Attachment E

Geologic Drilling Investigation

Fine Gold and RM286 Dam Sites

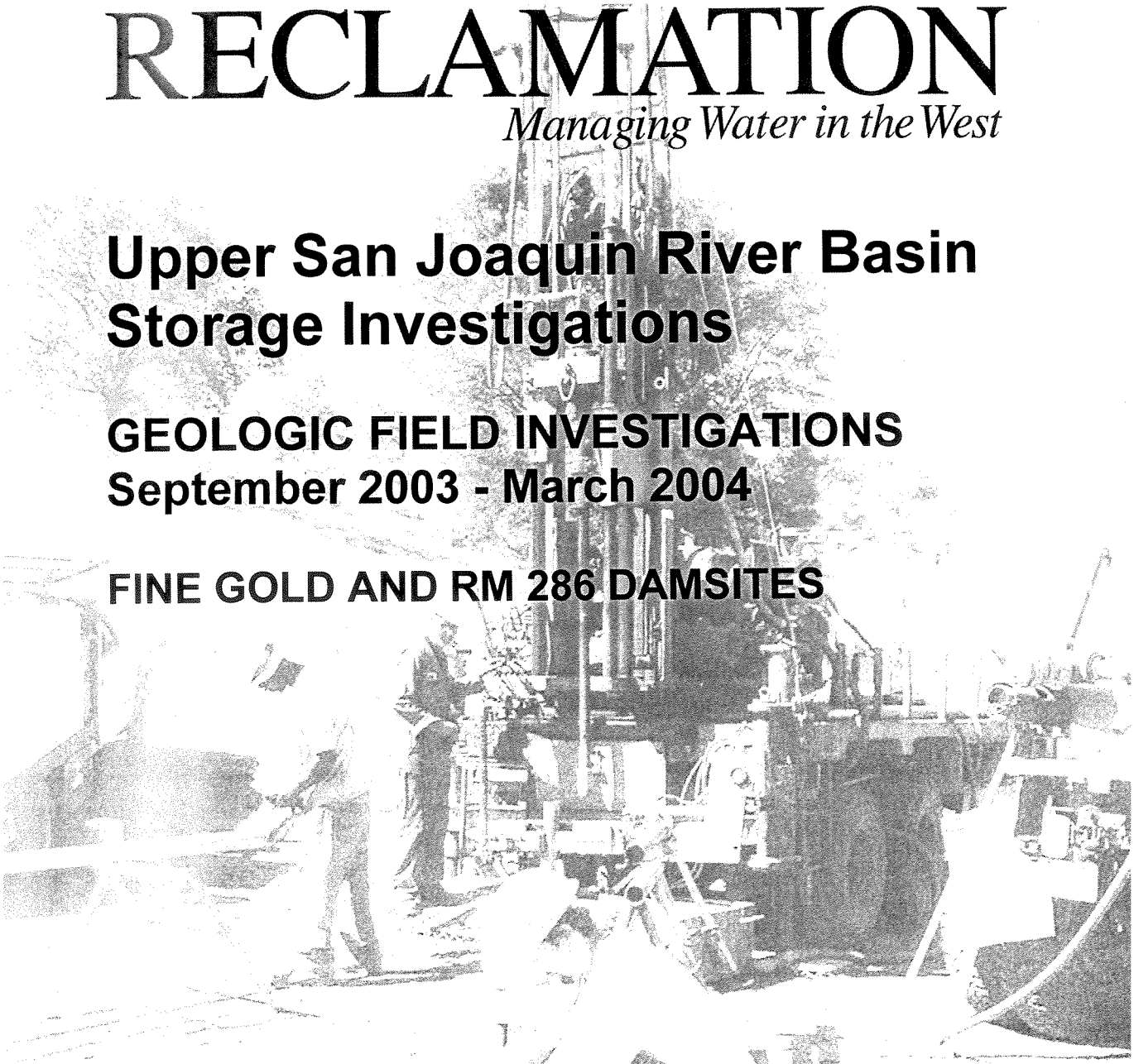
RECLAMATION

Managing Water in the West

Upper San Joaquin River Basin Storage Investigations

GEOLOGIC FIELD INVESTIGATIONS
September 2003 - March 2004

FINE GOLD AND RM 286 DAMSITES



U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

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APPENDICES

I. INTRODUCTION AND BACKGROUND

This report describes geologic surface and subsurface conditions at two proposed damsites, Fine Gold and RM 286; Fine Gold Saddledam Site; and within the proposed Fine Gold Reservoir in an area designated the Fine Gold Reservoir Borrow Area. Geologic conditions were characterized by geologic field investigations conducted by the U.S. Bureau of Reclamation (Reclamation) over a seven-month period from September 2003 through March 2004 that included:

1) Five, 200-foot-deep diamond drill holes
2) Six, 50 to 70-foot-deep hollow-stem auger / diamond drill holes
3) Limited inspections of surface geology
4) Inspection of the Kerckhoff Powerplant No. 2 underground excavation
5) Inspection of Kerckhoff Tunnel No. 1 Adits 1 and 2

A comprehensive geologic report containing geologic drill hole logs, core photographs and soil and rock testing data is currently being prepared by Reclamation and should be completed by April 2005.

Surface geologic conditions at Fine Gold Damsite and Saddledam Site and within the Fine Gold Reservoir area are also described in two previous reports prepared by the U.S. Bureau of Reclamation (Reclamation August 2002 and September 2002).

The latest phase of field investigations included core drilling as shown in Tables 1, 2 and 3. Rotary diamond core drilling and packer permeability testing was conducted at Fine Gold Damsite and Saddledam Site and at RM 286 Damsite by drilling contractor Spectrum Exploration, Inc. A combination of hollow-stem flight auger drilling and sampling and rotary diamond core drilling were conducted by Reclamation's Mid Pacific Region Drill Crew at the Fine Gold Reservoir Borrow Area. All geologic core logging was conducted by Reclamation engineering geologists who were present throughout the entire period of field investigations.

Only a cursory examination of surface geologic conditions at all sites was made while drilling operations were in progress. Observations are documented in the attached photographs. Detailed geologic mapping or joint surveys were not conducted. A brief inspection of the Kerckhoff No. 1 Powerplant, owned by the Pacific Gas and Electric Company (PG&E), by Reclamation engineering geologists took approximately 2 hours and included no detailed geologic mapping or joint surveys.

As initially planned, three drill holes were proposed for each dam and saddledam site: one on each abutment and one in the channel area. Due to limited access and time constraints, only those drill holes that could be accessed by existing roads were completed (Table 1). Table 2 summarizes the rock and engineering geologic conditions observed in core obtained from these drill holes.

All drill holes were continuously cored from the ground surface to total depth. Drill core was collected, boxed, photographed, and labeled, and is currently stored and available for inspection at Reclamation's Friant Dam Operations and Maintenance Office, 18015 Friant Road, Friant, California. Please contact Reclamation geologists Greg Mongano at (916) 978-5331 or Joel Sturm at (916) 978-5305 to arrange for inspection of core.

TABLE 1. SUMMARY OF DRILLING INVESTIGATIONS

LOCATION	DRILL HOLES		OTHER INVESTIGATIONS
	Number	Depth	
FINE GOLD			
Damsite Left and Right Abutment	2	200 ft	
Saddledam Site Mid Point of Saddle	1	200 ft	
Reservoir Borrow Area	6	48.9-69.5 ft	
RM 286			
Damsite Left Abutment	2	200 ft	Inspection of PG&E's Kerckhoff Powerplant No. 2 and Adits 1 and 2

TABLE 2. DRILL HOLE SURVEY COORDINATES AND ELEVATIONS

DRILL HOLE	NORTHING	EASTING	ELEVATION
FINE GOLD DAMSITE			
FG-03-1	2269614	6374262	1040
FG-03-3A	2268136	6371214	1125
FINE GOLD SADDLEDAM SITE			
FGD-03-2	2279350	6363992	1043
FINE GOLD RESERVOIR BORROW AREA			
FGR-03-1	2273649	6368018	981
FGR-03-2	2275125	6368977	940
FGR-03-3	2278678	6370353	852
FGR-03-4	2280698	6372463	950
FGR-03-5	2270986	6369315	980
FGR-03-6	2272565	6370500	962
RM 286 DAMSITE			
MP286-03-1	2289163	6407915	2095
MP286-04-2	2286034	6405783	1120

Note. The designations MP 286, where MP stands for Mile Post, and RM 286, where RM stands for River Mile, were used interchangeably through early 2004. The MP designation is reflected in Reclamation's naming of drill holes.

TABLE 3. SUMMARY OF DRILL HOLE DATA AND DRILLING CONDITIONS

NUMBER OF DRILL HOLE	DATE STARTED	DATE FINISHED	TOTAL DAYS	REMARKS
FG-03-3	11/3	11/10	6	Rods twisted off; fished out. Lost circulation at +/-40'. Core barrel extended, water blocked, burned bit. Rods broke; couldn't fish out; left +/-120' in hole. **Abandoned hole at 139.5.** --- 0-25: decomp to int wx 25-125: int to mod wx 125-139.5: mod to slt wx
FG-03-3A	11/11	11/20	7.5	Redrilled 7' east of FG-03-3. Lost circulation at start. **Replaced FG-03-3.** --- 0-135.5: int to mod wx 135.5-200: mod wx
FG-03-1	11/20	12/10	7.5	11/21: Set CS to 59.0'. 11/24: CS separated @ 45' 11/25: 64.5-89.5: Rec 1.5'/25.0' due to bend/offset in CS (6% core recovery). --- 0-129.5: decomp to int wx 129.5-134.5: mod wx 134.5-200: slt wx to fresh
FGD-03-2	12/11	12/15	5	0-15: very int wx 15-35: mod to slt wx 35-200: slt wx to fresh
MP286-03-1	12/29	1/13	8	12/30: Rained out (not counted as a work day). 1/5: Thaw pump. 1/6: CS broke. Drilling w/o CS slowed by "sanding in" of rods. Rods stuck. 1/7: Water truck ran off road. Set up to recirculate water. --- 0-24: decomp to int wx 24-200: slt wx to fresh
MP286-04-2	1/14	1/20	5	0-200: slt wx to fresh Drill water obtained onsite.
TOTAL DAYS			39	

II. REGIONAL GEOLOGY

Rock in the project area consists predominantly of Mesozoic plutonic intrusive rocks of the Sierra Nevada Batholith (granitic rocks) and widely scattered remnants of older, Paleozoic metamorphosed sedimentary and volcanic rocks that have been intruded by the plutonic rocks. Occasional remnants of Tertiary andesitic lava flows are present in the Millerton Lake area and form flat-topped plateaus at the higher elevations (Plate 1. Regional Geology).

Intrusive Sierra Nevada batholith rocks (granitic rock) underlie most of Millerton Lake and the proposed left abutment of Fine Gold Damsite, Fine Gold Saddledam Site, RM 286 Damsite and most of the Fine Gold Reservoir area. Metasedimentary rock underlies the right abutment of Fine Gold Damsite.

The above description of regional geology is summarized from, *Geologic Map of the Millerton Lake Quadrangle West-Central Sierra Nevada, California by Paul C. Bateman and Alan J. Busacca, 1982.* (Bateman & Busacca, 1982).

III. FINE GOLD DAMSITE

Location and Topography

The Fine Gold Damsite is named for Fine Gold Creek which enters the San Joaquin River at about MP 273.25, about 5 miles upstream of Friant Dam. At this point Fine Gold Creek forms an arm of Millerton Lake which has a normal reservoir water surface of elevation 578.

The proposed maximum crest elevation for the proposed Fine Gold Dam is elevation 1100 feet. Streambed elevation at the dam axis is about elevation 520 feet, resulting in a maximum dam height of about 580 feet. Dam designs with crest elevations greater than 1100 feet are probably not feasible.

Primary land use in the area is grazing, low density, rural residential development and recreation. No existing structures or facilities are located along the proposed dam axis up to elevation 1100 feet. Residential areas exist above and downstream of the right abutment area. The reservoir area contains scattered residential structures below the proposed maximum reservoir elevation of 1100.

At the damsite, Fine Gold Creek canyon rises steeply from elevation 520 in the creek channel to about elevation 800 on the right abutment, and then more gradually to elevation 1160, before continuing through a series of saddles to elevation 1847 at Hulbert Mountain. The left abutment rises steeply from the channel to elevation 650, and then continues more gradually to elevation 1100. The abutment then continues to rise through a series of saddles and hilltops until reaching Crook Mountain at elevation 2006.

Drilling Investigations
Two exploratory drill holes were located at the proposed damsite: FG-03-3 on the right abutment and FG-03-1 on the left abutment. A drill hole in the channel area was not drilled due to a lack of existing access.

Site Geology
Based on drill hole data and limited surface observations, the two abutments are underlain by completely different rock units. The right abutment is underlain primarily by mica schist metasedimentary rock intruded by granitic dikes. The left abutment is underlain entirely by granitic rock. The contact between these two rock units is an intrusive contact that was not crossed by either drill hole.

Right Abutment Geology
Drill hole FG-03-3 encountered intensely to moderately weathered, moderately hard to moderately soft, intensely fractured mica schist (metasedimentary rock) intruded by numerous, very hard granitic and aplite dikes. Packer permeability test water losses were relatively low in the mica schist (0.5 to 3gpm) and high at dike/schist contacts (5 to 20 gpm). The mica schist encountered in this drill hole is similar to the metasedimentary rock forming the foundation of Friant Dam. Excellent core recovery was achieved for the entire 200-foot depth of the drill hole.

Geotechnical Considerations
1) Drill hole FG-03-3 encountered metasedimentary rock close to an intrusive granite/metasediment contact resulting in relatively complex and variable geologic conditions and engineering properties.
2) High water losses associated with granitic dikes is a geotechnical concern that needs additional study.

Left Abutment Geology
Drill Hole FG-03-1 encountered a thick interval of decomposed to intensely weathered granite from the ground surface to approximately 130 feet and moderately to slightly weathered granite from 130 to the bottom of the drill hole at 200 feet as follows:

0-120': Very soft to soft decomposed to intensely weathered granite (DG). Excellent core recovery except as noted below.

65-90': No Recovery. Soft, saturated DG shaken out of core barrel due to rod vibration caused by a slight bend in the casing installed from 0-60'.

120-130': Soft to moderately hard intensely to moderately weathered granite. Excellent core recovery.

130-140': Moderately hard to hard, moderately to slightly weathered granite.

135-200': Hard, slightly weathered granite.

Rock mass permeability of the upper left abutment of the Fine Gold Damsite appears to be very low. Packer permeability tests performed in drill hole FG-03-1 measured water takes as follows:
0 to 100 feet: 0.1 to 10 gpm, mostly 0.2 to 2 gpm
100 to 200 feet: 0 to 2 gpm, mostly 0 to 1 gpm

Geotechnical Considerations

1) Intense weathering to a depth of approximately 120 feet was not anticipated. Decomposed to intensely weathered rock would not provide an acceptable foundation for a concrete dam. Extremely deep weathering is believed to be restricted to the saddle on the upper left abutment where drill hole FG-03-1 was located and is not thought to be representative of rock underlying the main left abutment slope adjacent to Fine Gold Creek where the depth of weathering appears to be much shallower based on the presence of abundant, hard outcrops of granitic rock.
2) Very low rock mass permeability suggests that only limited seepage through the dam foundation would be anticipated and that grout takes would be low.

Conclusions

1) The proposed main damsite appears to be suitable for either a concrete or embankment dam.
2) Extremely deep weathering encountered by drill hole FG-03-1 on the upper left abutment suggests that an embankment dam would be required in this area.
3) Rock units and engineering properties differ between the two abutments. The resulting complex geology and lack of information on the intrusive contact between the granitic rocks on the left abutment and the metasedimentary rocks on the right will likely require more extensive geologic field investigations than would a site with relatively simple geology.
4) The geotechnical conditions associated with complex geology and an intrusive contact may require special foundation treatment.
5) Site geologic conditions could be simplified and improved by relocating the dam axis about 1000 feet upstream to a point where the dam footprint would be located entirely on granitic rock. This may be impractical as it would significantly lengthen the dam.

IV. FINE GOLD SADDLEDAM SITE

Location and Topography

The proposed saddledam site is located approximately 2 miles northwest of Fine Gold Damsite. The saddledam would block a broad topographic low where the reservoir rim dips to about El. 1038. Primary land use in the area is grazing, low density, rural residential development and recreation. No existing structures or facilities are located along the proposed dam axis up to elevation 1100 feet. Residential areas exist upstream (northwest) of the right abutment area.

Drilling Investigations
One drill hole, FGD-03-2, was drilled at about the midpoint of the saddle, about 800 feet upstream (northeast) of the proposed dam axis. Drill holes on the two abutments were not drilled due to the refusal of local landowners to grant right of entry permission to Reclamation for this purpose. Right of entry was withheld mainly due to landowner opposition to the flooding of private lands by the proposed Fine Gold Reservoir.

Site Geology
Drill hole FGD-03-2 encountered subsurface geologic conditions very much as predicted:

0-15': very intensely weathered granite
15-35': moderately to slightly weathered granite
35-200': slightly weathered to fresh granite

Rock mass permeability at the Fine Gold Saddledam Site appears to be very low. Packer permeability tests performed in drill hole FGD-03-02 ranged from 0 to 3 gpm and were mostly 0 to 1 gpm.

Geotechnical Considerations

1) The shallow weathering profile in granite encountered by drill hole FGD-03-2, as predicted, and the presence of hard, moderately to slightly weathered granite at a depth of 15 feet indicates that only routine foundation preparation should be required for an embankment dam and may indicate that the site may be made suitable for a roller compacted concrete (RCC) dam with a modest amount of additional excavation.
2) Very low rock mass permeability suggests that only limited seepage through the dam foundation would be anticipated and that grout takes would be low.

Conclusions
1) The site appears suitable for an embankment dam and possibly for an RCC dam.
2) Subsurface geologic conditions were very much as predicted.
3) No unusual or problematic subsurface conditions were identified on the basis of core obtained from a single drill hole.

V. FINE GOLD RESERVOIR BORROW AREA

Location and Topography
As currently proposed, a Fine Gold Reservoir with maximum water surface at elevation 1100, would extend approximately 2 to 3 miles north of the proposed damsite near Millerton Lake, 1 to 2 miles west and 0.5 miles east of Fine Gold Creek. The reservoir area is a broad, upland drainage basin containing numerous hills and ridges separated by small, steep-sided drainages, such as Willow Creek, feeding into Fine Gold Creek. Vegetation consists of dense stands of oak alternating with grassland areas. Most of the reservoir area and four of six

drill hole sites are accessed by County Road 210 (CR 210). The remaining two drill hole sites are located on private dirt roads that connect to CR 210.

Drilling Investigations

Six drill holes, FGR-03-01 thru FGR-03-06, were drilled within the limits of the proposed reservoir area (Plate 2, Table 4). The purpose of the drilling program was to characterize the near-surface soil and rock and to determine the depth to and quality of hard, unweathered (fresh) rock to evaluate their suitability as potential sources of construction materials for the proposed Fine Gold Dam across Fine Gold Creek. Soil and weathered rock are a potential source of impermeable fill; hard, fresh rock is a source of crushed aggregate and rip rap. Drill holes range in depth from 48.8 to 69.5 feet and were terminated in slightly weathered to fresh granitic bedrock. Drilling operations in the Fine Gold Valley area began on 9/3/03 and ended on 9/27/03.

Drill holes FGR-03-01 and -02 were completed on property belonging to Mr. John Olmstead. Drill holes FGR-03-05 and -06 were completed on property belonging to Mr. Ben Ewell. Permission to drill on their property was granted prior to drilling operations. Drill holes FGR-03-03 and -04 were completed along the shoulder of Madera County Road 210. A permit from Madera County was obtained prior to starting drilling operations. Additional planned exploratory drill holes were deleted from the program because these holes were located on land owned by individuals currently living in the Fine Gold Creek drainage basin who would not allow Reclamation personnel and equipment onto their property.

All holes were drilled by Reclamation's Mid Pacific drill crew using a CME 75 truck-mounted drill rig. Drilling and sampling was performed from the ground surface to the top of hard rock (or refusal) using 8-1/4 inch o.d. by 4-1/4 inch i.d. hollow-stem flight augers with a with a five foot long 3-3/8 inch i.d. split tube inner barrel for sample collection in alluvium and/or decomposed granite (soil and soil-like rock). Coring in hard rock used an HQ rotary diamond coring system and NX rods. Diamond core drilling employed a conventional five-foot-long core barrel and face-discharge diamond bit with 3.8-inch o.d. and 2.4-inch i.d. yielding 2.4-inch diameter core (HQ core). All drill holes were backfilled with bentonite holeplug from total depth to the ground surface.

TABLE 4. FINE GOLD RESERVOIR BORROW AREA DRILL HOLE DATA

Drill Hole	Total Depth (ft.)	Depth to Slightly Weathered to Fresh Granite
FGR-03-01	53.4	20.4
FGR-03-02	49.1	15.3
FGR-03-03	49.3	19.3
FGR-03-04	48.8	21.8
FGR-03-05	54.2	50.7
FGR-03-06	69.5	54.6

Site Geology

All six drill holes encountered saprolite soil (soil produced by the inplace weathering of rock), alluvium or decomposed to intensely weathered granitic rock to depths ranging from 15.3 to 54.6 feet, and hard, slightly weathered to fresh granitic rock below these depths. Drill holes typically encountered soil classified as Silty Sand to Sandy Silt (SM-ML) according to the Unified Soil Classification System (USCS). As shown in Table 4 depth to hard rock ranged from 15.3 to 54.6 feet. Four of six holes encountered hard rock at depths of 15.3 to 21.8 feet, an average depth of about 20 feet.

Geotechnical Considerations

1) Drill holes encountered 15.3 to 54.6 feet of saprolite soil, alluvium or decomposed to intensely weathered granitic rock over hard rock.
2) Soil contains non-plastic fines and classifies as Silty Sand to Sandy Silt (SM-ML).
3) Drill holes encountered hard rock, suitable for crushing into aggregate, at depths ranging from 15.3 to 54.6 feet with four of six holes encountering hard rock at an average depth of about 20 feet.
4) Drill holes FGR-03-05, -06, indicate a deep weathering profile (50 to 55 feet to hard rock) in the area between CR 210 and Millerton Lake.
5) Drill holes FGR-03-01, -02, -03, -04 indicate a shallow weathering profile along CR 210.

Conclusions

1) Crushed aggregate could be obtained from hard, slightly weathered to fresh granitic rock that is present at depths ranging from 15 to 55 feet.
2) Hard, fresh granitic rock could be could be quarried most economically near CR 210 where depth of excavation appears to be shallowest.
3) Saprolite soil and very intensely weathered to decomposed granite occurring in limited thickness over most of the reservoir area would provide a source of silty sand fill with low plasticity fines.
4) Potential construction uses for the borrow material include: concrete aggregate, rock fill, rip rap, sand and gravel, and earth fill.

VI. RM 286 DAMSITE

Location and Topography

The RM 286 Site is located about 4 miles northwest of Auberry, CA. and about 12 miles upstream of Friant Dam, near and named for river milepost 286 (RM 286) on the San Joaquin River. The site occupies a steep-sided, v-shaped canyon with continuous exposures of jointed granite on both canyon slopes. Both abutments rise steeply from about elevation 780 in the San Joaquin River channel to about elevation 1100 and then flatten from elevation 1100 to about elevation 2093 at an unnamed mountain on the right abutment and about elevation 2869 at Rock Mountain on the right abutment. At the time of the current investigations a maximum reservoir water surface elevation was proposed at about elevation 1400.

Primary land use in the area is grazing, low density, rural residential development and recreation. No existing structures or facilities are located along the proposed alignments of the dam axis and appurtenant structures up to at least elevation 2000 feet. The reservoir area may contain scattered residential structures below the proposed maximum reservoir elevation of 1400. Water storage (Kerckhoff and Reddinger Dams and Reservoirs) and power generation facilities (Wishon and Big Creek 5 Powerplants), State Highway 222 and the recently-constructed San Joaquin River Bridge at Wishon would be inundated at water surface elevation1400.

Drilling Investigations

Two exploratory drill holes were located on existing roads, as near as possible to the proposed damsite: MP286-03-1 on the upper left abutment at elevation 2095 on a northeast projection of the proposed dam axis and MP286-04-2 on the left abutment at elevation 1120, approximately 1500 feet downstream of the dam axis. Drill holes in the channel area and right abutment were not drilled due to a lack of existing access.

Site Geology

Geologic conditions are very consistent throughout the proposed damsite area and for a distance of a few miles upstream and downstream of the damsite. As revealed by extensive surface outcrops, core from the two drill holes and exposures in two nearby adits and the underground opening for Kerckhoff Powerplant No. 2, a dam constructed at the RM 286 site would be founded on fresh to slightly weathered, slightly to very slightly fractured, hard to very hard granitic rock with very few and very widely spaced shears that typically have been healed with quartz.

The most prominent geologic structure in the site area is strongly developed, widely spaced and continuous joints. Surface outcrops and drill core both show that joints are open as much as a few inches to a depth of 20 to 30 feet below the existing ground surface and that joints are tight or non-existent below a depth of 20 to 30 feet. Fracture density in core below about 30 feet was none to slightly fractured.

Rock mass permeability of the left abutment of the RM 286 Damsite appears to be high from 0 to a depth of 20 to 30 feet and very low from a depth of 20 to 30 feet to a depth 200 feet below the ground surface. Permeability tests performed in drill hole RM 286-03-2 ranged from 0 to 3 gpm and were mostly 0 to 1 gpm. Packer permeability tests performed in drill hole RM 286-04-2 measured water takes as follows:
0 to 19 feet: Greater than 40 gpm (maximum pump capacity)
19 to 39 feet: 2.2 gpm
39 to 200 feet: 0 to 0.2 gpm

Geotechnical Considerations

1) Hard, massive granite should provide an excellent foundation for any type of dam including a thin concrete arch.
2) Concrete aggregate could be produced by quarrying and crushing granitic rock.
3) Permeability tests show the rock mass to be extremely impermeable below a depth of 20 to 30 feet below the ground surface. The need for extensive grouting of the foundation rock should be seriously questioned.
4) The apparent absence of major discontinuities (shears and faults) and the lack of strongly developed or open joints below a depth of 20 to 30 feet, suggest that foundation treatment would be relatively minimal. Removal of the upper 20 to 30 feet of rock and excavation of a shallow keyway would probably suffice.

Conclusions

Based on appraisal level explorations the granite has adequate strength and stability for embankment, rock fill, concrete gravity, RCC, or concrete arch structures. The granite is geotechnically an excellent foundation for an RCC, concrete gravity or arch dam and associated river bypass and outlet works tunnels.

Kerckhoff Project

PG&E's Kerckhoff Project consists of two major hydroelectric plants, Kerckhoff Powerplants Nos. 1 and 2, and their associated water conveyance tunnels and appurtenant structures. Kerckhoff Powerplant and Tunnel No. 1 and associated features were constructed in the 1920's as was Kerckhoff Dam and Reservoir. Kerckhoff Powerplant and Tunnel No. 2 were constructed in the early 1980's. Intake structures for both water conveyance tunnels are located in Kerckhoff Reservoir on the left abutment of Kerckhoff Dam. Both tunnels pass through the right abutment of the RM 286 damsite. Tunnel No. 1 passes within a few hundred feet laterally and 180 vertical feet below the collar of drill hole MP286-04-02. The drill hole had to be relocated so as to safely avoid penetrating Tunnel No. 1.

Exposures of granitic rock in two adits excavated as part of the Tunnel No. 1 work and in the underground excavation for Powerplant No. 2 provide excellent opportunities to view rock that is representative of the foundation of the proposed RM 286 dam. Geotechnical data collected as part of the preconstruction investigation for the Kerckhoff No. 2 Project and limited available construction information are also pertinent to the proposed project. The summary of this data that follows is based on information received from PG&E describing the Kerckhoff No. 2 Powerplant and appurtenant structures (PG&E, February 2004). A complete geotechnical report has been informally requested from PG&E, but had not been received as of the date of this report.

Kerckhoff Powerplant No. 1, Tunnel No. 1 and Adits 1 and 2
PG&E's Kerckhoff Dam and Powerplant Project consisting of Kerckhoff Dam and Reservoir, a 16, 970-foot long, 17-foot wide by 19-foot high, horseshoe-shaped water conveyance tunnel (Kerckhoff Tunnel No. 1) and a 34 MW powerhouse (Kerckhoff Powerplant No. 1) was constructed in the 1920's. Tunnel No. 1 was excavated by conventional drill and blast methods and completed as unlined in 1921. Adits 1 and 2, located in the vicinity of Drill Hole MP286-04-02, are both easily accessed from a jeep trail leading to the drilling site and the downstream overlook for the proposed RM 286 Damsite. The adits were excavated as part of the original construction, probably to facilitate tunnel excavation and muck removal and to provide ventilation and access for mining equipment and pressurized air lines. The approximately 30-foot-diameter, unlined adits extend 80 to 100 feet horizontally in from the existing ground surface and terminate at concrete plugs of unknown thickness that separate the adits from Tunnel No. 1. The two adits provide excellent exposures of hard, slightly weathered to fresh, slightly fractured granitic rock that is considered to be representative of the granitic rock occurring throughout he damsite area. Granite exposed in adit walls is in excellent condition. Unsupported granite has remained stable for over 80 years. Rockfall or overbreak is nonexistent.

Adit walls are mostly dry with localized minor seeps. Groundwater covers most of the invert of Adit 2 as a 1-foot deep, pool which reaches its maximum extent in the winter rainy season and recedes noticeably throughout the dry summer months. Significant leakage from Tunnel No. 1 past the concrete plug in Adit 1 results in a constant flow from the adit, obscuring any evidence of groundwater accumulation.

Kerckhoff Powerplant No. 2 Project
The Kerckhoff Powerplant No. 2 Project includes a 140 MW underground powerplant, intake and discharge structures, water conveyance tunnel (Kerckhoff Tunnel No. 2), surge chamber, and associated construction adits, access tunnels and service tunnels. Construction was accomplished by a combination of drill and blast, tunnel boring machine (TBM) and raise boring methods in 1981. Approximately 60,000 cubic yards were excavated for the powerplant and ancillary facilities and about 320,000 CY for the tunnel excavation. Kerckhoff Reservoir provides 575 feet of head for generating hydroelectric power.

Preconstruction geologic investigations included a number of exploratory drill holes, laboratory testing for rock strength, petrographic examinations and hydrofracturing stress measurements. A summary of these results indicated the rock in the project area has a specific gravity of 2.7, Mohr hardness of 6.5, abrasiveness of 12, a modulus of elasticity of 530,000 kg/cm^2, average grain size 1mm, average quartz 25%, feldspar 60%, hornblende 15%. In situ stress was measured at a depth of 90 meters for sigma v, H_{min}, and H_{max} at 25, 55 and 90 kg/cm^2 respectively.

Kerckhoff Powerplant No. 2

PG&E's Powerplant No. 2, located about three miles downstream of the RM286 damsite, was inspected on March 15, 2004 to observe rock mass conditions exposed in this extensive underground excavation. The underground powerplant excavation, one of the largest in the world, is a high domed cavern, 95 feet in diameter by 148 feet high. Rock observed in the powerplant excavation is unsupported except for chain link mesh with a geotextile fabric mainly to direct minor water inflows away from metallic structures to prevent corrosion. A circular concrete ring estimated to be three feet thick by 4 feet wide is founded on an excavated shelf and secured with rock bolts to provide support for a 256 ton crane. The dome roof is not visible due to a false ceiling.

Access to the powerplant and associated underground openings is by a 1,242- foot-long by 22-foot-diameter horseshoe-shaped tunnel. The access tunnel was observed to be in good to excellent condition. Steel support fabric covered by shotcrete functions primarily as raveling protection and does not appear to structurally support the excavation.

All rock observed is hard, fresh, slightly fractured granite crossed by up to three joint sets. Rock is unsupported and in good to excellent condition.

Three joint sets were observed on unlined, excavation walls.

1) High-angle joint set dipping 70^0. Joints widely spaced 10 to 20 feet apart, moderately to highly continuous over a distance of 30+ feet, moderately open to tight with no to thin infillings and no surface alteration.
2) Low-angle joint set dipping $10\text{-}30^0$. Joints widely spaced 3 to 10 feet apart, highly continuous over a distance of 100+ feet, moderately open to tight with no to thin infillings and no surface alteration.
3) Moderate-angle joint set dipping $20\text{-}45^0$ (relatively minor set). Joints widely spaced 3 to 10 feet apart, moderately continuous over a distance of 5-20 feet, moderately open to tight with no to thin infillings and no surface alteration.

Evidence of rock mass instability such as unstable wedges, toppling, or rockfall were not observed.

Groundwater seepage into the powerplant excavation was localized (point source) and of small volume. The maximum seepage observed at any one location was estimated to be less than 5 gpm. Other occurrences of point-source seepage were each estimated to be less than 0.5 gpm.

Kerckhoff Tunnel No. 2

Completed in 1981, Kerckhoff Tunnel No. 2 is a 22,000-foot-long, unlined tunnel with a 24-foot circular cross section that was excavated entirely by tunnel boring machine (TBM). The tunnel can deliver up to 5,000 cfs of water with a

Manning's "n" friction value of 0.016 over a 175 foot elevation drop. Design velocity is 10.5 ft/sec (37 min residence time). Tunnel No. 2 is inspected at roughly 5 year intervals. The tunnel was not inspected by Reclamation personnel as part of the Powerplant No. 2 inspection.

Tunnel No. 2 features a three-cell "Celcep" style rock trap upstream of the surge chamber. Capacity of the rock trap is 0.10 CY/1000 ft of tunnel. After construction and three years of operation only 25 CY of rock had accumulated in the trap indicating that very minor to negligible raveling occurs within the unlined tunnel. Most of the trapped material is believed to be from original construction. Rock strength in the 8-20,000 psi range caused early problems with the TBM excavation in terms of proper cutting disc selection. This was the only reported rock condition affecting excavation performance. Advance rate averaged 1.4m/hr.

An underground penstock linking Tunnel No. 2 to the powerplant is 617 feet long by 21 feet in diameter with a 55^0 inclination from horizontal and a 400-foot elevation drop. The upstream 417 feet of the penstock is concrete lined, the lower 200 feet is steel lined. The penstock was not inspected.

VI. REFERENCES

1) Reclamation, August 2002, *Upper San Joaquin River Storage Investigation Field Trip Logs, August 2002,* U.S. Bureau of Reclamation, Mid Pacific Regional Office, Sacramento, CA and Technical Service Center, Denver, CO.

2) Reclamation, September 2002, *Appraisal Geologic Study, Storage Options in the Millerton Lake Watershed, Upper San Joaquin River Storage Investigation, September 2002,* U.S. Bureau of Reclamation, Mid Pacific Regional Office, Sacramento, CA and Technical Service Center, Denver, CO.

3) U.S. Geological Survey, *Geologic Map of the Millerton Lake Quadrangle, West-Central sierra Nevada, California by Paul C. Bateman and Alan J. Busacca, 1982.*

4) PG&E, February 2004, *Kerckhoff 2 Powerhouse Information* received from Nicholas J. Markevich, Senior License Coordinator, Pacific Gas and Electric Company, February 17, 2004.