Upper San Joaquin River Basin Storage Investigation

Hungry Hollow 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

Upper San Joaquin River Basin Storage Investigation

Hungry Hollow in the Vicinity of the Potential Dam Site

Hungry Hollow 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

Prepared by:

MWH

October 2003

SURFACE WATER STORAGE OPTION TECHNICAL MEMORANDUM

HUNGRY HOLLOW RESERVOIR

UPPER SAN JOAQUIN RIVER BASIN STORAGE INVESTIGATION

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Acronyms and Abbreviations List

CEQA	California Environmental Quality Act
cfs	cubic feet per second
CNDDB	California Natural Diversity Database
Corps	United States Army Corps of Engineers
CVP	Central Valley Project
elevation	number of feet above mean sea level
FWUA	Friant Water Users Authority
HEP	Habitat Evaluation Procedure
Investigation	Upper San Joaquin River Basin Storage Investigation
NEPA	National Environmental Policy Act
NRHP	National Register of Historic Places
NRDC	Natural Resources Defense Council
Reclamation	Bureau of Reclamation
ROD	Record of Decision
SAW	sycamore alluvial wetland
TAF	thousand acre-feet
TM	Technical Memorandum
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

EXECUTIVE SUMMARY

The Upper San Joaquin River Basin Storage Investigation (Investigation) considered several potential storage options in the San Joaquin Valley. This document describes a potential dam and reservoir to be constructed on Deer Creek, a tributary of the Tule River, about 3 miles south of Lake Success and 6 miles east of Porterville. Hungry Hollow Dam would be a zoned earthfill structure 267 feet in height and 5,200 feet in length and would impound an off-stream reservoir with a storage capacity of up to 800 thousand acre-feet. Additional features would include two saddle dams, a spillway, outlet works, and relief wells along the downstream toe of the dam.

Two configurations for the dam and reservoir were previously considered. The first would divert water from the Friant-Kern Canal via a two-way canal and pump it into the reservoir. This diversion would require three pump stations and two small regulating reservoirs. Stored water would be conveyed back to the Friant-Kern Canal. The second option involves diverting water from the Tule River at Lake Success and pumping it into Hungry Hollow Reservoir via a 10-foot diameter tunnel nearly 3 miles in length. In this case, stored water would be released down Deer Creek and diverted into the Friant-Kern Canal in exchange for releases from Millerton Lake.

Extensive young alluvial deposits, over 300 feet thick, lie beneath the axis of the potential dam. These deposits are unconsolidated, loose, permeable, and subject to liquefaction during an earthquake. Although no significant faults passing through the site have been identified, the alluvium would not provide an adequate foundation. Costly actions to provide a suitable foundation might be required, such as removal and recompaction or densification in place.

Other aspects of construction appear to pose few or no problems. Sufficient impervious, pervious, and riprap materials can be found within 2 miles of the dam site and potential staging and lay-down areas are immediately upstream and downstream of the potential site. Existing roads provide direct site access, and electrical power is likely available from sources in Porterville; along the county road within Hungry Hollow or Deer Creek valleys; or from high voltage power lines to the east.

Most of the inundated area would be common annual grassland. However, the reservoir would inundate up to 8 miles of Deer Creek, which supports well-developed sycamore alluvial woodland (SAW), an important regional wildlife habitat. Wetland habitat may be present as well. Also, several listed plant and wildlife species are found in the area of the potential dam and reservoir. Populations of fish and other organisms adapted to stream environments would be reduced or eliminated, while species suited to lake environments would be enhanced. Twenty-nine archaeological sites were identified in the late 1960s and it is likely that additional sites would be found with more extensive surveys.

This option has undesirable foundation conditions and would cause adverse and unmitigable affects to SAW habitat. Therefore, it was dropped from further consideration in the Investigation.

THIS PAGE LEFT BLANK INTENTIONALLY

CHAPTER 1. INTRODUCTION

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

The Investigation identified several potential surface storage sites to be initially considered through prefeasibility-level studies of engineering and environmental issues. This Technical Memorandum (TM), prepared as a technical appendix to the Phase 1 Report, presents findings from a prefeasibility-level review of the potential Hungry Hollow Dam and Reservoir.

OPTION SUMMARY

The potential Hungry Hollow Reservoir would be located in Tulare County, about 4 miles southeast of Porterville and a few miles south of Lake Success. Hungry Hollow Dam would be situated on Deer Creek, an intermittent stream just south of the Tule River. The general site location is shown in Figure 1-1. A map of Deer Creek, Hungry Hollow, and vicinity is presented in Figure 1-2.

Hungry Hollow Reservoir would have a maximum capacity of 800 thousand acre-feet (TAF) and would primarily provide off-stream storage for water pumped from the Friant-Kern Canal. Stored water would be later conveyed back to the Friant-Kern Canal to supplement existing Central Valley Project (CVP) deliveries or to offset releases from Millerton Lake to the San Joaquin River.

EXISTING FACILITIES

No water storage facility presently exists at the site. Success Dam, which impounds Lake Success on the Tule River, is located approximately 4 miles north northwest of the potential Hungry Hollow Dam site.

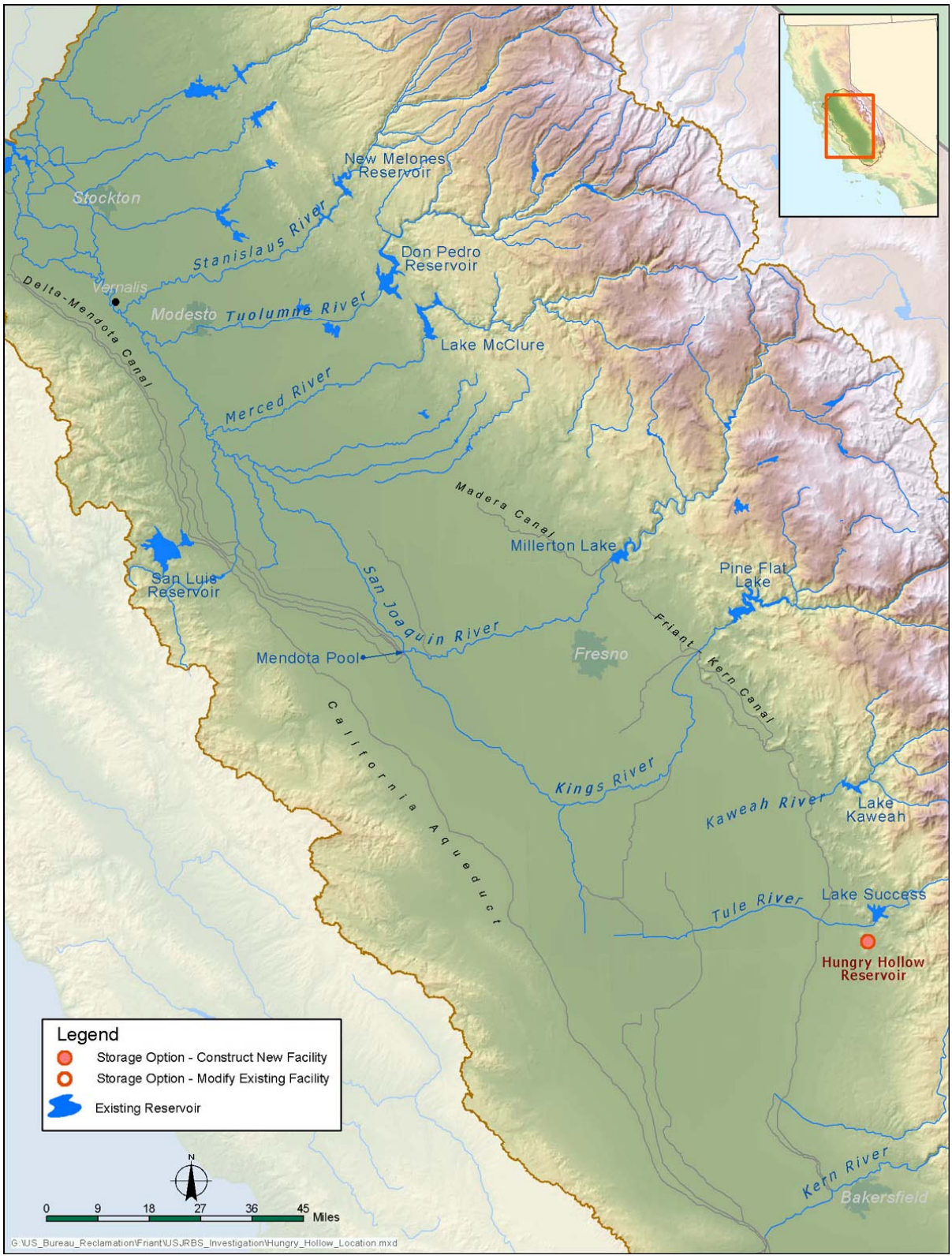


FIGURE 1-1. HUNGRY HOLLOW SITE LOCATION MAP

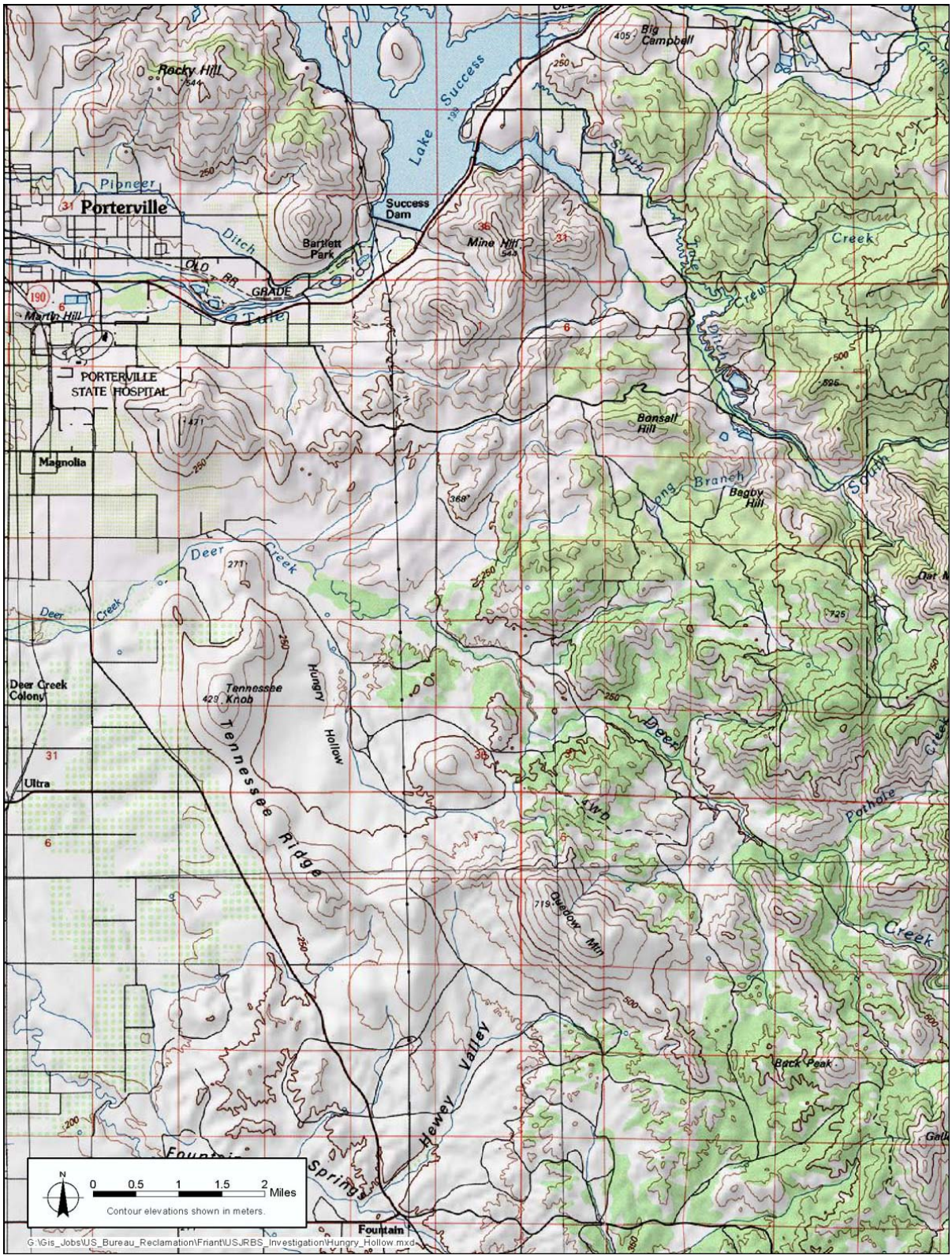


FIGURE 1-2. HUNGRY HOLLOW AND VICINITY

SUMMARY OF PREVIOUS INVESTIGATIONS

Reclamation first studied the possibility of constructing a storage facility at Deer Creek and Hungry Hollow in the late 1950s and early 1960s. In January 1961, Reclamation prepared an engineering geology report that discussed the geotechnical conditions associated with pumping plants and a canal that would convey water from the Mid-Valley Canal, then being considered in planning studies (Reclamation, 1961a). In March 1961, Reclamation prepared a reconnaissance design drawing and cost estimate for a dam within the valley of Deer Creek (Reclamation, 1961b). The dam would allow for the storage of water conveyed from the Mid-Valley Canal. Conceptual level cross sections, plan views, and details were included for a proposed embankment dam, outlet works, and spillway. The documentation also included area-capacity-discharge curves.

In 2000, Hungry Hollow Reservoir was also considered in a report prepared for the Friant Water Users Authority (FWUA) and Natural Resources Defence Council (NRDC) Coalition (URS, 2000). The study proposed that the reservoir be filled principally by excess Tule River flood flows diverted via tunnel from Lake Success.

POTENTIAL IMPROVEMENTS CONSIDERED

The potential impounding structures would consist of a 267-foot-high zoned earthfill main dam and two saddle dams, creating a reservoir that could store approximately 800 TAF of water. The main dam crest would be approximately 5,200 feet long (Figure 1-3). Normal maximum conservation pool elevation would be at 812 feet above mean sea level (elevation 812).

Reclamation's 1961 reconnaissance-level studies proposed an off-stream reservoir designed to principally store water from the Mid-Valley Canal, plus local runoff from the Deer Creek drainage, for later use during the irrigation season (Reclamation, 1961b). As a modification to Reclamation's original concept, the current proposal involves using the Friant-Kern Canal as the principal source of water. This would involve construction of three pump stations and 9 miles of canal. (This is shown as "Option 1" in Figure 1-3.) In addition to a regulating reservoir previously included in the Mid-Valley Canal study, a second, small, lined regulating reservoir would be needed near the Friant-Kern Canal.

The report prepared in 2000 for the FWUA/NRDC Coalition proposed diverting excess Tule River flows from Lake Success via a 15,000-foot-long, 10-foot-diameter gravity tunnel. However, since Hungry Hollow Reservoir's normal maximum water surface would be at elevation 812 and the maximum pool at Lake Success is elevation 653, an intake structure and pumping plant at Lake Success would be required to fill Hungry Hollow reservoir. (This is shown as "Option 2" in Figure 1-3.) Such an option would also involve exchanging water from Millerton Lake for any water taken from the Tule River.

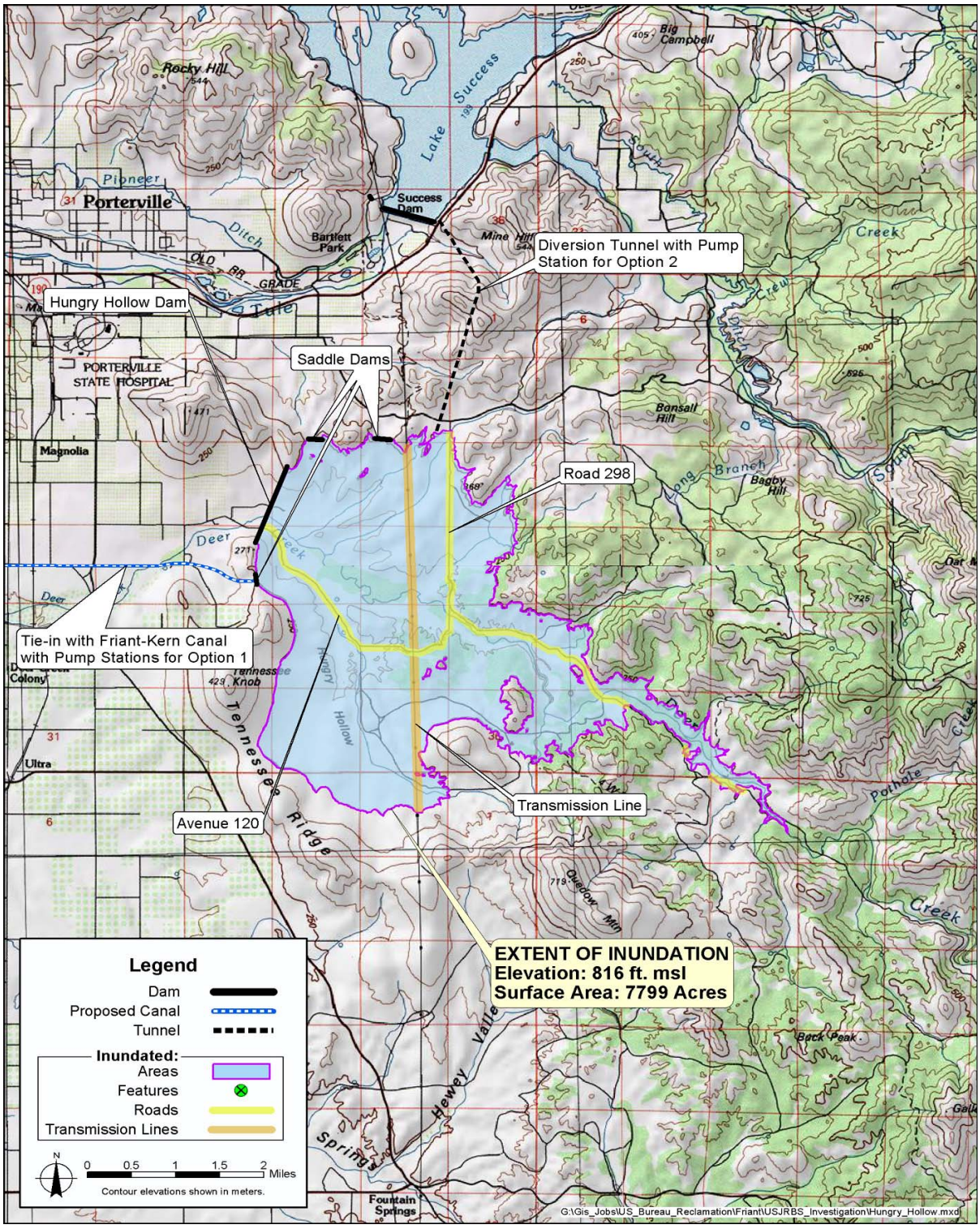


FIGURE 1-3. POTENTIAL STRUCTURES AND INUNDATED FACILITIES

APPROACH AND METHODOLOGY

This Technical Memorandum (TM) was prepared from a brief review of the prior studies listed above, an engineering field reconnaissance on 13 June 2002 (Appendix A), and an environmental field reconnaissance of the dam and reservoir on 31 May 2002 (Appendix B).

During the June 2002 field trip, engineers and geologists examined the site under consideration. Locations of existing and potential structures were visually assessed. Topography, geology, geotechnical conditions, and utilities were noted. Access routes and possible borrow, staging, and lay-down areas were considered.

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

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

For prefeasibility-level planning studies, designs and analyses are typically quite general. Extensive efforts to optimize the design have not been conducted, and only limited value engineering techniques have been used.

CHAPTER 2. TOPOGRAPHIC SETTING

Regional topography consists of the nearly level floor of the San Joaquin Valley rising abruptly to moderately steep, northwest-trending foothills with rounded canyons. Elevations in the immediate area range from about elevation 530 to over elevation 1,300.

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 Tule River is the main river in the area. Deer Creek is a west- to northwest-trending intermittent stream that eventually terminates near the community of Terra Bella, about 25 miles to the west.

At the potential dam site, the valley floor is relatively broad (about 2,000 feet). The streambed at the potential dam axis is at approximately elevation 555. The left abutment is a moderately steep 3:1, while the right abutment is about 5:1, becoming steeper to about 3:1 above the proposed crest elevation. The left ridge rises to about elevation 890 and the right ridge to about elevation 1,050.

AVAILABLE TOPOGRAPHIC MAPPING

Topographic mapping other than that available publicly from the United States Geological Survey (USGS) is not known. Base maps apparently used by Reclamation in its geologic investigation appear to be from USGS sources.

AVAILABLE AERIAL PHOTOGRAPHY

Aerial photography of various scales and imagery is available from the archive files of USGS. Additional aerial imagery may also be available from the U.S. Department of Agriculture, Reclamation, and the United States Army Corps of Engineers (Corps). A specific search of the available photography was not conducted for this TM nor was any aerial photography reviewed.

THIS PAGE LEFT BLANK INTENTIONALLY

CHAPTER 3. GEOLOGIC AND SEISMIC SETTING

The Hungry Hollow site area is located near the boundary of the Sierra Nevada Geomorphic Province and the San Joaquin Valley portion of the Great Valley Geomorphic Province. The Great Valley basin is filled with thick accumulations of marine (at depth) and non-marine sediments shed largely from the Sierra Nevada mountain range. Recent alluvium of lake and river origin blankets most of the present-day surface, while dissected remnants of Pleistocene alluvial fans rim the valley margin.

The Sierra Nevada mountains are characterized by batholiths of Mesozoic granitic rock and Paleozoic roof pendants of the Calaveras Complex and related rocks. The Sierra Nevada foothills take the form of outliers of low to irregular hills of Mesozoic granitic, and late Paleozoic to Mesozoic basic and ultrabasic, rock (ophiolites) of the "serpentine belt" of the Kings-Kaweah suture, as well as other associated Mesozoic metamorphic rocks.

Overall, seismic hazard potential at the site is low. Preliminary earthquake loading analysis for this prefeasibility-level evaluation, considered two types of potential earthquake sources: fault sources and areal/background sources (Reclamation, 2002).

Twenty-two potential fault sources for the site were identified, including 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 system. No major through-going or shear zones have been identified in this area of the Sierra Nevada and historic seismicity rates are low.

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

Probabilistic seismic hazard analysis performed shows that peak horizontal accelerations to be expected at the site are 0.13g with a 2,500-year return period, 0.18g with a 5,000-year return period, and 0.23g with a 10,000-year return period.

SITE GEOLOGY

The oldest rocks exposed in the area are Paleozoic-Mesozoic metamorphics (amphibolite schists), which are intruded at depth by the dominantly granitic Sierra Nevada batholith in which they remain as roof pendants, sometimes of considerable extent.

Miocene to recent sediments overlap the eroded surface of the Basement Complex. The oldest is the continental Mio-Pliocene "Santa Margarita" formation, which is not known to be exposed in the area but is encountered in oil wells of the Deer Creek Oil Field to the west. The Plio-Pleistocene continental Kern River Series overlies the "Santa Margarita" formation in the western part of the area, and laps onto the Basement Complex to the east.

The term "Kern River Series" includes both the Kern River formation and the overlying "Old Alluvium" from which it is generally indistinguishable. When the two units are separately mapped, the separation is usually based on topography. For practical purposes, lithologies, depositional environment, and engineering properties are identical. The Kern River Series is a heterogeneous sequence of fluviatile sediments deposited by streams emerging from the Sierra Nevada and forming fans, which coalesced to form a piedmont. This piedmont was in turn dissected as further Sierran uplift and glaciation occurred.

These deposits consist of reddish-brown, arkosic sand, silts, clays, and occasional gravels, frequently with clayey topsoils.

The Kern River Series is the main groundwater storage unit of the area. Groundwater movement is relatively unrestricted, although rates vary, since differences in degree of weathering and compaction affect permeability.

The Porterville clays are weathered decomposition products of basic igneous and metamorphic rocks, transported generally by soil creep and slopewash. They form sloping belts on the lower flanks of Tennessee Ridge (left abutment) and occur as a thin mantle of soil at higher elevations. The clays are black to reddish-brown, variably fat, calcareous, with scattered sand grains and rock varying from angular fragments to boulder-size material.

The younger fluvial/alluvial deposits beneath the axis of the potential dam were found to be around 318 feet thick, grading into thinner deposits of rocky clay slope wash (Porterville clay) on the flanks of the right and left abutments. The younger alluvium is dominated by gray to brownish-gray, arkosic, relatively clean sands, which are occasionally silty but in which clay beds are rare. Gravels are sparse or absent at the surface, but were encountered in drilling performed by Reclamation along the proposed dam axis. The younger alluvium is generally pervious, loose, and uncompacted.

No significant through-going faults have been identified in the potential Hungry Hollow Dam and Reservoir site.

SITE GEOTECHNICAL CONDITIONS

Geologic mapping conducted as part of the geologic investigation shows that the dam site, the two saddle dikes, and a tunnel from Lake Success would be founded largely on metamorphic amphibolite. Where fresh, this rock is hard with medium-spaced joints and fractures. It would not require appreciable grouting for seepage control. Where weathered to highly weathered in the upper 50 to 75 feet, decomposition of this rock makes it medium hard to soft, with closely to very closely spaced fractures requiring grouting for seepage control.

The younger alluvium beneath the dam may have to be removed or densified beneath the clay core zone and beneath the upstream and downstream shells because it is unconsolidated, loose, and permeable, and would be subject to liquefaction during an earthquake. Excavated slopes would be stable at a 2:1 ratio for non-saturated portions above groundwater and stable at flatter slopes below the water table. Excavated materials would be suitable as free-draining shells surrounding a clay core comprised of compacted Porterville clay.

A potential regulating reservoir adjacent to the Friant-Kern Canal in the Old Deer Creek Channel would be underlain by the loose, pervious, sandy alluvium that partially fills the channel. Here it is estimated that this younger alluvium is about 35 feet thick and is too pervious for an unlined reservoir.

Pumping Plant No. 1 would be located close to the junction with the present stream channel and flood plain. Here, channels are incised in older, often well-consolidated, alluvial sediments of the Kern River Series and are partially filled with younger, pervious alluvium. It is estimated that these deposits overlie older, clayey, consolidated sediments.

Pumping Plant No. 2 would be a short distance south of the left edge of the Deer Creek flood plain. Pervious sand and pebble gravels of the present channel and flood plain are underlain by older, often well-consolidated alluvial deposits of the Kern River Series.

The Hungry Hollow Pumping Plant would be founded in hard, fresh amphibolite, which would require rock excavation (drill and blast) below a depth of 5 feet. Slopes of the excavation would be stable at ½: 1.

THIS PAGE LEFT BLANK INTENTIONALLY

CHAPTER 4. HYDROLOGIC SETTING

The watershed upstream of the potential Hungry Hollow Dam is approximately a 20-square-mile drainage area containing the intermittent Deer Creek.

RAINFALL

Normal annual precipitation in the Tule River Basin varies from about 6 inches at the lower elevations to 50 inches at the headwaters. The normal annual rainfall for the basin above Success Lake is 30 inches. Rainfall within the drainage basin of Deer Creek is expected to be very similar.

EROSION, RUNOFF, AND RECHARGE

The drainage basin contains medium and fine-textured soils developed in alluvium weathered from igneous and metamorphic rocks. Permeability ranges from slight to moderate. In the conceptual design of Hungry Hollow Dam, Reclamation allowed for 3.20 TAF of sedimentation.

Winter rain floods generally occur from November through April and are characterized by sharp peaks with most of the volume occurring within a few days.

The design flood has a peak inflow of 36,700 cubic feet per second (cfs) and 3-day volume of 76.4 TAF.

AVAILABLE FLOOD DATA

Detailed flood data were not identified in the documents reviewed.

THIS PAGE LEFT BLANK INTENTIONALLY

CHAPTER 5. STORAGE STRUCTURES AND APPURTENANT FEATURES

This chapter describes the recommended storage structure and appurtenant features for the Hungry Hollow site, and the constructibility, cost, and systems operations for this option.

STORAGE STRUCTURE

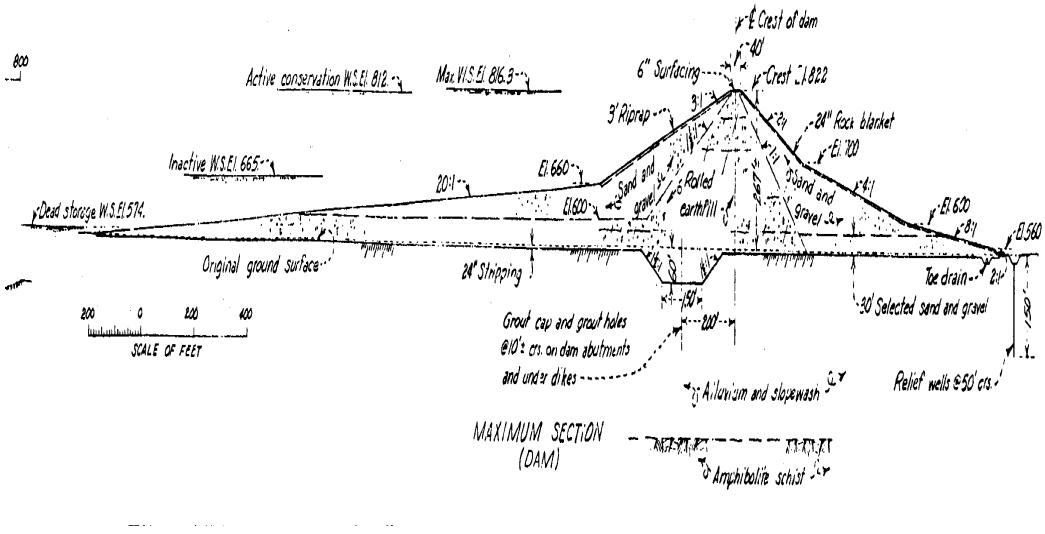
The original Reclamation reconnaissance design drawing for the potential Hungry Hollow Dam shows a 267-foot-high zoned earthfill embankment dam. The potential structure has a 3:1 (horizontal to vertical) upstream slope initially, from crest elevation 822 to elevation 660; the upstream slope flattens to a 20:1 slope from elevation 660 to elevation 600. The downstream slope is shown to be 4:1 from the crest to elevation 600, then flattening to 8:1 in the lower portion, from elevation 600 to elevation 560. Figure 5-1 is a cross section from the 1961 Reclamation study.

As designed, the rolled earthfill core would be keyed 60 feet into the alluvium with a grout cap and curtain of undetermined depth. The upstream slope would be protected with a 3-foot thick layer of riprap and the downstream slope would have a 2-foot thick rock blanket. The upstream and downstream shells would be constructed using compacted sand and gravel. Smaller finger dikes, on the ridges surrounding the reservoir, would be constructed in a similar manner, but they would be built on amphibolite schist bedrock.

The river outlet works would consist of a 250-foot-long, 6-foot-diameter circular tunnel leading to a 4-foot by 4-foot tandem gate valve. Downstream of the gate valve, the outlet would consist of a 6-foot by 8-foot tunnel. The tunnels and gate chamber would be founded in amphibolite schist.

A second outlet works, the canal outlet works, would consist of a 200-foot-long, 16-foot-diameter circular tunnel to a 12.5-foot by 16-foot gate with a gate shaft to the crest of the dam. From the gate valve, a distance of 250 feet, there would be a 22-foot-diameter tunnel with a 16-foot-diameter steel penstock. This penstock surfaces in an excavation and then necks down to a 12-foot-diameter steel pipe, which bifurcates just before the control house and pumping plant into two 7.5-foot-diameter steel pipes.

The spillway would be located on the left abutment and founded in amphibolite schist. A surcharge storage of 31 TAF (maximum pool elevation 816.3), in combination with a spillway discharge capacity of 24,000 cfs, would be provided to protect against an inflow design flood with a peak discharge of 36,700 cfs and 3-day volume of 76.4 TAF.



Source: Reclamation, 1961b

FIGURE 5-1. CROSS SECTION OF POTENTIAL HUNGRY HOLLOW DAM

This original Reclamation plan probably would not be approved under current design criteria for seismic conditions due to the potential for liquefaction of the loose, saturated, recent stream alluvium (sand and gravel) beneath the central portion of the embankment (about one-quarter of the embankment length). If constructed using current seismic design standards, the potentially liquefiable alluvium would have to be excavated to bedrock (a depth of about 300 feet) and replaced with compacted clay in the core area and compacted sand and gravel beneath the shells. *In situ* densification of the loose sands and gravels could be contemplated, but to the depths needed, it is doubtful this technique would be effective. Additional geotechnical exploration and testing would be required to further evaluate liquefaction potential.

RESERVOIR ELEVATION/CAPACITY CURVE

The reservoir storage volume versus elevation curve is shown in Figure 5-2.

APPURTENANT FEATURES

This section describes major appurtenant features that would be associated with the dam.

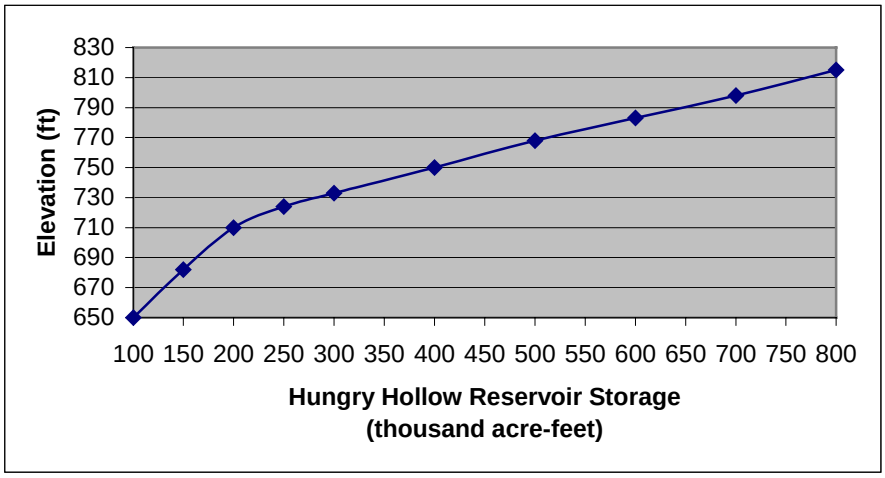


FIGURE 5-2. ELEVATION VS. STORAGE CURVE

Conveyance

Two conveyance systems would be considered, depending on whether the potential Hungry Hollow Dam and Reservoir option would draw water from the Friant-Kern Canal or from Lake Success.

For the Friant-Kern Canal option, about 9 miles of channel, three pumping plants, and two regulating reservoirs would be required. The total lift from the Friant-Kern Canal at elevation 425 to the Hungry Hollow Reservoir maximum conservation pool at elevation 812 would be 387 feet.

With the Lake Success concept, a pumping plant and intake structure would be required along with 3 miles of tunnel from Lake Success to the potential Hungry Hollow Reservoir. The total lift from Lake Success would be approximately 175 feet.

Pumping Plants

Three pumping plants would be required to take water from the Friant-Kern Canal. A plant with similar capacity would be needed to draw water from Lake Success.

CONSTRUCTIBILITY

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

Land, Rights-of-Way, Access, and Easements

Based on the 1961 Reclamation Cost Estimate (Reclamation, 1961a), lands costs for Hungry Hollow Dam would be $1,250,000. The number of potential residents affected was not reported.

Approximately 8 miles of county road, a county road camp, and about 5 miles of high-voltage power lines would have to be relocated. Power and telephone lines along the county road would have to be relocated. The 1961 costs for relocating the existing county road was set at $585,000 and cost to relocate utilities was set at $500,000.

Easements for the various canals and pumping plants connecting to the Friant-Kern Canal would be required. For tunnel construction from Lake Success, it is expected that an easement similar to a pipeline easement would be required.

Borrow Sources/Materials

It is not clear whether detailed evaluation of borrow source volumes was previously conducted by Reclamation. However, a brief review of the literature and a field reconnaissance indicate that sufficient impervious, pervious, and riprap materials can be located within 2 miles upstream and downstream of the potential dam.

Portland cement is available from nearby commercial sources, including six producers within a few hundred miles of the potential dam site. Bulk transport to the site could be by truck or railcar. Pozzolan is available locally from producers in Stockton or Sacramento.

Foundations

It is anticipated that the dam foundation would be in stiff, hard clay deposits and loose, recent alluvium overlying relatively hard rock with relatively tight, medium to closely spaced fractures and joints. Pre-split drilling and light blasting could be required for rock excavation. Some soft, sheared zones might be encountered, but these could be backfilled with lean concrete for minor dental preparation of the foundations.

Replacement of the loose sand and gravels with more stable material beneath the core and shells of the main dam would be required. Conceivably, as an alternative approach, the loose alluvium might be densified in place.

The spillway would be founded in generally sound amphibolite schist. Spillway excavation would be about 75 percent rock consisting of lightly to moderately weathered, moderately jointed rock with occasional intensely fractured zones. Slopewash and residual soils are expected to be several feet thick. The apron of clayey, rocky colluvium at the base of the slope is expected to be several hundred feet thick.

A tunnel from Lake Success would extend through pre-Cretaceous meta-sedimentary and meta-volcanic rocks and ultrabasic, basic, and granitic rocks.

Power Sources

Electrical power is expected to be available from sources in Porterville or along the county road within Hungry Hollow/Deer Creek valley, or from the high voltage power lines to the east.

Staging and Lay-Down Area

Potential staging and lay-down areas are located immediately upstream and downstream of the site.

Contractor Availability and Resources

There are several local general engineering contractors or regional-based general engineering contractors capable of performing the embankment construction, rock excavation, concrete-forming and placement, rock berm construction, and general grading and excavation.

Construction Schedule and Seasonal Constraints

The dam, canals, pumping plants, and/or tunnel would require multiple construction seasons. Seasonal constraints would include the period between April and June when spring snowmelt floods usually occur and possibly late October when the wet season starts. At this elevation, construction should be able to continue through the winter, if long periods of heavy rain do not prevail.

Flood Routing During Construction

The river and canal outlet works would likely be sufficient for the very infrequent flood routing that might be needed during construction of the dam embankment and spillway.

Environmental Impacts During Construction

Environmental impacts during construction could be mitigated with proper planning and implementation of best management practices. The site is not close to urbanized areas; therefore, visual impacts would be minimal and few people would be affected by construction noise. The county road would require re-routing. Public access could be restricted, except for those property owners with lands upstream. Air quality issues could be mitigated by dust control measures for both the spillway excavation and the berm construction. Truck traffic for importing rock and excavation equipment would discharge exhaust to the local air basin. Blasting for the spillway would require both noise and vibration monitoring on the dam. A cultural survey should be conducted to identify any ancestral American Indian or historic artifacts and construction activities would be restricted in those areas. Importing rock from distant quarries would cause traffic impacts, but with proper planning and coordination with CALTRANS, major impacts could be mitigated. All construction equipment should have spark arresters, and fire control equipment should be keep readily accessible during construction. Construction water would have to be controlled and provisions made for runoff and erosion control. A spill control plan would be needed to control any construction-related fuels, lubricants, and other materials.

Permits

Federal projects are not subjected to the same level of permitting required for non-Federal projects; however, assuming relevant potential environmental and cultural impacts exist, at a minimum, the certain permits may be required from the permitting agencies listed in Table 5-1.

TABLE 5-1. POSSIBLE PERMITS REQUIRED

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

Key:

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

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

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

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

- Construction Plan and Summary Documents
- Quality Control Inspection Plan
- Highway Notification Plan
- Blasting Plan
- Noise Monitoring Plan
- Water Quality Monitoring Plan

- Noxious Weed Control Plan
- Bat Protection Plan
- Management Plan for Avoidance and Protection of Historic and Cultural Properties
- Storm Water Pollution Prevention Plan
- Spill Prevention/Containment Plan
- Visual Quality Control Plan
- Dust Control and Air Quality Plan

Another important regulatory requirement involves compensation/mitigation for habitat loss. In October 1998, USFWS issued 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.

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

COSTS

The 1961 Reclamation cost estimate (Reclamation, 1961a) was updated to April 2002 unit costs using Reclamation Construction Cost Trends, then adjusted to reflect conveying the Friant-Kern Canal, instead of from the Mid-Valley Canal as originally conceived. A variation of the resulting cost estimate was also produced that substitutes conveyance of water from Lake Success via tunnel, instead of the Friant-Kern Canal. Estimated costs were evaluated by MWH dam cost estimators and modified as needed to reflect current material costs and standards of practice, especially with respect to seismic requirements. Costs for items not included in the original Reclamation cost estimate were estimated based on experience with similar facilities and general conditions.

Initial Construction Costs

Summaries of the estimated costs are presented in Table 5-2 and Appendix C. Field costs represent the estimated cost to construct identified features, plus provisions for unlisted items (15 percent), contingencies (25 percent), and mitigation (5 percent). To be consistent with the estimating methodology used for storage options at other sites, costs for relocations of existing infrastructure are captured in the provision for "unlisted items." Total costs include field costs, estimated costs for future analyses and planning documentation, development of designs, and construction management (15 percent), and land costs. The estimated total first cost to construct the potential Hungry Hollow Dam and Reservoir, with conveyance from the Kern-Friant Canal, is approximately $771 million. The estimated first cost of the option with conveyance from Lake Success is approximately $777 million.

Operations and Maintenance Costs

Operations and maintenance costs were not evaluated in any previous studies of the potential Hungry Hollow Dam and Reservoir and were not estimated during the current prefeasibility-level stage of the Investigation.

SYSTEMS OPERATIONS

Water stored in Hungry Hollow Reservoir would be conveyed to the Friant-Kern Canal to supplement existing CVP deliveries or to offset releases from Millerton Lake to the San Joaquin River.

TABLE 5-2.
SUMMARY OF FIRST COSTS

Hungry Hollow Dam and Reservoir	Estimated Cost ($Million)	
Cost Component	**Conveyance from Friant-Kern Canal**	**Conveyance from Lake Success**
Diversion and Care of River	0.5	0.5
Main Dam	349.1	349.1
Spillway	5.2	5.2
Tunnel	-	54.0
Canals / Pipelines	15.0	15.0
Pumping Stations	60.0	20.0
Regulating Reservoirs	10.0	-
Unlisted Items	66.0	66.6
Contingency	127	128
Mitigation	32	32
Total Field Cost	**665**	**670**
Investigation/Design/CM	100	101
Lands	6	6
Total First Cost	**771**	**777**

CHAPTER 6. HYDROELECTRIC POWER OPTIONS

Various hydroelectric power options were considered for each storage site, including Hungry Hollow.

PUMPED STORAGE CONSIDERATIONS

Development of Hungry Hollow Reservoir would provide an opportunity to store water pumped from the Friant-Kern Canal.

ADDED HYDROELECTRIC POWER TO EXISTING STRUCTURES

There are no existing water storage or hydroelectric structures on Deer Creek.

NEW HYDROELECTRIC POWER

If additional study of storage options at Hungry Hollow were pursued, hydroelectric power generation capability could be incorporated into the potential dam.

TRANSMISSION AND DISTRIBUTION

If hydroelectric power generation at Hungry Hollow were to be pursued, the existing transmission and distribution system in the area would need to be evaluated for its ability to support the transmission of additional power generation.

THIS PAGE LEFT BLANK INTENTIONALLY

CHAPTER 7. ENVIRONMENTAL CONSIDERATIONS

This chapter describes existing environmental resources at the site and qualitatively describes potential effects of reservoir development. The discussion in this chapter is intended to indicate the extent to which expected or potential environmental effects might pose a constraint to reservoir development. Where evident, opportunities for improving environmental resources or mitigating adverse effects have been noted. Analysis focused on botany, terrestrial wildlife, aquatic biology, recreational resources, cultural resources, and existing land uses. Mining and other known past activities that might affect site conditions are also briefly discussed, along with the potential presence of hazardous or toxic materials. Temporary construction-related disruptions and impacts are discussed in Chapter 5.

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

BOTANY

The biotic habitat consists mostly of annual grassland with small amounts of oak woodland. Extensive riparian woodland occurs along Deer Creek. The stream environment hosts a well-developed sycamore alluvial woodland (SAW). Although sycamore trees are common, SAW has been described as a “very rare and essentially irreplaceable habitat type” (Carson, 1989). There are fewer than six viable occurrences and/or less than 2,000 acres of SAW in California and worldwide (Prose, 2002). Vernal pools may be present in much of the flatter portion of the area, although geologic formations that generally have vernal pools are not present.

Six special-status plant species occur in the area around the Hungry Hollow site: spiny-sepaled button-celery, Tulare pseudobahia, striped adobe-lily, Keck's checkerbloom, Madera linanthus, and calico monkeyflower. Two of these are listed: Tulare pseudobahia (Federally listed as threatened, State-listed as endangered) and striped adobe-lily (state-listed as threatened). Habitat for most of the six special status species may be present, but surveys are needed before a determination can be made. There may be a high potential for vernal pool species.

Constraints

Much of the habitat affected by this measure would be annual grassland. However, large amounts of riparian habitat may be affected, and wetland habitat may also be present. The potential for special-status species is low to moderate.

Reservoir construction and water diversion are considered threats to SAW, as sycamores have little tolerance to artificially manipulated water levels (Prose, 2002). Sexual regeneration of SAW depends on substantial scour caused by flood events (Enstrom, 2002). Developing Hungry Hollow Reservoir would thus be likely to adversely affect this resource.

Opportunities

On-site mitigation of large amounts of riparian habitat is unlikely. Replacing SAW is unlikely to be successful and its destruction therefore unmitigable (Enstrom, 2002).

WILDLIFE

The habitats of Hungry Hollow and adjoining Deer Creek are foothill woodland and grassland communities. As mentioned above, Deer Creek also hosts well-developed SAW, a sensitive habitat type that hosts a diverse assemblage of wildlife, particularly birds.

While the CNDDB does not list such sensitive species as the yellow-billed cuckoo and willow flycatcher as inhabiting the site, future studies would need to verify the presence or absence of these two species.

The San Joaquin kit fox is known to inhabit the area, and northern clay pan vernal pools may also be present. The vernal pools generally host fairy shrimp, which are State- and Federally designated sensitive species. The host plant for the valley elderberry longhorn beetle, *Sambucus mexicana*, is expected to be present; thus the beetle itself, a Federally listed threatened species, is also likely to be present.

Constraints

Loss of the SAW habitat would be an adverse effect of regional relevance. If this habitat also hosts species of wildlife that are considered sensitive, it would be an even greater concern.

AQUATIC BIOLOGY/WATER QUALITY

Deer Creek is an intermittent stream with a wide, braided channel and well-developed riparian vegetation. Numerous small fish were observed in the stream during the May 2002 field visit, so pool habitat likely persists through the dry season. The most likely native fish species to occur in this stream is the California roach. Its presence would need to be investigated. The San Joaquin form of this species has been designated a State Species of Special Concern. Habitat in Deer Creek is probably also suitable for the exotic species mosquito fish and green sunfish.

Constraints

At maximum pool, the reservoir would inundate nearly 8 miles of Deer Creek. The principal effects of this option on aquatic biological resources would result from replacing stream habitat with lacustrine habitat. Populations of fish and other organisms adapted to stream environments would be reduced or eliminated from inundated areas, while those of species adapted to lacustrine conditions would be enhanced. The most likely native fish species to be affected would be California roach, generally not found in lakes.

Storage and releases from the reservoir would likely alter flow and water temperature regimes of Deer Creek downstream of the potential dam. However, the section of the creek between the dam site and the Friant-Kern Canal is fairly short, so effects on aquatic biological resources would be limited.

Opportunities

The principal opportunity afforded by this option is substantial new fish habitat created by the potential reservoir. Hungry Hollow Reservoir would likely stratify each summer, but because it would be open and only moderately deep, stratification could be weak. Therefore, the reservoir would provide excellent conditions for warm-water fisheries. Cold-water fish could certainly survive part of the year, but annual stocking could be required to sustain a cold-water fishery.

Fish habitat in the new reservoir could be greatly improved if the dam were operated to minimize water level fluctuations, at least during times of year important for fish spawning and rearing.

RECREATION

No recreation facilities exist in the immediate area of the site.

Constraints

Construction of the Hungry Hollow Dam and Reservoir would not result in significant impacts to recreation resources because the reservoir would not inundate developed recreation facilities or dispersed recreation areas.

Assuming any water diverted from Lake Success would only be excess flood flows that otherwise would be released from Success Dam, this option would not affect recreational resources at Lake Success, since water levels at Lake Success would not be affected.

Opportunities

Developing Hungry Hollow Reservoir would not result in adverse impacts to recreational resources; thus, no mitigation would be required. However, reservoir creation would provide new recreation opportunities and draw recreation visitors. Consequently, any future plans should consider development of recreation facilities such as picnic and parking areas, camping areas, and a boat launch.

CULTURAL RESOURCES

The Hungry Hollow area is within Southern Valley Yokuts territory, specifically that of the Koyeti band. The Koyeti villages known as Ahsaw and Kiahlu were located on or near Deer Creek. The Bokninuwad Yokuts occupied Hungry Hollow proper, and after historic contact, Bankalachi and Tubatulabal people occupied villages in the area. Sototlo is said to have been a mixed Bankalachi-Tubatulabal village within Hungry Hollow. Most Southern Valley and Foothill Yokuts people now live on the Tule River Indian Reservation, near Porterville.

The riparian zone along Deer Creek and the adjacent blue oak woodland undoubtedly provided an attractive natural resource area. Archaeological reconnaissance of the area in 1968-1969 resulted in discovery of 29 archaeological sites. A complete survey would likely have revealed additional sites. Recorded sites include one site with house pits, several large midden sites with bedrock milling features, a number of small bedrock milling sites, isolated grinding features, a rock shelter, and a site with two mounds.

Specific information is presently unavailable regarding historic use of the Hungry Hollow area. A variety of potentially historic sites is likely to be present associated with mining, agriculture, and other activities.

Constraints

Numerous cultural resources are present, and there may be additional sites not yet recorded. Inundating archaeological sites (prehistoric or historic) can result in loss of important scientific data. As many as 29 archaeological sites could be adversely affected by constructing Hungry Hollow Dam and Reservoir. No sites eligible for the National Register of Historic Places (NRHP) have been recorded. However, future studies would likely result identify some sites as NRHP-eligible. No Native American sacred sites or Traditional Cultural Places are known, but Southern Valley Yokuts concerns would be expected.

Opportunities

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

LAND USE

Constructing the potential Hungry Hollow Dam and Reservoir would result in relocating several well-traveled roads (including several bridges) and also transmission lines:

- Avenue 120
- Avenue 138
- Road 298
- Two electric transmission lines (one high-voltage)

Constraints

Removing or relocating large road segments in a largely undeveloped area would be an added cost but is not likely to pose a constraint to development of the potential dam and reservoir.

MINING AND OTHER PAST ACTIVITIES

Literature reviews did not reveal any evidence of previous mining or industrial activities. Historic land use since the arrival of Europeans has been ranching and rural residential. What appear to be prospect pits were noted on the hill south of the axis of the potential dam. A gravel pit was noted about ½ mile upstream of the dam axis and within the reservoir area.

Constraints

No constraints have been identified.

HAZARDOUS AND TOXIC MATERIALS

Hazardous and toxic materials are not expected in the area. However, rural residential and ranching land use may have resulted in underground fuel storage tanks and septic systems in localized areas. Further studies would be required to determine the presence or absence of such systems and their residuals.

Pesticide and herbicide use appears to have been either nonexistent or incidental. The County Road Camp, about ½ mile upstream of the of the potential dam axis, may store herbicides for right-of-way weed control, and underground fuel tanks may be present at the County Road Camp.

Constraints

Potential impacts to the site from septic systems, fuel and lubricant hydrocarbons, herbicides, pesticides, and/or from electrical transformers may exist at the site and could require remediation.

THIS PAGE LEFT BLANK INTENTIONALLY

CHAPTER 8. FINDINGS AND CONCLUSIONS

This TM considered the construction-related issues associated with Hungry Hollow Dam and Reservoir. The potential dam would be constructed on Deer Creek, a tributary of the Tule River, about 3 miles south of Lake Success and 6 miles east of Porterville. The dam would be a zoned earthfill structure 267 feet in height and would impound an off-stream reservoir with a storage capacity of up to 800 TAF. Additional features would include two saddle dams, a spillway, outlet works, and relief wells along the downstream toe of the dam.

Two previously-considered configurations for the dam and reservoir were reviewed in this TM. The first would divert water from the Friant-Kern Canal via a two-way canal and pump it into the reservoir. This would require three pump stations and two small regulating reservoirs. Stored water would be conveyed back to the Friant-Kern Canal. The second option involves diverting water from the Tule River at Lake Success and pumping it into Hungry Hollow Reservoir via a 10-foot-diameter tunnel nearly 3 miles in length. In this case, stored water would be released down Deer Creek and diverted into the Friant-Kern Canal in exchange for releases from Millerton Lake.

Extensive young alluvial deposits, over 300 feet thick, lie beneath the axis of the potential dam. These deposits are unconsolidated, loose, permeable, and subject to liquefaction during an earthquake. Although no significant faults passing through the site were identified, the alluvium would not provide an adequate foundation. Costly actions to provide a suitable foundation might be required, such as removal and recompaction or densification in place.

Other aspects of construction appear to pose few or no problems. Sufficient impervious, pervious, and riprap materials can be found within 2 miles of the dam site and potential staging and lay-down areas are immediately upstream and downstream of the site. Existing roads provide direct site access, and electrical power is likely available from sources in Porterville; along the county road within Hungry Hollow or Deer Creek valleys; or from high voltage power lines to the east.

Most of the inundated area would be common annual grassland. However, the reservoir would inundate up to 8 miles of Deer Creek, which supports well-developed SAW, an important regional wildlife habitat. Elderberry (*Sambucus mexicana*), the host plant for the valley elderberry longhorn beetle (a threatened species as listed by the Federal government), is expected to be present in the riparian habitat. Wetland habitat may be present also. Populations of fish and other organisms adapted to stream environments would be reduced or eliminated, while species suited to lake environments would be enhanced. Twenty-nine archaeological sites were identified in the late 1960s and it is likely that additional sites would be found with more extensive surveys.

This option has undesirable foundation conditions and could cause adverse and unmitigable affects to SAW habitat. Therefore, it was dropped from further consideration in the Investigation.

THIS PAGE LEFT BLANK INTENTIONALLY

CHAPTER 9. LIST OF PREPARERS

NAME	ROLE
MWH	
William Swanson	Project Manager
Stephen Osgood	Planner
David Rogers	Engineering Team Leader
James Herbert	Engineering Geologist
Michael Preszler	Civil Engineer, Hydrologist
Irina Torrey	Environmental Team Leader
Sara Hamm	Environmental Coordinator
Philip Unger	Aquatic Biology
David Stevens	Wildlife Biology
Sandra Perry	Recreational Resources
Stephanie Murphy	Wildlife Biology
Barry Anderson	Botany
David White	Cultural Resources
James Darke	GIS Analyst
Steve Irving	GIS Technician
Emily McAlister	Technical Editor
Michelle Irwin	Document Coordinator

ACKNOWLEDGEMENTS

The preparers acknowledge the valuable assistance provided by Mr. Chuck Howard, Greg Mongano, and the summer interns who researched the Reclamation library and compiled much of the information reviewed. We are also grateful for the assistance of Mary Moore at the Corps library in Sacramento.

THIS PAGE LEFT BLANK INTENTIONALLY

CHAPTER 10. REFERENCES

CALFED. 2000a. Bay-Delta Program ROD. August.

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

California Department of Fish and Game (CDFG). 2001. Wildlife Habitats Relationships.

CDFG. 2002. Natural Diversity Database, Rare Find 2.

California Division of Mines and Geology (CDMG). 1965. Geologic Map of California – Bakersfield Sheet, 1:250,000. Second printing 1971.

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

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

Cantwell, R. J. 1984. Survey for PMR 84-01/PSP and 84-62/PSR, Artesian Ready Mix. Bakersfield, California: Southern San Joaquin Valley Information Center, S-13.

Carson, James D. 1989. Letter from USFWS to Corps of Engineers regarding Tule River and Kaweah River Basin Investigations. January 23.

Corps of Engineers (Corps). 1958. Design Memorandum No. 6, Success Project, Tule River California. General Design Memorandum (revised). U.S. Army, Sacramento District. December 1.

Corps. 1986. Kaweah and Tule River Reconnaissance Study, California, Hydrology U.S. Army, Sacramento District, South Pacific Division. September.

Corps. 1987. Tule River Basin Investigation, California, Reconnaissance Report. U.S. Army, Sacramento District, South Pacific Division. July.

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

Corps. 1990. Tule River Basin, California, Office Report, Hydrology. U.S. Army, Sacramento District, South Pacific Division. August.

Corps. 1992a. Tule River Basin Investigation, California, Interim Report. U.S. Army, Sacramento District, South Pacific Division. March.

Corps. 1992b. Tule River Basin Investigation, California, Interim Report. U.S. Army, Sacramento District, South Pacific Division. March.

Corps. 1993. Success Dam, Success Lake, Tule River, California, Dam Safety Assurance Program Reconnaissance Report, Seismic Evaluation. U.S. Army, Sacramento District, South Pacific Division. August.

Corps. 1999. Sacramento and San Joaquin River Basins, California, Post-Flood Assessment. U.S. Army, Sacramento District, South Pacific Division. March 29.

Corps. 1999. Tule River Basin Investigation, California, Draft Feasibility Report. U.S. Army, Sacramento District, South Pacific Division. April.

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

Drucker, Philip. 1948. Appraisal of the Archeological Resources of Success Reservoir, Tulare County, California. Washington, DC: Pacific Coast Area, River Basin Surveys, Smithsonian Institution.

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

Fenenga, Franklin F. 1952. The Archaeology of the Slick Rock Village, Tulare County, California. American Antiquity 17(4):339-347.

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

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

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

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

Jackson, Thomas L., C. Kristina Roper Wickstrom, Clinton M. Blount, Brian P. Wickstrom, Jeffrey T. Hall, and Jennifer M. Ducat. 1990. Kaweah River Basin Investigation Survey, Tulare County, California: Cultural Resources Inventory and Evaluation. Report. Prepared by BioSystems Analysis, Inc., Santa Cruz, California, for the United States Army Corps of Engineers, Sacramento District, California, Contract No. DACW05-89-C-0028.

Jones, Jeffrey, and Tom King. 1970. An Archaeological Reconnaissance of the Hungry Hollow Reservoir Region, Tulare County, California. Manuscript report prepared by the UCLA Archaeological Survey on behalf of San Francisco State College Archaeological Survey.

Kipps, J. A. 1981. An Archaeological Reconnaissance of Whisky Ridge in the Southern Sierra Nevada, California. M.A. thesis. Tucson: University of Arizona, Department of Anthropology.

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

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

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

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

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

MWH. 2002. Technical Memorandum, Environmental Constraints and Criteria for Application. February Pacific Gas and Electric Company (PG&E). 1999. Proponents Environmental Assessment for Application No. 99-09-053. Volume 7. October 29.

Pendergast, David W., and Clement W. Meighan. 1959. The Greasy Creek Site, Tulare County, California. Los Angeles: University of California, Los Angeles, Archaeological Survey Annual Report 1958-1959:1-14.

Prose, Caroline. 2002. Letter from USFWS to Corps of Engineers. February.

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

Reclamation. 1961a. Deer Creek Pump Connection and Hungry Hollow Pumping Plant Intake Channel Engineering Geology for Feasibility Cost Estimates. United States Department of the Interior, Bureau of Reclamation, Region 2, East Side Division CVP. January 12.

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

Reclamation. 1971. Ground-Water Geology and Resources Appendix. United States Department of the Interior, Bureau of Reclamation.

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

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

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

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

Von Werlhof, Jay C. 1961. Archaeological Investigations at Tul-145 (Cobble Lodge). San Francisco: Report to the National Park Service.

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

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

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

Wallace, William J. 1978. Southern Valley Yokuts. In Robert F. Heizer, ed., Handbook of North American Indians, vol. 8, California. Washington, DC: Smithsonian Institution. pp. 448-461.

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

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

APPENDIX A

Engineering Field Trip Report

Hungry Hollow Reservoir

Field Trip Log			
Trip Log Number:	5	**Project No.:**	1003032.01180502
Dates:	6/11/02	**Times:**	1545-1615
Site Name:	New Hungry Hollow	**Location:**	Porterville
Prepared By:	DKR/JMH/WAM	**Reviewed By:**	
Date:	6/11/02	**Date.:**	

Attendees/Visitors Name	**Organization/Phone/Email**
DKR	MWH, 925.685.6275 x125, david.k.rogers@mwhglobal.com
JMH	MWH, 925.685.6275 x143, james.m.herbert@mwhglobal.com
WAM	MWH, 425.602.4025 x1060, william.a.moler@mwhglobal.com

Weather Conditions:

Clear with slight haze, warm (low 90s), light breeze

Access Route (attach map):

Highway 99, State highway 190 (E) through Porterville to Plano Road (S), to Teapot Dome Rd (E), to Rd 268 (S), to Av. 120 (E).

Attachments:	Yes	No
Photo Log	✔	
Photos	✔	
Video Log (available)	✔	
Dictation Log (available)	✔	
Topographic Map	✔	

Purpose:

Review proposed location of new dam site.

Field Observations:

Existing Structures/Cultural Features:

Scattered ranch buildings and a County Road Yard were observed upstream of the proposed dam site.

Right of Way/Access Restrictions:

Access to the Hungry Hollow dam site is available via a paved county road (Av. 120).

Overhead/Buried Utilities:

Overhead power / telephone lines were observed on both sides of the valley. High voltage lines were noted crossing the reservoir area from north south.

Description of Potential Structures (attached a field sketch or sketch on a topo map):

Technical Memorandum 4 (URS, 2000) reported a USCOE Hungry Hollow dam site as a 5,200-foot long, zoned earthfill dam extending to a height of 267 feet. Gross pool elevation would be ~827 ft with a maximum storage of 800 TAF or 850 TAF. A 3-mile, 10-ft diameter tunnel would divert water to Hungry Hollow from Lake Success.

URS evaluated a new zoned earthfill dam extending to ~260 ft in height with a storage capacity of 850,000 ac-ft. In addition to Deer Creek runoff, a 15,000-ft, 10-ft diameter tunnel would divert water from Lake Success. Excess water from the Friant-Kern Canal was also considered. This would require two pump stations and a channel extending to the canal (URS, 2000).

A reconnaissance Design Drawing prepared by the USBR in 1961 showed a dam the same as that evaluated by URS. The spillway and outlet works were shown in the left abutment and a row of relief wells were illustrated along the downstream toe of the dam.

Description of Appurtenant Features (spillways, tunnels, pumping plants, flood routing/coffer dams/dewatering during construction, outlet works, switch yards, transformer yards, transmission lines, conveyance pipelines/canals, access roads, security, operation/maintenance):

The URS and USBR improvements would include the ~260-ft dam, spillway, outlet works, and three-mile diversion tunnel (URS, 2000, USBR, 1961). The tunnel alignment was not shown in either the URS or USBR documents.

Briefly Describe Geologic/Geotechnical Site Conditions:

The Hungry Hollow damsite is located at the boundary of the Sierra Nevada foothills and the Great Valley. The Hungry Hollow damsite would be located in a generally west-flowing tributary to the Tule River. The site is located in the "serpentine belt" along the western margin of the Sierra Nevada (USBR, 1975).

Both abutment locations are underlain by Mesozoic ultrabasic intrusive rocks. Pleistocene non-marine deposits (older alluvium) fill much of the valley floor, with the exception of a narrow strip of Recent alluvium associated with the active Deer Creek channel. It appears that the tunnel alignment would extend through pre-Cretaceous meta-sedimentary and meta-volcanic rocks and Mesozoic ultrabasic, basic, and granitic rocks. The tow dikes would probably be founded on pre-Cretaceous meta-sedimentary and Mesozoic ultrabasic rocks. Relatively thick Pleistocene and Recent alluvial sediments cover the valley floor. The reservoir area is underlain mostly by Mesozoic granitic and basic roacks and pre-Cretaceous meta-sedimentary rocks (CDMG, 1964 and 1965).

Previous studies indicate that there are no faults in the area capable of producing ground motions greater than those generated by four known regional sources that include the San Andreas fault system, the Sierra Frontal fault system, the White Wolf fault, and the Garlock fault (USCOE, 1990).

Location/Description of Nearest Borrow Areas (attach map or show on topo map):

A quarry operation was observed about 200 yards downstream of the dam site. The USGS topographic map showed a gravel pit ~2¼ -miles upstream of the proposed dam site. The Recent and older alluvium may provide borrow materials.

Location/Description of Equipment/Material Staging and Lay Down Areas (attach map or show on topo map):

Potential staging and laydown areas are located upstream and downstream of the potential Hungry Hollow dam site.

Identification of Environmental Sensitive Areas (wetlands, springs, rivers, streams, endangered/threatened species habitats, etc.):

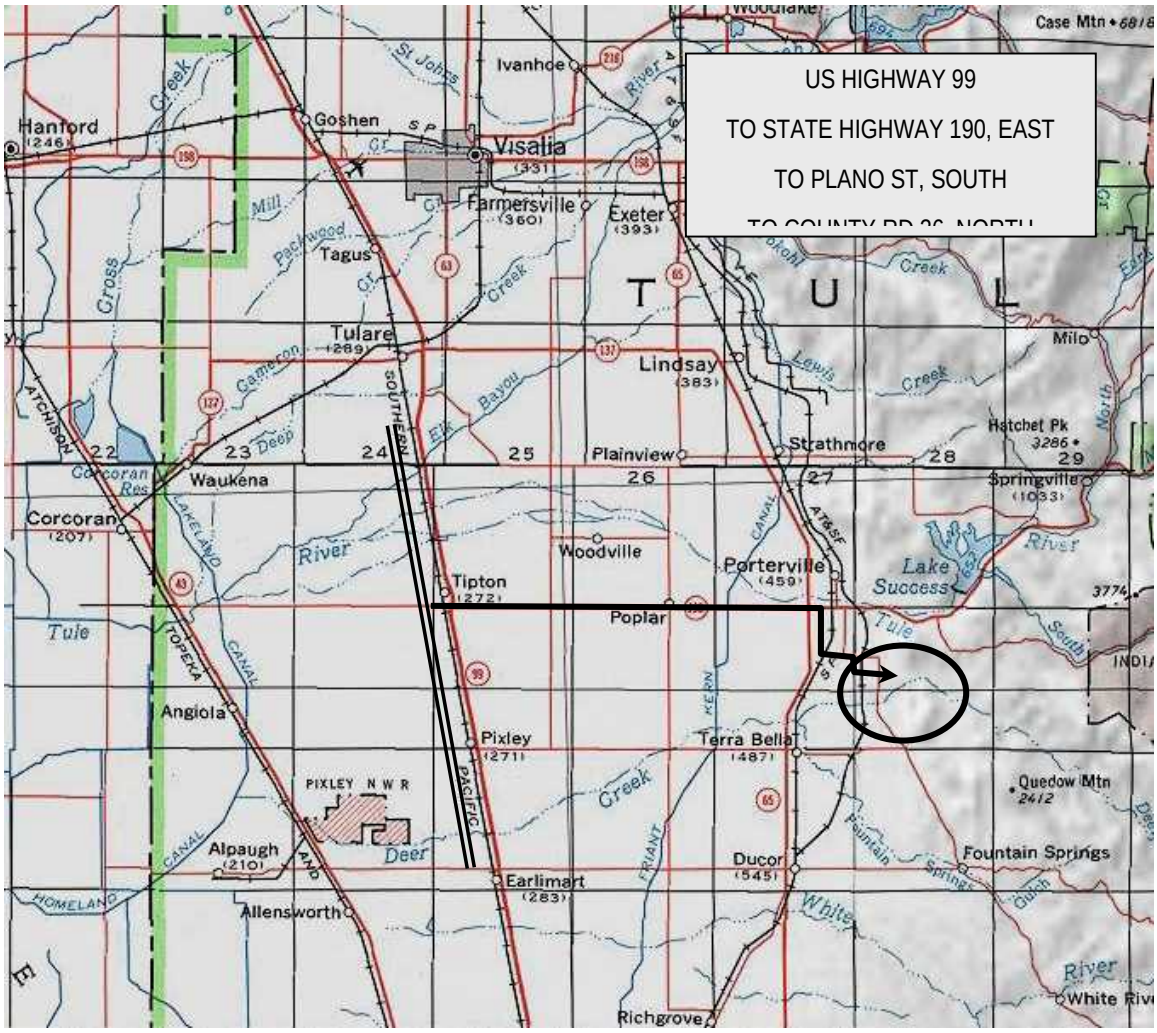
Oak woodland and riparian habitats were noted in Deer Creek valley. The flowing Deer Creek was about 10 feet wide.

Description of Mining or Other Anthropologic Activities:

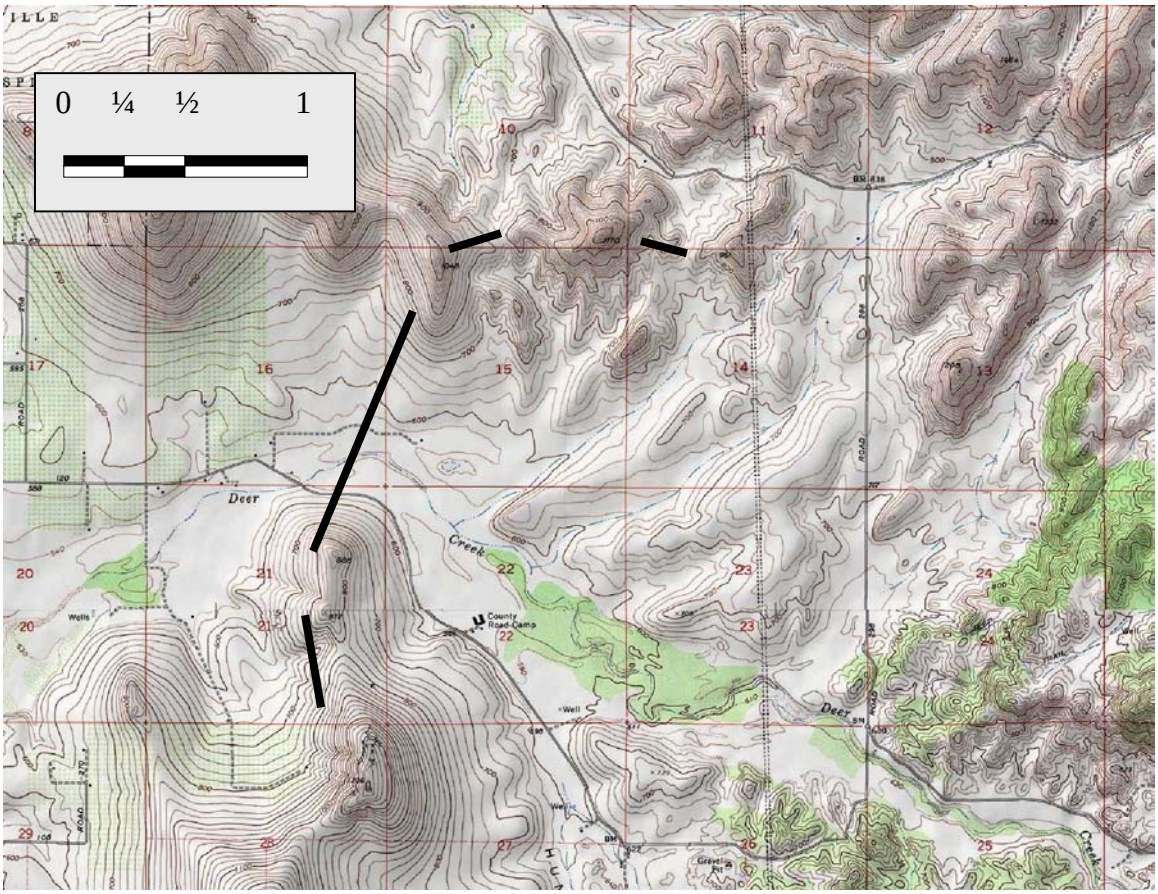
None noted with the exception of a gravel pit located about 2¼ - miles upstream of the damsite.

Action Items/Data Needs (list who has responsibility and schedule for completion):

- MWH to prepare draft Technical Memorandum by August 23, 2002.
- USBR to prepare regional seismicity / faulting evaluation by August 23, 2002.



VICINITY MAP



LOCATION OF POTENTIAL DAM

Hungry Hollow – Northward view of right abutment area.

Southward view of left abutment area.

Northeastward view of valley floor upstream of potential dam location.

APPENDIX B

Environmental Field Trip Report

Hungry Hollow Reservoir

ENVIRONMENTAL FIELD TRIP REPORT - HUNGRY HOLLOW RESERVOIR

A team of environmental specialists completed an initial field trip to the potential Hungry Hollow Reservoir site on May 31, 2002. The field trip was the first task in the environmental study of several potential surface storage options identified for initial review during the Upper San Joaquin River Basin Storage Investigation. For initial consideration, the environmental review focused mainly on construction and potential upstream impacts associated with surface storage sites. The site visit provided an opportunity to conduct preliminary reconnaissance of existing resources at the various locations for the following resource areas: terrestrial biology; aquatic biology and water quality; recreation; cultural resources; and land use.

This appendix includes a brief overview of the resource specialists' observations, trip logs prepared by team members, photographs taken during the field trip, and maps used to identify and review existing resources.

SUMMARY OF FIELD OBSERVATIONS

This measure would involve constructing a new dam on Deer Creek. The new dam site and reservoir would be situated on private property. Existing facilities include paved county roads, paved and unpaved private roads, private residences, ranch and farm buildings, and transmission towers and lines.

Botany

- This is a wide braded creek channel that is ephemeral but flows ½ cfs in late May.
- There is a well-developed riparian belt and woodlands with species including alder, willow, sycamore and mule fat.
- This measure could result in substantial impacts to riparian and wetland habitats.
- Possibility of special status plants is unknown, but probably low.

Wildlife

- The stream may support western pond turtle, willow flycatcher, VELB and San Joaquin kit fox.
- Possible effects include loss of significant riparian stands and conversion of the area from a stream and riparian-based ecosystem to a lake type ecosystem.

Aquatic Biology/Water Quality

- Deer Creek is an intermittent stream with well-developed riparian vegetation.
- Numerous small fish were observed in the stream, so pool habitat likely persists through the dry season.
- The creek likely contains no significant aquatic biological resources, but database and literature searches should be conducted to confirm.
- Construction of a reservoir would create new aquatic habitat and fisheries opportunities, primarily for exotic fish species.
- Inundation of abandoned mines, if any are present, could result in water quality degradation.
- Diversions from Lake Success would potentially affect fisheries and water quality of that reservoir.

Recreation

- There are no developed recreation facilities located in the immediate area.
- This option would involve diverting water from Lake Success to the new Hungry Hollow Dam Reservoir.
- Lower water levels at Lake Success could affect recreation facilities such as boat ramps and recreation opportunities such as fishing and boating.

Cultural Resources

- The riparian zone along Deer Creek and adjacent Blue Oak woodland would have provided an attractive natural resource area.
- Grassland in the lower part of the potential reservoir area may be recent, the result of removing Blue Oak to facilitate grazing.
- There is a high probability of prehistoric archaeological sites including BRM stations, hunting and fishing camps, and seasonal village sites.
- Historic sites are likely, associated with mining, agriculture and other activities.

Land Use

- There are scattered farm houses in the area surrounding the Creek. Depending on the inundation area some of them may be affected. Prime agricultural land or Williamson Act lands may also be affected.

Field Trip Log – Botany		
Trip Log Number:	S14	**Project No:** 8004094
Dates:	May 31, 2002	
Site Name:	New Hungry Hollow Dam	
Location:	Deer Creek southeast of Porterville	
Prepared By:	Jeff Glazner/Barry Anderson/David Stevens	
Date:	June 5, 2002	

Weather Conditions:	Hot and Dry
Areas Covered (attach map with notations	
Attachments	
Photo Log	Yes
Photos	Yes
Topographic Map(s)	No

Field Observations:

Existing Facilities:

None

Existing Environmental Features as Appropriate to Discipline (hydrology; aquatic-water quality; terrestrial—plants; wildlife; recreation; cultural resources; land use; aesthetic)

Deer Creek is an intermittent, braided stream (ephemeral but flowing ½ cfs in late May). that supports a substantial riparian zone. The surrounding area has grassland and oak woodland. Well developed riparian belt and woodlands with species including alder, willow, sycamore and mule fat.

Need for additional (engineering/hydrological, or other) information on measures

- Geology or soils information
- Spillway elevation and limits of inundation
- Location of diversion structures and new tunnel
- Location of new pump stations
- Location of realigned existing roads
- Location of transmission line towers and work areas
- Location of work pads, access roads, and other construction areas

Additional data needs (within each specific discipline)

- CNDDB report
- CNPS report
- Ceres report
- Field surveys for wetlands and special status species and habitats

Field Trip Log - Wildlife		
Trip Log Number:	S14	**Project No.:** 8004094
Dates:	May 31, 2002	
Site Name:	New Hungry Hollow Dam	
Location:	Deer Creek southeast of Porterville	
Prepared By:	Dave Stevens, Stephanie Murphy	
Date:	June 5, 2002	

Weather Conditions:	Hot and dry
Areas Covered (attach map with notations	
Attachments	
Photo Log	
Photos	
Topographic Map(s)	

Field Observations:

Existing Facilities:

None

Existing Environmental Features as Appropriate to Discipline (hydrology; aquatic-water quality; terrestrial—plants; wildlife; recreation; cultural resources; land use; aesthetic)

Wide braided creek channel, ephemeral but flowing ½ cfs in late May. Well developed riparian belt and woodlands with species including alder, willow, sycamore and mule fat. Stream may support western pond turtle, willow flycatcher, VELB and San Joaquin kit fox Constraints include loss of significant riparian stands, conversion of the area from a stream and riparian based ecosystem to a lake type ecosystem.

Need for additional (engineering/hydrological, or other) information on measures

- Hydrologic models, dam, inundation zones
- Potential features in addition to dam, size and location, etc.

Additional data needs (within each specific discipline)

a. Need to coordinate with resource agency biologists and agency files on known distribution of sensitive species for this area.

Field Trip Log – Fish and Water Quality		
Trip Log Number:	S14	**Project No.** 8004094
Dates:	May 31, 2002	
Site Name:	New Hungry Hollow Dam	
Location:	Deer Creek southeast of Porterville	
Prepared By:	Philip Unger	
Date:	June 10, 2002	

Weather Conditions:	Hot and dry
Areas Covered (attach map with notations	Hungry Hollow valley, Deer Creek
Attachments	
Photo Log	No
Photos	No
Topographic Map(s)	Yes

Field Observations:

Existing Facilities:

The new dam site and reservoir would be situated on private property. Existing facilities include paved and unpaved roads, private residences, ranch and farm buildings, and transmission towers and lines.

Existing Environmental Features as Appropriate to Discipline (hydrology; aquatic-water quality; terrestrial—plants; wildlife; recreation; cultural resources; land use; aesthetic)

Deer Creek is an intermittent, braided stream with well-developed riparian vegetation. The surrounding area has grassland and oak woodland. Flow was very low at the time of the field visit and surface flow likely ceases by mid summer. Numerous small fish (about 1 to 3 inches long) were seen in the stream, so pools are likely present through the

dry season.

Need for additional (engineering/hydrological, or other) information on measures

Need information on exact area that would be submerged by Hungry Hollow Dam Reservoir.
Need information on range of seasonal flow conditions in Deer Creek.
Need the following estimates for potential reservoir:

- Mean depth for each month, April – October.
- Mean surface area of shallow water habitat (less than 15 feet deep) in each month, April – October.
- Mean rate of water level fluctuation for each month, April – October.

Need information on how Lake Success and Tule River would be affected by diversions to Hungry Hollow Dam Reservoir, including changes in water level, timing and duration, and flows.

Additional data needs (within each specific discipline)

Need information on summer water temperatures and dissolved oxygen levels in Deer Creek and list of fish species likely present in the creek. Also, any existing water quality information and information on the location and types of active and abandoned mines in the inundation zone of the potential reservoir.
Need information on fish species residing in Lake Success.

Field Trip Log - Recreation		
Trip Log Number:	S14	**Project No:** 8004094
Dates:	May 31, 2002	
Site Name:	New Hungry Hollow Dam	
Location:	Deer Creek southeast of Porterville	
Prepared By:	Sandra Perry	
Date:	June 4, 2002	

Weather Conditions:	Hot and dry
Areas Covered (attach map with notations	Hungry Hollow valley, Deer Creek
Attachments	
Photo Log	No
Photos	No
Topographic Map(s)	Yes

Field Observations:

Existing Facilities:

This option would involve constructing a new dam on Deer Creek. The new dam site and reservoir would be situated on private property. Existing facilities include paved county roads, paved and unpaved private roads, private residences, ranch and farm buildings, and transmission towers and lines.

Existing Environmental Features as Appropriate to Discipline (hydrology; aquatic-water quality; terrestrial—plants; wildlife; recreation; cultural resources; land use; aesthetic)

There are no developed recreation facilities located in the immediate area. However, this option would involve diverting water from Lake Success to the new Hungry Hollow Dam Reservoir. Lower water levels at Lake Success could affect recreation facilities such as boat ramps and recreation opportunities such as fishing and boating.

Need for additional (engineering/hydrological, or other) information on measures

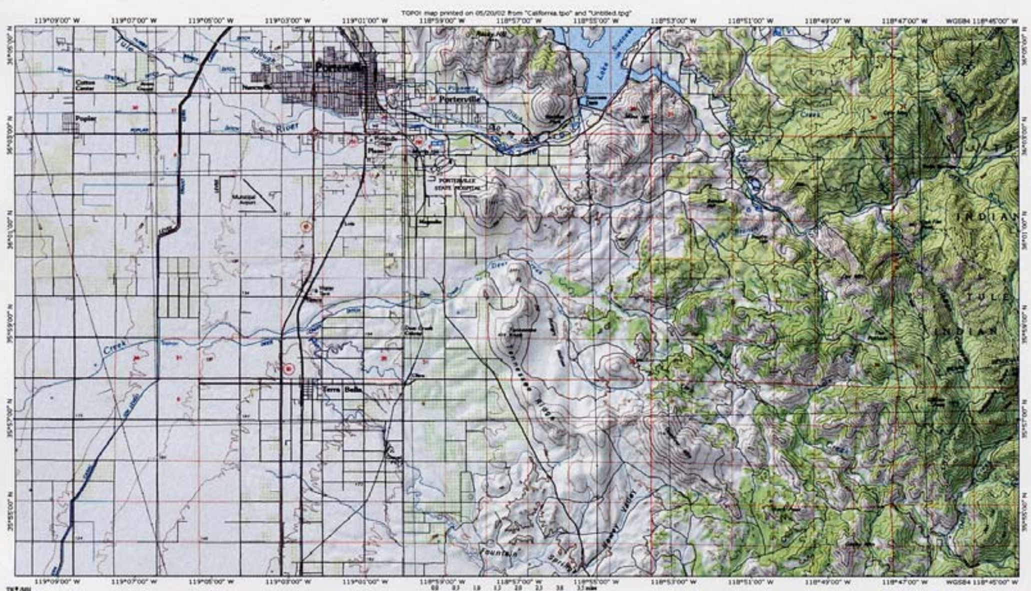
Need information on exact area that would be submerged by Hungry Hollow Dam Reservoir.
Need information on how Lake Success would be affected by diversions to Hungry Hollow Dam Reservoir, including changes in water level, timing and duration.

Additional data needs (within each specific discipline)

Need the following recreation-related information for Lake Success:

- Exact location of existing recreation facilities along the margins of Lake Success
- General information about recreation activities and use levels.

Hungry Hollow



No Recreation facilities but diversions from Lake Success
could affect recreation at Lake Success

Field Trip Log – Land Use		
Trip Log Number:	S14	**Project No.** 8004094
Dates:	May 31, 2002	
Site Name:	New Hungry Hollow Dam	
Location:	Deer Creek southeast of Porterville	
Prepared By:	Irina Torrey	
Date:	June 12, 2002	

Weather Conditions:	Hot and dry
Areas Covered (attach map with notations	Hungry Hollow valley, Deer Creek
Attachments	
Photo Log	Yes
Photos	Yes
Topographic Map(s)	No

Field Observations:

Existing Facilities:

This option would involve constructing a new dam on Deer Creek. The new dam site and reservoir would be situated on private property. Existing facilities include paved county roads, paved and unpaved private roads, private residences, ranch and farm buildings, and transmission towers and lines.

Existing Environmental Features as Appropriate to Discipline (hydrology; aquatic-water quality; terrestrial—plants; wildlife; recreation; cultural resources; land use; aesthetic)

There are a few scattered private residences and cattle farms in the area that may be within the area of inundation. There is an abandoned farm closest to the Creek.

Need for additional (engineering/hydrological, or other) information on measures

Need information on exact area that would be submerged by Hungry Hollow Dam Reservoir.

Additional data needs (within each specific discipline)

No additional information is needed.

Field Trip Log – Cultural Resources		
Trip Log Number:	S14	**Project No.** 8004094
Dates:	May 31, 2002	
Site Name:	New Hungry Hollow Dam	
Location:	Deer Creek southeast of Porterville	
Prepared By:	David White	
Date:	May 31 2002	

Weather Conditions:	Hot & dry
Areas Covered (attach map with notations)	Vehicular reconnaissance May 31, along Ave. 120 off Road 264
Attachments	
Photo Log	No
Photos	No
Topographic Map(s)	Success Dam, Fountain Springs quads

Field Observations:

Existing Facilities:

No existing dam. Residences, ranching, gravel pits.

Existing Environmental Features as Appropriate to Discipline (hydrology; aquatic-water quality; terrestrial—plants; wildlife; recreation; cultural resources; land use; aesthetic)

Cultural resources:
Prehistoric: Riparian zone along Deer Creek and adjacent Blue Oak woodland would have provided an attractive natural resource area. Grassland in lower part of potential reservoir area may be recent, the result of removing Blue Oak to facilitate grazing. High

probability of prehistoric archaeological sites including BRM stations, hunting & fishing camps, seasonal village sites.
Historic: Various sites likely, associated with mining, agriculture and other activities.

Need for additional (engineering/hydrological, or other) information on measures

Need precisely mapped footprint of reservoir, with various potential dam levels; also need footprint of all associated ground disturbance areas, to include but not be limited to offices and maintenance buildings, construction set-up and lay-down areas, access roads, electric transmission lines, water conveyance structures, and all other facilities.

Additional data needs (within each specific discipline)

Need archaeological records search with California Historic Resources Inventory System (CHRIS) information center. Clearinghouse: Southern San Joaquin Valley Info Center, CSU-Bakersfield.
Also need brief review of archaeological and ethnographic literature pertaining to the area. Minimal level of effort: (1) to identify types of archaeological remains expected, time periods represented; and (2) to identify Native American tribes historically occupying the area, along with published information on major named villages or other ethnographic sites.

Picture: P52900142 New Hungry Hollow DamsSite looking north.

Picture: P52900143 New Hungry Hollow Dam site looking northeast

Hungry Hollow, May 31, 2002

THIS PAGE LEFT BLANK INTENTIONALLY

APPENDIX C

Cost Estimate Summary

Hungry Hollow Dam and Reservoir

Upper San Joaquin River Basin Storage Investigation Cost Estimate		
HUNGRY HOLLOW DAM AND RESERVOIR		
267' high, 5,200' long, saddle dam 9 mi canal, 3 pump stns Tie to Friant Kern		
FIRST COST ITEMS		**(2002 dollars)**
DAMS Diversion Dam/Cofferdam		
Diversion Works/Tunnel	$	500,000
Main Dam	$	349,105,000
Spillway	$	5,225,000
Outlet Works		
SUBTOTAL	**$**	**354,830,000**
CONVEYANCE FACILITIES		
Power intake, tunnels & penstocks	$	-
Diversion Tunnel	$	-
Tunnel		
Canals/Pipelines	$	15,000,000
Pumping Stations	$	60,000,000
Regulating Reservoirs	$	10,000,000
SUBTOTAL	**$**	**85,000,000**
PERMANENT OPERATING EQUIPMENT		
Powerplants, generators & turbines	$	-
Transmission Lines, switchyards, & substns.	$	-
SUBTOTAL	**$**	**-**
TOTAL, LISTED ITEMS (rounded)	**$**	**439,800,000**
UNLISTED ITEMS (15%; rounded)	**$**	**66,000,000**
TOTAL, CONSTRUCTION ITEMS (rounded)	**$**	**506,000,000**
CONTINGENCIES ON CONSTRUCTION (25%; rounded)	**$**	**127,000,000**
TOTAL, CONSTRUCTION COST	**$**	**633,000,000**
MITIGATION (5%; rounded)	**$**	**32,000,000**
TOTAL FIELD COSTS	**$**	**665,000,000**
INVESTIGATION, DESIGN, & CONSTRUCTION MNGMT (15%; rounded)	**$**	**100,000,000**
LAND	**$**	**6,250,000**
TOTAL FIRST COST	**$**	**771,250,000**

Upper San Joaquin River Basin Storage Investigation

Cost Estimate

HUNGRY HOLLOW			
	267' high, 5,200' long, saddle dam		
	Success Tunnel		
FIRST COST ITEMS			**(2002 dollars)**
DAMS	Diversion Dam/Cofferdam		
	Diversion Works/Tunnel	$	500,000
	Main Dam	$	349,105,000
	Spillway	$	5,225,000
	Outlet Works		
SUBTOTAL		**$**	**354,830,000**
CONVEYANCE FACILITIES			
	Power intake, tunnels & penstocks	$	-
	Diversion Tunnel	$	-
	Tunnel	$	54,000,000
	Canals/Pipelines	$	15,000,000
	Pumping Stations	$	20,000,000
	Regulating Reservoirs		
SUBTOTAL		**$**	**89,000,000**
PERMANENT OPERATING EQUIPMENT			
	Powerplants, generators & turbines	$	-
	Transmission Lines, switchyards, & substns.	$	-
SUBTOTAL		**$**	**-**
TOTAL, LISTED ITEMS (rounded)		**$**	**443,800,000**
UNLISTED ITEMS (15%; rounded)		**$**	**66,600,000**
TOTAL, CONSTRUCTION ITEMS (rounded)		**$**	**510,000,000**
CONTINGENCIES ON CONSTRUCTION (25%; rounded)		**$**	**128,000,000**
TOTAL, CONSTRUCTION COST		**$**	**638,000,000**
MITIGATION (5%; rounded)		**$**	**32,000,000**
TOTAL FIELD COSTS		**$**	**670,000,000**
INVESTIGATION, DESIGN, & CONSTRUCTION MNGMT (15%; rounded)		**$**	**101,000,000**
LAND		**$**	**6,250,000**
TOTAL FIRST COST		**$**	**777,250,000**