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March 15, 2006

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Subject: Review of Bedrock Groundwater Conditions Technical Memorandum
PG&E Topock Compressor Station, Needles, California

Dear Mr. Shopay:

This letter transmits the *Technical Memorandum: Information Review of Groundwater Conditions in Bedrock Formations at PG&E's Topock Compressor Station*. The technical addendum is submitted in conformance with DTSC's January 6, 2006 letter.

Please contact me at (805) 546-5243 if you have any questions on this submittal.

Sincerely,

Julie Eakins for Yvonne Meeks

cc. Kate Burger/ DTSC

Enclosure

Technical Memorandum

Information Review of Groundwater Conditions in Bedrock Formations at PG&E's Topock Compressor Station Needles, California

March 15, 2006

Prepared for

California Department of Toxic Substances Control

On behalf of

Pacific Gas and Electric Company

CH2MHILL
155 Grand Avenue, Suite 1000
Oakland, CA 94612

Technical Memorandum

Information Review of Groundwater Conditions in Bedrock Formations at PG&E's Topock Compressor Station Needles, California

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This report was prepared under supervision of a California-Certified Engineering Geologist

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Project Hydrogeologist

Contents

Tables

Figures

Appendices

Acronyms and Abbreviations

ADEQ	Arizona Department of Environmental Quality
ADOT	Arizona Department of Environmental Quality
bgs	below ground surface
cm/sec	centimeters per second
Cr(VI)	hexavalent chromium
DTSC	California Department of Toxic Substances Control
E&E	Ecology & Environment, Inc,
EPNG	El Paso Natural Gas
gpm	gallons per minute
IM	Interim Measures
MSL	mean sea level
MTS	Mojave Topock Compressor Station
PG&E	Pacific Gas and Electric Company
RASA	Regional Aquifer-System Analysis
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RI	Remedial Investigation
TDS	total dissolved solids
USGS	U.S. Geological Survey

1.0 Introduction

This technical memorandum presents an information review and evaluation of geologic and hydrogeologic data regarding groundwater conditions in bedrock formations at Pacific Gas and Electric Company's (PG&E's) Topock Compressor Station near Needles, California. In the January 6, 2006 letter, *Requirement for Technical Memorandum Evaluating Potential Bedrock Fracture Porosity and Preferential Groundwater Migration Pathways, Pacific Gas and Electric Company, Topock Compressor Station, Needles, California (EPA ID No. Cat080011729),* the California Department of Toxic Substances Control (DTSC) requested that PG&E prepare a technical memorandum that presents and reviews available site data and published geologic and hydrogeologic literature on bedrock formations in the region. DTSC anticipates that information in this technical memorandum may be incorporated into the final RCRA Facility Investigation and Remedial Investigation (RFI/RI) report after review by DTSC and the Topock Geo/Hydro Technical Workgroup.

1.1 Study Area Location and Regional Setting

The PG&E Topock site and study area lie at the southern end of Mohave Valley in eastern San Bernardino County, California and western Mohave County, Arizona. Figure 1 shows the location of the study area, and portions of the surrounding groundwater basins. Following the nomenclature of Anderson and Freethey (1992), the study area is within the Mohave groundwater basin, which is bisected by the Colorado River. The Sacramento Valley groundwater basin lies to the east, in Arizona. Sacramento Wash is the principal surface drainage in the Sacramento Valley basin, and enters the Colorado River at Topock. The general groundwater flow directions in the Mohave and Sacramento Valley basins are shown on Figure 1. The study area includes the portions of California and Arizona where well log information is available. This information was reviewed for this technical memorandum. The published literature that was reviewed for this report covers territory beyond the study area.

1.2 Hydrogeologic Setting

This section introduces the geohydrologic setting of the study area (adapted primarily from Metzger and Loeltz 1973) and the terminology for the bedrock and hydrostratigraphic units addressed in this memorandum. Figure 2 presents a generalized geologic map of the study area. The oldest rocks in the Topock area are pre-Tertiary metamorphic and igneous rocks, which are exposed in the Chemehuevi Mountains and other basin-bounding ranges in the region. Miocene-age sedimentary and volcanic rocks, associated with the tectonic uplift and faulting in the region, were deposited on the metamorphic and igneous bedrock complex. Late Miocene-age and younger alluvium, and Colorado River fluvial deposits, unconformably overlie the faulted and steeply-dipping Miocene sedimentary and volcanic rocks. The "Fanglomerate" of Metzger and Loeltz (1973) refers to the consolidated basal alluvial fan sediments that were deposited on the unconformity. This regional unconformity

separates the bedrock formations from the overlying, flat-lying (undeformed) alluvial and fluvial deposits in the Mohave and Sacramento Valley basins (Metzger and Loeltz 1973).

Bedrock, as here used, refers to all rocks that are older than, and unconformably underlie, the Fanglomerate of Metzger and Loeltz. The undeformed Fanglomerate (believed to be late Miocene in age) is referred to as "Oldest Alluvium" on the study area geologic map (Figure 2). The geologic and hydrostratigraphic unit terminology used in PG&E's February 2005 RFI/RI Report (CH2M HILL 2005a) is summarized as follows:

- **Pre-Tertiary Metamorphic and Igneous bedrock:** includes primarily metadiorite (typically dark green to gray, hard), gneiss (light to dark gray, hard, layered felsic/mafic metamorphic rock), and granitic rocks (light gray, hard, fine- to medium-grained felsic plutonic rocks).
- **Miocene Conglomerate bedrock:** includes indurated, primarily cemented, reddish-brown, poorly-sorted conglomerate and gravelly sandstone, with 10 to 30 percent clay/silt content. The Miocene Conglomerate is massive to thick-bedded and typically contains angular clasts (sand to boulder size) of the pre-Tertiary metamorphic/igneous rocks exposed in the Chemehuevi Mountains. As noted in published geologic maps, this unit locally includes megabreccia (inferred landslide deposits). In outcrops, the Miocene Conglomerate bedrock is well-consolidated and locally fractured.
- **Oldest Alluvium:** includes moderately-consolidated and locally cemented, sandy gravel and silty/clayey gravel (characteristically subangular fragments of rock types found in the local bedrock). The Oldest Alluvium forms deeply-dissected alluvial terraces with desert pavement and steep canyon walls.
- **Bouse Formation:** includes well-bedded, moderately-indurated, green to bluish-gray clay, siliceous claystone, and tan to pink fine-grained sandstone (Metzger and Loeltz 1973). The Bouse Formation is exposed in dissected alluvial terraces and local outcrops only in the western portion of the study area (Figure 2).
- **Younger Alluvium:** includes unconsolidated, sandy gravel and silty/clayey gravel alluvial fan deposits and surficial deposits.
- **Colorado River sediments:** includes unconsolidated and moderately-consolidated fluvial sand, gravel, and floodplain silt/clay deposits.

1.3 Evaluation Approach

The primary purpose of this technical memorandum is to summarize and review the available site data and published geologic and hydrogeologic literature on bedrock formations in the region. Figure 3 shows the locations of the PG&E Topock site and the study area. This memorandum is organized as follows:

- **Section 2** summarizes the geologic reports and mapping of bedrock geology and structure in the study area and surrounding region. Additionally, published water resource reports for the Mohave basin and adjoining region are summarized regarding the occurrence and characteristics of groundwater in bedrock geologic formations.

- **Section 3** presents and describes the available drilling, well log, testing and characterization data for the wells and borings at PG&E's Topock site that have been completed in bedrock formations. Drilling records and well information for selected water supply wells in western Mohave County, Arizona were also reviewed, and this information was included in the evaluation of groundwater conditions in the study area. Available vertical hydraulic gradient data and water quality data for wells completed in bedrock are also considered.
- **Section 4** presents the conceptual hydrogeologic site model for the study area, which includes defining the framework and characteristics of bedrock units at the Topock site. Additional review of published literature on the regional faulting and groundwater flow in comparable geologic settings is provided.
- **Section 5** provides a summary and conclusions of this evaluation of geologic and hydrogeologic data regarding bedrock groundwater conditions in the study area.

2.0 Review of Published Reports on Bedrock Geology and Hydrogeology

2.1 Geologic Reports and Mapping

The U.S. Geological Survey (USGS) and other authors have issued a number of reports and maps on the geology, structure, and bedrock tectonic framework and setting of the study area. The available mapping and reporting documentation relevant for this review include:

Miller and others (1983) - *Mineral Resources Potential of the Chemehuevi Mountains Wilderness Study Area.* Provides a geologic map of the Chemehuevi Mountains that describes the geologic structure and low-angle normal (detachment) faults that encircle the Chemehuevi Mountains.

John (1987a) - *Geologic Map of the Chemehuevi Mountains area, San Bernardino County, California and Mohave County, Arizona.* Provides detailed mapping and description of the geology and structure of the metamorphic basement rocks and detachment faults that are exposed in the Chemehuevi Mountains, including the mapping of bedrock formations and detachment faults near PG&E's Topock Compressor Station. Excerpts of this mapping report are included in Appendix A1 of this memorandum.

John (1987b) - *Geometry and evolution of a mid-crustal extensional fault system: Chemehuevi Mountains, southeastern California.* Provides a description and interpretation of the structure and characteristics of the detachment faults in the Chemehuevi Mountains, and includes interpretative geologic cross sections of the detachment faulting south and east of the Topock site. Excerpts from this publication are included in Appendix A1.

Howard and others (1997) - *Preliminary Geologic Map of the Eastern and Northern Parts of the Topock 7.5-minute Quadrangle, Arizona and California.* Provides mapping and description of the geology and structure of the metamorphic basement rocks and detachment faults that are exposed in the Mohave Mountains, including the mapping of Quaternary deposits and geologic structure in Mohave County, Arizona. Excerpts of this mapping report are included in Appendix A2.

Miller and John (1999) - *Sedimentation Patterns Support Seismogenic Low-Angle Normal Faulting, Southeastern California and Western Arizona.* Provides geologic maps, data, and discussion of the Miocene sedimentary and volcanic rocks that were deposited during the extensional faulting in the Chemehuevi Mountains. The publication describes the lithology and depositional setting of the Miocene Conglomerate and associated megabreccia deposits (bedrock units at Topock site).

2.2 Water Resource and Supply Reports

The USGS, agencies of Arizona, and other authors have issued a number of geohydrology/water resources reports, maps, and assessments for the Mohave and Sacramento Valley groundwater basins. Table 1 provides a summary of the information on groundwater conditions of bedrock formations in the region. The published reports and mapping relevant for this review include:

Metzger and Loeltz (1973) - *Geohydrology of the Needles Area, Arizona, California, Nevada.* This is the "benchmark" publication on the hydrostratigraphy, groundwater conditions, water resources, and surface water-groundwater supply history for the study area. This publication provides description and data pertaining to the limited capacity of water yield from bedrock formations in the study area.

Gillespie and Bentley (1971) - *Geohydrology of Hualapai and Sacramento Valleys, Mohave County, Arizona.* Provides water resource evaluation and maps for the Sacramento Valley groundwater basin, including description and data pertaining to groundwater occurrence in bedrock formations in the Sacramento Valley area.

Anderson and others (1992) - *Geohydrology and Water Resources in Alluvial Basins in South-Central Arizona and Parts of Adjacent States.* This report, and related publications completed under the USGS Alluvial Basins Regional Aquifer-System Analysis (RASA) program, addresses groundwater conditions in the Mohave and Sacramento Valley groundwater basins, including a description of valley-bounding bedrock formations serving as alluvial aquifer boundaries.

Robertson (1991) - *Geochemistry of Ground Water in Alluvial Basins of Arizona and Adjacent Parts of Nevada, New Mexico, and California.* Provides data and discussion of geochemistry and hydrologic characteristics of groundwater in 72 alluvial basins in the RASA study area, includes data from Sacramento Valley, Arizona.

Wilson and Owen-Joyce (1994) - *Method to identify Wells that Yield Water that will be replaced by Colorado River Water in Arizona, California, Nevada, and Utah.* Provides discussion, maps, and data regarding a methodology for river-aquifer "accounting surface" evaluation for the Lower Colorado River, and includes a description of bedrock formations that serve as alluvial aquifer boundaries. This publication includes data and discussion of gravity studies used to delineate buried bedrock ridges that act as subsurface barriers to flow, and affect the extent and thickness of the river-aquifer in the La Posa Plain, Vidal Valley, and other areas in the Lower Colorado River region.

Rascona (1991) - *Map Showing Groundwater Conditions in the Sacramento Valley Basin, Mohave County, Arizona – 1991.* Provides data and a 1990 water table elevation map of the Sacramento Valley, including water table elevations and geochemical data for water wells in the vicinity of Topock.

Towne and Freark (2001) - *Ambient Groundwater Quality of the Sacramento Valley Basin: a 1999 Baseline Study.* Provides data and discussion on water quality sampling and assessment of alluvial basin and hardrock (bedrock) wells in the Sacramento Valley area.

Refer to Table 1 and Section 6 (References) for more information on the water resources publications available for the regional study area.

3.0 Evaluation of Existing Bedrock Data in Study Area

This hydrogeologic review focuses on the available drilling records, well information, and site characterization data for the bedrock groundwater wells, and investigations conducted to date at PG&E's Topock site. The wells completed in bedrock at the Topock site include three groundwater monitoring wells (MW-23, MW-24BR, and MWP-2RD) and two inactive wells (PGE-7 and the former injection well PGE-8) (Table 2). Figure 4 shows the locations of the wells that are completed in bedrock, the borings that have encountered bedrock formations, and general features of the site. This section also provides a review of the available well logs and hydrogeologic data for the adjoining portion of the study area in western Mohave County, Arizona (Table 3).

3.1 Groundwater Monitoring Wells Completed in Bedrock

Monitoring and characterization data on bedrock groundwater conditions at the Topock site are provided from boring logs for monitoring wells MW-23 and MW-24BR (completed in pre-Tertiary metamorphic bedrock). Data are also available for monitoring well MW-2RD (completed in metadiorite bedrock), which was decommissioned in 1995. Figure 4 shows the location of the three bedrock groundwater monitoring wells, and Table 2 provides a summary of the drilling and construction records for these wells. The drilling and well elevations for the bedrock monitoring wells are shown in a schematic hydrogeologic cross section in Figure 5.

3.1.1 Well MW-23

Well MW-23 is completed in the Miocene Conglomerate unit (referred to in some previous PG&E reports as Red Fanglomerate), with a 20-foot well screen. The formation is described as cemented, pebble conglomerate and sandstone. In 2002, a rising head slug-test was conducted to estimate the hydraulic properties of this bedrock formation. After a short duration of pumping generated 10.8 feet of drawdown, the well required almost 15.5 hours for water levels to fully recover. Based on this test, the estimated hydraulic conductivity of the formation was estimated to be 1.5×10^{-6} centimeter per second (cm/sec) (4.3×10^{-3} ft/day), similar to that of silt or poorly fractured bedrock (Ecology & Environment [E&E] 2002).

3.1.2 Well MW-24BR

Well MW-24BR is completed with a 60-foot screen in pre-Tertiary(?), cemented sandstone and/or crystalline metamorphic bedrock, which underlies the Miocene Conglomerate unit. The well is located immediately northwest of PG&E's Topock Compressor Station (Figure 4). In 2002, the well was pumped for one minute, resulting in an initial drawdown of 11.1 feet. The water level in the well almost fully recovered in 37 hours. During routine groundwater sampling, well MW-24BR typically takes up to six days to fully recover after a

3-casing-volume purge. Based on the 2002 rising-head test, the estimated hydraulic conductivity for the bedrock formation is 9.7×10^{-7} cm/sec (2.8×10^{-3} ft/day), similar to that of clay or well-cemented, unjointed sandstone (E&E 2002).

3.1.3 Old Ponds Site and Well MWP-2RD

During the period of 1985 through 1995, PG&E conducted hydrogeologic investigations and groundwater monitoring at the former wastewater evaporation ponds (Old Ponds site), located approximately 1,800 feet west of the Compressor Station (Figure 4). A total of 12 groundwater monitoring wells were installed and used for compliance monitoring when the Old Ponds site was in operation. In 1995, as part of site closure, all but three of the monitoring wells were decommissioned.

The specific hydrogeologic and geotechnical investigations, and extensive groundwater monitoring data available for the Old Ponds site, are presented in several project reports (PG&E 1993; PG&E 1995; Alisto 1997). These reports, and the individual site investigations and studies cited in these reports, were reviewed for characterizing bedrock groundwater conditions. Appendix B1 includes excerpted figures from these reports, which illustrate the hydrogeology and bedrock conditions in this portion of the Topock site.

In 1985, site investigations and preliminary geotechnical evaluations of potential evaporation pond sites were conducted (Alpha Geotechnical Consultants 1986a, 1986b) and a refraction seismic survey of the Old Ponds site was performed (Louke & Associates 1986). One of the purposes of these studies was to investigate the depth and characteristics of bedrock in the Old Ponds area. The seismic survey delineated the approximate depth and subsurface configuration of crystalline bedrock at the Old Ponds site, and nearby at upper Bat Cave Wash (see Appendix B2 for the seismic investigation figures). Both weathered and sheared zones in the metadiorite bedrock were inferred from the seismic refraction investigation.

At the Old Ponds site, an initial deep boring was drilled to a depth of 500 feet below ground surface (bgs), and a 280-foot interval of metadiorite bedrock was logged (1985 well log MWP-2, Appendix B1). The bedrock interval, drilled with air percussion method, was generally logged as dry, hard/fresh to slightly weathered metadiorite, with occasional moist to wet rock (potentially indicative of fractured) zones. This location was subsequently redrilled in 1992, and bedrock monitoring well MWP-2RD was installed (see Table 2 for well construction details).

As shown on Figure 5, well MWP-2RD exhibited very low permeability characteristics and inconsistent/erratic water level data; in fact, the recovery response of this well was so slow that insufficient recharge prevented routine quarterly sampling during the Old Ponds monitoring program (PG&E 1993). Water chemistry for bedrock well MWP-2RD is discussed in Section 3.5. This well was permanently abandoned in 1995.

3.2 Former Injection Well PGE-8

3.2.1 Well Construction and History

The former injection well PGE-8 was completed in June 1969. The original boring extended 530 feet bgs (ground surface is 593 feet mean sea level [MSL]), drilled with a combination of mud and air rotary techniques. Water levels measured during air rotary drilling were consistently around 138 feet bgs, indicating to observers that the bedrock was sufficiently fractured and that there were no isolated, confined water-bearing zones in the bedrock (Dames & Moore 1969). The alluvium-Miocene conglomerate contact was estimated at 504 feet MSL, and the alluvium/conglomerate-metadiorite contact at 421 feet MSL. During drilling, a sharp increase in groundwater specific conductance was noted at and below 320 feet MSL (Dames & Moore 1969). Well records for PGE-8 are included in Appendix C1.

The boring was originally completed with 6-inch steel casing to 405 feet MSL, with the remainder of the borehole open. Soon after wastewater injection began (June 1970; detailed below), collapse of the bottom 15 feet of the well was noted (PG&E 1995). The well was subsequently cleaned and deepened from 530 to 562 feet bgs via air rotary drilling. A Johnson well screen and liner assembly, composed of 4-inch diameter stainless steel, was installed from 405 to 550 feet bgs.

3.2.2 Well Testing

As originally completed, PGE-8 was tested on various occasions for short durations (12-60 minutes) at flow rates ranging from 20 to 51 gallons per minute (gpm), then for a longer period (26 hours) at 26 gpm. Dames & Moore (1969) calculated a transmissivity of 10,000 gpd/ft (~1,300 ft^2/d), based on the longer duration test (using a porous media analysis). The results from the 26-hour test, rapid drawdown in early time followed by stabilized water levels for an extended period of time, show a response typical of double-porosity aquifers or leakage from overlying layers. In either case, a porous media approach is inappropriate, and will yield erroneously high permeability values. Data and records from the 1969 well pumping test at PGE-8 are included in Appendix C1.

Injection tests were performed in April 1970, when fresh water was injected at rates as high as 40 gpm for 24 hours with no pressure buildup. The results from this injection test have similar problems in quantitative analysis as the 1969 pumping data. From a strictly qualitative perspective the aquifer takes water over a 24-hour period, but the data do not allow for quantitative analysis using either porous or fractured media techniques. The tests were designed to give the driller a general idea of whether the wells had sufficient capacity to achieve the pumping or injecting goals, and were not of sufficient quality or duration to allow for fractured media analysis.

3.2.3 Injection Operations

Wastewater injection began on May 30, 1970 (Dames & Moore 1970). Pump pressure soon reached 30 psi, and by June 4, 1970, the pressure had reached 180 psi despite the addition of 38 percent hydrochloric acid into the injection tubing. After the deepening and completion with stainless steel screen in June 1970 as detailed above, PGE-8 was used as a destination for treated wastewater disposal until August 1973. After this time, treated wastewater was

disposed in the well and in the former Old Evaporation Ponds on a 3-day alternating cycle (PG&E 1995). The last record of injection was in a February 8, 1974 report, noting the injection of 1,100 gallons since the last report on January 15, 1974 (PG&E 1995).

3.3 Inactive Supply Well PGE-7

3.3.1 Well Construction and Bedrock Characteristics

Well PGE-7 is located approximately 200 feet northwest of the north gate to the Topock Compressor Station (Figure 4), in an area known as the MW-24 bench. PGE-7 was originally installed in 1964 to 182 feet bgs, as a replacement industrial water supply well for the Topock Compressor Station. The original well was constructed with 14-inch steel casing, with perforations from 110 feet to 180 feet bgs. In 1969, the well was deepened to 330 feet bgs, with a 7-inch-diameter blank steel liner installed to 195 feet bgs, and the remainder of the hole uncased to 330 feet bgs. Table 2 summarizes well construction information for PGE-7. The depth of the contact of the alluvial aquifer with the Miocene Conglomerate (bedrock) at the PGE-7 location is estimated at 220 feet bgs. Therefore, approximately 25 feet of the open-hole portion of PGE-7 is exposed to the base of the alluvial aquifer.

However, a 1998 video log indicates angular rock with possible fractures is visible in the open borehole from 234 feet to the top of fill at 303 feet bgs (video log report included in Appendix C2). Based on logs from nearby borings (MW-24BR and TW-1), the bedrock formation present in PGE-7 is believed to be consolidated/cemented Miocene Conglomerate. The lower portion of the PGE-7 deepened borehole may have also encountered the pre-Tertiary metadiorite bedrock that was logged in the former injection well PGE-8 (located approximately 750 feet south of PGE-7).

At DTSC's request, PG&E submitted a technical assessment of the conditions and feasibility of hydrogeologic investigation, and of the potential for re-completing the openhole interval as a bedrock groundwater monitoring well. If reconstruction is pursued, existing PGE-7 could provide an additional bedrock groundwater monitoring well to assess and monitor bedrock groundwater conditions at the Topock site.

In November 2003, PG&E drilled and installed pilot test well TW-1 at a location approximately 200 feet south of PGE-7, and 650 feet north of PGE-8 (Figure 4). TW-1 was drilled to a depth of 312 feet bgs, and encountered 41 feet of Miocene Conglomerate bedrock. The boring was geophysically logged and selectively cored, and spinner log testing was performed in the alluvial aquifer well installed at TW-1 (CH2M HILL 2003). The geophysical logs for TW-1 are included in Appendix C3.

Additional geophysical logging data were collected for the Miocene Conglomerate bedrock unit at well TW-2D. The geophysical logs are provided in Appendix C3, and include a P- and S-wave borehole velocity log. The Miocene Conglomerate bedrock exhibits average shear-wave velocities over 1,700 meters per second (compared to 1,000 meters per second for the Oldest Alluvium saturated deposits). The collective set of geophysical logs for wells TW-1 and TW-2D indicate that the Miocene Conglomerate is distinct (in terms of geophysical properties) from the alluvial basin deposits at the Topock site.

3.4 Vertical Hydraulic Gradients

Locations available for quantification of vertical hydraulic gradients between bedrock and unconsolidated material are limited to the MW-24 well cluster (Figure 4). The bedrock monitoring well MW-24BR has consistently recorded a higher total hydraulic head (corrected for salinity and temperature) than MW-24A and MW-24B over four years of monitoring, with calculated upward hydraulic gradients ranging from 0.002 to 0.006 (Table 4).

Water level data from PGE-8 also indicate an upward hydraulic gradient exists between the bedrock and the alluvial aquifer at this location. The groundwater elevations measured in 2004 in PGE-8 (well screen 405-500 feet bgs) ranged from 1 to 2 feet higher than groundwater elevations measured in nearby alluvial aquifer wells MW-24B and TW-1 (water level data adjusted for salinity).

As presented in PG&E's February 2005 RFI/RI Report (CH2M HILL 2005a), the water levels in well clusters completed in unconsolidated alluvial aquifer (MW-20, MW-32, MW-33, and MW-34) typically indicate upward hydraulic gradients up to an order of magnitude greater than horizontal gradients. While these wells are not completed within the bedrock saturated zone, upward gradients in the alluvium immediately above the bedrock lend support to discharging conditions within the site bedrock.

3.5 Water Quality Data

To supplement this information review, water quality data for the PG&E wells that were completed in bedrock formations are summarized in Table 5. The groundwater sampled in bedrock wells MW-24BR and PGE-8 is very saline, and exhibits a pH between 8 and 9 and negative oxidation-reduction potential (indicating reducing conditions). The groundwater sampled from MW-23 is saline, has lower pH, and is isotopically lighter than the deeper bedrock well MW-24BR. Due to current well construction, the water chemistry for PGE-7 likely reflects water contribution from the overlying alluvial aquifer (see Table 2).

Also listed on Table 5 are water quality data in the Arizona water wells that were reviewed for this hydrogeologic compilation. Groundwater samples for the Arizona wells show much lower total dissolved solids (TDS), chloride, and sulfate than the bedrock wells at the Topock site.

3.6 Water Supply Wells in Western Mohave County, Arizona

As part of this hydrogeologic review, drilling records and well information for selected water supply wells in western Mohave County, Arizona were reviewed. Figure 3 shows the locations of Arizona water wells that were reviewed for this study. Seven of the wells are active supply wells, with drilling logs and relevant production/testing data. The well data was obtained from the Arizona Department of Water Resources, the Arizona Department of Environmental Quality (ADEQ), and PG&E records.

3.6.1 City of Needles Wells Topock-2 and Topock-3

At Topock, Arizona, the City of Needles owns and operates two municipal water supply wells, informally designated Topock-2 and Topock-3. These wells supply the water needs of the Topock community and PG&E's Topock Compressor Station. Figure 3 shows the location of the City of Needles wells. Table 3 provides a summary of the drilling, well construction, and reported production rates for these wells. Well records and driller's logs are included in Appendix D1. The drilling and well elevations for the Topock-2 and Topock-3 are shown in a schematic hydrogeologic cross-section in Figure 6.

The Topock wells are currently completed to depths of 140 and 150 feet bgs, in materials that appear to be coarse-grained alluvial deposits. The high production rates (consistent daily operations at 200 to 350 gpm per well) support this assessment. Based on the driller's log, the hydrostratigraphic assignment of the drilled interval below 150 feet (broken and decomposed granite) can not be determined with confidence. The deeper interval may be a very coarse alluvial boulder zone or Miocene-age granitic megabreccia (bedrock unit), as described by John (1987) and Miller and John (1999).

3.6.2 Mojave Pipeline Company Wells at Mojave Topock Compressor Station

At the Mojave Topock Compressor Station, the Mojave Pipeline Company operates two industrial supply wells (installed in 1991), informally designated MTS-1 and MTS-2 (Figure 3). The drilling, well completion, and production information are summarized in Table 3, and illustrated on Figure 6. Drilling records, borehole geophysical logs, and well completion aquifer testing data for MTS-1 and MTS-2 are included in Appendix D2.

As shown on the driller's logs, both wells are completed at depths of approximately 600 to 700 feet bgs, in material that was logged as sand, reddish rock, hard reddish rock, and clay. The borehole geophysical log for MTS-2 (Appendix D2) indicates overall uniform natural gamma log response from 160 to the total log depth of 725 feet bgs. The short and normal resistivity logs show very consistent increasing resistivity (indicative of increased consolidation) with depth. Based on the drilling and geophysical logs for MTS-2, no abrupt formation change was observed.

The geophysical log for MTS-1 shows overall decreasing gamma ray and short and normal resistivity log responses from 150 to the total log depth 591 feet bgs. The reported pumping test data demonstrates that the screen intervals in MTS-1 and MTS-2 are within significantly permeable formations (see Appendix D2 test reports). Hydrostratigraphic assignment of the well completion zones in MTS-1 and MTS-2 is inconclusive based on the logging data alone. In wells at the PG&E Topock site, the Miocene Conglomerate bedrock typically shows a strong signal in the gamma ray log. This signal is not seen in gamma ray logs from MTS-1 and MTS-2. The hydraulic test data (Appendix D2) suggest similarities to the reported production characteristics for Sacramento Valley basin wells that are completed in the Oldest Alluvium (Gillespie & Bentley 1971). It is unclear if either of the MTS wells penetrates bedrock.

3.6.3 El Paso Natural Gas Wells at Topock Camp

At Topock Camp, drilling logs and production records are available for two active supply wells, owned by El Paso Natural Gas, and informally designated EPNG-1 and EPNG-2

(Figure 3). Both wells were originally installed in the early 1950s, and have subsequently been relined and/or rehabilitated for domestic supply. The drilling, well completion, and production information are summarized in Table 3, and illustrated on Figure 6. Drilling records, well completion, and pumping test data for EPNG-1 and EPNG-2 are included in Appendix D3.

As shown on the driller's logs, both wells encountered comparable intervals of blue and gray clay to depths of 350 to 400 feet bgs, overlying a sequence of sand and gravel (to 500 feet) and interbedded shale/clay and fine to coarse sand to total depth of 880 feet bgs (Figure 6). Metzger and Loeltz (1973) assigned the clay interval and underlying sand and gravel sequence in EPNG-2 as the Bouse Formation and Fanglomerate (undeformed Oldest Alluvium). It is likely that neither of the EPNG wells penetrates bedrock.

3.6.4 Arizona Department of Transportation (ADOT) Wells

At the Needle Mountain facility, well records for two Arizona Department of Transportation (ADOT) supply wells, informally designated ADOT-New and ADOT-Old, were reviewed (see Figures 3 and 6). Well information for the ADOT wells is summarized in Table 3, and well logs are included in Appendix D4.

As shown on the driller's logs, both ADOT wells encountered comparable intervals of blue and gray clay to an approximate depth of 300 feet bgs, overlying a sequence of hard sand and gravel, locally reddish, to drill depths of 396 and 530 feet bgs (Figure 6). Based on the drilling depths and correlation with the nearby EPNG-2 well, the ADOT wells appear to be completed in the pre-Bouse Fanglomerate unit (undeformed Oldest Alluvium), and not in bedrock.

3.7 Bedrock Elevation Data and Mapping

Figure 4 shows the locations of well borings and exploratory borings that encountered Miocene Conglomerate and the pre-Tertiary crystalline bedrock during the site investigations completed through March 2005. The data shown on Figure 4 are from the following sources:

- 1988-1992 Old Ponds site drilling and investigations (PG&E 1993, 1995)
- 1996-2003 RFI drilling programs (E&E 2004)
- 2004-2005 Interim Measures (IM) drilling program (CH2M HILL 2005a)
- 2004-2005 IM No. 3 drilling program (CH2M HILL 2005b)
- Early 1960s boring logs for the I-40 bridge crossing at Topock (Caltrans 1962)

Additional information for bedrock elevation mapping comes from the 2004 seismic reflection survey along the Colorado River, which was conducted for the Topock project by the USGS.

For preliminary review, Figure 7 is a structure elevation contour map of the Miocene bedrock surface that underlies the floodplain area, based on drilling data obtained through March 2005. The map shows the boring locations and elevations of the top of the cemented, hard Miocene Conglomerate bedrock.

In February 2006, PG&E initiated additional drilling under the IM performance monitoring program. The objectives of the 2006 drilling are to confirm the depth and conditions of

bedrock at additional locations in the floodplain and adjoining IM area, and to install additional wells for monitoring the performance of the IM.

Following the completion of the current IM drilling program, an updated Miocene bedrock elevation map will be prepared in Spring 2006 to support ongoing site characterization activities, the groundwater numerical model, and preparation of the final RFI/RI report for the Topock site.

4.0 Conceptual Hydrogeologic Site Model

Figure 8 is a generalized site cross-section that illustrates the conceptual hydrogeologic site model (the cross-section location shown on the inset map on Figure 8). This hydrogeologic section illustrates the elevations of the upper, middle, and lower depth intervals of the alluvial aquifer, the elevation of the top Miocene bedrock surface, and inferred bedrock structure along this section. Also shown are the screened intervals of monitoring well clusters and other key wells, and the hexavalent chromium (Cr[VI]) results from the October 2005 monitoring event. The sampling data show a wide range of Cr(VI) concentrations within the alluvial aquifer sampling locations and depths. The wells that monitor groundwater in the Miocene and older bedrock formations (MW-24 cluster deep well, PGE-7, and PGE-8) were non-detect for Cr(VI) in 2005.

Upward hydraulic gradients would be expected near the lower end of the Mohave basin, where the study area is located. In this area, the bedrock becomes shallower and the basin becomes narrower. Groundwater flowing southward down the basin would be forced upward as the bedrock becomes shallower. Upward hydraulic gradients are observed at several locations - in alluvial well clusters, and between bedrock and the alluvial aquifer at the MW-24 well cluster. Contour plots provided by ADEQ in a presentation to the Topock Geo/Hydro Technical Workgroup in October 2005 indicate that groundwater levels in deep wells MTS-1 and MTS-2 near the Mojave Topock Compressor Station are more than 10 feet higher than water levels in the shallower Topock-2 and Topock-3 wells located less than a mile away. This suggests upward gradients probably exist on both sides of the river. Upward gradients would limit or prevent the movement of water from the alluvial system downward into the bedrock.

4.1 Faulting and Bedrock Structure in the Study Area

The most prominent geologic structure in the study area is a Miocene-age, low-angle detachment fault system, which forms the northern boundary of the Chemehuevi Mountains (Figure 2). The Chemehuevi detachment fault is part of a series of low-angle detachment faults that formed in the middle-Miocene (approximately 23 to 15 million years ago), and have offset lower plate Pre-Cambrian and Mesozoic-age metamorphic and plutonic rocks from overlying upper plate pre-Tertiary metamorphic/plutonic, and Miocene volcanic and sedimentary rocks (Miller & others 1983; John 1987a, 1987b; see Appendix A1).

The surface expression of the Chemehuevi detachment fault is evident as the pronounced northeast-southwest lineament that can be traced along the northern boundary of the Chemehuevi Mountains, terminating at an abrupt bend in the Colorado River east of the compressor station (Figure 2). The surface trace of the detachment fault is partially concealed by younger alluvial deposits in the southwestern portion of the study area. According to the geologic literature, there is no evidence of continued fault movement on the detachment faults, or evidence of other more recent active faulting in the study area (Howard & John 1997; Howard & others 1999). Based on published geologic reports, the Chemehuevi detachment fault slopes away from the Chemehuevi Mountains, and is

projected to extend to the northeast into Arizona (John 1987b). According to the interpretation presented by John (1987b) and Howard & others (1999), the low-angle regional detachment fault east of the Colorado River is projected at depths ranging from 1,000 to 2,000 feet bgs (see Appendix A1 published information).

A regional unconformity separates the Miocene and older bedrock formations from the overlying unconsolidated alluvial/fluvial deposits (Metzger and Loeltz 1973). As noted above, faulting and deformation are confined to the metamorphic bedrock core complex and the consolidated Miocene Conglomerate. In the area east of PG&E's Compressor Station, the Miocene Conglomerate has a structural dip up 40° to the northeast beneath the unconformity. North of the Compressor Station, the Miocene bedrock surface plunges in the subsurface steeply to the north, as shown on Figure 7.

The bedrock structure map for the Topock site and adjoining area will be updated in 2006 with data from the ongoing IM drilling investigations.

4.1.1 Groundwater Conditions in Bedrock Formations at Topock Site

Based on hydrogeologic investigations and hydraulic characteristics observed in the bedrock wells at the site, groundwater locally occurs in weathered and fractured areas that are highly variable laterally and vertically. No areas or locations have been identified where saturated bedrock formations are capable of significant storage, or sustained production or yield. The available data indicate that bedrock formations below the water table are poorly permeable. The short-term performance of the former injection well PGE-8 (capable of accepting an average of 600,000 gallons [14 gpm] of treated wastewater per month, over an approximately 4-year pressure-injection operation period), suggest that the bedrock formation at this location was sufficiently fractured to provide modest permeability. The data collected from the short duration tests run at the well are insufficient to determine whether the storage for this water is within the fractured bedrock, or if it moved through leakage to overlying layers.

The ability of the bedrock to convey water is dependant upon the interconnectedness of the fracture system(s) in the rock. The very low to exceedingly slow well recharge characteristics observed in the crystalline bedrock monitoring wells demonstrate that the bedrock formations exist without any significant secondary permeability. As noted in surface lineament mapping (PG&E 1995), two principal directions of bedrock fractures and joints have been mapped at the site: one set runs sub-parallel to the northern front of the Chemehuevi Mountains, and the other is sub-perpendicular to the front of the range. However, as shown by the extremely low bedrock permeability exhibited in areas where substantial shear zones and fracture systems were recognized in the vicinity of the mapped detachment fault structures (i.e., at the PGE-8 borehole, and from the Old Ponds area seismic investigations), it appears that these fracture systems are not laterally persistent or extensive.

4.1.2 Hydrogeologic Evaluation of Supply Wells in Western Mohave County, Arizona

The lithologic and geophysical logs from the water supply wells in western Mohave County within the study area suggest that these wells are not completed in bedrock. The

hydrogeologic, and hydraulic testing and sustained well yield data suggest that these wells are producing most (if not all) of their yield from the alluvial basin deposits, specifically the undeformed Oldest Alluvium hydrostratigraphic unit (the pre-Bouse Fanglomerate unit of Metzger and Loeltz 1973). As reported by Gillespie and Bentley (1971), the principal aquifer in the Sacramento Valley basin is the Older Alluvium. Reported yields from wells drilled into the Older Alluvium in this basin range from less than 100 to over 1,000 gpm (Rascona 1991). The direction of groundwater flow in the principal aquifer parallels the flow of Sacramento Wash (see Figure 1 and Rascona 1991; Anderson 1992). The water quality data for the supply wells in western Mohave County, Arizona (Table 5) are also consistent with the reported spatial groundwater quality patterns as groundwater migrates downgradient within the basin (Robertson 1991; Towne & Freark 2001).

4.1.3 Faulting and Influence on Groundwater Flow

There is no site-specific evidence of faults acting as barriers or conduits to groundwater flow at the Topock site. Impedance to groundwater flow has been observed in several southwest U.S. groundwater basins, and possible mechanisms have been noted as 1) offsetting of permeable beds against less permeable beds, 2) the presence of low-permeability fault gouge, 3) local deformation and/or compaction of permeable beds in the vicinity of faults, and 4) cementation/chemical precipitation in and around the fault zone (Schaefer 1978; Londquist & Martin 1991).

There are several published examples of this phenomenon in groundwater basins to the west and south of the Topock site; faults have been noted as barriers to groundwater flow in the Mojave River, Fort Irwin, and Morongo groundwater basins by Mendez and Christensen (1997); and in the Deadman Valley and Twentynine Palms Valley basins by Schaefer (1978).

Impedance to groundwater flow is usually indicated by a steep drop in head across a fault in the direction of flow, sometimes accompanied by artesian conditions or springs on the upward side of the fault. In the Mojave River basin, the Calico-Newberry Fault creates a dramatic 60-foot drop in water level in the direction of flow about 10 miles east of Barstow. Across the Surprise Spring Fault in the Morongo groundwater basin (about 10 miles east of Landers), the groundwater drops more than 300 feet in the direction of flow (Mendez & Christensen 1997). Furthermore, numerous springs have been observed at these and other fault boundaries in the above basins, indicating that groundwater flow has been blocked and diverted to the surface (Mendez & Christensen 1997).

The Helendale fault also bisects the Mojave River basin, and is a significant barrier to groundwater flow to the point where it defines the boundary between two water management subareas (Stamos & others 2003). In this area, the fault impedes groundwater flow in the older regional aquifer and basement rocks, but not in the younger floodplain aquifer.

These examples provide evidence of faulting as a barrier to groundwater flow in settings similar to those at the Topock site, and provide reasonable mechanisms for these impediments to flow. This supports the position that faults occurring in and near the Topock site (e.g., the Chemehuevi detachment fault) likely act as barriers to groundwater flow, particularly in the Miocene Conglomerate and bedrock complex.

5.0 Conclusions

As stated in the introduction, the purpose of this technical memorandum is to present the available geologic and hydrogeologic data regarding groundwater conditions in bedrock formations at PG&E's Topock Compressor Station. This information was provided in Sections 2 and 3, and evaluated with respect to the site conceptual model in Section 4. While the information was presented in its entirety to facilitate a comprehensive review of the issues, several conclusions can be made that summarize the results of evaluating the data.

- A total of five Topock wells have been completed in the bedrock at the PG&E Topock site; three monitoring wells (MW-23, MW-24BR and decommissioned well MWP-2RD), a former supply well (PGE-7) and a former injection well (PGE-8). The three monitoring wells were completed solely in bedrock, and when pumped for sampling could be rapidly purged dry with recovery being measured in days. PGE-7 is completed in both alluvium and bedrock, which is reflected in its hydraulic response and precludes the historic data from this well being used to characterize bedrock. Of the Topock site bedrock wells, only PGE-8 shows a hydraulic response that indicates moderate permeability. The field test results for PGE-8 show a response typical of double-porosity fractured aquifers or leakage from overlying layers. In either case, only general statements on the hydraulic response can be made with these data. A quantitative approach for test analysis is inappropriate and would yield erroneous permeability values.

- Eight water supply wells on the Arizona side of the Colorado River (Topock-2, Topock-3, MTS-1, MTS-2, EPNG-1, EPNG-2, ADOT-new and ADOT-old) were initially included in the review of bedrock groundwater conditions in the study area. These wells were not included in the final analysis after a review of the available geologic and geophysical information showed that they were most likely not completed in bedrock formations. The reported high pumping rates for testing and current production for the majority of these wells support completion in the more permeable alluvium. Overall, the water quality characteristics for the Arizona wells (lower TDS, chloride, and sulfate) are distinct from the Topock site bedrock wells.

- Large scale faults occurring in and near the Topock site (e.g., the Chemehuevi detachment fault) have not been identified within the bedrock wells at the site. PGE-8 is the only well that has been projected to intersect the detachment fault, at shallow depth (see Figure 8), but was not geologically logged with sufficient detail to identify the fault. Site-specific information on the effect of large scale faulting does not exist, but regional examples show that such faults are likely to be impediments to flow.

- The ability of the bedrock to convey water is dependant upon the interconnectedness of the fracture system(s) in the rock. Based on hydrogeologic investigations and hydraulic characteristics observed in the bedrock wells at the site, groundwater locally occurs in weathered and fractured areas that are highly variable laterally and vertically. No areas or locations have been identified where saturated bedrock formations are capable of significant storage, or sustained production or yield.

- Consistently upward vertical hydraulic gradients are observed between the Topock site bedrock and alluvial wells. The bedrock monitoring well MW-24BR has consistently recorded a higher total hydraulic head than alluvial wells MW-24A and MW-24B over four years of monitoring. Water level data from PGE-8 also indicate upward movement between the bedrock and the alluvium at this location. The groundwater elevations measured in 2004 in PGE-8 ranged from 1 to 2 feet higher than groundwater elevations measured in nearby wells MW-24B and TW-1.
- Water levels in well clusters completed in unconsolidated alluvium (MW-20, MW-32, MW-33, and MW-34) typically indicate upward flow within the alluvium. While these wells are not completed within the bedrock saturated zone, upward gradients in the alluvium immediately above the bedrock lend support to discharging conditions within the site bedrock. Upward gradients would inhibit or prevent downward movement of contaminated groundwater from the alluvium into the bedrock.

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Tables

TABLE 1

Summary of Published Reports on Regional Geohydrology

Technical Memorandum: Review of Bedrock Groundwater Conditions

PG& E Topock Compressor Station

Water Resources Assessment Report	Study Area	Bedrock Formations in Basin (geologic age)	Groundwater Occurrence in Bedrock Formations
Metzger & Loeltz, 1973	**Mohave Groundwater Basin** Needles area, CA to western Mohave County, AZ	Consolidated, cemented igneous, metamorphic, volcanic & sedimentary rocks	All rocks that are collectively referred to as bedrock are relatively impermeable. Thus only small yields are likely to be developed and these principally from fractures
Gillespie & Bentley, 1971	**Hualapai & Sacramento Valley Groundwater Basins** Western Mohave County, AZ	Consolidated & cemented igneous, metamorphic, volcanic & sedimentary rocks (Miocene & older)	The granitic and metamorphic rocks generally do not yield water except along fractures and in weathered zones. Yields average from 1 to 5 gpm.
		Tertiary volcanic rocks (layered basaltic flows, basaltic andesite flows and tuff) in Kingman area	The younger volcanic rocks comprise a productive aquifer that has been utilized for municipal supply in the Kingman area.
Rascona, 1991	**Sacramento Valley Basin** Western Mohave County, AZ	Consolidated & cemented igneous, metamorphic, volcanic & sedimentary rocks (Miocene & older)	The igneous rocks of the Black Mountains (western boundary of Sacramento Valley) contain water in fracture zones and interbedded tuffs, but yield little water to wells.
		Tertiary volcanic rocks in Kingman area	The younger volcanic rocks comprise a productive aquifer that has been utilized for municipal supply in the Kingman area.
Anderson & others, 1992	**Southwest Alluvial Basins** AZ and portions of CA, NV, NM	Consolidated & cemented igneous, metamorphic, volcanic & sedimentary rocks (Miocene & older)	Nearly impermeable except for some Tertiary sedimentary rocks. Bedrock ranges form the hydraulic boundaries to alluvial basins in the study area.
Robertson, 1991	**Southwest Alluvial Basins** AZ and portions of CA, NV, NM	Consolidated & cemented igneous, metamorphic, volcanic & sedimentary rocks (Miocene & older)	In general, well yields of intrusive and metamorphic rocks are limited to a few gallons per minute.
Towne & Freark, 2001	**Sacramento Valley Basin** Western Mohave County, AZ	Consolidated & cemented igneous, metamorphic, volcanic & sedimentary rocks (Miocene & older)	The granitic and metamorphic rocks generally do not yield water except along fractures and in weathered zones. Yields average from 1 to 5 gpm.
		Tertiary volcanic rocks in Kingman area	The younger volcanic rocks comprise a productive aquifer that has been utilized for municipal supply in the Kingman area.
Wilson & Owen-Joyce, 1994	**Lower Colorado River Basins**	Consolidated & cemented igneous, metamorphic, volcanic & sedimentary rocks (Miocene & older) that are commonly are tilted, faulted & folded	Nearly impermeable except for some Tertiary sedimentary rocks. Buried bedrock ridges act as subsurface barriers to flow in the river-aquifer system.

TABLE 2
Information for PG&E Wells Completed in Bedrock
Technical Memorandum: Review of Bedrock Groundwater Conditions
PG&E Topock Compressor Station

Well ID monitored zone	Completion Date	Ground Elevation ft MSL	Well Depth ft bgs	Drilling Method	Well Material	Typical Groundwater Elevation ft MSL	Well Perforation / Screen Interval		Screen Length feet	Remarks
							Depth ft bgs	Elevation ft MSL		
PGE-7	Jun-64	561	180	mud rotary?	14" steel	455.8	(1)	---	---	installed as replacement supply well for Station
Miocene & older Bedrock; & base of Alluvial Aquifer	Jul-69		330		7" steel liner to 195'		195 - 330 6.7" openhole	368 - 283	135	re-completed for monitoring wastewater injection at PGE-8 March 1998 video log: liner to 195' , openhole in bedrock
PGE-8 Metadiorite Bedrock	Apr-69	595	562	mud rotary, air rotary & air percussion	4" steel liner	457.0	404 - 550	461 - 441	146	for injection of treated wastewater; operated May 1970 to December 1973
MW-23 Miocene Bedrock	Apr-98	505	80	Stratex/air rotary	4" PVC	454.5	60 - 80	369 - 349	20	
MW-24BR Miocene & older Bedrock	Apr-98	565	438	Stratex/air rotary	4" PVC	455.0	378 - 438	185 - 125	60	
MWP-2RD Metadiorite Bedrock	Jun-92	674	279	air percussion	5" PVC	443.0	265 - 275	409 - 399	10	monitoring well at Old Ponds site; well decommissioned in 1995

NOTES:

(1) well perforation depths on original completion of PGE-7 are not available; assume similar 70-foot perforated well completion as PGE-6 (80-180 feet bgs)

MSL = mean sea level. ft bgs = feet below ground surface. (--) = data not available. PVC = polyvinyl chloride.

Ground surface elevations and well depths are rounded-off to whole-foot.

TABLE 3
Information for Selected Water Supply Wells in Mohave County, Arizona
Technical Memorandum: Review of Bedrock Groundwater Conditions
PG&E Topock Compressor Station

Well ID	Well Reg. No.	Completion Date	Well Location Mohave County, AZ	Approximate Ground Elevation feet MSL	Drilled Boring Depth feet bgs	Well Perforation or Screen Interval		Static Water Level feet bgs	Well Use	Reported Production
						Depth feet bgs	Elevation feet MSL			
PGE-9N	15N/21W3A	Apr-97	Topock	460	95	25 - 95	435 - 365	28	inactive PG&E supply well	--
PGE-9S	15N/21W3B	Apr-97	Topock	460	100	30 - 100	430 - 360	29	inactive PG&E supply well	--
Smith	565878	Feb-98	Topock		80	48 - 68		50	private well; inactive (abandoned?)	--
Topock-2	85599	Sep-80	Topock	520	140	100 - 140	420 - 380	47	original Old Well #2	400 gpm
Topock-2	600189	--	Topock	520	140	100 - 140	420 - 380	47	City Needles active supply	--
Topock-3	600187	May-74	Topock	520	250	85 - 250	435 - 270	48	City Needles active supply	300 gpm
						85 - 150	435 - 370		recompletion by sealing off 150-250' perforations	350 gpm
MTS-1	531889	Jul-91	Mojave Topock Compressor Station	638	744	605 - 705	33 - (-67)	174	active industrial & domestic supply	300 gpm
MTS-2	531890	Oct-91	Mojave Topock Compressor Station	638	720	603 - 703	35 - (-65)	174	active industrial & domestic supply	200 gpm
EPNG-1	611577	Sep-50	Topock Camp	710	880	617 - 819	93 - (-109)	218	active EPNG supply	
		Apr-95				617 - 819		218	well cleaned & new pump	73 gpm
EPNG-2	611578, orig.	Jun-53	Topock Camp	725	503	331 - 493	394 - 232	214	original well completion	70-85 gpm
	529685, relined	Oct-90				322 - 482	403 - 243	240	active rehab'd supply	
ADOT-New	577479	Nov-99	Needle Mountain	760	530	330 - 530	430 - 230	220	active domestic well	55 gpm
ADOT-Old	628108	Jun-72	Needle Mountain	760	396	290 - 385	470 - 375	217	inactive domestic well	34 gpm

NOTES:

See Figure 3 for well locations. MSL = mean sea level. feet bgs = feet below ground surface. gpm = gallons per minute

Ground surface elevations and well depths are rounded-off to whole-foot. (--) = data not available

TABLE 4
Vertical Hydraulic Gradients at MW-24 Well Cluster
Technical Memorandum: Review of Bedrock Groundwater Conditions
PG&E Topock Compressor Station

Shallower Well	Deeper Well	Date	Shallower Well Groundwater Elevation feet MSL	Deeper Well Groundwater Elevation feet MSL	Water Level Elevation Difference feet	Vertical Distance between Screens feet	Vertical Hydraulic Gradient feet/foot
MW-24B	MW-24BR	21-Aug-01	456.20	456.72	0.52	205	0.003
		27-Nov-01	454.41	455.08	0.67		0.003
basal zone	Bedrock	4-Mar-02	454.76	455.40	0.64		0.003
Alluvial Aquifer		10-Jun-02	456.25	457.10	0.84		0.004
		16-Sep-02	455.77	456.41	0.63		0.003
		9-Dec-02	454.45	455.14	0.69		0.003
		17-Mar-03	455.17	456.05	0.87		0.004
		9-Jun-03	456.57	457.60	1.02		0.005
		8-Sep-03	456.18	456.92	0.74		0.004
		8-Dec-03	455.20	456.43	1.23		0.006
		15-Mar-04	455.25	455.93	0.68		0.003
		8-Jun-04	456.48	457.22	0.73		0.004
		21-Sep-04	455.64	456.66	1.02		0.005
		17-Dec-04	454.60	455.46	0.86		0.004
		7-Mar-05	454.12	455.03	0.91		0.004
		18-May-05	455.43	456.28	0.85		0.004
MW-24A	MW-24BR	21-Aug-01	455.98	456.72	0.73	294	0.002
		27-Nov-01	454.29	455.08	0.79		0.003
upper zone	Bedrock	4-Mar-02	454.82	455.40	0.58		0.002
Alluvial Aquifer		10-Jun-02	456.24	457.10	0.86		0.003
		16-Sep-02	455.66	456.41	0.75		0.003
		9-Dec-02	454.44	455.14	0.70		0.002
		17-Mar-03	455.12	456.05	0.92		0.003
		9-Jun-03	456.52	457.60	1.08		0.004
		8-Sep-03	456.10	456.92	0.81		0.003
		8-Dec-03	455.12	456.43	1.31		0.004
		15-Mar-04	455.19	455.93	0.74		0.003
		8-Jun-04	456.51	457.22	0.71		0.002
		21-Sep-04	455.47	456.66	1.19		0.004
		17-Dec-04	454.58	455.46	0.89		0.003
		7-Mar-05	454.05	455.03	0.98		0.003
		18-May-05	455.38	456.28	0.90		0.003

NOTE:
MSL = relative to mean sea level
Positive hydraulic gradient is upward

TABLE 5
Selected Groundwater Chemistry Results for Wells in Study Area
Technical Memorandum: Review of Bedrock Groundwater Conditions
PG&E Topock Compressor Station

Well ID	Sample Date	Total Dissolved Solids mg/L	Specific Conductance µS/cm	Chloride mg/L	Sulfate mg/L	pH pH units	Field Temperature °C	Field Oxidation Reduction Potential mV	Fluoride mg/L	Oxygen 18 0/00	Deuterium 0/00	Data Source
PG&E Wells Completed in Bedrock Formations												
MW-23	30-Nov-01	12200	16100	6210	491	6.88	---	---	1.80	---	---	E&E (2004)
MW-23	12-Jun-03	11000	20100	5560	730	7.43	29.1	-155	ND (1.0)	---	---	CH2M
MW-23	08-Jun-04	10000	17000	5700	690	7.31	28.5	-66	ND (1.0)	-8.9	-72	CH2M
MW-24BR	29-Nov-01	8280	13800	5380	366	8.61	30.0	---	4.40	---	---	E&E (2004)
MW-24BR	13-Jun-03	8470	14500	4590	409	8.29	32.4	-359	5.20	---	---	CH2M
MW-24BR	08-Jun-04	7800	14000	4600	470	7.92	33.1	-312	1.40	-10.7	-82	CH2M
MWP-02RD	21-Aug-92	1100	1730	440	150	7.70	30.3	---	0.82	---	---	PG&E (1995)
MWP-02RD	01-Nov-92	1300	2110	560	180	7.90	---	---	0.67	---	---	PG&E (1995)
MWP-02RD	01-Feb-93	1300	2340	590	200	7.50	---	---	0.67	---	---	PG&E (1995)
PGE-07	01-Sep-00	9120	14200	4530	1360	8.07	---	---	3.30	---	---	E&E (2004)
PGE-07	29-Nov-01	8100	11200	4500	1190	7.80	28.7	---	3.70	---	---	E&E (2004)
PGE-07	10-Dec-03	9130	14300	---	---	8.08	26.3	94.0	---	---	---	CH2M
PGE-08	01-Sep-00	11600	15500	4230	3710	9.10	---	---	6.07	---	---	E&E (2004)
PGE-08	29-Nov-01	12200	16100	4870	3050	8.51	---	---	6.20	---	---	CH2M
PGE-08	09-Dec-03	12300	17100	---	---	8.48	30.8	-269	---	---	---	CH2M
Selected Supply Wells in Mohave County, Arizona												
EPNG-1	01-Jun-93	643	770	217	84.0	7.70	---	---	---	---	---	EPNG drilling record (1953)
EPNG-2	18-May-05	665	984	195	69.7	7.83	33.3	111	3.68	-10.4	-77	CH2M
MTS-1	26-Aug-91	1300	1860	270	160	9.20	---	---	1.67	---	---	Mojave Pipeline Co. (1991)
ADOT New Well	18-May-05	695	1030	208	70.6	7.88	31.3	83.0	4.20	-10.5	-77	CH2M
Topock-2	22-Jun-05	1050	1930	437	118	7.84	38.3	-120	3.90	-9.9	-72	CH2M
Topock-3	17-May-05	930	1430	304	96.8	7.97	37.8	-8.0	4.03	-10	-76	CH2M
Sanders	18-May-05	1370	2040	357	229	7.58	25.4	166	6.17	-10.3	-78	CH2M
TMLP-2	12-May-05	328	420	25.6	17.4	7.87	33.6	1.00	1.20	-10.7	-78	CH2M

Notes:

Primary sample results only
See Figures 3 and 4 for location of wells.
Additional well TMLP-2 (screen depth 750-880 ft bgs) is located approximately 3 miles northeast of well EPNG-1

mg/L	milligrams per liter
0/00	differences from global standards in parts per thousand
µS/cm	micro Siemens per centimeter
mV	millivolts
ND	parameter not detected at the listed reporting limit
---	data not collected, not available

Figures

Needles

MOHAVE BASIN

Black Mountains

Sacramento Wash

Yucca

I-40

CALIFORNIA

ARIZONA

Golden Shores

Topock Marsh

Sacramento Mountains

Sacramento Wash

I-40

Topock

Study Area (Figure 3)

Topock Gorge

Chemehuevi Mountains

Mohave Mountains

SACRAMENTO VALLEY BASIN

N

0 0.5 1 1.5 2

Miles

LEGEND

Approximate groundwater basin boundaries from Anderson and Freethey (1992).

General direction of groundwater flow from Anderson (1992) and Rascona (1991).

FIGURE 1
GROUNDWATER BASINS IN STUDY AREA
REVIEW OF BEDROCK GROUNDWATER CONDITIONS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

TOPOCK MARSH

COLORADO RIVER

Needles Graben
(Quaternary-age fault
structure) located approximately
6 miles north of study area

El Paso Natural Gas
Mojave Topock
Compressor Station

PARK
MOABI

BAT CAVE WASH

BN&SF RAILROAD

TOPOCK, ARIZONA

Chemehuevi Fault

PG&E TOPOCK
COMPRESSOR
STATION

CHEMEHUEVI MOUNTAINS

Mohave Wash Fault

Tb
Qa
Qrf
QTrg
Toa
Tmc
pTbr

LEGEND

- Qrf = Quaternary Colorado River and recent Floodplain Deposits
- QTrg = Quaternary-Tertiary River Gravels
- Qa = Quaternary Alluvium and surficial deposits, undifferentiated
- Tb = Bouse Formation
- Toa = Oldest Alluvium (Undeformed Fanglomerate)
- Tmc = Miocene conglomerate (Bedrock)
- pTbr = Pre-Tertiary Bedrock (Metadiorite, Gneiss, Granitic Rocks)

Normal Fault
ball on downthrown side

Detachment Fault
barbs on downthrown side

Detachment Fault concealed

NOTE:
Generalized surface geologic map compiled from Metzger and Loeltz (1973), John (1987), Howard and others (1997) and PG&E technical reports.

N

0 1,500 3,000
Feet

FIGURE 2
GEOLOGIC MAP OF STUDY AREA
REVIEW OF BEDROCK GROUNDWATER CONDITIONS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

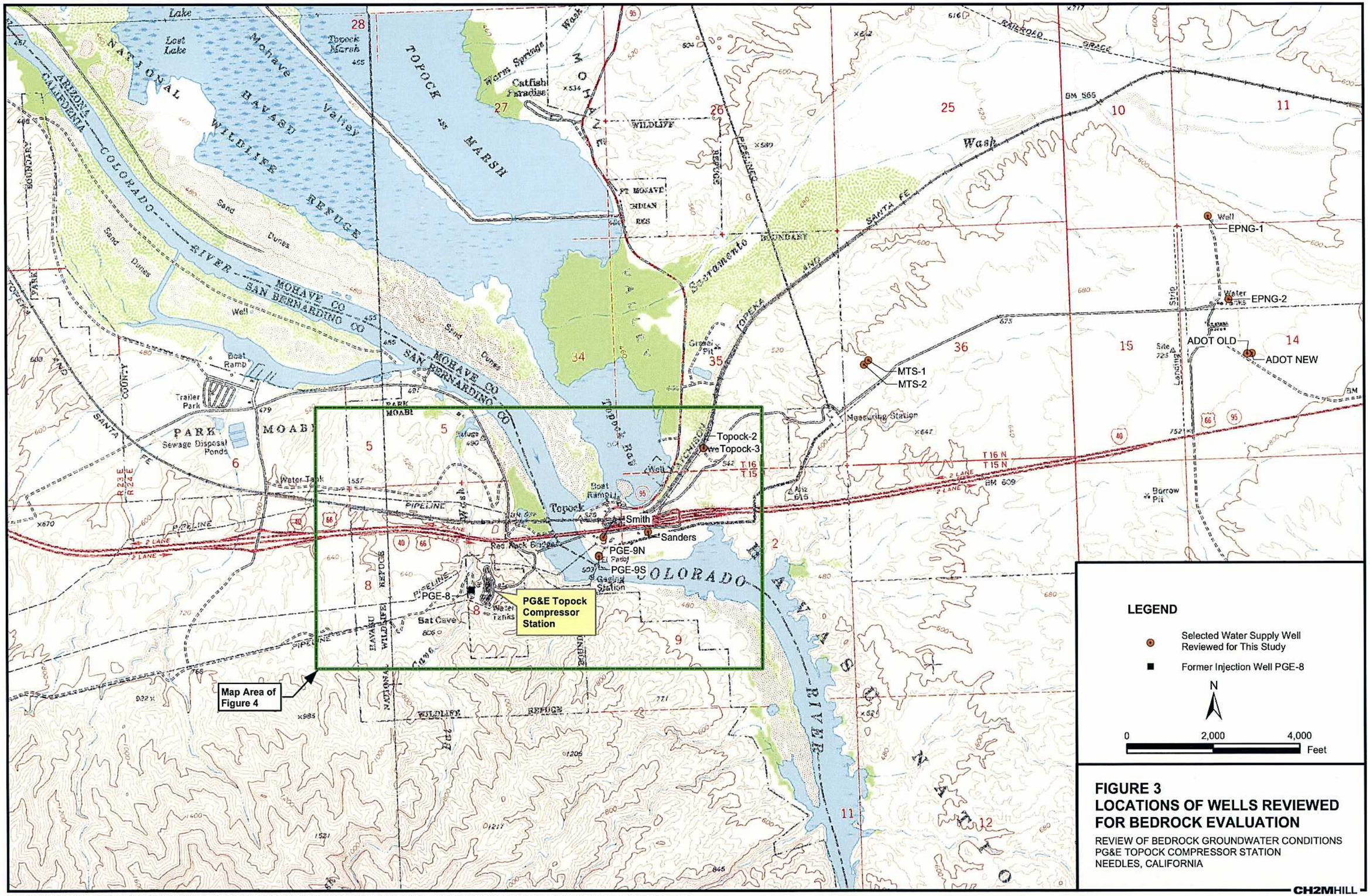

FIGURE 3
LOCATIONS OF WELLS REVIEWED FOR BEDROCK EVALUATION

REVIEW OF BEDROCK GROUNDWATER CONDITIONS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

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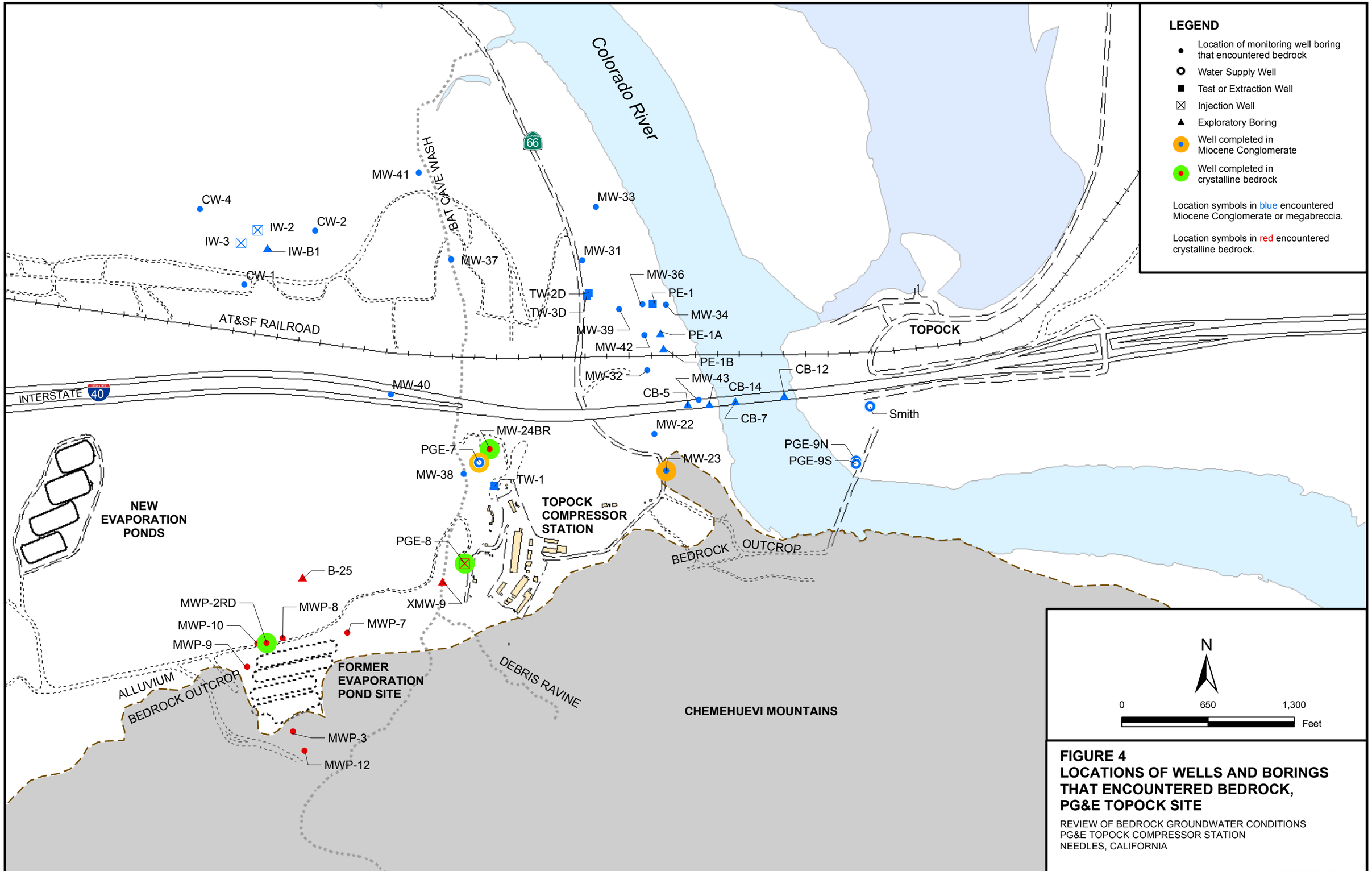

FIGURE 4
LOCATIONS OF WELLS AND BORINGS THAT ENCOUNTERED BEDROCK, PG&E TOPOCK SITE

REVIEW OF BEDROCK GROUNDWATER CONDITIONS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

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WEST

EAST

California | Arizona

Old Ponds Site

MWP-2RD
(abandoned 1995)
674

Former Injection Well

PGE-8
545

Bat Cave Wash

PGE-7
563

MW-24BR
565

MW-23
505

PGE-9S
460

Colorado River

Elevation (feet MSL)

700
600
500
400
300
200
100
0
sea level

Feb-93
444' MSL

pTbr
dk. green metadiorite; weathered, hard, dry to wet where fractured
279

purged dry at 11 gal.
Extremely slow recovery, no consistent static water levels. Not capable for routine sampling.

Alluvial Aquifer
(alluvial fan deposits)

Tmc
reddish cemented sandy conglomerate
80

purged dry at 15 gal.
estimated yield 12 gpd from recovery test

Alluvial Aquifer
(fluvial deposits)

Tmc
105

Boring for well PGE-9S encountered hard, cemented red conglomerate at 104'

Tmc

Tmc

Tmc

no boring log.
no tests
330

pTbr
dk. green metadiorite with fractures, shear zones and pegmatite veins
562

See Appendix C2 for 1969 constant discharge pumping test conducted in PGE-8

logged as red conglomerate and cemented sandstone

purged dry at 150 gal.
estimated yield 5 gpd from recovery test
438

LEGEND

565 — ground surface elevation

static water level

Well screen interval

438 — total depth of boring

BEDROCK FORMATIONS

Tmc — Miocene Conglomerate

pTbr — Pre-Tertiary Metamorphic & Igneous Rocks

Note: This schematic elevation cross-section summarizes drilling, well screen, and purging/testing data for wells completed in bedrock formations.

No Horizontal Scale (see Figure 4 for well locations).

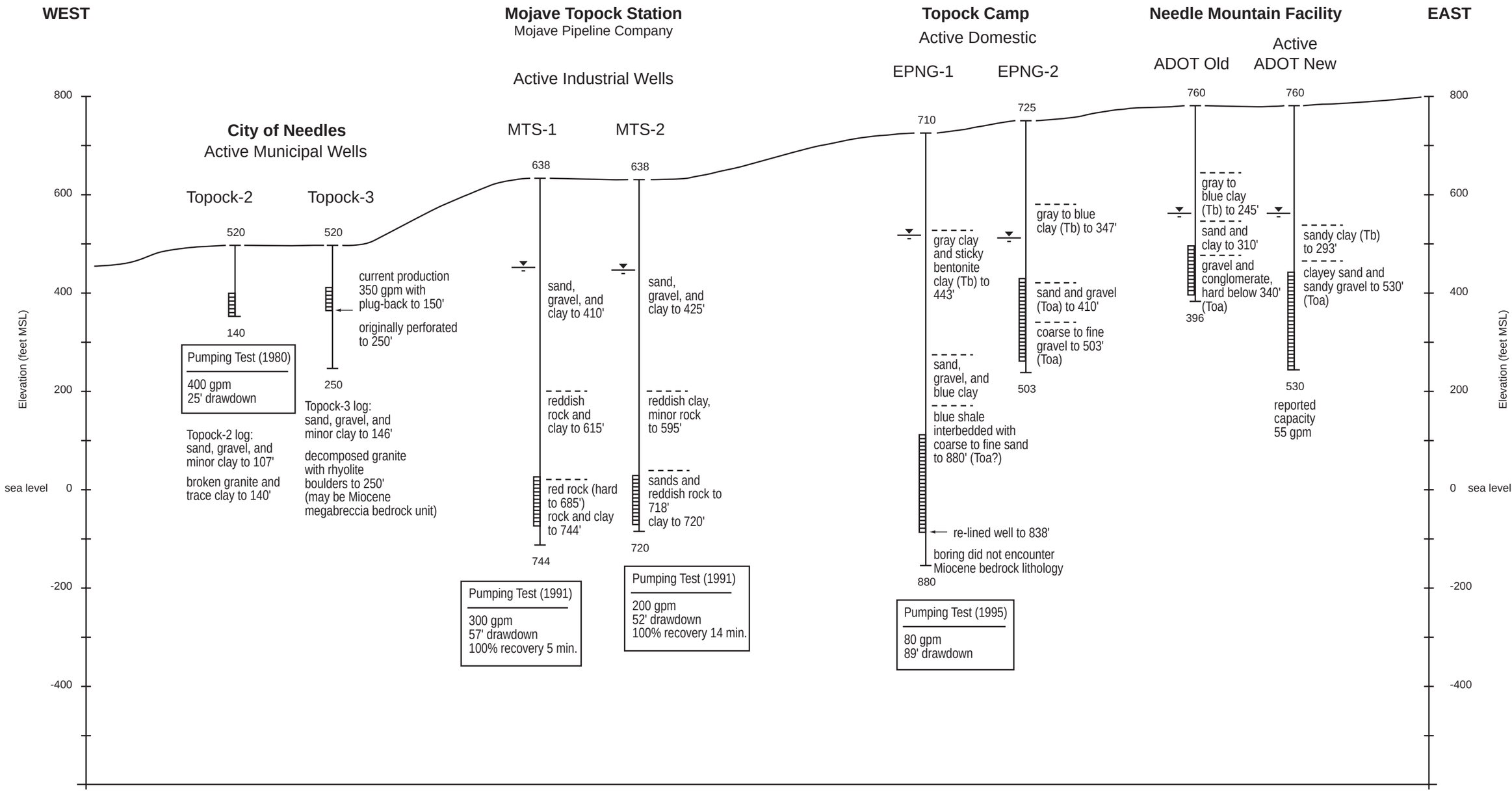
Ground surface profile and geologic contacts are generalized and approximate for schematic presentation.

gpd = gallons per day MSL = mean sea level

FIGURE 5
SCHEMATIC HYDROGEOLOGIC SECTION FOR WELLS COMPLETED IN BEDROCK, PG&E TOPOCK SITE
REVIEW OF BEDROCK GROUNDWATER CONDITIONS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

ES032006002BAO_330689.RF.05.00_Schematic HG Section Bedrock Wells CA_3-15-06 ez



LEGEND

565 ground surface elevation

static water level

Well screen interval

438 total depth of boring

STRATIGRAPHIC UNITS

Tb Bouse Formation

Toa Oldest Alluvium (Fanglomerate of Metzger and Loeltz, 1973)

Note: This schematic elevation cross-section summarizes drilling, well screen, and purging/testing data for wells.

No Horizontal Scale (see Figure 3 for well locations).

Ground surface profile and geologic contacts are generalized and approximate for schematic presentation.

gpm = gallons per minute

FIGURE 6
SCHEMATIC HYDROGEOLOGIC SECTION FOR SELECTED WELLS, MOHAVE COUNTY, ARIZONA
REVIEW OF BEDROCK GROUNDWATER CONDITIONS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

ES032006002BAO_330689.RF.05.00_Schematic HG Section AZ Wells_3-15-06 ez

N

0 300 600 Feet

LEGEND

- Monitoring Well (Deep Boring)
- Exploration Boring
- Groundwater Supply or Test Well
- Groundwater Extraction Well
- Bedrock elevation contour, dashed where inferred
- 436 — Elevation of Top Miocene Conglomerate (cemented bedrock formation) feet above mean sea level (MSL)
- (est) 330 — Bedrock elevation estimated

NOTE: This bedrock elevation map reflects drilling data through March 2005. Elevation map will be revised and updated with additional data collected in 2006.

Colorado River

River elevation typically ranges from 453 to 457 feet MSL

Miocene Bedrock at Surface

Park Moabi Road

Bat Cave Wash

BN & SF Railroad

Interstate 40

PG&E

PG&E

PG&E Topock Compressor Station

MW-35-135 (est) 245
MW-41D 177
MW-37D 284
MW-19 (est) 310
MW-28-90 (est) 305
MW-31-135 (est) 330
MW-20 Bench
TW-2D 347
MW-20-130 (est) 350
MW-39-100 357
MW-36-100 369
MW-34-100 361
PE-1 378
PE-1A 378
PE-1B 381
MW-27-85 372
MW-25 (est) 320
MW-32-35 424
MW-26 (est) 370
MW-43-90 369
MW-40D 302
MW-22 446
MW-21 450
MW-12 436
MW-23 504
MW-38D 338
TW-1 350
XMW-9 475

200 225 250 275 300 325 350 375 400 425 450 475

FIGURE 7
ELEVATION CONTOUR MAP FOR TOP OF MIOCENE BEDROCK

REVIEW OF BEDROCK GROUNDWATER CONDITIONS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

SOUTHWEST
A

EAST
A'

Elevation (feet above msl)

Distance (feet)

Bat Cave Wash

Interstate 40

Bend in Section

Bend in Section

Colorado River

XMW-9

PGE-8
proj: 120'

MW-9
proj: 40'

MW-10
proj: 30'

TW-1
proj: 150'

PGE-7

MW-24 cluster

MW-26
proj: 300'

MW-20 cluster

TW-2S
TW-2D
proj: 140'

MW-39 cluster
proj: 20'

MW-36 cluster

PE-01
proj: 20'

MW-34 cluster

UPPER DEPTH INTERVAL

MIDDLE DEPTH INTERVAL

LOWER DEPTH INTERVAL

ALLUVIAL AQUIFER

Alluvial Fan Deposits

Fluvial Deposits

Metamorphic and Igneous Bedrock (pTbr)

Miocene Conglomerate (Tmc)

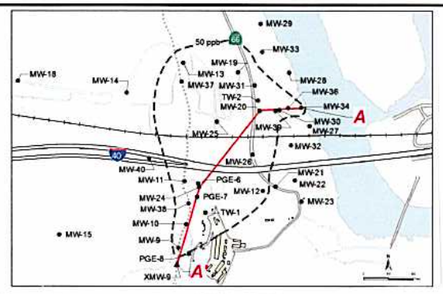
pTbr

inferred fault location - actual depth uncertain

geologic contact inferred location - actual depth uncertain

perforated casing former injection well

77.5	309	4,570	3,990	3,120	5,240	3,040	6,060	10,200	9,590	3,360	NA	ND (1.0)	ND (1.0)
	99	99	312		330	71			132	180	118.3	108	105	116	732
			ND (1.0)								ND (0.2)	ND (1.0)	ND (1.0)
											ND (10)	ND (1.0)	
											72.3	ND (1.0)	
											840	ND (1.0)	
											3,000	302	
											4,010	383	
	ND (1.0)J			ND (1.0)*									
	562			442									



well ID MW-26

water level

well screen 5,240

total depth of boring 71

Hexavalent Chromium [Cr(VI)] Sampling Results, October 2005
Groundwater concentrations in micrograms per liter (ug/L)

Maximum Cr(VI) concentrations detected in October 2005 primary and duplicate samples

NA = Data not available
ND = Not detected at listed reporting limit
* = December 2005 sampling result presented when October 2005 data not available

NOTE:
Cross section prepared at approximate 3 times vertical exaggeration.

FIGURE 8
SITE HYDROGEOLOGIC CROSS SECTION

REVIEW OF BEDROCK GROUNDWATER CONDITIONS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

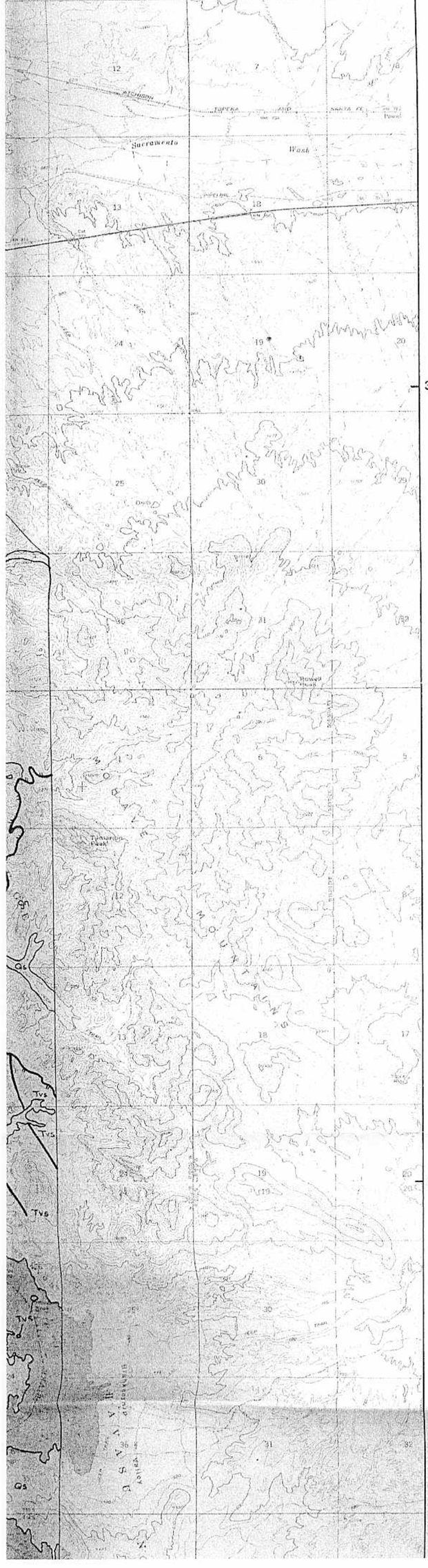
CH2MHILL

Appendix A
Geologic Information on Bedrock Geology

A1 Geologic Data on Chemehuevi Mountains and Detachment Faults

EPARED BY THE
Y AND THE U.S. BUREAU OF MINES
FOR THE
OF LAND MANAGEMENT

Miller and others (1983)
Mineral Resource Potential of the Chemehuevi Mountains Wilderness Study Area



EXPLANATION

OUTLINE OF AREA CONTAINING ANOMALY--Numbers refer to discussion in text
- M Concentrations of base and precious metals
- HS Thermal-spring alteration
- G Geothermal anomaly

BOUNDARY OF WILDERNESS STUDY AREA

BOUNDARY OF GEOLOGIC MAPPING

CORRELATION OF MAP UNITS

Qs, Qch	Holocene, Pleistocene	QUATERNARY	CENOZOIC
Tb, Tvs	Miocene, Oligocene(?)	TERTIARY	CENOZOIC
Kg, Kpg		CRETACEOUS	MESOZOIC
Mzd		CRETACEOUS	MESOZOIC
MzPlg		MESOZOIC(?) AND PROTEROZOIC(?)	
gn		PROTEROZOIC(?)	

DESCRIPTION OF MAP UNITS

Qs SURFICIAL DEPOSITS (QUATERNARY)--Unconsolidated to consolidated alluvium, colluvium, and dissected older alluvium. Consist of sand, pebbly sand, and gravel

Qch CHEMEHUEVI FORMATION (PLEISTOCENE)--Sand, silt, clay, and Colorado River gravel and cobbles

Tb BASALT (MIOCENE)--Post-tectonic dikes and flows of olivine basalt

Tvs VOLCANIC AND SEDIMENTARY DEPOSITS (MIOCENE AND OLIGOCENE?)--Flows and flow breccia of rhyolite, rhyodacite, dacite, andesite and basalt, and ash-flow tuff; and sedimentary volcaniclastic breccia, crystalline-clast fanglomerate, sandstone, and siltstone. Predate detachment faulting

Kg LEUCOCRATIC GRANITE (CRETACEOUS)--Medium-grained subequigranular muscovite-biotite monzogranite to granodiorite and garnetiferous muscovite monzogranite. Includes coarse-grained pegmatite dikes

Kpg PORPHYRITIC GRANITE (CRETACEOUS)--Medium- to coarse-grained subequigranular to porphyritic biotite-sphene monzogranite to granodiorite

Mzd FOLIATED DIORITIC ROCKS (MESOZOIC)--Heterogeneous fine- to coarse-grained hornblende-biotite granodiorite, quartz monzodiorite, and monzodiorite, and hornblende diorite and gabbro. Granodiorite and quartz monzodiorite commonly host wallrock xenoliths and cognate mafic inclusions. Locally bears a penetrative subhorizontal northeast-trending mylonitic lineation

MzPlg LAYERED GNEISS AND MIGMATITE (MESOZOIC? AND PROTEROZOIC?)--Foliated and locally lineated fine- to coarse-grained biotite-bearing quartzofeldspathic gneiss and subordinate coarse pegmatite, amphibolite, and locally recrystallized gabbro or diorite

gn GNEISS AND GRANITE (PROTEROZOIC?)--Undifferentiated porphyritic granite, quartz monzonite, monzodiorite, fine-grained leucocratic orthogneiss, paragneiss, amphibolite, and coarse-grained augen gneiss. The porphyritic granite and associated intrusive rocks have textural, mineralogic, and compositional affinities to rocks 1.4 to 1.5 b.y. old

CONTACT--Dashed where approximately located

FAULT--Dashed where approximately located; dotted where concealed. Arrow in dip direction of fault plane

LOW-ANGLE NORMAL FAULT (DETACHMENT)--Dashed where approximately located; dotted where concealed; queried where uncertain. Hachures on upper plate

STUDIES RELATED TO WILDERNESS
Bureau of Land Management Wilderness Study Areas

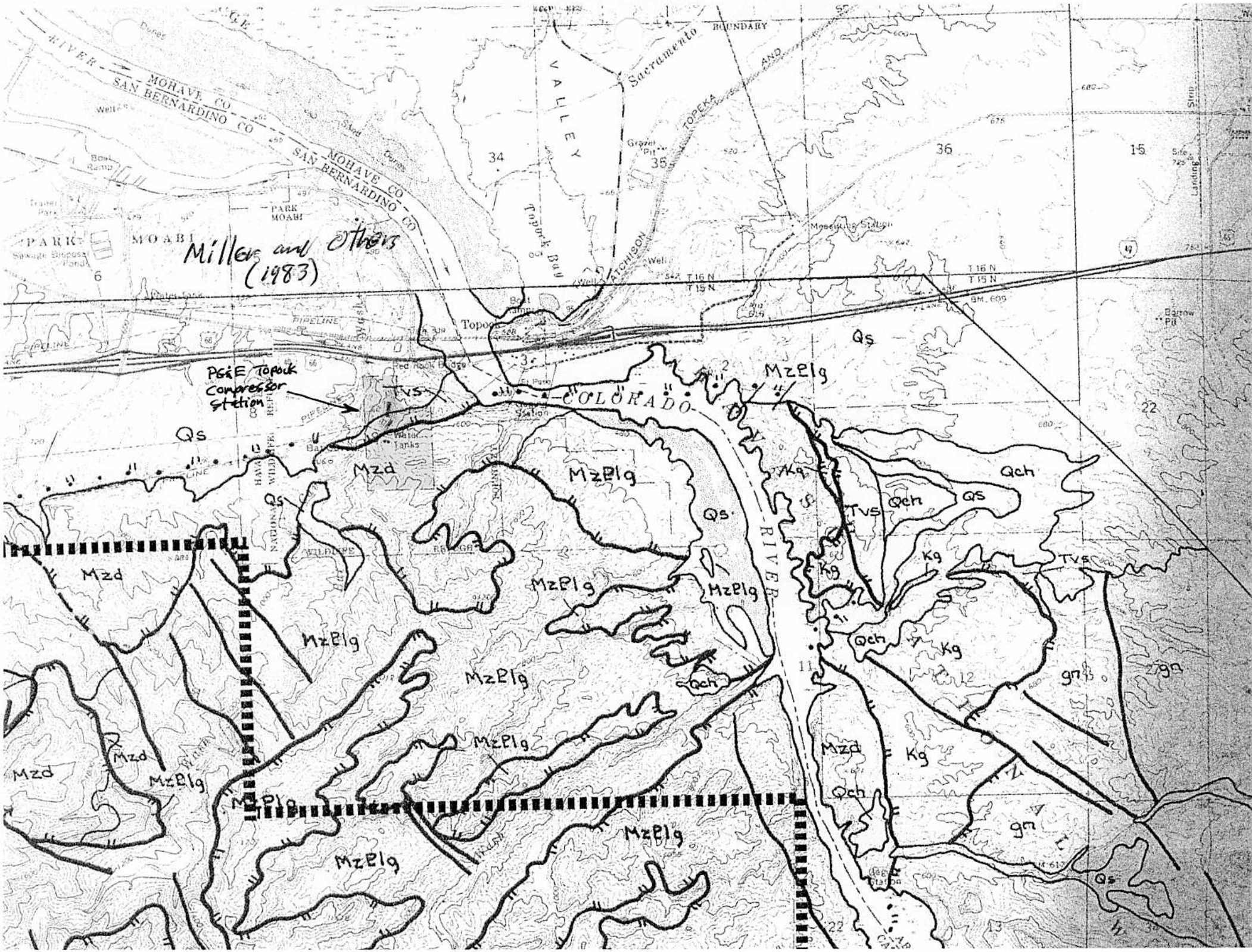
The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) requires the U.S. Geological Survey and the U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine their mineral resource potential. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of the Chemehuevi Mountains Wilderness Study Area (CDCA-310), California Desert Conservation Area, San Bernardino County, California.

SUMMARY

Geologic, geochemical, and geophysical evidence, together with a review of historical and modern mining and prospecting activities, suggests that all of the Chemehuevi Mountains Wilderness Study Area has a low potential for the occurrence of mineral and energy resources. Possible resources considered include base and precious metals, building stone and aggregate, fossil fuels, radioactive-mineral resources, geothermal resources, and chemical sources for fertilizer. Sparsely distributed mineralized areas of low mineral resource potential consist of small copper-barite-silver vein systems carrying minor lead, gold, and zinc. The veins are associated with Tertiary fault breccia and quartz veins in Proterozoic(?) gneiss.

INTRODUCTION

The Chemehuevi Mountains Wilderness Study Area is in San Bernardino County, southeastern California, in the Chemehuevi Mountains and adjacent lowlands of the Chemehuevi Wash (fig. 1). The study area lies about 11 mi south of the town of Needles and encompasses an area of approximately 86,500 acres that adjoins, along its east border, both the Havasu National Wildlife Refuge and the Chemehuevi Indian Reservation. The study area was examined in


Miller and others (1983)
PG&E Topock Compressor Station
COLORADO RIVER
MOHAVE CO - SAN BERNARDINO CO
PARK MOABI
Topock
Sacramento BOUNDARY
TOPEKA AND
ATCHISON
T 16 N
T 15 N
Qs
MzPlg
Tvs
Mzd
Kg
Qch
gn

Geometry and evolution of a mid-crustal extensional fault system: Chemehuevi Mountains, southeastern California

B.E. John

SUMMARY: The extensional fault system exposed in the Chemehuevi Mountains area of the southern Cordillera provides data on the mode of mid-crustal accommodation to continental extension. A stacked sequence of three mid-Tertiary low-angle normal faults cut gently down-section through deformed Proterozoic and Mesozoic crystalline basement below Cenozoic strata. Hanging wall blocks are consistently displaced relatively NE across these three detachment faults, recording unidirectional extension of quartzofeldspathic crust at palaeodepths of 6–10 km. The two structurally deepest faults in the sequence are exposed over 22 km in a down-dip direction, across a total area in excess of 350 km^2, and were initiated with a regional dip of less than 15° NE. Both of the structurally deepest faults are corrugated parallel to the direction of transport; wavelengths of the corrugations range between 200 m and 10 km, and amplitudes range from 30 to 400 m. These undulations are broad mullion structures that developed coeval with fault slip. Amplitude and wavelength vary with footwall rock type and pre-existing structural grain. Slip on the faults at the present level of exposure was accomplished by brittle deformation, with the generation of gouge, breccias, rocks of the cataclasite series, and rare pseudotachylites. Major mylonite zones in the Chemehuevi Mountains are older and unrelated to the extensional faulting. These data support the conclusion that mid-crustal extension in the Chemehuevi Mountains area was accommodated by an asymmetrical normal-slip shear system. Extension occurred along seismically active, gently NE-dipping, undulating surfaces. During their evolution they rose from middle- to upper-crustal depths.

Shallow-crustal structure associated with Cenozoic continental extension is relatively well documented from geological studies in the northern Basin and Range (Stewart 1980; Proffett 1977; Proffett & Dillas 1984). Knowledge of deeper-crustal structure, however, is based largely on geophysical studies and limited well data (Anderson *et al.* 1983; Smith & Bruhn 1984; Allmendinger *et al.* 1983). As most of these data represent an indirect observation of continental extension, the mode of mid-crustal accommodation to stretching remains poorly understood. Published studies on the geometry and kinematics of extensional regimes often present models that are confined to the geometry of deformation within the upper few kilometres of the Earth's surface and lose validity with greater structural depth, or are based on inadequate knowledge of the timing of structural events. This paper reports on a mid-crustal extensional fault system exposed in the Chemehuevi Mountains area of the southern Cordillera. Extension was accomplished here along a stacked sequence of very low-angle normal or detachment faults with unidirectional slip. Above the regionally developed Chemehuevi detachment fault, the hanging wall block is distended by innumerable high-angle faults. Structurally below the Chemehuevi detachment fault lies the smaller-displacment Mohave Wash fault. Little deformation occurred in the footwall to this fault system. Both the Mohave Wash and Chemehuevi faults are broadly corrugated parallel to the direction of transport, and were originally formed with regional dips of less than 15° NE. Slip on the faults at palaeodepths of 6–10 km, the present level of exposure, was accomplished by brittle deformation. This paper seeks to document the geometry and evolution of a mid-crustal continental extensional fault system in an exceptionally well-exposed area, in order to constrain better models of crustal extension.

Regional setting

Major zones of thrust faulting, folding, and metamorphism have been documented through the eastern Mojave and Sonoran Deserts of California and Arizona (Fig. 1). Thrust faults and folds of late-Mesozoic age, marked by deformed Palaeozoic and Mesozoic strata and crystalline basement (Howard *et al.* 1980; Miller *et al.* 1982; Hamilton 1982; Frost & Martin 1982a), can be traced into the region from the Sevier orogenic belt of Utah and Nevada (Armstrong 1968; Burchfiel & Davis 1981). Thick zones of mylonitic gneiss that outcrop in eastern California and western Arizona are believed to be of similar age to the Mesozoic thrusting (John 1982, 1986; Howard *et al.* 1982c; Shackelford 1980; Davis *et al.* 1982). In

From COWARD, M.P., DEWEY, J.F. & HANCOCK, P.L. (eds), 1987, *Continental Extensional Tectonics*, Geological Society Special Publication No. 28, pp. 313–335.

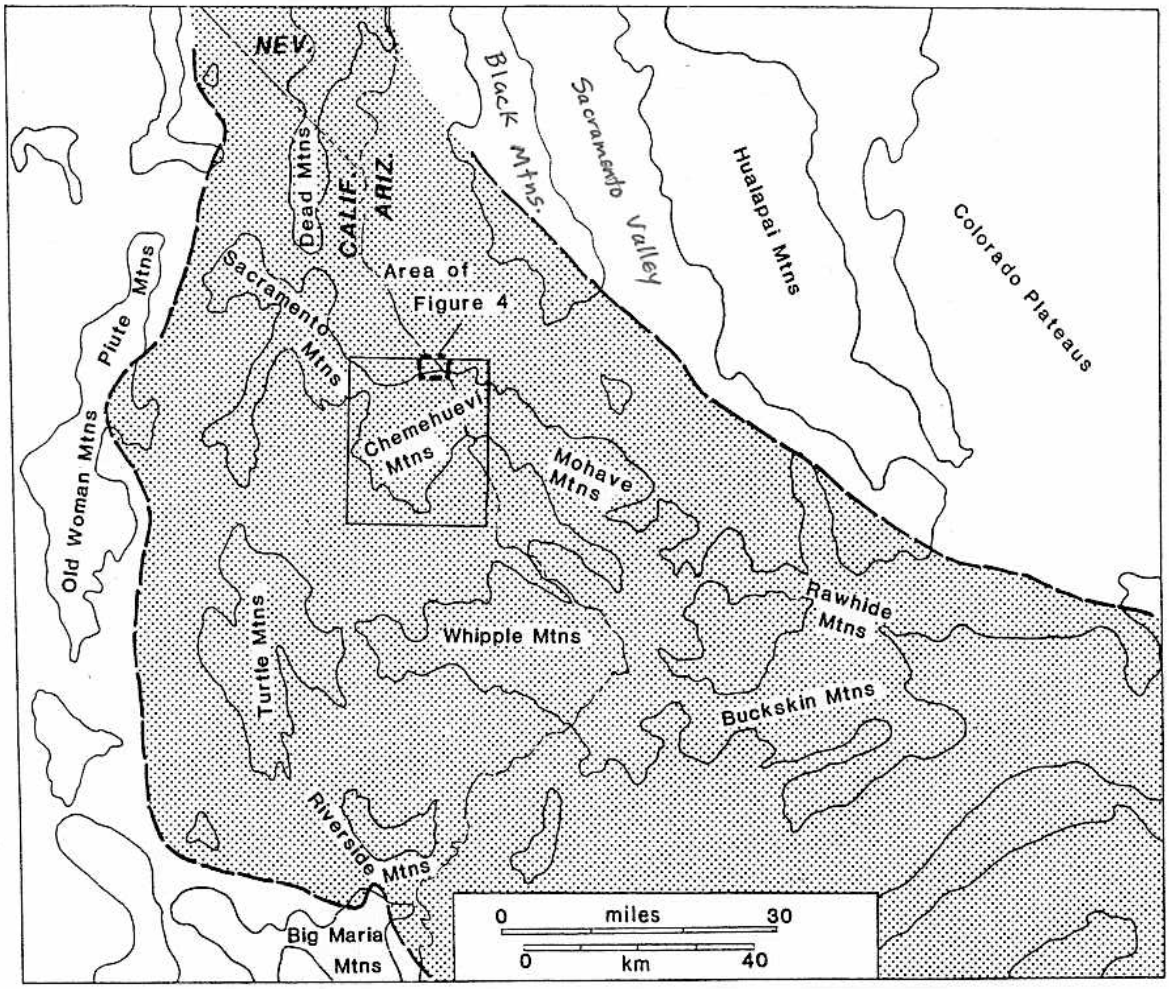


FIG. 2. Map of the Colorado River extensional corridor (shaded between the heavy dashed lines) in California and Arizona, as defined in Howard & John (this volume). The Chemehuevi Mountains (outlined in box) lie in the central belt of metamorphic core complexes that include from N to S, the Dead, Sacramento, Chemehuevi and Whipple Mountains. The eastern limit of extension marked by highly faulted and tilted blocks lies W of the Hualapai Mountains. Detachment faults exposed around the core complexes dip under the Hualapai Mountains and Colorado Plateau.

Geology of the Chemehuevi Mountains

Three structural plates or allochthons, separated by three Tertiary low-angle normal or detachment faults, have been recognized in the Chemehuevi Mountains. The footwall or 'autochthon, A', of the Chemehuevi Mountains includes the structurally deepest exposed rocks in the range, below the deepest exposed detachment, the Mohave Wash fault (Fig. 3). Successively higher plates or allochthons are termed B, C and D (Figs 3 & 4a, b). Because the low-angle normal or detachment faults juxtapose mainly crystalline rocks of different structural levels from the upper and middle crust, usually with a gross lithological 'mis-match', it is necessary to separate rocks by their relative structural position. Rocks in the Chemehuevi Mountains are divided into two assemblages defined by their relative structural positions and lithology (Fig. 3). The structurally deeper rock assemblage (I) consists of a large, crudely zoned plutonic suite of probable Cretaceous age, that intrudes foliated mylonitic gneiss at least 1.5 km thick, and makes up most of the footwall, A, and lowest allochthon, B. These two plates are separated by the Mohave Wash fault (Figs 3 & 4). The higher rock assemblage (II) lies above the Chemehuevi detachment fault in allochthon C, and above the Devils Elbow fault in allochthon D. Assemblage (II) consists of Proterozoic igneous and metamorphic rocks, and an overlying Oligocene(?) and Miocene volcanic and sedimentary sequence. Locally, intrusive rocks of assemblage (I) are found above the Chemehuevi detachment fault, and some

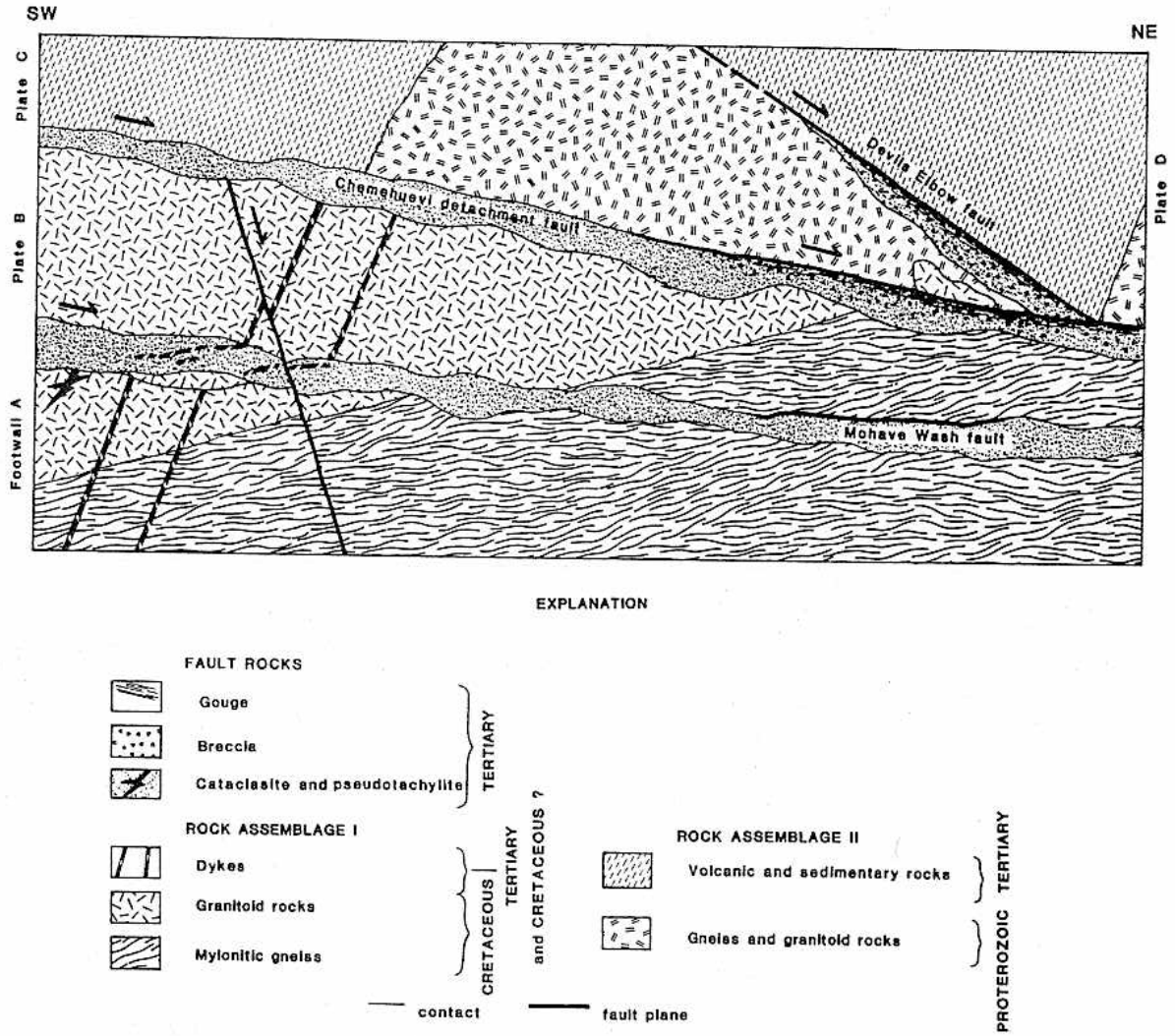


FIG. 3. Schematic composite section through the extensional fault system in the Chemehuevi Mountains. The range is cut by three low-angle normal or detachment faults—from structurally deepest to highest; the Mohave Wash, Chemehuevi and Devils Elbow faults. Each fault shows NE separation of its hanging wall. Variation in fault rock type and progressive reworking, from SW to NE, is shown diagramatically.

assemblage (II) rocks occur below the Chemehuevi fault (Fig. 4a). Each fault has normal-slip displacement shallow rocks against deeper-crustal rocks. This juxtaposition forms a distinctive tectonic layering (Fig. 3). Howard *et al.* (1982b) constructed a generalized crustal column for the extensional corridor. The reconstructed column indicates a gross 5–10 km scale layering of the crystalline upper and middle crust throughout the Colorado River area.

In this paper I use the terms low-angle normal and detachment fault interchangeably. The term low-angle normal fault implies knowledge of fault orientation and shear sense during slip, and conveys significant information about the geometry of the faults. Recognizing that the term detachment fault has been used without consistent meaning (cf. Pierce 1973; Carr & Dickey 1976; Reynolds & Spencer 1985), I will use it here for major unrotated, low-angle normal faults, to conform with previous usage in the region (Davis *et al.* 1980; Frost & Martin 1982a).

The time of initiation of extensional faulting is not well constrained, but is probably late Oligocene or early Miocene. In the nearby Whipple and Buckskin Mountains (Fig. 2), syntectonic sediments and interstratified volcanic rocks deposited in basins that developed during extension have been dated as early Miocene and late Oligocene (Davis *et al.* 1980, 1982). Cenozoic deformation in the Chemehuevi Mountains ended by the late Miocene; basalt plugs and local flows, dated at 11.6±1.2 Ma (K–Ar, whole rock—J. Nakata pers. comm., 1984), intrude or overlie and fuse cataclasites in

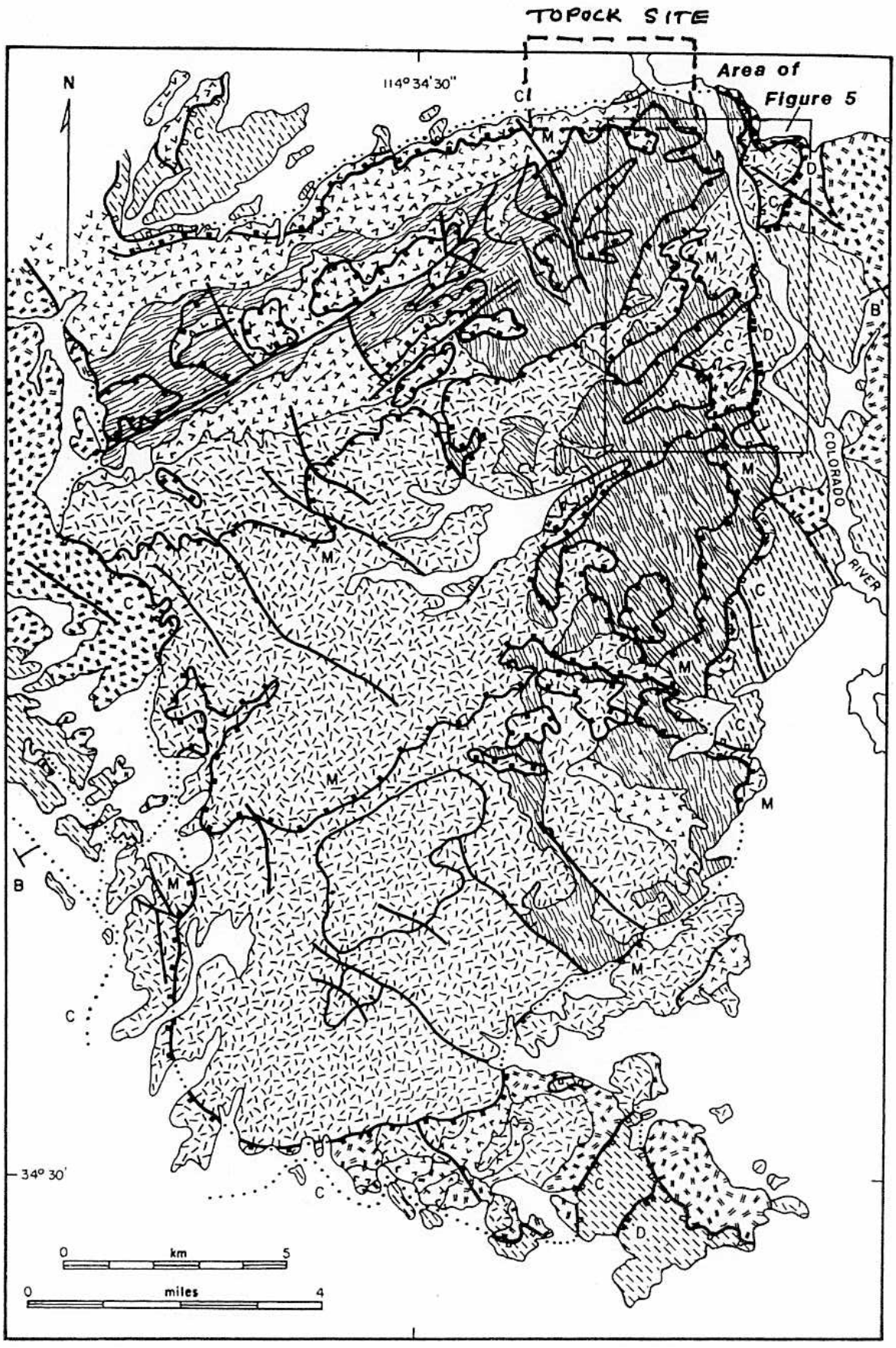

TOPOCK SITE
Area of
Figure 5
N
114°34'30"
34°30'
COLORADO
RIVER
0 km 5
0 miles 4

FIG. 4(a)

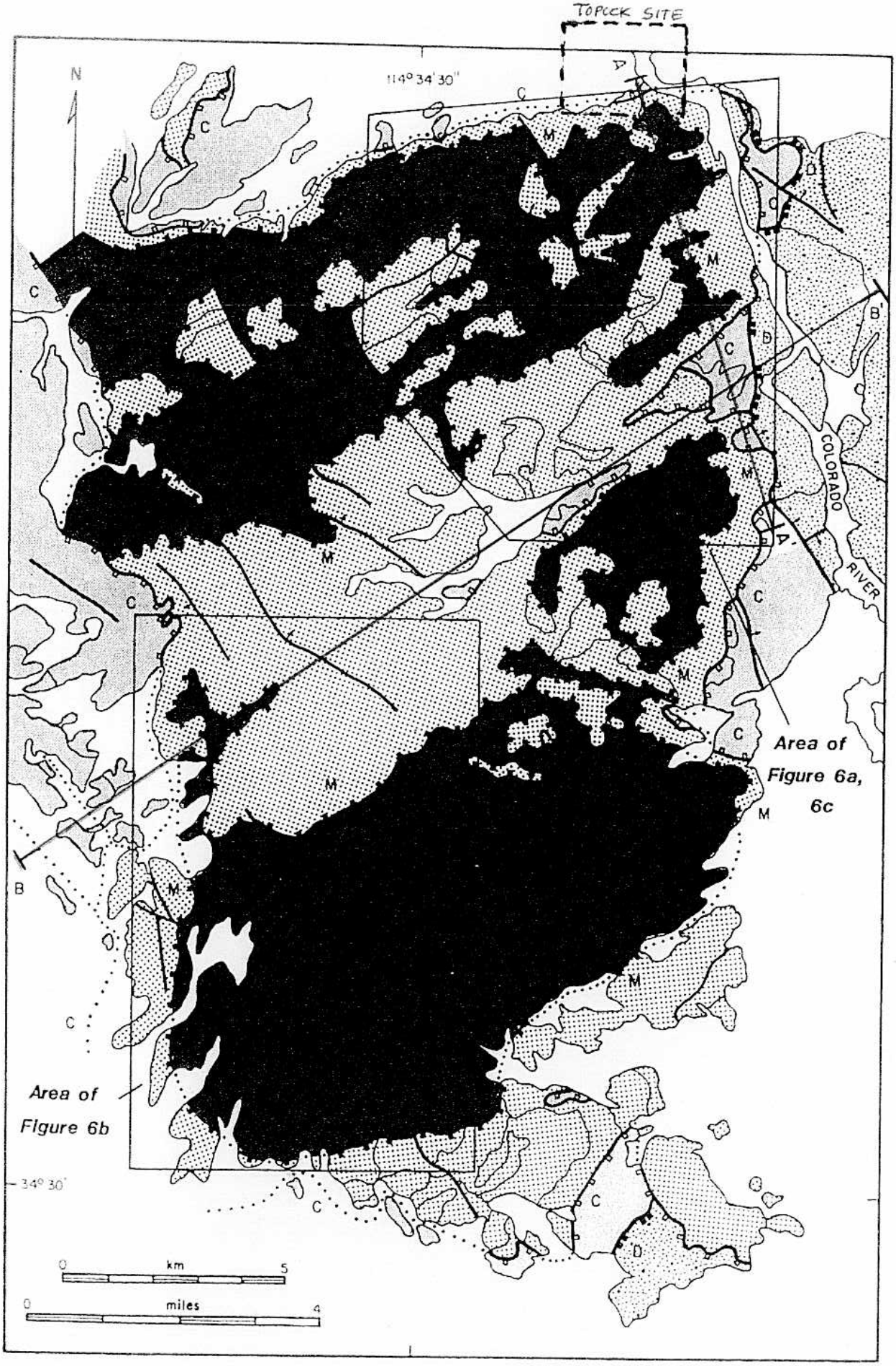
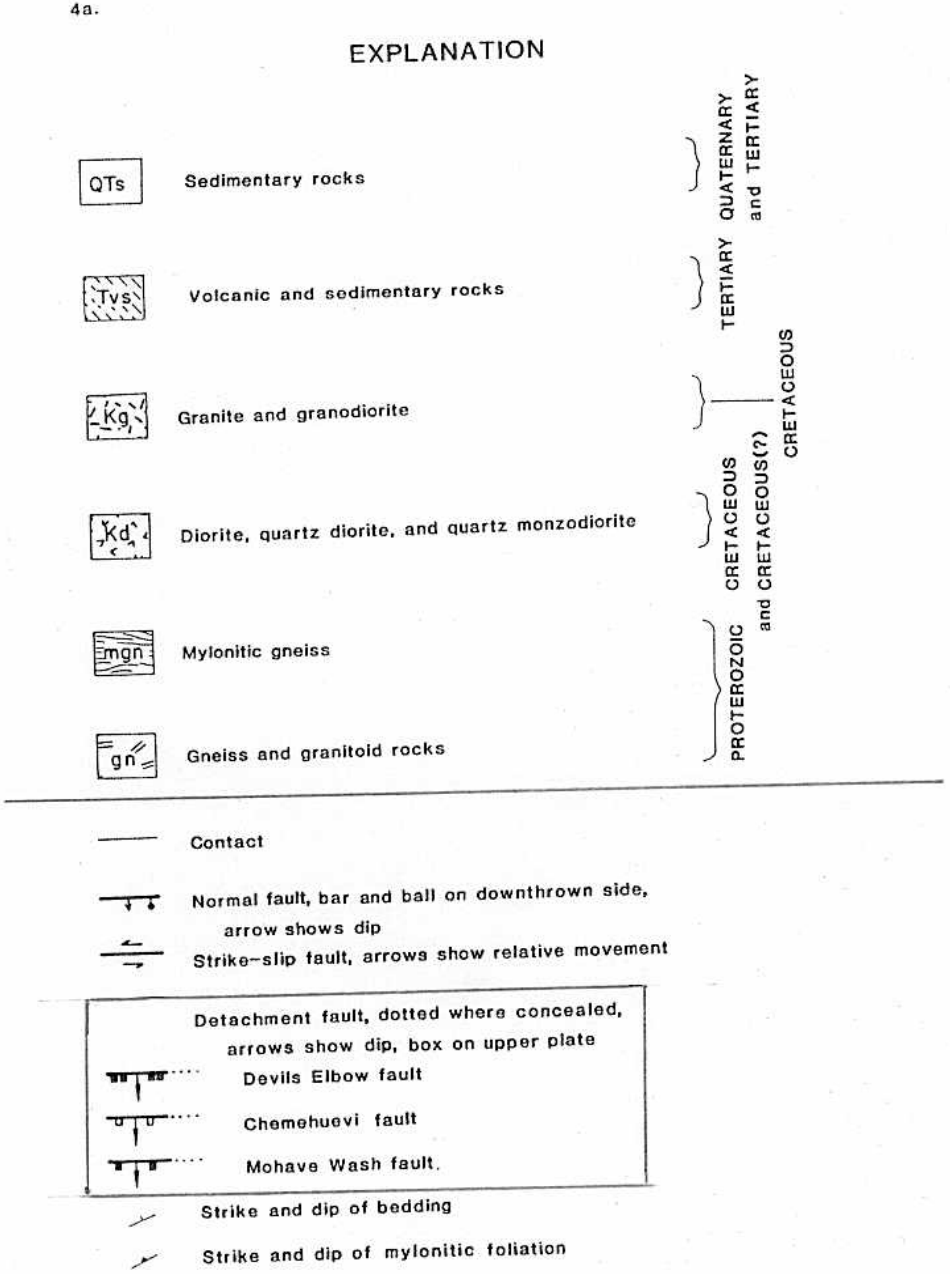

TOPOCK SITE
N
114°34'30"
34°30'
COLORADO RIVER
Area of Figure 6a, 6c
Area of Figure 6b
0 km 5
0 miles 4
A
A'
B
B'
C
D
M

FIG. 4(b)

4a.



4b.

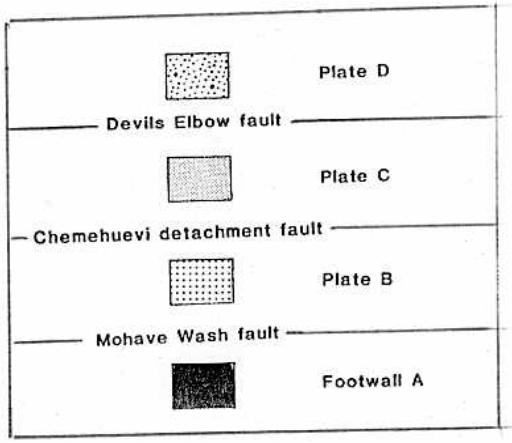


FIG. 4. (a) Generalized geological map of the Chemeheuvi Mountains area in California and Arizona. The three detachment faults are indicated by M = Mohave Wash fault; C = Chemehuevi fault; and D = Devils Elbow fault. (b) Tectonic map of the Chemehuevi Mountains portraying the Tertiary detachment faults and intervening plates. Unpatterned areas outline post-detachment deposits that are Pliocene and younger. The patterned areas outline plates discussed in the text. The footwall, A, is the structurally deepest plate exposed. Plate B lies above the Mohave Wash fault. Plate C lies above the regionally developed Chemehuevi detachment fault. The structurally highest plate, D, is above the Devils Elbow fault, in the southern and eastern part of the range. Plates C and D, both of which are broken and shingled by numerous E-dipping(?) normal faults, moved together during slip on the Chemehuevi detachment fault, after the Devils Elbow fault became inactive.

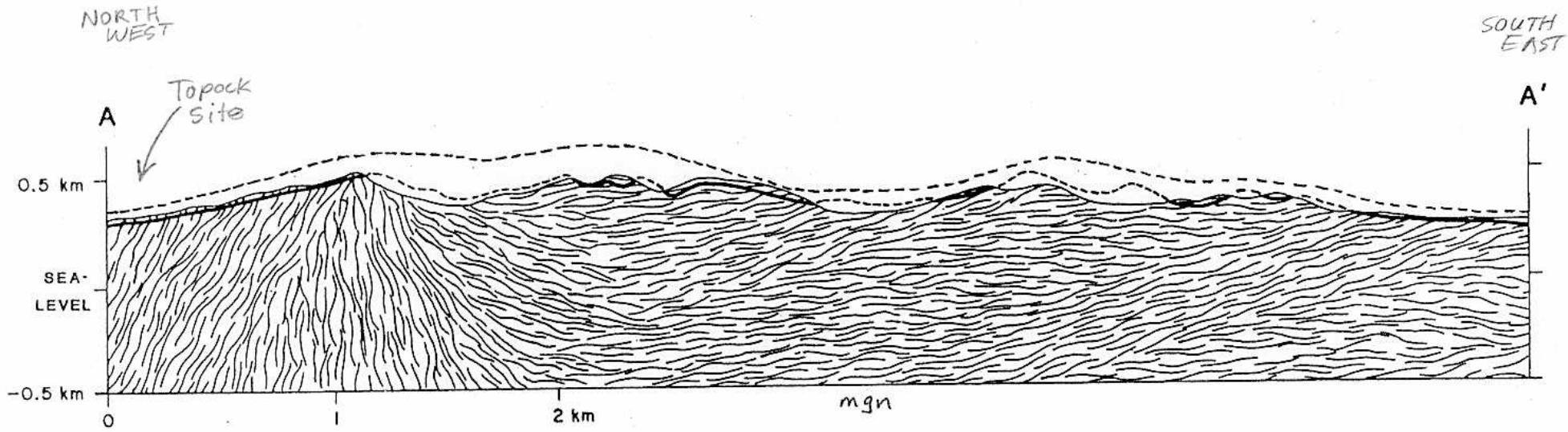


FIG. 7. Geological section along the line A–A′ (Fig. 4b), drawn NW–SE normal to the corrugation axes. Corrugations of the Mohave Wash fault cut the mylonitic foliation.

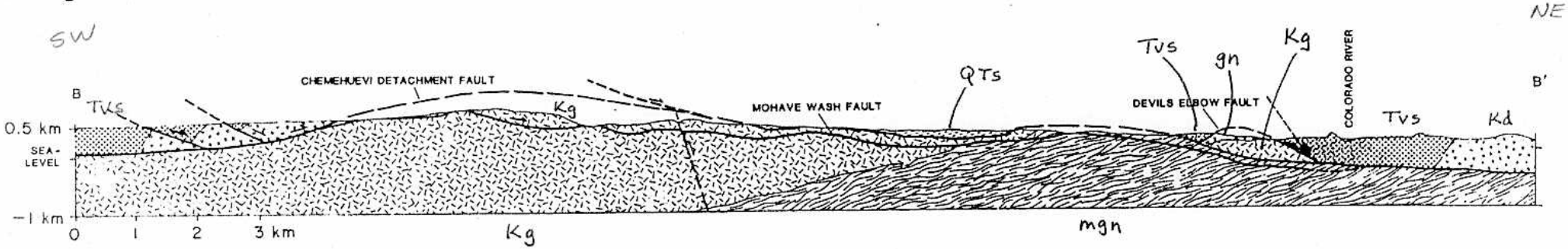
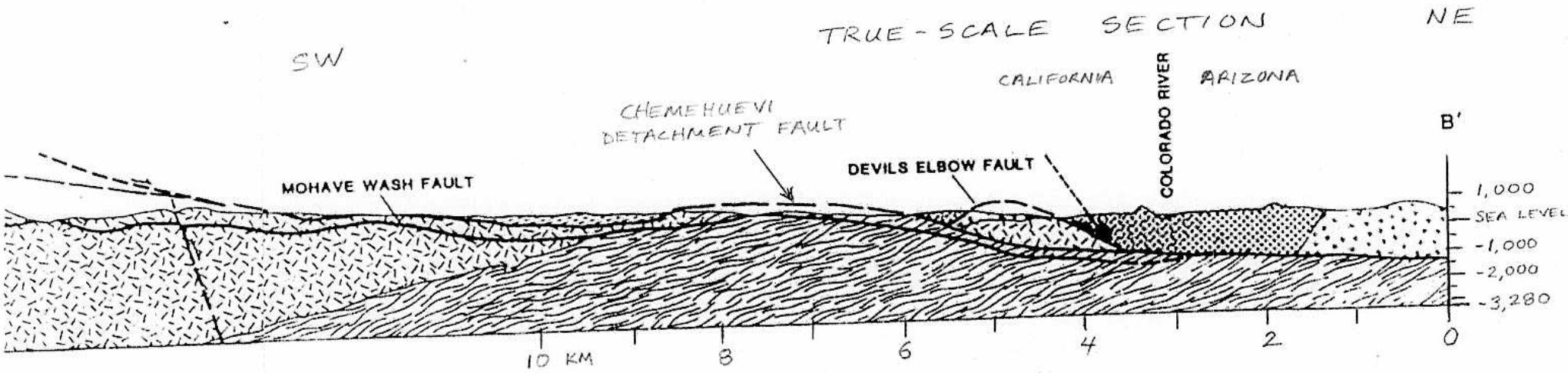


FIG. 8. Geological section along B–B′ (Fig. 4a), drawn SW–NE parallel to the corrugation axes. The Tertiary section is repeated by numerous faults above the regionally developed Chemehuevi detachment fault. The Mohave Wash fault is truncated by the structurally higher Chemehuevi fault in the W, and inferred to be cut in the E. Patterns shown are the same as in Fig. 4.

(QTs & Tvs are different patterns)



g. 4a), drawn SW–NE parallel to the corrugation axes. The Tertiary
ove the regionally developed Chemehuevi detachment fault. The Mohave
/ higher Chemehuevi fault in the W, and inferred to be cut in the E.

B. Johns (1987)

DESCRIPTION OF MAP UNITS

Qa **Alluvium (Holocene)** -- Silt, sand, and gravel in modern drainages. Poorly sorted, angular to subrounded, unconsolidated material of local origin

Qs **Sand dunes and river sand (Holocene)** -- Stabilized and active dunes, sand sheets, and river sand. Deposits along the Colorado River up to 20 meters thick

Qg **Gravel (Quaternary)** -- Gravel, sand, and silt associated with the Colorado River. Well-sorted, subrounded to rounded material of sedimentary origin, characterized by limestone and quartzite clasts, and rare volcanic material

QTch **Chemehuevi Formation of Longwell (1963) (Pleistocene and Pliocene)** -- Sand, silt, clay, and ancestral Colorado River gravel and cobbles

QTa **Older alluvium (Pleistocene and Pliocene)** -- Poorly sorted, poorly consolidated alluvium. Commonly forms terraces with extensive covering of desert pavement consisting of varnished cobbles. Unit also includes older partially consolidated and extensively dissected alluvium in the southern part of the range

Tbo **Bouse Formation (Piocene)** -- Pale-red to tan calcareous clay, silt, sand and marl, moderately to poorly indurated, well-bedded

Tb **Basalt (Miocene)** -- Dark-purplish brown augite-olivine basalt flows, dikes, and plugs. Includes mudstone below basalt in the southwest part of the map area. Flows with conspicuous columnar joints. Locally intrudes and fuses cataclasites associated with the Chemehuevi detachment fault. K-Ar whole-rock age of 11.1± 0.4 and 14.5± 1.0 Ma by M.A. Pernokas (written communication; in John, 1986)

Tgf **Granite-clast fanglomerate (Miocene)** -- Light-tan- and orange-weathering, virtually monomictic alluvial-fan deposits, comprising white to tan granite and granodiorite clasts, and clasts of dike rock types, equivalent of rocks below the Chemehuevi detachment fault, and clasts of altered cataclasite. Locally contains thin siliceous tuff beds, and basalt flows

Tgm **Granite megabreccia (Miocene)** -- Light-tan- and pale orange-weathering granite-clast landslide-megabreccia deposits; silicified. Granite blocks up to ~ 1 km x 20 m within the deposits. Megabreccia deposit comprises granitic debris characteristic of rocks below the Chemehuevi detachment fault. Locally, includes altered granitic cataclasite debris, possibly derived from exhumed fault scarps

Tgnf **Gneiss-clast fanglomerate (Miocene)** -- Dark red to red-brown weathering, poorly sorted alluvial-fan deposits. Includes subangular to subrounded clasts of Proterozoic gneisses (Xgn), granite (Yg) and amphibolite, characteristic of rocks above the Chemehuevi detachment fault

Tgnm **Gneiss-clast megabreccia (Miocene)** -- Dark-reddish-brown weathering gneissic- and granite-clast landslide-megabreccia deposits; silicified. Landslide blocks up to 500 m x 20 m within the deposits. Megabreccia deposit comprises gneissic and granitic debris characteristic of rocks above the Chemehuevi detachment fault

Tvf **Volcanic-clast fanglomerate (Miocene)** -- Dark reddish-brown, poorly sorted alluvial-fan deposits,

Northeast corner Geologic Map of Chemehuevi Mtns. area
B. E. John USGS Open File Report 87-666

A2 Geologic Map for Western Mohave County, Arizona

U. S. DEPARTMENT OF THE INTERIOR
U. S. GEOLOGICAL SURVEY

Preliminary Geologic Map of the Eastern and Northern Parts of the Topock 7.5-minute Quadrangle Arizona and California

by

Keith A. Howard[1], Barbara E. John[2], and Jane E. Nielson[1]

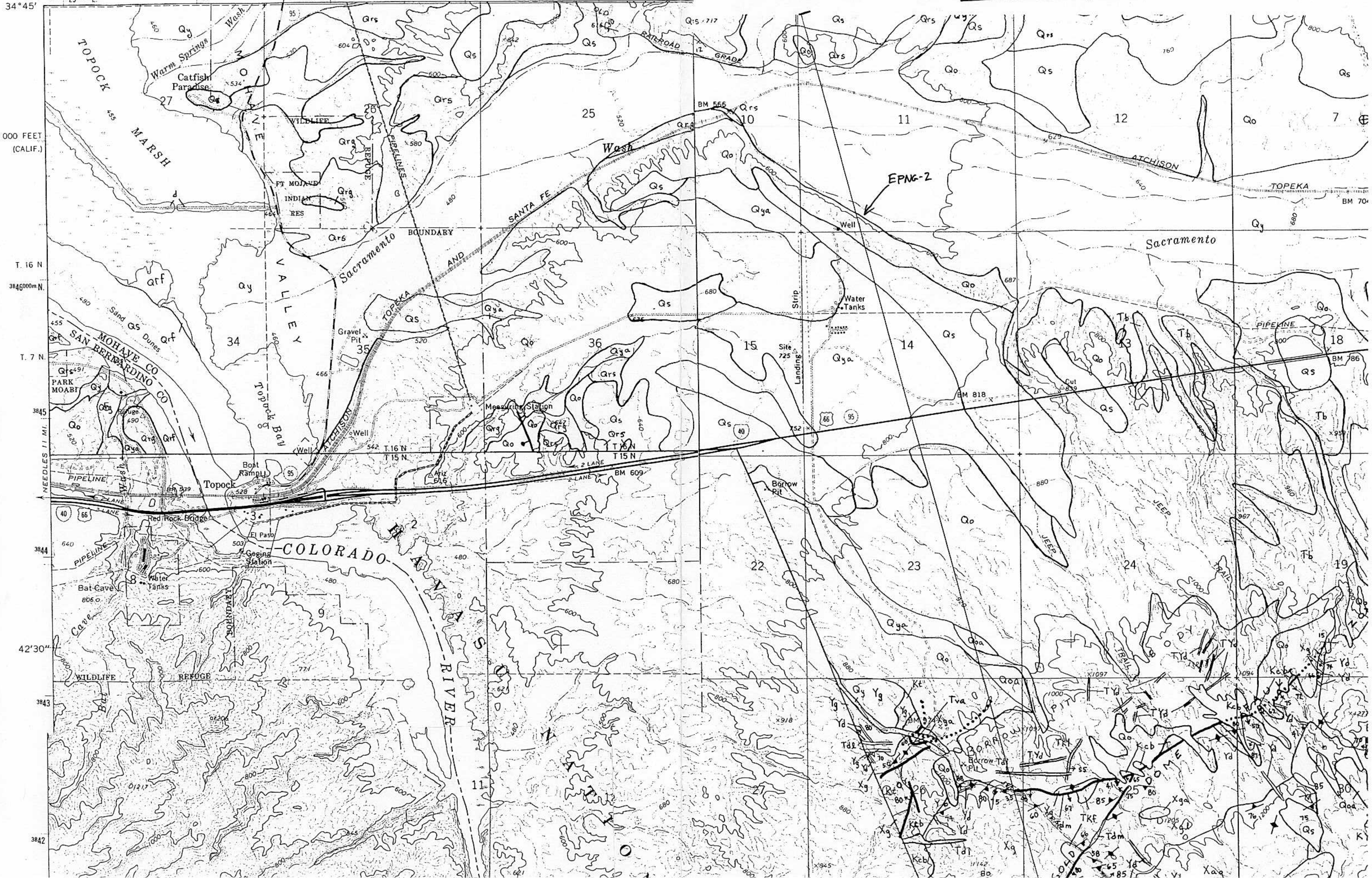
Open-File Report 95-534

Geology mapped by J.E. Nielson (1981, 1982, 1990) assisted by V.L. Hansen (1981); K.A. Howard and B.E. John (1980, 1981, 1989, 1990).

[1]Menlo Park, California 94025
[2]Department of Geology and Geophysics, University of Wyoming, Laramie, Wyoming 82071

1997

(Topock) 7.5 minute Quad. From: Howard and others, 1997



Appendix B
Site Characterization Data for PG&E's Old Evaporation Ponds Area

B1 Hydrogeological Maps and Cross Sections

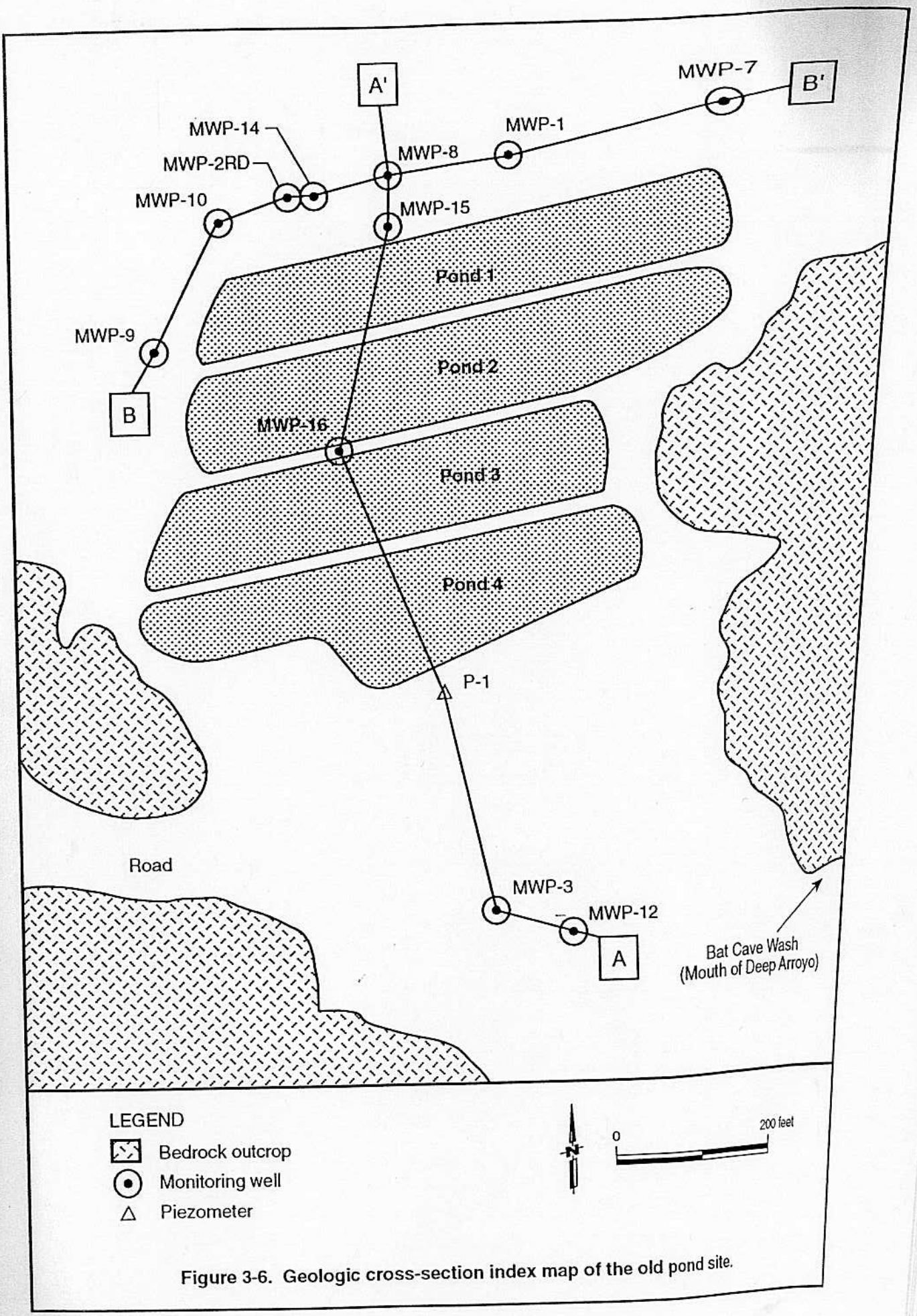


Figure 3-6. Geologic cross-section index map of the old pond site.

PG & E PURGING AND SAMPLING LOG

SITE TOPOCK-CLD JOB ID: 4458-04 WELL # MWP-2RD

PURGE DATE 9/21 BY KLM Bedrock

SAMPLE DATE 9/21 BY KLM MWP-2RD WEATHER > 100°F

★ NEW WELL

WATER ELEVATION / VOLUME CALCULATIONS

MEASURING POINT (MP): TOC @ HYDROCARBON ODOR: YES (NO)

DEPTH OF WELL (DTB): 275' FT. THICKNESS

DEPTH TO WATER (DTW): 263.98' FT

TOTAL WATER DEPTH: 11.02' FT

MEASUREMENT METHOD: (SOLINST) SLOPE INDICATOR

TOC ELEV.: FT - DTW: FT = GW ELEV.: FT

PURGE VOLUME CALCULATIONS

11.02' FT WATER * CASING FACTOR = 11.02 GAL/CASING VOL * 3 VOLUMES = 33.06 TOTAL PURGED (GALS)

CASING FACTOR (CIRCLE ONE): FOR 2" DIA = 0.17 GAL / FT. FOR 3" DIA = 0.38 GAL / FT. FOR 4" DIA = 0.66 GAL / FT.

5" DIA = 1.0 GAL/FT

PURGING

TIME START	TIME END	CUMULATIVE DISCHARGE (GAL)	pH	CONDUCTIVITY umho/cm	TURBIDITY	°C TEMP	COMMENTS
1122		1	7.64	1,953	28.43	30.4	SLIGHTLY CLOUDY, FINE SANDS, SILTS
1300		4	7.67	1,877	71.10	29.7	SAME
1745		5	7.53	1,911	11.41	30.1	CLEANER, CLEAR
1412	1412	10.5	7.61	1,886	7.64	30.3	SAMPLED - DRY

METHOD OF DISCHARGE DISPOSAL: (GROUND) BARREL POND (CIRCLE ONE)

METHOD OF PURGING: HOMELITE BAILER HAND PUMP (SUBMERSIBLE) WATERRA (CIRCLE ONE)

METHOD OF SAMPLING: (WELL WIZARD) TEFLON BAILER HAND PUMP DISPOSABLE BAILER (CIRCLE ONE)

METHOD OF CLEANING: ALCONOX / DI WATER STEAM CLEANER / DI WATER (CIRCLE ONE)

PUMP LINES / BAILER BORES: NEW, (CLEANED, OR DEDICATED) (CIRCLE ONE)

pH METER: YSI CALIBRATED: (YES) NO COND. METER: YSI CALIBRATED: YES (NO)

TEMP. CORRECTED: (YES) NO CALIBRATION DATA pH: 4 = 4.0 COND. 1,000=

pH: 7 = 7.0 COND. 10,000=

pH: 10 = 10.0

SAMPLES:

LAB ANALYSIS: GEN. MIN., FLUORIDE, PHENOLS, TOC, TOX, TOTAL Cr, TOTAL (P)

LABORATORY: BCA

SAMPLE TIME: 1417

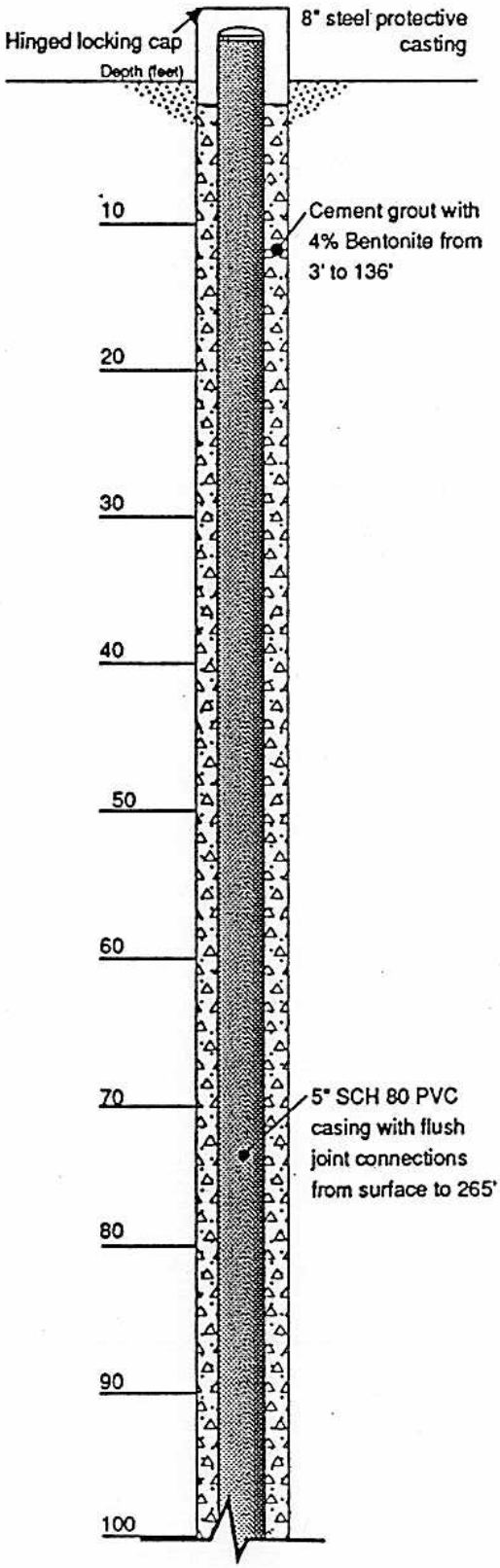
REMARKS: VERY LOW FLOW / GOES DRY, DOES NOT RECOVER

PG&E Topock Compressor Station

Bore Hole MWP-2RD

Date Started 6/27/92
Drilling Method ARCH-air rotary
Sampling Method
Surface Elevation 674.00

Well As-Built



Description of Materials

(from previous report for MWP2)

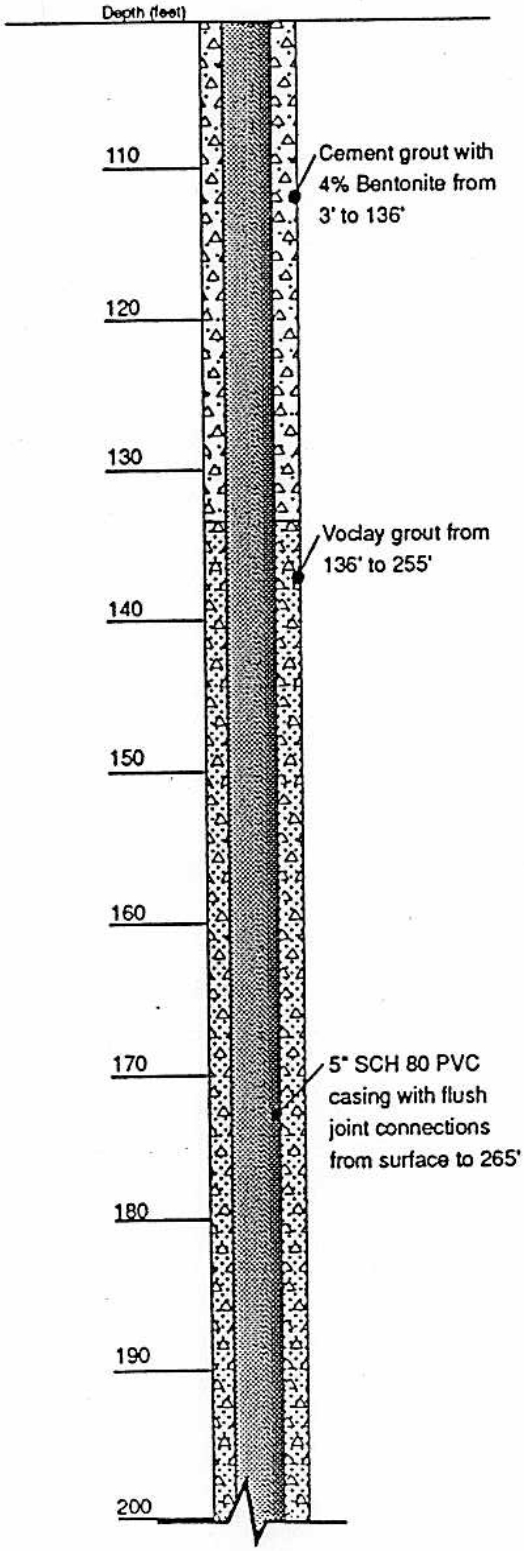
Soil Class	Depth (feet)	
GW		SANDY GRAVEL - Med gray, dry F gr. sand matrix w/subangular to subrounded meta-diorite gravels to 3cm
	10	
SP		SAND -Red brown sl.moist, VF-F gr. subrounded to subangular uniform
SP	20	SAND -as above w/caliche veins & cemented ($caco_3$) nodules
SW	30	SAND - Yellow brown, sl. moist, VF-F gr. w/aug. gravels to 2cm
		SAND - Med. brown, VF-F gr. sl. moist w/small meta-diorite, subangular gravels to 1 cm.
SW	40	GRAVELLY SAND - Brown gray, dry to sl. moist, F-M gr. sand w/subangular gravel to 0.5cm.
	50	
GW		SANDY GRAVEL - Med. gray, dry, F-C gr. sand w/subrounded to subangular meta gravels & cobbles to 4cm.
	60	
SP		SAND - Red brown, VF-F gr. moist, uniform texture
	70	
GW		SANDY GRAVEL - Med. gray, dry, F-C gr. sandy matrix w/subangular meta gravels to 3cm.
	80	
SW		GRAVELLY SAND - Med. gray, sl. moist, F-M gr. sand w/subangular meta gravels to 3cm
GW	90	SANDY GRAVEL - Med. gray, dry to sl. moist, poorly sorted sandy matrix; subangular to aug. meta gravels & cobbles to 4cm.
SW		GRAVELLY SAND - Med. brown, moist F-C gr. sand w/subang to aug. meta gravels & cobbles to 4cm.
	100	

PG&E Topock Compressor Station

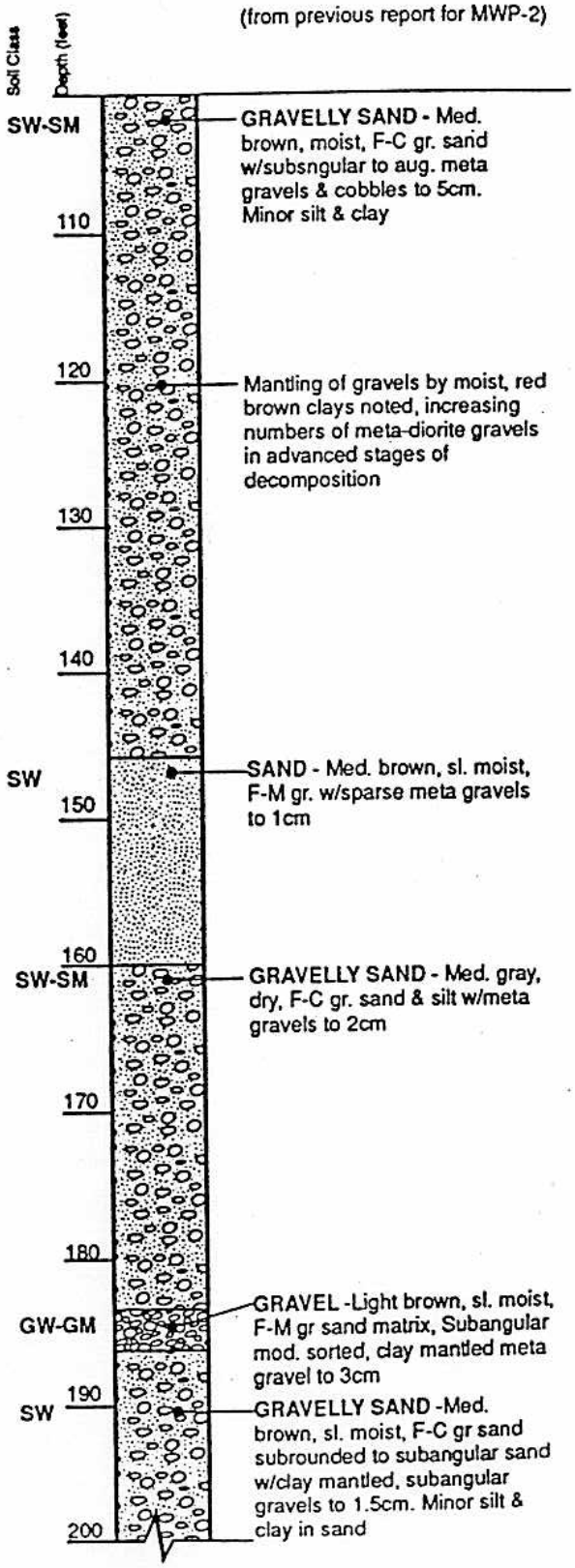
Bore Hole MPW-2RD

Date Started 6/27/92
Drilling Method ARCH-air rotary
Sampling Method
Surface Elevation 674.00

Well As-Built



Description of Materials
(from previous report for MWP-2)



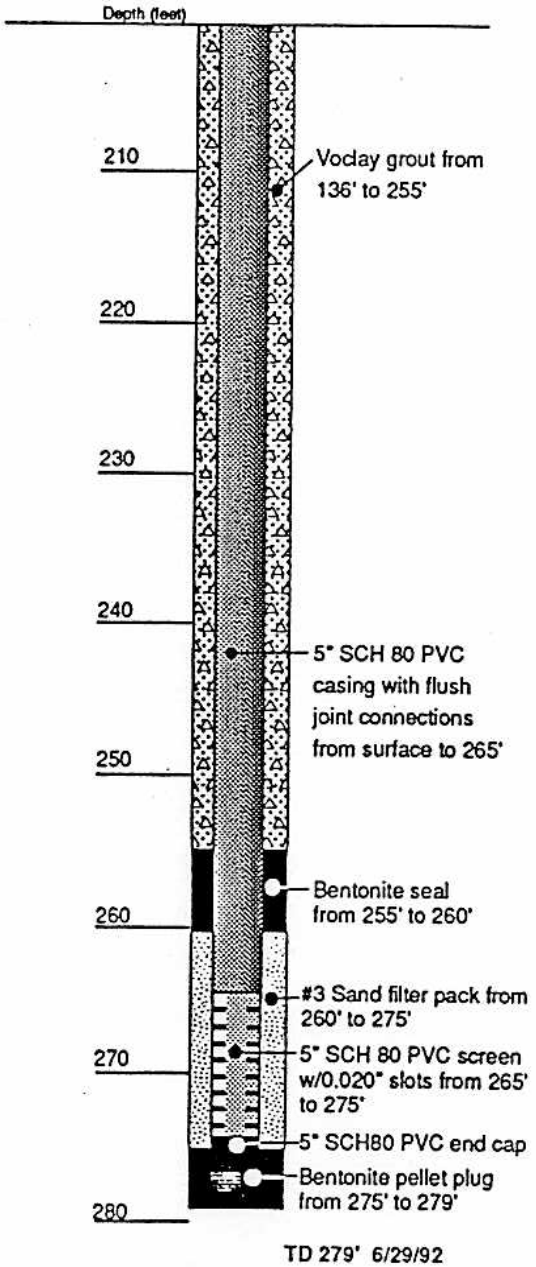
PG&E Topock Compressor Station

Bore Hole MWP-2RD

page 3 of 3

Date Started 6/27/92
Drilling Method ARCH-air rotary
Sampling Method bag cuttings
Surface Elevation 674.00

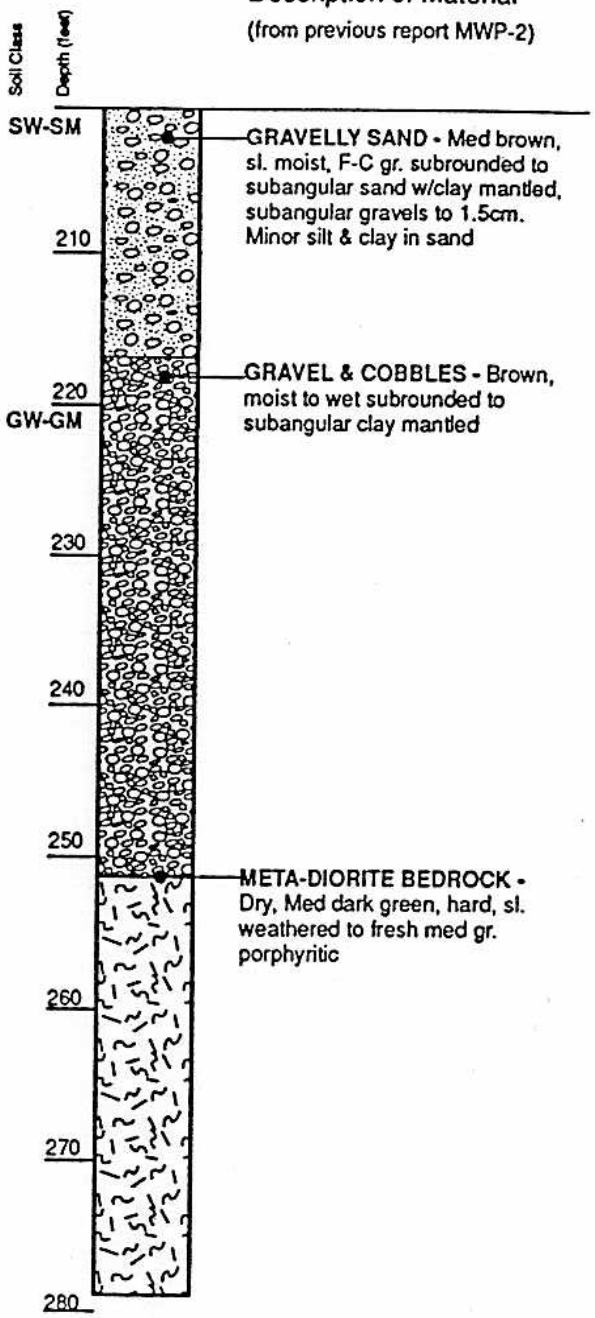
Well As-Built



TD 279' 6/29/92

Description of Material

(from previous report MWP-2)

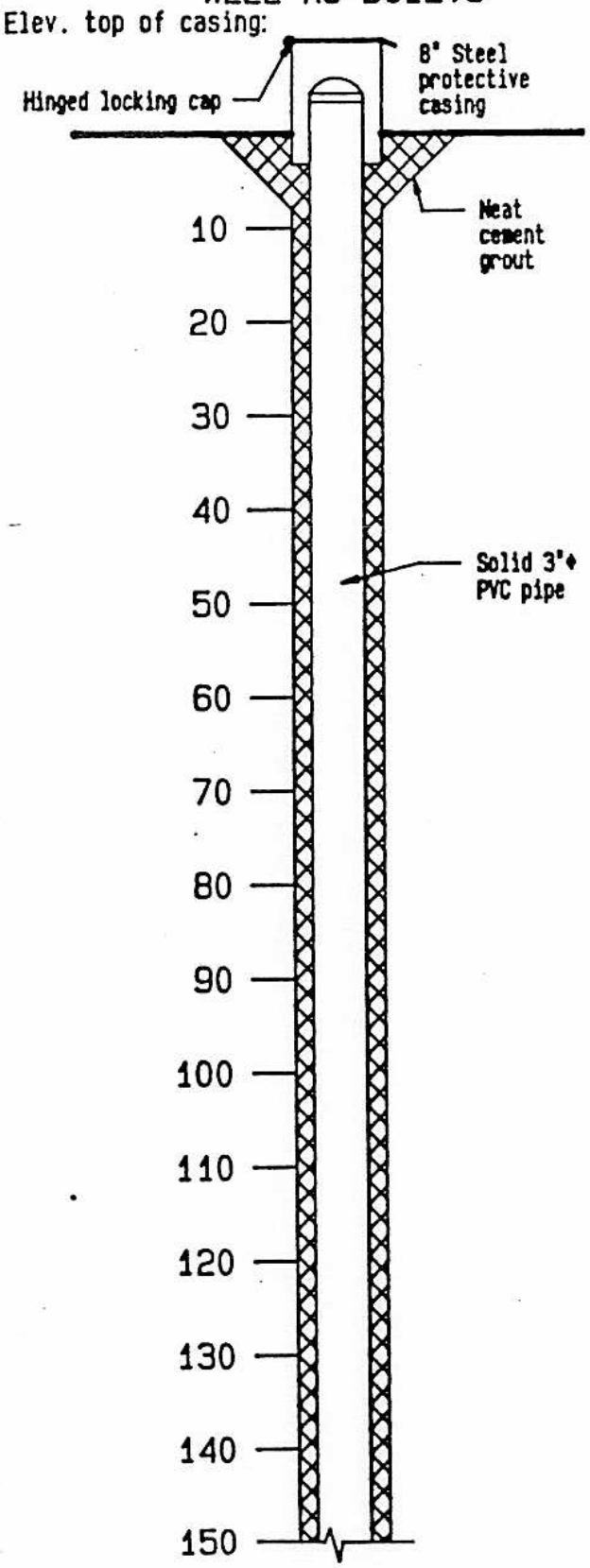


BOREHOLE LOGS AND WELL CONSTRUCTION RECORD
TOPOCK COMPRESSOR STATION

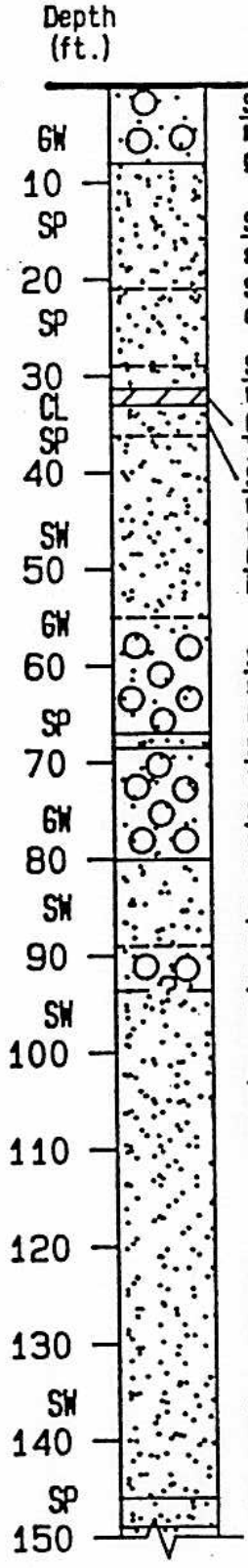
BORE HOLE (MWP-2)

DATE STARTED 7/19/85

WELL AS-BUILTS



DESCRIPTION OF MATERIALS



SANDY GRAVEL - Med gray, dry, F gr. sand matrix w/subang to subrdd meta-diorite gravels to 3"

SAND - Red brn, sl. moist, VF-F gr, subrdd to subang, uniform.

SAND - As above w/caliche veins & cemented ($CaCO_3$) nodules.

SAND - Yellow brn, sl. moist, VF-F gr, w/aug. gravels to 2".

CLAY - Med gray, moist, hard, low plasiticit limonite stained.

SAND - Med brn, VF-F gr, sl. moist w/small meta-diorite, subang gravels to 1"

GRAVELLY SAND - Brn gray, dry to sl. moist, F-M gr sand w/ subang gravel to 1/2".

SANDY GRAVEL - Med gray, dry, F-C gr, sand w/ subrdd to subang meta gravels & cobbles to 4".

SAND - Red brn, VF-F gr, moist, uniform texture.

SANDY GRAVEL - Med gray, dry, F-C gr sandy matrix w/ subang meta gravels to 3".

GRAVELLY SAND - Med gray, sl. moist, F-M gr sand w/subang meta gravels to 3".

SANDY GRAVEL - Med gray, dry to sl. moist, poorly sorted sandy matrix; subang to aug meta gravels & cobbles to 4".

GRAVELLY SAND - Med. brn, moist, F-C gr sand w/ subang to aug meta gravels & cobbles to 5". Minor silt & clay.

Mantling of gravels by moist, red brn clays noted, increasing numbers of meta-diorite gravels in advanced stages of decomposition.

GRAVELLY SAND - Med brn, moist, F-C gr sand w/ subang to aug gravel & cobbles to 5" (some clay mantling of clasts).

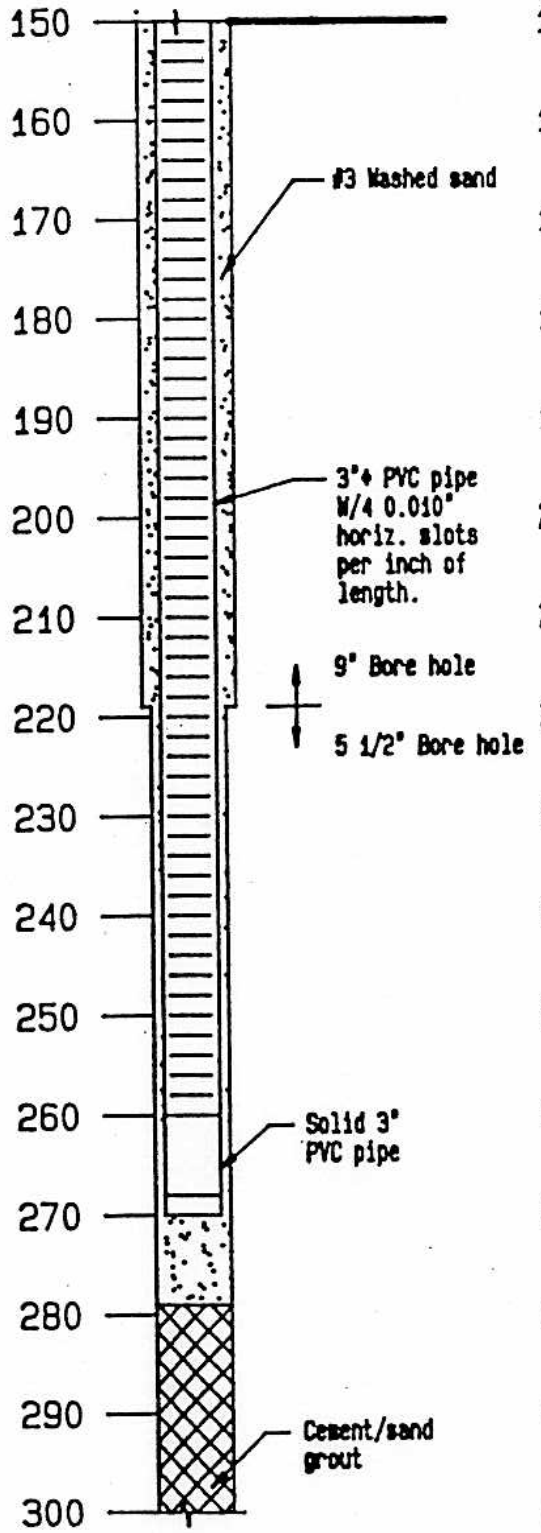
SAND - Med brn, sl. moist, F-M gr w/ sparse meta gravels to 1".

BOREHOLE LOGS AND WELL CONSTRUCTION RECORD
TOPOCK COMPRESSOR STATION

BORE HOLE (MWP-2) CONT'D

DATE STARTED

WELL AS-BUILT



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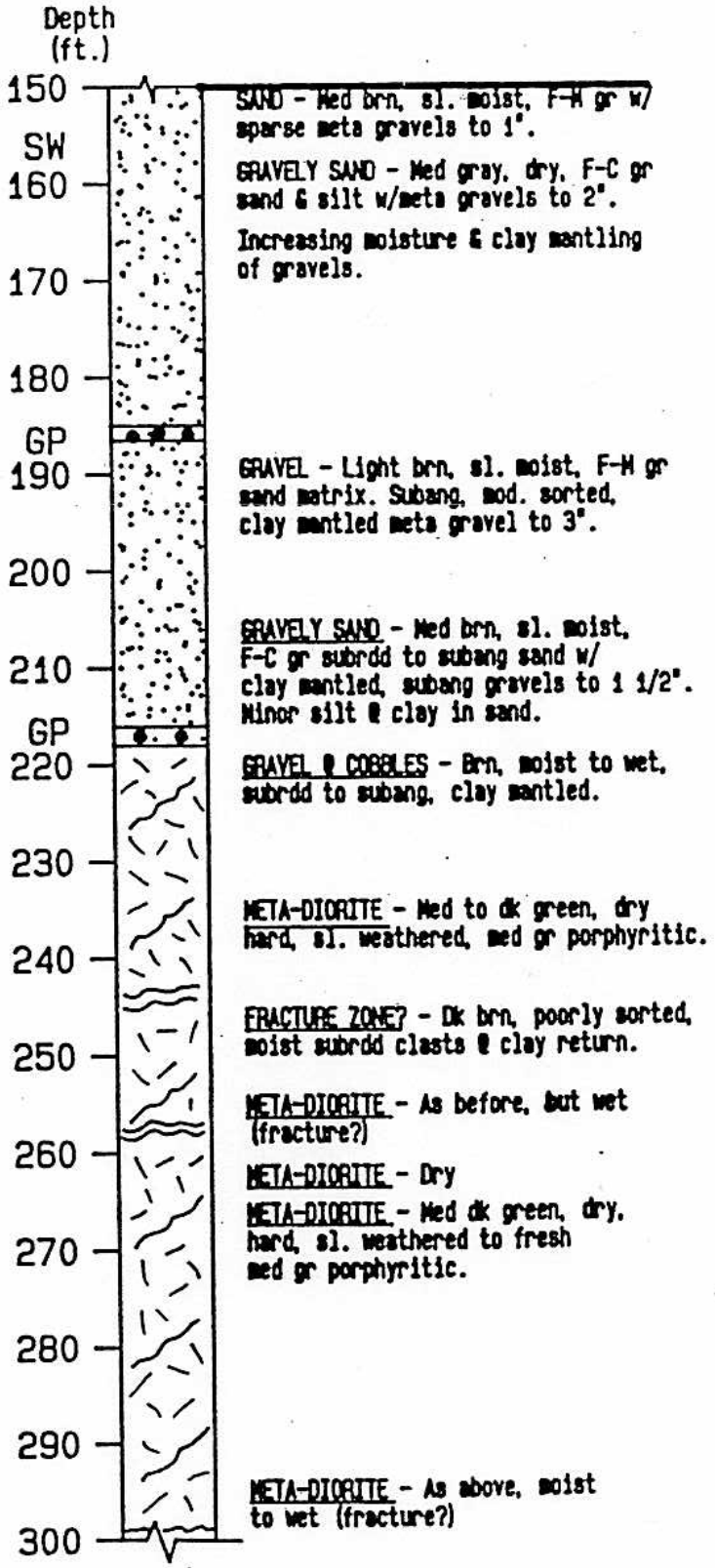
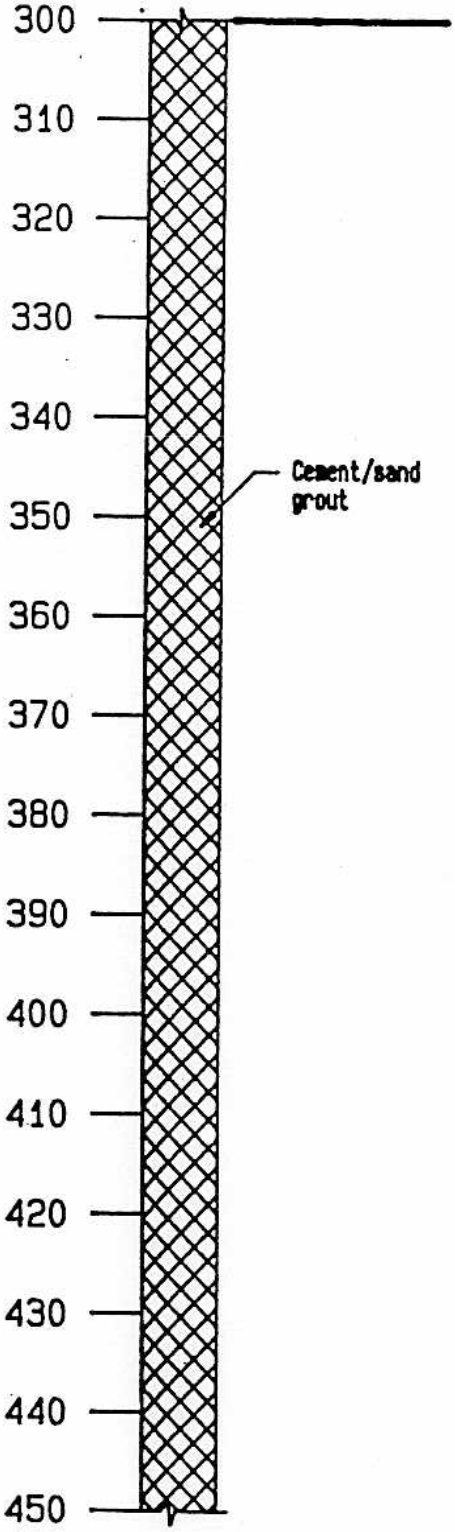


BOREHOLE LOGS AND WELL CONSTRUCTION RECORD
TOPOCK COMPRESSOR STATION

BORE HOLE MWP-2 CONT'D

DATE STARTED

WELL AS-BUILT



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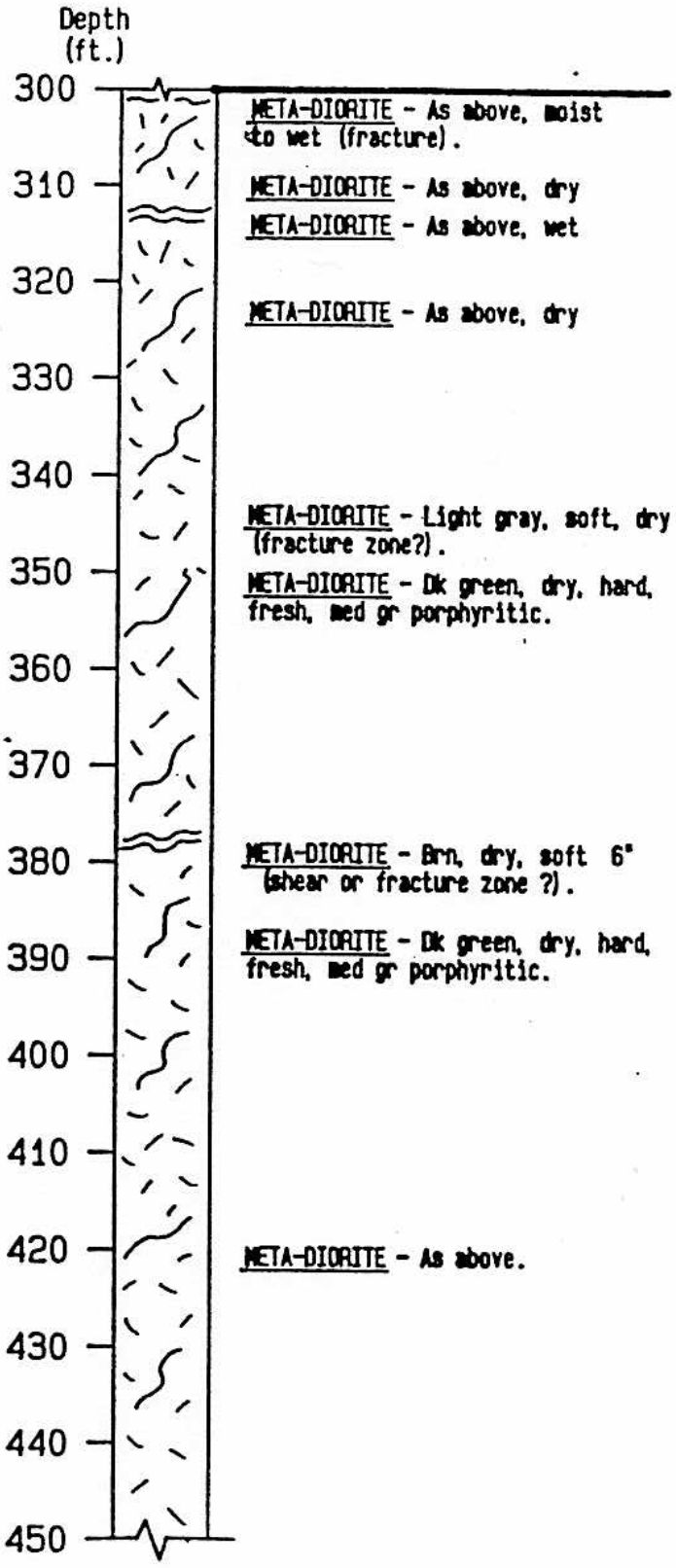
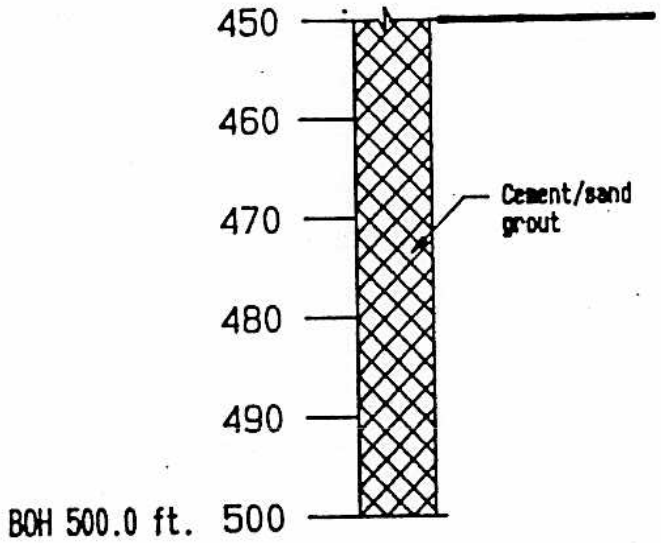


BOREHOLE LOGS AND WELL CONSTRUCTION RECORD
TOPOCK COMPRESSOR STATION

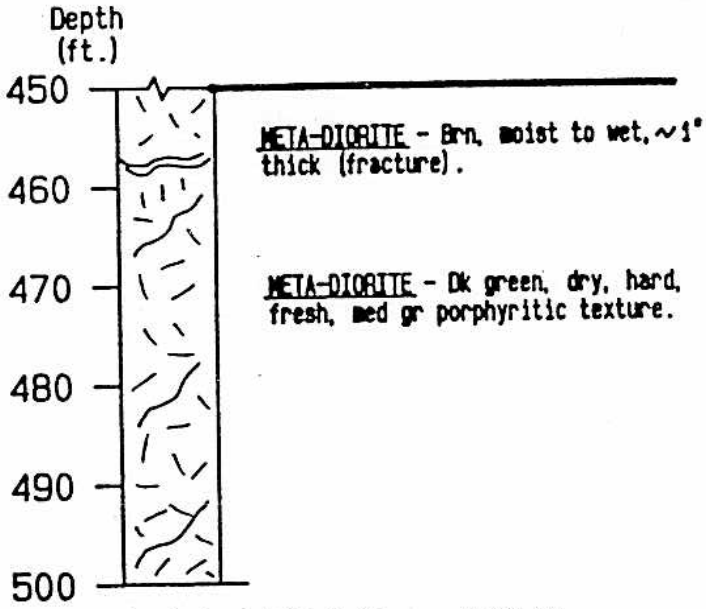
BORE HOLE MWP-2 CONT'D

DATE STARTED

WELL AS-BUILT

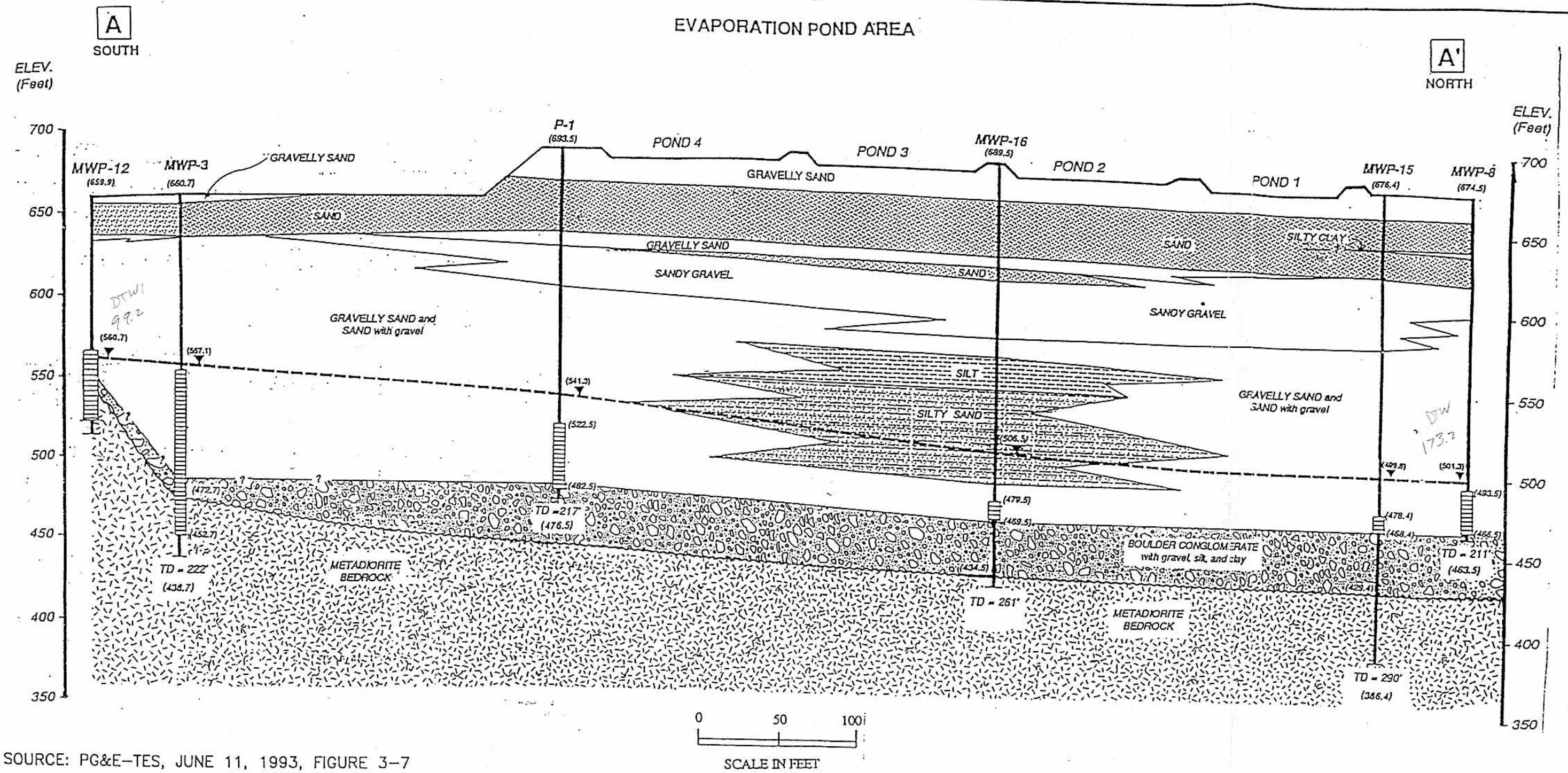


DESCRIPTION OF MATERIALS



Hole terminated at 500.0 ft. on 7-22-85

NOTES:
1. Hole advanced by Drill Systems 6 1/2" & 9" down hole hammer and Terra drills 5 1/2" Rotary down hole hammer-Bill Mehlhorn drilling supervisor.
2. Borehole logged by L.A. Flora.
3. Elevation reference to



SOURCE: PG&E–TES, JUNE 11, 1993, FIGURE 3–7

LEGEND

(440) Elevation above sea level

Water elevation August, 1992

Screened interval

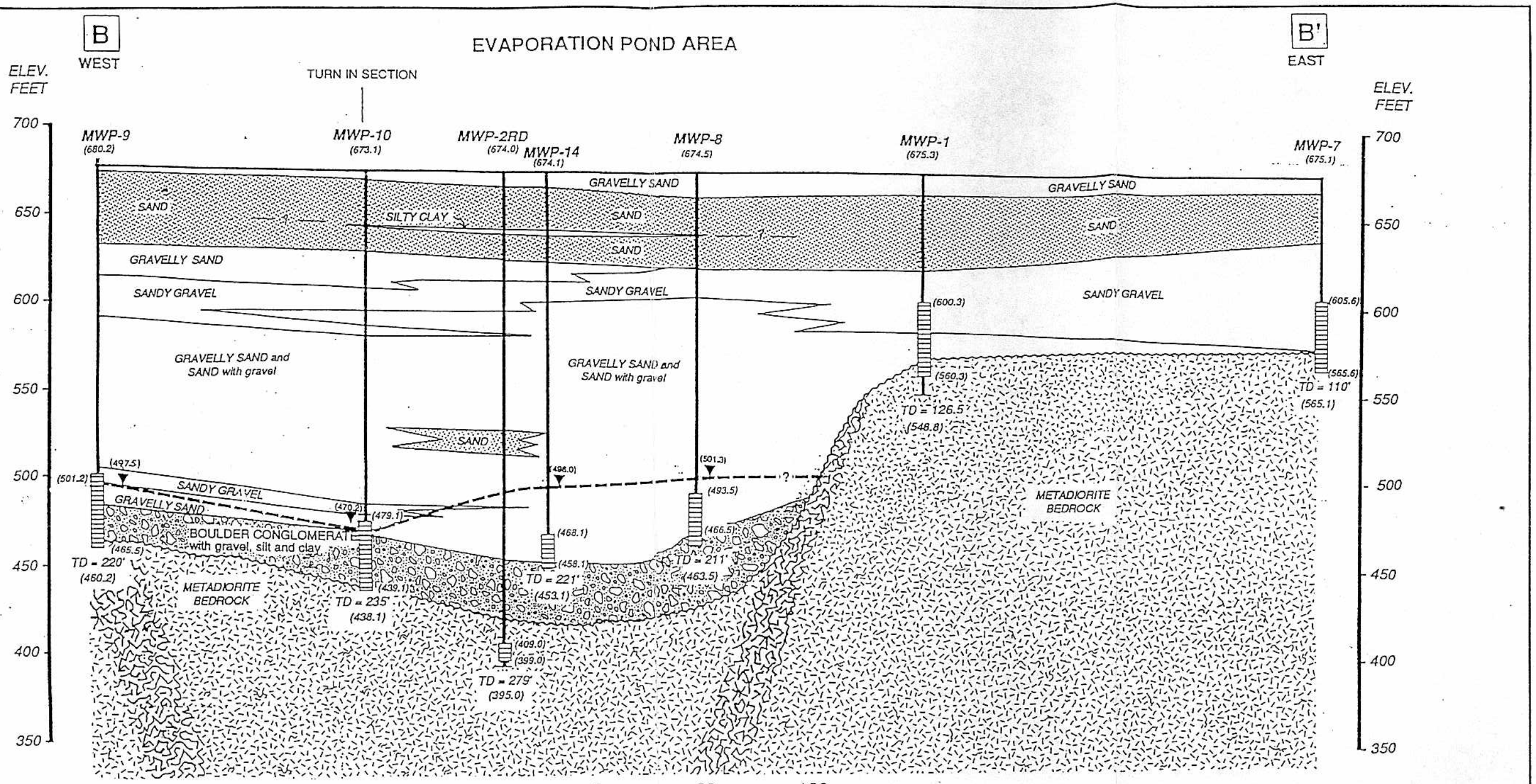
FIGURE 4–5

GEOLOGIC CROSS SECTION A–A'

BAT CAVE WASH
PACIFIC GAS AND ELECTRIC COMPANY
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

PROJECT NO. 10–320

ALISTO ENGINEERING GROUP
WALNUT CREEK, CALIFORNIA



SOURCE: PG&E–TES, JUNE 11, 1993, FIGURE 3–7

LEGEND

(478) Elevation above sea level

Water elevation August, 1992

Screened interval

Postulated fractures in basement rocks

FIGURE 4–6

GEOLOGIC CROSS SECTION B–B'

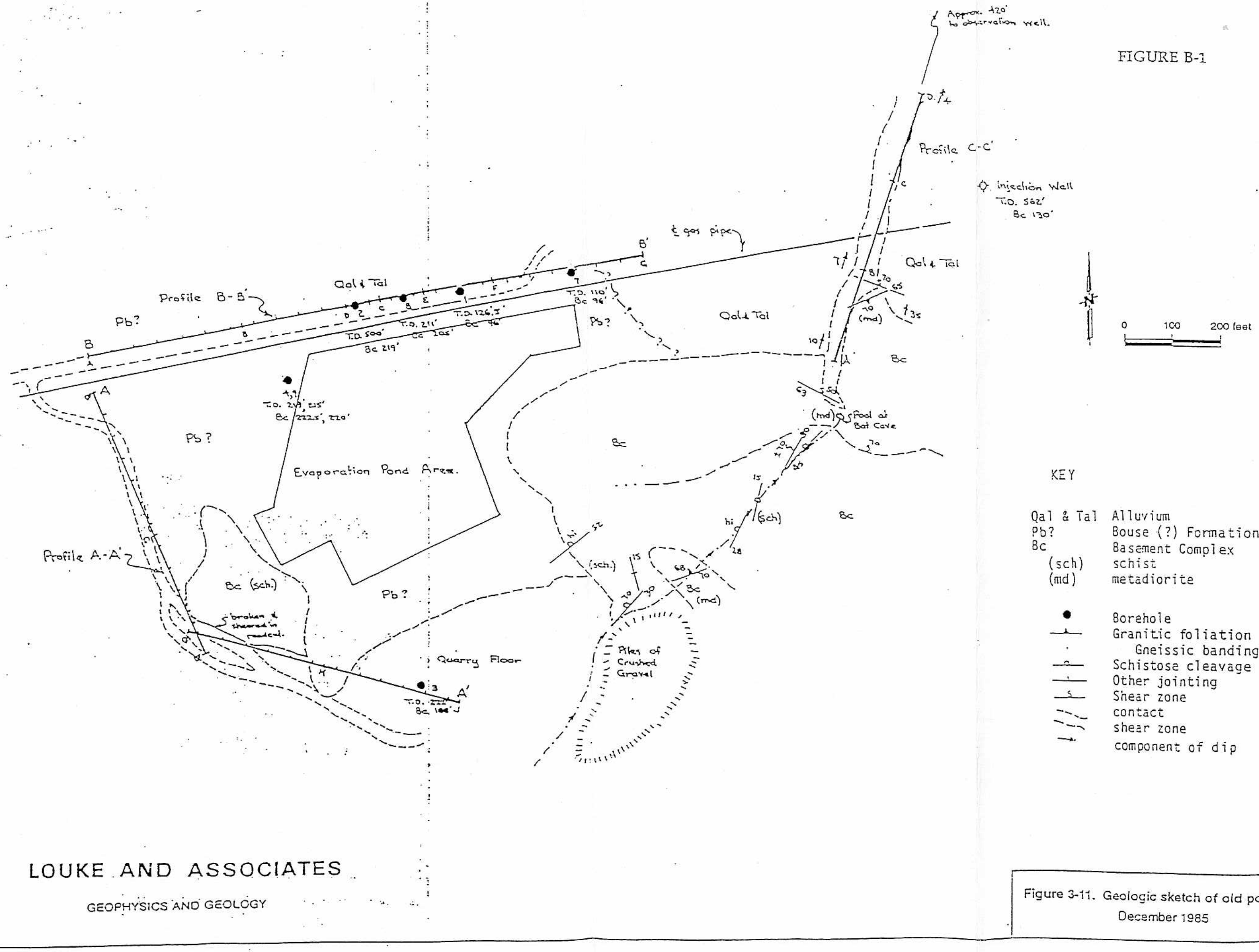
BAT CAVE WASH
PACIFIC GAS AND ELECTRIC COMPANY
TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

PROJECT NO. 10–320

ALISTO ENGINEERING GROUP
WALNUT CREEK, CALIFORNIA

B2 Geophysical Seismic Survey

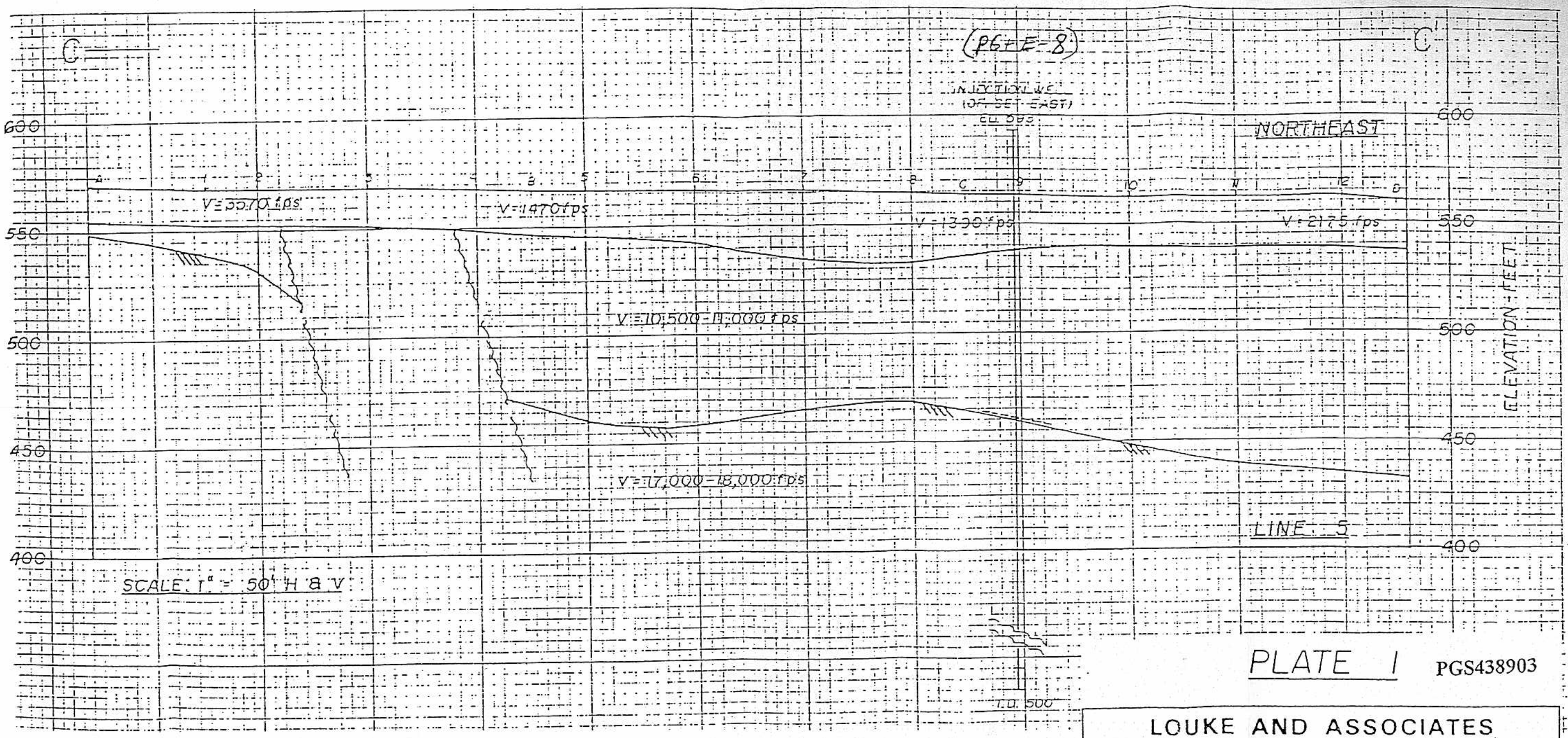
FIGURE B-1



LOUKE AND ASSOCIATES

GEOPHYSICS AND GEOLOGY

Figure 3-11. Geologic sketch of old pond site.
December 1985



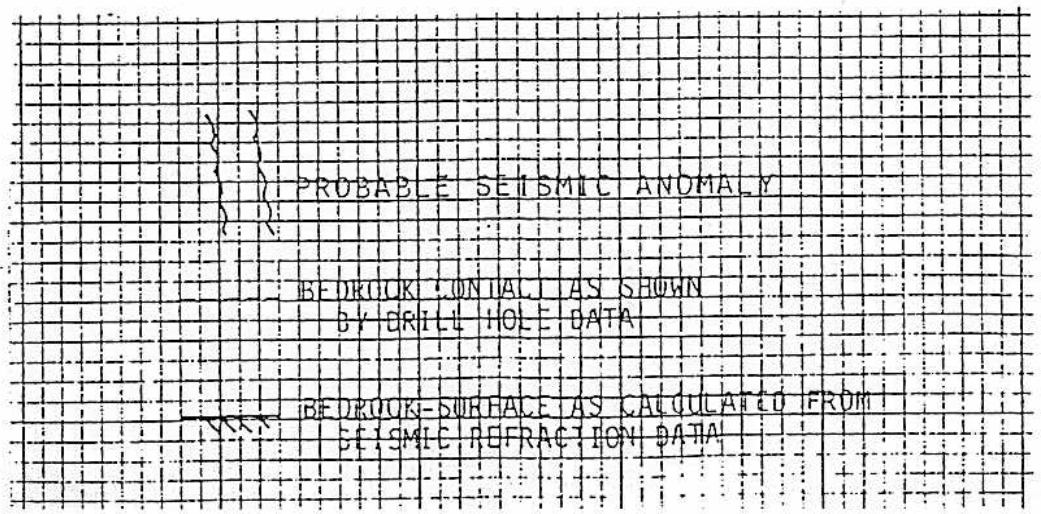


PLATE 1 PGS438903

LOUKE AND ASSOCIATES

GEOLOGY AND GEOPHYSICS

SEISMIC SECTIONS
LINES 1 THROUGH 5
TOPOCK COMPRESSOR STATION
EVAPORATION PONDS
SAN BERNARDINO, CALIFORNIA

FILE NO: 8510 DATE: December 1985

Appendix C
Bedrock Hydrogeologic Data for Former Injection Well Area

C1 PGE-8 Construction, Geophysical Log and Operations Records

Table 4-1

Construction Details for the Injection Well

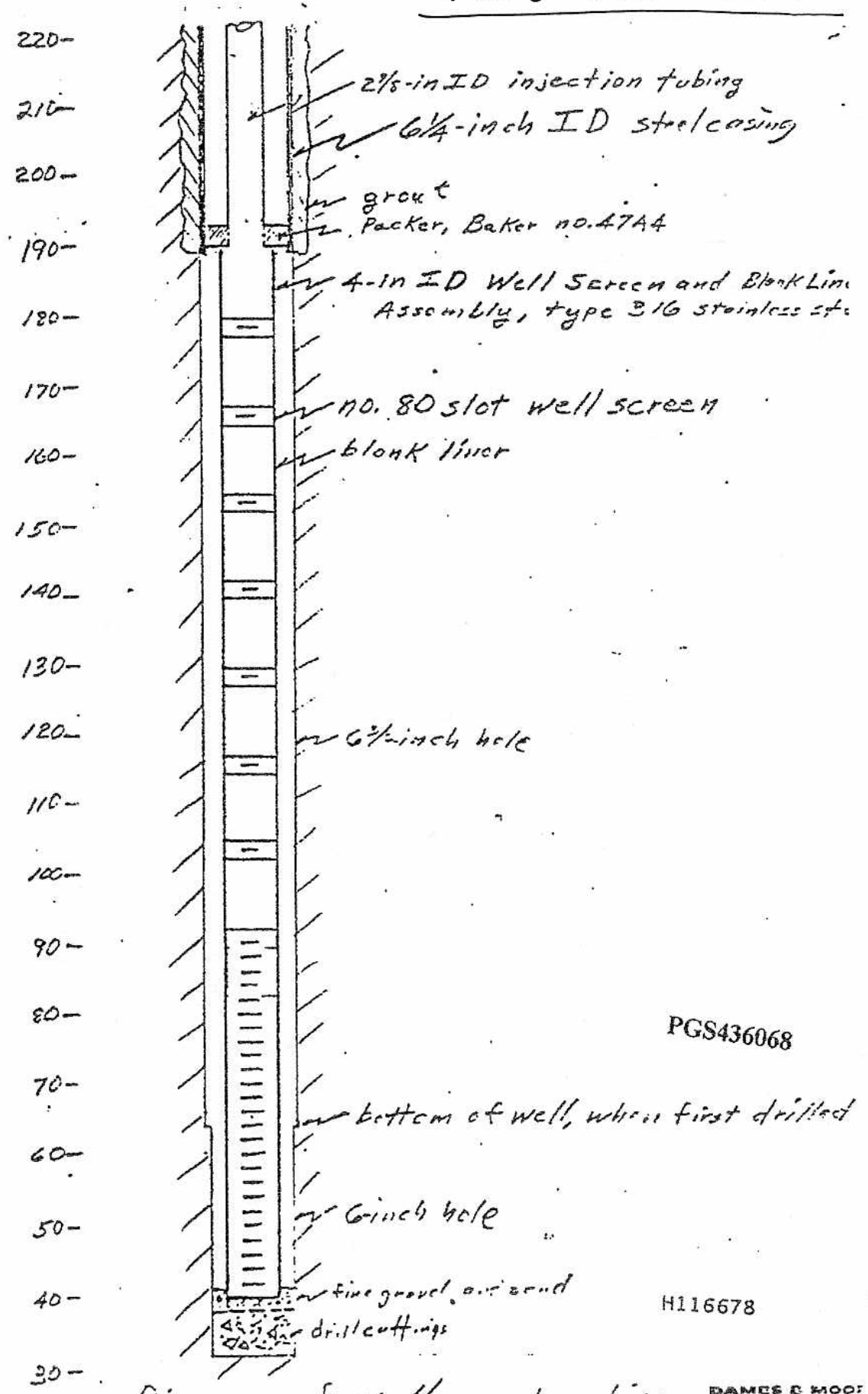
Location:	215' FSL, 129.5' FWL, NE1/4, Sec 8, T7N, R21W, San Bernardino County, California
Elevation Of Land Surface:	593 Feet
Total Depth Of Well:	530 Feet
Date Drilling Started:	March 20, 1969
Date of Completion:	June 6, 1969
Drilling Copntractor:	Bill Belknap, Reedley, California
Drilling Rig:	Failing FH3

Drilling Methods And Completion:

1. Mud-rotary: 0-184 feet, 9-7/8-inch bit.
2. Temporary 7-inch casing set to 184 feet.
3. Air percussion: 184-222 feet, 6-1/2-inch bit.
4. Temporary casing removed.
5. Mud-rotary: 184-312 feet, 9-7/8-inch bit.
6. Temporary 7-inch casing set to 312 feet.
7. Air-rotary: 312-530 feet, 6-3/4-inch bit.
8. Bridge plug set at 450 feet.
9. Temporary casing removed.
10. Mud-rotary: 312-405 feet, 8-3/4-inch bit
11. Permanent 6-1/4-inch I.D. casing set to 405 feet cemented by Halliburton Company; 100 sacks of cement used. (Casing O.D. is 6-3/4-inch)
12. Air-rotary; drill out cement shoe and bridge plug with a 5-5/8-inch bit.

Static Water Level:	138 feet below land surface
Injection Tubing:	2-7/8-inch to 405 feet; set into Baker 47A4 packer at 405 feet.

PGE-8 Final Completion



PGS436068

H116678

Diagram of well construction

DAMES & MOOR
APPLIED EARTH SCIENCE

REVISIONS
BY _____ DATE _____

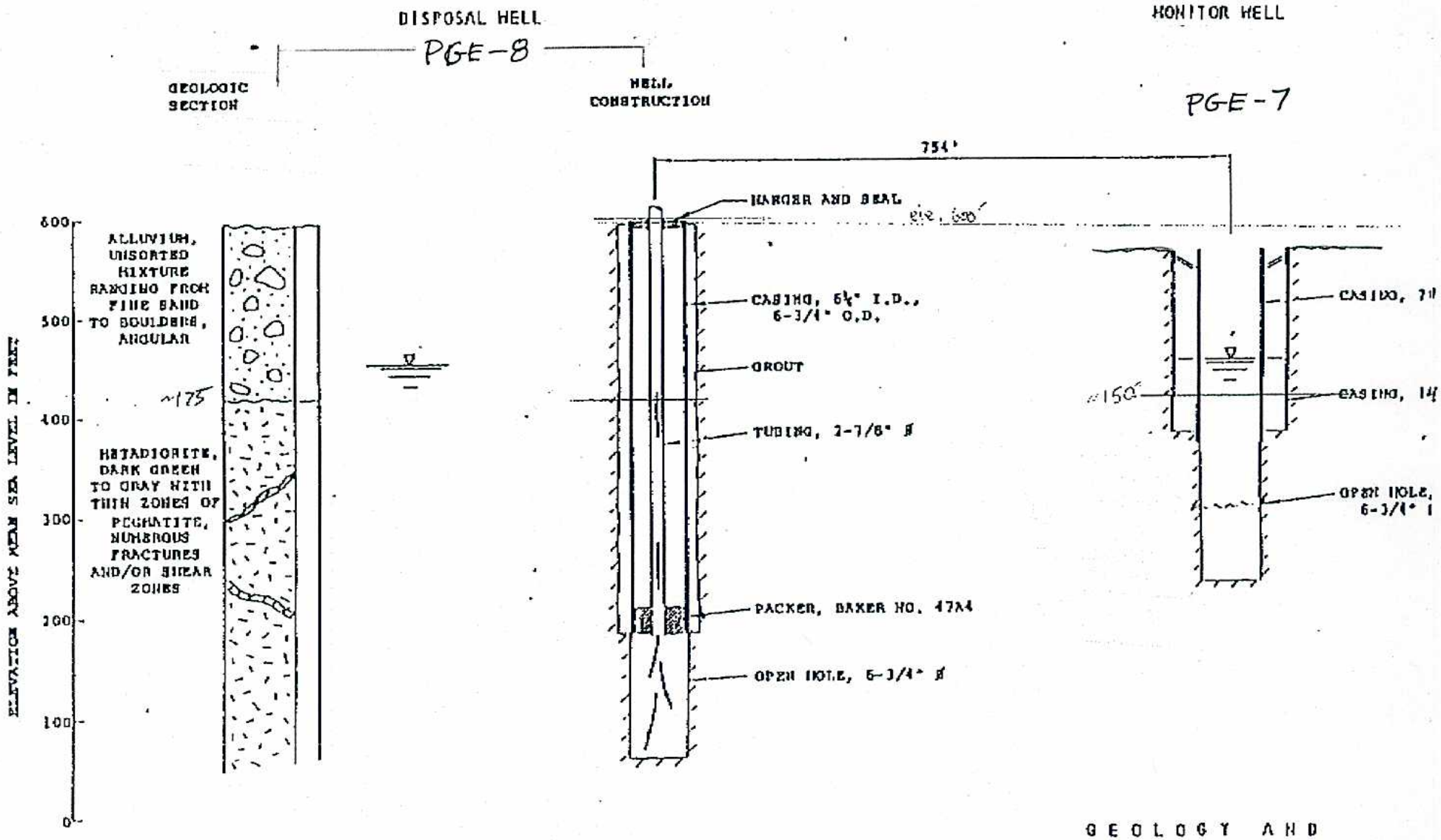
FILE 160-148-02

BY [illegible] DATE 8-28-70
CHECKED BY _____

946.1

PG40089193

FIGURE B-4



GEOLOGY AND WELL CONSTRUCTION

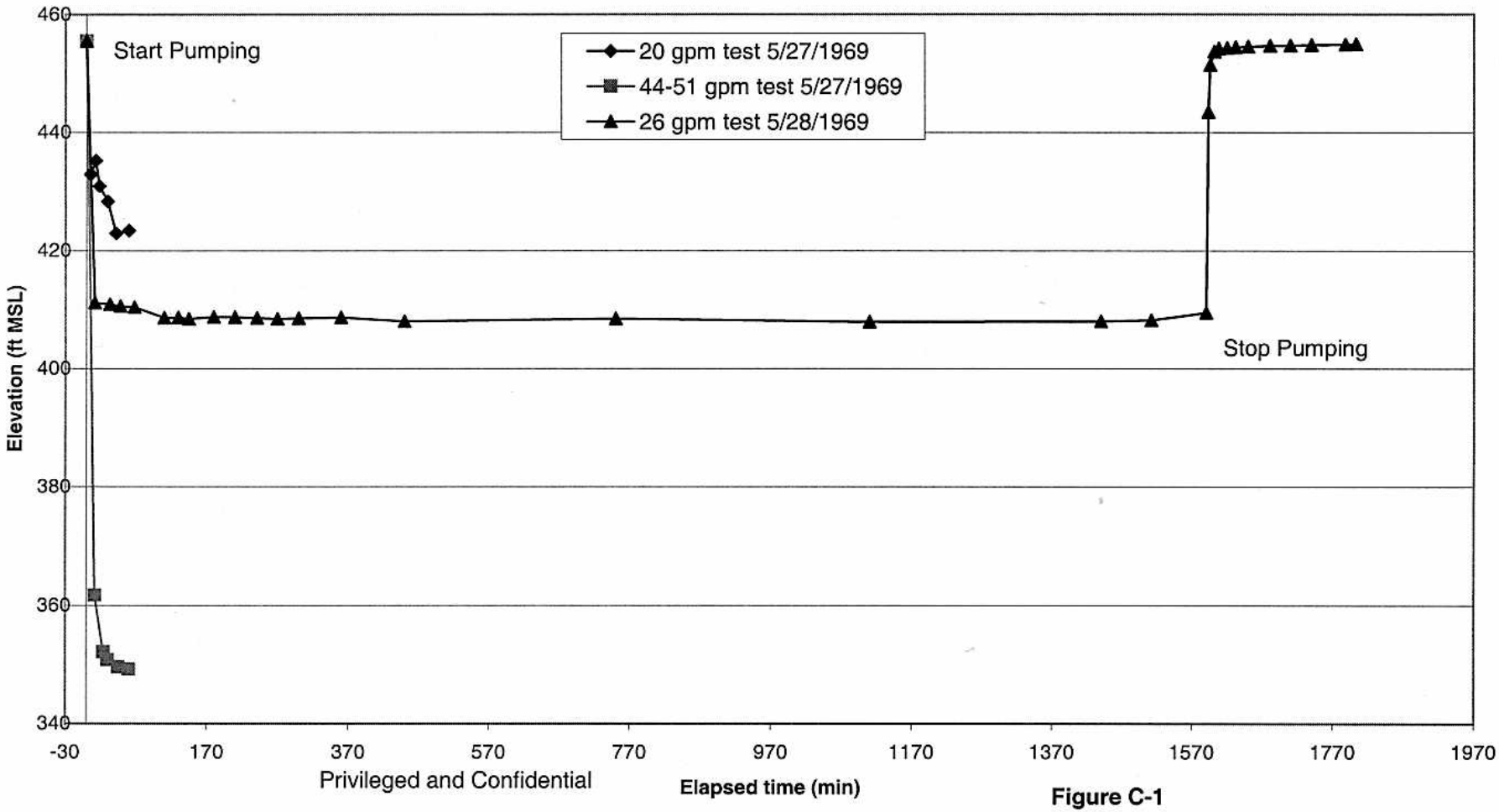
PLATE

1969 Dames + Moore

Table 4-2

Pumping Test Information
Results of Pumping Test on Exploratory Well
(Current PG&E-08)

Date	Time	Water Level Elevation (feet)	Pumping Rate	Remarks
4/29/69	5:30 pm	455.47	--	
5/27/69	12:15	455.63	--	
	2:00	455.70	17.9	Pumping started
	2:06	432.93	14.5	
	2:13	435.22	14.5	
	2:18	430.92	20.3	
	2:30	428.32	20.3	
	2:42	422.91	20.3	
	3:00	423.38	19.1	
	3:28	--	--	Pumping stopped
	5:00	455.50	51.0	
	5:12	361.75	51.0	
	5:24	352.06	43.8	
	5:30	350.76	43.8	
	5:45	349.55	43.8	
	6:00	349.20	43.8	
5/28/69	8:00 am	455.50	26.4	Pumping stopped Pumping Started
	8:12	411.14	26.4	
	8:33	410.89	26.4	
	8:48	410.57	26.4	
	9:08	410.40	26.4	Salinity 14,000 ppm
	9:50	408.59	26.4	
	10:10	408.63	26.4	
	10:25	408.42	26.4	
	11:00	408.73	26.4	
	11:30	408.70	26.4	
	12:01 pm	408.53	26.4	
	12:30	408.42	26.4	
	1:00	408.49	26.4	
	2:00	408.65	26.4	Salinity 14,000 ppm
	3:30	408.00	26.4	
	8:30	408.44	26.4	Salinity 14,000 ppm
5/29/69	2:30 am	407.89	26.4	Salinity 14,000 ppm
	8:00	407.98	26.4	Temperature 91.5 F
	9:12	408.19	26.4	Salinity 14,000 ppm
	10:30	409.41	26.4	Pumping stopped
	10:33	443.45	--	
	10:36	451.40	--	
	10:42	453.72	--	
	10:48	454.20	--	
	11:00	454.32	--	
	11:12	454.46	--	
	11:30	454.52	--	
	12:01 pm	454.68	--	
	12:30	454.72	--	
	1:00	454.80	--	
	1:48	454.92	--	
	2:03	454.95	--	
	2:06	--	8.3	Begin injection
	2:48	461.50	8.3	
	2:50	--	--	Stop injection
	2:56	455.33	--	



Note:
Data from Dames & Moore 1969

Figure C-1
Plot of Drawdown and Recovery in PGE-08 Pumping Test May 1969
PG&E Topock Compressor Station
Needles California

PGE-8 Records

November 16, 1987

CALIFORNIA DEPARTMENT OF HEALTH SERVICES
TOXIC SUBSTANCES CONTROL DIVISION

HAZARDOUS WASTE INJECTION WELL STATEMENT

[Required by California Health and Safety Code Section 25159.13(a) to be completed by the owner or operator of each injection well used for the discharge of hazardous waste on or after January 1, 1960.]

OWNER

Name: Pacific Gas and Electric Company
Address: 77 Beale Street
Telephone Number: (415) 972-7746

OPERATOR (If different from owner.)

Name: Pacific Gas and Electric Company
Address: 375 N. Widget Lane, Suite 130
Telephone Number: (415) 943-7986

EPA IDENTIFICATION NUMBER

WELL LOCATION:

County: San Bernardino
Section, Township, Range: Section 8, T7N, R24E, SBB&M
City (If not located in a city, state nearest city, distance and direction from this city.): 14 miles Southeast of Needles, California
Address (If not applicable, state road directions for reaching this well.):

14 miles Southeast of Needles, CA, off interstate 40; take the Park Moabi Road exit, turn left on Park Moabi Rd., turn right on old Route 66 (see attached location map).

EMERGENCY CONTACT PERSON (For currently operating wells.):

Name: Not applicable, well is not currently operating
24 Hour Telephone Number: ( )

WELL DESCRIPTION (Type of construction, drilling and geologic logs, age of well, etc.)

See attachment 2 - well description and attachment 3 - well logs

HAZARDOUS WASTE DISCHARGES (List information for each discharge. This information is not required if this well has not been in operation since January 1, 1980 and the owner or operator can demonstrate that this information cannot be ascertained.)

Date of Discharge: May 30, 1970 through December 1973
Approximate Volume Discharged: 29,400,000 (units). Gallons (20,000 gal/day)
Hazardous Waste Constituents Discharged

See attachment 1

Describe methods used to monitor the well for leaks and migration of hazardous constituents into the surrounding soils or ground water.

See attachment 1

Additional sheets and/or documents may be attached as necessary to properly complete this statement.

CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those directly responsible for gathering the information, the information is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Nov. 16, 1987
Date

Victor C. Furtado
Signature of owner or operator

PENALTIES: Any person failing to submit this statement and fee to the Department for each injection well by January 1, 1987 is subject to a civil penalty of not less than 1,000 dollars and not more than 10,000 dollars per day for each day that the statement has not been received. Any person submitting false information to the Department is subject to a civil penalty of not less than 2,000 dollars and not more than 25,000 dollars per day for each day that the false information goes uncorrected [California Health and Safety Code, Section 25159.13(d)].

ATTACHMENT 1

DHS HAZARDOUS WASTE INJECTION WELL STATEMENT

Hazardous Waste Constituents Discharged:

No hazardous waste was disposed of in Topock's injection well. Topock's injection well was used to dispose of treated, nonhazardous cooling tower wastewater. Prior to treatment, the cooling tower wastewater would be classified as hazardous because it contained 10 to 20 mg/l of hexavalent chromium.

A wastewater treatment system was installed in conjunction with the construction of the injection well. The wastewater treatment process was basically a two-step process; 1) reduction of the hexavalent chromium to trivalent chromium, and 2) precipitation and removal of the trivalent chromium in the form of chromic hydroxide sludge.

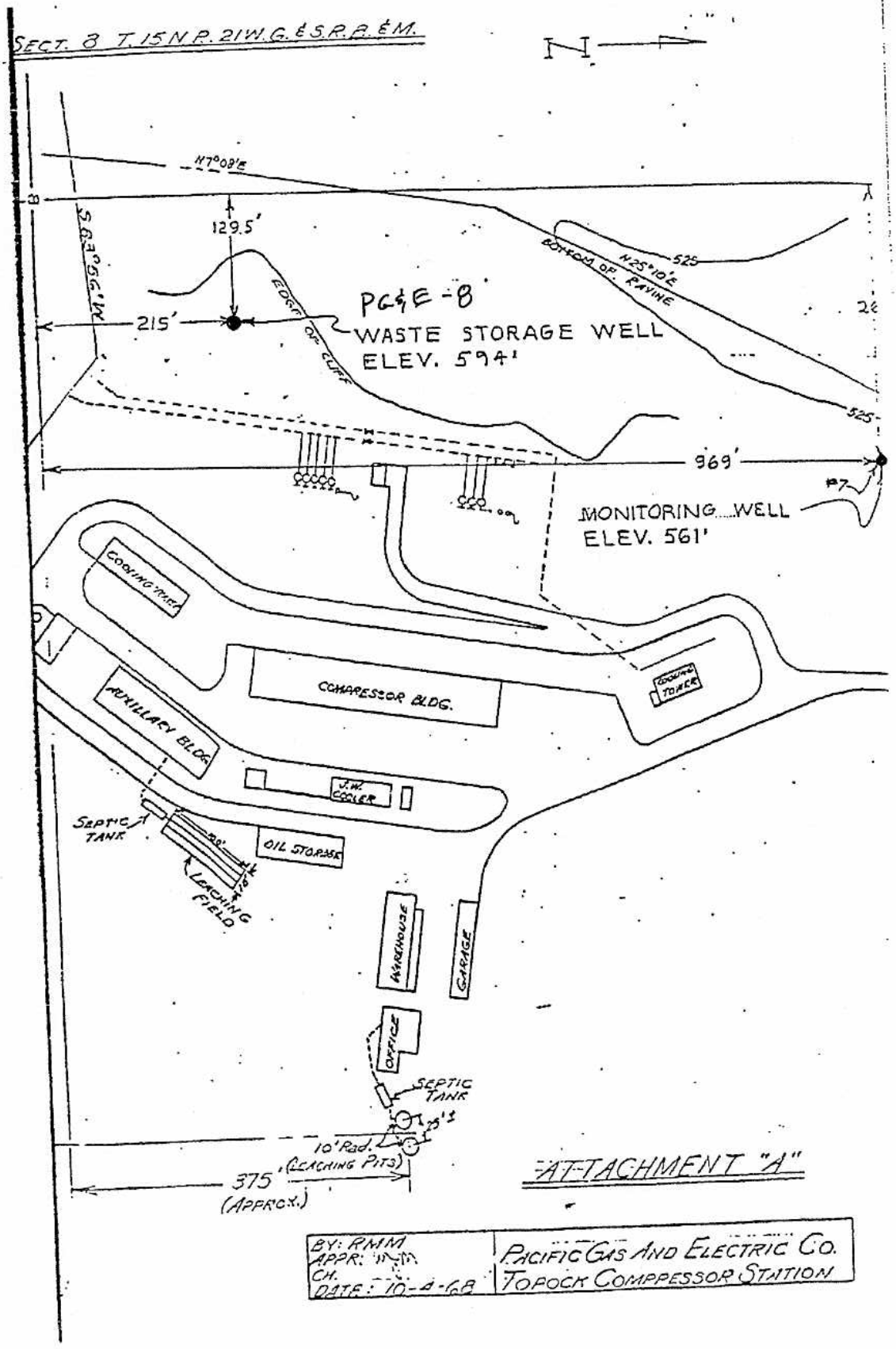
The first treatment step, reduction of hexavalent chromium, was achieved by lowering the pH of the wastewater to a pH of 2.9. This process took place in a 1,500-gallon tank where sulfur dioxide gas was injected and mixed with the wastewater. After reduction of the hexavalent chromium to trivalent chromium, the wastewater was piped to another tank for the second treatment step.

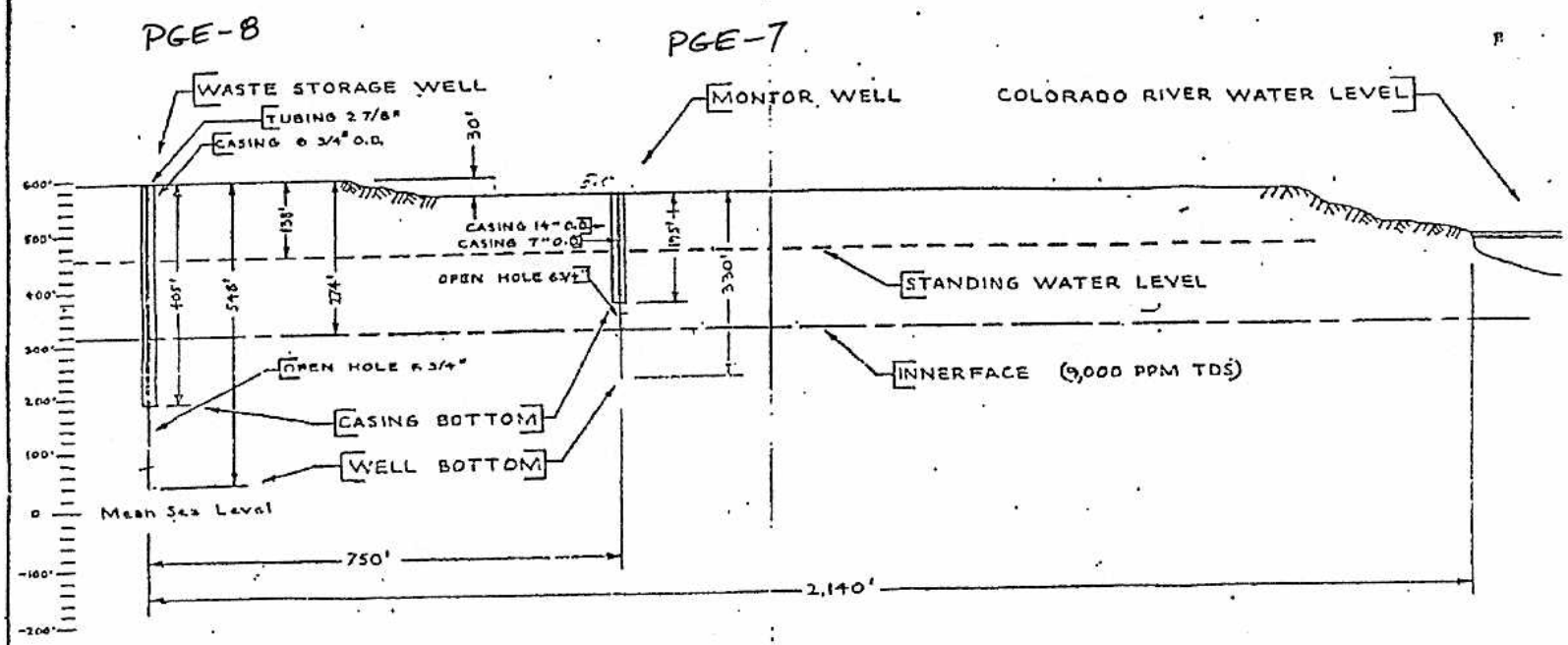
The second treatment step was the precipitation and removal of the trivalent chromium from the wastewater. This was accomplished in a 15,000-gallon tank where liquid sodium hydroxide was added to the wastewater, thereby raising the pH of the wastewater to a pH of 7. This caused the trivalent chromium to combine with the sodium hydroxide and form a chromic hydroxide precipitate.

After completion of the two step treatment process, the wastewater contained less than 1 mg/l of chromium. This wastewater was then disposed of in Topock's injection well.

The chromic hydroxide precipitate was transferred from the precipitator tank, through a gravity-feed piping system, to concrete drying beds where it was dehydrated prior to off-site disposal.

An out-of-service water well was converted to a monitoring well at the time the injection well was constructed. The monitoring well was located approximately 750 feet north of the injection well (see attached diagram). The salinity of the water in the monitoring well was measured on a routine basis during injection as a method of detecting leaks in the injection well.


SECT. 8 T. 15 N R. 21 W. G. & S. R. B. & M.
N
N7°08'E
N.35°E.
129.5'
215'
EDGE OF CLIFF
PG&E-8
WASTE STORAGE WELL
ELEV. 594'
N25°10'E
525
BOTTOM OF RAVINE
525
969'
PG&E-7
MONITORING WELL
ELEV. 561'
COOLING TOWER
COMPRESSOR BLDG.
AUXILLARY BLDG.
J.W. COOLER
SEPTIC TANK
OIL STORAGE
LEACHING FIELD
WAREHOUSE
GARAGE
OFFICE
SEPTIC TANK
10' Rad. (LEACHING PITS)
375' (APPROX.)
ATTACHMENT "A"
BY: RMM
APPR:
CH.
DATE: 10-4-68
PACIFIC GAS AND ELECTRIC CO.
TOPOCK COMPRESSOR STATION



NOTE: CASING DIAMETERS ARE NOT DRAWN TO SCALE

NO.	DATE	DESCRIPTION	APPROVED	CHK.	DRN.	REVISIONS

DRAWN
IN. W. T. M.
S. D. J.
W. J. M.
SITE | SCALE 1"=100'

WASTE STORAGE WELL
TOPOCK COMPRESSOR STATION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CAL.

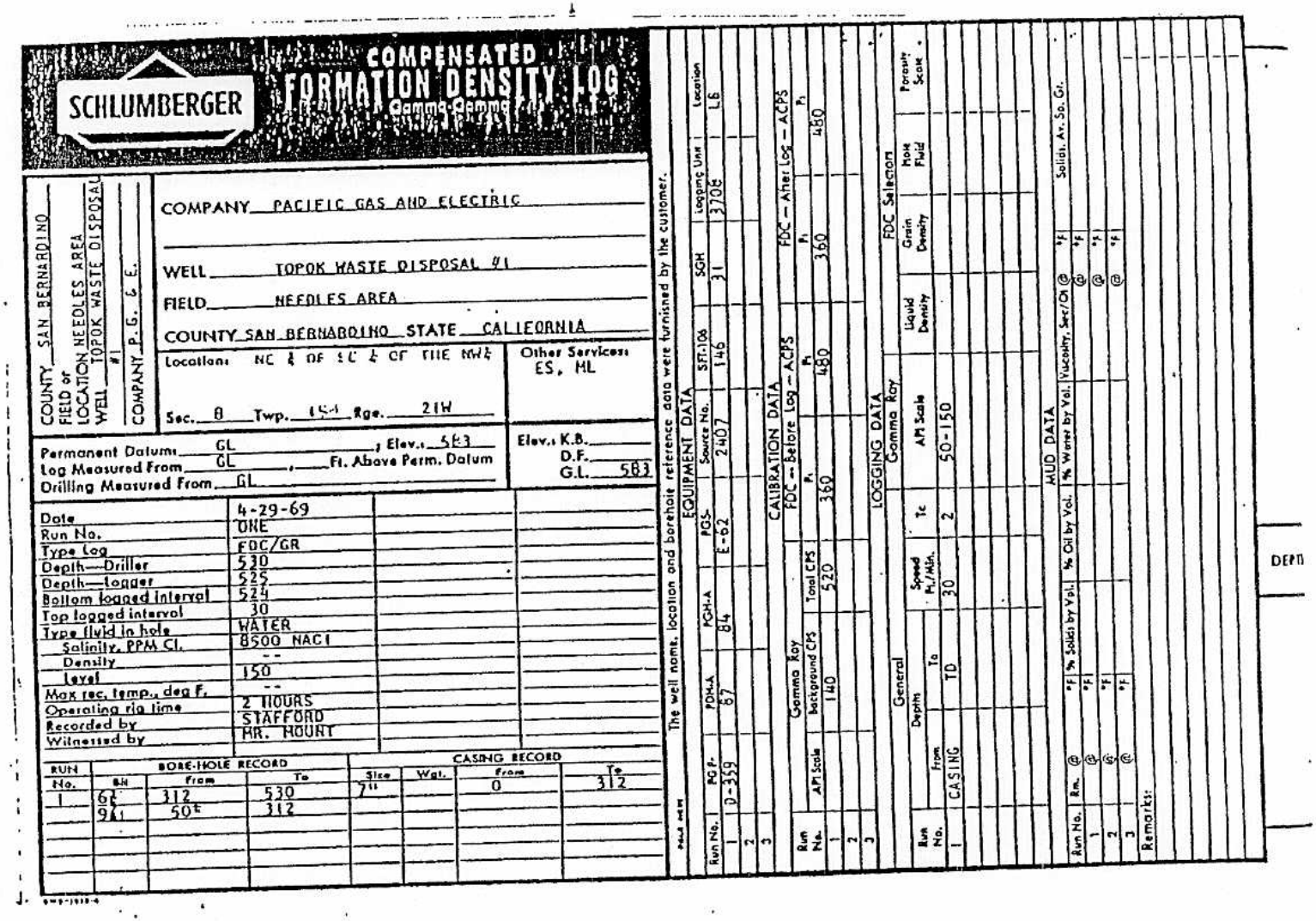
SUPERSEDES
SUPERSEDED BY
SHEET NO. | SHEETS

ATTACHMENT 2

TOPOCK INJECTION WELL DESCRIPTION
DHS HAZARDOUS WASTE INJECTION WELL STATEMENT

Completion Date:	April 1969 (The injection well was reworked in June 1970)
Operational Date:	May 30, 1970
Total Depth:	562 feet below surface elevation, 58 feet above mean sea level
Casing Size and Material:	6-1/4 inch ID stainless steel
Tubing Size:	2-7/8 inch ID
Packer Depth:	404 feet below surface elevation, 179 feet above mean sea level
Screened Interval:	405 to 550 feet below surface elevation
Abondonment Date:	December 1973
Abandonment Method:	The well was disconnected from surface piping and sealed with a steel cap. Tubing and packer were left installed.
Well Schematic:	Attached

POOR QUALITY
ORIGINAL



SCHLUMBERGER

COMPENSATED FORMATION DENSITY LOG
Gamma-Gamma

COUNTY SAN BERNARDINO
FIELD or LOCATION NEEDLES AREA
WELL TOPOK WASTE DISPOSAL #1
COMPANY P. G. & E.

COMPANY PACIFIC GAS AND ELECTRIC
WELL TOPOK WASTE DISPOSAL #1
FIELD NEEDLES AREA
COUNTY SAN BERNARDINO STATE CALIFORNIA

Location: NE ¼ OF SE ¼ OF THE NW¼
Sec. 8 Twp. 15N Rge. 21W

Other Services: ES, ML

Permanent Datum: GL , Elev.: 583
Log Measured From GL , Ft. Above Perm. Datum
Drilling Measured From GL

Elev.: K.B.
D.F.
G.L. 583

Date	4-29-69
Run No.	ONE
Type Log	FDC/GR
Depth—Driller	530
Depth—Logger	525
Bottom logged interval	524
Top logged interval	30
Type fluid in hole	WATER
Salinity, PPM Cl.	8500 NACl
Density	--
Level	150
Max rec. temp., deg F.	--
Operating rig time	2 HOURS
Recorded by	STAFFORD
Witnessed by	MR. HOUNT

RUN No.	BIT	BORE-HOLE RECORD From	To	CASING RECORD Size	Wgt.	From	To
1	6¼	312	530	7"		0	312
	9¼	50±	312				

The well name, location and borehole reference data were furnished by the customer.

EQUIPMENT DATA

Run No.	PG Ft.	PDM-A	PGS Source No.	SFT-106	SGH	Logging Unit	Location
1	0-359	84	E-62	2407	146	31	3706	L6
2		87					
3							

CALIBRATION DATA

FDC — Aher Log — ACPS

Run No.	Gamma Ray API Scale	Background CPS	Total CPS	FDC — before Log — ACPS Ft.	FDC — Aher Log — ACPS Ft.
1		140	520	480	360
2				360	480
3					

LOGGING DATA

FDC Selection

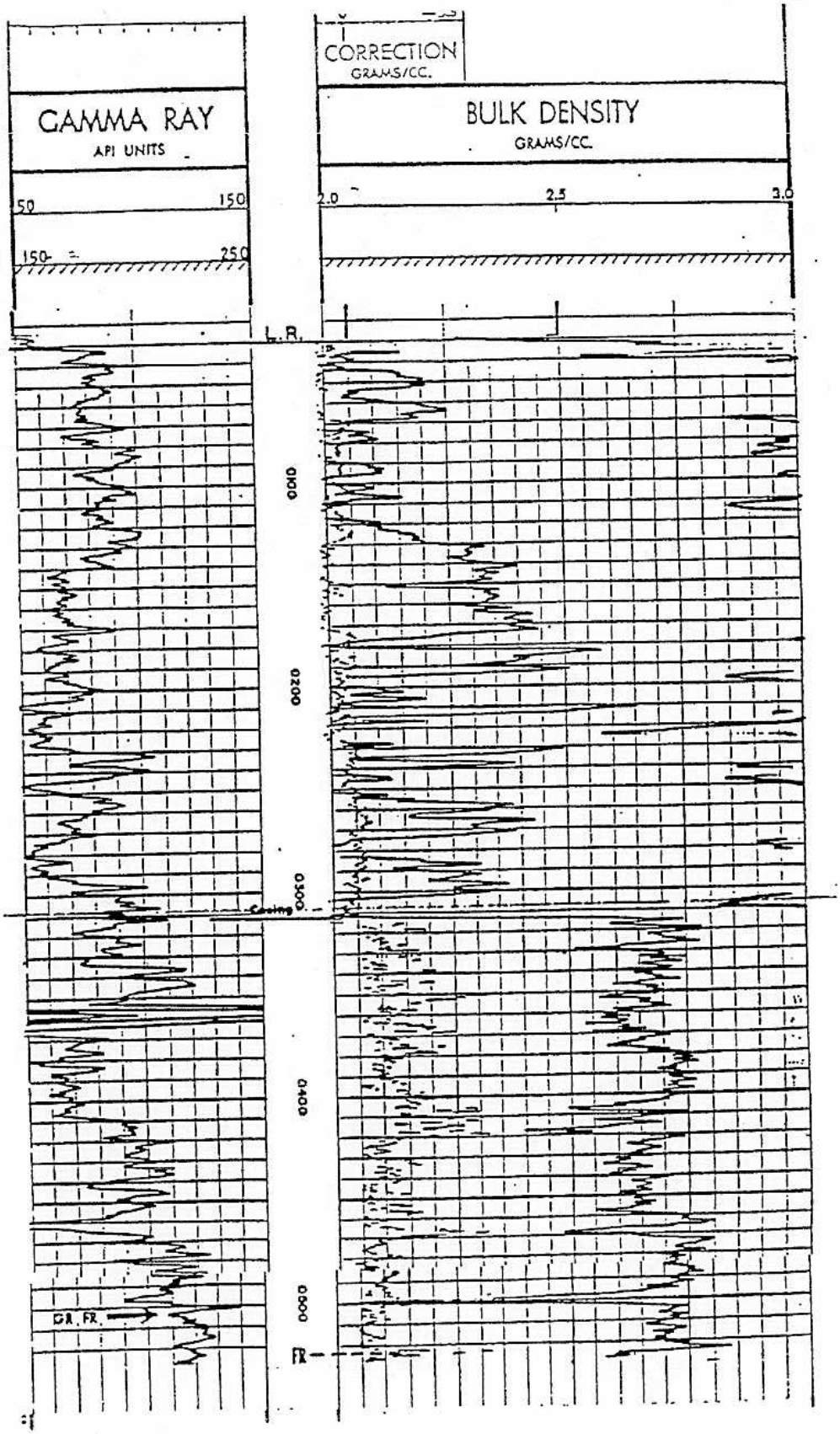
Run No.	General Depths From	To	Speed Ft./Min.	Tc	Gamma Ray API Scale	Liquid Density	Grain Density	Hole Fluid	Porosity Scale
1	CASING	TD	30	2	50-150				
2									
3									

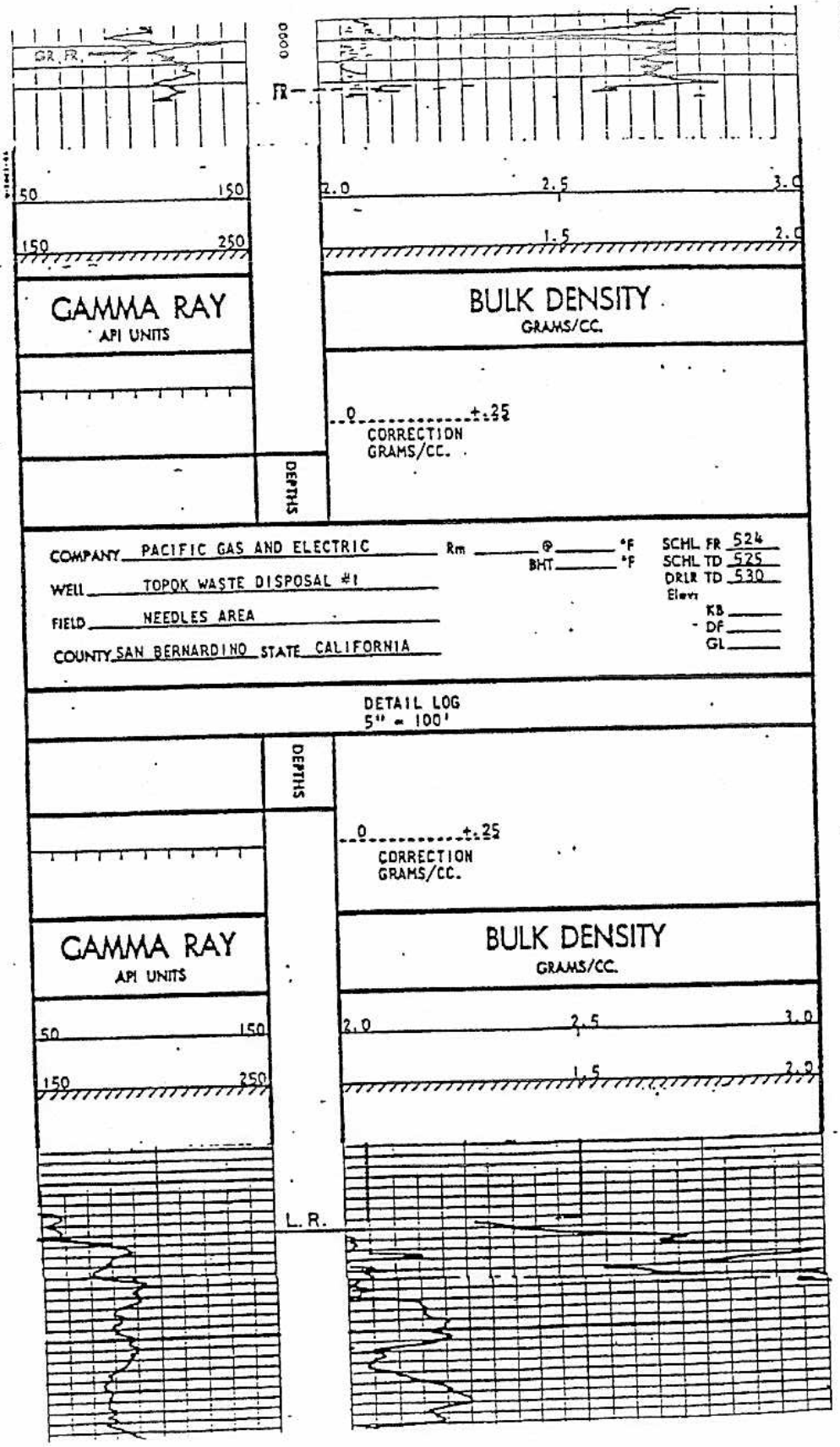
MUD DATA

Run No.	Rm. @ °F	% Solids by Vol.	% Oil by Vol.	% Water by Vol.	Viscosity, Sec/Qt @ °F	Solids, Av. Sp. Gr.
1	@ °F				@ °F	
2	@ °F				@ °F	
3	@ °F				@ °F	

Remarks:

DEPTH





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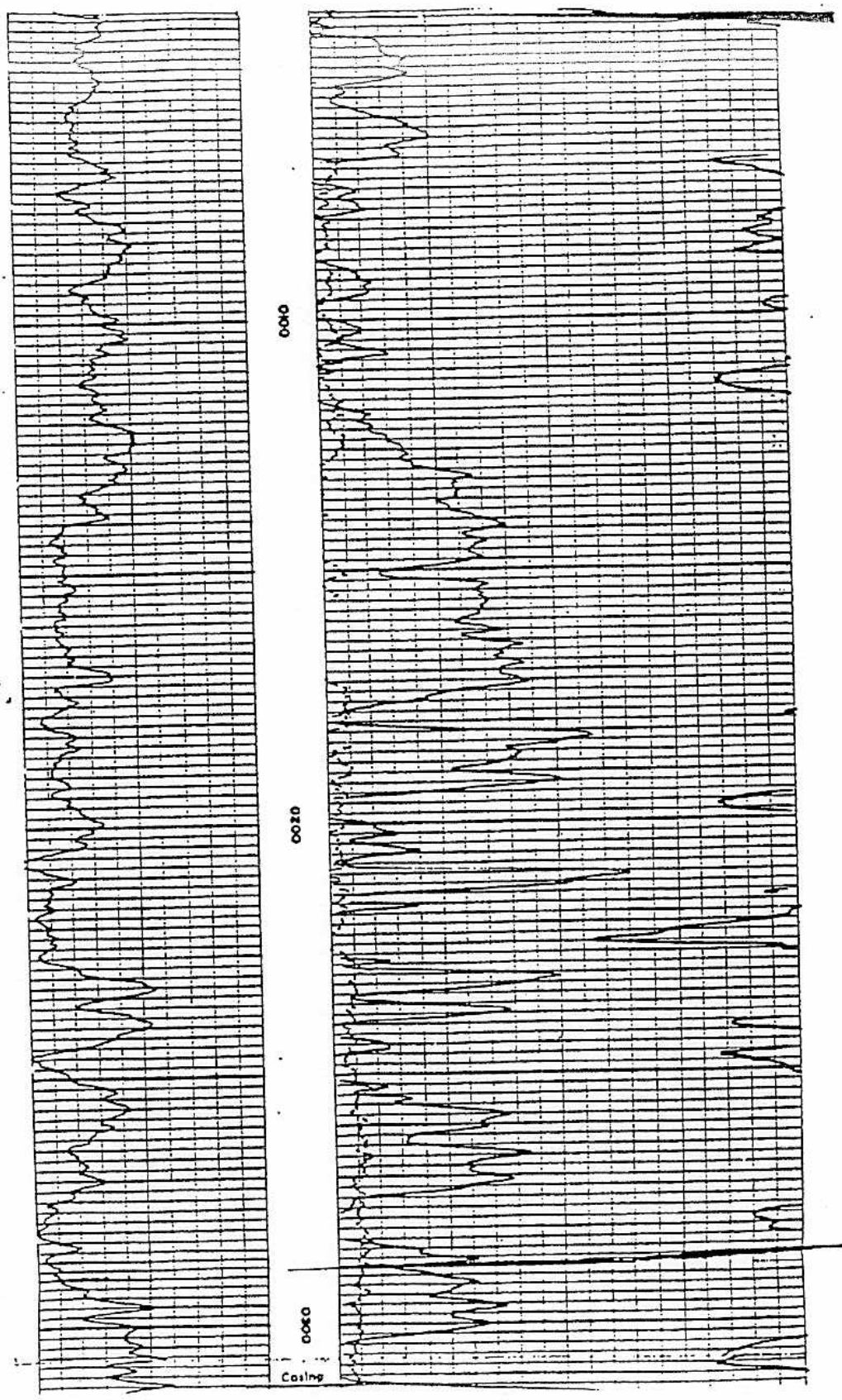
ORIGINAL



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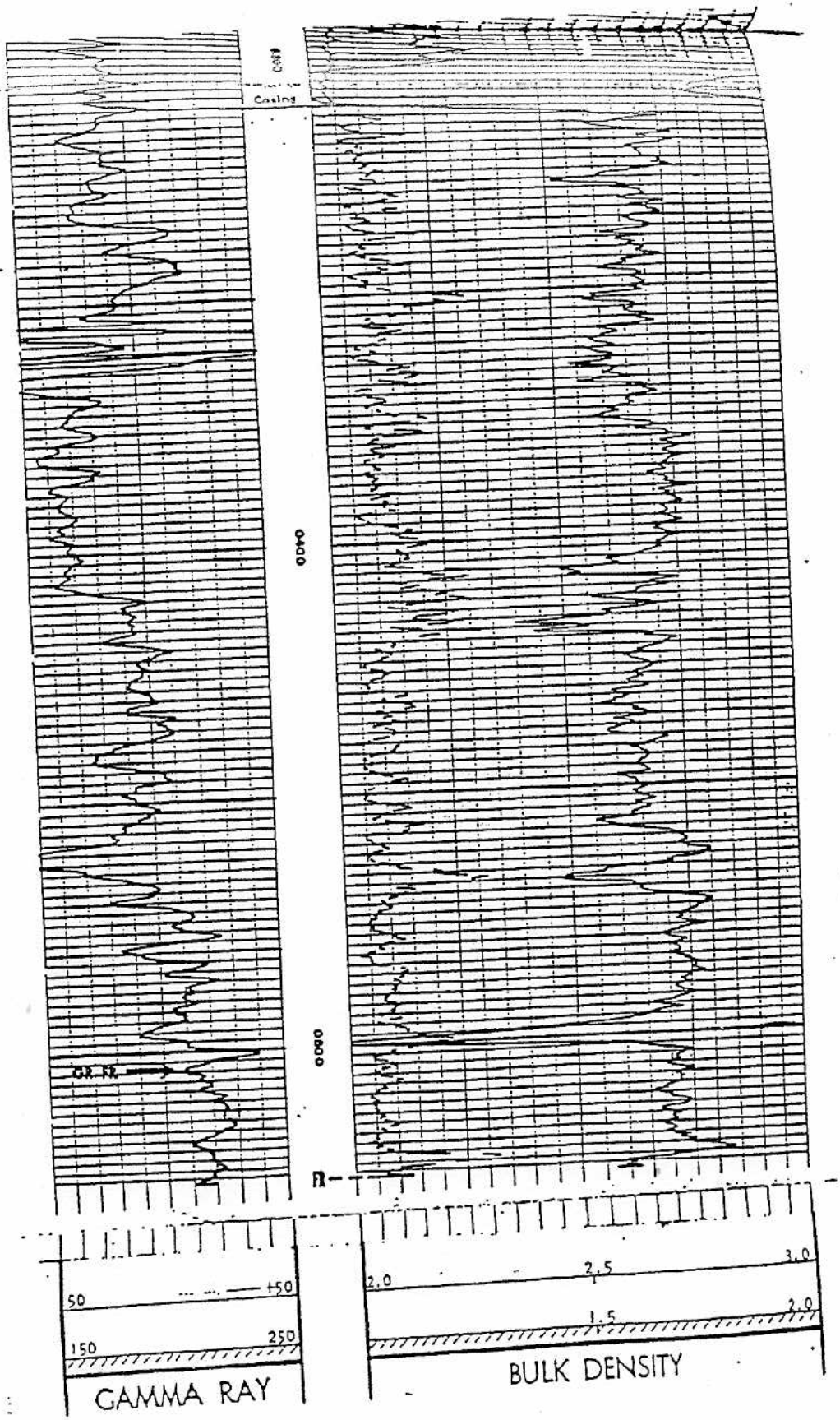
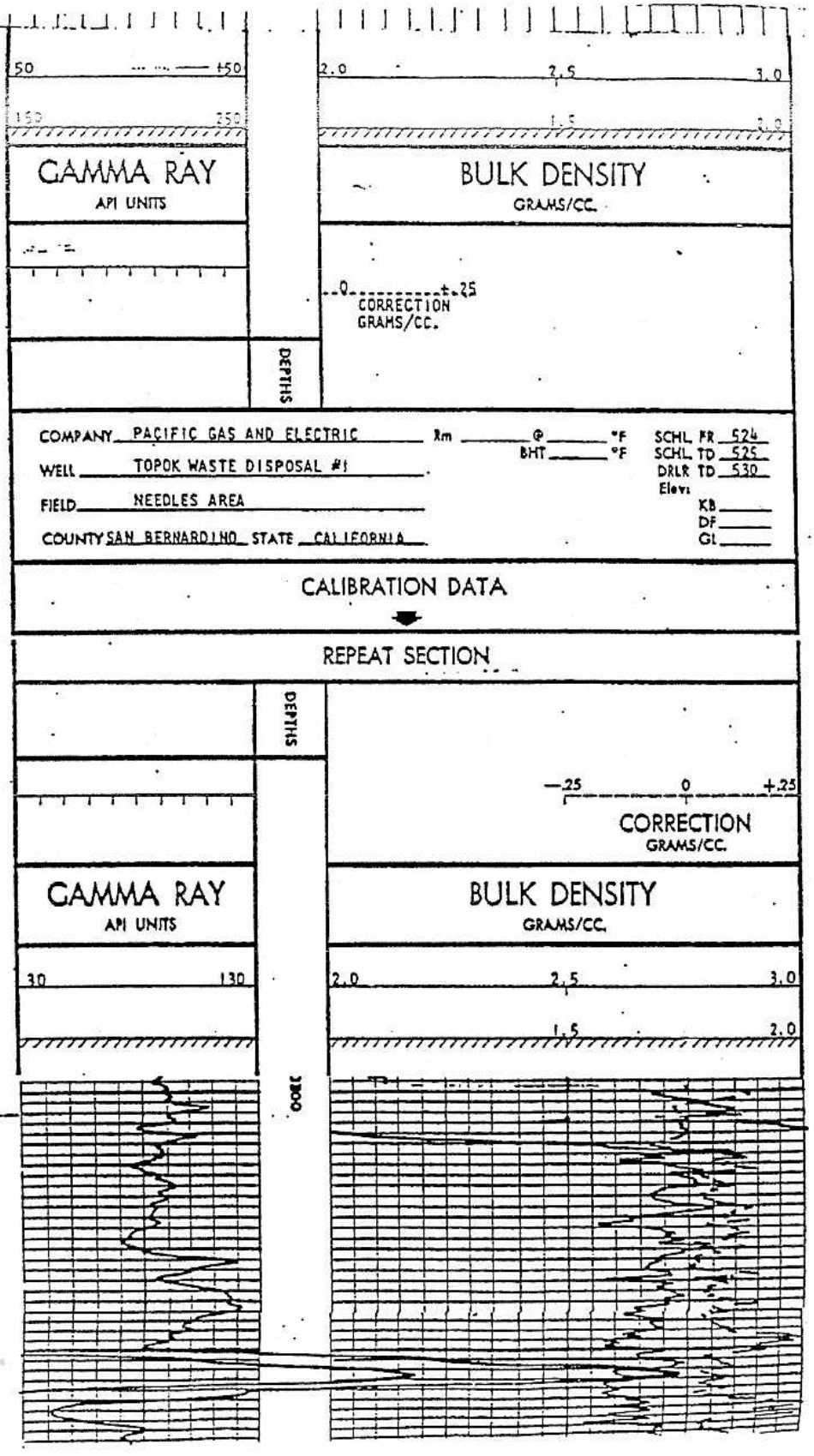
ORIGINAL

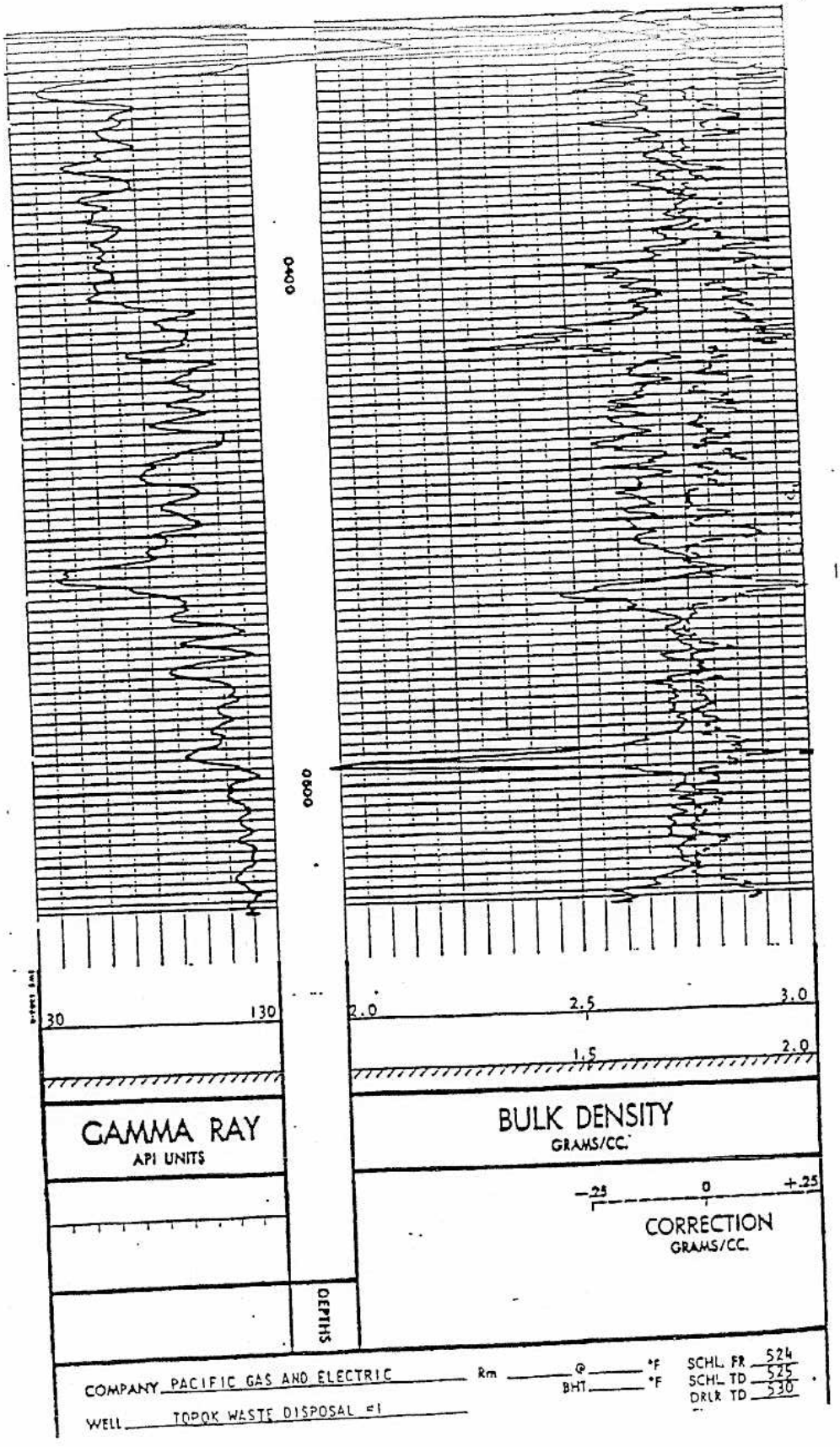
PG40323924





POOR QUALITY
ORIGINAL

PG40323926



X

August 31, 1970

Pacific Gas & Electric Company
Pipeline Operations Division
245 Market Street
San Francisco, California 94106

PGE-8 Records

Attention: Mr. H. P. Prudhomme
Manager

Gentlemen:

Report - Proposed System for
Waste Water Disposal
Topock Compressor Station
Near Needles, California
For Pacific Gas & Electric Company

INTRODUCTION

This report discusses the activation of the waste water disposal well at Topock Compressor Station. The well was completed in June 1969. Details of the drilling and development of this well are presented in our report:

Proposed System for Waste Water Disposal
Topock Compressor Station
Near Needles, California
For Pacific Gas & Electric Company

Dated August 19, 1969

PGS436062

H116672

PG40089187

The well remained unused for approximately one year after it was completed. In tests run at completion, the well performed in accordance with design specifications, as presented in our report of August 19, 1969.

INITIAL INJECTION

On or about April 1, 1970 fresh water was injected into the well at a rate of approximately 20 gallons per minute. At this rate, there was no noticeable injection pressure. For one 24-hour period, 40 gallons per minute of fresh water was injected into the well. This water was injected with no corresponding buildup of the tubing head pressure.

Injection of waste water began on May 30, 1970. Pump pressure built up rapidly, resulting in approximately 30 pounds per square inch tubing head pressure. Injection was started and stopped intermittently, and each time injection started there was a greater buildup of tubing head pressure.

Waste water injection was stopped, and fresh water was reinjected into the well. Tubing head pressure was approximately 35 pounds per square inch at an injection rate of about 20 gallons per minute.

Injection of waste water was resumed, with tubing pressures of approximately 120 pounds per square inch. Some precipitate and entrained air were noticed in water discharged from the injection pump.

ATTEMPTS AT CORRECTION

The injection pressure problems were related to Dames & Moore on June 1, 1970. Hydrochloric acid treatment was initially recommended in hopes that any precipitate that might be clogging the well could be dissolved. On

June 2, 1970, 50 gallons of 38 percent hydrochloric acid were poured directly into the tubing followed by 100 gallons of fresh water. After three hours, injection of waste water was resumed, but the tubing pressure did not decrease, holding approximately at 165 pounds per square inch. The pressure increased to 180 pounds per square inch by June 4, 1970.

The well was sounded, and it was discovered that some of the rock formations had apparently caved in, filling the bottom 15 feet of the well. The water level in the well stood at 138 feet below the top of the well casing, about the same static level which existed at the time the well was completed.

We do not know the causes of improper functioning of the well, but believe that the following may be contributory:

1. Injection of entrained air and particulate matter, even though in minute quantities, resulted in some plugging of the formation near the well bore.
2. Alternating sudden application of and release of injection pressure resulted in caving of fractured rock formation, which might impede flow of water into pervious zones.
3. Waste water may have chemically altered certain clay minerals in the formation causing them to swell and plug openings.
4. Precipitation of particulate matter may result from interaction between waste water and formation water.

Adverse reaction between blowdown water and formation water seems unlikely, since chemical compatibility had been checked previously by competent chemists. However, we understand that the chemical composition of the blowdown water has changed since that time.

In an effort to improve the performance of the well, caved materials were cleaned out, and the well was deepened to 562 feet, in green metamorphosed diorite. No additional pervious zones were encountered; logging instruments were not used on the additional footage. Rotary air-drilling techniques were used, which kept the well dry and should have drawn into the well most of the particulate matter plugging the fomation.

To prevent future caving, a Johnson well screen and liner assembly, composed of Type 316 stainless steel, was lowered into the well and set at depth-interval 405-554 feet. Details of the screen and liner settings are shown on a diagram attached to this report.

After completion of these corrective measures, injection was resumed. However, there was no improvement in performance. The well would not accept the volume of waste water to be disposed of, with the existing injection pump.

A test was made, using a higher pressure pump, which could develop pressures on the order of 300 to 400 pounds per square inch. It was able to inject the full volume of waste water. It was used for a period of about two weeks, with no increase in pump pressure. Therefore, it was decided that higher pressure would be a solution to the problem.

PRESENT INJECTION

Around July 15, 1970, a high pressure injection pump was permanently installed. This pump develops pressures on the order of 300 to 400 pounds per square inch. This pump is presently injecting the required amount of blowdown waste into the well.

We also understand that rough grading for an evaporation pond is being done now. This would permit rapid completion of the pond in the event of future failure of the well.

RECOMMENDATIONS FOR OPERATION

We recommend that greater efforts be applied toward prevention of entrained air and elimination of all particulate matter. The maintenance of recently installed diatomaceous earth filters is encouraged.

It is our understanding that chemical tests have been performed by Betz Laboratories to investigate the possibility of reactions that might cause plugging of the well. We believe that these tests should be performed under existing formation pressures. In addition, any possible or observable reaction between effluent and formation materals should be checked by using cuttings obtained from drilling.

In the future, there may again be a problem with the well. Before a decision is made to abandon the well, the possibility of chemical treatment should be explored. It is our opinion that better results might be obtained with hydrochloric acid treatment if the acid is introduced at the bottom of the well through the use of a tremie, a much larger volume of acid is used (on the order of 500 to 1000 gallons) and the acid is allowed to stand in the well for several days. Forcing the acid into the formation under pressure might be helpful. The possibility of applying special chemical reagents, which break down interstitial clay particles, should also be explored.

We are concerned with the problems which occurred in getting the well into operation. We hope that future satisfactory operation can be maintained with existing pumps and further clarification of the injection waste water. We hope you will let us know from time to time how the well is performing. Also, please call on us for any questions you may have in regard to operation of the well.

The following is attached and completes this report:

Plate 1 - Diagram of Well Construction

Very truly yours,

DAMES & MOORE

Vernon A. Smoots

VAS JRM jm
(5 copies submitted)

PGE-8 Final Completion

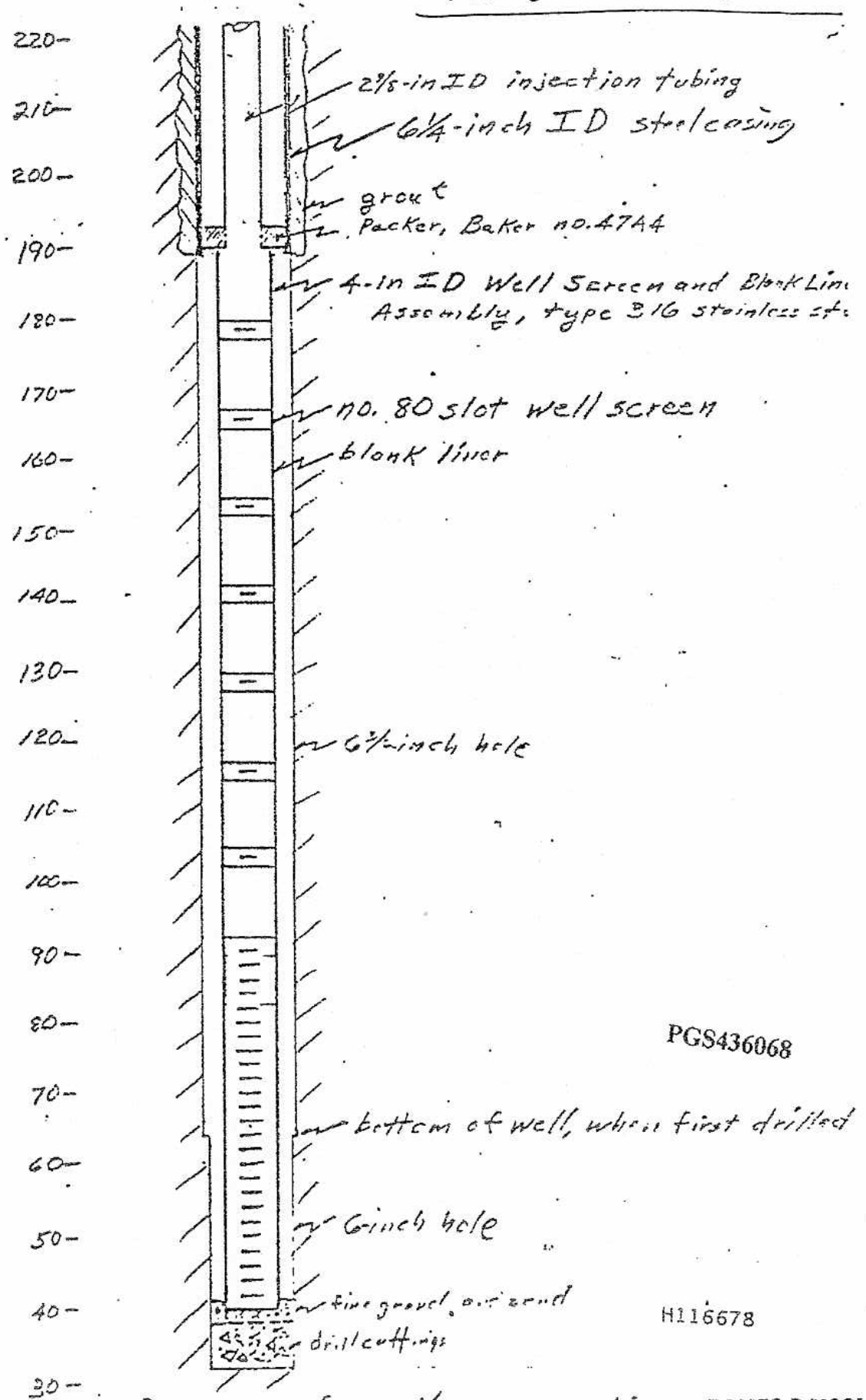


Diagram of well construction

DAMES & MOORE APPLIED EARTH SCIENCE

PGS436068

H116678

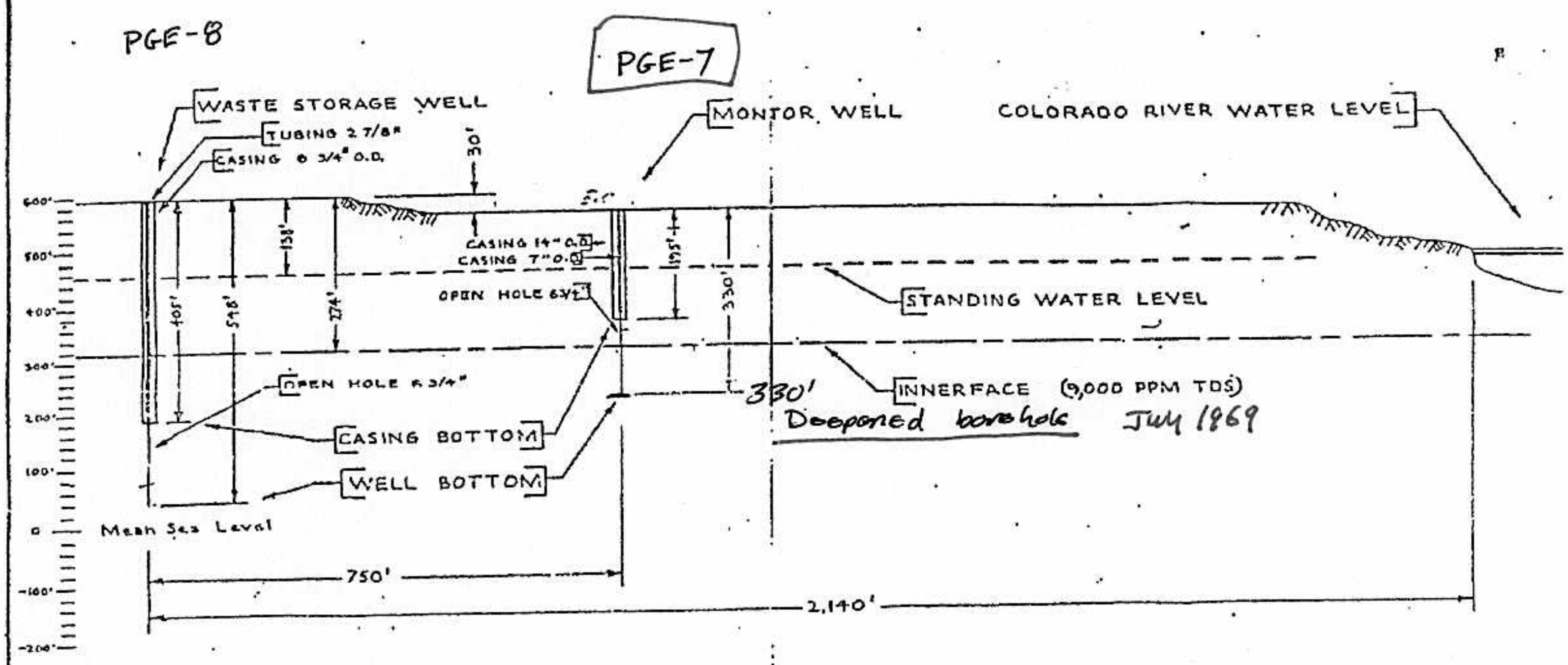
REVISIONS BY DATE

BY [illegible] DATE 8-28-70
CHECKED BY

FILE 1600-148-02

946.1

C2 Well PGE-7 Records



NOTE: CASING DIAMETERS ARE NOT DRAWN TO SCALE

WASTE STORAGE WELL
TOPOCK COMPRESSOR STATION
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CAL.

welenco
VIDEO SURVEY REPORT

Fax (805) 834-2550 • (800) 445-9914 • (805) 834-8100

Customer ECOLOGY & ENVIRONMENT	Job No. 29098 Run No. ONE
Address 350 SANSOM ST, STE-300	Well No. PG&E #7 Date
City SAN FRANCISCO State CA Zip 94104	Location TOPOCK COMPRESSOR STATION - NEEDLES AREA - I-40 & COLORADO RIVER
Request By RALPH LAUBATT Cust. P.O.	
Copy To	Zero Datum TOP OF CASING
Reason for Survey GENERAL INSPECTION	Survey By DAN IHDE Truck No. I-17

DEPTH	REMARKS
0 FT	RECORDING STARTS
50	CORROSION INCREASES
106	STATIC WATER LEVEL - MURKY
125	VISIBILITY IMPROVES
195	BOTTOM OF CASING - OPEN HOLE BEGINS
234	ANGULAR ROCK - FRACTURES?
247	ANGULAR ROCK - FRACTURES?
250	ANGULAR ROCK - FRACTURES?
258	ANGULAR ROCK - FRACTURES?
265	ANGULAR ROCK - FRACTURES
270+	ANGULAR ROCK - FRACTURES
303	FILL - BOTTOM OF WELL

NOTE:

CASING CONDITION:

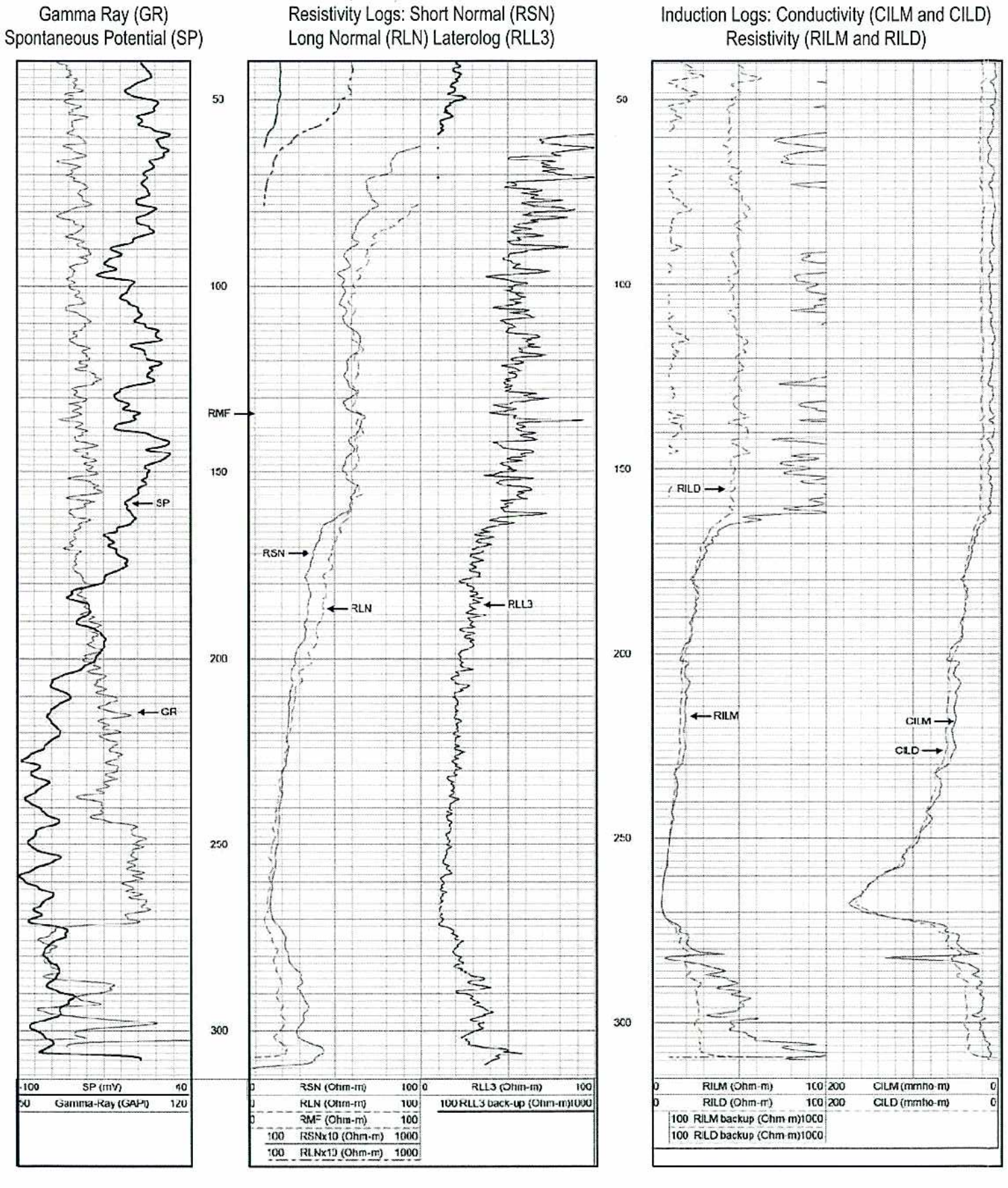
Surface 7" Reduces to OPEN HOLE at 195' : _____ at _____ : _____ at _____

Diameter Reference: ☐ Caliper Survey ☐ Estimate from TV/Photo Survey ☐ Well Records

Corrosion/Incrustation Build-up ☐ Light ☐ Moderate ☒ Heavy ☒ Increases with Depth

C3 Geophysical Logs for TW-1 and TW-2D

GEOPHYSICAL LOGS	CORES	WELL CONSTRUCTION	LITHOLOGY



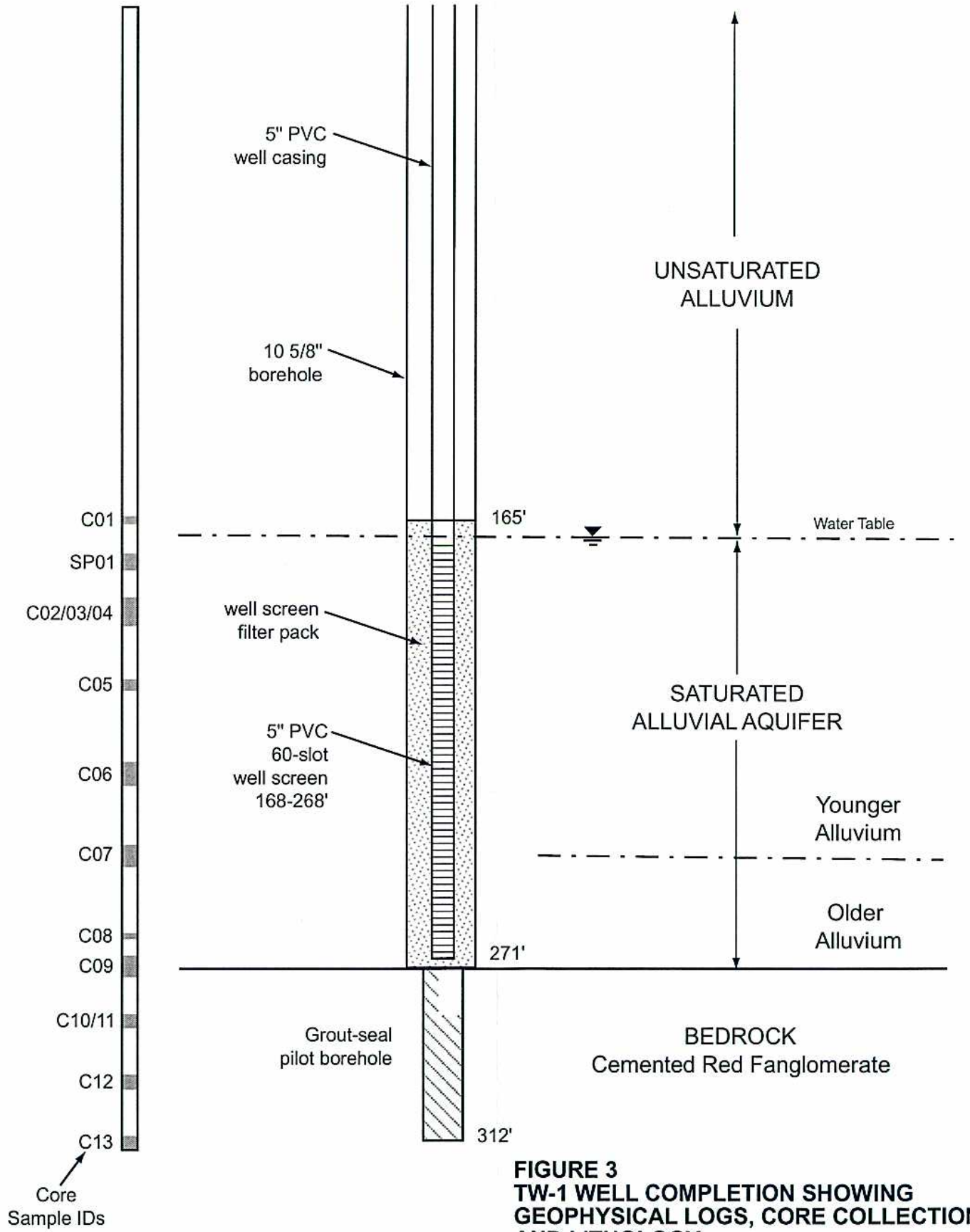
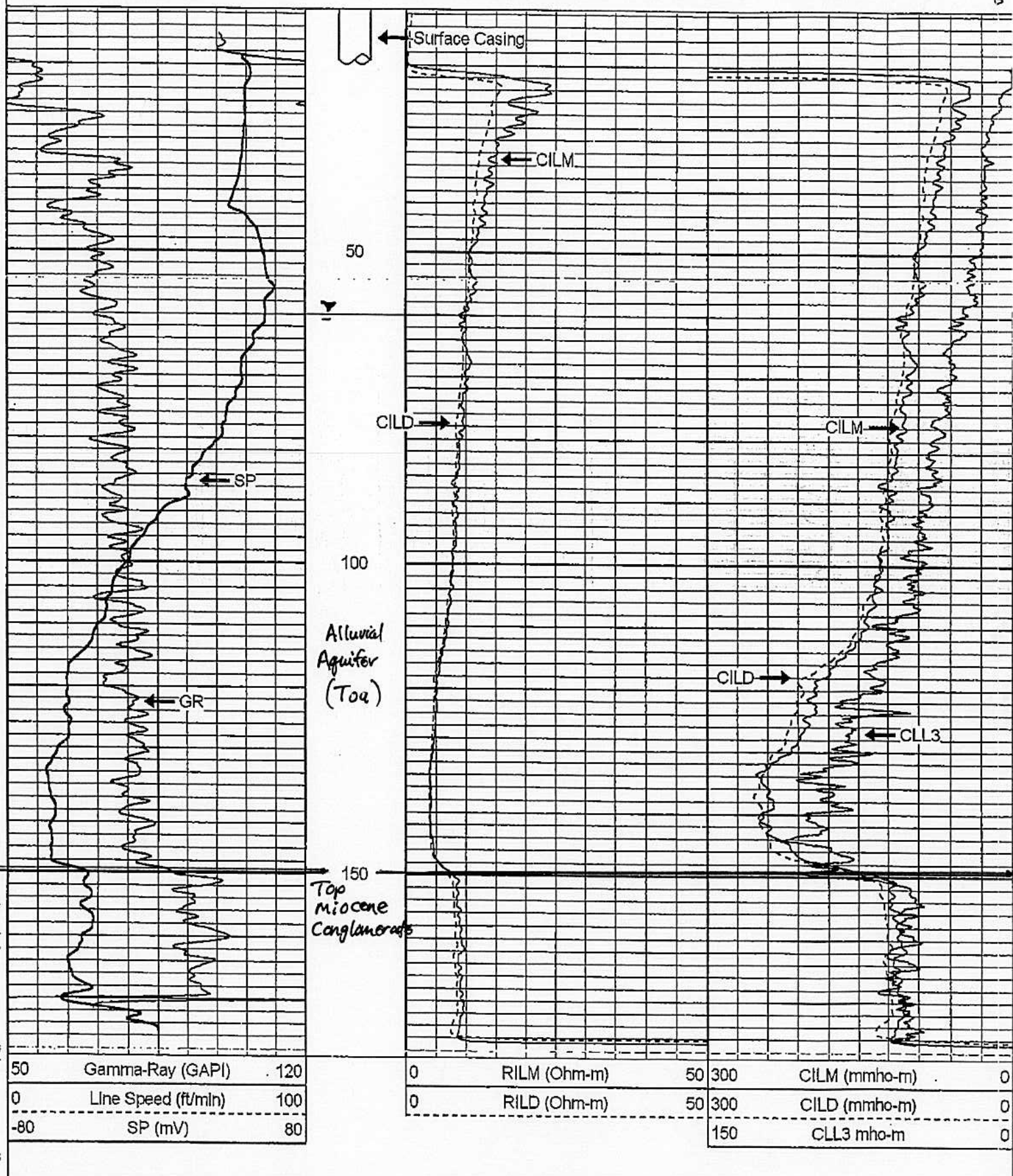


FIGURE 3
TW-1 WELL COMPLETION SHOWING GEOPHYSICAL LOGS, CORE COLLECTION AND LITHOLOGY
EXPLORATORY DRILLING RESULTS
PG&E TOPOCK

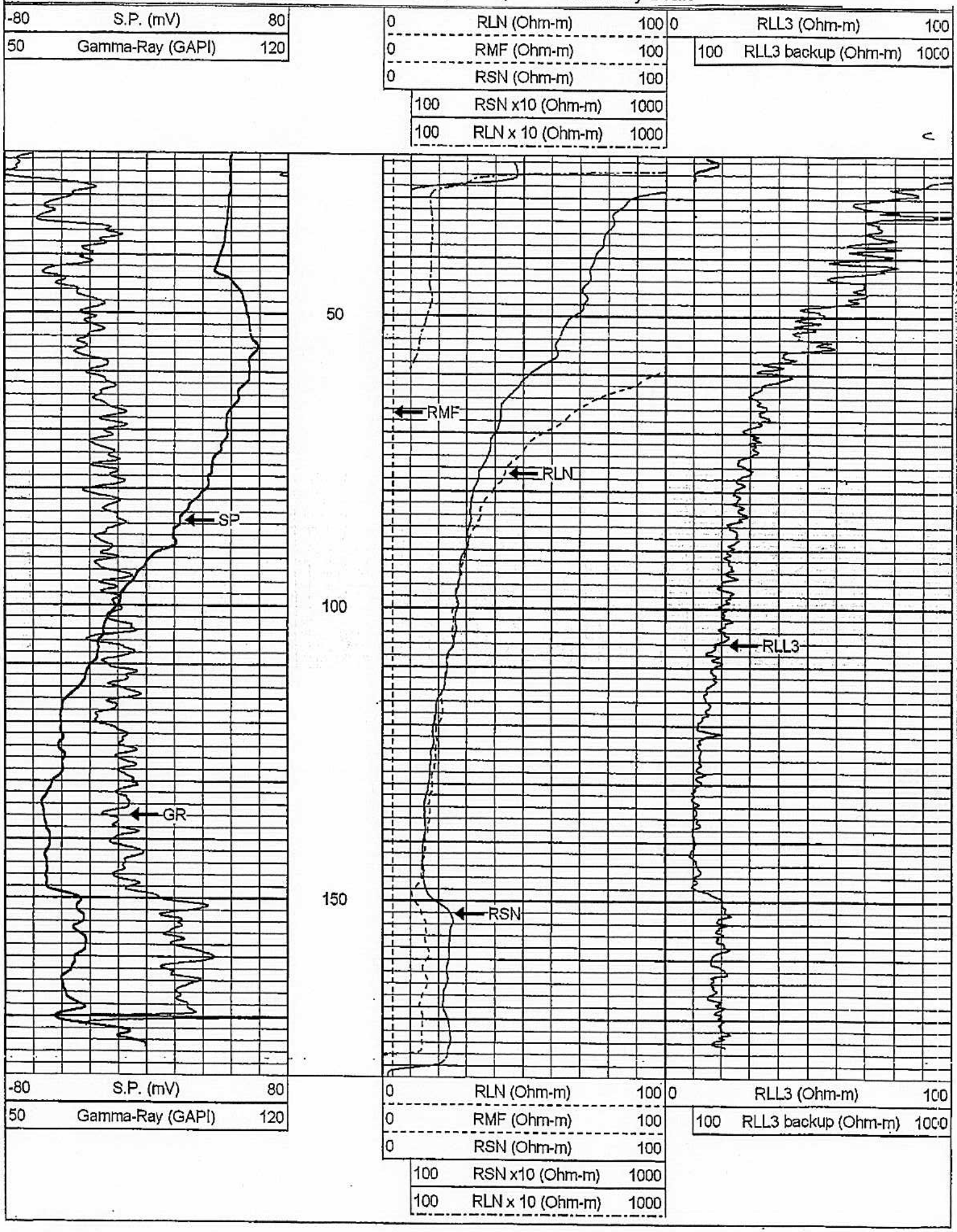
Topock TW-2D Geophysical Logs (4/1/04) - Preliminary Draft

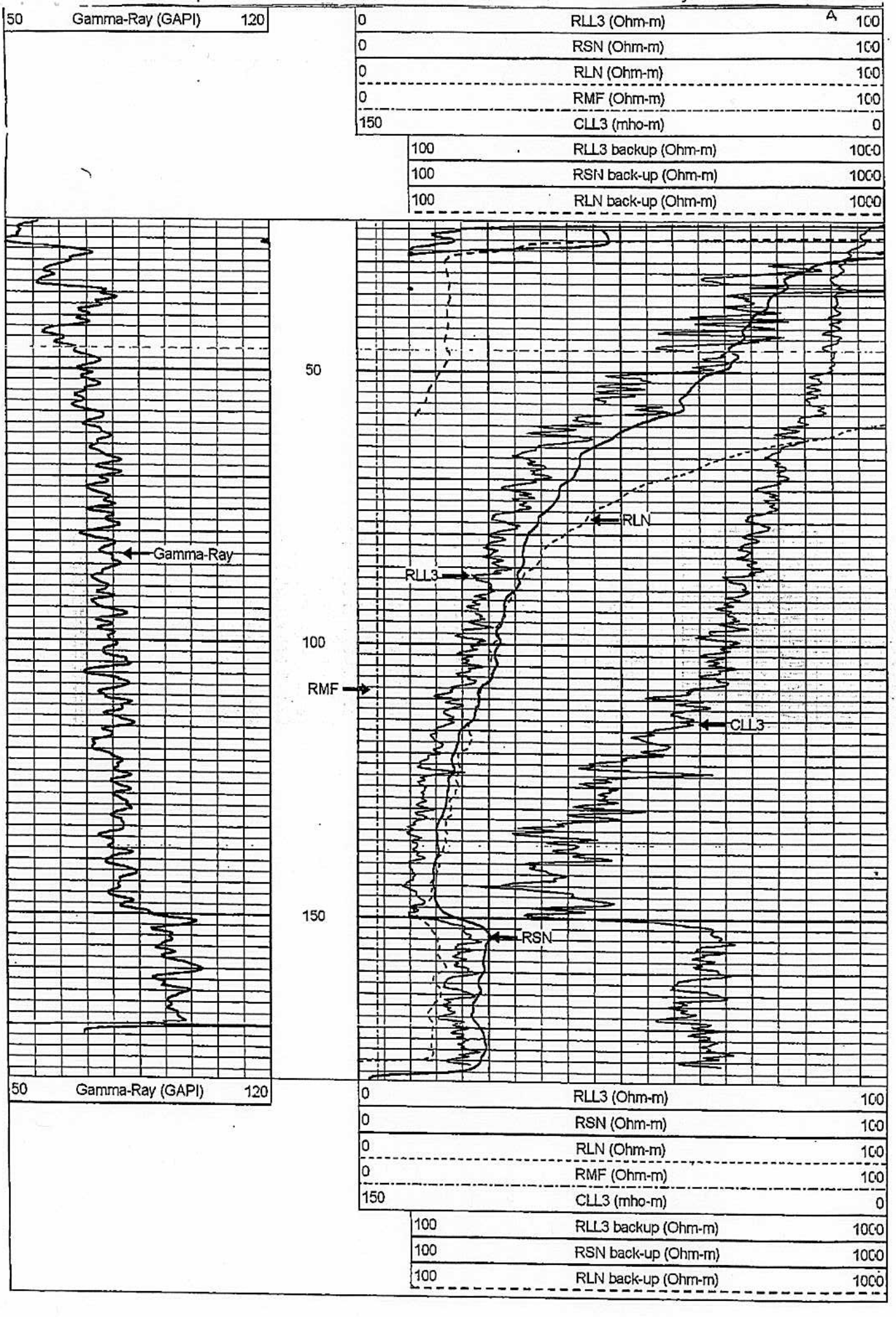
50 Gamma-Ray (GAPI) 120	0 RILM (Ohm-m) 50	300 CILM (mmho-m) 0
0 Line Speed (ft/min) 100	0 RILD (Ohm-m) 50	300 CILD (mmho-m) 0
-80 SP (mV) 80		150 CLL3 mho-m 0



50 Gamma-Ray (GAPI) 120	0 RILM (Ohm-m) 50	300 CILM (mmho-m) 0
0 Line Speed (ft/min) 100	0 RILD (Ohm-m) 50	300 CILD (mmho-m) 0
-80 SP (mV) 80		150 CLL3 mho-m 0

Topock TW-2D Geophysical Logs (4/1/04) - Preliminary Draft




50 Gamma-Ray (GAPI) 120
0 RLL3 (Ohm-m) 100
0 RSN (Ohm-m) 100
0 RLN (Ohm-m) 100
0 RMF (Ohm-m) 100
150 CLL3 (mho-m) 0
100 RLL3 backup (Ohm-m) 1000
100 RSN back-up (Ohm-m) 1000
100 RLN back-up (Ohm-m) 1000
Gamma-Ray
RLN
RLL3
RMF
CLL3
RSN
50
100
150
50 Gamma-Ray (GAPI) 120
0 RLL3 (Ohm-m) 100
0 RSN (Ohm-m) 100
0 RLN (Ohm-m) 100
0 RMF (Ohm-m) 100
150 CLL3 (mho-m) 0
100 RLL3 backup (Ohm-m) 1000
100 RSN back-up (Ohm-m) 1000
100 RLN back-up (Ohm-m) 1000

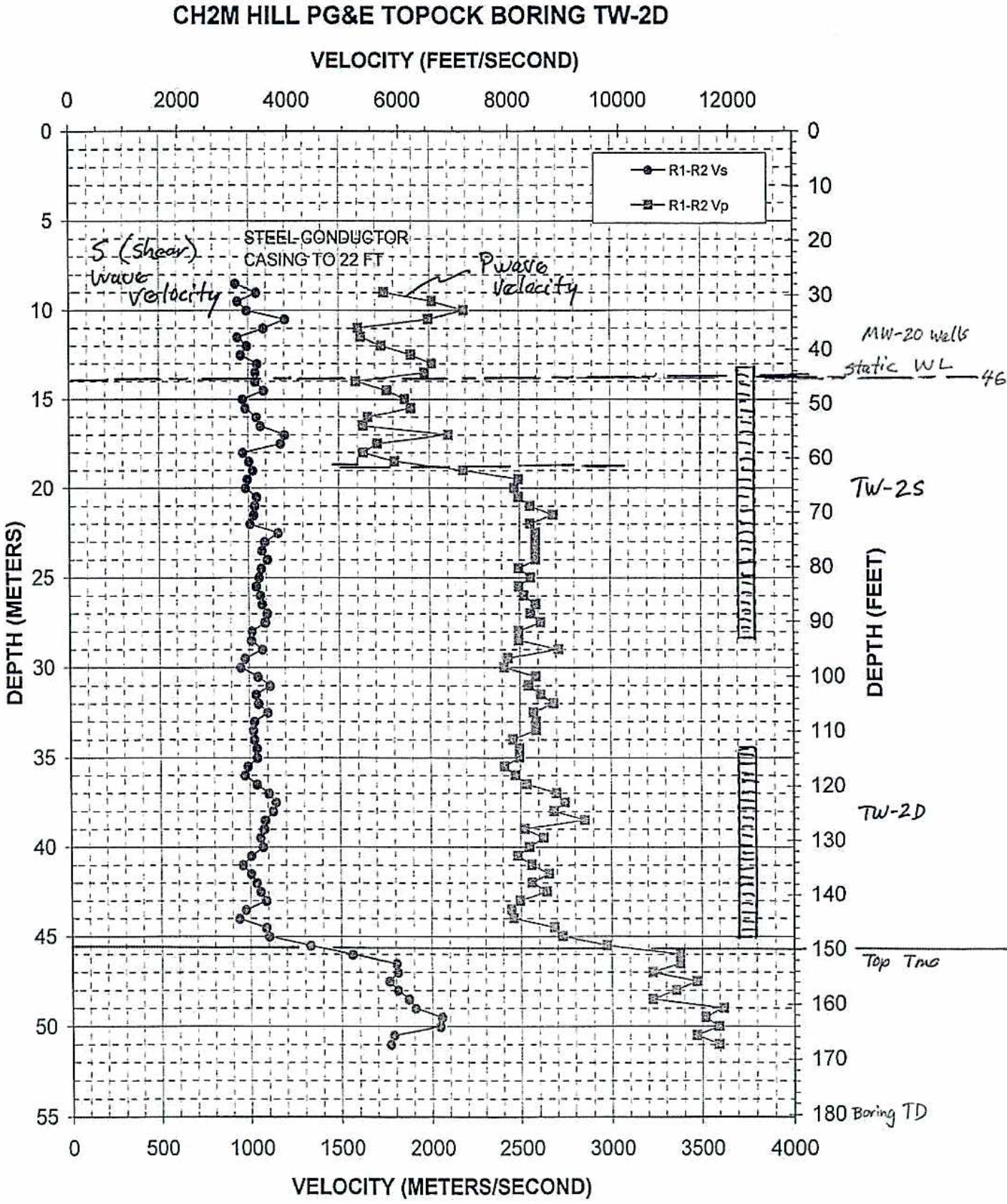


Figure 4: Borehole TW-2D, Suspension P- and S_H-wave Velocities

April 1, 2004

Appendix D
Drilling Records and Logs for Selected Wells in Mohave County, Arizona

D1 City of Needles Wells (Topock-2, Topock-3)

DEPARTMENT OF WATER RESOURCES
99 EAST VIRGINIA AVENUE
PHOENIX, ARIZONA 85004

REGISTRATION OF EXISTING WELLS

READ INSTRUCTIONS ON BACK OF THIS FORM BEFORE COMPLETING
PRINT OR TYPE — FILE IN DUPLICATE

02

REGISTRATION FEE (CHECK ONE)	
EXEMPT WELL (NO CHARGE)	☐
NON-EXEMPT WELL — $10.00	☒

FOR OFFICE USE ONLY
REGISTRATION NO. 55- 600189
FILE NO. B (16-21) 35 cdd
FILED 9-18-81 (DATE) AT 8 am (TIME)
INA ✓
AMA ✓

Topock-2

1. Name of Registrant:
Southwest Gas of Arizona Well No. 2
Box 646, Bullhead City, Arizona 86430
(Address) (City) (State) (Zip)

2. File and/or Control Number under previous groundwater law: (08-33)
B (16-21) (File Number) 35- cdd (Control Number)

3. a. The well is located within the SE ¼ SE ¼ SW ¼, Section 35, of Township 16N N/S, Range 21W E/W, G & SRB & M, in the County of Mohave.

b. If in a subdivision: Name of subdivision _____, Lot No. _____, Address _____.

4. The principal use(s) of water (Examples: irrigation - stockwater - domestic - municipal - industrial)
PG&E Gas Compressor Station and 4 meters serving 30 people.

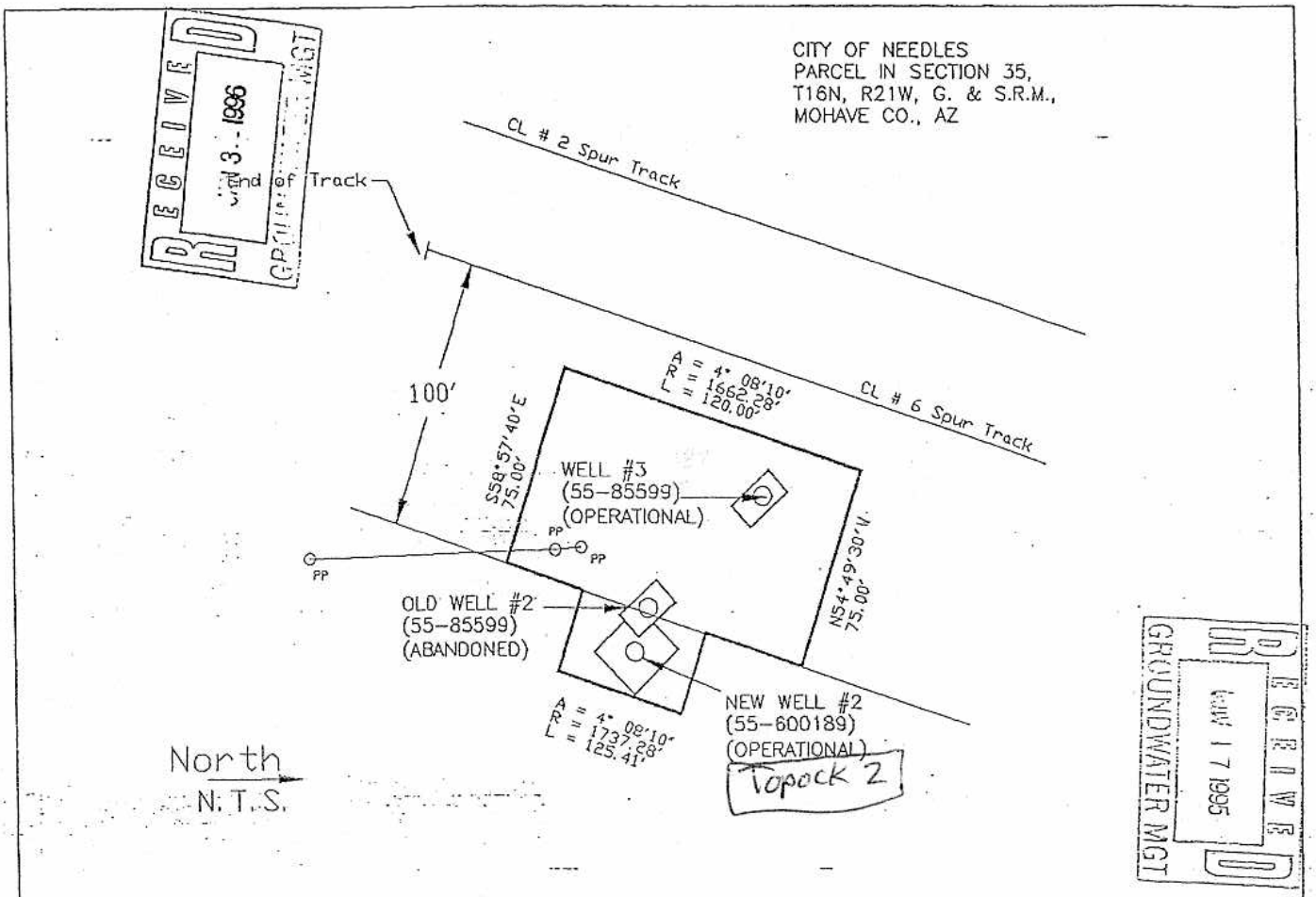
5. If for irrigation use, number of acres irrigated from well N/A.

6. Owner of land on which well is located. If same as Item 1, check this box ☐
Santa Fe Railroad
(Address) Winslow, (City) AZ (State) 86047 (Zip)

7. Well data (If data not available, write N/A)
a. Depth of Well 150 feet
b. Diameter of casing 12" inches
c. Depth of casing N/A feet
d. Type of casing Steel.
e. Maximum pump capacity 400 gallons per minute.
f. Depth to water N/A feet below land surface.
g. Date well completed N/A (Month) (Day) (Year).

8. The place(s) of use of water. If same as Item 3, check this box ☐.
____¼ ____¼ ____¼, Section ____ Township 8T 7N Range 24E
____¼ ____¼ ____¼, Section ____ Township ____ Range ____
Attach additional sheet if necessary.

9. DATE 9/15/81 SIGNATURE OF REGISTRANT [signature]



Title	Date	By	File
SITE PLAN FOR REGISTERED WELLS No. 55-8559, 55-600189, & 55-600187	11/07/95	J.W.	TOPOCK.DWG

Topock - 2

LOG OF WELL

Indicate depth at which water was first encountered, and the depth and thickness of water bearing beds. If water is artesian, indicate depth at which encountered, and depth to which it rose in well.

FROM (FEET)	TO (FEET)	DESCRIPTION OF FORMATION MATERIAL
0'	50'	Boulders
50'	60'	SANDSTONE
60'	97'	" + CLAY
97	107	GRAVEL
107	130	Broken granite (sm. amount of clay)
130	140	Broken granite
		1st h²O 97'
		Bearing h²O strata 97 - 140'

I hereby certify that this well was drilled by me (or under my supervision), and that each and all of the statements herein contained are true to the best of my knowledge and belief.

Driller Wellette + Askew
Name

POB 2268 Blue Az. 86431
Address

Date 10-2-80

4

STATE OF ARIZONA

DEPARTMENT OF
WATER RESOURCES

WELL DRILLER'S REPORT

This report should be prepared by the driller in all detail and filed with the Department within 30 days following completion of the well.

TOPOCK - 2A

1. Owner Southwest Gas of Arizona (Name)

Box 646, Bullhead City, Az. 86430 (Address)

2. Lessee or Operator SAME AS BELOW (Name)

(Address)

3. Driller ~~Wellotte & Askew~~ (Name)

(Address)

4. Location of well: T16N, R21W, Sec. 35, SE¼ SE¼ SW¼

5. Permit No. 55-85599 (if issued)

10 40 160

DESCRIPTION OF WELL

6. Total depth of hole 140' ft.

7. Type of Casing STEEL

8. Diameter and length of casing 12 in. from 0' to 140', _____ in from _____ to _____.

9. Method of sealing at reduction points _____

10. Perforated from 100' to 140', from _____ to _____, from _____ to _____

11. Size of cuts ¼" x 3" Number of cuts per foot 10

12. If screen was installed: Length _____ ft. Diam _____ in. Type _____

13. Method of construction (drilled) dug, driven, bored, jetted, etc.

14. Date started 9 (Month) 24 (day) 80 (year)

15. Date completed 9 (Month) 29 (day) 80 (year)

16. Depth to water 47' ft. (If flowing well, so state.)

17. Describe point from which depth measurements were made, and give sea-level elevation if available.

ground level approx. 550' above sea level

18. If flowing well, state method of flow regulation _____

19. REMARKS: _____

DO NOT WRITE IN THIS SPACE
OFFICE RECORD

Registration No. 55-85599

Received _____ By _____

Entered OCT 2 8 1980 By [illegible]

File No. B(16-21)35 cdd

(Well log to appear on Reverse side)

Phoenix, Arizona 85004

Registration No. 55-85599
Owner of
Well Site Southwest Gas of Arizona

File No. B(16-21)35 cdd

COMPLETION REPORT

1. Completion Report to be filed with the Department within 30 days after installation of pump equipment.

2. The tested pumping capacity of the well in gallons per minute for a non-flowing well should be determined by measuring the discharge of the pump after continuous operation for at least 4 hours and for a flowing well by measuring the natural flow at the land surface.

3. Drawdown of the water level for a non-flowing well should be measured in feet after not less than 4 hours of continuous operation and while still in operation and for a flowing well the shut-in pressure should be measured in feet above the land or in pounds per square inch at the land surface.

4. The static groundwater level should be measured in feet from the land surface immediately prior to the well capacity test.

LOCATION OF THE WELL

Topock-2

T16N, R21W, Sec. 35, SE¼ SE¼ SW¼ .

Date Well Completed 9-20-80 Depth of Well 140'

1. Well Test:
Test Pumping Capacity 400 (Gal. per min.) Date Well Tested 10/15/80
Method of Discharge Measurement Current Meter (weir, orifice, current meter, etc.)
Static Groundwater Level 50' 8" ft. Drawdown 25' ft.
Total Pumping Lift 425' ft. Drawdown _____ lbs. (Flowing Well)

2. Equipment Installed:

Kind of Pump Submersible turbine (turbine, centrifugal, etc.)
Kind of Power Elec (Elec., Nat. Gas, Etc.) H.P. Rating of Motor 60

I HEREBY CERTIFY that the above statements are true to the best of my knowledge and belief.

Signature

PO. Box 1178
Address

12/19/80, 19
Date

Bullhead City Az 86430
City State Zip

DEPARTMENT OF WATER RESOURCES
99 EAST VIRGINIA AVENUE
PHOENIX, ARIZONA 85004

REGISTRATION OF EXISTING WELLS

READ INSTRUCTIONS ON BACK OF THIS FORM BEFORE COMPLETING
PRINT OR TYPE — FILE IN DUPLICATE

02

REGISTRATION FEE (CHECK ONE)	
EXEMPT WELL (NO CHARGE)	☐
NON-EXEMPT WELL — $10.00	☒

FOR OFFICE USE ONLY
REGISTRATION NO. 55- 600187
FILE NO. B(16-21)35 cdd
FILED 9-18-81 (DATE) AT 8am (TIME)
INA ✓
AMA ✓

1. Name of Registrant:
Southwest Gas of Arizona Well No. 3
Box 646, (Address) Bullhead City, (City) AZ (State) 86430 (Zip)

2. File and/or Control Number under previous groundwater law: (08-33)
B (16-21) (File Number) 35- cdd (Control Number)

3. a. The well is located within the SE ¼ SE ¼ SW ¼, Section 35, of Township 16N N/S, Range 21W E/W, G & SRB & M, in the County of Mohave.

b. If in a subdivision: Name of subdivision _____, Lot No. _____, Address _____.

4. The principal use(s) of water (Examples: irrigation - stockwater - domestic - municipal - industrial)
PG&E Gas Compressor Station and 4 meters serving 30 people.

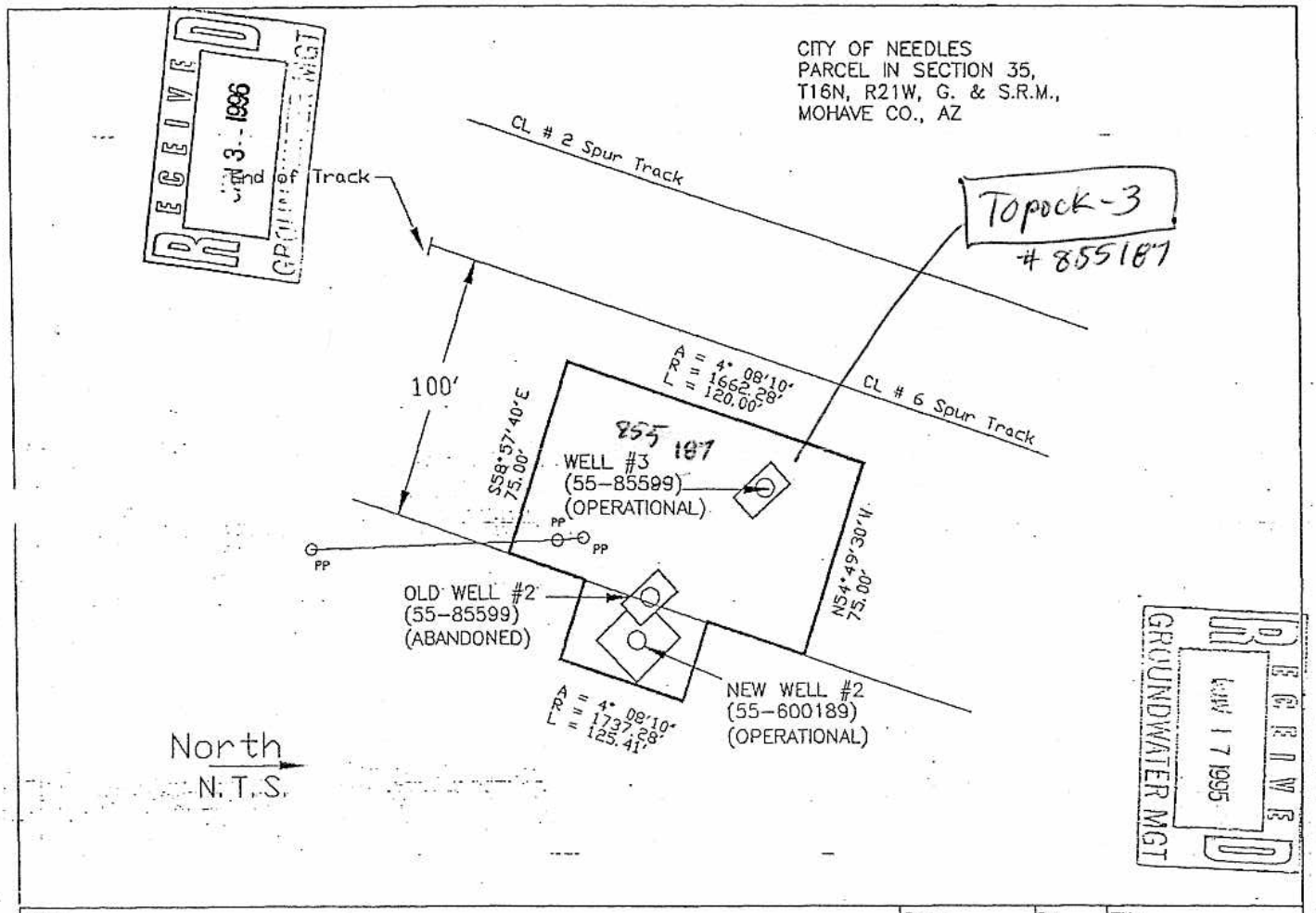
5. If for irrigation use, number of acres irrigated from well N/A.

6. Owner of land on which well is located. If same as Item 1, check this box ☐
Santa Fe Railroad
(Address) Winslow, (City) AZ (State) 86047 (Zip)

7. Well data (If data not available, write N/A)
a. Depth of Well 250 feet
b. Diameter of casing 12 inches
c. Depth of casing N/A feet
d. Type of casing Steel.
e. Maximum pump capacity 300 gallons per minute.
f. Depth to water N/A feet below land surface.
g. Date well completed 5 (Month) 17 (Day) 74 (Year).

8. The place(s) of use of water. If same as Item 3, check this box ☐.
____¼ ____¼ ____¼, Section ____ Township 8T 7N Range 24E
____¼ ____¼ ____¼, Section ____ Township ____ Range ____
Attach additional sheet if necessary.

9. DATE 9/15/81 SIGNATURE OF REGISTRANT [signature]



Title	Date	By	File
SITE PLAN FOR REGISTERED WELLS No. 55-8559, 55-600189, & 55-600187	11/07/95	J.W.	TOPOCK.DWG

Topock #3

Phone (702) 878-7757

DRILLING & PUMPS INC.
3521 SPRING MOUNTAIN ROAD
LAS VEGAS, NEV. 89102

Topock-3

June 5 1974

Southwest Gas Corporation
P O Box 46
Bullhead City Ariz

Well #3 at Topack Ariz

Drillers log of formations

0-11	sand & boulders
11-23	gravel.sand & boulders
23-30	gravel w/ few boulders
30-33	boulder
33-43	clay
43-46	silty sand
46-52	boulders & gravel
52-91	clay w/ interbedded rock
91-146	boulders & gravel
146-180	decomposed granite
180-250	decomposed granite w/ rhyolite boulders

DEPARTMENT OF WATER RESOURCES
GROUNDWATER MANAGEMENT SUPPORT SECTION
500 North Third Street
Phoenix, Arizona 85004-3903
Phone (602) 417-2470 Fax (602) 417-2422

REQUEST FORM TO CHANGE WELL INFORMATION
OWNERSHIP * DRILLER

Please complete the appropriate section of this request form and return to the above address with applicable fee. NOTE: A.R.S. §45-593.C requires that the Department be notified of change of well ownership and that the new owner is required to keep the Department's Well Registration records current and accurate. Well data and ownership changes must be submitted within thirty days after changes take place.

SAVE THIS FORM TO REPORT FUTURE CHANGES IN OWNERSHIP, CHANGES IN ADDRESS, OR CHANGE IN WELL DATA SUCH AS PUMP CAPACITY, CORRECTION OF LEGAL DESCRIPTION, CHANGE OF WELL DRILLER AND AMENDING INFORMATION PREVIOUSLY FILED.

1. CHANGE OF WELL INFORMATION: (NO FEE REQUIRED)

NOTE: If the location of the proposed well changes after drilling authority has been issued, **attach a $10.00 reissue fee for each well.**

WELL REGISTRATION NO. 55- N/A FILE NO: _____

If known, I/We request the following well information be changed: _____

2. STATEMENT OF CHANGE OF WELL OWNERSHIP: ($10.00 FEE REQUIRED)

If this change consists of more than one well and the names are common: attach a $10.00 fee. Otherwise, each well requires a separate fee of $10.00.

I, The City of Needles, state that I am the Previous/~~New Owner~~ of the well described below: WELL #3 (Topock) Topock-3

SE ¼ SE ¼ SW ¼ Section 35 Township 16N N/S Range 21W E/W
10 Acre 40 Acre 160 Acre

Well Registration No. 55- 600187 File No. B(16-21) 35 cdd (if known)

Southwest Gas of Arizona	City of Needles
PRINT Previous Owner's Name	PRINT New Owner's Name
P.O. BOX 646	817 Third Street
Mailing Address	Mailing Address
Bullhead City, AZ 86430	Needles, CA 92363
City State Zip	City State Zip
(520) 754-2263	(619) 326-5700
Telephone	Telephone

Date Nov. 7, 1995 Signature of Previous/~~New~~ Well Owner _____

DWR 55-71 (Rev 10/95)

ENTERED JAN - 5 1996

D2 Mojave Pipeline Company Wells (MTS-1, MTS-2)

STATE OF ARIZONA
DEPARTMENT OF WATER RESOURCES
15 South 15th Avenue
Phoenix, Arizona 85007

WELL DRILLER REPORT

This report should be prepared by the driller in all detail and filed with the Department within 30 days following completion of the well.

1. Owner MOJAVE PIPELINE OPERATING CO.
Name
P.O. BOX 10269 BAKERSFIELD, CA 93389
Mailing Address

2. Driller BOB WAY
Name
PO BOX 130 MORAITOWN, AZ 85342
Mailing Address

3. Location of well: 16N 21W 5-36 NW NW SW

4. Permit No. 55-531889 (If issued)

MTS-1

DESCRIPTION OF WELL

5. Total depth of hole 744 ft.
6. Type of casing STEEL
7. Diameter and length of casing 12 in. from 0 to 20, in from 8 to 705.
8. Method of sealing at reduction points
.050 SCREEN
9. Perforated from 605 to 705, from ____ to ____, from ____ to ____.
10. Size of cuts .050 Number of cuts per foot
11. If screen was installed: Length 100 ft. Diam 8 in. Type STEE
12. Method of construction DRILLED
drilled, dug, driven, bored, jetted, etc
13. Date started JUN (Month) 5 (Day) 91 (Year)
14. Date completed JUL (Month) 31 (Day) 91 (Year)
15. Depth to water 147 ft. (If flowing well, so state)
16. Describe point from which depth measurements were made, and give sea-level elevation if available
17. If flowing well, state method of flow regulation:
18. Remarks:

AUG 27 1991

DO NOT WRITE IN THIS SPACE

REG. No. 55-531889
File No. B(16-21)36 CBB
Entered By
ENTERED AUG 29 1991

DWR-55-55-2/89

LOG OF WELL

Indicate depth at which water was first encountered, and the depth and thickness of water bearing beds. If water is artesian, indicate depth at which encountered, and depth to which it rose in well.

From (feet)	To (feet)	Description of formation material
0 '	140 '	sand, gravel, boulders.
140'	320 '	Brown clay, small rock
320'	410'	Brown clay large rock
410'	515'	Reddish rock with clay
515'	585'	less clay, more reddish clay
585'	615'	red hard rock no clay.
615'	625'	Very hard rock reddish
625'	685	red hard rock no clay
685'	705	red rock & clay
705'	725'	red rock & more clay
725'	728'	gum ball clay
728'	744'	more clay & small rock.

I hereby certify that this well was drilled by me (or under my supervision), and that each and all statements herein contained are true to the best of my knowledge and belief.

Driller [signature]
Name

P O Box 130
Address

Mooristown, AL 85342
City State Zip

Date 21 Aug 91

Century GEOPHYSICAL CORP.

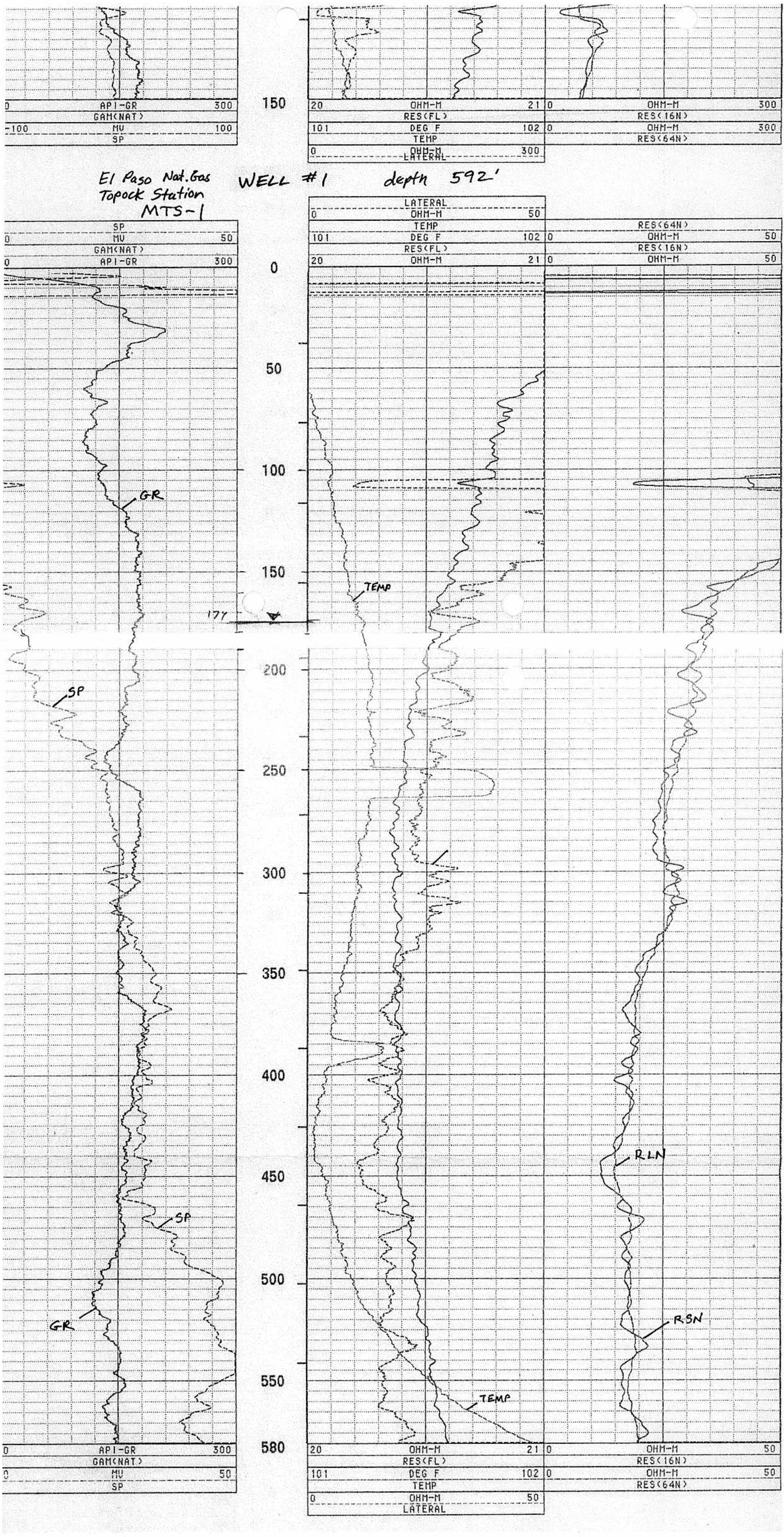
TOPOCK COMP.ST. WELL # 1

MTS-1

COMPANY	: FLUOR DANIEL			OTHER SERVICES:	
WELL	: TOPOCK COMP.ST. WELL # 1				
LOCATION/FIELD	: TOPOCK COMPRESSOR STATION				
COUNTY	: MOHAVE				
STATE	: ARIZONA				
SECTION	:	TOWNSHIP	:	RANGE	:
DATE	: 06/19/91	PERMANENT DATUM	: GL	ELEVATIONS	
DEPTH DRILLER	: 500'	ELEV. PERM. DATUM:		KB	:
LOG BOTTOM	: 591.60	LOG MEASURED FROM:	GL	DF	:
LOG TOP	: 2.50	DRL MEASURED FROM:	GL	GL	:
CASING DRILLER	: 20	LOGGING UNIT	: 9006		
CASING TYPE	: STEEL	FIELD OFFICE	: CHINO VALLEY		
CASING THICKNESS	: .188	RECORDED BY	: R.FEDERWISCH		
BIT SIZE	: 7.82	BOREHOLE FLUID	: BENT	FILE	: ORIGINAL
MAGNETIC DECL.	: 13.5	RM	: 00	TYPE	: 9041A
MATRIX DENSITY	: 2.65	RM TEMPERATURE	: 00	LOG	: 4
FLUID DENSITY	: 1.0	MATRIX DELTA T	: 00	PLOT	: MONT41 0
NEUTRON MATRIX	: SANDSTONE	FLUID DELTA T	: 00	THRESH	: 50000
REMARKS	:				

El Paso Nat. Gas
Topock Station
MTS-1

WELL #1 depth 592'



15 South 15th Avenue
Phoenix, Arizona 85007

MTS-1

Registration No. 55-531889

File No. B(16-21)36 CBB

COMPLETION REPORT

1. Per A.R.S. §45-600, the Completion Report is to be filed with the Department within 30 days after installation of pump equipment by the registered well owner.
2. Drawdown of the water level for a non-flowing well should be measured in feet after not less than 4 hours of continuous operation and while still in operation and for a flowing well the shut-in pressure should be measured in feet above the land or in pounds per square inch at the land surface.
3. The static groundwater level should be measured in feet from the land surface immediately prior to the well capacity test.
4. The tested pumping capacity of the well in gallons per minute for a non-flowing well should be determined by measuring the discharge of the pump after continuous operation for at least 4 hours and for a flowing well by measuring the natural flow at the land surface.

LOCATION OF THE WELL:

16N	21W	36	NW NW SW
Township	Range	Section	¼ ¼ ¼

EQUIPMENT INSTALLED:

Kind of pump SUBMERSIBLE
Turbine, centrifugal, etc.

Kind of power ELECTRIC H.P. Rating of Motor 40
Electric, natural gas, gasoline, etc.

Pumping Capacity 300 Date pump installed: 7/26/91
Gallons per minute

WELL TEST:

Test pumping capacity 300 ✓ Date Well Tested: 7/26/91 - 7/27/91
Gallons per minute

Method of Discharge Measurement METERED
Weir, orifice, current meter, etc.

Static Groundwater Level 174 ✓ ft. Drawdown 64 (57') ft.

Total Pumping Lift 238 ft. Drawdown _____ lbs.
(Flowing Well)

I HEREBY CERTIFY that the above statements are true to the best of my knowledge and belief.

Mojave Pipeline Operating Company
Print Well Owner's Name

October 31, 1991
Date

M. Ferguson /by
Signature of Well Owner or Agent

P.O. Box 10269
Address

Bakersfield CA 93389
City State Zip

DWR-55-56-2/88

ENTERED JAN 10 1992

WAY'S DRILLING & PUMP CO.

MTS-1

Equipment Report

SUBMERSIBLE PUMP INSTALLATION

CUSTOMER Mojave Pipeline Co. Job No. _____

MAILING ADDRESS _____ Well No. #1

LOCATION _____

SALESMAN _____ DATE 11/18/91 PHONE NO. _____

WELL: Driller WAY Size 8" ✓ Depth _____ Cased STEEL ✓

Perforations 580' - 680' ? Static Water Level 174.03'

History REPLACING GOULDS 200LL

SUBM. PUMP: Make GRUNDFOS Model 2258200-8 Serial No. 9131BB

Size Drop Pipe 3" Pump Setting 580' Draw Down _____

SUBM. MOTOR: Make FRANKLIN Model 2366176045 Code J Date E91

H.P. 40 Volts 460v Phase 3ø Cycle 60

Amps. 53.5 S.F. 1.15 S.F.A. 62.0

Megs _____ R.B. RX1 1.1 R.Y. RX1 1.1 B.Y. RX1 1.1

DISCONNECT: Make CHALLENGER Model _____ Fuses – Fusetrons _____

MAGNETIC STARTER: Make FURNAS Size _____ Heaters _____

SYSTEM: Tank Size _____ Size Drop Cable #6/3

Tank Pressure OPEN FLOW Lightning Arrester IN MOTOR

OTHER MATERIAL – OPTIONAL EQUIPMENT:

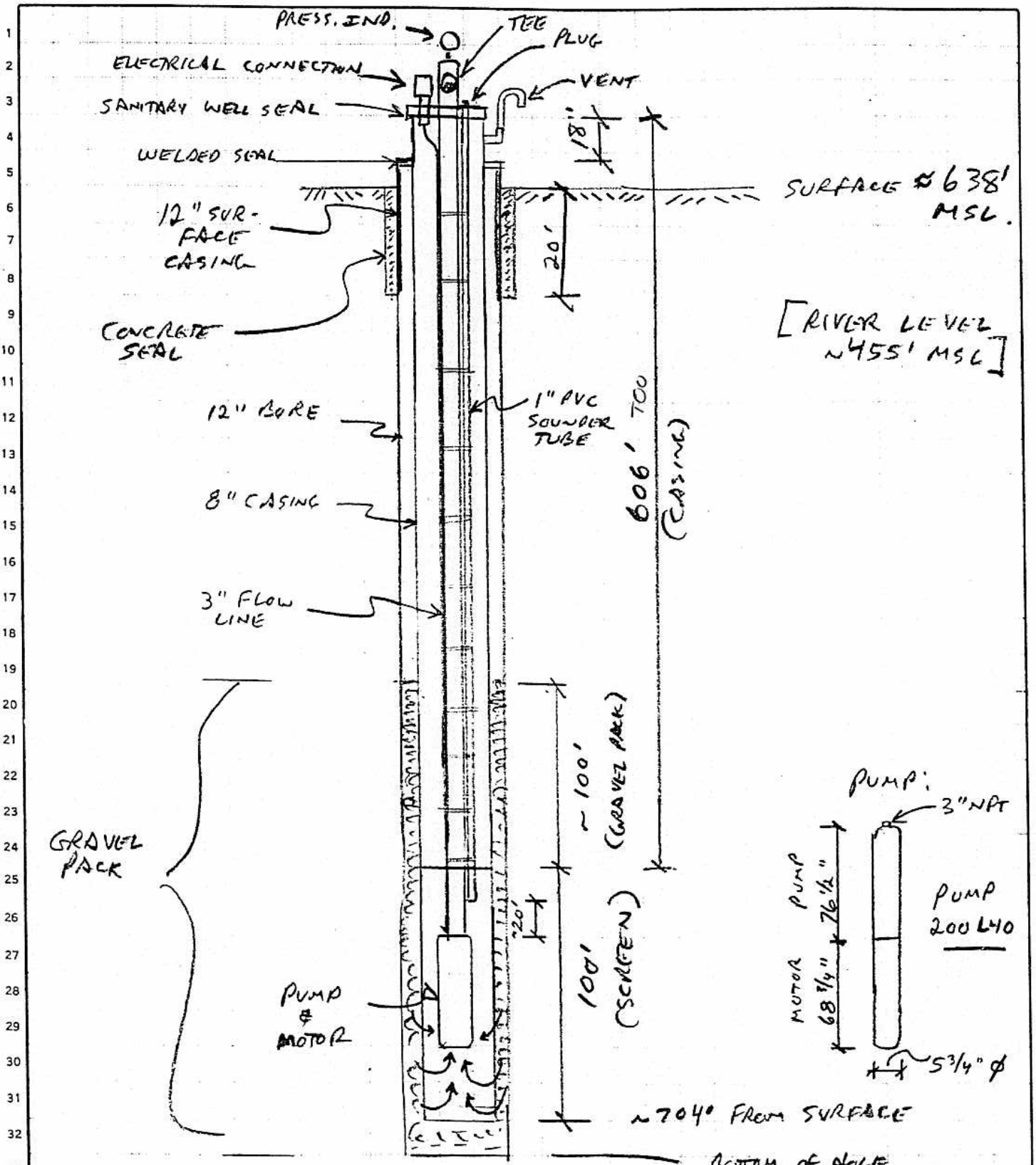
SYSTEM IS SAME AS WELL # 2

FLUOR DANIEL

CALCULATIONS and SKETCHES

DATE 8/29/91
CONT. NO. 06630450
BY PDM CHK'D
SHEET NO. 1/1

TOPOCK COMPRESSOR STATION WATER WELL #1 (MTS-1)



MW	gals/mol
16	C_1 6.40
30	C_2 9.67
44	C_3 10.44
58	IC_4 12.40
58	C_4 11.95
72	IC_5 13.88
72	C_5 13.74
86	IC_6 15.5
86	C_6 15.59
100	IC_7 17.2
100	C_7 17.49
114	C_8 19.41
28	$C_2^=$ 9.64
42	$C_3^=$ 9.67

MISC

MW	gals/mol
44	CO_2 8.47
34	H_2S 5.18
28	N_2 4.18
2	H_2 3.38

FORM E-050 REV. 6/88
PRINTED IN U.S.A.

-4 LICENSED & BONDED

BOB WAY (602) 684-3301

P.O. BOX 130 MORRISTOWN, AZ 85342

MTS-1

TO ROCK WELL NO 1

5 JUN 1991 TO 25 JUN 1991

0 - 140 SAND, GRAVEL & BOULDERS

140 - 320 BROWN CLAY & SMALL ROCK

320 - 410 BROWN CLAY & LARGER ROCK

410 - 515 REDISH ROCK WITH CLAY

515 - 585 LESS CLAY MORE REDISH ROCK

585 - 615 RED HARD ROCK NO CLAYS

615 - 625 VERY HARD ROCK REDISH

625 - 685 RED HARD ROCK NO CLAYS

685 - 705 RED ROCK & CLAYS

705 - 725 RED ROCK & MORE CLAYS

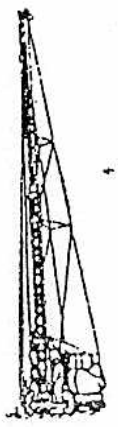
725 - 728 GUMM BALL CLAY

728 - 744 MORE CLAY & SMALL ROCK

ROCK ZONES

370, 470, 490, 500, 510 & 585 DOWN

1 JUL 91



THE COMMON LAW OF BUSINESS BALANCE

It's unwise to pay too much but it's worse to pay too little. When you pay too much, you lose a little money — that is all. When you pay too little you sometimes lose everything, because the thing you bought was incapable of doing the thing it was bought to do. The common law of business prohibits paying a little and getting a lot — it can't be done. If you deal with the lowest bidder, it is well to add something for the risk you run. And if you do that, you will have enough to pay for something better.

LINE - LINE 300 V
LINE - ⏚ 300 V
Y - 58 AMPS
B - 60 AMPS
R - 60 AMPS

WAY'S DRILLING
PO BOX 130
MORRISTOWN, AZ
(602) 684-3301

NOTE - 2.0 FROM GROUND LEVEL TO SOUNDER TUBE.
- ALL MEASUREMENTS TAKEN FROM SOUNDER TUBE

PUMP TEST LOG (MTS-1)

DATE	TIME	DRAWDOWN	GPM(Q)	ML/S	COMMENTS
7/26	1230	SWL 173.09'	250+	10.0	START OF TEST
	1245	193.58		10.0	DIRTY/MUD
	1300	220.03		2.0	DIRTY/MUD
	1305	221.01		1.0	MILKY
	1310	221.75		.7	CLOUDY
	1315	222.03		.5	CLOUDY
	1320	222.25		.5	CLOUDY
	1325	222.41		.5	CLOUDY
	1330	222.75	250+	.3	CLOUDY
	1331	SURGE	FOR	30 MIN	
	1400	230.00	300+	.5	CLOUDY
	1410	230.33		.3	CLOUDY
	1445	225.14		1.0	DIRTY
	1515	225.89	308.0	.05	TRACES OF SAND CLEAR
	1600	226.10	300.0	.03	CLEAR T/S
	1700	226.82		.03	CLEAR T/S
	1800	227.56		.03	CLEAR T/S
	1900	228.78		.03	CLEAR T/S
	2000	229.10		.03	CLEAR T/S
	2100	229.20	300.0	.02	CLEAR T/S
	2200	229.25		.02	CLEAR
	2300	229.28		.02	CLEAR
7/26	2400	229.31		.02	CLEAR
7/27	0100	229.31	300.0	.01	CLEAR
7/27	0200	229.29	300.0	.01	CLEAR

0 HR → 7/26 1230

1/3 ON GATE VALVE

50 psi ON GUAGE

SURGE — 1331

OPEN FULL ON GATE VALVE 25psi

5MIN. SURGE — 1445

40psi, 300gpm FOR REST OF TEST

12½ HR → 7/26 2400 (172,000 GALLONS)

108.9° F

* WELL RECOVER IN 5MIN.

= INSTALLED GPM METER #31945235

END OF PAGE 1

WAY'S DRILLING
PO BOX 130
MORRISTOWN, AZ
(602) 684-3301

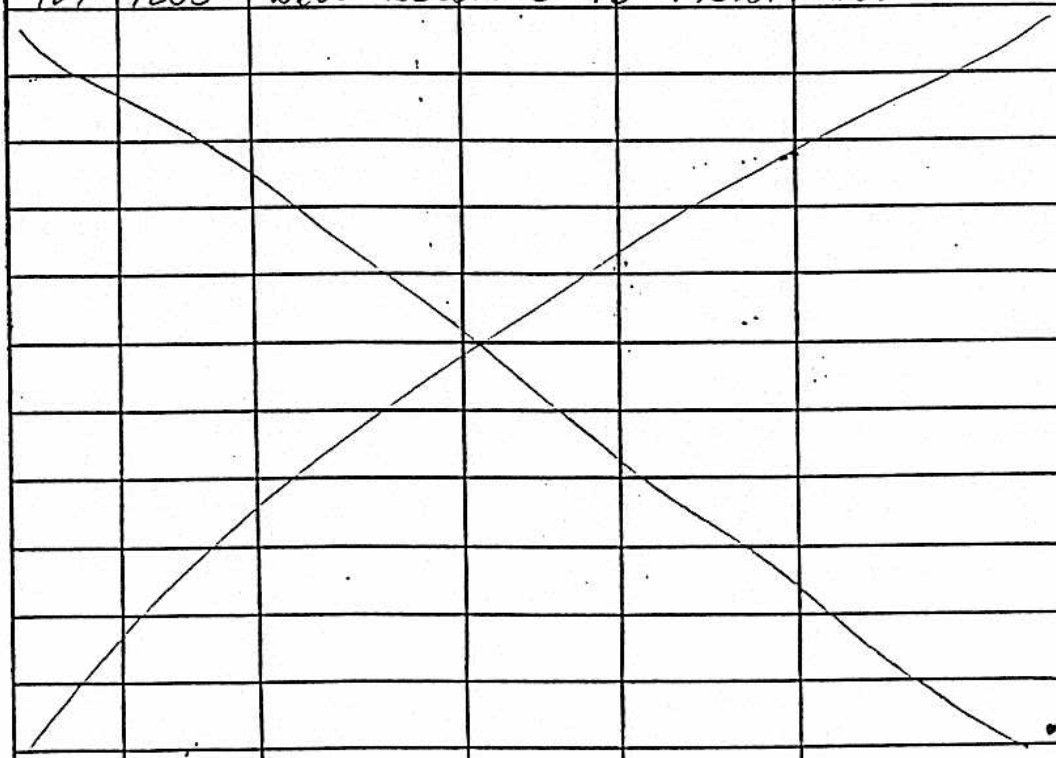
MTS-1

PUMP TEST LOG

DATE	TIME	DRAWDOWN	GPM(Q)	ML/S	COMMENTS
7/27	0300	229.38	300.0	0	CLEAR, 108.9°F
	0400	229.57		0	CLEAR, METER READS 234,900 GALLONS
	0500	229.61		0	CLEAR, 108.9°F
	0600	229.73		0	CLEAR, PULLING 60 AMPS
	0700	229.81	300.0	0	CLEAR
	0800	229.81		0	CLEAR, 110.0°F
	0900	229.83		0	CLEAR
	1000	229.81		0	CLEAR, PULLING 62 AMPS
	1100	229.82		0	CLEAR
	1200	229.80		0	CLEAR
7/27	1230	229.81	300.00	0	CLEAR
7/27	1230	END OF	24 HR	TEST	METER READS 386,100 GALLONS
7/27	1235	WELL RECOVERED TO		173.09'	183.00 IN 35 SEC. — THE LAST 10', IN 4.5 MIN.

40 psi, operating pressure

24 HRS →



RECE
OCT 2 1 1991
DIV.

STATE OF ARIZONA
DEPARTMENT OF WATER RESOURCES
15 South 15th Avenue
Phoenix, Arizona 85007

WELL DRILLER REPORT

This report should be prepared by the driller in all detail and filed with the Department within 30 days following completion of the well.

1. Owner MOJAVE PIPELINE OPERATING CO.
Name
PO BOX 10269 BAKERSFIELD, CA. 93389
Mailing Address

2. Driller BOB WAY
Name
POBOX 130 MORRISTOWN, AZ 85342
Mailing Address

3. Location of well: 16N 21W S-36 NW NW SW

4. Permit No. 55-531890 (If issued)

MTS-2

DESCRIPTION OF WELL

5. Total depth of hole 720 ft.

6. Type of casing STEEL

7. Diameter and length of casing 12 3/4 in. from 0 to 40, 8 5/8 in from 0 to 703.

8. Method of sealing at reduction points

9. Perforated from 603 to 703, from ____ to ____, from ____ to ____.

10. Size of cuts SCREEN Number of cuts per foot .060

11. If screen was installed: Length 100 ft. Diam 8 5/8 in. Type .060

12. Method of construction DRILLED
drilled, dug, driven, bored, jetted, etc

13. Date started AUG 13 91
Month Day Year

14. Date completed ~~SEP~~ OCT 2 91
Month Day Year

15. Depth to water 174 ft. (If flowing well, so state)

16. Describe point from which depth measurements were made, and give sea-level elevation if available

17. If flowing well, state method of flow regulation:

18. Remarks: 24 HOUR PUMP TEST COMPLETED

DO NOT WRITE IN THIS SPACE

REG. No. 55-531890

File No. B(16-21)36 CBB

Entered ____ By ____

ENTERED OCT 22 1991

DWR-55-55-2/89

LOG OF WELL MTS-2

Indicate depth at which water was first encountered, and the depth and thickness of water bearing beds. If water is artesian, indicate depth at which encountered, and depth to which it rose in well.

From (feet)	To (feet)	Description of formation material
0	160	SAND, GRAVE & BOULDERS
160	340	BROWN CLAY & SMALL ROCK
340	425	BROWN CLAY LITTLE ROCK
425	525	REDDISH CLAY SOME ROCK
525	595	REDDISH CLAY
595	718	SANDS, ROCK REDDISH (LITTLE CLAY)
718	720	GUNA BALL CLAY

I hereby certify that this well was drilled by me (or under my supervision), and that each and all statements herein contained are true to the best of my knowledge and belief.

Driller Todd Way
Name

PO BOX 130
Address

MORRISTOWN, AZ
City State Zip

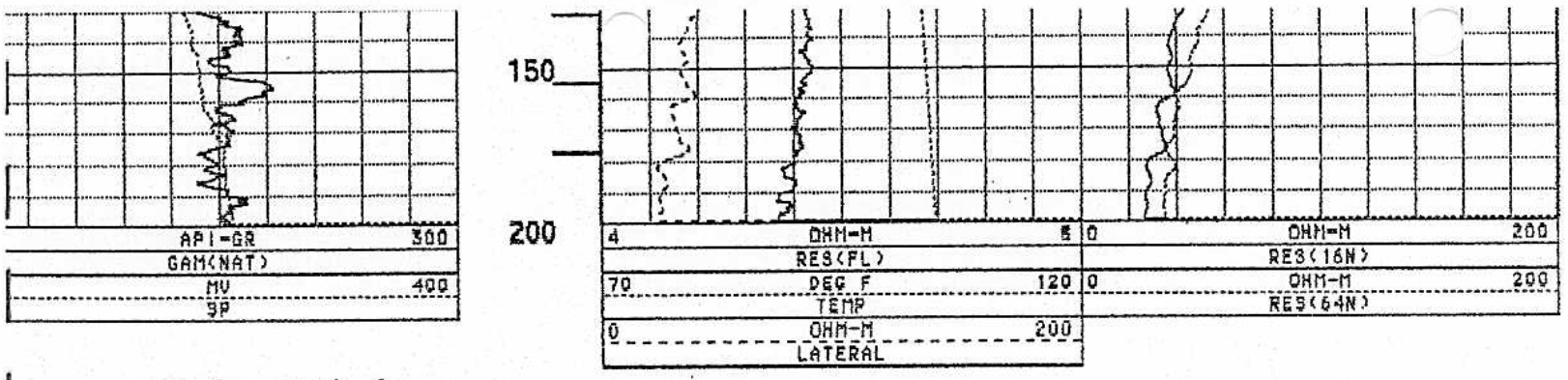
Date 18 OCT 91

Century GEOPHYSICAL CORP.

TOPOCK COMP. ST. # 2

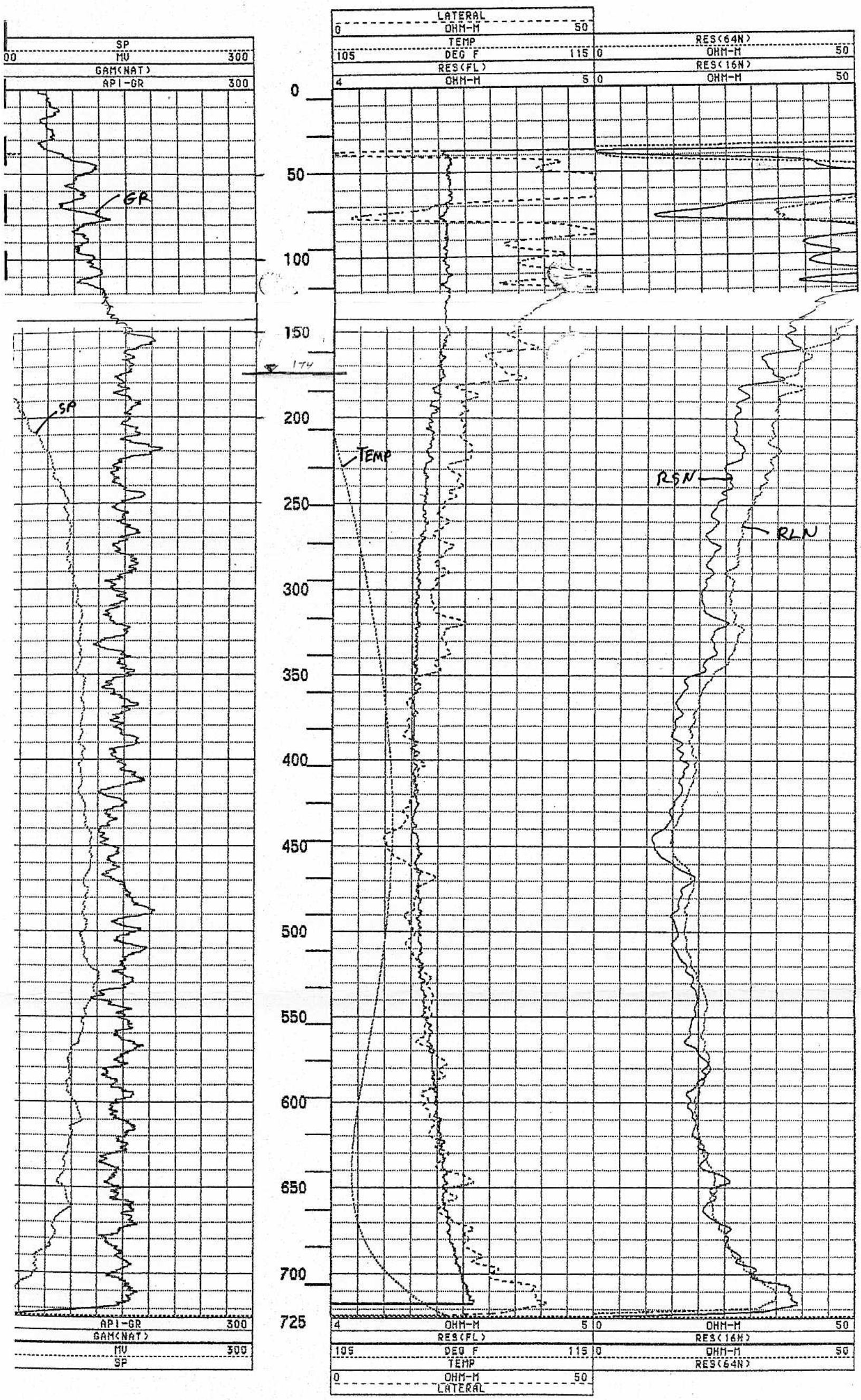
MTS-2

COMPANY	: WAY DRILLING			OTHER SERVICES:	
WELL	: TOPOCK COMP. ST. # 2			FLOW	
LOCATION/FIELD	: TOPOCK AZ				
COUNTY	:				
STATE	: ARIZONA				
SECTION	:	TOWNSHIP	:	RANGE	:
DATE	: 08/31/91	PERMANENT DATUM	: G.L.	ELEVATIONS	
DEPTH DRILLER	:	ELEV. PERM. DATUM:		KB	:
LOG BOTTOM	: 724.60	LOG MEASURED FROM:	T.O.C.	DF	:
LOG TOP	: -7.40	DRL MEASURED FROM:	G.L.	GL	:
CASING DRILLER	: -	LOGGING UNIT	: 9006		
CASING TYPE	: STEEL	FIELD OFFICE	: CHINO VALLEY		
CASING THICKNESS:	.25	RECORDED BY	: R.FEDERWISCH		
BIT SIZE	: 7.8	BOREHOLE FLUID	: BENT	FILE	: ORIGINAL
MAGNETIC DECL.	: 13.5	RM	: 00	TYPE	: 9041A
MATRIX DENSITY	: -	RM TEMPERATURE	: 00	LOG	: 0
FLUID DENSITY	: 7	MATRIX DELTA T	: 00	PLOT	: 41ELOG 3
NEUTRON MATRIX	: SANDSTONE	FLUID DELTA T	: 00	THRESH:	50000



El Paso Natl. Gas
Topock Station
MTS-2

WELL #2 depth 724'



Phoenix, Arizona 85007

MTS-2

Registration No. 55-531890

File No. B(16-21) 36 CBB

COMPLETION REPORT

1. Per A.R.S. §45-600, the Completion Report is to be filed with the Department within 30 days after installation of pump equipment by the registered well owner.
2. Drawdown of the water level for a non-flowing well should be measured in feet after not less than 4 hours of continuous operation and while still in operation and for a flowing well the shut-in pressure should be measured in feet above the land or in pounds per square inch at the land surface.
3. The static groundwater level should be measured in feet from the land surface immediately prior to the well capacity test.
4. The tested pumping capacity of the well in gallons per minute for a non-flowing well should be determined by measuring the discharge of the pump after continuous operation for at least 4 hours and for a flowing well by measuring the natural flow at the land surface.

LOCATION OF THE WELL:

16N	21W	36	NW ¼ NW ¼ SW ¼
Township	Range	Section	

EQUIPMENT INSTALLED:

Kind of pump SUBMERSIBLE
Turbine, centrifugal, etc.

Kind of power ELECTRIC H.P. Rating of Motor 30
Electric, natural gas, gasoline, etc.

Pumping Capacity 200 Date pump installed: 10/1/91
Gallons per minute

WELL TEST:

Test pumping capacity 200 ✓ Date Well Tested: 10/1/91-10/2/91
Gallons per minute

Method of Discharge Measurement METERED
Weir, orifice, current meter, etc.

Static Groundwater Level 174 ft. Drawdown 61 ft.

Total Pumping Lift 235 ft. Drawdown _____ lbs.
(Flowing Well)

I HEREBY CERTIFY that the above statements are true to the best of my knowledge and belief.

Mojave Pipeline Operating Company
Print Well Owner's Name

October 31, 1991
Date

N. Ferguson by
Signature of Well Owner or Agent

P.O. Box 10269
Address

Bakersfield CA 93389
City State Zip

DWR-55-56-2/88

ENTERED JAN 10 1992

MTS-2

WAY'S DRILLING & PUMP CO.

Equipment Report

SUBMERSIBLE PUMP INSTALLATION

CUSTOMER MOJAVE PIPELINE Co. Job No. _____

MAILING ADDRESS _____ Well No. #2

LOCATION TOPOC COMPRESSOR STATION, TOPOC, ARIZONA

SALESMAN S. Lacey DATE 9/26/91 PHONE NO. _____

WELL: Driller WAY'S DRILLING Size 8" Depth 700' Cased STEEL

Perforations 600'-700' Static Water Level 182.23'

History MAKES 200+ GPM

SUBM. PUMP: Make GRUNDFOS (U.S.) Model SP45-225S200-8 Serial No. 9131

Size Drop Pipe 3" GALV. (U.S.) Pump Setting 600' Draw Down 234.65

SUBM. MOTOR: Make FRANKLIN ELEC. (U.S.) Model 2366166020 Code J Date H 91

H.P. 30 Volts 460 Phase 3Ø Cycle 60

Amps. 39.5 S.F. 1.15 S.F.A. 45.2

Megs Ø R.B. RX1 .40-.59 R.Y. RX1 .40-.59 B.Y. RX1 .40-.59

DISCONNECT: Make ITE Model F352 Fuses – Fusetrons 50 AMP FRN

MAGNETIC STARTER: Make FURNAS Size 2½ Heaters K 74

SYSTEM: Tank Size OPEN DISCHARGE Size Drop Cable #6/3 FLAT

Tank Pressure Ø Lightning Arrester NOT INSTALLED @ THIS TIME

OTHER MATERIAL – OPTIONAL EQUIPMENT:

- SOUNDER LINE ALSO INSTALLED (1" PVC)
- BANDED EVERY 100'
- 24 HR PUMP TEST PERFORMED

WAY'S DRILLING
PO BOX 130
MORRISTOWN, AZ
(602) 684-3301/388-2092

MTS-2

PUMP TEST LOG

CUSTOMER: MOJAVE PIPELINE CO. DATE: 9/30 - 10/2

ADDRESS: _____ PHONE: _____

JOB LOCATION: TOPOC COMPRESSOR STATION, TOPOC ARIZONA

METER READING START: 0049500 METER READING END: 0077480

DEPTH OF WELL: 700' SWL: 182.23' PUMP SETTING: 599.05

TOTAL GALLONS PUMPED: 0028030 MAX GPM: 206.00 DRAWDOWN: 234.65 = 52.4'

COMMENTS: GENERATOR (# N170748 100 KW) * SWL WILL VARY W/ THE PUMPING OF WELL #1. GENERATOR (# N21521 100 KW) STARTING HR - 0.0 / ENDING HR 55.3

DATE	TIME	DRAWDOWN	GPM(Q)	ML/S	AMPS	COMMENTS
9/31	1330	182.23'	0	0	62.0 / 520	MALFUNCTION IN SYSTEM 100 PSI (NO FLOW METER)
9/31	1333	— GENERATOR IS SINGLE PHASING —				NOTIFIED EMPIRE OF PROBLEM NEW GENERATOR FOR 10/1
10/1	1330	— START OF 24 HR			PUMP TEST	
	1330	182.23	208.	.10	34.0	70 PSI / 107°F / CLOUDY T/S
	1332	208.41	206. QV	.21	34.0	
	1334	208.57	206.	.13	34.0	
	1336	208.45	206.	.10	33.0	
	1338	208.25	206.	.07	33.0	
	1340	208.16	206.	.05	34.0	70 PSI / 108°F / CLEAR T/S
	1345	207.86	206.	.05	35.0	
	1350	207.88	206.	.04	35.0	
	1355	207.68	206.	.04	33.0	
	1400	207.49	206.	.01	33.0	70 PSI / 108°F / CLEAR NO T/S
10/1	1401	—	—	—	—	WELL #1 IS "ON"

*NOTE: MEASUREMENTS TAKEN FROM TOP OF 8" CASING, FROM 8" CASING TO GROUND LEVEL IS 1.65'

MTS-2

WAY'S DRILLING
PO BOX 130
MORRISTOWN, AZ
(602) 684-3301/388-2092

PUMP TEST LOG

CUSTOMER: MOJAVE PIPELINE CO. PAGE #: 2

DATE	TIME	DRAWDOWN	GPM(Q)	ML/S	AMPS	COMMENTS
10/1	1402	208.36	206.	0	33.0	WELL #1 IS "ON"
	1404	210.10	Q↓			
	1406	212.61	Q↓	.01		70 Psi / 108°F / CLOUDY
	1408	212.90				
	1410	213.50				
	1412	214.01	200. Q↓	.03	34.0	WELL #1 IS "OFF" 70 psi / 108°F / CLOUDY
	1414	212.45				
	1416	210.55	Q↑			
	1418	209.88				
10/1	1420	209.27	206. Q↑	.00	33.0	70 Psi / 108°F / CLEAR
	1422	208.80				
	1424	208.68				
	1426	208.61				
	1428	208.31				
	1430	208.17				10 psi / 108°F / CLEAR NO T/S
	1432	219.13	200 Q↓	.01	32.0	10psi VALVE OPEN Full
	1432					PUMP TEST STOPPED METER INSTALLED
	1434	188.65	0	0	0	PUMP RECOVERED
	1436	182.71	0	0	0	IN 4 MINUTES.
10/1	1530	182.23	206.	.0	32.0	10 psi VALVE OPEN Full 108°F / CLEAR
	1532	215.31	203. Q↓	.0	33.0	
	1534	219.34	201. Q↓	.0	33.0	
10/1	1535	220.85	201. Q↓	.0	33.0	10 psi / 108°F / CLEAR

MTS-2

WAY'S DRILLING
PO BOX 130
MORRISTOWN, AZ
(602) 684-3301/388-2092

PUMP TEST LOG

CUSTOMER: MOJAVE PIPELINE CO. PAGE #: 3

DATE	TIME	DRAWDOWN	GPM(Q)	ML/S	AMPS	COMMENTS
10/1	1545	223.40	200	.00	32.0	10 psi / 108°F / WELL #1 IS "ON"
	1550	229.02				
	1555	229.90				
	1556	229.94	199 Q↓	.00	32.0	WELL #1 IS "OFF"
10/1	1600	227.32	200	.00	32.0	10 psi / 108°F / CLEAR
	1610	225.15				
	1620	225.00				
	1630	225.01				
10/1	1700	224.98	200	.00	32.0	10 psi / 108°F / CLEAR
	1730	225.00				
	1800	225.02				
	1830	225.13				
	1900	225.28				
	2000	225.35				
	2100	225.51				
	2200	225.65				
	2300	225.78				
10/1	2400	225.83	200	.00	32.0	10 psi / 108°F / CLEAR
12 hrs. → 10/2	0100	225.95	200	.00	32.0	10 psi / 108°F / CLEAR
	0200	226.00				
	0300	226.14				
	0400	226.25				
10/2	0500	226.32	200	.00	32.0	10 PSI / 108°F / CLEAR

WAY'S DRILLING
PO BOX 130
MORRISTOWN, AZ
(602) 684-3301/388-2092

MTS-2

PUMP TEST LOG

CUSTOMER: MOJAVE PIPELINE CO. PAGE #: 4

DATE	TIME	DRAWDOWN	GPM(Q)	ML/S	AMPS	COMMENTS
10/1	0600	226.31	200	.00	32.0	10 psi / 105°F / CLEAR
	0621	226.30	200	.00	32.0	WELL #1 IS "ON"
	0626	230.21				
	0631	232.10				
	0635	232.88	199 Q↓	.00	32.0	WELL #1 IS "OFF"
	0640	228.53	200 Q↑	.00	32.0	10 psi / 108°F / CLEAR
	0645	227.90	200	.00	32.0	
	0700	227.18	200	.00	32.0	WELL #1 IS "ON"
	0705	231.70				
	0710	233.01				
	0713	233.38	200	.00	32.0	WELL #1 IS "OFF"
	0730	225.58		.00	32.0	10 psi / 108°F / CLEAR
	0800	227.53				WELL #1 OFF
	0900	225.80				OFF
	1000	226.60				OFF
	1100	226.60				OFF
	1200	226.60				OFF
	1300	226.65				OFF
	1400	227.40				OFF
	1445	226.40	200.0	.00	32.0	10 psi / 108°F / CLEAR
10/2	1446	— END OF	PUMP	TEST		
	1500	182.23	0	0	0	WELL RECOVERED IN FULL-15 MIN.

D3 El Paso Natural Gas Wells (EPNG-1, EPNG-2)

WELL NO.
EPNG-1

LOG OF WELL -- TOPOCK

DOE 1.88 177
155-611577

Indicate depth at which water was first encountered, ~~and the depth and~~ thickness of water bearing beds. If water is artesian, indicate depth at which encountered, and depth to which it rose in well.

From (feet)	To (feet)	Description of formation material
0	60	Surface sand and gravel
60	80	Brown Clay
80	158	Coarse dark sand
158	189	Sandy Brown Clay
189	420	Grey clay
420	443	Bentonite, (white sticky clay) with streaks of grey cl
443	461	Small variegated sand and gravel
461	535	Sand embedded inclay with occasional streaks of blue shale.
535	545	Blue shale
545	555	Sandy clay
555	567	Variegated sand
567	568	Blue shale
568	584	Coarse variegated sand, with streaks of blue shale
584	750	Blue shale with streaks of sandy clay
750	880	Variegated sand with streaks of blue shale

5-7

EL PASO NATURAL GAS COMPANY

WATER WELL DATA REPORT

EPNG-1

Topock Meter STATION

· Well No. 1

· Well Drilled By

ing Completion Date 10-50

B(16-20)11-E1

Elevation 720'

DATA

TOTAL WELL DEPTH - FEET	880
STATIC LEVEL (TOP TO BOTTOM) - FEET	214.5
PUMPING LEVEL (TOP TO BOTTOM) - FEET	290 (est. from measurements of rust on column 75)
DRAW DOWN - FEET	364.5
PUMP SETTING	50
PUMPING CAPACITY G.P.M.	
NO. OF FLATS IMPELLER RAISED FOR TEST	2/2/53
DATE ABOVE TEST TAKEN	O.B. Peacore
TEST SUPERVISED BY	
DATA	
MAKE	Peerless
MODEL	Hi-Lift (temp. Compensate)
TYPE	51
RATED CAPACITY G.P.M.	80503
SERIAL NUMBER OF PUMP	1 3/16"
ROD SIZE	5" ~~8~~ ID
COLUMN SIZE	Hi-Lift Pumping Element
NO. OF BOWLS	Size No. ~~35~~ 53
MOTOR DATA	General Electric
MAKE	5K6503XA2B
MODEL	15
RATED HP	39.2/19.6
AMPS	220/440, 60V, 3 phase
VOLTS	XGU68054515
SERIAL NUMBER OF MOTOR	Type K Code F Frame 6503 Speed 1755 RPM

NG DATA (TOP TO BOTTOM)

____FT. CASING SIZE	8 5/8" Casing
____FT. CASING SIZE	
____FT. CASING SIZE	
____FT. CASING SIZE	
____FT. SCREEN INSTALLED	
____FT. SCREEN INSTALLED	
____FT. PERFORATION	
ER OF PERFORATIONS PER FOOT	
OXIMATE LENGTH EACH PERFORATION ____IN.	
CASING SEAL	

H138652

PGS435211

RKS:

: ATTACH DRILLERS LOG & COPY OF WATER ANALYSIS WHERE AVAILABLE

John L. Allison
PREPARED BY

12/27/54
DATE

G0550660

WATER WELL NO. 2 MOCK METER STATION

EPNG Well #2

Drilled June 1953

Graph of Driller's Log *

Depth in Feet	Thickness in Feet	Formation
0		
	80	Sand
80		
	10	Gravel
90		
	30	Sand & Gravel
120		
125	5	Clay (no sample submitted)
	25	Sand & Gravel
150		
	10	Gravel
160		
	20	Clay
180		
	30	Clay, Sand & Gravel
210		
	30	Silt, Sand & Gravel with some Clay
240		
	107	Clay
347		
	33	Sand & Gravel (WATER)
380		
	123	Sand & Gravel, slightly cemented (WATER)
503		TD

* Corrected to agree with formation samples taken every ten feet; see classification sheet for details.

Casing Schedule

179' 14" OD Electric Welded, EE Pipe for Surface Casing

331.7' of 10 3/4" OD, Solid, Electric Welded, EE Pipe

214 SL

57'00

271 PL

331'

347

160' of 10 3/4" OD, Perforated, Elec. Welded, EE

10' of 10 3/4" OD, Solid, Elec. Welded, EE Pipe with Shoe

setting 407'6" bottom of ff valve 7/18/53

Perf. Interval 331 - 493'

NOTE: Perforations are 1/8" x 12" spaced 4" apart along the length of the pipe in 8 staggered rows 45 degrees apart around its circumference.

PUMP DATA

DRILLING CONTRACTOR
Folk Drilling Co.
Rodeo, New Mexico

Date Begun: 5-26-53
Date Completed: 6-19-53
Rig Type: Bucyrus-Erie Model 24-L Spudder
Drilling Time: 166 hrs.

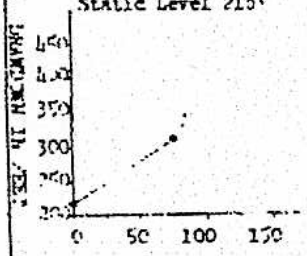
WATER ANALYSIS

pH	
Total Hardness as $CaCO_3$	177
Calcium as $CaCl_2$	85
Magnesium as $CaCO_3$	92
P Alkalinity as $CaCO_3$	0
Total Alkalinity as $CaCO_3$	95
Chloride as Cl	212
Sulfate as SO_4	84
Silica as SiO_2	24
Iron as Fe	
Flouride as F	
Total Dissolved Solids expressed as ppm	643
Spec. Cond., Micromhos	770

TDS 643 ppm

PUMPING TEST

Static Level 218'



LOCATION:

NE 1/4 of SW 1/4 of NW 1/4 of Sec. 14, TWS-16-N, R-20½-W

Elevation:

EL PASO NATURAL GAS COMPANY

Transmission Department

El Paso Texas

DWG. NO. CH-151

Original 1953

TOPOCK METERING STATION - WELL #2

Log of Formations

From (Ft.)	To (Ft.)	Description of Formations
0	50	Surface Sand
50	90	Sand - Coarse Gravel
90	120	Gravel - Coarse Sand
120	125	Gray Clay
125	155	Medium Sand
155	160	Medium Gravel
160	168	Gray Clay
168	185	Blue Clay
185	235	Blue Clay
235	295	Blue Clay
295	347	Blue Clay
347	350	Sand - Gravel (Water at 347 ft.)
350	365	Sand - Gravel
365	373	Sand - Gravel
373	382	Sand - Gravel
382	390	Sand - Gravel
390	400	Sand - Gravel
400	410	Sand - Gravel
410	420	Gravel
420	422	Gravel
422	424	Gravel
424	430	Fine Gravel
430	460	Fine Gravel
460	480	Fine Gravel
480	497	Gravel
497	503	Fine Gravel - (Hard)

This information extracted from daily drilling reports.

Clint de la Houssaye

Southern Division Laboratory
March 18, 1955

PGS435186

H138628

(6)

Form 5-7

EL PASO NATURAL GAS COMPANY

WATER WELL DATA REPORT

Topock Meter STATION

EPNG-2

Water Well No. 2
Water Well Drilled By Folk Drilling Co.
Drilling Completion Date June 19, 1953

WATER DATA

TOTAL WELL DEPTH - FEET	503
STATIC LEVEL (TOP TO BOTTOM) - FEET	214 after 21 hr. shutdown
PUMPING LEVEL (TOP TO BOTTOM) - FEET	284
DRAW DOWN - FEET	70
PUMP SETTING	408.25
PUMPING CAPACITY G.P.M.	56
NO. OF FLATS IMPELLER RAISED FOR TEST	
DATE ABOVE TEST TAKEN	12/21/54
TEST SUPERVISED BY	J. L. Allison

PUMP DATA

MAKE	Peerless
MODEL	
TYPE	Hi-Lift (temp.Conpensat.)
RATED CAPACITY G.P.M.	51
SERIAL NUMBER OF PUMP	80859
ROD SIZE	1 3/16"
COLUMN SIZE	5" Standard (ID)
NO. OF BOWLS	Hi-Lift Pumping Element Size No. 53

PUMP MOTOR DATA

MAKE	U.S. Auto Start
MODEL	
RATED HP	15
AMPS	40/20
VOLTS	220/440, 60 n, 3 phase
SERIAL NUMBER OF MOTOR	961490 Type CFU-H Frame 326-3 Code F Design B

CASING DATA (TOP TO BOTTOM)

_____ FT. CASING SIZE _____
_____ FT. CASING SIZE _____
_____ FT. CASING SIZE _____
_____ FT. CASING SIZE _____
_____ FT. SCREEN INSTALLED
_____ FT. SCREEN INSTALLED
_____ FT. PERFORATION
NUMBER OF PERFORATIONS PER FOOT _____
APPROXIMATE LENGTH EACH PERFORATION _____ IN.
TYPE CASING SEAL _____

PGS435185

REMARKS: _____

NOTE: ATTACH DRILLERS LOG & COPY OF WATER ANALYSIS WHERE AVAILABLE

John L. Allison
PREPARED BY

1-10-55
DATE

H138627

(5)

G0550635

3

Well #2 Topock Camp

DEPARTMENT OF WATER RESOURCES
99 EAST VIRGINIA AVENUE
PHOENIX, ARIZONA 85004

REGISTRATION OF EXISTING WELLS

READ INSTRUCTIONS ON BACK OF THIS FORM BEFORE COMPLETING
PRINT OR TYPE — FILE IN DUPLICATE

02

FOR OFFICE USE ONLY	
REGISTRATION NO. 55-	611578
FILE NO.	B(16-20½)14bca
FILED (DATE)	5/27/82 AT (TIME) 9:31
INA	—
AMA	—

REGISTRATION FEE (CHECK ONE)	
EXEMPT WELL (NO CHARGE)	☐
NON-EXEMPT WELL – $10.00	☒

1. Name of Registrant:

El Paso Natural Gas Company

P. O. Box 1492 (Address) | El Paso (City) | Texas (State) | 79978 (Zip)

well #2
EPNG-2

2. File and/or Control Number under previous groundwater law:

B(16-20½) 14 bca (File Number) 35- (Control Number)

3. a. The well is located within the NE ¼ SW ¼ NW ¼, Section 14, of Township 16 N/S, Range 20½ E/W, G & SRB & M, in the County of Mohave.

   b. If in a subdivision: Name of subdivision _____, Lot No. _____, Address _____.

4. The principal use(s) of water (Examples: irrigation - stockwater - domestic - municipal - industrial)
Domestic.

5. If for irrigation use, number of acres irrigated from well _____.

6. Owner of land on which well is located. If same as Item 1, check this box ☒

_____
(Address) (City) (State) (Zip)

7. Well data (If data not available, write N/A)
   a. Depth of Well 503 feet
   b. Diameter of casing 10-3/4 inches
   c. Depth of casing 503 feet
   d. Type of casing Steel slotted.
   e. Maximum pump capacity 70 gallons per minute.
   f. Depth to water (240) 214' feet below land surface.
   g. Date well completed 6 (Month) 19 (Day) 1953 (Year).

8. The place(s) of use of water. If same as Item 3, check this box ☐.
SW ¼ NW ¼ ____¼, Section 14 Township 16N Range 20½W
____¼ ____¼ ____¼, Section ____ Township ____ Range ____
Attach additional sheet if necessary.

9. DATE 5-26-82 SIGNATURE OF REGISTRANT John W. McCarthy

4

STATE OF ARIZONA
DEPARTMENT OF WATER RESOURCES
15 South 15th Avenue
Phoenix, Arizona 85007

WELL DRILLER REPORT

OCT 15 1990

This report should be prepared by the driller in all detail and filed with the Department within 30 days following completion of the well.

1. Owner EL PASO NATURAL GAS COMPANY
   Name
   8645 RAILROAD DRIVE EL PASO TEXAS 79904
   Mailing Address
2. Driller ODOM'S INC.
   Name
   327 N. 1st STREET BUCKEYE ARIZONA 85326
   Mailing Address
3. Location of well: Twn 16N, RGE 20½W SEC. 14 NE, SW, NW
4. Permit No. 55-529685 (If issued)

EPNG-2
recomplete 1990

DESCRIPTION OF WELL

5. Total depth of hole 500 ft.
6. Type of casing STEEL
7. Diameter and length of casing 8 in. from 0 to 500, ____ in from ____ to ____.
8. Method of sealing at reduction points STEEL PLATE
9. Perforated from 322 to 482, from ____ to ____, from ____ to ____.
10. Size of cuts 3/16' Number of cuts per foot 20
11. If screen was installed: Length ____ ft. Diam ____ in. Type ____
12. Method of construction ____
    drilled, dug, driven, bored, jetted, etc
13. Date started OCTOBER (Month) 1 (Day) 1990 (Year)
14. Date completed OCTOBER (Month) 7 (Day) 1990 (Year)
15. Depth to water ____ ft. (If flowing well, so state)
16. Describe point from which depth measurements were made, and give sea-level elevation if available ____
17. If flowing well, state method of flow regulation: ____
18. Remarks: 8" CASING INSTALLED AND WELL CLEANED OUT ONLY:

DO NOT WRITE IN THIS SPACE

REG. No. 55-529685
File No. B(16-20.5)14 BCA
Entered ENTERED OCT 16 1990 BY ____

DWR-55-55-2/89

ARIZONA DEPARTMENT OF WATER RESOURCES
500 North Third Street
Phoenix, Arizona 85004

WELL DRILLER REPORT

This report should be prepared by the driller in all detail and filed with the Department within 30 days following completion of the well.

RECEIVED
MAR 3 2000
RECORDS MGT

ADOT - New well
Nov. 1999

1. DRILL-TECH, INC.
P.O. BOX 3568
CHINO VALLEY, AZ 86323-3568

2. Owner Name: ADOT
Address: 206 S 17th Ave 176 A Phoenix, Az 85007
City State Zip
T16N, R20W

3. Location: 16 N N/S 20.5W E/W 14 ¼ NW ¼ NE ¼ SW
Township Range Section 10-acre 40-acre 160-acre

4. Well Registration No. 55- 577479 (Required)
5. Permit No. _____ (If issued)

DESCRIPTION OF WELL

6. Total depth of hole 530 ft.
7. Type of casing Steel 8.62
8. Diameter and length of casing 16in. from 0 to 20 , 12.75in from 0 to 530
9. Method of sealing at reduction points _____
10. Perforated from _____ to _____ ,from _____ to _____ from _____ to _____
11. Size of cuts _____ Number of cuts per foot _____
12. If screen was installed: Length _____ ft. Diam _____ in. Type _____
13. Method of construction Drilled
(drilled, dug, driven, bored, jetted, etc)
14. Date started October 18, 1999
Month Day Year
15. Date completed November 18, 1999
Month Day Year
16. Depth to water 220 ft. (If flowing well, so state)
17. Describe point from which depth measurements were made, and give sea-level elevation if available
_____
18. If flowing well, state method of flow regulation: _____
19. Remarks: 12.75 .250 wall
s/blank 0-257' 8.62" 200'
.188 wall sch 10 304s/s
blank 120'
~~8.62 extra heavy 304~~ wire
wrap 200'

DWR-55-55-7/95 (Rev.)

DO NOT WRITE IN THIS SPACE
OFFICE RECORD

Registration No. 55-577479
File No. B(16-20.5) 14 CAB
Received _____ By _____
Entered _____ By _____

ANSWERED MAR 1 3 2000

D4 Arizona Department of Transportation Wells (ADOT-New, ADOT-Old)

LOG OF WELL ADOT - New Well Nov. 1999

Indicate depth at which water was first encountered, and the depth and thickness of water bearing beds. If water is artesian, indicate depth at which encountered, and depth to which it rose in well.

From (feet)	To (feet)	Description of formation material
0	52	Sandy Silt Caliche Zones present grayish white
52	72	Silty Sandy Gravel
72	92	Silty Gravely Sand
92	102	Silty Sand
102	180	Silty Sand & Gravel
180	210	Silty Sand & Clay
210	230	Clayey Gravelly Sand
230	240	Sand
240	278	Sandy Clay
278	293	Claystone Lightly to moderately
293	310	Clayey Sandy Gravel
310	330	Sandy Gravel
330	340	Feet sieve Sample
340	530	Sandy Gravel

I hereby certify that this well was drilled by me(or under my supervision), and that each and all statements herein contained are true to the best of my knowledge and belief.

Driller Name: DRILL-TECH, INC.

P.O. BOX 3568
Street

CHINO VALLEY, AZ 86323-3568
City State Zip Phone N

Garth R. Dunn 3-02-00
Signature of Driller Date

ADOT - old well

ARIZONA HIGHWAY DEPARTMENT
WELL DESCRIPTION LOG

RECEIVED
JUN 22 1972
ARIZONA HIGHWAY DEPARTMENT
ROADSIDE DEVELOPMENT DIV.

ROADSIDE DEVELOPMENT

5/16/72 thru 5/18/72
(Date)

Sheet 1 of 4

WELL DESCRIPTION

LOCATION: Topock Maint. Camp - Ariz. Hwy. Dept. COUNTY: Mohave

WELL NO. OR OTHER IDENTIFICATION: AEE 05000 DATE WELL COMPLETED: 6/6/72

DRILLER: Penrod Drilling Co. ADDRESS: Kingman, Ariz.

ADOT - Old

TOP OF CASING TO BE 1 FOOT ABOVE GROUND LEVEL

GROUND LEVEL

CASING WALL THICKNESS: 0.322"

PERFORATED
FROM ____' TO ____'
FROM ____' TO ____'

WATER LEVELS

INDICATE ALL WATER ZONES ON THE GRAPHIC LOG AT RIGHT WITH DEPTH AND THICKNESS OF EACH ZONE.

QUANTITY

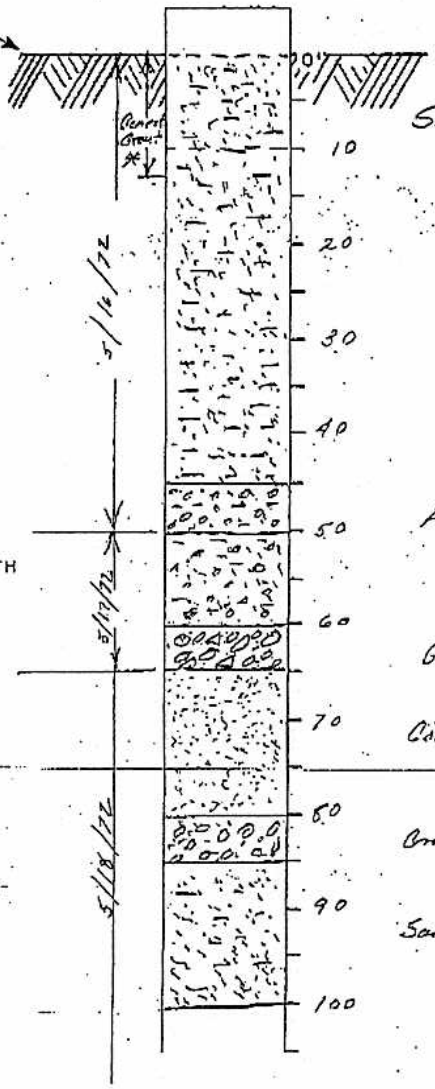
GIVE AMOUNT OF WATER IN EACH ZONE AND NOTE WHETHER THIS IS AN ESTIMATE OR BASED UPON A BAILER TEST.

TYPE OF SHOE:

DRILLING LOG

DESCRIBE FORMATIONS AND GIVE DEPTHS FOR EACH TYPE OF MATERIAL. SHOW FORMATIONS ON GRAPHIC LOG ALSO BY USING SYMBOLS SHOWN ON THE BACK OF THIS SHEET.

Interval = 5'



Sand / some silt

* Casing encased in cement grout

Fine Gravel / silt

Gravel
Course Sand
} poorly consolidated

(Caving at approx. 60' to 80'
Set 12" casing to 80'

Gravel - well consolidated

Sand & Clay

- Use second sheet if necessary -

AHD 60-4415 1-69

ARIZONA HIGHWAY DEPARTMENT
WELL DESCRIPTION LOG

5/18/72 thru 5/20/72
(Date)

Sheet 2 of 4

WELL DESCRIPTION

LOCATION: Topock Maint. Camp - Ariz. Hwy. Dept. COUNTY: Mohave

WELL NO. OR OTHER IDENTIFICATION: AFE 05000 DATE WELL COMPLETED: 6/6/72

DRILLER: Preston Penrod ADDRESS: Kingman, Ariz

DRILLING LOG

DESCRIBE FORMATIONS AND GIVE DEPTHS FOR EACH TYPE OF MATERIAL. SHOW FORMATIONS ON GRAPHIC LOG ALSO BY USING SYMBOLS SHOWN ON THE BACK OF THIS SHEET.

TOP OF CASING TO BE 1 FOOT ABOVE GROUND LEVEL

GROUND LEVEL

CASING WALL THICKNESS: 0.322"

PERFORATED

FROM ____' TO ____'

FROM ____' TO ____'

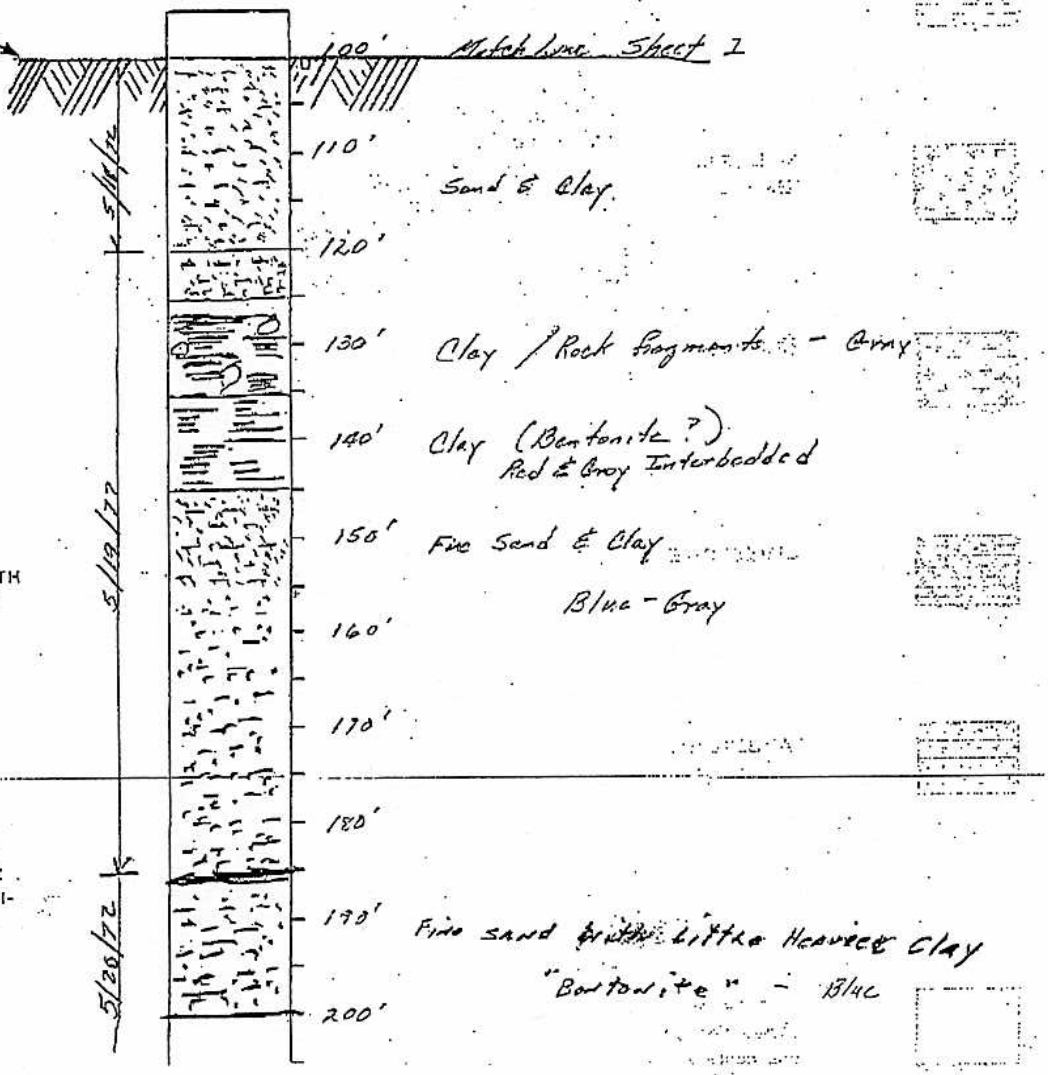
WATER LEVELS

INDICATE ALL WATER ZONES ON THE GRAPHIC LOG AT RIGHT WITH DEPTH AND THICKNESS OF EACH ZONE.

QUANTITY

GIVE AMOUNT OF WATER IN EACH ZONE AND NOTE WHETHER THIS IS AN ESTIMATE OR BASED UPON A BAILER TEST.

TYPE OF SHOE:



- Use second sheet if necessary -

ARIZONA HIGHWAY DEPARTMENT
WELL DESCRIPTION LOG

5/20/72 thru 5/22/72
(Date)

WELL DESCRIPTION

sheet 3 of 4

LOCATION: Topock Maint. Camp - Ariz Hwy Dept. COUNTY: Mohave

WELL NO. OR OTHER IDENTIFICATION: AFE 05000 DATE WELL COMPLETED: 6/6/72

DRILLER: Preston Penrod ADDRESS: Kingman, Ariz.

TOP OF CASING TO BE
1 FOOT ABOVE GROUND LEVEL

GROUND LEVEL

CASING WALL THICKNESS: 0.322"

PERFORATED
FROM 290 TO 385
FROM ____ TO ____

WATER LEVELS

INDICATE ALL WATER ZONES ON THE GRAPHIC LOG AT RIGHT WITH DEPTH AND THICKNESS OF EACH ZONE.

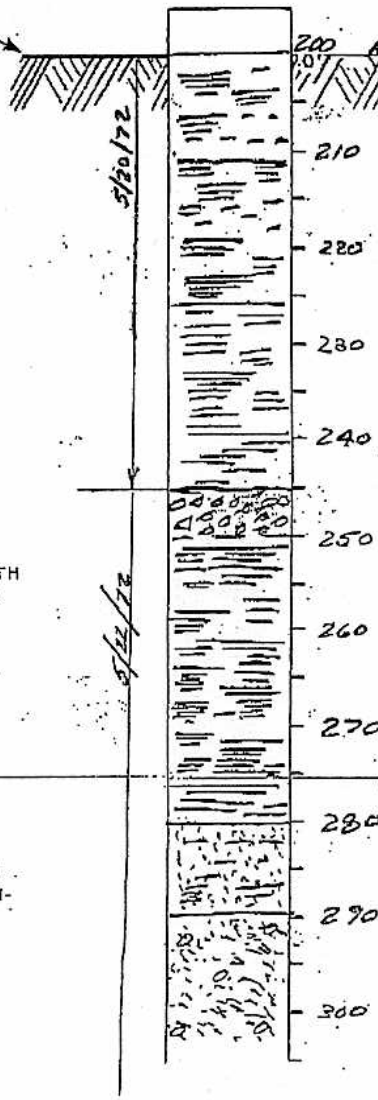
QUANTITY

GIVE AMOUNT OF WATER IN EACH ZONE AND NOTE WHETHER THIS IS AN ESTIMATE OR BASED UPON A BAILER TEST.

TYPE OF SHOE:

DRILLING LOG

DESCRIBE FORMATIONS AND GIVE DEPTHS FOR EACH TYPE OF MATERIAL. SHOW FORMATIONS ON GRAPHIC LOG ALSO BY USING SYMBOLS SHOWN ON THE BACK OF THIS SHEET.



200 Match Line sheet #2

210 Blue color Bentonite Clay

Gravel — Estimated ½ gpm/min. water 245 to 250

Clay Gray - Bentonite

(Water inflow, probably begins at 280±)

* Coarse sand & clay (Buff colored)

Course sand with a few rock fragments

* Water 280' to 340', possibly some water 340' to 393', Water raised to 175' ± - drew down to 270' during 24 hr. pump test conducted 6/6/72

Use second sheet if necessary.

24 hr. Pump test 37 G.P.M. for 24 hrs. no decrease in water inflow.

ARIZONA HIGHWAY DEPARTMENT
WELL DESCRIPTION LOG

5/23/72 Hma
(Date)

Sheet 4 of 4

WELL DESCRIPTION

LOCATION: Tejocek Maint Camp - Ariz. Hwy Dept. COUNTY: Mohave

WELL NO. OR OTHER IDENTIFICATION: AFE 05006 DATE WELL COMPLETED: 6/9/72

DRILLER: Preston Pennel ADDRESS: Kingman, Ariz.

ADOT-old

TOP OF CASING TO BE
1 FOOT ABOVE GROUND LEVEL

DRILLING LOG

DESCRIBE FORMATIONS AND GIVE DEPTHS FOR EACH TYPE OF MATERIAL. SHOW FORMATIONS ON GRAPHIC LOG ALSO BY USING SYMBOLS SHOWN ON THE BACK OF THIS SHEET.

GROUND LEVEL

Natural Line 300

Course Sand (Hard)

310

320

Gravel (Conglomerate?) (Hard)
Gray

330

340

Gravel (Hard) (Conglomerate?)
Redish

350

360

370

Course Sand with Rock Fragments, Hard
Redish

380

390

Bottom — Depth 396±
Conglomerate(?) Very Hard, Buff color

400

CASING WALL THICKNESS: 0.322"

PERFORATED
FROM 290 TO 385
FROM ____ TO ____

5/24/72

5/25/72

5/26/72

5/27/72 TO BOTTOM

WATER LEVELS

INDICATE ALL WATER ZONES ON THE GRAPHIC LOG AT RIGHT WITH DEPTH AND THICKNESS OF EACH ZONE.

QUANTITY

GIVE AMOUNT OF WATER IN EACH ZONE AND NOTE WHETHER THIS IS AN ESTIMATE OR BASED UPON A BAILER TEST.

TYPE OF SHOE:
8" ID - Forge heat treated
Rockwell 'C' hardness 30-32

- Use second sheet if necessary -

AHD 60-4415 1-69

ARIZONA DEPARTMENT OF TRANSPORTATION
MAINTENANCE SECTION

PUMP AND WATER SYSTEM DATA

LOCATION:

NAME Needle Mtn. M/C ADOT - Old Well

ADDRESS I-40

DATE 7/1/99

SYSTEM NO. 08-303

PHONE NO. 768-4355

WELL NO. 55628108

REQUISITION NUMBERS

	MAKE	MODEL	INSTALLED	HP	VOLTS	S AMPS	R AMPS	PHASE	MEGS	L.M.	L.C.	M.C.
MOTOR AND PUMP DATA	Franklin		7/1/99	7.5	230	23.0	18A	3		1.2	1.2	2.4
	Grundfos	60S7 5-13	10/29/96	"	"		18A	"			"	

	DRILLER	DRILLED	DEPTH	DIAM	CASED	PERFORATIONS	STATIC	PUMP SETTING	DRAW DOWN	RECOVERY RATE	SURF. DISCH.	TANK
WELL DATA	Pearce	6/72	327'	2"	8" ALL	290-385	207'	315'	22'		60gpm	3-12,000 gal
												1,500 pressure

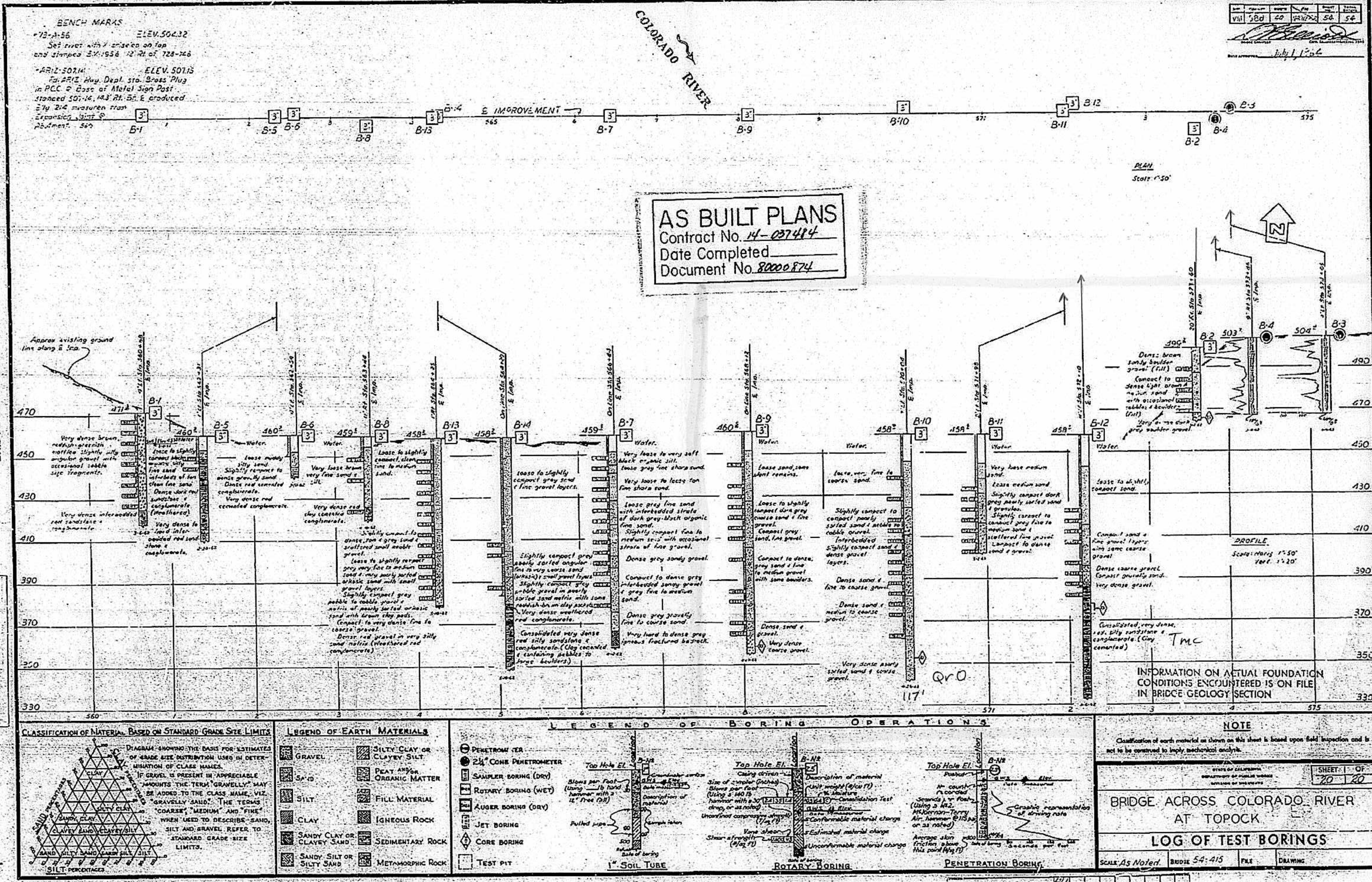
	PIPE SIZE	LENGTHS	CHECK VALVES	SPECIAL FITTINGS - SIZE AND DESCRIPTION
WELL PIPING DATA	2"	20	1	20' up from pump
			SIZE 2½"	

	MAKE	MODEL	FUSES	WIRE SIZE	PROTECTION DEVICES	YES	NO	
PUMPING PLANT PANEL	Furnas	Size 1	Breaker 60A	#6	LIGHTING ARRESTORS		✓	Press. Syst. = I-Sta-rite DHHG-3-53
				TYPE	PHASE PROTECTORS		✓	230V/3Ø/2 HP - Furnas ESP100
								11.5A (11/96) 14DSF32AA

COMMENTS ON THE WELL:

- removed the check valve from top of pump 7/1/99
also contains high-low probes - low 10' above pump, high 35' above pump
→ not hooked up!

Appendix E
Caltrans I-40 Bridge Boring Logs



I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN

Approx. existing ground line along ℄ Imp.

4' Lt. Sta. 560+68 ℄ Imp.

11' Lt. Sta. 562+31 ℄ Imp.

4' Lt. Sta. 562+54 ℄ Imp.

11' Rt. Sta. 563+44 ℄ Imp.

11' Rt. Sta. 564+25 ℄ Imp.

On Line Sta. 564+29 ℄ Imp.

On Line Sta. 566+44 ℄ Imp.

B-1 3" — 471.3

B-5 3" — 460.2

B-6 3" — 460.2

B-8 3" — 459.5

B-13 3" — 458.2

B-14 3" — 458.2

B-7 3" — 459.3

470

450

430

410

390

370

350

330

Very dense brown, reddish-greenish mottled slightly silty angular gravel with occasional cobble size fragments.

Very dense interbedded red sandstone & conglomerate.

3-6-62

GWS Elev 457.2 Water 3-8-62

Loose to slightly compact black organic silty fine sand interbeds of tan clean fine sand.

Dense dark red sandstone & conglomerate (Weathered)

Very dense to hard interbedded red sandstone & conglomerate.

3-30-62

Water.

Loose muddy silty sand.

Slightly compact to dense gravelly sand.

Dense red cemented conglomerate.

3-31-62

Very dense red cemented conglomerate.

Water.

Very loose brown very fine sand & silt.

Very dense red clay cemented conglomerate.

4-10-62

Loose to slightly compact, clean, fine to medium sand.

Slightly compact to dense, tan & grey sand & scattered small pebble gravel.

Loose to slightly compact grey very fine to medium sand & very poorly sorted arkosic sand with small gravel layers.

Slightly compact grey pebble to cobble gravel & matrix of poorly sorted arkosic sand with brown clay pods.

Compact to very dense fine to coarse gravel.

Dense red gravel in very silty sand matrix. (Weathered red conglomerate)

5-10-62

Loose to slightly compact grey sand & fine gravel layers.

Slightly compact grey poorly sorted angular fine to very coarse sand (arkosic) & small gravel layers.

Slightly compact grey pebble gravel in poorly sorted sand matrix with some reddish-brown clay pockets.

Very dense weathered red conglomerate.

Consolidated very dense red silty sandstone & conglomerate (Clay cemented & containing pebbles to large boulders.)

5-16-62

Water.

Very loose to very soft black organic silt.

Loose grey fine sharp sand.

Very loose to loose tan fine sharp sand.

Loose grey fine sand with interbedded strata of dark grey-black organic fine sand.

Slightly compact fine to medium sand with occasional strata of fine gravel.

Dense grey sandy gravel.

Compact to dense grey interbedded sandy gravel & grey fine to medium sand.

Dense grey gravelly fine to coarse sand.

Very hard to dense grey igneous fractured bedrock.

4-4-62

1 2 3 4 5 6 7

20' Rt. Sta. 573+60 ℄ Imp.

9' Rt. Sta. 573+85 ℄ Imp.

4' Lt. Sta. 574+05 ℄ Imp.

B-2 — 499.2 — 3" — B-4 — 503.1 — B-3 — 504.4

Dense brown sandy boulder gravel. (Fill)

Compact to dense light brown medium sand with occasional cobbles & boulders (Fill)

Very dense dark grey boulder gravel.

3-7-62

100 — 100 — 100

C 78 5/12"

3-9-62

C 60 3/12"

3-9-62

On Line Sta. 568+12 ℄ Imp.

B-9 — 460.5 — 3"

Water.

very soft ilt.

sharp sand.

loose tan

ne sand d strata lack organic

ct fine to th occasional gravel.

sandy gravel.

dense grey ndy gravel medium

ravelly sand.

dense grey ed bedrock.

Loose sand, some plant remains.

Loose to slightly compact dark grey coarse sand & fine gravel.

Compact grey sand, fine gravel.

Compact to dense, grey sand & fine to medium gravel with some boulders.

Dense sand & gravel.

AX

Very dense coarse gravel.

4-17-62

7' Lt. Sta. 570+04 ℄ Imp.

B-10 — 458.2 — 3"

Water.

Loose, very fine to coarse sand.

Slightly compact to compact poorly sorted sand & pebble to cobble gravel.

Interbedded slightly compact sand & dense gravel layers.

Dense sand & fine to coarse gravel.

Dense sand & medium to coarse gravel.

AX

Very dense poorly sorted sand & coarse gravel.

4-29-62

2' Lt. Sta. 571+98 ℄ Imp.

B-11 — 458.5 — 3"

Water.

Very loose medium sand.

Loose medium sand.

Slightly compact dark grey poorly sorted sand & granules.

Slightly compact to compact grey fine to medium sand & scattered fine gravel.

Compact to dense sand & gravel.

5-2-62

11' Lt. Sta. 572+10 ℄ Imp.

B-12 — 458.1 — 3"

Water.

Loose to slightly compact sand.

Compact sand & fine gravel layers with some coarse gravel.

Dense coarse gravel.

Compact gravelly sand.

Very dense gravel.

AX

Consolidated, very dense, red, silty sandstone & conglomerate (Clay cemented)

5-6-62

490

470

450

430

410

390

370

350

330

PROFILE

Scale: Horiz. 1"=50'

Vert. 1"=20'