, provides fishing access, sanitation facilities, a boat launching ramp, and a parking area with space for 22 cars and trailers (SCE, 1997). The other public recreation site is located adjacent to the dam, on the north shore of the reservoir, and consists of a large unpaved parking area equipped with outhouses. There are no developed campgrounds at Redinger Lake, but overnight camping is allowed within specific boundaries in the parking area adjacent to the dam (SCE, 1997). In addition to the two public recreation facilities, there are three private boat-launching areas, located at the upper end of the reservoir.

Cultural Resources

Below are described the archaeology, ethnography, and history of the Temperance Flat area upstream to Redinger Lake and its immediate vicinity.

Archaeology

California is rich in archaeological remains, including evidence of human occupation from early prehistoric times through historic exploration and settlement. Archaeological sites can be found almost anywhere in the State, although some areas have more sites than others, often reflecting more favorable living conditions and more attractive natural resources. Because California is relatively arid, sites tend to be concentrated in areas with more reliable water supplies. Hence, the major rivers in California are also areas in which there are many archaeological sites.

A number of archaeological surveys and excavations have taken place in and above the Temperance Flat area. Pertinent studies include Beatty, Becker, and Crist (1978); Cursi and Varner (1979); Napton and Greathouse (1977); Shull (1998); Smith (1999); Steidl, Steidl, and Lindahl (1995); Theodoratus and Crain (1962); and Wilson (1976).

A recent archaeological records search by Reclamation archaeologists indicates the presence of 33 archaeological sites within or near the existing pool of Millerton Lake (Welch, 2002). Sites are mostly prehistoric and include habitation sites with housepits, sweathouses, and human burials; bedrock mortars (BRMs); rock rings; and lithic scatters. Some of the prehistoric sites are within the Squaw Leap National Register District. Three of the archaeological sites are historic sites, associated with mining.

Farther upriver, portions of the area were surveyed, with varying levels of intensity, for PG&E hydroelectric relicensing (Varner and Bernal, 1976; Varner, 1977). Occupation as early as AD 500 has been documented (Moratto, 1984). In Exhibit W of the relicensing application, PG&E stated that there were 13 archaeological sites, 2 of which were found to be significant (PG&E, n.d.). Later reports, reflecting additional survey efforts (Varner, 1983; Wren, 1994), identified 23 sites but only 1 property on the National Register of Historic Places (NRHP). The archaeological inventory conducted for the Kerckhoff Project appears to have been incomplete, but it is possible that reservoir perimeters were completely surveyed (CPUC, 2000). It is likely that additional sites occur near Kerckhoff Lake at elevations higher than those surveyed in connection with relicensing; additional sites are certainly to be expected farther upstream.

Hindes (1962) gave early attention to the San Joaquin River canyon upstream from Big Creek No. 4 Powerhouse, where ephemeral use sites are likely. Blue oak/foothill pines vegetation would have presented diverse natural resources for use by prehistoric occupants of the area. Indeed, 22 prehistoric archaeological sites were inundated by Redinger Lake (Wallace and Lathrap, 1950; White, 1986). There are also known archaeological sites in the vicinity of the SCE Big Creek No. 3 Powerhouse, including a small village known as *Somhau* (Theodoratus, 1978; McCarthy et al., 1985). A limited archaeological survey in the vicinity of the Big Creek No. 3 Powerhouse was conducted by Varner and Beatty (1980); one was conducted by White around both Big Creek No. 3 and No. 4 powerhouses (1986). On gentle terrain throughout the area there is a high probability of prehistoric archaeological sites, including BRMs, and hunting and fishing camps. Even so, most gentle terrain above RM 286 has already been impacted either by Kerckhoff Lake or Redinger Lake.

Ethnography

The San Joaquin River was a very important resource for the California Indian people who lived along its reaches; salmon fishing was a key subsistence activity. Northern Valley Yokuts depended heavily on salmon and acorns for their subsistence. Other wild plant foods were crucial to their diet, and waterfowl hunting was also important. Hunting deer and other mammals was of marginal importance. Most settlements were located along major waterways on low mounds (Wallace, 1978). Western Mono people fished for salmon and other river fish, and deer hunting was important. Wild plant foods, including acorns, were essential to their diet, and small game was heavily used. Western Mono also traded across the Sierra Nevada for pine nuts. Foot trails along the San Joaquin River were important to the Mono people (Hindes, 1959). Western Mono hamlets were located along major streams, including the San Joaquin, Kings, and Kaweah rivers.

Millerton Lake is at the approximate border between Foothill Yokuts traditional territory and traditional territory of the Western Mono or Monache people. There is, however, some uncertainty in the literature regarding specific boundaries between the groups, and even what some groups were called. Spier (1978a) indicated that the territory of the Northfork Mono extended into the upper part of Millerton Lake, but he also showed the area from Millerton to North Fork as territory of the Dumna Foothill Yokuts. Kroeber separated the Northfork Mono into two groups, an unnamed band north of the San Joaquin River and the Posgisa on Big Sandy Creek, but he placed the Toltichi Foothill Yokuts along the San Joaquin River as far upstream as North Fork and identified another Foothill Yokuts group, the Kechayi, as having been on the south side of the San Joaquin River (1925). The village of Tsopotipau at the A. G. Wishon Powerhouse site was attributed to Toltichi Yokuts by Kroeber (1925). Rivers, on the other hand, discusses the ethnography of the Millerton Lake area in some detail, and suggests that the Toltichi might have been Mono (1988).

Yokuts people currently live at the Table Mountain Rancheria in Friant. Northfork Mono people now live primarily at North Fork Rancheria, and the Posgisa are at Big Sandy Rancheria in Auberry. The river at the SCE Big Creek No. 3 Powerhouse was a traditional fishing spot for Posgisa people from Big Sandy Rancheria.

History

American fur trappers entered the San Joaquin River drainage as early as 1827, and mining began along the river in 1850. A variety of historic sites are present along the San Joaquin River. Fairly diverse mining features occur around Temperance Flat: remains from Chinese placer mining, an arrastra, and two mine portals associated with the Sullivan Mine, where mining began in 1853 and continued into the 1930s (Stammerjohan, 1979). On the north side of the river, the Patterson Mine presents an exceptionally diverse set of remains, including an arrastra, mine portals, remains of cabins, and can/equipment dumps. A two-stamp lift wheel and various other mining remains, including a ball mill, an ore car, and rail tracks, are present near a contemporary cabin on the north side of the river a short distance upstream from the Patterson Mine. Historic mining sites were noted in the vicinity of Italian Bar by Wallace and Lathrap (1950).

The PG&E Kerckhoff Powerhouse, constructed in 1920, is a potentially significant historic property. Wishon Powerhouse has been evaluated for eligibility on the NRHP, along with four other powerhouses associated with the PG&E Crane Valley Project. The structure was found to be ineligible based on a loss of historic integrity (PG&E, 1986b). The SCE Big Creek Hydroelectric System has long been noted for its engineering significance (Redinger, 1949; Johnston, 1965; Myers, 1983); it might be found eligible as a district for the NRHP, as was previously recommended (White, 1986; Shoup et al., 1988). Presently, it is not known whether the SCE Big Creek Powerhouse No. 4 has been evaluated for NRHP eligibility. There are remains of an SCE employee community at Big Creek No. 3 Powerhouse, and a construction camp was located near Redinger Dam. Other sites are likely, associated with mining, logging, hydroelectric development, recreation, and other activities.

Land Use

The reservoir and adjacent shoreline of Millerton Lake are designated as an SRA, which is managed by the California Department of Parks and Recreation (CDPR) under an operating agreement with Reclamation. The Millerton Lake SRA provides a wide range of recreation opportunities, including, boating, fishing, swimming, camping, hiking, and picnicking.

The upland areas adjacent to Millerton Lake and the Patterson Bend area of the San Joaquin River are surrounded mainly by private land. The Millerton Lake area is moderately to heavily developed and numerous large homes dominate the landscape. The Patterson Bend area is undeveloped.

The San Joaquin River forms the boundary between Madera and Fresno counties. Private land on the north side of the San Joaquin River falls under the jurisdiction of Madera County. Private land on the south side of the river falls under the jurisdiction of Fresno County. The Madera and Fresno County General Plans provide overall direction regarding land use, development, and environmental protection in Madera and Fresno counties, respectively. The Fresno County Sierra-North Regional Plan provides additional direction for the areas east of the Friant-Kern Canal and north of the Kings River.

Most of the land along the upper portion of Millerton Lake and the San Joaquin River upstream to RM 286 is public land managed by BLM as part of the San Joaquin River Gorge Management Area (formerly known as the Squaw Leap Management Area). BLM has not prepared a management plan specific to the San Joaquin River Gorge Management Area, but in general manages the area to protect natural and cultural resources and to provide recreation opportunities. Grazing is also allowed within the management area.

Most of the area between RM 286 and Kerckhoff Dam is private land, with scattered parcels managed by BLM. Kerckhoff Dam is situated on the western boundary of the SNF. As such, most of the land upstream of Kerckhoff Dam, including the area surrounding Kerckhoff and Redinger Lakes, is public land managed by USFS.

The SNF Land and Resource Management Plan (LRMP) was adopted in 1991 and dictates the long-term management of forest lands. The LRMP's overall goal is to provide management direction that reflects a mix of activities and to allow the use and protection of forest resources while addressing local, regional, and national issues (SCE, 1997). The LRMP provides forest-wide land management goals, policies, standards, and guidelines. It also identifies management prescriptions that specify the goals and objectives of SNF for specific lands within the forest. Those applicable to the potential reservoir area include

"Front Country," "General Forest," and "Research Natural Areas," which are described in the LRMP as follows:

- Front Country. Land areas where wildlife and range management activities with adequate protection of watershed values are emphasized.
- General Forest. Lands generally available, capable, and suitable for timber production. Included in this area are lands with limited, modified, and full timber yield prescriptions. Resource considerations such as watershed, wildlife, visuals, and cultural activities often place constraints on timber management activities.
- RNAs. Areas protected and managed for research in their natural condition.

One RNA is located in the area; the Backbone Creek RNA is located on the south side of the San Joaquin River, between Redinger and Kerckhoff lakes, at the apex of Horseshoe Bend. The RNA encompasses 430 acres of land and was established in 1972 because it has significant potential for botanical and ecological research of *Carpenteria californica*, a California shrub with a natural range of 50 square miles (USFS, 1970). The RNA designation discourages recreation use in the area and prohibits livestock grazing and mining, land encumbrances (except those needed for research), roads, trails and trailheads.

Mineral Resources

Temperance Flat is an historic mining district located on the south side of the San Joaquin River, near the upper end of Millerton Lake. Lode mining began in the Temperance Flat area in 1853 at the Sullivan Mine and continued intermittently until about 1915. The area was prospected again during the 1930s (CDMG, 1970; Stammerjohan, 1979).

The Temperance Flat mining district included a number of individual mines: Henrietta, Keno, Quien Sabe, Providence, Rattlesnake, San Joaquin, Sullivan, Temperance, and White Mule (CDMG, 1970). All of these mines have been abandoned and little field evidence of their existence is visible.

The location of the Sullivan Mine is identified on the USGS 7.5-minute Millerton Lake East quadrangle. Remnants of the Sullivan Mine, mostly hidden by brush, include two partially collapsed mine tunnels, small tailings piles, arrastras, and hand-stacked walls. An unpaved road provides access to the Sullivan Mine from Wellbarn Road.

According to California Division of Mines and Geology (CDMG) Bulletin 193, in its time, the Sullivan mine produced about $100,000 of gold (CDMG, 1970). Rock types, mineralogy, and mine remnants observed in the field are consistent with information contained in Bulletin 193. Main rock types are granite or granodiorite, which are not extensively altered. Small quartz veins and boulders are present at the tunnel entrances, suggesting gold was present in quartz veins. No sulfide, arsenic, or copper minerals were observed in either the tunnel entrances or tailings piles at either mine, although Bulletin 193 indicates pyrite was often abundant.

In addition to the mines named above, the Millerton Lake East quadrangle shows a series of prospect pits located about 1 mile west-northwest of the Sullivan Mine, on the opposite side of the upper portion of Millerton Lake. Reclamation identified these prospects as the Patterson Mine, another historic gold mine. Remnants of the Patterson Mine include several mine tunnels, a well-preserved arrastra, small tailings piles, and a small stamp mill foundation. A cabin and stamp mill are located about 1 mile upstream and upslope, but it is unclear whether these last two features are part of the Patterson Mine or another historic mining operation.

Both the Sullivan and Patterson mines appear to have been relatively small mining operations, as suggested by the very small tailings piles, relatively short tunnels, and absence of extensive mineralization or alteration of the host rock.

CHAPTER 3. STORAGE STRUCTURES AND APPURTENANT FEATURES

This chapter focuses on technical aspects of design and construction of a potential dam and reservoir in the Temperance Flat area. It includes an overview of dam sites considered, describes site-specific physical characteristics, dam options evaluated, appurtenant features, site-specific considerations related to constructibility, and estimated field costs for each site considered, and discusses considerations common to all potential dam sites.

POTENTIAL DAM SITES CONSIDERED

Initially, four potential dam sites between Friant Dam and Kerckhoff Dam were identified on the basis of topographic characteristics and previous studies. These potential dam sites were located at RM 274, RM 279, RM 280, and RM 286.

An initial comparison of site features showed that the RM 279 site was superior to the RM 280 site, although these two sites are close in proximity and similar in many respects. A reservoir at either site with the same maximum surface elevation would result in similar environmental effects. Both of these sites also have similar geologic conditions, would be accessed in the same manner, would use the same construction lay-down area, and would obtain dam materials from the same general borrow area.

However, a dam at RM 280 would require more material than a dam at RM 279 to create a reservoir of equivalent storage capacity, and would therefore incur higher costs. Therefore, RM 280 was dropped from further consideration, while further analysis was conducted for potential dams at RM 274, RM 279, and RM 286.

RM 274

The RM 274 site is located in Millerton Lake, just upstream of the confluence with Fine Gold Creek. It is the most downstream site of those considered.

Site Characteristics

The RM 274 site rises uniformly from elevation 385 in the original San Joaquin River channel at RM 274: the left abutment rises uniformly to elevation 1,582 at Pincushion Mountain and the right abutment rises uniformly to elevation 1,473 at an unnamed mountain. A low spot exists along the reservoir rim at elevation 1,120 on a ridge making up part of the left abutment adjacent to RM 275.

Both abutments and the channel section are mostly granite and granodiorite, with alluvium in the channel section. The granite is typically hard to very hard where exposed in the bottom of drainages and along the reservoir shoreline. The upper 1 to 10 feet of the granite are intensely weathered to decomposed, and soft to very soft.

Hard, erosion-resistant granite outcrops are scattered on the abutments. Some of these outcrops are detached blocks of rock up to 25 feet in maximum dimension. A zone of hard, slightly fractured meta-granite or granite gneiss is present near the dam centerline on the left abutment and appears to outcrop in a shallow drainage located upstream of the dam centerline on the right abutment.

Alluvium of unknown thickness occurs below the reservoir water surface in the San Joaquin River channel. The alluvium probably ranges from fine-to-coarse grained, with rock blocks up to 25 feet in maximum dimension that detached from the abutment slopes.

Unstable wedges, toppling, or slides were not observed at the site. The granitic bedrock has adequate strength and stability for embankment, rockfill, concrete gravity, or concrete arch dam structures and for any river diversion feature. The granite is an adequate foundation for a plunge pool or overflow spillway. There are no known faults at the RM 274 site or in the vicinity (Reclamation, 2002b).

Potential Dam Types and Sizes

The RM 274 site is suitable for a concrete arch dam or RCC or CFRF gravity type dams. A central-core earthfill dam is not considered economically viable due to the limited availability of plastic, fine-grained materials for the core. An asphaltic-core earthfill dam might be viable for the site, but was not considered due to limited use and experience with this type of dam in the United States.

Concrete Arch Dam

Foundation conditions are excellent for a concrete arch dam. However, the abutments are uniform with relatively flat slopes, producing a wide canyon that would require large volumes of concrete. Therefore, a conventional concrete arch dam was not considered for prefeasibility-level designs.

Concrete Gravity Dam

Foundation conditions are excellent for an RCC gravity dam. This dam type was not developed in detail for the RM 274 site but would be similar to the structure developed for the RM 279 site, described later in the chapter.

Concrete-Face Rockfill Dam

CFRF dam layouts, including appurtenances, are shown in Appendix D. A vertical cross section of a CFRF dam, perpendicular to the dam axis, is shown in Figure 3-1. A more detailed cross section is also included in Appendix D. The design is based on standard practice, as described in Concrete-Face Rockfill Dam: II. Design (Cook and Sherard, 1987).

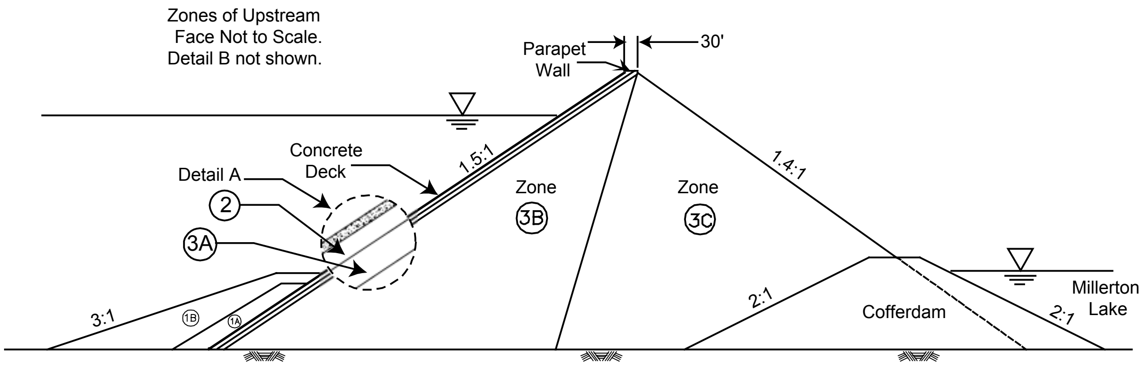


FIGURE 3-1. CFRF DAM CROSS SECTION

The cross section shows a concrete deck, which would act as the impervious water barrier for the dam. Beneath the deck is a layer of silty/clayey sand and gravel (Zone 2), which would provide the placement surface for the concrete deck and a secondary water barrier for seepage passing through joints in the deck. Below Zone 2 is the first of three shell zones. This first zone (Zone 3A) would provide a transition to coarser zones downstream, and would consist of gravel and cobble sizes. The two remaining zones are designated upstream (Zone 3B) and downstream (Zone 3C) for their relative position to the dam centerline. Zone 3B would be more compacted to minimize settlements. Zone 3C could be less compacted due to its location within the cross section and lower potential for settlement. Upstream of the concrete deck, material (Zone 1A) would be placed over the perimeter joint to prevent seepage and minimize joint damage from reservoir debris. Zone 1A material would be primarily fine-grained and impermeable. A stability zone would be placed over Zone 1A to buttress the barrier for greater slope stability.

Foundation grouting would consist of a single row curtain with an average depth of 250 feet, and companion blanket grouting with rows on either side of the curtain. Blanket holes would average 30 feet deep. Spacing of curtain holes would be 30 feet, and the spacing of blanket holes would be 10 feet. Closure pattern grouting is assumed to achieve a complete cutoff. Grouting details are shown on the cross section in Appendix D.

Preliminary Dam Sizes Evaluated

For the potential RM 274 dam site, preliminary designs and cost estimates were developed for CFRF dams with crests at elevations 800 and 1,100. The resulting dams would be 415 and 715 feet high, respectively, measured from the existing riverbed. The cost estimates for these two dam sizes were then used to create an interpolated cost estimate for a CFRF dam with the crest at elevation 960 (575 feet high). Table 3-1 displays the range of options evaluated for constructibility and cost.

TABLE 3-1. DAM OPTION EVALUATED AT RM 274

Dam Crest Elevation (feet above mean sea level)	Dam Height (feet)	Dam Types		
		RCC	CFRF	Arch
800	415		X	
960	575		X	
1,100	715		X	

Key:
CFRF – concrete face rockfill
msl – mean sea level
RCC – roller-compacted concrete

Although a smaller dam could readily be considered, topography limits the potential height of a dam before extensive saddle dams would be required on the reservoir perimeter. In addition, while designs and cost estimates were not specifically developed for the RCC dam type at RM 274, it is expected that they would resemble those prepared for the RM 279 site, as described in a later section.

Reservoir Area and Storage

As shown in Table 3-2, the dam sizes for which designs and cost estimates were produced would result in reservoir net storage capacities varying from nearly 500 TAF to more than 2 million acre-feet. Reservoir surface area would range from 3,300 to 8,200 acres. Curves showing potential new storage capacity and surface area for a reservoir at RM 274 are presented in Figure 3-2.

TABLE 3-2. RM 274 POTENTIAL RESERVOIR CAPACITIES

Dam Crest Elevation (feet above mean sea level)	Dam Height (feet)	Area (acres)	Gross Storage (TAF)	Net Storage (TAF)
800	415	3,270	531	462
960	575	5,620	1,246	1,174
1,100	715	8,200	2,187	2,114

Key:
TAF – thousand acre-feet
Note:
Net storage accounts for lost storage capacity in Millerton and Kerckhoff lakes.

Appurtenant Features

Prefeasibility-level designs for appurtenant structures were based on the assumption that Millerton Lake would be continuously operated within the approximate range of elevation 550 to elevation 575. Storage at the RM 274 site would be gravity-fed into Millerton Lake, and downstream deliveries or releases could use the existing outlet works at Friant Dam.

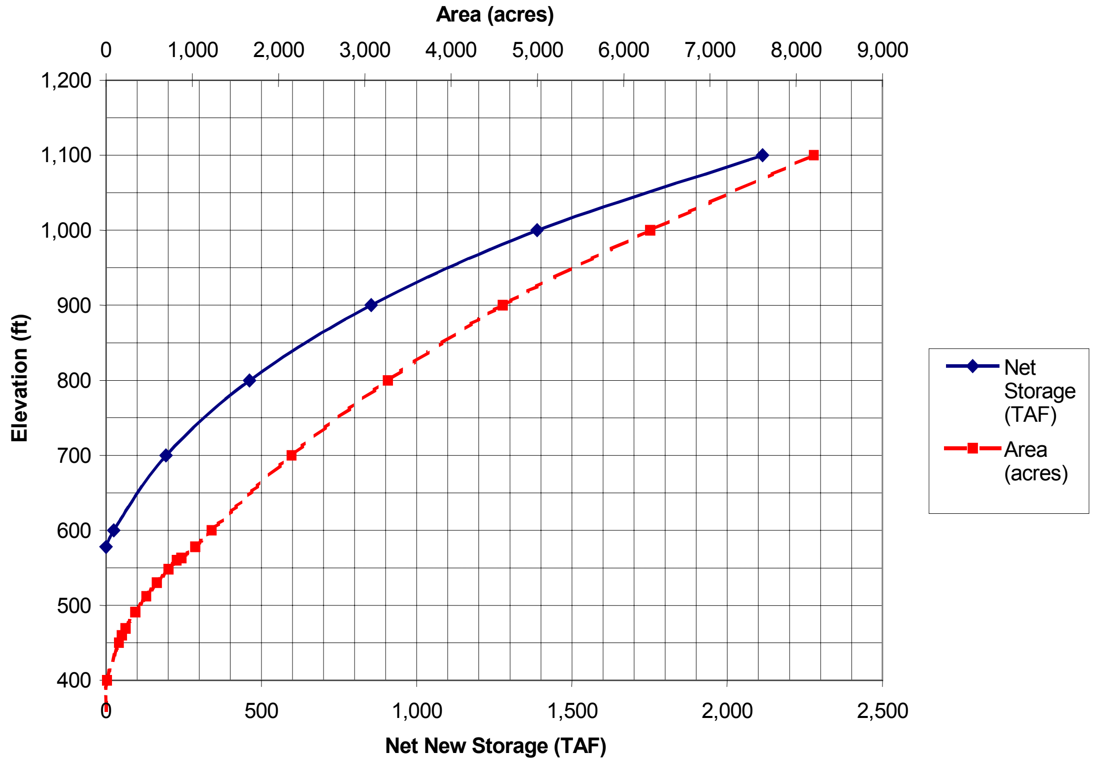


FIGURE 3-2. RM 274 DAM SITE: RESERVOIR SURFACE ELEVATION VERSUS STORAGE AND AREA

Diversion Works

Diversion during construction was based on passing a peak discharge of 65,000 cfs, which corresponds to an approximate 25-year return period. Diversion for the dam options would be accomplished by constructing diversion tunnels through each abutment. A 30-foot-diameter tunnel would be constructed through the left abutment, and a 40-foot-diameter tunnel would be constructed through the right abutment. The capacity of the left abutment tunnel would be about 25,000 cfs during construction, and would later serve as the outlet works for the dam. The capacity of the right abutment tunnel would be about 40,000 cfs. This tunnel would be plugged following construction, or would be converted to a spillway, as discussed below.

Upstream and downstream cofferdams would be required for diverting stream flows during construction and to prevent inundation of the site from Millerton Lake. Cofferdams would be sized for estimated diversion flows, and to allow normal operation of Millerton Lake during construction. The downstream cofferdam would require a minimum crest at elevation 578, and height of about 195 feet. The upstream cofferdam would need a crest at elevation 635 to provide sufficient head to pass the diversion flows, and a height of approximately 250 feet. A significant portion of both cofferdams would need to be constructed within the existing reservoir pool, at a maximum depth of 175 feet.

Spillway

The spillway design was based on passing a peak discharge of 145,000 cfs. This would be accomplished using an uncontrolled ogee crest spillway with a crest length of 450 feet, and a head of 20 feet. The spillway for the elevation 800 dam would be located on the right abutment, and the spillway for the elevation 1,100 dam would be located through a saddle on the left reservoir rim more than a mile upstream from the dam.

Downstream channels for each spillway would be excavated through the existing foundation rock. A reinforced concrete apron and training wall would be constructed within the first 100 feet upstream from the crest structure and 200 feet downstream from the crest structure, to control flows within the vicinity of the dam or saddle. Energy would be dissipated by the tailwater at the end of the natural channel, which would be over 100 feet deep, depending on the level of Millerton Lake. For future designs, a labyrinth spillway should be considered for raising the crest elevation, providing more storage, and reducing the overall width of the spillway, including the outlet channel.

The alignment for the saddle spillway would cross Fine Gold Drive, near the road’s end. This road provides access to several residences and a park. A bridge would be required to pass over the spillway.

Recent safety-of-dam studies for Friant Dam (Reclamation, 2002d; 2002e) indicate that existing facilities can safely pass about 30 percent of the PMF before overtopping would occur. A risk assessment of the overtopping condition suggests that the existing concrete gravity dam at Friant can withstand the depth and duration of overtopping without failure. A similar assessment would likely be true for a new RCC dam at the RM 274 site. However, a rockfill dam would very likely fail at this same threshold condition. For purposes of this study, the spillway capacity was increased to 145,000 cfs at RM 274 (up from about 85,000 cfs for the existing Friant Dam spillway), to increase the level of threshold before overtopping would occur. Operation studies have not been completed for the potential new dams, so flood routings have not been performed. Future studies would need to include determining an appropriate inflow design flood for this site. Options for addressing a larger peak discharge include flood forecasting operations, increased spillway capacity, and additional surcharge.

Outlet Works

The left abutment diversion tunnel would be converted to the outlet works. The outlet works layout would consist of a trash-racked intake structure, a water conveyance system, and a series of regulating gates with upstream guard gates. Energy from releases would be dissipated in the tailwater from Millerton Lake (plunge pool). The size of the conveyance system is dictated by diversion during construction, but normal reservoir operation requirements would control the size and number of gates. The capacity of the outlet works was set to closely match the capacity of the existing river and canal outlets at Friant Dam. Bulkheads would be required for the intake structure, and outlet gates within the upstream end of the tunnel would also be provided for dewatering. The control structure for the outlet works would be combined with the powerhouse.

A low-level outlet works with the capability of evacuating the reservoir below elevation 570 was not included in these studies. This range of reservoir level would be within the current operating pool of Millerton Lake, and could only be evacuated if Millerton Lake was drawn down below elevation 435. The need for a low-level outlet works should be considered in future studies. If considered, a tunnel through the abutment could be used for the CFRF dam options, which would require placing the downstream cofferdam further downstream to provide room for constructing the outlet end of the tunnel. The low-level outlet for any RCC dam options would be constructed through the dam.

Powerhouse

For purposes of preliminary powerhouse design and cost estimation, it was assumed that three turbines of equal size would be put in place to operate within the head range and discharge capacity that is available during most of the year. For the dam with a crest at elevation 800, it was assumed that approximately 40 MW of capacity would be installed. For an elevation 1,100 dam crest, 60 MW of capacity were assumed. Each turbine would operate independently within specific ranges of reservoir elevations. Hydropower generation analysis presented in Chapter 4 suggests that the generation capacity assumed for preliminary cost estimates might be low.

The powerhouse and outlet works control structure would be located at the downstream portal of the left abutment diversion tunnel. During normal releases, all flows would pass through the turbines. During periods of significant inflow, the outlet works might be needed to supplement releases in combination with the spillway as necessary. Once potential reservoir operations are defined, a more refined power operations study should be performed to take advantage of the expected releases and reservoir elevations.

Constructibility

This section discusses issues of concern related to constructing the potential dam, reservoir, and appurtenant features at RM 274.

Land, Rights-of-Way, and Easements

Private and public lands would have to be acquired to construct the facilities. The dam and appurtenant structures would be located on public land; however, several parcels of land immediately upstream from the construction area are privately owned. The potential reservoir areas include both public and private land, Kerckhoff Powerhouse, and Kerckhoff Powerhouse No. 2, all of which would have to be acquired. For the elevation 1,100 reservoir option, Kerckhoff Dam, Wishon Powerhouse, and Big Creek No. 4 Powerhouse would need to be acquired or relocated.

Access

Access to the dam site is across both public and private land. The site is not directly accessible by existing roads, although Fine Gold Drive terminates downstream of the left abutment, and a jeep trail provides access to higher elevation lands within a mile of the right abutment. Both abutments are accessible by boat from Millerton Lake.

Borrow Sources and Materials

Rockfill could be quarried from the reservoir area and obtained from excavation required for the dam and appurtenant structures. Earthfill is available in limited quantities. Low-plasticity, fine-grained soil might be available in the Auberry Valley area, and in an area south of Millerton Road near the Millerton Lake Recreation Area entrance. Road cuts in Temperance Flat and the Auberry Valley expose decomposed to intensely weathered granite.

Processed sands and gravels could be supplied by commercial sources and/or by crushing and processing of quarried rock in the reservoir area. Concrete aggregates can be obtained from commercial sources and/or crushing and processing quarried rock in the reservoir area.

Foundations

Foundations would be in sound granitic rock, as previously described in Site Geology for RM 274. No special foundation considerations are known for this site at this time; foundation preparation would be typical for any of the options considered.

Staging and Lay-Down Areas

No specific staging and lay-down area has been identified for the RM 274 site. This site has a moderate amount of nearby development due to its location in Millerton Lake. Residential properties and developed recreation facilities infringe on this site, making identifying staging areas difficult at this prefeasibility-level of study.

Construction Costs

Field costs are summarized in Table 3-3. Field costs are based on 2003 price levels and represent direct costs to construct the dam and appurtenant features. Field costs include the estimated cost to construct listed features, plus allowances for mobilization (5 percent), unlisted items (15 percent), and contingencies (25 percent). Details of the estimates are included in Appendix C. Costs of road and bridge construction, relocation or acquisition of existing facilities, reservoir clearing, lands acquisition, easements, rights-of-way, environmental mitigation, investigations, designs, construction management, administration, and interest during construction are not included in the estimated field costs.

TABLE 3-3. ESTIMATED CONSTRUCTION COST FOR RM 274 OPTIONS

Dam Crest Elevation (feet above mean sea level)	Dam Height (feet)	Gross Storage (TAF)	Dam Type	Field Cost ($ Million)
800	415	531	CFRF	490
960	575	1,246	CFRF	670
1,100	715	2,187	CFRF	800
Key: CFRF – concrete-face rockfill TAF – thousand acre-feet				

Cost estimates were developed for CFRF type dams with crests at elevations 800, 960, and 1,100. For those crest elevations, estimates were based on quantities calculated from preliminary dam designs. The cost estimate for the elevation 960 dam was interpolated from cost estimates for the elevation 800 and 1,100 dams. Where quantities or unit prices for a pay item varied between the elevation 800 and 1,100 estimates, the corresponding pay item entries for the elevation 960 estimate used linearly interpolated values.

Cost estimates were not specifically developed for the RCC dam type at RM 274. However, cost estimates were prepared for both RCC and CFRF dam types at RM 279 and the range of variation between RCC and CFRF dam costs that occurs for the RM 279 site generally would be expected to apply at RM 274.

RM 279

The RM 279 site is also located in Millerton Lake, just downstream from the Temperance Flat area. Site and construction characteristics would be similar to those for the RM 274 site, as discussed in the following sections.

Site Characteristics

The RM 279 site rises uniformly from elevation 460 in the original San Joaquin River channel at RM 278.9 to elevation 1,080 on the left abutment, and then through a saddle at elevation 1,040 before continuing to elevation 1,416 at an unnamed mountain. The right abutment rises uninterrupted to elevation 1,566 at an unnamed mountain. Readily observable geologic conditions at the RM 279 site are very similar to those at the RM 274 site.

Potential Dam Types and Sizes

The RM 279 site is appropriate for concrete arch and RCC and CFRF gravity dam types. A central-core earthfill dam is not considered economically viable due to the limited availability of plastic, fine-grained materials for the core. An asphaltic-core earthfill dam might be viable for the site but was not considered due to limited use and experience with this type of dam in the United States.

Concrete Arch Dam

Foundation conditions at RM 279 are excellent for a concrete arch dam. However, the abutments are uniform with relatively flat slopes, resulting in a wide canyon that would require large volumes of concrete. Therefore, a conventional concrete arch dam was not considered for prefeasibility-level designs.

Concrete Gravity Dam

The RCC gravity dam layout, including appurtenances, is shown in Appendix D. A representative cross section of the RCC gravity dam option is shown in Figure 3-3 and also presented with additional details in Appendix D. The design is based on standard practice, as described in Design of Gravity Dams (Reclamation, 1976). The cross section shows a vertical upstream face with a 0.75H:1V downstream face. The downstream slope of 0.75H:1V was used to develop the prefeasibility-level designs, but preliminary stability analyses show that a steeper slope might be possible.

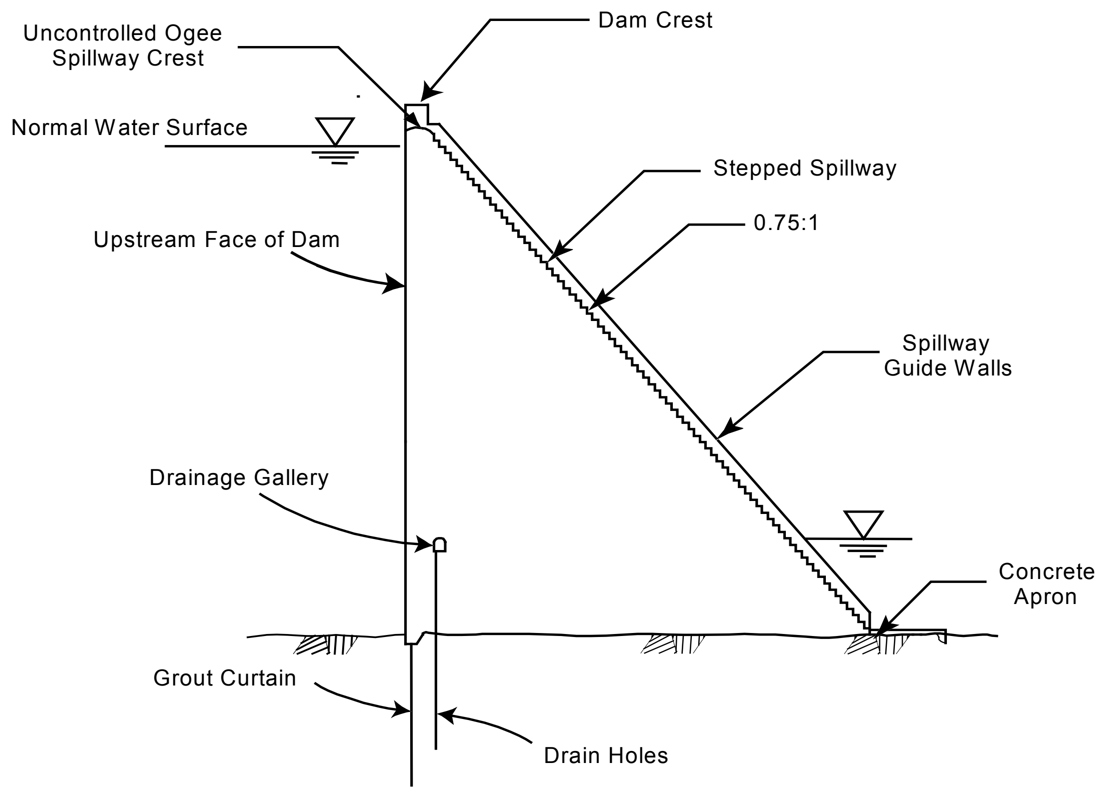


FIGURE 3-3. PROFILE OF RCC DAM

The mass of the dam would be constructed with RCC. The upstream and downstream faces of the dam would be covered with conventional concrete-facing elements to provide a more durable surface on the exposed faces of the dam. Leveling concrete requirements were estimated for the dam foundation (an average thickness of 1 foot was assumed) and a conventional concrete cap would be provided on the dam crest. The dam crest width and details would be similar to the existing Friant Dam.

Foundation grouting would consist of a single curtain with an assumed spacing of 10 feet. A drainage gallery would be placed in the RCC above the high tailwater elevation. Drainage holes on 10-foot centers would be drilled from the gallery into the foundation, with additional drain holes drilled from the dam crest into the gallery. For the lower height dam (elevation 900), grout holes were assumed to extend 150 feet into the foundation, with drain holes extending 100 feet into the foundation. For the higher dam (elevation 1,100), grout holes were assumed to extend 250 feet into the foundation, with drain holes extending 200 feet into the foundation. For the highest dam considered (elevation 1,300), the grout holes were assumed to be 250 feet into the foundation, and the drain holes were 200 feet into the foundation.

Concrete-Face Rockfill Dam

CFRF dam layouts, including appurtenances, are shown in Appendix D. A cross section of the CFRF dam option is shown in Figure 3-1 and is also presented with additional detail in Appendix D. Design characteristics of a CFRF dam is described previously under the discussion for RM 274. Similar assumptions apply for the RM 279 dam design.

Preliminary Dam Sizes Evaluated

For the RM 279 dam site, preliminary designs and cost estimates were developed for RCC and CFRF type dams with crests at elevations of 900, 1,100, and 1,300. Corresponding dams heights range from 440 to 840 feet. Additional cost estimates were developed by interpolation for crests at elevations of 960 and 1,200. The full array of dam options evaluated for constructibility and cost is shown in Table 3-4. Although a smaller dam could readily be considered, topography limits the potential height of a dam before extensive saddle dams would be required.

TABLE 3-4. DAM OPTIONS EVALUATED AT RM 279

Dam Crest Elevation (feet above mean sea level)	Dam Height (feet)	Dam Types		
		RCC	CFRF	Arch
900	440	X	X	
960	500	X	X	
1,100	640	X	X	
1,200	740	X	X	
1,300	840	X	X	

Key:
CFRF – concrete-face rockfill
msl – mean sea level
RCC – roller-compacted concrete

Reservoir Area and Storage

Table 3-5 lists storage capacities associated with a range of dam sizes for which designs and cost estimates were produced. As shown, a reservoir of up to more than 2.7 million acre-feet could be developed with a dam at the RM 279 site. Curves showing potential new storage capacity and surface area for a reservoir at RM 279 are presented in Figure 3-4.

TABLE 3-5. RM 279 POTENTIAL RESERVOIR CAPACITIES

Dam Crest Elevation (feet above mean sea level)	Dam Height (feet)	Area (acres)	Gross Storage (TAF)	Net Storage (TAF)
900	440	2,670	460	444
960	500	3,470	655	637
1,100	640	5,541	1,263	1,243
1,200	740	7,426	1,937	1,913
1,300	840	9,365	2,775	2,736

Key:
TAF – thousand acre-feet

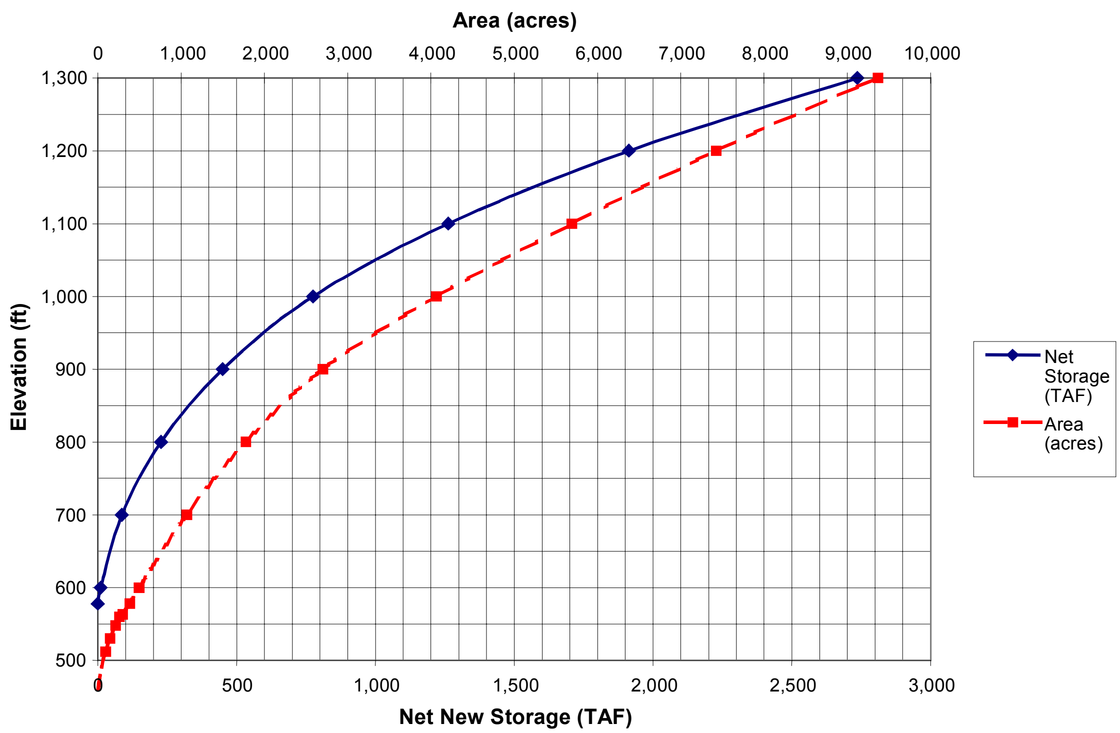


FIGURE 3-4. RM 279 DAM SITE: RESERVOIR SURFACE ELEVATION VERSUS STORAGE AND AREA

Appurtenant Features

Prefeasibility-level designs for appurtenant structures were based on the assumption that Millerton Lake would be continuously operated within the approximate range of elevations 550 to 575. Storage at the RM 279 site could be gravity-fed into Millerton Lake, and downstream releases could use the existing conveyance system at Friant Dam.

Diversion Works

Diversion during construction for all dam options was based on passing a peak discharge of 65,000 cfs, which approximately corresponds to a 25-year return period. Diversion for the dam options would be accomplished by constructing diversion tunnels through each abutment. A tunnel 30 feet in diameter would be constructed through the left abutment, and a 40-foot, diameter tunnel would be constructed through the right abutment.

The capacity of the left abutment tunnel would be about 25,000 cfs during construction, and would later serve as the outlet works for the dam. The capacity of the right abutment tunnel would be about 40,000 cfs. This tunnel would be plugged following construction, or would be converted to a spillway, as discussed below.

Upstream and downstream cofferdams would be required for diverting stream flows during construction and to prevent inundation of the site by Millerton Lake. The cofferdams would be sized for estimated diversion flows, and to allow normal operation of Millerton Lake during construction. The downstream cofferdam would need a minimum crest at elevation 578, and height of about 125 feet. The upstream cofferdam would require a crest at elevation 635 and a height of approximately 185 feet. A significant portion of both cofferdams would need to be constructed within the existing reservoir pool.

Spillway

The spillway for all options was based on passing a peak discharge of 145,000 cfs. This would be accomplished using an uncontrolled ogee crest spillway with a crest length of 450 feet, and a head of 20 feet.

For the CFRF dam options, the spillway would be located on the right abutment. The downstream channel would be excavated through the existing rock abutment, and would daylight into a natural draw that leads back into the reservoir. To control flows within the vicinity of the dam, a reinforced concrete apron and training wall would be constructed within the first 100 feet upstream from the structure crest and 200 feet downstream from the structure crest.

Energy would be dissipated by the tailwater at the end of the natural channel, which could be over 100 feet deep, depending on the level of Millerton Lake. For future designs, a labyrinth spillway should be considered for raising the crest elevation, providing more storage, and reducing the overall width of the spillway, including the outlet channel.

For the concrete dam options, the spillway overflow section would be located near the center of the dam. Guide walls would be provided to contain flows within the width of the spillway crest. Energy dissipation would be accomplished as the flow passes over the stepped downstream face of the dam. A concrete cutoff at the toe of the dam would be provided to ensure undercutting does not occur. The depth of tailwater would be expected to be over 100 feet for this option.

Recent safety-of-dam studies for Friant Dam (Reclamation, 2002d; 2002e) indicate that the existing facilities can safely pass about 30 percent of the PMF before overtopping occurs. A risk assessment of the overtopping condition suggests that the existing concrete gravity dam at Friant can withstand the depth and duration of overtopping without failure. A similar conclusion would likely hold true for an RCC dam at the RM 279 site. However, a rockfill dam would very likely fail at this same threshold condition. Consequently, for purposes of this study, the spillway capacity was increased to 145,000 cfs at RM 279 (up from about 85,000 cfs for the existing Friant Dam spillway), to increase the threshold at which overtopping would occur. Operation studies have not been completed for the potential new dams, so flood routings have not been performed. Future studies would need to include determining an appropriate inflow design flood for this site.

Outlet Works

The left abutment diversion tunnel would be converted to the outlet works. The outlet works layout for both dam types would consist of a trash-racked intake structure, a water conveyance system, and a series of regulating gates with upstream guard gates. Energy from release flows would be dissipated in the tailwater from Millerton Lake (plunge pool). The size of the conveyance system would be dictated by diversion during construction, but normal reservoir operation requirements would control the size and number of gates. The designed capacity of the outlet works was set to closely match the capacity of the existing river and canal outlets at Friant Dam. Bulkheads would be required for the intake structure, and outlet gates within the upstream end of the tunnel would also be provided for dewatering. The control structure for the outlet works would be combined with the powerhouse.

A low-level outlet works with the capability of evacuating the reservoir below elevation 570 was not included in the prefeasibility-level designs. Reservoir levels below elevation 570 would be within the current operating pool of Millerton Lake, and could only be evacuated if Millerton Lake was drawn down below elevation 450. The need for a low-level outlet works should be considered in future studies. If considered, a tunnel through the abutment could be used for the CFRF dam options, which would require placing the downstream cofferdam farther downstream to provide room for constructing the outlet end of the tunnel. A low-level outlet for the RCC dam options could be constructed through the dam.

Powerhouse

For purposes of preliminary powerhouse design and cost estimation, it was assumed that three turbines of equal size would be put in place to operate within the head range and discharge capacity that is available during most of the year. For a dam with a crest at elevation 900, it was assumed that approximately 40 MW of capacity would be installed. For a dam crest at elevation 1,100, a generation capacity of 60 MW was assumed. 80 MW was assumed for an elevation 1,300 crest. Each turbine would operate independently within specific ranges of reservoir elevations. Hydropower generation analysis presented in Chapter 4 suggests that the generation capacity assumed for preliminary cost estimates might be low.

The powerhouse and outlet works control structure would be located at the downstream portal of the left abutment diversion tunnel. During normal releases, all flows would pass through the turbines. During periods of significant inflow, the outlet works might be needed to supplement releases in combination with the spillway, as necessary. Once potential reservoir operations are defined, a more refined power operations study should be performed to take advantage of the expected releases and reservoir elevations.

Closure Dike

For a dam with a crest at elevation 1,300, a closure dike would be required on the left abutment, downstream of the dam centerline. A narrow saddle in a ridge at this location has a low point at elevation 1,180, leading to the need for a 120-foot-tall dike. Due to the ground surface sloping away from the centerline of the ridge, a dike with a small footprint would be required to minimize the structure's volume. Therefore, RCC construction was selected for the dike and applied to both CFRF and RCC main dam options.

Constructibility

This section discusses issues of concern related to constructing a potential dam, reservoir, and appurtenant features at RM 279.

Land, Rights-of-Way, and Easements

Private and public lands would have to be acquired to construct the facilities. The dam and appurtenant structures would be located on public land; however, several parcels of land immediately upstream from the construction area are privately owned. Temperance Flat, which would be required for construction staging and potential borrow areas, contains private land and two residences. The potential reservoir areas include public and private land, Kerckhoff Powerhouse, and Kerckhoff No. 2 Powerhouse, all of which would have to be acquired. Kerckhoff Dam, Wishon Powerhouse, and Big Creek No. 4 Powerhouse also would need to be acquired or relocated for a reservoir at elevation 1,100 or greater.

Based on visual inspection of utility markers, there are no pipeline, communication, or power easements through this site. Overhead power lines, originating at the Kerckhoff and Kerckhoff No. 2 powerhouses, run just east of and parallel to Wellbarn Road, and just north of Marshall Station. Signs marking buried phone lines were observed near roads in Temperance Flat.

Access

Access to the dam site is across both public and private land. Currently, access to the left abutment is by gated Wellbarn Road (Marshal Station) and hiking trail. Access to the right abutment is via Road 210, private road, and jeep trail. Both abutments can be accessed by boat from Millerton Lake.

Borrow Sources and Materials

Rockfill can be quarried from the reservoir area and obtained from excavation required for the dam and appurtenant structures. Earthfill is available in limited quantities. Low-plasticity, fine-grained soil has been identified in the reservoir area at Temperance Flat. Additional quantities of fine-grained soils might be available in the Auberry Valley area, and in an area south of Millerton Road near the Millerton Lake Recreation Area entrance. Road cuts in Temperance Flat and the Auberry Valley expose decomposed to intensely weathered granite.

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

Foundations

Foundations for any of the dam options would be in sound granitic rock. No foundation conditions of special concern are known at this time; foundation preparation would be expected to be typical for each option. Excavation for the concrete gravity dams was assumed to extend 10 feet deep to remove overburden and weathered bedrock.

Staging and Lay-Down Areas

Areas for construction use, staging, and/or lay-down would likely be located at Temperance Flat about 1.5 miles upstream from the dam site, or along the right side of the river about 0.5 to 1.0 miles upstream.

Construction Costs

Field costs were estimated using 2003 price levels and include direct costs to construct the dam and appurtenant features. Field costs represent the estimated cost to construct listed features, plus allowances for mobilization (5 percent), unlisted items (15 percent), and contingencies (25 percent). Field costs and estimated reservoir capacity are summarized in Table 3-6. Details of the estimates are included in Appendix C.

Costs of road and bridge construction, relocation or acquisition of existing facilities, reservoir clearing, lands acquisition, easements, rights-of-way, environmental mitigation, investigations, designs, construction management, administration, and interest during construction are not included in the estimated field costs. Cost estimates were developed for RCC and CFRF type dams with crest elevations of 900, 1,100, and 1,300, based on quantities calculated from preliminary designs. Costs for other sizes were interpolated.

TABLE 3-6. ESTIMATED CONSTRUCTION COST FOR RM 279 OPTIONS

Dam Crest Elevation (feet above mean sea level)	Dam Height (feet)	Gross Storage (TAF)	Dam Type	Field Cost ($ Million)
900	440	460	RCC	410
			CFRF	430
960	500	655	RCC	520
			CFRF	530
1,100	640	1,263	RCC	750
			CFRF	730
1,200	740	1,937	RCC	1,100
			CFRF	1,000
1,300	840	2,775	RCC	1,400
			CFRF	1,200

Key:
CFRF – concrete-face rockfill
RCC – roller-compacted concrete
TAF – thousand acre-feet

RM 286

The RM 286 Site is upstream of Millerton Lake, in the portion of the San Joaquin River that is bypassed by diversions at Kerckhoff Dam to the Kerckhoff powerhouses. Site characteristics and design considerations differ from those for RM 274 and RM 279.

Site Characteristics

The RM 286 site rises uniformly and steeply from elevation 740 in the original San Joaquin River channel at RM 286.1 to elevation 1,450 on the left abutment, and then rises at a flatter slope from elevation 1,450 to 1,650, before continuing to elevation 2,100. The right abutment rises uninterrupted and uniformly from the river channel to over elevation 1,850 at an unnamed mountain.

Both abutments and the channel section are mostly granite and granodiorite, with alluvium in the channel section. The granite is typically hard to very hard where exposed on steep slopes and along the San Joaquin River. On roughly half the dam site, the upper 1 to 10 feet of the granite are intensely weathered to decomposed and soft to very soft. Hard, slightly fractured, erosion-resistant granite is exposed on the abutments.

Alluvium of unknown thickness occurs in the San Joaquin River channel. The alluvium probably ranges from fine- to coarse-grained, with rock blocks up to 50 feet in maximum dimension that detached from the abutment slopes. No unstable wedges, toppling, or slides were observed at the RM 286 site. The granitic bedrock has adequate strength and stability for embankment, rockfill, concrete gravity, or concrete arch structures and any river diversion feature. The granite also is an adequate foundation for a plunge pool or overflow spillway. There are no known faults at the RM 286 site or in the vicinity (Reclamation, 2002b).

Potential Dam Types and Sizes

This site is appropriate for concrete arch and RCC or CFRF gravity dam types. A central-core earthfill dam is not considered economically viable due to the limited availability of plastic, fine-grained materials for the core. An asphaltic-core-earthfill dam might be viable for the site but was not considered due to limited use and experience with this type of dam in the United States.

Concrete Arch Dam

The concrete arch dam layouts, including appurtenances, are shown in Appendix D and a representative cross section is shown in Figure 3-5. The design is based on standard practice as described in Design of Arch Dams (Reclamation, 1977). The cross section illustrates the crown cantilever section of a double curvature arch dam. The dam would be constructed with conventional mass concrete with provisions for initial and final cooling and contraction joint grouting. Individual concrete blocks would be placed in approximate 10-foot lifts within forms. The formed surfaces of the upstream and downstream faces of the dam would provide a more durable surface. Leveling concrete requirements were estimated for the dam foundation (an average thickness of 1 foot was assumed) and a conventional structural concrete cap would be provided for on the dam crest. Dam crest details could include curbs and parapets on both faces of the dam.

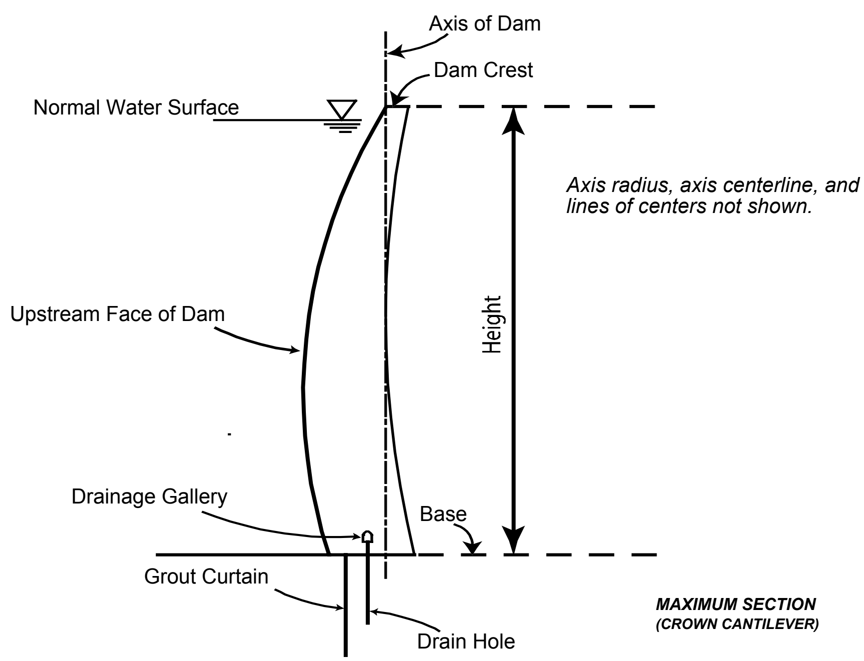


FIGURE 3-5. ARCH DAM PROFILE

Foundation grouting would consist of a single curtain with an assumed spacing of 10 feet. A drainage gallery would be placed in the arch about 20 feet above the foundation. Drainage holes on 10-foot centers would be drilled from the gallery into the foundation. For the elevation 1,200 dam, grout holes were assumed to extend 150 feet into the foundation, and the drain holes would extend 100 feet into the foundation. For the elevation 1,400 dam, grout holes would extend 250 feet into the foundation, and drain holes would extend 200 feet.

A preliminary static stability analysis of the dam using the computer model ADSAS indicated that the initial geometry would satisfy Reclamation criteria for normal loads. With further analysis, it is likely that the geometry could be modified to reduce the volume of the dam while still meeting appropriate factors of safety.

Concrete Gravity Dam

RCC dam layouts, including appurtenances, are shown in Appendix D and a representative cross section for RCC gravity dam options is shown in Figure 3-3. The design is based on standard practice as described in Design of Gravity Dams (Reclamation, 1976).

The cross section shows a vertical upstream face with a 0.75H:1V downstream face. The downstream slope of 0.75H:1V was used for developing the prefeasibility-level designs, but preliminary stability analyses show that a steeper slope might be possible, especially for the elevation 1,200 dam.

The mass of the dam would be constructed with RCC. The upstream and downstream faces would be covered with conventional concrete-facing elements to provide a more durable surface on the exposed faces of the dam. Leveling concrete requirements were estimated for the dam foundation (an average thickness of 1 foot was assumed) and a conventional concrete cap would be provided on the dam crest. The dam crest width and details would be similar to the existing Friant Dam.

Foundation grouting would consist of a single curtain with an assumed spacing of 10 feet. A drainage gallery would be placed at locations within the dam to minimize interruptions during the placement of RCC. Drainage holes on 10-foot centers would be drilled from the gallery into the foundation, with additional drain holes drilled from the dam crest into the gallery. For the elevation 1,200 foot dam, grout holes were assumed to extend 150 feet into the foundation, and drain holes 100 feet into the foundation. For the elevation 1,400 dam, grout holes would extend 250 feet into the foundation and drain holes would extend 200 feet.

Concrete-Face Rockfill Dam

CFRF dam layouts, including appurtenances, are shown in Appendix D and a cross section for CFRF options is shown in Figure 3-1. The design is based on standard practice as described in Concrete-Face Rockfill Dam: II. Design (Cook and Sherard, 1987). A description of design characteristics and assumptions for a CFRF dam is described in the discussion of the RM 274 dam site.

Preliminary Dam Sizes Evaluated

For the RM 286 dam site, preliminary designs and cost estimates were developed for RCC, CFRF, and concrete arch type dams with crests at elevations 1,200 and 1,400. Corresponding dams heights would be 460 and 660 feet. Additional cost estimates were developed by interpolation for a crest at elevation 1,300. Dam options evaluated for the RM 286 site are shown in Table 3-7.

TABLE 3-7. DAM OPTIONS EVALUATED AT RM 286

Dam Crest Elevation (feet above mean sea level)	Dam Height (feet)	Dam Types		
		RCC	CFRF	Arch
1,200	460	X	X	X
1,300	560	X	X	X
1,400	660	X	X	X

Key:
CFRF – concrete-face rockfill
msl – mean sea level
RCC – roller-compacted concrete

The upper limit on reservoir size is constrained by the presence of upstream hydropower facilities. A reservoir option at or above an elevation of approximately 1,000 would inundate Wishon and Big Creek No. 4 powerhouses and would affect the Kerckhoff powerhouses. A reservoir surface above elevation 1,400 (approximately 1,400 TAF storage capacity) would inundate Big Creek No. 3 Powerhouse. Incremental yield from a reservoir larger than 1,400 TAF would not likely justify the additional impact to hydroelectric generation facilities and increased construction cost. Hydropower impacts are discussed more fully in Chapter 4. Yield estimates are discussed in the Hydrologic Modeling Technical Appendix to the Phase 1 Report.

Reservoir Area and Storage

As shown in Table 3-8, dam sizes for which designs and cost estimates were produced would result in reservoir net storage capacities of approximately 450 TAF to nearly 1,400 TAF. Reservoir surface area would range from 3,000 acres to more than 6,000 acres. Figure 3-6 shows curves for potential new storage capacity and surface area for a reservoir at RM 286.

TABLE 3-8. RM 286 RESERVOIR CAPACITIES

Dam Crest Elevation (feet above mean sea level)	Dam Height (feet)	Area (acres)	Gross Storage (TAF)	Net Storage (TAF)
1,200	460	3,155	465	457
1,300	560	4.692	856	833
1,400	660	6,262	1,403	1,364

Key:
TAF – thousand acre-feet

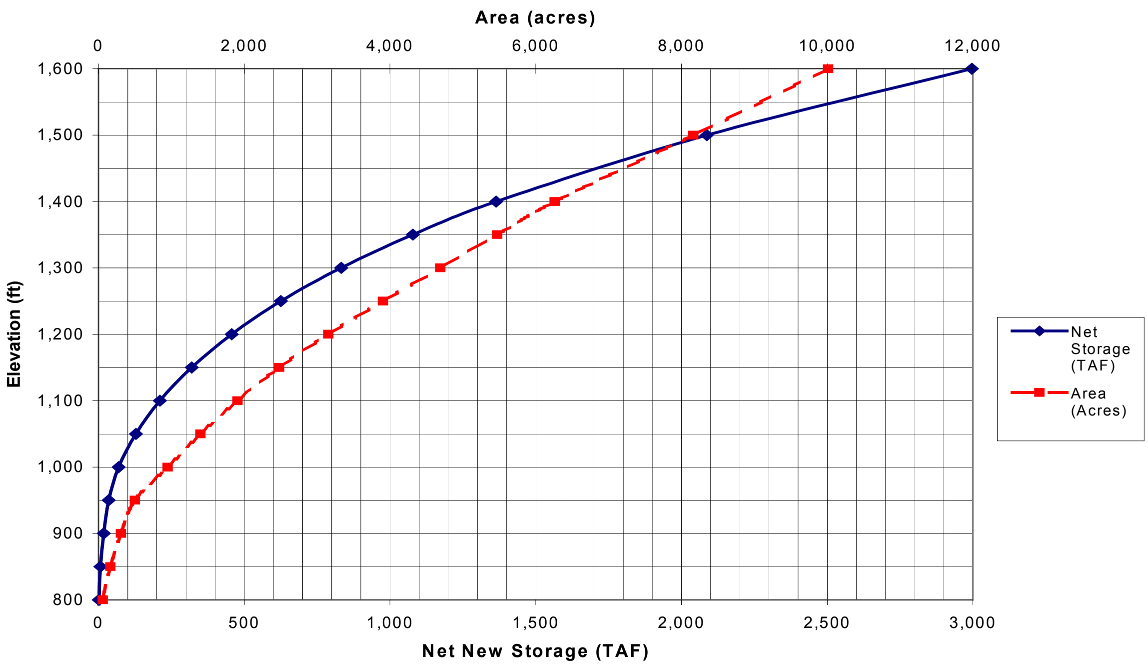


FIGURE 3-6. RM 286 DAM SITE: RESERVOIR SURFACE ELEVATION VERSUS STORAGE AND AREA

Appurtenant Features

Prefeasibility-level designs for appurtenant structures were based on the assumption that releases from RM 286 would be controlled to keep Millerton Lake at a relatively constant level. The outlets were generally sized to match current outlets at Friant Dam. Storage at the RM 286 site could be gravity-fed into Millerton Lake, and downstream releases could use the existing outlet works at Friant Dam.

Diversion Works

Diversion during construction for all dam options was based on passing a peak discharge of 65,000 cfs, which corresponds to an approximate 25-year return period. Diversion for the dam options would be accomplished by constructing diversion tunnels through each abutment. A tunnel 30 feet in diameter would be constructed through the right abutment, and a 40-foot diameter tunnel would be constructed through the left abutment. The capacity of the right abutment tunnel would be about 25,000 cfs during construction and would later serve as the outlet works for the dam. The capacity of the left abutment tunnel would be about 40,000 cfs. This tunnel would be plugged following construction, or would be converted to a spillway, as discussed below.

Upstream and downstream cofferdams would be required for diverting stream flows during construction. Cofferdams would be sized for estimated diversion flows. The downstream cofferdam would have a crest at about elevation 770, and height of about 30 feet. The upstream cofferdam crest would need to be placed at elevation 850 to provide sufficient head to pass the diversion flood, resulting in a cofferdam approximately 110 feet high.

Spillway

Spillway design for all options was based on passing a peak discharge of 145,000 cfs. This would be accomplished using an uncontrolled ogee crest spillway with a crest length of 450 feet and a head of 20 feet. For the rockfill dam options, the spillway would be located on the right abutment for the elevation 1,200 alternative, and on the left abutment for the elevation 1,400 alternative. The downstream channel would be excavated through the existing rock abutment, and daylight into a natural draw that leads back into the reservoir. A reinforced concrete apron and training wall would be constructed within the first 100 feet upstream from the structure crest and 200 feet downstream from the structure crest to control flows within the vicinity of the dam. Energy would be dissipated by the tailwater that develops in the San Joaquin River at the end of the natural channel. For future designs, a labyrinth spillway should be considered for raising the crest elevation, providing more storage, and reducing the overall width of the spillway, including the outlet channel.

For the concrete arch dam options, the spillway would be divided into two sections, each about half of the total required length. The spillways would be located near each abutment to allow the arch stresses from the center of the dam to dip into the abutments with little or no interference from the open spillways. A flip bucket at the end of each spillway crest would project discharges away from the toe of the dam and onto the massive granite abutments. During future field investigations, it would be necessary to determine if a concrete cap and/or rock anchors would be required to protect the impact areas.

For the concrete gravity (RCC) dam options, the spillway overflow section would be located near the center of the dam. Guide walls would be provided to contain the flows within the width of the spillway crest. Energy dissipation would be accomplished as the flow passes over the stepped downstream face of the dam. A concrete cutoff at the toe of the dam would be provided to prevent undercutting. Minimal tailwater would be developed by a control weir downstream from the powerhouse.

Recent safety-of-dam studies for Friant Dam (Reclamation 2002d; 2002e) indicate that existing facilities can safely pass about 30 percent of the PMF before overtopping occurs. A risk assessment of the overtopping condition suggests that the existing concrete gravity dam can withstand the depth and duration of overtopping without failure. A similar conclusion would likely be true for a potential RCC or arch dam at the RM 286 site. However, a rockfill dam would very likely fail at this same threshold condition. Consequently, for purposes of this TM, the spillway capacity was increased to 145,000 cfs at RM 286 (up from about 85,000 cfs for the existing Friant Dam spillway) to increase the flow threshold before overtopping would occur. Operation studies have not been completed for the potential new dams, so flood routings have not been performed. Future studies would need to determine an appropriate inflow design flood for this site.

Outlet Works

The left abutment diversion tunnel would be converted to the outlet works. The outlet works layout for both dam types would consist of a trash-racked intake structure, a water conveyance system, and a series of regulating gates with upstream guard gates. The energy from releases would be dissipated in the tailwater developed by the weir across the San Joaquin River just downstream from the powerhouse (plunge pool). The size of the conveyance system would be dictated by diversion during construction, but normal reservoir operation requirements would control the size and number of gates. The design capacity of the outlet works was set to closely match the capacity of the existing river and canal outlets at Friant Dam. Bulkheads would be required for the intake structure, and outlet gates within the upstream end of the tunnel would also be provided for dewatering.

A low-level outlet works with the capability of evacuating the reservoir below elevation 770 was not included in the prefeasibility-level designs. A dead pool of about 20 feet would remain in the event of a reservoir drawdown, which is not significant for any of the dam options considered at RM 286.

Powerhouse

For purposes of preliminary powerhouse design and cost estimation, it was assumed that three turbines of equal size would be put in place to operate within the head range and discharge capacity that is available during most of the year. For a dam crest at elevation 1,200, it was assumed that approximately 40 MW of capacity would be installed. For an elevation 1,300 dam crest, 60 MW of capacity were assumed. Each turbine would operate independently within specific ranges of reservoir elevations. Hydropower generation analysis presented in Chapter 4 suggests that the generation capacity assumed for preliminary cost estimates might be low.

During normal releases, all flows would pass through the turbines. During periods of significant inflow, the outlet works could be needed to supplement releases in combination with the spillway, as necessary. Once potential reservoir operations are defined, a more refined power operations study should be performed to take advantage of the expected releases and reservoir elevations.

Constructibility

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

Land, Rights-of-Way, and Easements

Private and public lands would have to be acquired for constructing the facilities. The dam and appurtenant structures would be located on public land; however, several parcels of land immediately upstream from the construction area are privately owned. The potential reservoir areas include both public and private land, which would have to be acquired. Kerckhoff

Dam, Wishon Powerhouse, and Big Creek No. 4 Powerhouse also would need to be acquired or relocated (i.e., reconstructed at a new location).

Access

There is no existing direct road access to the RM 286 dam site. Jeep trails provide access within approximately 1 mile of the dam site at elevations above the river channel, from which the site can be accessed by foot on steeply sloped terrain. Access is across both public and private land.

Borrow Sources and Materials

Rockfill could be quarried from the reservoir area and obtained from excavation required for the dam and appurtenant structures. Earthfill is available in limited quantities. Road cuts in the vicinity and Auberry Valley expose decomposed to intensely weathered granite. Processed sands and gravels could be supplied by commercial sources and/or by crushing and processing quarried rock in the reservoir area, as could aggregates.

Foundations

Foundations for any of the options would be in sound granitic rock. No special foundation considerations are known at this site at this time; foundation preparation would be typical for each option. Excavation for the concrete gravity dams was assumed to extend 10 feet deep to remove overburden and weathered bedrock.

Staging and Lay-Down Areas

A potential construction use/staging/lay-down area was located about 3/4 of a mile downstream of the dam site on the left side of the river. An abandoned trailer was found at this location and the area appears to have been previously used as a staging area.

Construction Costs

Field costs for constructing each evaluated option were estimated using 2003 price levels and include direct costs to construct the dam and appurtenant features. For each surface storage option, field costs represent the estimated cost to construct listed features, plus allowances for mobilization (5 percent), unlisted items (15 percent), and contingencies (25 percent). Field costs and estimated reservoir capacity are summarized in Table 3-9. Details of the estimates are included in Appendix C.

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

TABLE 3-9. ESTIMATED CONSTRUCTION COST FOR RM 286 OPTIONS

Dam Crest Elevation (feet above mean sea level)	Dam Height (feet)	Gross Storage (TAF)	Dam Type	Field Cost ($ Million)
1,200	460	465	RCC	340
			CFRF	430
			Arch	330
1,300	560	856	RCC	450
			CFRF	510
			Arch	500
1,400	660	1,403	RCC	560
			CFRF	590
			Arch	630

Key:
CFRF – concrete-face rockfill
RCC – roller-compacted concrete
TAF – thousand acre-feet

Cost estimates were developed for RCC, CFRF, and concrete arch type dams with crests at elevations 1,200 and 1,400, based on quantities calculated from preliminary designs. Cost estimates for dam options at elevation 1,300 were interpolated from the design-based estimates.

CONSTRUCTIBILITY CONSIDERATIONS COMMON TO ALL DAM SITES

Issues of constructibility that would apply to all dam site options are described in this section.

Power Sources

Grid power is available from the transmission facilities serving the PG&E Kerckhoff Project. Lower power service is available from existing trunks supplying local residences.

Contractor Availability and Resources

All dam options would be typical of heavy construction projects for the western United States. For the high dam options, several contractors might need to form a consortium to assemble adequate capacity.

Construction Schedule and Seasonal Constraints

A summary table of climate data is included for the Friant Dam area in Appendix E. The climate of central California is mild with no snow. The coldest month is January with an average daily high and low 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.

Flood Routing During Construction

A peak flow frequency analysis was performed to determine diversion requirements during construction (Reclamation, 2002d). The same stream gage used to develop the 100-year snowmelt flood was used for this peak flow frequency analysis. During larger flows, the upstream reservoirs were assumed to be passing inflows, which is similar to current operations. For diversion floods in the range of 10-year to 25-year return periods, it was assumed that the gage record adequately reflects future conditions. Peak flows were calculated for a location just below Kerckhoff Dam, and are considered appropriate for the Temperance Flat area. Results of this study are presented in Table 3-10.

TABLE 3-10. PEAK FLOOD FLOWS

Return Period (years)	Peak Flow (cfs)
5	27,500
10	41,600
25	65,100
50	87,300
100	113,900
Key: cfs – cubic feet per second	

The peak discharge of 65,000 cfs with a return period of approximately 25 years was used to size the diversion structures for each option at all potential dam sites.

Pumping Plants

Distribution of developed water would be by gravity to Millerton Lake. No pumping plant would be required for water supply purposes.

Environmental Impacts During Construction

This site is in a primarily rural area with little habitation. Due to the size of the potential dam and reservoir, it would be preferable to use on-site materials for construction to minimize haul on public roads, and thus reduce traffic concerns. Among the options, noise levels would be about the same. Most noise would be generated by the processing plant, which is typical for construction of this type. Work would include typical construction practices and procedures, which would not be expected to have environmental impacts beyond those of standard large construction projects. All construction equipment should have spark arresters, and fire control equipment should be kept readily accessible during construction. Construction water would have to be controlled and provisions made for runoff and erosion control. A spill control plan would be needed to control any construction-related fuels, lubricants, and other materials. A cultural survey would have to be conducted to identify any ancestral American Indian or historic artifacts, and construction activities would be restricted in those areas.

It is expected that environmental impacts during construction could be mitigated with proper planning and implementation of best management practices. Standard procedures would be used to minimize air quality (dust) and water quality concerns. Air quality issues could be mitigated by dust control measures for quarrying, material processing, and construction of the dam. Quarries and blasting for abutment excavation would require both noise monitoring and vibration monitoring on the dam. Importing cement and concrete aggregate from distant sources could cause traffic impacts on feeder roads, but with proper planning and agency coordination, major impacts could be mitigated.

Permits

Since the options include construction within the existing Millerton Lake, typical permits through the United States Army Corps of Engineers (Corps) would have to be obtained for working in waters of the United States. Standard water quality and air quality permits would also be required for this work (401, 402, 404). All options considered would require the same permits.

It is probable that both Federal and non-Federal sponsors would be involved in the implementation of any project, which would complicate the permitting process. Permits could be required from the permitting agencies listed in Table 3-11.

TABLE 3-11. POSSIBLE PERMITS REQUIRED

Permit	Permitting Agency
Permit to Construct	FERC, DSOD, Fresno/Madera County
Encroachment	Caltrans, Fresno/Madera County
Air Quality	CARB, Fresno/Madera County
Low/No Threat NPDES	RWQCB
Waste Discharge	RWQCB
401 Certification	SWRCB
Blasting	Fresno/Madera County
Stream Bed Alteration	CDFG
Fire/Burn	CDF, Fresno/Madera 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
FERC	Federal Energy Regulatory Commission
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 the review of permit conditions:

- Bureau of Indian Affairs
- BLM
- State Historic Preservation Office

- Advisory Council on Historic Preservation
- USFWS

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

- 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 its 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.

If power generation is included in a project or is modified for an existing project, FERC could become involved in the permitting process for decommissioning of existing facilities and permitting new facilities that would be operated by a non-Federal entity.

Operation and Maintenance Costs

Operations and maintenance costs have not yet been estimated for options considered in this TM. Future evaluations will apply representative operations and maintenance, depreciation, and replacement costs based on a review of other similar projects and agency guidance.

System Operations

Chapter 4 of the present TM discusses hydropower operations. Potential reservoir yields are discussed in the Phase 1 Hydrologic Modeling TM.

CHAPTER 4. HYDROELECTRIC POWER OPTIONS

Development of any of the reservoir options considered in this TM would affect the operations of existing hydropower project facilities and provide opportunities for generating new hydroelectric energy. This chapter describes the methodology used to estimate potential energy generation potential, summarizes possible impacts to existing energy production facilities, presents preliminary estimates of potential new generation, and discusses potential opportunities for development of pumped-storage hydropower projects at each Temperance Flat area dam site.

To estimate the potential range of energy production that could be affected or generated with each option, preliminary estimates were made for each dam site under consideration. Estimates of generation were made using a spreadsheet approach based on output from the CALSIM hydrologic water balance model. CALSIM simulates the operation of major water projects throughout California and is widely used to identify how potential projects and actions would affect system-wide water operations. During Phase 1 of the Investigation, CALSIM was revised to reflect the decision-making process used to allocate water supplies at Friant Dam, and then used to estimate the amount of water available for release to the San Joaquin River or diversion to the Friant-Kern and Madera canals. Details regarding CALSIM can be found in the Investigation Phase 1 Hydrologic Modeling TM.

Estimates of potential generation impacts are average annual values based on energy generation data published in FERC annual reports for each of the existing powerhouses that could be affected by a new reservoir at Temperance Flat. These historic generation data are presented in Chapter 2.

HYDROPOWER ANALYSIS METHODOLOGY

Figure 4-1 shows the relationship between a typical powerhouse configuration at the base of a dam and primary variables that affect energy generation, namely head and flow. Energy generation also depends on generating and pumping efficiencies, and equipment operational constraints. Energy generated by a hydroelectric project, therefore, is a function of the available net head, available water flows, efficiency of the turbine-generator equipment, and the period of time under consideration (often, monthly, or annually). Net head is the gross head available less hydraulic losses in water conduits.

Source of Flow Data

Preliminary estimates of potential energy generation at each of the candidate dam sites were produced using a spreadsheet approach based on output from CALSIM. During Phase 1, CALSIM was revised to reflect the decision-making process used to allocate water supplies at Friant Dam based on hydrologic conditions, and to estimate the availability of water for release to the San Joaquin River or diversion to the Friant-Kern and Madera canals. CALSIM was used to estimate the new water supply that could be developed for a range of storage sizes for Temperance Flat options and other storage options considered in the Phase 1 Investigation, as described in the Hydrology and Modeling Appendix to the Phase 1 Investigation Report. New water supply is defined as water that could be made available at Friant Dam, over and above the amount currently made available for delivery.

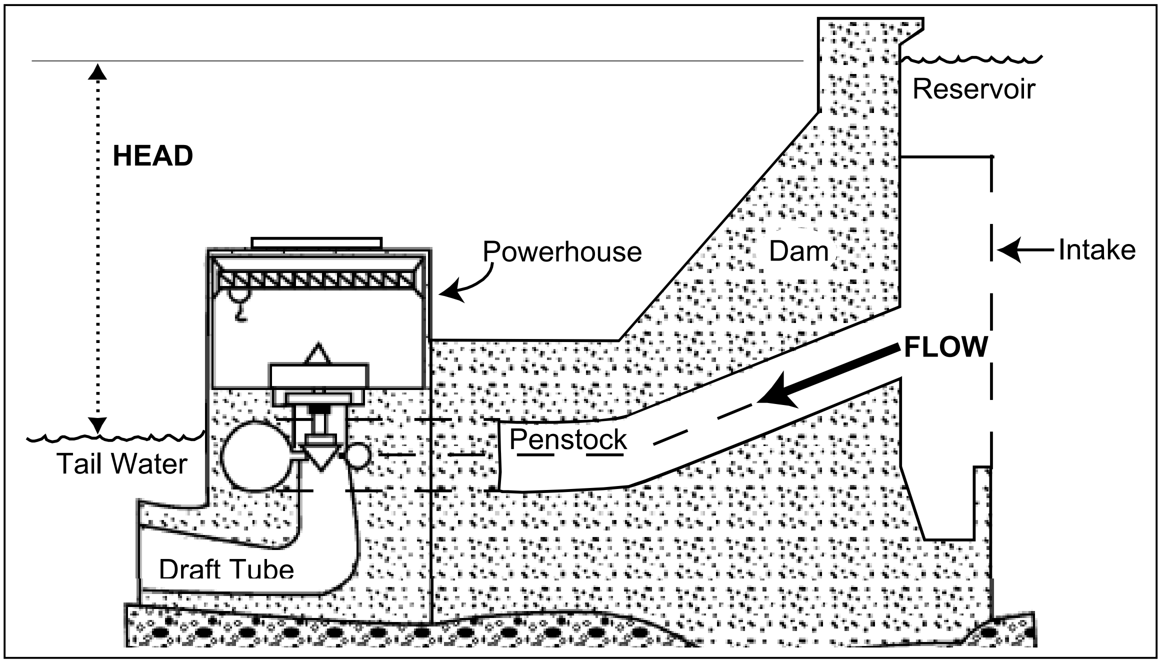


FIGURE 4-1. TYPICAL HYDROELECTRIC ENERGY GENERATION FACILITY

CALSIM simulations were made assuming that new water supply would be used for a single purpose (releases to the San Joaquin River for water quality or restoration purposes, or to increase water supply reliability in the Friant Division) to identity how new supply would vary in relationship to water uses. For the power generation analysis, water quality and restoration flow single-purpose analyses were used because the single-purpose analysis for water quality would hold new water yield in storage until it is released to the San Joaquin River late in the irrigation season. In contrast, the restoration flow single-purpose analysis would release water to the San Joaquin River early in the year. The water supply reliability single-purpose analysis would be expected to produce results that are intermediate to the water quality and restoration flow single-purpose analyses. No modifications were made to CALSIM output from single-purpose analyses to optimize the potential power generation.

CALSIM output included monthly inflows to Temperance Flat Reservoir; water volumes and evaporation at Temperance Flat Reservoir and at Millerton Lake; inflow to Millerton Lake from Fine Gold Creek; and canal and river releases from Friant Dam. Output from CALSIM accounted for flood storage and dead storage requirements. Water levels in Temperance Flat

Reservoir and Millerton Lake were calculated using tables of reservoir areas and volumes with respect to elevation.

The flow from Temperance Flat Reservoir to Millerton Lake available for power generation was calculated from CALSIM output, taking into account reservoir inflows, increases or decreases in the volume of water stored, evaporation losses, and outflow requirements.

Potentially Affected Power Facilities

Depending on the location and height of the dam, Temperance Flat Reservoir could affect the operations of up to five powerhouses and two diversion dams upstream of Millerton Lake. Elevations at which power facilities would be affected by each of the reservoir options are shown in Figure 4-2, along with corresponding storage capacities. Potential losses of energy generation at these facilities are based on reported recent historical values, as summarized in Chapter 2.

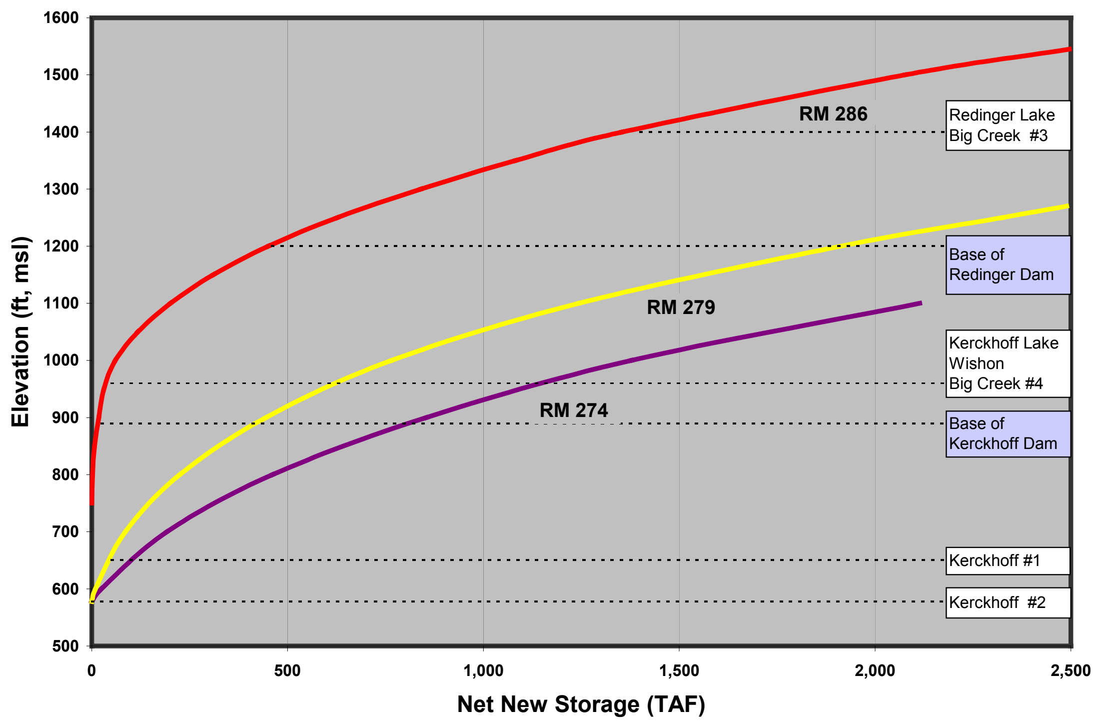


FIGURE 4-2. EXISTING HYDROPOWER FACILITIES POTENTIALLY AFFECTED BY TEMPERANCE FLAT RESERVOIR OPTIONS

Storage Sizes Considered in Hydropower Evaluation

The objective of the hydropower analysis is to determine if options under consideration could generate net additional energy. The results of this preliminary analysis will be used in combination with other information to screen options in the next phase of study. Therefore, for the analysis of hydropower generation potential, storage sizes were selected that would correspond to elevations at which total generation losses would change.

Figure 4-3 shows the total amount of installed generation capacity that would be affected for each Temperance Flat reservoir option. Impacts to installed capacity would increase as storage capacity increases in discrete steps. When reservoir storage for each site surpasses a threshold value, additional energy generation capacity would be impacted as additional powerhouses are affected. More detailed study of each potentially affected powerhouse would be needed to identify specific generation impacts as tailwater levels rise.

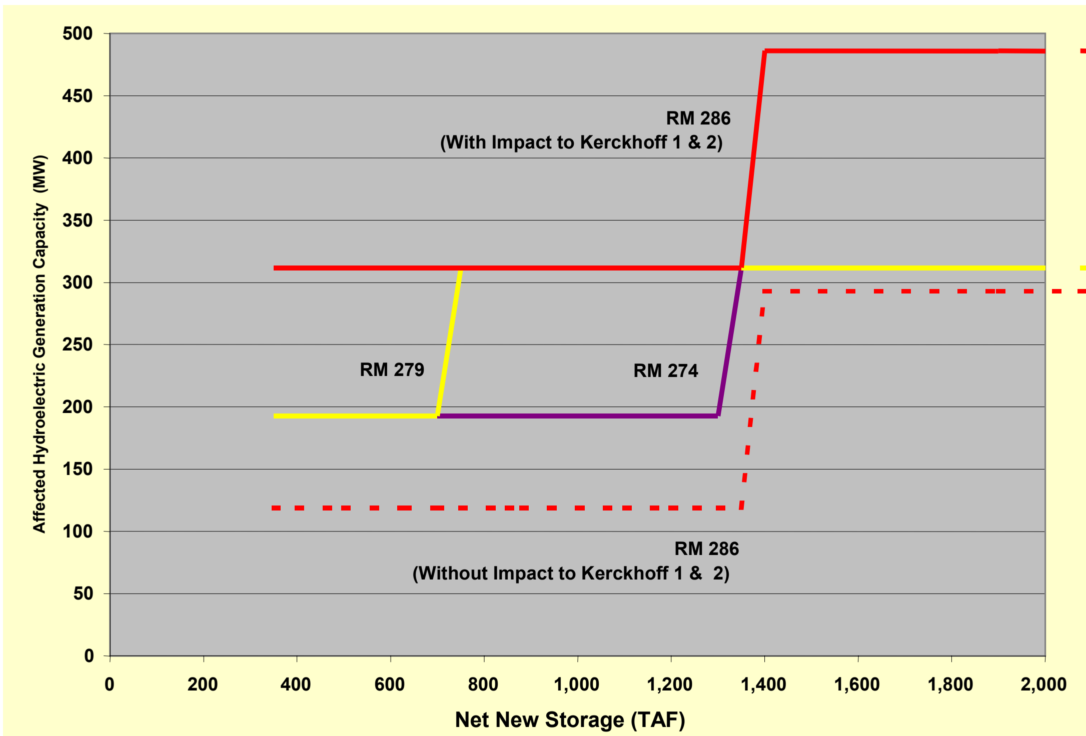


FIGURE 4-3. HYDROPOWER GENERATION CAPACITY POTENTIALLY AFFECTED BY TEMPERANCE FLAT OPTIONS

To simplify the analysis, reservoir storage volumes of 725 TAF and 1,350 TAF were analyzed for power production potential. These volumes were chosen to generally correspond with storage volumes associated with threshold impacts to existing power generation facilities. Assumptions were made regarding turbine and generator efficiencies, turbine restrictions on minimum and maximum heads and flows for generation, and head losses in water passages. From these data and assumptions, preliminary estimates of energy generated on an annual basis were made. Results reflect the assumptions made at this level of study, and therefore give only a preliminary indication of possible energy generation output.

Power Generation Assumptions

In the analysis of power generation, several assumptions must be made regarding operation and facility characteristics. Assumptions described in this section were incorporated in the spreadsheet model and applied in the energy generation analysis of all options.

An overall constant turbine–generator efficiency of 0.85 was used for this prefeasibility analysis. This value accounts for the efficiencies of the turbine, generator, and step-up transformers and also the effects of unscheduled downtime.

It is assumed that the installed generation capacity would likely range from 100 MW to 120 MW. It is assumed this capacity would be provided by three or four units and would be configured in a manner that would allow generation under a wide range of discharges.

Although no generation restrictions were placed on high heads, releases from Temperance Flat Reservoir at a heads less than 100 feet were assumed to produce no energy. Head losses in waterway passages were assumed to be relatively low. Net head for generation was estimated by applying a 2 percent reduction to gross head.

RM 274 OPTION

At the RM 274 site, the dam would be constructed in Millerton Lake and therefore would have a relatively high water level on the downstream face. This would reduce the net head available for power generation compared to sites farther upstream.

Powerhouse Assumptions

RCC, concrete gravity, and CFRF type dams are being considered for this site. For a concrete gravity dam at this site, a powerhouse could be located integrally with the dam or abutment. For a CFRF type dam, the powerhouse would be located at the base of an abutment and the river diversion tunnel would be used to supply water to the powerhouse. The powerhouse could also be located across a bend in the river in the vicinity of the dam and served by a short tunnel. The intake to this tunnel would be at a point between RM 274 and RM 275 and the flow from the powerhouse would discharge directly into Millerton Lake. This tunnel could also be used for river diversion purposes during dam construction.

For this study, it has been assumed that the powerhouse would be located at the dam or at the base of an abutment, with an intake structure and a very short conduit leading to the turbines. Discharge from the powerhouse would be directly into Millerton Lake.

Estimated Energy Generation and Losses

Estimated energy generation and potential lost energy generation associated with two storage sizes for the RM 274 option are shown in Table 4-1. As shown, estimated generation would range from 160 GWh/yr to 260 GWh/yr over the range of storage sizes and operational scenarios considered. This analysis shows that energy generated from new powerhouses would be significantly less than lost energy generation from existing powerhouses that would be inundated, based on recent historic annual generation reported for the Kerckhoff hydroelectric project. These estimates do not consider the additional generation that would result from releases through the Friant powerhouses at the canals or at the river outlet from Friant Dam.

The Kerckhoff and Kerckhoff No. 2 powerhouses would be inundated by the 725 TAF and 1,350 TAF sizes. The 1,350 TAF size was selected to correspond generally with the level of Kerckhoff Lake. Energy generation at the Wishon and Big Creek No. 4 powerhouses would not be affected.

TABLE 4-1. POTENTIAL ENERGY GENERATION AND LOSSES FOR RM 274 DAM SITE OPTIONS

Net Storage Capacity (TAF)	Pool Elevation (ft)	Potential New Energy Generation		Potential Losses of Energy Generation	
		Operating Scenario	Potential New Energy Generation (GWh/yr)[1]	Powerplants Potentially Affected	Potential Reduction in Existing Energy Generation (GWh/yr)[2]
725	870	WQ	160 – 210	Kerckhoff Kerckhoff No. 2	579
		RF	160 – 210		
1,350	990	WQ	220 – 270	Kerckhoff Kerckhoff No. 2	579
		RF	210 – 260		

Key:
GWh/yr – gigawatt hours per year
TAF – thousand acre-feet
RF – restoration flow single-purpose analysis
WQ – water quality single-purpose analysis
Notes:
1. Generation range results from variations in head and releases from Temperance Flat Reservoir to Millerton Lake.
2. Average annual reported generation from 1994 through 2002.

Although direct comparison of the estimated average annual generation for the scenarios evaluated with actual historic generation is not appropriate for detailed findings, it is not likely that additional refinements to operational scenarios for the RM 274 site would result in sufficient replacement power for the existing projects. The principal reasons for the significant difference between new power generation and losses to existing generation is that the existing Kerckhoff powerhouses operate at a fairly constant head, whereas the Temperance Flat powerhouse at RM 274 would operate at a variable, and often lower, head. Total estimated replacement power generation would likely increase when additional generation from the Friant powerhouses is considered under specific operational scenarios. If, for the 725 TAF option, a new powerhouse were built at Kerckhoff Dam to replace some of the lost Kerckhoff generation, generation would be higher.

Potential for Pumped Storage Development

A pumped storage arrangement could be constructed and operated with the RM 274 option. The proximity of the Temperance Flat Reservoir to Millerton Lake, and the great depth of water at the downstream dam face (up to 200 feet), provide physical conditions that could support pumped storage operations. The financial feasibility of a pumped storage project at RM 274 would require additional study under a variety of operational objectives. It is possible that operations that would favor power generation and pumped storage would conflict with operations that would maximize water supply benefits or support recreation on Millerton Lake.

RM 279 OPTION

For the RM 279 option, the potential dam would be constructed at the upstream end of Millerton Lake. Millerton Lake levels would affect tailwater elevation at the toe of the dam, but the head available for generation would be greater than for the RM 274 option.

Powerhouse Assumptions

As at the RM 274 site, concrete gravity and CFRF type dams would be suitable for the RM 279 site. With RCC or other concrete gravity dams, the powerhouse could be located integrally with the dam or in an abutment. For a CFRF type dam, the powerhouse would be located at the base of an abutment and the river diversion tunnel would be used to supply water to the powerhouse. For this study, it has been assumed that the powerhouse would be located at the dam or in an abutment, with an intake structure and a very short conduit leading to the turbines, and discharge from the powerhouse directly into Millerton Lake.

Estimated Energy Generation and Losses

Estimated energy generation and potential lost energy generation associated with two storage sizes for the RM 279 option are shown in Table 4-2 As shown, estimated generation would range from 330 GWh/yr to 450 GWh/yr over the range of storage sizes and operational scenarios considered. This analysis shows that energy generated from new powerhouses would be less than lost energy generation from existing powerhouses that would be inundated, based on recent historic annual generation reported for the Kerckhoff Project. These estimates do not consider the additional generation that would result from releases through the Friant powerhouses at the canals or at the river outlet from Friant Dam.

The 725 TAF size would inundate the Kerckhoff and Kerckhoff No. 2 powerhouses with a gross pool generally at the same elevation as Kerckhoff Lake. It is assumed that generation at the Wishon and Big Creek No. 4 powerhouses would not be affected by this option. The 1,350 TAF option would have a gross pool at elevation 1,100 and would inundate the Kerckhoff plants as well as the Wishon and Big Creek No. 4 powerhouses.

As evaluated, the RM 279 options would not provide sufficient power to replace existing projects that would be impacted. The principal reason for the difference between new power generation and losses to existing generation, is that the existing powerhouses operate at a fairly constant head. Total estimated replacement power generation would increase when additional generation from the Friant powerhouses is considered under specific operational scenarios.

For the 1,350 TAF reservoir option, some replacement power might also be possible through relocation of the Wishon and Big Creek No. 4 powerhouses. Preliminary review suggests that the Wishon powerhouse could be raised to a higher level with an installed capacity of approximately 17 MW. At Big Creek No. 4 Powerhouse, a replacement powerhouse with an installed capacity of approximately 60 MW could be constructed at Redinger Dam. The economic feasibility of potential replacement powerhouses has not been evaluated.

TABLE 4-2. POTENTIAL ENERGY GENERATION AND LOSSES FOR RM 279 DAM SITE OPTIONS

Net Storage Capacity (TAF)	Pool Elevation (feet above mean sea level)	Potential New Energy Generation		Potential Losses of Energy Generation	
		Operation Scenario	Potential New Energy Generation[1] (GWh/yr)	Powerplants Potentially Affected	Potential Reduction in Existing Energy Generation[2] (GWh/yr)
725	990	WQ	330 – 380	Kerckhoff Kerckhoff No. 2	579
		RF	330 – 380		
1,350	1,100	WQ	400 – 450	Kerckhoff Kerckhoff No. 2 Wishon Big Creek No. 4	1,125
		RF	400 – 450		

Key:
GWh/yr – gigawatt hours per year
TAF – thousand acre-feet
RF – restoration flow single-purpose analysis
WQ – water quality single-purpose analysis
Notes:
1. Generation range results from variations in head and releases from Temperance Flat Reservoir to Millerton Lake.
2. Average annual reported generation from 1994 through 2002.

Potential for Pumped Storage Development

A pumped storage arrangement could be constructed and operated with the RM 279 option. The proximity of the Temperance Flat Reservoir to Millerton Lake, and the great depth of water at the downstream dam face (up to 100 feet), provide physical conditions that could support pumped storage operations. The financial feasibility of a pumped storage project at RM 279 would require additional study under a variety of operational objectives. It is possible that operations that would favor power generation and pumped storage would conflict with operations that would maximize water supply benefits or support recreation on Millerton Lake.

RM 286 OPTION

The RM 286 option differs from the RM 274 and RM 279 options in two important ways. First, the dam site is not located in Millerton Lake; thus, the available head is at least as great as the depth of water behind the dam. Second, it is located between Kerckhoff Dam and the Kerckhoff powerhouses, creating the potential for existing facilities to be incorporated into the design and thereby reducing both impacts to existing generation and total cost.

Powerhouse Assumptions

The RM 286 site is located approximately 3 miles upstream from Millerton Lake. In addition to the head available for power generation at the dam, about 140 feet of additional head would be available if the powerhouse were located RM 283, which is the approximate location of the Kerckhoff No. 2 Powerhouse. Alternatively, if the powerhouse were located at the dam, power generation at RM 286 would be comparable to that at RM 279. For this study, it is assumed that the powerhouse would be located downstream of the dam at about RM 283. Water would be supplied through an intake at or near the dam by means of a tunnel, surge chamber, and penstocks. Discharge from the powerhouse would be directly into Millerton Lake. It might be possible to utilize many of the existing Kerckhoff Project facilities.

The effect of the distance from the dam to the powerhouse for the RM 286 option, compared to the relatively short distance for the RM 274 and RM 279 options where powerhouses are located at the dams, is a dramatic increase in available head. The longer conveyance tunnel and need for a surge chamber and penstocks would also result in a greater percentage head loss. Accordingly, gross head was reduced by 10 percent for this option to estimate net head available for power generation.

Estimated Energy Generation and Losses

Estimated energy generation and potential lost energy generation associated with two storage sizes for the RM 286 option are shown in Table 4-3. As shown, estimated generation would range from 630 GWh/yr to 740 GWh/yr over the range of storage sizes and operational scenarios considered. Energy generated from new powerhouses would be less than lost energy generation from existing powerplants that would be affected. This result assumes that all existing generation at the Kerckhoff powerhouses would be lost.

The 725 TAF option would inundate Kerckhoff Lake and Dam, the Wishon powerhouse, and the Big Creek No. 4 powerhouse. The Kerckhoff powerhouses would not be inundated, since they are downstream of RM 286. The 1,350 TAF option would result in a reservoir pool at or below the level of Redinger Lake. It would inundate the same power generation facilities as the 725 TAF option and would not impact the Big Creek No. 3 Powerhouse.

For both reservoir options, one or both of the Kerckhoff powerhouses might continue to be utilized, although the results reported in Table 4-3 do not assume this to be the case. The Kerckhoff Powerhouse could possibly remain in place for smaller flows, although modifications such as rebuilding and repowering the powerhouse would likely be needed to account for the higher operating head. The Kerckhoff No. 2 Powerhouse could possibly be operated in its current configuration, although replacement of generation equipment might be required due to higher operating head. For both options, the existing diversion structure would need to be modified to assure a satisfactory means to control inflow to the tunnels. One approach might involve a gate in a gate chamber, accessed from the new, higher elevation by a vertical shaft. The ability of the conveyance systems and surge chambers to withstand greater pressures, or to be modified to withstand them, would need to be assessed before final recommendations can be made on using existing facilities.

TABLE 4-3. POTENTIAL ENERGY GENERATION AND LOSSES FOR RM 286 DAM SITE OPTIONS

Net Storage Capacity (TAF)	Pool Elevation (feet above mean sea level)	Potential New Energy Generation		Potential Losses of Energy Generation	
		Operating Scenario	Potential New Energy Generation[1] (GWh/yr)	Powerplants Potentially Affected	Potential Reduction in Existing Energy Generation[2] (GWh/yr)
725	1,270	WQ	630 – 680	Kerckhoff Kerckhoff No. 2 Wishon Big Creek No. 4	1,125[3]
		RF	630 – 680		
1,350	1,400	WQ	690 – 740	Kerckhoff Kerckhoff No. 2 Wishon Big Creek No. 4	1,125[3]
		RF	690 – 740		

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

Notes:
1. Generation range results from variations in head and releases from Temperance Flat Reservoir to Millerton Lake.
2. Average annual reported generation from 1994 through 2002.
3. Generation loss assumes lost generation at all four powerhouses listed. Replacement power generation is estimated using a different method than lost power. Reported losses at Kerckhoff and Kerckhoff No. 2 from historical records might be higher than corresponding estimated generation at similarly located powerhouses in this analysis due to the general nature of the energy generation simulation.

As discussed previously, estimated generation is not directly comparable to actual generation at impacted powerhouses due to differences in methodologies. Therefore, estimated generation associated with the RM 286 option should not be compared directly to losses at the Kerckhoff powerhouses. Additional detailed power simulations would be needed to estimate comparable generation and losses. Also, the estimates described above do not consider the additional generation that would result from releases through the Friant powerhouses at the canals or at the river outlet from Friant Dam.

For the 725 TAF option, a new powerhouse to replace Wishon could be built at a higher elevation with an installed capacity of approximately 14 MW; Big Creek No. 4 Powerhouse could be replaced by a powerhouse with an installed capacity of approximately 12 MW at Redinger Dam. However, construction and operation of such small replacement powerhouses would likely not be economically favorable. For the 1,350 TAF option, a replacement for Wishon Powerhouse could probably be built at a higher level with an installed capacity of approximately 12 MW, although it would not likely be economically justifiable. Maintaining operation of Big Creek No. 4 Powerhouse does not appear possible for the 1,350 TAF option.

The control center for the SCE Big Creek Hydroelectric Project is located at Big Creek No. 3 Powerhouse. This control center would not be impacted by the two options considered in the hydropower analysis, but would be affected by options larger than 1,400 TAF.

Potential for Pumped Storage Development

The long distance from Lake Millerton to the RM 286 site would likely preclude using the RM 286 site for pumped storage purposes. For RM 286, the ratio of water conveyance length to available head is considerably greater than 10, which is generally considered an upper limit for economically feasible operations of a pumped storage project.

TRANSMISSION

Due to the proximity of the Temperance Flat dam sites to existing facilities, it is expected that new power generation facilities could connect to existing transmission systems. Existing transmission line capacity from Wishon is 70 kV, from Kerckhoff No. 1 and No. 2 is 115 kV, and from Big Creek No. 3 and No. 4 is 220 kV. Additional study is needed to determine if existing lines have adequate capacity to serve new power facilities, and to ascertain requirements for electrical control and protection.

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CHAPTER 5. ENVIRONMENTAL CONSIDERATIONS

This chapter qualitatively describes the extent to which expected or possible environmental effects of the surface storage options under consideration might constrain their development. Where evident, opportunities for improving existing environmental resources or mitigating adverse effects to resources have been noted. Analysis focuses on the environmental resources described in Chapter 2: botanic resources, terrestrial wildlife, aquatic biology and water quality, recreational resources, cultural resources, and existing land uses. Conditions related to past mineral extraction activities that might affect water quality are also discussed.

Potential effects of the maximum contemplated level of reservoir inundation are addressed for each of the three candidate dam sites. Temporary construction-related disruptions are discussed in Chapter 3. This assessment does not examine downstream effects of using or releasing newly developed water. Flood protection, growth inducement, implications for regional or statewide energy systems, and other off-site issues will be addressed at a later stage of the Investigation.

Potential constraints to reservoir development were identified at a prefeasibility level of planning for each type of environmental resource, using criteria that 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). The application of criteria that may be used for NEPA or CEQA evaluation is not intended to imply that the analysis has been conducted at a level that would be necessary to support an Environmental Impact Statement (EIS) or Environmental Impact Report (EIR).

This chapter is organized by the environmental resource categories listed above. For each type of resource, criteria used to identify potential constraints to reservoir development are presented, followed by a discussion of the potential constraints and opportunities related to those resources for each of the three dam sites under consideration.

BOTANY

Potentially, constraints to reservoir development could arise from the anticipated loss of habitat or particular botanical species of concern. The extent to which such losses might pose a constraint is influenced by their ability to be mitigated. Species of concern include special status plant species listed as threatened or endangered by State or Federal agencies. Habitats of special concern include habitats that are experiencing significant losses on a local or regional basis (e.g., riparian, wetlands).

Constraints and Opportunities

The loss of riparian habitat and special status plant species is the primary botanical constraint for all options under consideration. Of the species discussed here, Mariposa pussypaws could pose the most difficult challenges to adequate mitigation, if this plant species were found within the affected area (e.g., above Kerckhoff Lake). It is a very rare species, although suitable habitat is widespread (Clines, 2003). The reasons for its rarity are unknown, but the species could have very restricted ecological requirements that are not now apparent. Mariposa pussypaws often grows with orange lupine, a more common species that tolerates a broader range of conditions.

Blue elderberry (*Sambucus mexicanus*) is the sole habitat for the valley elderberry longhorn beetle, a Federally listed threatened insect discussed further below. John Stebbins (2003) has indicated that elderberries are much more common in the San Joaquin River gorge than might be expected and impacts to the beetle could be substantial.

Aside from riparian habitat and special status plant species, all of the pool elevations would affect to various degrees at least one of two areas managed by Federal resource agencies: the San Joaquin River Gorge Management Area and the Backbone Creek RNA. The latter harbors a large population of tree anemone. A portion of the population occurs near the confluence of Backbone Creek and the San Joaquin River at Horseshoe Bend (Safford, 2003). This location, at about elevation 1,100, would be affected by several of the storage options studied here, and therefore could be a constraint for developing a reservoir at this site.

Opportunities are few for offsetting impacts to botanical resources. It is unlikely that there would be sufficient suitable land within the watershed to create enough riparian habitat to mitigate potential impacts. Impacts to rare plant species might be offset by finding other suitable habitat within the region for transplanting species.

RM 274

The San Joaquin River from RM 274 to Kerckhoff Lake lies in a steep, deeply incised canyon. Riparian vegetation is not common in this portion of the river, nor along any of the small tributaries that enter below Kerckhoff Dam. Portions of this gorge are composed of metamorphic rock types other than granite. Due to the steepness of the canyon and the presence of non-granitic rocks, the probabilities of Mariposa pussypaws and orange lupine being present are low, since these species are restricted to decomposing granite domes. Mariposa pussypaws is a Federally listed threatened species; orange lupine is on CNPS List 1B. Stebbins (2003) indicates that habitat conditions for these two species are absent or at least not common in this portion of the area studied.

Small areas of suitable habitat for tree anemone do occur in the gorge, but no extensive surveys for this species have been conducted in the area. The tree anemone is State-listed as threatened. Several populations of Madera linanthus are recorded along the shores of Millerton Lake, and one population near Big Bend would be affected by a dam at RM 274. Madera linanthus is on CNPS List 1B; this species could occur anywhere in the river canyon.

Pool options for RM 274 range from elevation 800 to elevation 1,100. A pool at elevation 1,100 would affect riparian vegetation occurring along the river and in tributaries between Kerckhoff and Redinger lakes. In addition, this pool elevation would just reach the

Backbone RNA, but would not be likely to affect the tree anemone population at that location. Lower pool elevations would affect less riparian habitat and potentially less special status species habitat (e.g., Madera linanthus).

RM 279

A dam at RM 279 would affect the San Joaquin River gorge in a manner similar to the dam at RM 274. However, the two higher pool options for RM 279 (elevations 1,200 and 1,300) would adversely affect riparian habitat at and above Kerckhoff Lake, especially at the Fish Creek confluence. Both of these higher pool options would extend nearly to Redinger Lake. Consequently, they would also affect some riparian habitat at Willow Creek. Portions of the Backbone Creek RNA and a small portion of the tree anemone population would be adversely affected by pool elevations of 1,200 and 1,300 (Clines, 2003).

RM 286

High pool elevation options at this dam site (elevation 1,400) would produce greater impacts on botanical resources than the other two dam sites being considered. Riparian habitat in Fish Creek and Willow Creek would be inundated. Portions of the Backbone Creek RNA would be significantly affected, and an unknown amount of the tree anemone population would be lost (Clines, 1997).

Topographic and geologic maps suggest that suitable habitat for orange lupine and possibly Mariposa pussypaws might occur at elevations approaching elevation 1,400. Without field surveys and quantifiable aerial analyses, the full impacts of this option cannot be determined.

WILDLIFE

Species of special concern are animal species whose status as a stable resource is threatened or is in a state of decline. Often these species are experiencing population declines due to loss or alteration of habitat. Species of special concern include those listed as threatened or endangered by State or Federal agencies; other species of concern could become threatened or endangered if habitat losses and alteration continue to a point that their existence as a viable species, locally or regionally, is threatened with extinction. Some habitat types also are recognized by CDFG as habits of special concern. Regional effects can also influence whether wildlife impacts pose a constraint to development of a potential reservoir.

Constraints and Opportunities

Although the Temperance Flat area is not biologically pristine, wildlife habitats would be affected and species could be displaced by a new reservoir. Table 5-1 lists species of special concern that potentially occur in the Temperance Flat area, their respective status with applicable resource and land management agencies, and habitats used by each.

TABLE 5-1. SENSITIVE WILDLIFE SPECIES AND ASSOCIATED HABITAT IN THE TEMPERANCE FLAT AREA

Wildlife Species	State	Federal	Source	Habitat
Valley Elderberry Longhorn Beetle *Desmocerus californicus dimorphus*	CSSC	FT	WHR	BOP, BOW, R, VFR, VOW
California Tiger Salamander *Ambystoma californiense*	CP CSSC	FC	WHR	AG, BOP, BOW, R, **VFR**, VOW
Western Spadefoot Toad *Spea hammondi*	CP CSSC	BLMS	WHR	AG, BOP, BOW, FEW, L, **PG, R**
Foothill Yellow-Legged Frog *Rana boylii*	CFP	FSS	WHR	AG, BOP, BOW, MC, **R, VFR**, **WM**
Western Pond Turtle *Clemmys marmorata*	CP CFP	FSS	WHR	**AG**, **BOP**, **BOW**, **L**, **FEW**, MC, PG, **R**, **VFR**, **WM**
Bald Eagle *Haliaetus leucocephalus*	CFP CE CDFS	FT	WHR	AG, BOP, BOW, FEW, L, MC, PG, **R**, **VFR, WM**
Prairie Falcon *Falco mexicanus*	CSSC	N/A	WHR	**AG, BOP, BOW,** FEW**, MC, PG, VFR, WM**
Great Grey Owl *Strix nebulosa*	CE, CDFS	FSS	WHR	**WM**
Willow Flycatcher *Empidonax traili*	CE	FE, FSS	WHR	**VFR, WM**
Tricolored Blackbird *Agelaius tricolor*	CSSC	N/A		**AG, FEW, PG, VFR,** WM
Red Fox *Vulpes vulpes*	ST, FSS	SOC	WHR	AG, MC, **WM**
Western Mastiff Bat *Emops perotis*	SSC	N/A	WHR	**AG**, BOP, BOW, VFR, VOW, **WM**

Key:
Habitat Abbreviations:
AG - annual grassland
BOP - blue oak-foothill pine woodland
BOW - blue oak woodland
FEW - fresh water emergent wetland
L - lacustrine
MC - Montane chaparral
PG - perennial grassland
R - riverine
VFR - valley foothill riparian
VOW - valley oak woodland
WM - wet meadow
Note:
Habitat types in **bold** indicate preferred habitats.

Status Abbreviations:
BLMS - Bureau of Land Management Listed as Sensitive
CDFS - California Department of Forestry Listed as Sensitive
CE - California Listed as Endangered
CFP - California Listed as Fully Protected
CP - California Listed as Protected
CSSC - California Species of Special Concern
CT – California Listed as Threatened
FC - Candidate for Federal Listing
FE - California Listed as Endangered
FSS - Forest Service Listed as Sensitive
FT – Federally Listed as Threatened
N/A not applicable

Source: Wildlife Habitat Relationships (WHR) Program. California Department of Fish and Game, 2001.

Issues of potential habitat loss, wildlife population losses, and impacts to species of special concern are similar for each of the dam sites because wildlife habitats within the three areas of potential impact are similar. Development of a reservoir could affect regional wildlife populations through displacement of species to other areas in the region. Development of a reservoir could also attract wildlife species that have not previously inhabited the area. A new reservoir could also attract increased human recreational use, which can impact wildlife communities in the larger region.

Reservoir development could attract and benefit some species, such as osprey, bald eagle, and waterfowl. However, opportunities afforded such species might not offset losses of existing habitat resulting from reservoir development. Replacement of existing biotic communities with those suited to a reservoir environment could pose a constraint. Constraints could arise from impacts to species or habitats of special concern, or from impacts to regional wildlife populations.

RM 274

The presence of the species listed in Table 5-1, and loss of their supporting habitats and the habitats of more common species of wildlife, would be constraints for the RM 274 dam site. Impacts to the western pond turtle are likely to be a constraint as this species is declining throughout its range. Western pond turtle, listed by the State as protected and by the Forest Service as sensitive, has been identified in the area. If populations of this species are present along the San Joaquin River and its tributaries in the potential dam and reservoir area, the impact could be substantial.

Impacts to any listed threatened or endangered species would need to be addressed. Of particular note is the presence of elderberry shrubs within the watershed. This shrub is the habitat for the valley elderberry longhorn beetle, a Federally listed threatened species. It is quite likely this species is present in potentially impacted areas. Also, the presence of California tiger salamander in the area would pose an additional constraint, as this species is a candidate for listing under the Federal ESA, and is expected to be listed as a threatened species by the end of 2003.

RM 279

As with the RM 274 potential dam site, many of the species identified in Table 5-1 are expected to occur in the area of the potential dam and reservoir. The presence of important populations of these species could be a constraint. Of particular interest are species listed as threatened and endangered or are known to be experiencing substantial population and habitat declines regionally.

Among those listed in Table 5-1, the valley elderberry beetle, California tiger salamander, and western pond turtle are expected to be present and pose potential constraints. Historically, the foothill yellow-legged frog was present in parts of the area; however, it is not known if this species is still present. Loss of these species' habitats and local populations would be difficult and expensive to mitigate.

RM 286

Constraints associated with a dam at this location are likely to be similar to those for RM 274 and RM 279. However, it appears that a reservoir at RM 286 would inundate more miles of river that are likely to contain western pond turtles and foothill yellow-legged frogs. Valley elderberry longhorn beetles are likely to be present, and much of the area could include important deer winter ranges and bear habitat. Loss of habitats for these species could cause impacts of regional importance. Loss of deer winter range is recognized as an important cause in decline of deer herds along the western slope of the Sierra Nevada.

AQUATIC BIOLOGY/WATER QUALITY

Generally, constraints to reservoir development could be posed by potential impacts to special status aquatic species, native fish or their habitat, game fish, or water quality:

- Special-Status Species. As is the case for botany and wildlife, special-status species listed by the State and Federal governments as endangered or threatened are of the highest priority. CDFG maintains a list of fish species of special concern (Moyle et al., 1995). Although species on this list do not have statutory or regulatory protection, CDFG would likely oppose unmitigated impacts to these species.
- Native Species. Native fish fauna of California have been greatly reduced due to many disturbances, including habitat disruption resulting from water development projects. Therefore, CDFG and other resource agencies are interested in protecting native fish species and their habitats. CDFG would likely oppose impacts to these species and to any relatively undisturbed aquatic habitats.
- Game Species. Game fish species, including native trout and many exotic species, are under the jurisdiction of CDFG. These species constitute a major recreational and economic resource for the State, and CDFG would oppose unmitigated impacts to this resource.
- Water Quality. The State Water Resources Control Board and the Regional Water Quality Control Boards are charged with protecting California's water quality. Water quality must meet objectives to protect beneficial uses, as spelled out in RWQCB Basin Plans. Water quality standards of the streams and reservoirs included in this assessment are provided in the Basin Plans for the Sacramento River, San Joaquin River, and Tulare Lake basins.

Constraints and Opportunities

Reservoir options at all three potential dam sites could affect special status, native, and game fish species. Hardhead, which is classified as a State of California Species of Special Concern and a USFS Sensitive Species, is found in all lakes and reaches of the San Joaquin River that could be inundated by a new Temperance Flat Reservoir. Kern brook lamprey, which is the subject of a petition for listing under the Endangered Species Act, might be present in the Millerton Lake to Kerckhoff Lake reach of the river. Native fish, including hardhead, are also present in all lakes and reaches of the San Joaquin River that might become inundated. Numerous game species inhabit Millerton Lake. Fewer game species are present in the reach of the San Joaquin River between Millerton and Kerckhoff lakes. Rainbow trout occur in the reach between Kerckhoff and Redinger lakes. More details of existing aquatic conditions are presented in Chapter 2.

Another factor that could constrain Temperance Flat Reservoir options relates to a unique landlocked population of American shad that inhabits Millerton Lake and the reach of the San Joaquin River upstream of the lake. In addition, the Horseshoe Bend reach of the San Joaquin River between Kerckhoff Lake and Redinger Lake is designated by CDFG as a Central Valley Drainage Hardhead/Pikeminnow Stream.

The only potential constraint related to water quality that has been identified relates to the potential mobilization of sediments currently trapped behind Kerckhoff Dam.

Principal impacts to aquatic resources of creating a new reservoir in the Temperance Flat area would be related to the depth and inundation zone and changes in flows downstream of the reservoir. To evaluate these impacts, it is important to understand the location, depths, and upstream extent of the inundation zone for each potential dam site and the locations of existing aquatic resources that potentially would be affected.

The three Temperance Flat dam sites are in the upper end of Millerton Lake and in the canyon upstream of the reservoir. Depending on the dam site selected, and the height of the dam, impacts to aquatic resources would potentially occur in Millerton Lake; the reach of the San Joaquin River upstream of Millerton Lake to Kerckhoff Dam; Kerckhoff Lake; the San Joaquin River between Kerckhoff Lake and Redinger Dam (Horseshoe Bend reach); and Redinger Lake. Table 5-2 provides the locations of these water bodies in relation to the locations of the dam sites and maximum elevations of reservoirs under consideration.

The range of maximum water elevations for reservoirs created by the potential dams includes elevations 800 to 1,100 for the RM 274 dam, elevations 900 to 1,300 for the RM 279 dam, and elevations 1,200 to 1,400 for the RM 286 dam. All of these reservoir options would inundate portions of the San Joaquin River upstream of Millerton Lake (see Figures 1-3 through 1-5). None of the potential reservoirs at the RM 286 dam site would inundate any portion of Millerton Lake or the portion of the Millerton Lake – Kerckhoff Dam reach of the San Joaquin River downstream of the dam site.

The maximum inundation zone of an elevation 800 reservoir would extend to approximately RM 288, which is about halfway up the reach between the upper end of Millerton Lake and Kerckhoff Dam. The maximum inundation zone of an elevation 900 reservoir would extend to Kerckhoff Dam. A reservoir at elevation 1,000 or above would submerge all of the Millerton Lake to Kerckhoff Dam reach of the San Joaquin River upstream of the dam site and also would submerge Kerckhoff Lake. A reservoir with a maximum water surface elevation of 1,100 would inundate about one-third of the Horseshoe Bend reach of the San

Joaquin River between Kerckhoff Lake and Redinger Dam. Any higher reservoir would nearly or completely inundate the entire reach.

In the following sections of the report, organized by potential dam site, likely impacts to aquatic resources and water quality are discussed, along with additional site specific information related to potential constraints and opportunities.

TABLE 5-2. LOCATIONS AND ELEVATIONS OF EXISTING FACILITIES AND POTENTIAL RESERVOIR OPTIONS

Approximate Location (river mile)	Approximate Elevation (feet above mean sea level)	Feature
274	385	Original river channel at RM 274 dam site
278.9	460	Original river channel at RM 279 dam site
282.7	580	Kerckhoff No. 2 Powerhouse
283.6	578	Millerton Lake (upstream limit)
284.2	620	BLM footbridge
284.5	636	Kerckhoff Powerhouse
286.1	740	River channel at RM 286 dam site
288.2	800	Elevation 800 reservoir (upstream limit)
292.5	889	Base of Kerckhoff Dam
292.5	900	Elevation 900 reservoir (upstream limit)
292.5	960	Elevation 960 reservoir (upstream limit)
292.5	971	Kerckhoff Dam crest
294.7	1,000	Wishon Powerhouse
295.0	980	Bridge at Powerhouse Road
295.8	1,000	Big Creek No. 4 Powerhouse
295.9	985	Kerckhoff Lake (upstream limit)
298.2	1,100	Elevation 1,100 reservoir (upstream limit)
300.0	1,200	Elevation 1,200 reservoir (upstream limit)
301.0	1,210	Channel Crossing @ Willow Creek
301.7	1,220	Base of Redinger Dam
301.7	1,300	Elevation 1,300 reservoir (upstream limit)
301.7	1,400	Elevation 1,400 reservoir (upstream limit)
301.7	1,401	Redinger Dam Crest
305.6	1,410	Bridge at Italian Bar, Big Creek No. 3 Powerhouse
307.0	1,600	Residences, Chawanakee

RM 274

Principal impacts to fisheries resources associated with constructing a dam at RM 274 would result from increases in seasonal reservoir water level fluctuations compared to current water level fluctuations in Millerton Lake and inundation of the San Joaquin River and Kerckhoff Lake upstream of Millerton Lake. Specific effects would be related to the size of reservoir created. Because maximum pool elevation would be increased (from elevation 800 to 1,100), seasonal water level fluctuations would probably grow larger, although operations studies, which were not included in the environmental review, would be needed to confirm this.

Seasonal water level fluctuations can adversely affect fish. Rapidly changing water levels can result in habitat instability, particularly for species that use shallow water habitats. Water level fluctuations adversely affect nearshore spawners such as largemouth bass, which spawn in the spring when the reservoir water level rises with the capture of snowmelt. The rising water level results in increased water depth for largemouth bass nests, exposing them to water temperatures too cold for 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.

Water level fluctuations can also inhibit development of shoreline vegetation. Shoreline vegetation provides cover and feeding substrates for many warm-water game species in Millerton Lake. Vegetation also stabilizes shoreline sediments, reducing erosion and sedimentation. Because of effects on vegetation, increases in water level fluctuations could adversely affect fish species in Millerton Lake.

Creating a new reservoir in the upper portion of the existing Millerton Lake would change the amount of shallow water habitat. Shallow water habitat benefits many reservoir fish species. This habitat is highly productive because bottom nutrients and surface sunlight, both required for plankton growth, are found together in shallow water. In addition, shallow water habitat tends to be warmer than deep-water habitat, and thus, promotes more rapid growth of warm-water game species. Therefore, a reduction in shallow water habitat would likely affect most fish adversely, while an increase in shallow water habitat would be beneficial. Although creation of a new reservoir at Temperance Flat would be expected to cause the total length of shoreline to increase, the change in surface area of shallow water habitat would depend on the bathymetry of both the new Temperance Flat Reservoir and the truncated Millerton Lake. 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 and anticipated operations of the reservoirs would be needed to determine the effects of different water levels on surface area of shallow water habitat.

The inundation zone of a new reservoir at RM 274 would increase with reservoir size such that a reservoir with a surface elevation of 800 would inundate only a portion of the San Joaquin River upstream of Millerton Lake, while larger reservoirs would inundate all or nearly all of the river upstream to Kerckhoff Dam (Figure 1-3, Table 5-2). A reservoir with a surface elevation of 1,100 would also submerge Kerckhoff Lake and a portion of the Horseshoe Bend reach of the San Joaquin River upstream of Kerckhoff Lake.

Any of the reservoir sizes considered would inundate current spawning areas for American shad and striped bass in upper Millerton Lake and the San Joaquin River. It is possible that the shad would be able to successfully shift their spawning areas upstream to the inflow region of an elevation 800 reservoir. It is less likely that shifts to accommodate a larger reservoir would be successful because American shad have narrow water temperature requirements for spawning, and water released from a larger, upstream reservoir would likely be too cold for shad spawning. Additional study would be required to identify operating objectives of the potential new reservoirs for American shad. American shad also have water velocity requirements for spawning; therefore, adequately assessing the effect of increasing maximum pool elevations on shad spawning would require complex analysis, including hydraulic modeling.

The inundation zone of a new reservoir created by a dam at RM 274 would flood important habitat for native fish species, including hardhead, a CDFG Species of Special Concern and a USFS Sensitive Species. The inundation zone might also affect Kern brook lamprey, which is a State Species of Special Concern, and which is also included in a petition for listing to USFWS. As previously noted, the presence of Kern brook lamprey in the dam site areas is uncertain. The two smaller reservoir options, those with surfaces at elevations 800 and 900, would inundate only portions of the San Joaquin River between Millerton Lake and Kerckhoff Dam, while the two larger reservoir options would inundate the entire reach, and the largest option would also inundate portions of the Horseshoe Bend reach upstream of Kerckhoff Lake. The Horseshoe Bend reach provides especially important native fish habitat, and is managed as a native fish area by CDFG. Inundation of the riverine habitat of hardhead and other native fish, particularly Sacramento pikeminnow and Sacramento sucker, would not necessarily result in reductions of their populations because these species are well-adapted to reservoirs. However, reduction of their natural habitat would likely be considered a substantial impact in and of itself, and could pose a constraint. Inundation of Kerckhoff Lake probably would have little effect other than to provide somewhat more habitat for the fish populations currently inhabiting the reservoir.

Few water quality constraints on increasing the maximum pool elevation of upper Millerton Lake have been identified. Increasing the reservoir depth would likely lead to more stable thermal stratification and a larger pool of cold water. However, sediments accumulating in the reservoir near the Kerckhoff Powerhouse intakes, which are at Kerckhoff Dam, could contain toxic materials. Sluicing these sediments from the reservoir could affect water quality in the San Joaquin River and Millerton Lake. Inundation of Kerckhoff Lake would likely raise concerns regarding mobilization of these potentially toxic sediments. However, if the dam were not removed, the sediments would likely remain in place.

Raising the maximum pool of the upper portion of Millerton Lake to any of the alternative elevations for the RM 274 dam site could create some opportunities to enhance existing aquatic resources. A new reservoir would result in a substantial increase in total volume of fish habitat. A reservoir of elevation 1,100 would submerge the existing Kerckhoff Lake, increasing its size as well. Deep, cold-water habitat used by species such as trout and salmon would be most enhanced. Populations of hardhead and other native species would also likely be enhanced by a new reservoir. The new reservoir would be much more open and lacustrine than the existing reservoir in this location, which is narrow and riverine. Stocking the new reservoir with salmon and other cold-water species should be considered as an aspect of a new reservoir.

Increasing the maximum pool elevation might increase or reduce the shallow water habitat available, depending on the bathymetries and operations of Millerton Lake and Temperance Flat Reservoir, and on the contours of the newly inundated areas upstream of Millerton Lake. Further analysis of reservoir operations are needed to estimate effects more accurately.

The large volume of storage of the potential new Temperance Flat reservoir would provide an opportunity to regulate water levels in Millerton Lake downstream of the RM 274 dam site. By regulating water levels, spawning and rearing conditions for warm-water fish that spawn nearshore could be greatly enhanced.

Adverse effects on American shad and striped bass spawning habitat of raising the reservoir level could be unavoidable and require mitigation.

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

RM 279

Principal impacts to fisheries resources associated with constructing a dam at RM 279 would be similar to those described above for RM 274. In both cases, the dam would be constructed within the existing Millerton Lake and would produce much greater depths and more open water in the upper portion of the reservoir. Also, in both cases, much or all of the reach of the San Joaquin River between Millerton Lake and Kerckhoff Dam would be inundated. The only major differences are related to the territory between the dam sites and the higher surface elevations of the reservoir options considered for RM 279. The portion of Millerton Lake between RM 274 and RM 279 is very narrow and steep-sided; if this area is covered by a new reservoir, it would provide deep, cold-water habitat. This area already provides deep, cold-water habitat in Millerton Lake, but the volume of this habitat would increase.

Differences in impacts related to the location of a potential dam at RM 279 compared to RM 274 are likely to be much less important than those related to the differences in maximum water surface elevation. The smallest reservoir at the RM 279 site would have a surface with maximum elevation 900 and the largest would have a surface with maximum elevation 1,300. The elevation 900 reservoir would inundate almost the entire reach of the San Joaquin River upstream of Millerton Lake, but would not affect Kerckhoff Lake, while the two largest reservoirs, at elevations 1,200 and 1,300, would inundate Kerckhoff Lake and nearly all or all of the Horseshoe Bend reach of the river (Figure 1-4, Table 5-2). None of the reservoirs considered for this dam site would inundate Redinger Lake. The inundation of the Horseshoe Bend reach is especially relevant to potential constraints because of the importance of this reach to native fish, including hardhead, a State Species of Special Concern.

The impacts on fish and water quality for the RM 279 reservoir options, resulting from increasing the maximum pool elevation in upper Millerton Lake and from inundating two reaches of the San Joaquin River would be similar to those for RM 274. Potential constraints would therefore be similar as well.

At the prefeasibility level of evaluation conducted for this TM, opportunities associated with the RM 279 site would be essentially the same as those described for RM 274.

RM 286

Several important differences for a potential dam at RM 286 affect expected impacts related to aquatic resources. First, because the dam site is upstream of Millerton Lake, a potential new reservoir would not encompass any portion of Millerton Lake. In addition, the reservoir water surface elevations considered for this dam, which range from elevations 1,200 to 1,400, are higher than any of those considered for the RM 274 dam site and include an elevation option higher than those being considered for the RM 279 dam site. Thus, the inundation zone of the reservoir options considered for the RM 286 dam site extend further upstream than most of the reservoir options considered for the other two dam sites.

The large storage volume of the new reservoir would be expected to change the volume and timing of storage in Millerton Lake and of flows in the reach of the river above Millerton Lake. The temperatures of the water released from the new reservoir would likely be colder than that of the water that currently flows in the San Joaquin River upstream of Millerton Lake. However, the change in the temperature of inflow to Millerton Lake might not be very significant because most of the current inflow comes from Kerckhoff Project powerhouse tailraces, from which discharges are already relatively cold. Potential changes in river flow, reservoir water levels, and river water temperatures would likely affect fish and water quality in the river and Millerton Lake. However, these changes depend on operation of the new reservoir, which has not yet been determined, so potential temperature effects on fish and water quality cannot be fully evaluated at this time.

Constraints related to upstream inundation by the new reservoir are largely the same as those described for the RM 274 and RM 279 dam site options. One important difference is that there would be little, if any, inundation of American shad and striped bass spawning habitat in and above upper Millerton Lake. In addition, all RM 286 reservoir options would inundate the Horseshoe Bend reach of the river (Figure 1-5, Table 5-2). As noted previously, inundation of Horseshoe Bend would not necessarily reduce fish populations, but would eliminate native fish habitat currently managed by CDFG.

At the prefeasibility level of evaluation conducted for this TM, many opportunities associated with a dam at the RM 286 site are the same as described above for other Temperance Flat dam site options. However, this option provides important additional opportunities not available with the other options. These include the opportunity to control flows and water temperatures in the lower portion of the Millerton Lake to Kerckhoff Dam reach of the San Joaquin River, and the opportunity to regulate water levels in Millerton Lake. Regulation of flows and water temperatures in the river is particularly important for enhancing spawning conditions for American shad and striped bass, but could also be used to enhance habitat for hardhead and other native fishes in the river. The opportunity to regulate flow would depend on how the reservoir was operated, and the opportunity to regulate water temperatures would require constructing an outlet structure with controls for releasing water from different depths in the new reservoir. Also, regulation of water levels in Millerton Lake could be used to enhance spawning and rearing conditions for warm-water game fish in the reservoir. The RM 274 and RM 279 dam site options provide the opportunity to regulate water levels in lower Millerton Lake, but this option would allow regulation of water levels in the entire reservoir. As with regulating flow in the river, opportunities to regulate water levels in Millerton Lake would depend upon how the new reservoir would be operated, which has not yet been determined.

RECREATION

Recreation resources were assessed with respect to the criteria below, posed as questions. Would implementation of the potential dam and reservoir:

- Increase the use of existing parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?
- Include recreation facilities or require the construction or expansion of recreational facilities that might have an adverse physical effect on the environment?
- Substantially conflict with established or planned recreation uses?
- Conflict with USFS, BLM, or CDPR management objectives related to recreation, or those of any other agency?
- Displace certain user groups such as whitewater boaters, equestrian users, or water skiers?
- Permanently eliminate a recreation opportunity, activity, or facility?

Constraints and Opportunities

All of the dam configurations under consideration would inundate existing recreation facilities, including campgrounds, boat launches, day use areas, roads, and trails. In most cases, the inundation of existing facilities is not considered a major constraint because the facilities can be reconstructed. Exceptions involve cases where the facilities support a unique experience that would no longer be available.

All of the Temperance Flat dam configurations under consideration would inundate river segments that currently support a variety of recreation activities, including fishing and whitewater boating. Loss of river-oriented recreation opportunities, particularly those that are not easily replaced, would be considered a major constraint.

Conversely, creating a new reservoir would provide new recreation opportunities for water- or land-based recreation. Further study is needed to estimate demand and to determine what types of facilities would be appropriate.

RM 274

Dam elevations associated with the RM 274 dam site range from elevations 800 to 1,100. The elevation 800 option would flood the upper end of Millerton Lake and the San Joaquin River to about the middle of Patterson Bend. This option would inundate the Hewitt Valley Environmental Camp, Temperance Flat Boat-in Camp, portions of various trails that traverse the area, and the lower third of the Patterson Bend whitewater boating run. Most facilities associated with the BLM San Joaquin River Gorge Management Area would be unaffected.

The elevation 1,100 option would inundate the upper end of Millerton Lake, Kerckhoff Lake, and the San Joaquin River to about the middle of Horseshoe Bend. This option also would inundate the Hewitt Valley Environmental Camp, Temperance Flat Boat-in Camp, various trails and roads that traverse the area, and recreation facilities located at Kerckhoff Lake. In addition, all of the developed facilities associated with the BLM San Joaquin River Gorge Management Area would be submerged, and all of the Patterson Bend whitewater boating run and half of the Horseshoe Bend run would be inundated.

In general, inundating existing recreation facilities, roads, and trails would not be considered unmitigable impacts because most could be reconstructed at higher elevations. The exceptions are some of the facilities associated with the San Joaquin River Gorge Management Area, which offer a unique experience that might not be replaceable. Inundating all or substantial portions of the San Joaquin River Gorge Management Area would be considered a substantial adverse impact.

Inundating all or portions of the San Joaquin River would adversely affect rafting and boating opportunities. The elevation 800 option would inundate the lower portion of the Patterson Bend run, destroying the only existing take-out locations at the Kerckhoff and Kerckhoff No. 2 powerhouses. As noted above, the elevation 1,100 option would inundate all of the Patterson Bend Run and half of the Horseshoe Bend Run; these runs provide low elevation whitewater boating opportunities for expert and intermediate boaters, respectively. Submerging these runs would displace boaters and would result in the loss of whitewater boating opportunities. Inundating the river would also affect angling opportunities. Loss of rafting, boating, and fishing opportunities would be considered adverse impacts.

Constructing a dam at RM 274 could increase reservoir recreation opportunities such as fishing and flat water boating. These new opportunities would draw new users, which could warrant constructing new facilities. The number, size, and type of facilities required would depend on the size of the reservoir and estimated demand. Consideration could also be given to improving river access above or below the reservoir, to enhancing trails, or providing additional improvements that support existing remote recreation uses (e.g., small parking areas, ventilated primitive toilets).

RM 279

Dam elevations associated with the RM 279 dam site range from elevation 900 to 1,300. The elevation 900 option would flood the upper end of Millerton Lake and the San Joaquin River to the toe of Kerckhoff Dam. This option also would inundate the Hewitt Valley Environmental Camp, Temperance Flat Boat-in Camp, portions of various trails that traverse the area, and nearly all of the Patterson Bend whitewater boating run. Most of the facilities associated with the BLM San Joaquin River Gorge Management Area would be unaffected.

The elevation 1,300 option would inundate the upper end of Millerton Lake, Kerckhoff Lake, and the San Joaquin River to the base of Redinger Dam (Dam No. 7). This option also would inundate the Hewitt Valley Environmental Camp, Temperance Flat Boat-in Camp, various trails and roads that traverse the area, and recreation facilities located at Kerckhoff Lake. In addition all of the developed facilities associated with the BLM San Joaquin River Gorge Management Area would be submerged, and the Patterson Bend and Horseshoe Bend whitewater boating runs would be eliminated. These would be considered substantial adverse impacts.

However, as with RM 274, constructing a dam at RM 279 could increase reservoir recreation opportunities such as fishing and flat-water boating. These opportunities would be likely to draw new users, and could require new facilities.

RM 286

The dam elevations associated with the RM 286 dam site range from elevation 1,200 to elevation 1,400. The potential dam site is upstream of the Millerton Lake Recreation area and the BLM San Joaquin River Gorge Management Area; consequently, the facilities associated with these areas would be unaffected. The site is situated above the downstream end of the Patterson Bend whitewater run.

The elevation 1,200 option would submerge the San Joaquin River from about 1 mile upstream of Kerckhoff Powerhouse nearly to the base of Redinger Dam. This would split and submerge nearly all of the Patterson Bend whitewater boating run, submerge Kerckhoff Lake and its recreation facilities, and submerge nearly all of the Horseshoe Bend whitewater run.

Higher elevation reservoir options would differ in only two major respects. First, they would submerge additional higher elevation portions of trails and roads that traverse the area. Second, the most upstream remainder of the Horseshoe Bend whitewater boating run would be submerged, in addition to the majority of the run that would be inundated by the elevation 1,200 option.

In general, inundating existing recreation facilities, roads, and trails would not be considered substantial impacts because they might be reconstructed at higher elevations. However, the whitewater boating runs provide relatively low elevation whitewater boating opportunities for expert and intermediate whitewater enthusiasts that are not easily replaced. Although both runs are remote, especially Horseshoe Bend, and each can only be used when releases are made from the hydroelectric project diversion dam immediately upstream, submerging these runs would nevertheless displace some boaters and would result in the loss of whitewater opportunities. Inundating the river would also affect angling opportunities. The loss of rafting, boating, and fishing opportunities would be considered adverse impacts that would be difficult to mitigate.

Creating a new reservoir at any of the Temperance Flat sites would provide new reservoir recreation opportunities such as fishing and boating. New fishing and boating opportunities could draw more visitors to the area, creating demand for new facilities. However, the area above Millerton Lake is relatively undeveloped and currently provides excellent opportunities for visitors who prefer minimally developed and primitive recreation experiences. Any new recreation improvements should consider the needs of all users, including those who prefer more primitive outdoor experiences.

CULTURAL RESOURCES

In determining the extent to which cultural resources might pose a constraint on developing a new reservoir in the Temperance Flat area, the analysis focused on the following:

- Presence of historic properties
- Presence of Traditional Cultural Properties (TCPs)
- Presence of affected lands within the traditional territories of California Indians

Historic properties, including prehistoric and historic archaeological sites, extant historic structures, and places with traditional cultural significance to Native American people, are protected by the National Historic Preservation Act (NHPA) of 1966, as amended, and by implementing regulations at 36 Code of Federal Regulations (CFR) 800. Archaeological sites are also protected by the Archaeological Resource Protection Act of 1979. Sites that are listed on the NRHP, or that have been determined eligible for listing on the NRHP, would require development and implementation of mitigation measures if the sites would be adversely affected by an undertaking.

Native American sacred sites and TCPs enjoy a degree of legal protection. The American Indian Religious Freedom Act of 1978 places a certain burden on land-managing agencies of the Federal government to ensure access to sacred sites by practitioners of American Indian religions. Executive Order 130007 (1996) reinforced the obligations of Federal agencies regarding sacred sites. TCPs qualify as "historic properties" under the NHPA; consequently, NRHP-eligible TCPs enjoy protection similar to that of other types of historic properties — except that impact mitigation for TCPs is less well-defined and therefore more subjective.

Whether or not a project is within the traditional territory of a California Indian group is helpful information for evaluating potential constraints on a project, as concerns of California Indian people must be given special attention. In addition to concerns about sacred sites and TCPs, other concerns are also relevant due to requirements for Federal and State agencies to engage in consultations. Executive Order 13084 of 1998 requires "consultation and coordination with Indian tribal governments" by all Federal agencies. In addition, CEQA-permitted projects require consultation with the California Native American Heritage Commission, which recognizes California Indian groups that do not enjoy Federal recognition. Consequently, tribal concerns could place constraints on a project if those concerns lead to development delays. Although knowing whether or not a potential project is within the traditional territory of a California Indian group does not directly determine if development constraints exist, the information does serve to identify the particular group(s) of people likely to have tradition-based concerns.

Constraints and Opportunities

Inundation of archaeological sites (prehistoric or historic) can result in the loss of important scientific data. It is always preferable to avoid impact to NRHP-eligible properties, but if this is not possible, data recovery programs could be undertaken at archaeological sites, and standing structures documented in keeping with standards set by the Historic American Buildings Survey/Historic American Engineering Records program of the National Park Service.

Reservoir projects provide an opportunity for expanding knowledge of historic and prehistoric resources and for enhancing public interpretation of the past. For ancillary facilities, such as roads, powerlines, or other structures, there could be an opportunity to avoid impact to archaeological sites through design or facility placement.

RM 274

As mentioned in Chapter 2, records indicate the presence of 33 archaeological sites within or close to the existing pool of Millerton Lake (Welch, 2002). The sites are mostly prehistoric, including habitation sites with housepits, sweathouses, and human burials; BRMs; rock rings; and lithic scatters. Three historic sites are associated with mining. With presently available data, it is not known how many of these sites would be impacted by an expanded reservoir or by its various configurations. However, some prehistoric sites that would be inundated are within the Squaw Leap National Register District. Additional sites, not included in the Millerton Lake inventories, are expected to occur along the San Joaquin River to RM 298, the maximum extent of new inundation from an elevation 1,100 pool resulting from a dam at RM 274.

Numerous cultural resources are known to be present in the area, and there might be additional resources not yet recorded. As many as 47 known archaeological sites (and possibly more) might be adversely affected by constructing a dam at RM 274.

Available information does not indicate whether known historic properties in the area potentially affected by a dam and reservoir at RM 274 are NRHP-eligible, but there is a strong probability that such properties exist. The Sullivan and Patterson mines, in particular, are likely to be found eligible for the NRHP. Minimal pool levels would also inundate the

PG&E Kerckhoff Powerhouse, a potentially significant historic property constructed in 1920 that has not been evaluated for eligibility on the NRHP.

The PG&E Wishon Powerhouse has been evaluated for NRHP eligibility and was found lacking in historic integrity (CPUC, 2000; PG&E, 1986b), but re-evaluation could lead to a different result. A gross pool at elevation 1,100 would inundate the PG&E Kerckhoff Dam, A. G. Wishon Powerhouse, and SCE Big Creek No. 4 Powerhouse. It is not known whether the SCE Big Creek No. 4 Powerhouse has been individually evaluated for NRHP eligibility. However, the Big Creek Hydroelectric System, to which Big Creek Powerhouse No. 4 belongs, has long been noted for its engineering significance and might be NRHP-eligible as a historic district, as has been recommended previously (White, 1986; Shoup et al., 1988).

No Native American sacred sites or TCPs are known to occur in the area, but Squaw Leap might qualify as a TCP. Yokuts and Northfork Mono concerns about the area would be expected.

RM 279

Potential impacts from a dam at RM 279 are broadly similar to those resulting from a dam at RM 274, and with presently available data, differences cannot readily be quantified. Inundation from a dam at RM 279 with an elevation 1,300 pool contour could extend nearly to RM 302, reaching Redinger Dam. Numerous cultural resources are known to be present in the area, and there could be additional resources not yet recorded. It is not known how many cultural sites would be impacted by RM 279 storage options.

A dam at RM 279 would result in inundation of known archaeological sites in the Temperance Flat area and at the Squaw Leap NRHP District. In the late 1970s, PG&E identified 13 archaeological sites. Two of the sites were found to be significant (PG&E, n.d.). Later reports, reflecting additional surveys (Varner, 1983; Wren, 1994), identified 23 sites but only one property on the NRHP. It is likely that additional sites occur at elevations higher than those surveyed for PG&E in connection with Kerckhoff Lake, and additional sites are certainly to be expected farther upstream.

The potential RM 279 reservoir area is within the traditional territory of the Western Mono people. No Native American sacred sites or TCPs are known to occur in the area that would be affected by a dam at RM 279, but Squaw Leap might qualify as a TCP. Northfork Mono concerns about the area are expected.

RM 286

Numerous cultural resources are known to be present in the area, and there could be additional resources not yet recorded. It is unknown how many sites might be adversely affected by construction of a dam at RM 286. NRHP-eligible prehistoric sites are likely.

Potential impacts from a dam at RM 286 appear to be less than for dams at RM 274 or RM 279. Sites around Temperance Flat, the Squaw Leap NRHP District, and the PG&E Kerckhoff powerhouses would not be inundated. However, any of the RM 286 options under consideration would submerge Big Creek No. 4 Powerhouse, part of the SCE Big Creek Hydroelectric System, which has been recommended as an NRHP-eligible historic district.

No Native American sacred sites or TCPs are known to occur in the area, but the traditional fishing spot near the Big Creek No. 3 Powerhouse might qualify as a TCP. In addition, Northfork Mono concerns about the area are expected.

LAND USE

Constraints and opportunities associated with land uses in the project area were assessed with respect to the criteria below, posed as questions. Would the potential dam and reservoir:

- Physically divide an established community?
- Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the potential dam and reservoir?
- Conflict with any applicable habitat conservation plan or natural community conservation plan?

For this prefeasibility evaluation, the Madera and Fresno County General Plans, Fresno County's Sierra-North Regional Plan, and the SNF LRMP were reviewed. The assessment of land use constraints, below, is limited to land use topics associated with the dam sites and inundation areas. It does not address downstream effects or the potential for increased growth.

Constraints and Opportunities

No established communities are located within any of the Temperance Flat dam option boundaries. Therefore, none of the Temperance Flat Dam options would physically divide an established community. However, some individual private homes and public facilities could be inundated, depending on the option under consideration.

None of the comprehensive planning documents reviewed at this stage appears to prohibit water resources projects. However, some of the options under consideration would inundate portions of the Backbone Creek RNA, which is protected under the SNF LRMP. In addition, BLM lands in the San Joaquin River Gorge Management Area are managed primarily for recreation and wildlife habitat values.

RM 274

Dam elevations associated with the RM 274 dam site options range from elevation 800 to elevation 1,100. The elevation 800 option would flood the upper end of Millerton Lake and the San Joaquin River to about the middle of Patterson Bend. The dam would be located upstream of the major developed areas surrounding Millerton Lake. Therefore, most but not all private residences in the Millerton Lake area would be unaffected. This option would inundate the PG&E Kerckhoff Powerhouse and Kerckhoff No. 2 Powerhouse and ancillary facilities. It would also submerge several recreation facilities, as discussed in a prior section of this chapter.

The elevation 1,100 option would inundate the upper end of Millerton Lake, Kerckhoff Lake, and the San Joaquin River to about the middle of Horseshoe Bend, submerging the following facilities:

- PG&E Kerckhoff Powerhouse and No. 2 Powerhouse
- Kerckhoff Dam and Reservoir
- Most ancillary facilities associated with the Kerckhoff Hydroelectric Project, including penstocks, substations, and some transmission lines
- Various recreation facilities and trails located along the San Joaquin River, within the BLM San Joaquin River Gorge Management Area, and at the PG&E Smalley Cove recreation area.
- Portions of private and public access roads, including the bridge crossing at the upper end of Kerckhoff Lake
- PG&E Wishon Powerhouse
- SCE Big Creek No. 4 Powerhouse

Inundating the existing roads, bridges, power facilities, and public and private structures in the areas potentially affected by the dam site options would be considered a constraint. Impacts associated with inundation of roads, bridges, and public facilities can be mitigated by reconstructing facilities at a higher elevation. It is unknown whether reconstructing the existing hydropower facilities would be feasible. However, lost power generation could be partially compensated for by constructing new power generation facilities in conjunction with a Temperance Flat dam.

RM 279

Dam elevations associated with the RM 279 dam site range from elevation 900 to elevation 1,300. The elevation 900 option would flood the upper end of Millerton Lake and the San Joaquin River to Kerckhoff Dam. The elevation 1,300 option would inundate the upper end of Millerton Lake, Kerckhoff Lake, and the San Joaquin River to Redinger Dam (Big Creek Dam No. 7). Potential impacts and constraints associated with the RM 279 options are the same as those described for RM 274. In addition, reservoir options with an elevation over 1,100 would submerge portions of the Backbone Creek RNA.

RM 286

Dam elevations associated with a potential RM 286 dam site range from elevation 1,200 to elevation 1,400. The elevation 1,200 option would flood the San Joaquin River from about 1 mile upstream of the Kerckhoff Powerhouse to Redinger Dam.

The potential RM 286 dam site is upstream of the Millerton Lake Recreation Area, the BLM San Joaquin River Gorge Management Area, and the PG&E Kerckhoff Powerhouse and No. 2 Powerhouse; none of these facilities would be affected. However, a reservoir at RM 286 would inundate the following facilities:

- Kerckhoff Dam and Reservoir
- PG&E Smalley Cove recreation area
- Portions of private and public access roads, including the primary bridge crossing at the upper end of Kerckhoff Lake
- PG&E Wishon Powerhouse
- SCE Big Creek No. 4 Powerhouse
- Portion of the Backbone Creek RNA

Inundating existing roads, bridges, power facilities, and public and private structures in the area of the options under consideration would be considered a major constraint. Impacts associated with inundating roads, bridges, and public facilities might be mitigated by reconstructing facilities at a higher elevation. Reconstructing existing hydropower facilities, however, could be infeasible.

MINERAL RESOURCES

There is concern that inundation of abandoned mines or mine tailings in the Temperance Flat area could result in mobilization of metals or other chemicals from ore or mine wastes into a new reservoir. Under CEQA, this concern relates mainly whether the potential dam and reservoir would result in a release of hazardous materials that would create a significant hazard to the public or environment.

Constraints and Opportunities

This section focuses on the potential of mines in the area to adversely affect the water quality of a new reservoir. For example, if mercury had been used in the gold mining and recovery process, it could be present at mine sites in the area. Soil samples from tailing piles collected during field trips were collected. No free mercury was observed.

Water quality could be affected by possible acid mine drainage or acids from mining residuals. Tests for pH performed on standing water present in the Sullivan Mine tunnels indicated that the water was slightly basic (7.8).

RM 274

The lowest elevation remnants of both the Sullivan and Patterson mines are located at about elevation 700. Maximum pool elevations associated with the various RM 274 dam site options range from an elevation 800 to elevation 1,100. Therefore, all of the RM 274 options under consideration would inundate most or all of the Sullivan and Patterson mine workings and associated features.

Based on preliminary testing, inundation of the Sullivan and Patterson mines is not expected to result in significant impacts to water quality. Field observations and published literature suggest the mines were very small, few, if any, minerals are present that would cause metals contamination, and few, if any, sulfide minerals present that would cause acidic conditions.

Two open tunnels are present at the Sullivan Mine and three open tunnels are present at the Patterson Mine. All of the tunnels are in poor condition and are collapsing at the entrances. The tunnels at both the Sullivan and Patterson mines are accessible to the public by boat or by road, and could present a public safety hazard. Inundating the tunnels would remove this potential public safety hazard.

RM 279

The lowest elevation remnants of both the Sullivan and Patterson mines are located at about elevation 700. Maximum pool elevations associated with the various RM 279 dam site options range from elevation 900 to 1,300. Therefore, all of the RM 279 options under consideration would inundate the Sullivan and Patterson mine workings and associated features. Inundation of the Sullivan and Patterson mines is not expected to result in significant impacts to water quality, as discussed above.

Two open tunnels are present at the Sullivan Mine and three open tunnels are present at the Patterson Mine. All of the tunnels are in poor condition and are collapsing at the entrances. The tunnels at both the Sullivan and Patterson mines are accessible to the public by boat or by road, and could present a public safety hazard. Inundating the tunnels would eliminate this potential public safety hazard.

RM 286

The RM 286 dam site is located upstream of the Temperance Flat area and upstream of both the Sullivan and Patterson mine workings. Neither the Patterson nor Sullivan mines could affect water quality of a reservoir at RM 286. The USGS North Fork 7.5-minute quadrangle shows two small mines or prospects upstream of the RM 286 dam site, on the north side of the river, but these sites are located at elevations 2,000 and 2,200, above the highest inundation level under consideration. Therefore, neither of these other mining sites would affect water quality of a reservoir built at RM 286.

CHAPTER 6. FINDINGS AND CONCLUSIONS

This TM considered options for developing a reservoir in the Temperance Flat area. Potential dam sites were considered at three locations: RM 274, RM 279, and RM 286 on the San Joaquin River. Reservoir sizes range from 460 thousand acre-feet (TAF) to 2.8 million acre-feet in gross storage capacity. A portion of the storage capacity would replace existing Millerton Lake, Kerckhoff Lake, or Redinger Lake storage space. Several types of dam designs at each site were considered. Estimated field construction costs range from $330 million to $1.4 billion, as listed in Table 6-1.

TABLE 6-1. ESTIMATED CONSTRUCTION FIELD COSTS

Gross Pool Elevation (feet above mean sea level)	Gross Storage[1] (TAF)	Net Storage[2] (TAF)	Dam Type	Estimated Field Construction Cost[3] ($Millions)
RM 274 Dam Site				
800	531	462	CFRF	490
1,100	2,187	2,114	CFRF	800
RM 279 Dam Site				
900	460	444	RCC	410
			CFRF	430
1,100	1,263	1,243	RCC	750
			CFRF	730
1,300	2,775	2,736	RCC	1,400
			CFRF	1,200
RM 286 Dam Site				
1,200	465	457	Arch	330
			RCC	340
			CFRF	430
1,400	1,403	1,364	Arch	630
			RCC	560
			CFRF	590

Key:
Arch – thin concrete arch dam
CFRF – concrete-faced rockfill dam
RCC – roller-compacted concrete dam
RM – river mile
TAF – thousand acre-feet

Notes:
1. Total storage capacity of new reservoir.
2. Accounts for existing storage capacities of Millerton, Kerckhoff, and Redinger lakes.
3. Field cost represents the direct cost to construct the dam, spillway, powerhouse, and outlet works. Other costs are not included, such as lands, relocations, ancillary facilities, environmental mitigation, investigations, designs, construction management, administration, and interest during construction.

The San Joaquin River watershed above Millerton Lake is highly developed for hydropower generation. All reservoir options considered would impact existing hydropower projects and provide opportunities for hydroelectric energy generation. Depending on the location and height of the dam, Temperance Flat Reservoir has the potential to affect up to five powerhouses and two dams upstream of Millerton Lake. On the basis of preliminary estimates, new power generation associated with all options would be less than power generation lost due to construction of Temperance Flat Reservoir. Estimates of annual energy generation potential for Temperance Flat storage options are summarized in Table 6-2, along with an estimate of energy generation that would be impacted by each option.

TABLE 6-2. TEMPERANCE FLAT ENERGY GENERATION AND IMPACT

Dam Site	Net Storage[1] (TAF)	Average Annual New Energy Generation[2] (GWh/yr)	Average Annual Energy Generation Potentially Affected[3] (GWh/yr)
RM 274	725	160 – 210	579
	1,350	210 – 270	579
RM 279	725	330 – 380	579
	1,350	400 – 450	1,125
RM 286	725	630 – 680	1,125[4]
	1,350	690 – 740	1,125[4]

Key:
GWh/yr – gigawatt-hours per year
RM – river mile
TAF – thousand acre-feet
Notes:
1. Hydropower analyses were made for storage capacities that generally correspond to elevations at which existing powerhouses would be affected.
2. Estimated annual energy generation was based on single-purpose analyses for restoration flow and water quality releases to the San Joaquin River. Operations were not optimized for power generation. Increased generation at Friant powerhouses, potential for pumped storage, and potential generation from relocated impacted facilities are not included.
3. Average annual energy generation from impacted powerhouses for 1994 through 2002, as reported in FERC annual reports for the Kerckhoff and Big Creek projects. Direct comparison of generalized generation estimates to actual historical generation is indicative in magnitude only for the prefeasibility-level analysis described in this document.
4. The RM 286 option would not inundate Kerckhoff or Kerckhoff No. 2 powerhouses. Potentially affected generation includes total generation at Kerckhoff powerhouses. Further evaluation will identify potential modifications to existing Kerckhoff facilities as part of the RM 286 option.

Developing a reservoir in the Temperance Flat area would cause adverse environmental effects to aquatic and terrestrial wildlife, botanic, recreational, and cultural resources, and could affect land uses in the vicinity of the reservoir. Reservoir options at all three potential dam sites could affect special status, native, and game fish species. Aquatic life that would be affected by reservoir options at the RM 274 and RM 279 dam sites includes hardhead, American shad, and several types of bass. These fish reside in the upper portion of Millerton Lake, which would be within the new reservoir area for these dam sites. Reservoir options at RM 286 would affect fisheries in the reaches above and below Kerckhoff Lake and in

Kerckhoff Lake. While a new reservoir could inundate riverine native fish habitat and/or spawning habitat for striped bass and shad, it would also expand lacustrine habitat that could benefit cold water game species, and might create additional shallow water habitat beneficial to many species. It would also provide an opportunity to regulate flows so as to enhance conditions in Millerton Lake and/or the reach of the San Joaquin River above Millerton Lake that provides spawning habitat.

Wildlife species of concern that potentially would be affected by Temperance Flat Reservoir include the valley elderberry longhorn beetle, the California tiger salamander, the western pond turtle, and the foothill yellow-legged frog. Eagle, osprey, and waterfowl could benefit from a new reservoir.

Foothill woodlands and grasslands would be inundated by all reservoir options considered. Species for which mitigation would likely be required include tree anemone and Mariposa pussypaws.

Recreational resources could be affected in portions of the Millerton Lake State Recreation Area, the San Joaquin River Gorge Management Area, and the SNF. Recreational resources affected would depend on the reservoir option. The RM 274 and RM 279 options would inundate portions of the Millerton Lake State Recreation Area, but the RM 286 options would not. All options would affect some portion of the Patterson Bend or Horseshoe Bend whitewater boating runs. However, a new reservoir could provide new flat water recreation opportunities, improve access to recreational resources, and provide new recreational support facilities.

Prehistoric archaeological sites exist within the potentially inundated areas, as do homesteads and sites where mining occurred historically. Past mining sites have been identified but have yet to be assessed for their potential historic significance. While a new reservoir could inundate existing cultural resources, its development could create opportunities to expand knowledge of historic or prehistoric resources and enhance public interpretation of the past.

Existing land uses could be affected. Some of the options under consideration would inundate portions of the Backbone Creek RNA, which is protected under the SNF Long Range Management Plan, and the San Joaquin River Gorge Management Area, which is managed for recreation and wildlife habitat values by the BLM.

None of the Temperance Flat Reservoir options would physically divide an established community. However, individual private homes, private hydropower facilities and public facilities, including roads, bridges, and trails could be inundated. The RM 274 and RM 279 options would inundate the San Joaquin River Trail footbridge at Kerckhoff Powerhouse. Several of the reservoir options would submerge the bridge that crosses Kerckhoff Lake at Powerhouse Road (Road 222).

No engineering or environmental issues were identified that would preclude further consideration of a reservoir in the Temperance Flat area. However, all three potential dam locations would pose construction challenges related to site access or placement of cofferdams. Mitigation measures would need to be developed to reduce the significance of potential environmental impacts.

Temperance Flat Reservoir has been retained for further consideration in the Feasibility Study. Future work will include additional engineering, hydropower, and environmental evaluations of operations and impacts on existing resources.

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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
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