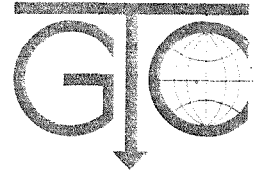


GEOTECHNICAL CONSULTANTS, INC.

Berkeley • Burbank • Santa Ana • Ventura, California



HYDROGEOLOGIC INVESTIGATION

**MISSION CREEK SUBBASIN
WITHIN THE DESERT HOT SPRINGS
COUNTY WATER DISTRICT**

for

DESERT WATER AGENCY

NOVEMBER, 1979

TABLE OF CONTENTS

	<u>Page</u>
INTRODUCTION	1
GENERAL STATEMENT	1
PURPOSE	1
SCOPE	2
FINDINGS	3
AREA OF INVESTIGATION	3
Regional Physiography	3
Background Information	4
Boundaries and Study Area Physiography	4
Climate and Drainage	5
AVAILABILITY OF BASIC DATA	8
General Statement	8
Water Well Locations and Boring Logs	9
Water Level and Water Quality Data	10
Specific Capacity Data	11
GEOPHYSICAL DATA	11
SOURCES OF WATER SUPPLY	12
Historical Development	12
Present Supplies	14
GEOLOGY	15
Background Information	15
Structure	17
HYDROGEOLOGY	18
General Statement	18
Water-Bearing Sediments	18
Semiwater-Bearing Sedimentary Rocks	20
Nonwater-Bearing Rocks	22
Occurrence and Movement of Ground Water	24
Hydrographs	27
Well Characteristics and Well Logs	29
Theoretical Aquifer Parameters	32
Analysis of Storativity	34
Predicted Future Drawdown	36
GEOHYDROLOGY	38
Ground Water in Storage	38
Ground Water in Storage by Others	38
Change in Ground Water in Storage	39
Change in Ground Water in Storage by Others	40

TABLE OF CONTENTS

(Continued)

	<u>Page</u>
WATER QUALITY	41
General Statement	41
Chemical Character	41
Water Quality Trends	44
SUMMARY AND CONCLUSIONS	45
1.10 GENERAL	45
1.20 AVAILABILITY OF BASIC DATA	45
1.30 GEOLOGY, GEOPHYSICS AND STRUCTURE	46
1.40 HYDROGEOLOGY	46
1.41 Water-Bearing Sediments	46
1.42 Occurrence and Movement of Ground Water	47
1.43 Water Level Fluctuations	48
1.44 Hydrograph Trends	48
1.50 AQUIFER CHARACTERISTICS	49
1.51 Transmissivity, Specific Capacity	49
1.60 GEOHYDROLOGY	49
1.61 Ground Water in Storage	49
1.62 Changes in Ground Water in Storage	49
1.70 WATER QUALITY	50
1.71 Chemical Character	50
1.72 Water Quality Trends	51
1.80 DISTRICT WELLS	51
1.81 Pump Bowl Settings	51
1.82 Casing Perforations	52
1.83 Specific Capacity Data	52
RECOMMENDATIONS	
2.10 GENERAL STATEMENT	52
2.20 CONSTRUCTION OF NEW WELLS	53
2.21 Well Locations	53
2.22 Well Design	54
2.23 Well Specifications	55
2.30 VIABILITY OF EXISTING WELLS	56
2.31 Well Abandonment	56
REFERENCES CITED	58
TABLE	
Table 1	Summary of Water Well Data
PLATES	
Plate 1	Location Map
Plate 2	Ground Water Basin Subdivisions
Plate 3	Annual Precipitation
	Following 29
	See 1
	" 4
	" 6



TABLE OF CONTENTS
(Continued)

		<u>Page</u>
PLATES		
Plate 4	Ground Water Extractions	See 14
Plate 5	Regional Geologic Map	" 15
Plate 6	Geological Sections A-A' and B-B'	" 15
Plate 7	Geologic Map of Study Area	" 18
Plate 8	Hydrogeologic Sections, C-C', D-D' and E-E'	" 18
Plate 9	Water Level Contour Map Spring 1978	" 24
Plates 10.1 and 10.2	Water Well Hydrographs	" 27
Plate 11	Specific Capacity and Transmissivity Map	" 31
Plate 12	Predicted Future Drawdown	" 36
Plate 13	Stiff Diagrams	" 41
Plate 14	Fluoride, Sulfate and Total Dissolved Solids Concentration Map	" 42
Plate 15	Recommended Water Well Location Map	" 53

APPENDIX A

GLOSSARY OF HYDROGEOLOGIC TERMS	A-1
Table A-1 Geologic Time Scale	A-8

APPENDIX B

AQUIFER TESTING AND WATER QUALITY DATA	B-1
TERMINOLOGY	B-1
ANALYSIS OF DATA	B-1
TABLES	
Table B-1 Observations Made during the Aquifer Tests	B-3
Table B-2 Temperature Data Obtained during the Aquifer Tests	B-4
PLATES	
Plates B-1.1 through B-1.4	Aquifer Test - Field Test Data
Plates B-2.1 through B-2.5	Drawdown and Recovery Data
Plates B-3.1 through B-3.9	General Mineral Analysis

TABLE OF CONTENTS

(Continued)

PageAPPENDIX C

GROUND WATER STORAGE		C-1
GENERAL STATEMENT		C-1
Classification of Materials		C-2
GROUND WATER STORAGE		C-2
TABLES		
Table C-1	Selected Specific Yield Values	C-3
Table C-2	Total Ground Water in Storage	C-4
PLATE		
Plate C-1	Ground Water Storage Zones	See C-1

APPENDIX D

WATER WELL IDENTIFICATION SYSTEM		D-1
Plate D-1	Water Well Location Map	See D-2

APPENDIX E

GEOPHYSICAL REPORT

INTRODUCTION

GENERAL STATEMENT

Presented in this report for the Desert Water Agency and the Desert Hot Springs County Water District are the findings, conclusions and recommendations of our hydrogeologic investigation of the portion of the Mission Creek Subbasin which underlies the service area of the Desert Hot Springs County Water District in the Upper Coachella Valley region of Riverside County, California. As shown on Plate 1 - Location Map, the 33-square mile study area which is served by the District also represents the northern portion of the distribution area of the Desert Water Agency.

Located within the study area are portions of the City of Desert Hot Springs and the community of North Palm Springs. The city of Banning is 21 miles west of Desert Hot Springs; Palm Springs is approximately ten miles to the south, while Indio lies 23 miles to the southeast.

Included within this report is a Glossary of Hydrogeologic Terms (Appendix A) to provide the reader with definitions of important ground water terms. Also, to familiarize the reader with additional concepts of geologic history, we have presented Table A-1 - Geologic Time Scale, in Appendix A.

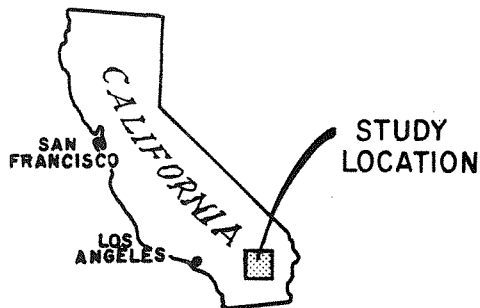
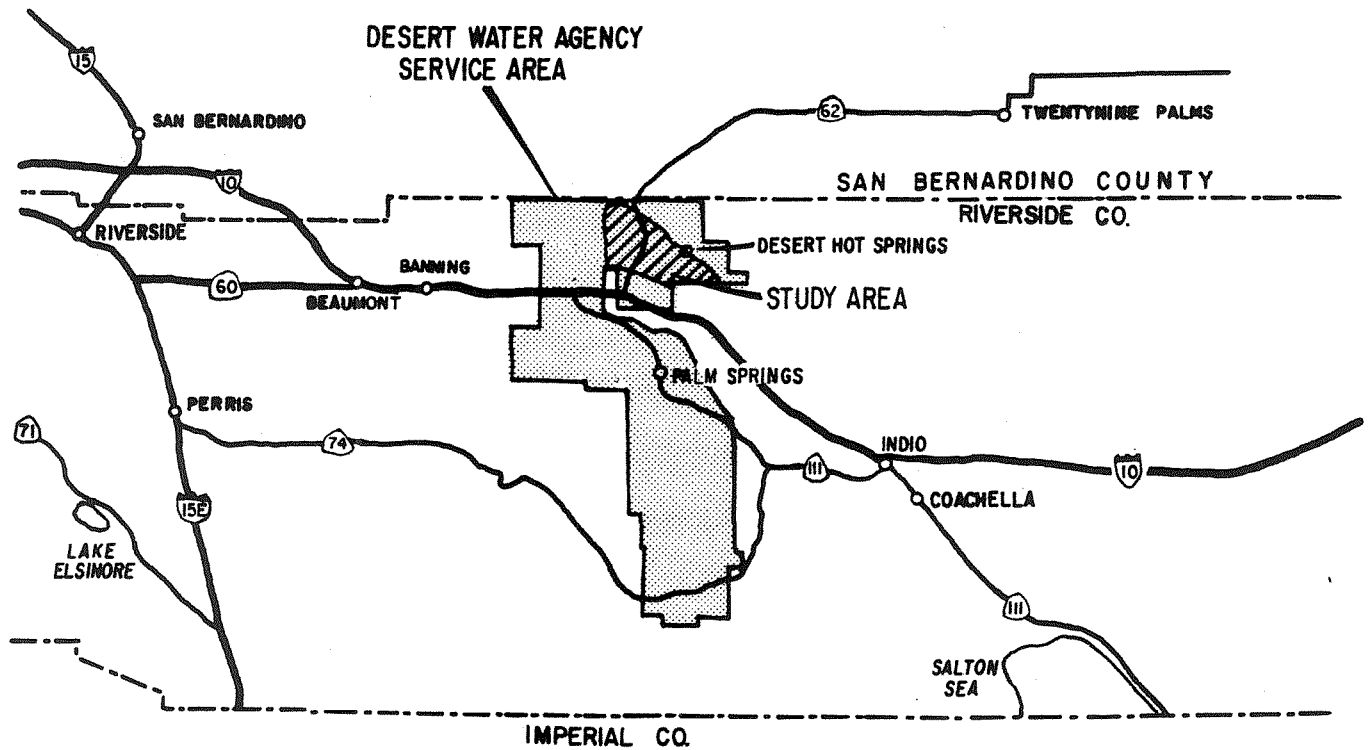
PURPOSE

Our study was initiated in July 1978 with overall goals being to:

- 1) determine the hydrogeologic configuration of and to develop basic hydrogeologic data for the subbasin;
- 2) provide an estimate of ground water in storage available to the Desert Hot Springs County Water District;
- 3) determine



LOCATION MAP



SCALE 1" = 16 MILES

STUDY CONDUCTED FOR DESERT WATER AGENCY



optimum areas for new production water wells based on basin hydrogeology; 4) recommend design and construction technology in new water wells based on basin hydrogeology; 5) recommend sampling and testing techniques to obtain better hydrogeologic data.

SCOPE

The scope of work for this project was developed through discussions and meetings with Messrs. Paul Payne, General Manager, and Erwin Null, Chief Engineer of the Desert Water Agency; and with Mr. Robert Krieger of Krieger & Stewart, Inc., Riverside, California. The scope was outlined in our letter of proposal dated May 2, 1978 and can be summarized as follows. The scope was divided into three phases. Phase I was to consist of research whereby we would obtain and review available geologic and hydrogeologic literature and data to determine material useful to the study area. Where possible, we should develop basic hydrogeologic data from sources within the study area. Data developed during research would be analysed and put into forms useful to the Agency. This was to include new estimates of ground water in storage. Progress meetings with the District were also planned. Phase II was to consist of a final report of findings, conclusions and recommendations. The scope was made flexible to allow for the implementation of Phase III subsurface exploration by Geophysical Survey if basin data was generally lacking. This was the case as discovered in Phase I and therefore Phase II was postponed to allow for the completion of Geophysical Surveys.

FINDINGS

AREA OF INVESTIGATION

Regional Physiography. The study area is found in the north end of the Coachella Valley. The Coachella Valley is the north part of a large structural depression known as the Salton trough. This ± 125 -mile long structural depression begins in the Gulf of California and includes the Imperial Valley and the Salton Sea area.

Boundaries of the Coachella Valley extend from the east end of San Geronio Pass to the Salton Sea. The north and east limits of the Valley near the study area are the San Bernardino and Little San Bernardino Mountains. The San Jacinto and Santa Rosa Mountains border the southwest side of the Valley.

Rugged relief and poorly accessible terrain characterize the east-west trending San Bernardino Mountains and the Little San Bernardino Mountains (located west and north of the study area, respectively). Both mountain blocks are part of the Transverse Ranges geomorphic province of California. These mountains and the San Jacinto and Santa Rosa Mountains west of Palm Springs (part of the Peninsular Ranges province) create the high mountain barriers which border the northern portions of the Coachella Valley. They form an effective barrier to the eastward movement of storms and cooler air masses from the Pacific coastal area.

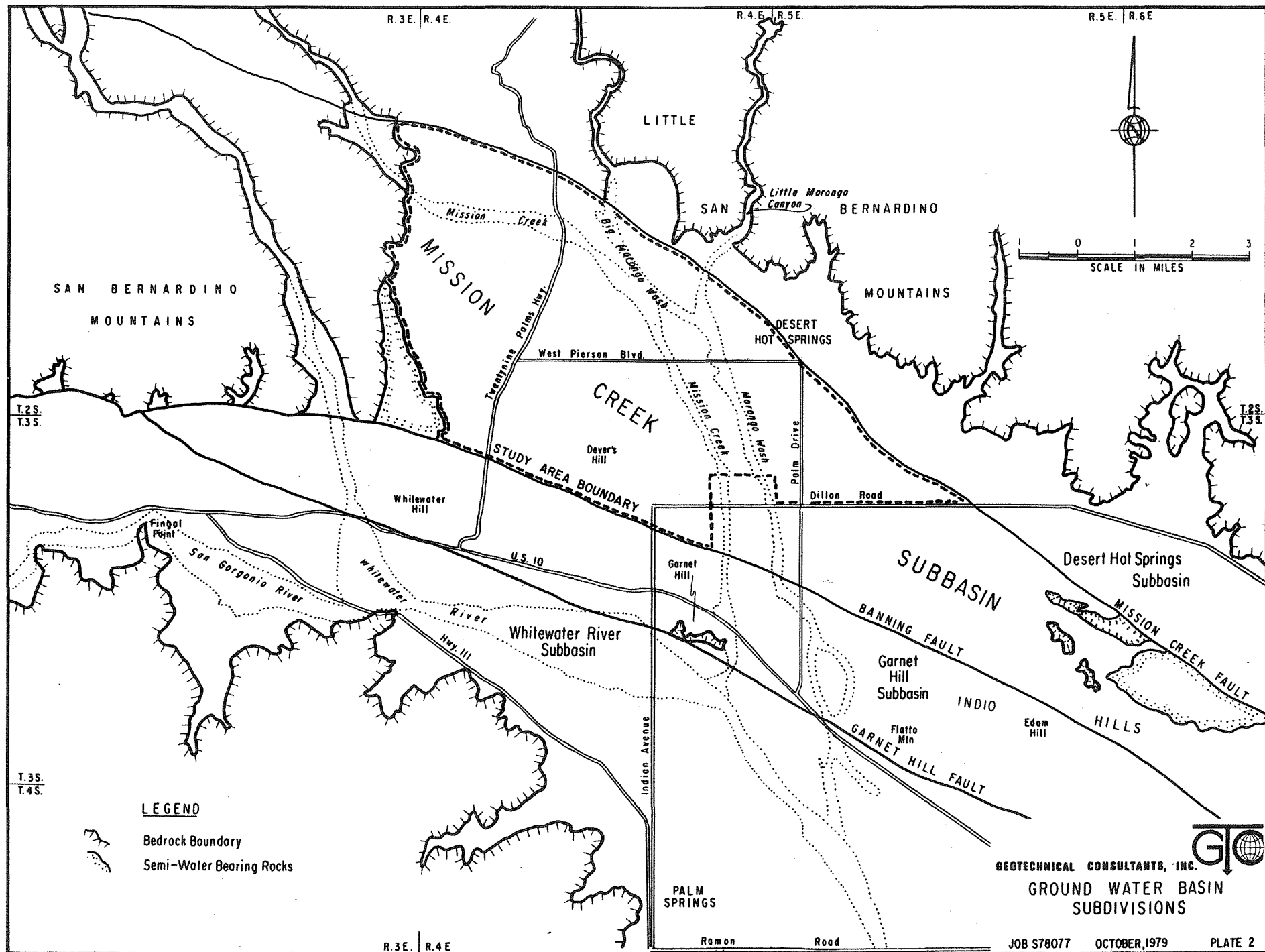
The San Bernardino and Little San Bernardino Mountains represent fault-uplifted mountain blocks. Uplift in the San Bernardino Mountains has created elevations as high as 11,502 feet (San Geronio Peak), while similar uplifts in the Little San Bernardino Mountains resulted in a lengthy drainage divide along the crest of this range at an elevation of approximately 5500 feet.

Overall elevation rise in these mountain blocks, however, are not as great as those exhibited to the south in the San Jacinto Mountains. There an elevation rise to over 10,000 feet occurs in a distance of only eight miles between San Jacinto Peak and the City of Palm Springs.

Background Information. Both the California Department of Water Resources (DWR) and the United States Geological Survey (USGS) have previously conducted separate ground water investigations in the Coachella Valley region. Fortunately for our present study, the subbasin boundaries and description of the Mission Creek subbasin by both DWR and the USGS, are identical.

Ground water subbasin divisions by the USGS in the Upper Coachella Valley region of the Coachella Valley Ground Water Basin are presented on Plate 2 - Ground Water Basin Subdivisions. As revealed, the study area occupies the westerly two-thirds of the Mission Creek Subbasin, which lies between the Desert Hot Springs Subbasin on the north and the Garnet Hill Subbasin on the south. The other subbasin identified in this region by the USGS is the Whitewater River Subbasin which is situated south of the Garnet Hill Subbasin. A Hydrogeologic investigation in the Palm Springs region of the Whitewater River Subbasin was completed in October 1978 by Geotechnical Consultants, Inc. for the Desert Water Agency.

Boundaries and Study Area Physiography. The study area is an approximately parallelogram-shaped region that is nearly ten miles long, four miles wide, and contains approximately 33 square miles (Plate 2). All of the surface area within the study area is underlain by water-bearing sediments. It is bounded on the north and east by the Mission Creek fault. On the north, this fault brings the Little San Bernardino Mountains non-water bearing bedrock up against the study area alluvium. On the east, this fault juxtaposes the study area and the water-bearing basin sediments of the Desert Hot Springs Subbasin. The southwesterly boundary is the Banning fault. Across the fault to the south is the water-bearing alluvium of the Garnet Hill Subbasin.



The southeasterly extent of the study area is a political boundary between the service area of the Desert Hot Springs County Water District and the Coachella Valley County Water District. The westerly boundary was taken as the contact between water-bearing sediments and older non-water-bearing tertiary to pre-cambrian rocks of the highland areas of the San Bernardino Mountains.

The study area represents a portion of an alluviated upland along the main floor of the Upper Coachella Valley. The upland area of the valley, designated the Mission Creek Upland by DWR (1964, p. 19) was created by the coalescence of alluvial fans from the eastern base of the San Bernardino Mountains with those of the westernmost Little San Bernardino Mountains. This created a sandy southeasterly-sloping alluvial plain.

The ground surface across the study area ranges in elevation between approximately 2600 feet and 800 feet, respectively, from northwest to southeast. Southeast of the study area, elevations continue to decrease, becoming as much as 250[±] feet below sea level at the Salton Sea. Surface slope inclinations on the desert floor are on the order of 230 horizontal to 1 vertical (24 feet per mile) in the northwesterly part of the study area and about 460 horizontal to 1 vertical (12 feet per mile) in the remainder of the area. The overall southeasterly slope across the study area is broken locally by Devers Hill, located in the south-central part of the area. This hill is one of several small structural hills associated with uplift and movement along the Banning and Garnet Hill faults. Other associated hills include Whitewater Hill and Garnet Hill, on the south, and Flat Top Mountain, and Edom Hill to the southeast.

Climate and Drainage. Desert floor temperatures in the Upper Coachella Valley are characterized by sharp climatic contrasts and a semi-arid to arid environment. Summers are very hot and dry while winters are mild and warm; precipitation is meager. As is typical of desert climate, the potential evaporation is much greater than average annual precipitation on the valley floor.



Temperature contour maps of the Colorado Desert, of which the Coachella Valley is a part, indicate a mean annual temperature for Desert Hot Springs of approximately 68° F. for a base period of 1931-1960 (Hely and Peck, 1964, Plate 4).

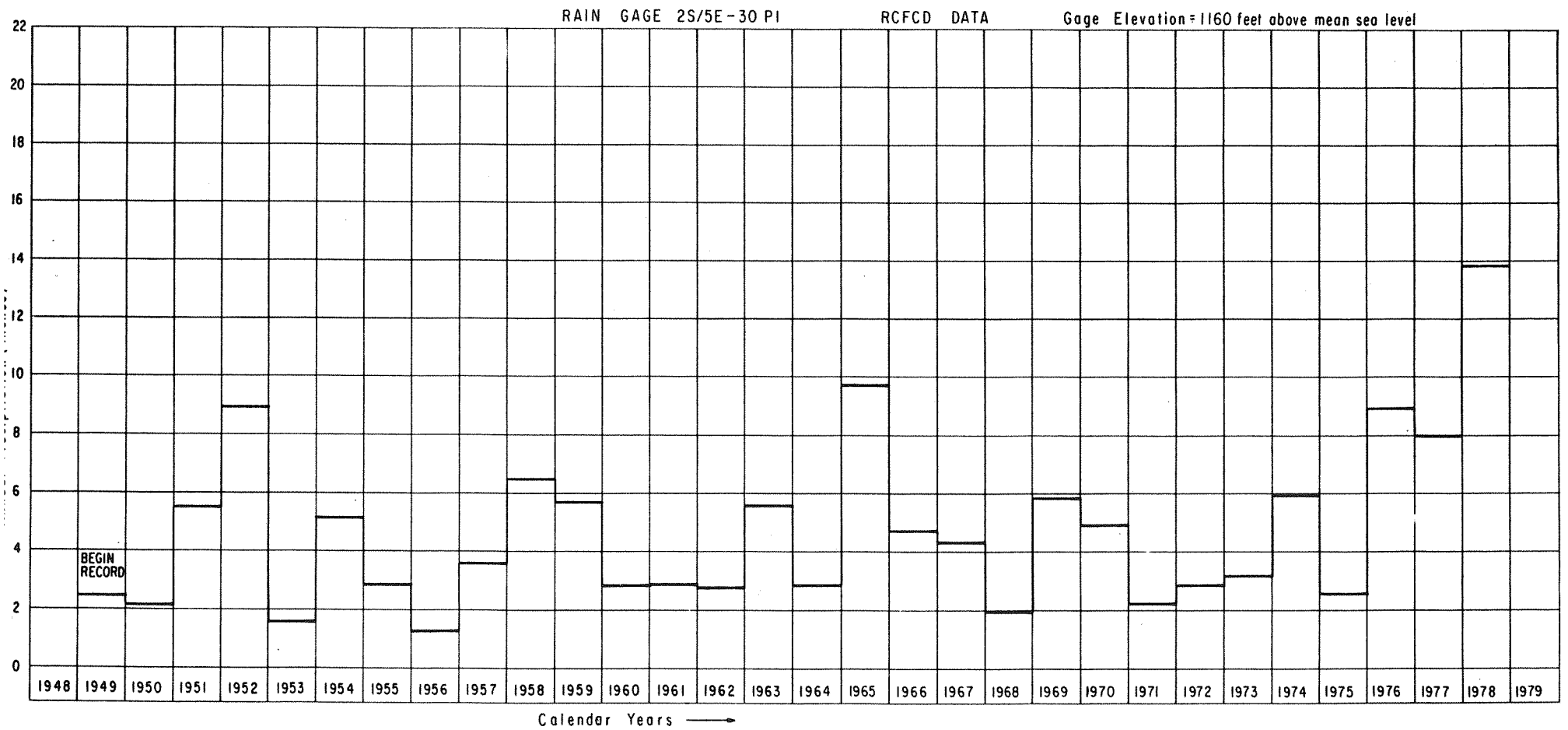
Because the mountains represent a significant and effective barrier against easterly coastal storm movement, precipitation on the desert floor in the Upper Coachella Valley is meager. The precipitation on a calendar year basis in the City of Desert Hot Springs just adjacent to the study area is shown on Plate 3 - Annual Precipitation. For the period of available data (1949-1978) rainfall has averaged only 4.7 inches. The years 1952, 1965, 1976, 1977 and 1978 have provided the relatively largest annual totals during the period of record, while the relatively lowest annual amounts of precipitation have occurred in 1953, 1956 and 1968. Precipitation for the first six months of 1979 is already over 5 inches, exceeding the average. Maps published by the Riverside Flood Control and Water Conservation District (1976, Figure 4) reveal the precipitation ranges from approximately 4.5 to 6.0 inches from southeast to northwest across the study area. Their work also shows that precipitation in areas tributary to the study area along the crest of the Little San Bernardino Mountains to the north and east averages about 10 inches per year. Precipitation in the San Bernardino Mountains to the west also tributary to the study area increases steadily to over 40 inches atop San Gorgonio Peak, 21 miles northwest of Desert Hot Springs. Abundant snowfall occurs at these higher elevations, also, although extensive snowpacks are seldom sustained. Due to the unusually high precipitation which occurred during the winter-1977 and spring-1978 months, snow could be observed on the flanks of San Gorgonio Peak even during August 1978.

Review of cumulative departure curves published by the USGS (Tyley, 1971, p. 47), the overall period of 1946 to the present is a rainfall deficient period, compared to a prior period (1932-1946) during which time annual precipitation was typically at or above its long-term average. As noted on Plate 3,

S78077

ANNUAL PRECIPITATION

Plate 3



STUDY CONDUCTED FOR DESERT WATER AGENCY



the years 1949-1964 in Desert Hot Springs represent a general period of low rainfall (average 3.9 inches) while the period of 1965-1970 represents a period of generally average precipitation (average 5.2 inches). The period of 1971 through 1978 shows an increasing rainfall with the eight year average at 5.9 inches. For any single year, approximately 70 to 80 percent of the annual rainfall occurs during the months of November through March.

During the summer, infrequent storms cause short duration-high intensity precipitation resulting in flash floods. Occasionally, precipitation from one of these storms can equal nearly half of the yearly average. As a result, desert floor precipitation varies considerably from season to season and from year to year. Such variations are typified by minimum and maximum annual totals in Desert Hot Springs which have been 1.20 inches (1956) and 13.83 inches (1978), respectively. Similar data, but for a much longer period of record, are available for Palm Springs (1889 to present) and reveal maximum and minimum annual totals of 0.79 inches (1924) and 19.07 inches (1943), respectively.

Surface runoff across the study area takes place in a southeasterly direction consistent with topographic conditions and is controlled by the Mission Creek and the Big Morongo and Little Morongo Creek washes. Runoff in these unlined channels is intermittent, flowing during or for a short time after the rainy season. These creeks are tributary to the Whitewater River which drains a major portion of the Upper Coachella Valley.

Both Big and Little Morongo Canyons drain the western slope of the Little San Bernardino Mountains. However, even though these canyons have relatively large watersheds, the upper (northerly) end of each drainage area is characterized by relatively limited precipitation creating little annual runoff to the study area. The USGS (Tyley, 1974, Table 2) estimates the average surface flow onto the desert floor from these two streams to be 1500 acre-feet per year.



Observations were made of surface runoff in August 1978 following the unusually heavy 1977-78 rainfall during this investigation in different parts of the study area. Estimated flows from these observations are as follows: no surface flow in either Little or Big Morongo Creek washes; surface flows in Mission Creek wash from northwest to southeast across the study area of 1980 gallons per minute (gpm) where it crosses Indian Avenue, 1440 gpm at Pierson Boulevard, 1000 gpm at 13th Street, 4 gpm at Little Morongo Road, and 0 gpm at Dillon Road.

As revealed by this data, runoff in these channels tends to readily percolate into the coarse grained alluvium of the fans. However, because of the lack of a perennial supply, there have been no diversion of stream flow from either the Mission Creek or the Morongo Creek washes.

AVAILABILITY OF BASIC DATA

General Statement. Hydrogeologic data in the Upper Coachella Valley was collected until the late 1960's by the State Department of Water Resources, the Riverside County Flood Control District, the Coachella Valley County Water District, the Desert Hot Springs County Water District, and the Desert Water Agency (or its predecessor water companies). Since that time, however, the well monitoring and well numbering functions of the Riverside County Water District in this portion of Riverside County have been the responsibility of the Coachella Valley County Water District; both agencies though continue to serve as repositories for newly-gathered hydrogeologic data. Within the Mission Creek Subbasin, the Desert Hot Springs County Water District stores data from its own wells while the Coachella Valley County Water District collects and files data from a few key, privately owned wells.



Data on the rates and quantities of precipitation in the Coachella Valley and adjacent mountains is collected from an extensive net of rain gages that are monitored by the Riverside County Flood Control District and the Coachella Valley County Water District. Since 1963, the USGS and/or the Riverside County Flood Control District have established stream gages on Mission Creek, Long Creek, and Desert Hot Springs Channel.

Beginning in 1960, the State Department of Water Resources initiated a study of the ground water subbasins in the Upper Coachella Valley. Included in this investigation were the collection and analysis of water well driller's logs, ground water levels, ground water quality, land use data, and hydrologic items of inflow and outflow. Results of the DWR study were published as Bulletin 108 in 1964.

Field-generated data obtained by the State Department of Water Resources during their 1960-1962 study and the fairly continuous monitoring of the wells operated by the District since the 1950's represent the only reliable and long-term collections of data for the Mission Creek Subbasin. Prior to this, data collection for the most part was sporadic and random in terms of basin location and date of collection.

Water Well Locations and Boring Logs. A large number of wells have been drilled within the study area, at least 50 of these have been subsequently located by the State Department of Water Resources. Of this number, 11 were drilled for municipal supply by the Desert Hot Springs County Water District or its predecessor companies; the bulk of the remaining wells have been drilled for domestic water and irrigation purposes. Most District wells are located within North Palm Springs or within two miles of Desert Hot Springs. In general, wells sites have been concentrated in well populated areas. Few wells have been drilled in the sparsely populated region west of Indian Avenue.



Available driller's logs for water wells in the study area and its environs are on file at the Riverside County Flood Control District and the Coachella Valley County Water District. Driller's logs are available for 30 of the 50 wells. Eight of the 11 District wells have boring logs. No electric logs are known to have been run in any of the wells within the study area.

Of the eleven wells owned by the District within the study area, five are classified as abandoned, one is used on a back-up emergency basis, and the remaining five are considered active. The relative status of each agency well and other pertinent facts concerning these wells are presented later in this report on Table 1 - Summary of Water Well Data.

The status and viability of the privately owned wells in the study area are not known at this time and the determination of these parameters was beyond the scope of the present study.

Deep basin data is not available from the three wildcat oil wells that have been drilled in the study area. One hole is west of Devers Hill and 975 feet deep, while two are in the Devils Garden area. The deepest of the Devil Garden holes, 25/3E-25Ja went 1250 feet. It is now used as a water well with a static of 150 $\pm$ (10/77).

Details of the State water well numbering system to be used in this report are provided in Appendix D - Water Well Identification System.

The locations of known historically drilled wells in the region of the study area are shown on Plate D-1 - Water Well Location Map. Wells with available boring data are specially denoted.

Water Level and Water Quality Data. Long-term accumulations (dating to the early 1950's) of the water level data are available for several District owned wells. Data gaps of several months or years, however, are present in these early records.



Water quality analyses are available for all of the District's active wells. The most recent of these analyses was done in 1978. The oldest recorded water quality analyses go back to the late 1940's.

Collection of water level and water quality data have historically been sporadic and random in privately-owned wells in the study area. Water level and water quality data have been monitored with sufficient frequency to be meaningful for study purposes for only a few privately-owned wells.

Specific Capacity Data. Specific capacity data have been determined on a more or less annual basis since the mid 1950's in most District wells by the Southern California Edison Company. These data include water level data, production rates, and pump and overall plant efficiency information. Virtually no specific capacity data were available to this study for the privately-owned wells in the study area. Data obtained by Geotechnical Consultants, Inc. for District Wells 12, 21, 22 and 24 is presented in Appendix B.

GEOPHYSICAL DATA

During the first quarter of 1979, a geophysical investigation was undertaken by Biehler (1979, unpublished) in order to provide essential geological constraints on the sedimentary and tectonic structure of the Mission Creek Subbasin. To obtain the necessary data, the geophysical techniques of seismic refraction, gravity, magnetics, and resistivity were employed. Prior to this study, the only other geophysical investigation was done by Biehler (1964) on the Salton Trough which included the present study area on a much smaller scale.

Two reversed seismic profiles were shot, one north-south and the other west-east. Gravity data was obtained to construct a $\frac{1}{2}$ - to $\frac{1}{4}$ -mile grid



pattern. The gravity values were obtained with a LaCoste and Romberg Model G Geodetic Gravity Meter with an accuracy of .01 mgals, but due to the lack of prior detailed survey of station elevations and locations, the accuracy is on the order of .3 mgals. Total field magnetic data were gathered for the study area at each gravity station. There were 76 stations measured with a Geometrics G-816 Portable Proton Magnetometer with an accuracy of 14 gamma; however, only 60 stations were used in the analysis due to magnetic storms. The resistivity data were measured using a Schlumberger array pattern and a Geotronic Ft Induced Polarization Transmitter with a time domain of 32 seconds and powered by a 400 hertz, 3-phase, 25 kilowatt generator which had a voltage output of 120-208 volts. The complete geophysical report is presented in Appendix E. The results obtained in that study will be incorporated in the following sections of this report.

SOURCES OF WATER SUPPLY

Historical Development. Except for numerous Indian tribes which have dwelled in the Coachella Valley for centuries, the region had few visitors or other settlements or inhabitants until the mid-19th Century. During the 1840's and 1850's freight lines were established through the region and expeditions were carried out by the Army. However, the completion of the Southern Pacific Company Railway through the desert in 1879 initiated the development of the area.

Because of the government incentive to railroad building in the west, every odd section along the right-of-way was deeded to the Southern Pacific. Thereby, the remaining lands in the Coachella Valley were available for agricultural development in the early 1900's. The towns of Niland, Mecca, Thermal, Coachella, Indio, and Palm Springs Station began with and died along the railroad. Desert Hot Springs had not been established at this time.

From Indio southward artesian wells (flowing?) were put into production after the well at Mecca (Walters well) was successfully drilled in 1894. All of the flowing wells were found below the sea level contour. This area than was readily put into agriculture. However, to the north of Indio wells required pumping. This northern portion of the Coachella Valley was considered the forebay or recharge area to the valleys' ground water basin. It was also early recognized that faults created barriers to ground water and that the area east of Palm Springs station and north of the Indio Hills (Mission Creek Subbasin) was promising for development. Artesian springs were found at Seven Palms along the Banning fault. Perennial stream flows were also recognized to the southeast along the fault at Willow Hole. However, in the early 1900's only one artesian well was noted in the Mission Creek Subbasin. This was the Talmadge well in Section 17, T. 3S., R.5E. about $\frac{1}{2}$ mile northeast of Seven Palms. This well was reportedly 320 feet deep and flowed 15 gallons a minute with water exhibiting 800+ part per million total dissolved solids.

The water resources development of the City of Desert Hot Springs came about slowly as the main interest in the area was the spa and therapeutic attraction of the hot springs occurring north of the Mission Creek fault. As more and more people came to the spa, services and living facilities sprang up. With a need to supply this growing population, the Desert Hot Springs County Water District was formed in 1953. This water district supplies the growing population through wells drilled in the Mission Creek Subbasin and Desert Hot Springs Subbasin.

In 1961, the Desert Water Agency was formed by an act of the State Legislature to augment local water supplies by importing water from the State Water Project.



Supplemental water was made available to the Desert Water Agency by contractual agreements with the State in 1962. Colorado River water from the Metropolitan Water District was substituted for State water in 1967 negotiations. Scheduled entitlements were first delivered to the Agency in 1973. At present, Colorado River water is being recharged into the active channel of the Whitewater River in the vicinity of Windy Point, south of the study area.

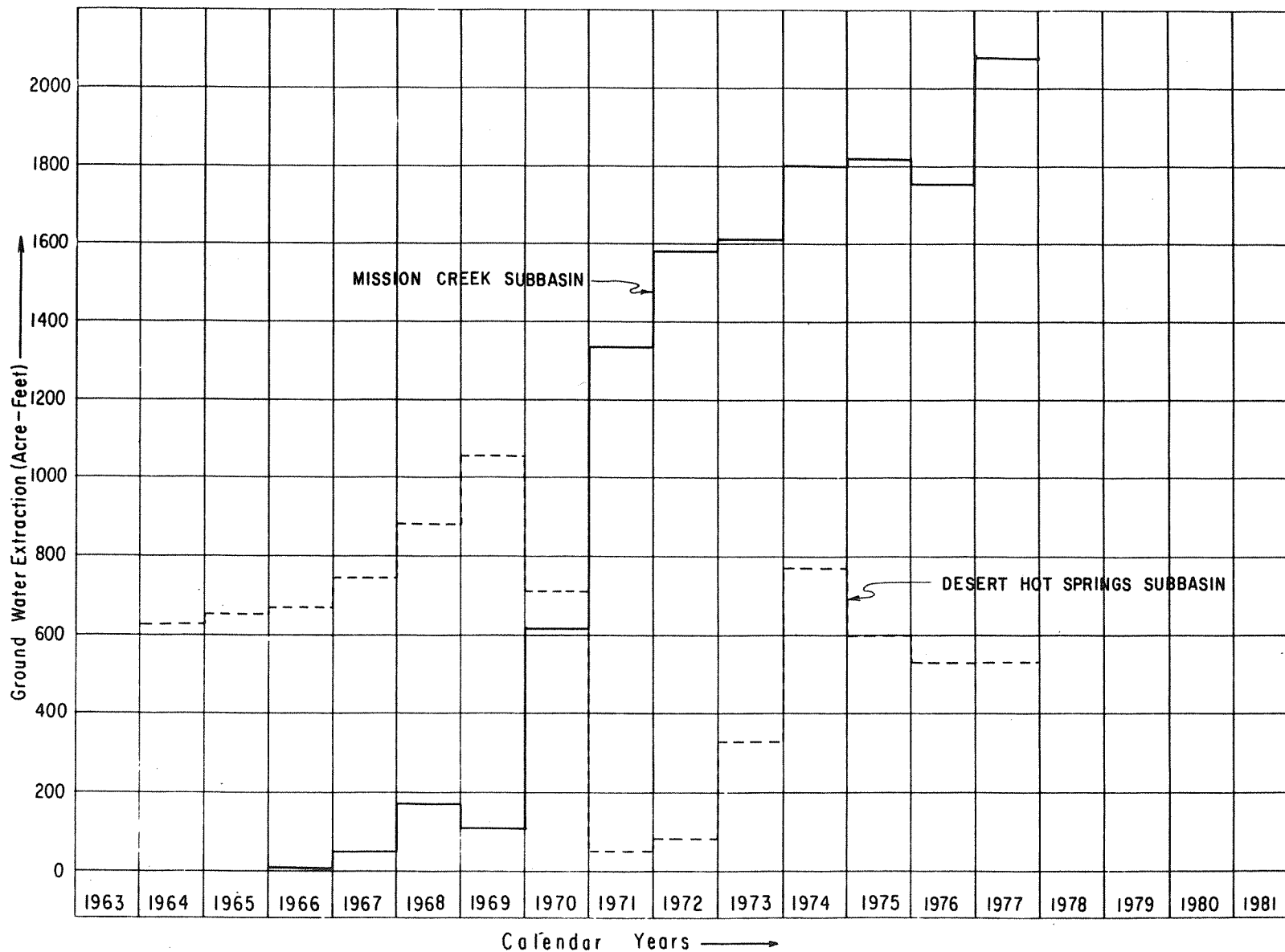
Since the Desert Hot Springs County Water District was not large enough to contract with the State for water, it annexed to the Agency in 1961. Although the District has not purchased water, it can through this annexation obtain State water.

Early history of the ground water development throughout the Coachella Valley have been well-prepared by Mendenhall (1909) and by Brown (1932) for the United States Geologic Survey.

Present Supplies. The Desert Hot Springs County Water District currently uses ground water from their municipal wells as their sole source of water.

Ground water extraction data between 1966 and 1978 are available for municipal pumpage from records on file at the Desert Hot Springs County Water District. These data, for the Mission Creek Subbasin have been plotted on a calendar year basis for the study area and are shown on Plate 4 - Ground Water Extractions. The rapid increase in the amount of extractions reflects the exploding population and the increased dependence of the District on water from the Mission Creek Subbasin. Recent (1978 to 1979) ground water extractions from the study area by the District are in the 2000 to 3000 acre-feet per year range. It is estimated that at least 2000 acre-feet is being extracted by private wells within the study area. Just to the south of the study area, but within the Mission Creek Subbasin, Coachella Valley County Water District wells extract 1500 to 2000 acre-feet per year from the subbasin.

GROUND WATER EXTRACTIONS
Desert Hot Springs County Water District



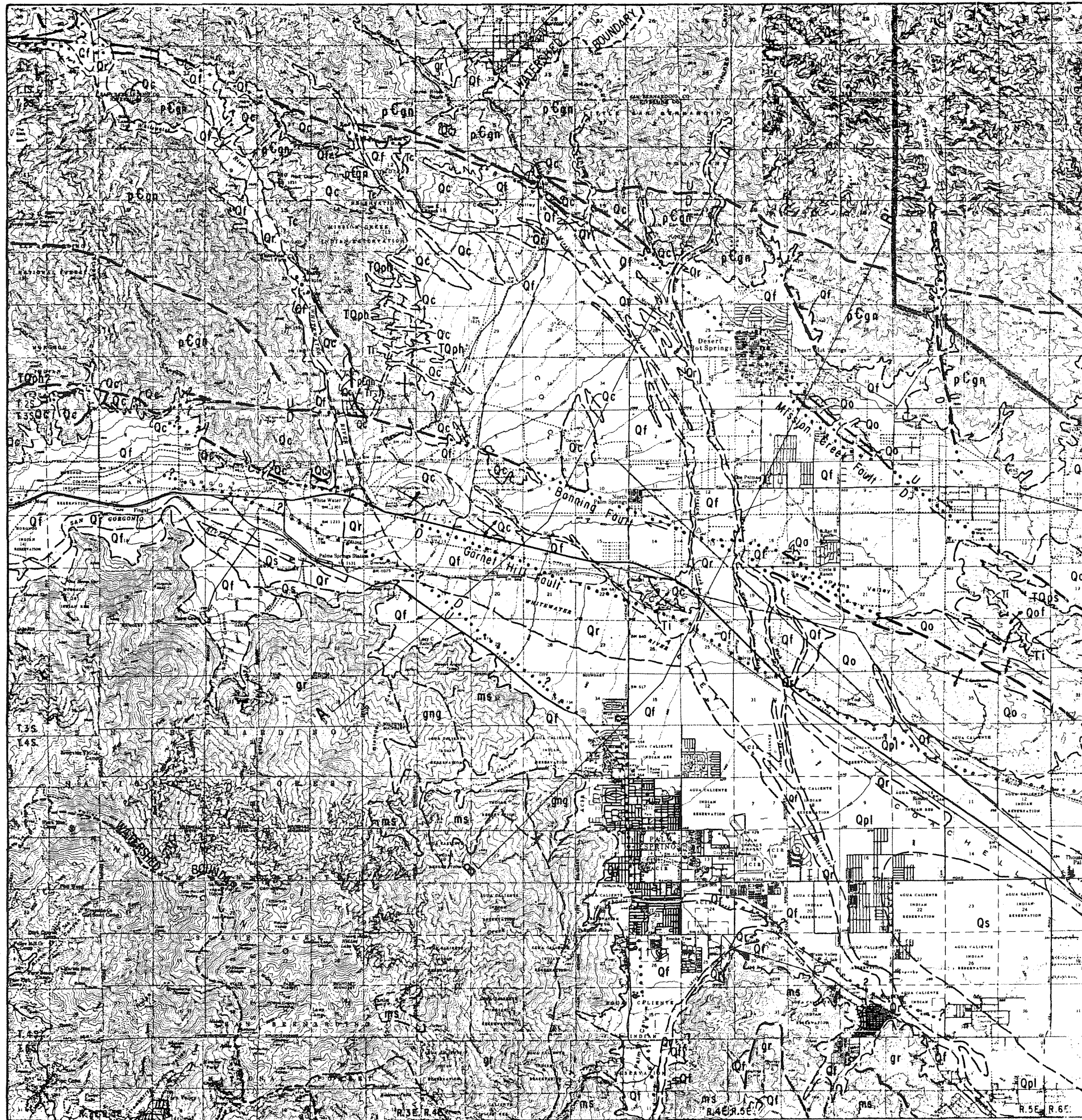
The sharp rise in ground water production from the Mission Creek Sub-basin by the District in 1970 (Plate 4) is also reflected by the decreased dependence on water from wells in the Desert Hot Springs Subbasin.

GEOLOGY

Background Information. The Mission Creek Subbasin is located in the far northeastern corner of the Coachella Valley. The Coachella Valley is the northern extension of the Salton Sea trough which represents the landward continuation of the Gulf of California. The trough is thought to be a currently active rift zone partially filled with sediments. This explains the complex system of strike-slip faulting, the patterns of magnetic, gravitational and thermal anomalies and the recent volcanism seen within the Salton Trough.

Geophysical (Biehler, 1964) and geological (Proctor, 1958) studies indicate that there are up to 20,000 feet of Cenozoic sediments filling the structural depression beneath the Coachella and Imperial Valleys. The sedimentary fill is only a thin veneer about the foothills of the San Bernardino and Little San Bernardino Mountains, but thickens rapidly to the south with approximately 4500 feet calculated near Garnet Hill, 6800 feet determined to be present near Indio, and over 7000 feet in the Mission Creek Subbasin.

The areal distribution of geologic formations is presented on Plate 5 - Regional Geologic Map, while the subsurface stratigraphy and structure are shown on Plate 6 - Geological Sections A-A' and B-B'. Geologic data and stratigraphic terminology presented on Plate 5, and for the remainder of this report, have been adopted from work by the Department of Water Resources (1964). The apparent steepness of the mountains and the geologic contacts on the geologic sections is a result of the exaggeration of the vertical (elevation) scale relative to the horizontal scale.



LEGEND

SEDIMENTARY ROCKS

QUATERNARY	Qr	ACTIVE CHANNEL DEPOSITS BOULDERS, GRAVEL AND SAND OF LARGER STREAMS
	Qs	DUNE SAND MICACEOUS SAND OF PRINCIPAL DUNES
	Qf	ALLUVIAL FAN AND STREAM WASH DEPOSITS BOULDERS, GRAVEL, SAND AND SILT
	Qpl	ALLUVIAL PLAIN AND LAKE DEPOSITS SAND AND CLAY
	Qof	OLDER ALLUVIAL FAN AND TERRACE DEPOSITS PARTIALLY WEATHERED GRAVEL, SAND AND SILT INCLUDES UPPER PORTIONS OF THE OCOTILLO CONGLOMERATE, AND UNDIFFERENTIATED TERRACE DEPOSITS
PLEISTOCENE	Qc	CABEZON FANGLOMERATE BOULDER CONGLOMERATE WITH SAND, SILT AND CLAY
	Qo	OCOTILLO CONGLOMERATE POORLY BEDDED SAND AND CONGLOMERATE, INCLUDES THIN BEDDED SILT AND CLAY
TERTIARY - QUATERNARY	TQph	PAINTED HILL FORMATION BUFF SILTY SANDSTONE AND CONGLOMERATE INCLUDES INTERLAYERED BASALT FLOWS
	TQps	PALM SPRINGS FORMATION INTERBEDDED SANDSTONE AND CONGLOMERATE AND THIN BEDDED SILTSTONE AND CLAYSTONE
	TQc	CANEBAKE CONGLOMERATE GRAY TO TAN, COARSE SILTY CONGLOMERATE AND SANDSTONE TORRENTIAL FACES OF PALM SPRINGS FORMATION
TERTIARY	Ti	IMPERIAL FORMATION SHALE AND VARICOLORED SANDSTONE, SILTSTONE FOSSILIFEROUS, MARINE
	Tc	COACHELLA FANGLOMERATE VARICOLORED, BASAL CONGLOMERATE AND BRECCIA INCLUDES INTERLAYERED, FLOWS OF BASALT
PRE-CAMBRIAN - CRETACEOUS (?)	gr	IGNEOUS AND METAMORPHIC ROCKS GRANITIC INTRUSIVE ROCKS GRANODIORITE, GRANITE, AND PEGMATITE OF THE SOUTHERN CALIFORNIA BATHOLITH
	gng	GNEISSIC GRANODIORITE
	ms	METAMORPHIC ROCKS OF THE SAN JACINTO AND SANTA ROSA MOUNTAINS METASEDIMENTARY SERIES OF GNEISS, SCHIST, MARBLE
	pEgn	SAN GORGONIO-CHUCKWALLA COMPLEX UNDIFFERENTIATED COMPLEX OF BANDED GNEISS, SCHIST, DIORITE, ANDESITE

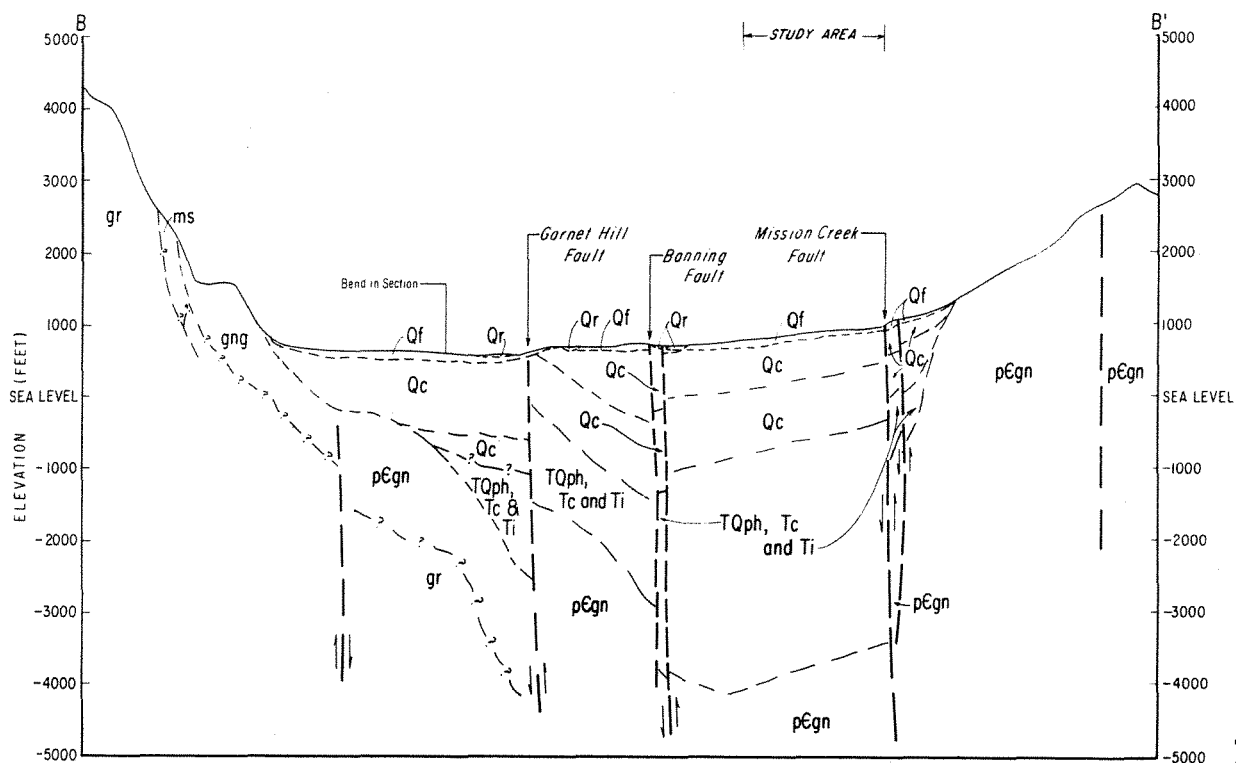
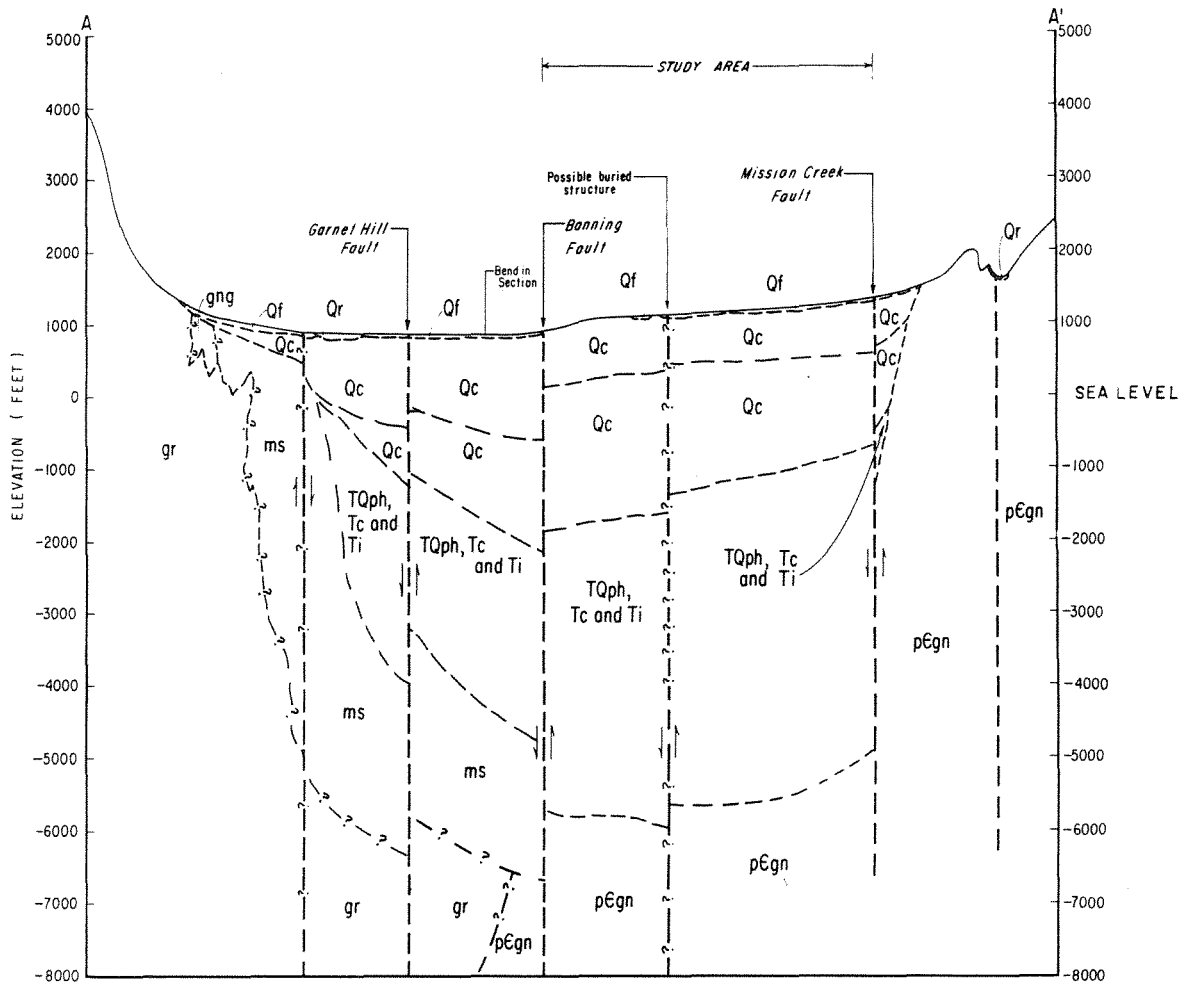
SYMBOLS

	FAULT, DASHED WHERE APPROXIMATELY LOCATED, DOTTED WHERE CONCEALED, ARROWS INDICATE DIRECTION OF RELATIVE LATERAL MOVEMENT, U-UPTHROWN, D-DOWNTOWN
	ANTICLINE, DASHED WHERE APPROXIMATELY LOCATED, ARROW INDICATES DIRECTION OF PLUNGE
	SYNCLINE, DASHED WHERE APPROXIMATELY LOCATED, ARROW INDICATES DIRECTION OF PLUNGE
	CONTACT, DASHED WHERE INFERRED AND QUESTIONABLE
	LINE OF GEOLOGIC SECTION
	WATERSHED BOUNDARY

DATA ADAPTED FROM D.W.R., 1964 AND C.D.M.G., 1966

SCALE IN FEET

GEOTECHNICAL CONSULTANTS, INC.
REGIONAL GEOLOGIC MAP
JOB 578077 OCTOBER 1979 PLATE 5
STUDY CONDUCTED FOR DESERT WATER AGENCY



LEGEND TO SYMBOLS ON PLATE 4,
REGIONAL GEOLOGIC MAP.

5000 0 5000 10000 15000 20000
SCALE IN FEET
Vertical Exaggeration 5 times

GEOTECHNICAL CONSULTANTS, INC.

GEOLOGIC SECTIONS A-A', B-B'

JOB S78077

OCTOBER, 1979

PLATE 6

STUDY CONDUCTED FOR DESERT WATER AGENCY

Numerous previous workers have studied, named and mapped the rock formations exposed in the region. Little work, however, has been done in verifying and delineating these formations beneath the valley floor. The detailed stratigraphy of the Salton Trough is therefore still incompletely understood. Subsurface contacts between various types of earth materials (refer to Plate 6) have been postulated on the basis of different seismic wave velocities monitored from the geophysical studies by Biehler (1964 and Appendix E). In general, the seismic velocity of our earth materials increases as the density increases and as density increases, the materials become less permeable.

Sedimentary materials in the vicinity of the general study area as shown on Plate 5 include: poorly to moderately consolidated alluvial deposits, dune sand, alluvial fan deposits, the Cabezon fanglomerate and the Ocotillo conglomerate; moderately consolidated strata of Pliocene to Lower Pleistocene age comprised of the Painted Hill, the Palm Springs, and the Canebrake Formations; consolidated rocks of Miocene to Lower Pliocene assigned to the Imperial Formation and the Coachella Fanglomerate.

The poorly to moderately consolidated, Holocene to Upper Pleistocene deposits are considered to be water-bearing in the general study area. All underlying, moderately consolidated sediments and consolidated rocks of Lower Pleistocene and older geologic age are considered as either semiwater-bearing or nonwater-bearing. On a regional basis, the subsurface location and relationship of these materials are depicted on Geologic Sections A-A' and B-B', Plate 6.

Crystalline igneous, metamorphic, and metasedimentary rocks exposed in the adjoining mountain ranges constitute the general type of basement rocks upon which all sedimentary rocks in the trough were subsequently deposited. Geologic Sections A-A' and B-B' (Plate 6) depict the approximate subsurface locations of the granitic basement rocks (bedrock) as adapted from the geophysical studies by Biehler (1964 and Appendix E).

Structure. Complicating the diverse stratigraphy and making interpretation and stratigraphic correlation difficult, are a series of major north-westerly trending principally strike-slip faults belonging to the San Andreas fault system. Faults comprising this system, border the southwestern and north-eastern margins of the Mission Creek Subbasin and include Mission Creek, Banning, and Garnet Hill faults (See Plate 5).

Faults in this system have marked influence on the occurrence and movement of ground water. In fact, these faults have compartmentalized the Coachella Valley into several fault-bounded subbasins as shown on Plate 2.

In general, the faults have had both a dip-slip (thrust) component of movement and a (strike-slip) right-lateral component. Because the fairly large displacements along these faults, opposite sides of each fault contain considerably different rock types, particularly in the older sediments. The general alignment of these faults are apparent from geomorphic evidence on air photos and by water level and water quality anomalies detected in water wells on opposite sides of the faults. The fault locations are also identifiable from geophysical data, principally seismic refraction profiles and gravity anomalies. The seismic activity of these faults is attested by the frequent occurrence of earthquakes along their traces. Because of the movement of these faults, many strata near and within the fault zone have been highly sheared and deformed, thereby creating barriers to the movement of ground water.

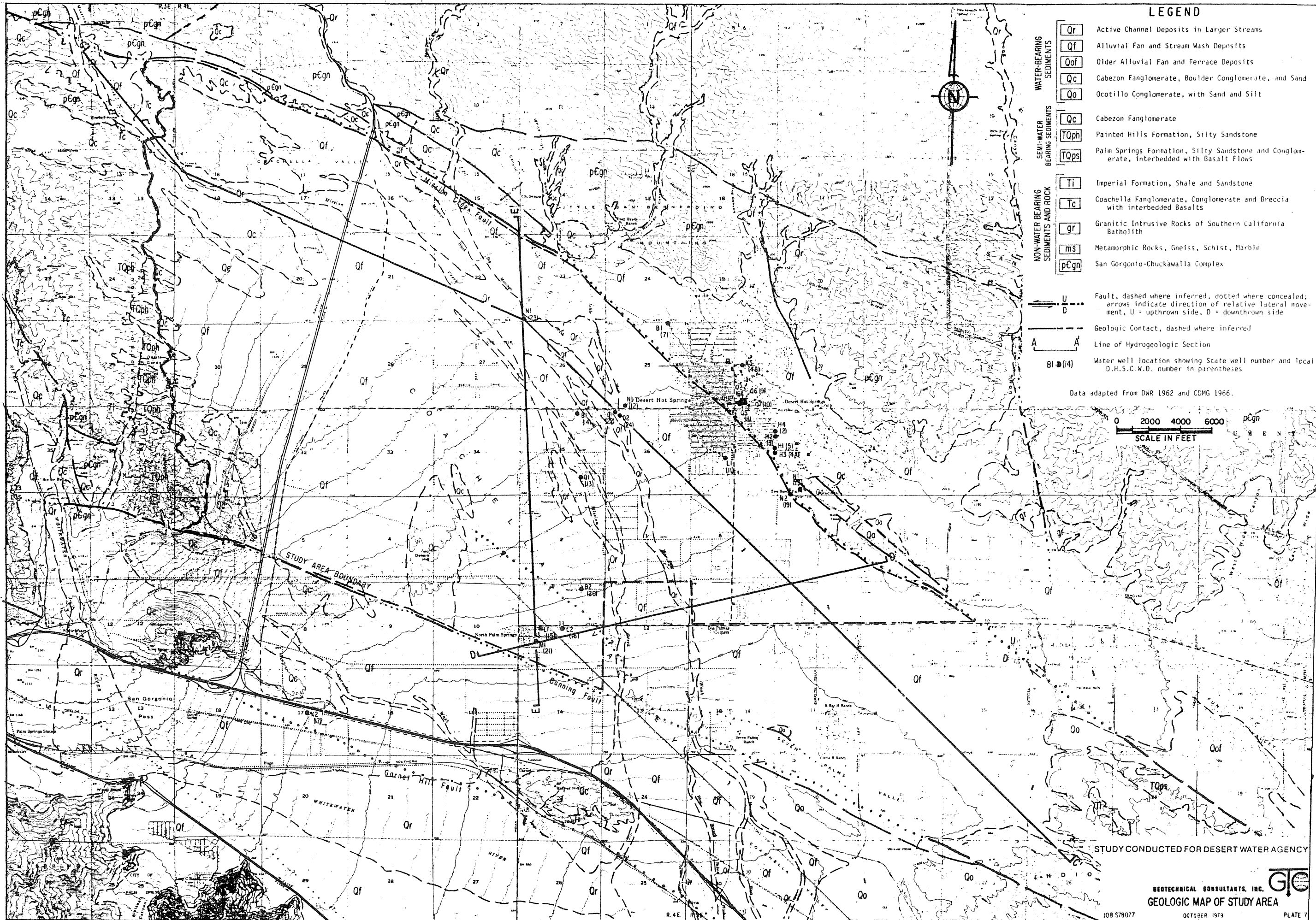
Geophysical data (Biehler) indicates the presence of a very deep 7000 feet sedimentary basin within the Mission Creek Subbasin. This work also delineated the major fault boundaries of the subbasin and the existence of lesser geologic structures. Such a structure was noted to the east of Devers Hill and has tentatively shown as a buried splay fault associated with the Banning fault.

HYDROGEOLOGY

General Statement. Within this report, geologic formations are grouped according to their general water-bearing characteristics or to their relative ability to contain, transmit, and yield ground water to wells. The three resulting groups are: water-bearing sediments; semiwater-bearing sedimentary rocks; and nonwater-bearing rocks. These groups are identified on Plate 7 - Geologic Map of the Study area and Plate 8 - Hydrogeologic Sections C-C', D-D' and E-E'.

On our interpretation of the subsurface relationships within the water-bearing sediments (Plate 8), potential aquifers or zones of relatively coarse-grained sediments have been correlated from one well to another by the use of drillers logs. Intervening aquicludes or zones of relatively fine-grained materials have been similarly correlated. Until more and better quality subsurface data become available (e.g., from geophysical electric log surveys), these hydrogeologic sections can serve as the present geologic interpretation to illustrate the depositional interfingering of the sediments in the study area and the presence of both relatively continuous aquifers and finer-grained aquicludes.

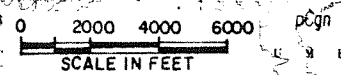
Water-Bearing Sediments. Sediments assigned to the water-bearing group in the study area have been derived from the erosion of the surrounding mountains of crystalline basement rock and subsequent deposition by the various stream channels that drain the San Bernardino and Little San Bernardino Mountains. The principal streams supplying sediment to the study area are Mission Creek and the Morongo Wash system. As is typical of sedimentary deposition, the sediments in the topographically steeper areas, nearest the headwaters of the streams or nearest the mountain front are the coarsest in grain size, while deposits in topographically flatter areas farthest from the point of origin of the materials are the finest grained. This is readily evidenced today, for example, by contrasting the cobble and boulder strewn alluvial fan deposits at the foot of the San Bernardino Mountains with the noticeably finer-grained surface materials two or three miles east on the valley floor.



LEGEND

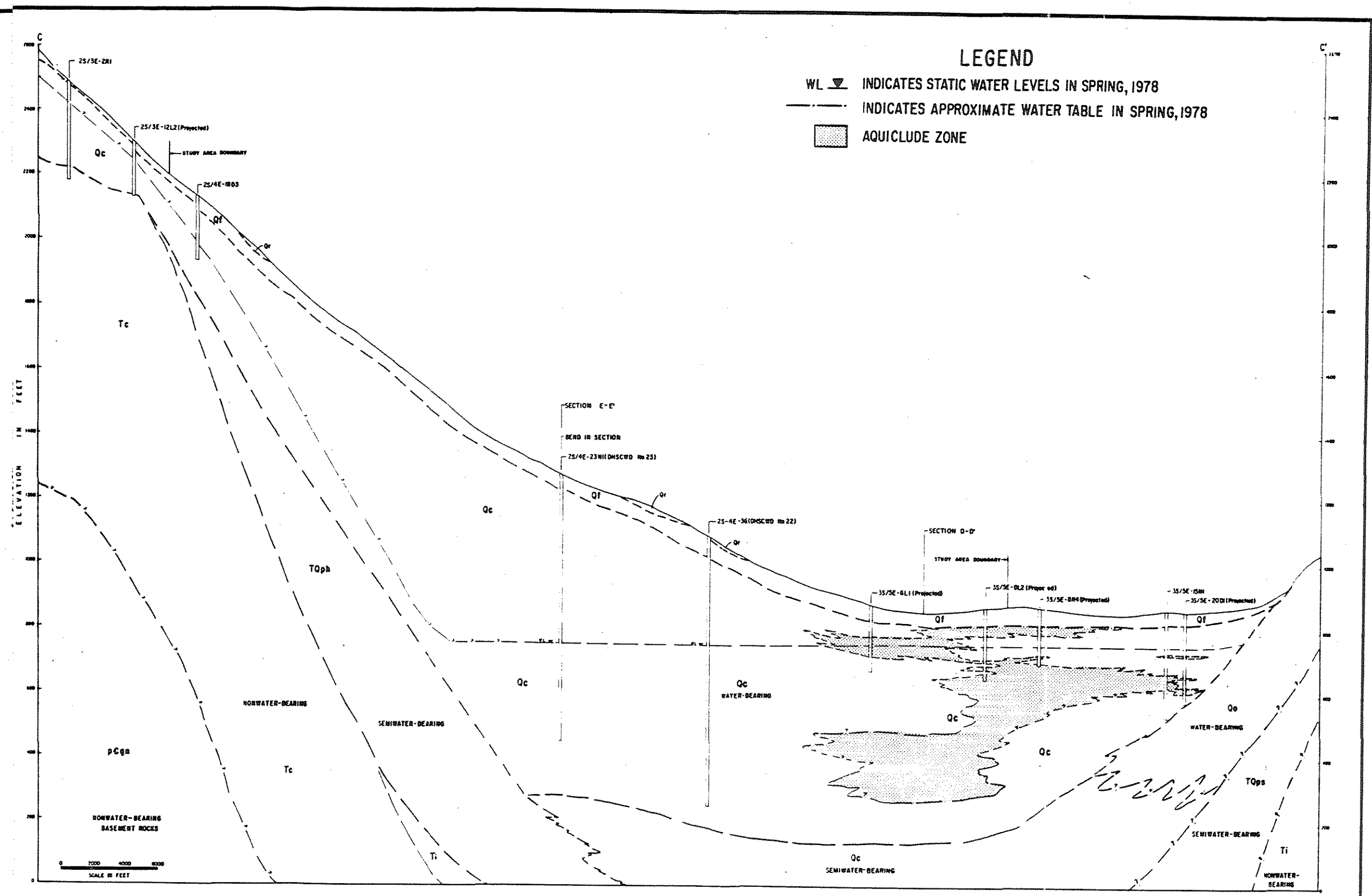
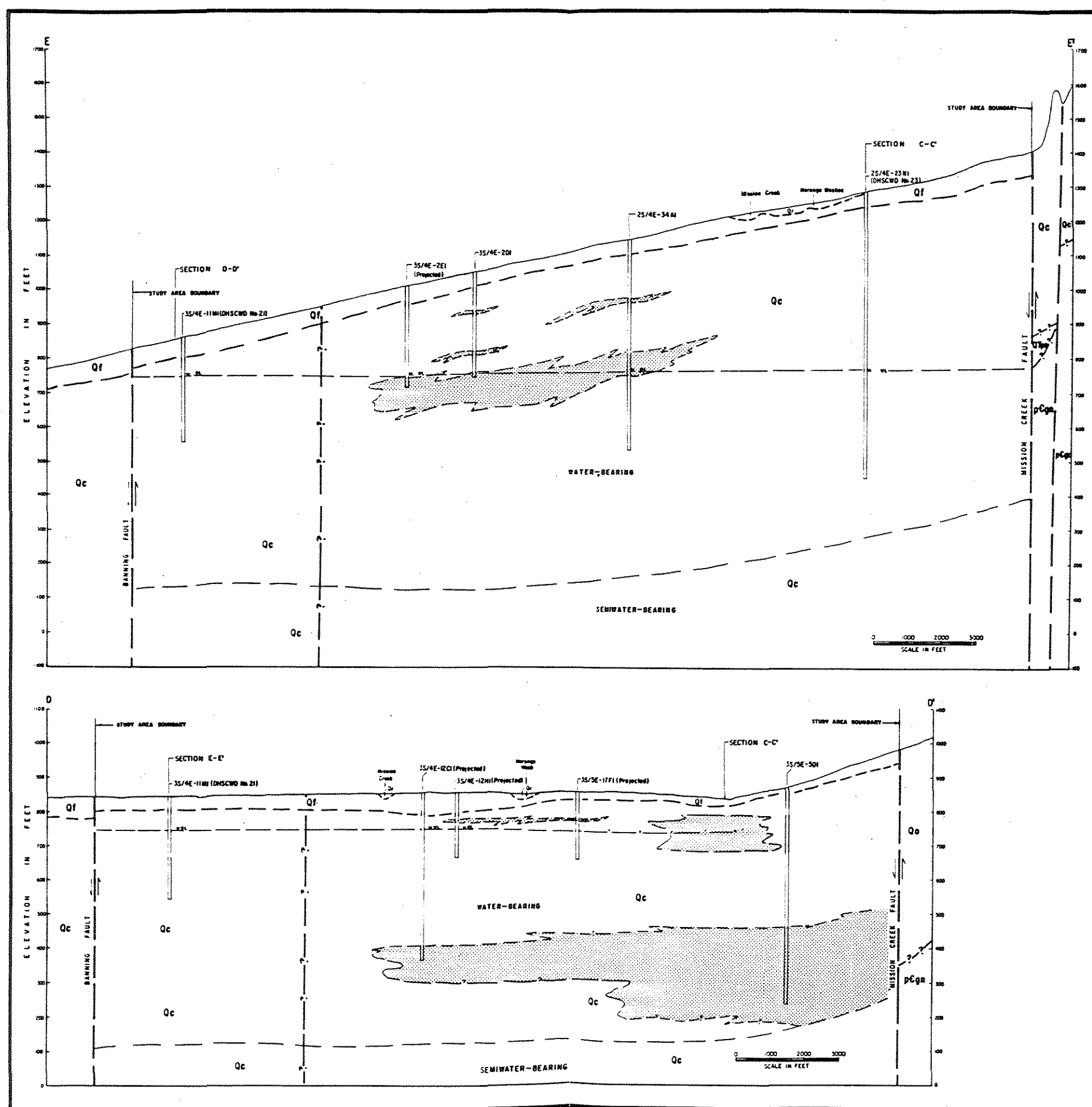
- | | | |
|---|------|--|
| WATER-BEARING
SEDIMENTS | Qr | Active Channel Deposits in Larger Streams |
| | Qf | Alluvial Fan and Stream Wash Deposits |
| | Qof | Older Alluvial Fan and Terrace Deposits |
| | Qc | Cabezon Fonglomerate, Boulder Conglomerate, and Sand |
| | Qo | Ocotillo Conglomerate, with Sand and Silt |
| SEMI-WATER
BEARING
SEDIMENTS | Qc | Cabezon Fonglomerate |
| | TQph | Painted Hills Formation, Silty Sandstone |
| | TQps | Palm Springs Formation, Silty Sandstone and Conglom-
erate, Interbedded with Basalt Flows |
| NON-WATER BEARING
SEDIMENTS AND ROCK | Ti | Imperial Formation, Shale and Sandstone |
| | Tc | Coachella Fonglomerate, Conglomerate and Breccia
with interbedded Basalts |
| | gr | Granitic Intrusive Rocks of Southern California
Batholith |
| | ms | Metamorphic Rocks, Gneiss, Schist, Marble |
| | pCgn | San Gorgonio-Chuckawalla Complex |
- Fault, dashed where inferred, dotted where concealed; arrows indicate direction of relative lateral movement, U = upthrown side, D = downthrown side
- Geologic Contact, dashed where inferred
- Line of Hydrogeologic Section
- Water well location showing State well number and local D.H.S.C.W.D. number in parentheses

Data adapted from DWR 1962 and COMG 1966.



STUDY CONDUCTED FOR DESERT WATER AGENCY

GEOTECHNICAL CONSULTANTS, INC.
GEOLOGIC MAP OF STUDY AREA



LEGEND TO SYMBOLS ON PLATE 7, GEOLOGIC MAP OF THE STUDY AREA

GEOTECHNICAL CONSULTANTS, INC. **GTC**

HYDROGEOLOGIC SECTIONS

C-C', D-D', and E-E'

JOB S78077

OCTOBER 1979

PLATE 8

STUDY CONDUCTED FOR DESERT WATER AGENCY

The lenticular and interfingering nature of these sediments is depicted on the Hydrogeologic Sections (Plate 8).

Assigned to the water-bearing group of sediments in the study area are: Holocene alluvium consisting of active channel deposits (map symbol Qr on Plate 7), of alluvial fan and stream wash deposits (Qf); the Upper Pleistocene Cabezon Fanglomerate (Qc); its eastern and southern depositional equivalent, the Ocotillo Conglomerate (Qo); and older alluvial fan deposits (Qof). All known water wells in the region extract ground water from one or more of these sediments. The hydrogeologic cross sections (Plate 8) depict subsurface relationships as determined by analysis of drillers logs of water situated close to the alignments of the sections.

Holocene alluvial deposits consist typically of poorly sorted (well-graded) sands and gravels with occasional cobbles and boulders; variable concentrations of silt and clay are also present. The size and frequency of boulders increases upgradient or in a depositionally upstream direction.

The Upper Pleistocene Cabezon Fanglomerate and Ocotillo Conglomerate are composed of layers and lenses of boulder conglomerate, poorly bedded sand and silty sand with occasional layers and lenses of silt and clay.

The water-bearing sediments as a group overlie all older rocks and form the entire ground water reservoir within each of the ground water sub-basins in the region.

For Mission Creek Subbasin and, in particular, for the principal study area, the base of these water-bearing sediments is considered the theoretical base of fresh water and represents the base to which ground water in storage was calculated for our study. Previous workers (DWR, 1964 and USGS, 1974) have considered the effective base of water-bearing sediments to be at a depth of approximately 1000 feet in this area.



Seismic refraction data indicates that the total sequence of water-bearing sediments along the data lines ranges from 600 to 1100 feet below ground surface with an average thickness of approximately 720 feet within the study area. The water-bearing sediments are present in only two discrete velocity layers (Biehler, Appendix E). The uppermost with an apparent velocity of only 3000 ft/sec. represents essentially above water table, dry sand, alluvium, and fan-glomerate deposits. The lower layer has an average velocity of 7000 ft/sec. and is composed of water saturated material with good intergranular porosity. This lower water-bearing unit grades gradually upward into the overlying surficial sediments that compose the low velocity zone. This implies that the boundary between the two layers is not lithologic, but merely results from the compaction of sediments under the weight of the overburden and the presence of water in the lower unit.

This result may be compared to the data obtained by Biehler (1964) for the nearby Palm Springs Subbasin where three potential water-bearing velocity layers were found having a combined thickness of approximately 2000 feet. This conclusion is not completely unexpected since the potential water-bearing sediments have for the most part been deposited since the Pleistocene and at least since that time the Whitewater River has transported and deposited significantly greater amounts of sediment than has Mission Creek. The sediments of the Quaternary units of the study area have, in general, been transported shorter distances as compared to Palm Springs Subbasin sediments, and so large boulders deposited with floods are common within the generally sandy silt matrix and are a possible cause for the higher seismic velocities.

Semiwater-bearing Sedimentary Rocks. Moderately consolidated sedimentary formations of Quaternary and late Tertiary geologic age underly the water-bearing deposits in the study area. These rocks have reduced permeability and transmissivity characteristics because of their moderate degree of consolidation and/or intergranular cementation and are considered semiwater-



bearing materials. These rocks are not considered part of the ground water basin in this report and were not used in the calculation of ground water in storage. No wells are known to extract water from these rocks within the study area.

As shown by the geologic contacts displayed on Plate 7 - Geologic Map of Study Area, the semiwater-bearing sedimentary rock group is represented only by small exposures of the Painted Hill Formation (TQph) and the Palm Springs Formation (TQps) of Lower Pleistocene age. A lower portion of the Upper Pleistocene Cabezon Conglomerate (Qc) we believe, occurs in the basin as semiwater-bearing sediments (Plate 8 - Hydrogeologic Section C-C'). While there is only seismic evidence to show the break between the water-bearing and semiwater-bearing, it is our feeling a thicker section of the Cabezon Formation must exist. This lower semiwater-bearing section may be due to compaction or to the existence of a very coarse conglomerate causing seismic velocities equal to semiwater-bearing sediments.

Seismic refraction data (Appendix E) indicates that a sharp velocity boundary exists between the water-bearing sediments with a velocity of 7000 ft/sec. and the semiwater-bearing with a velocity of 10,000 ft/sec., approximately 720 feet beneath the surface.

The bottom of the semiwater-bearing unit is interpreted as a gradational change in seismic velocity at about 2000 feet in depth. At this point and to a depth of over 6000 feet, exists a higher velocity zone (11,600 ft/sec.) probably consisting of sediments which both fall into the semi and nonwater-bearing groups. These sediments are essentially the same lithology except for the lowest portion of the nonwater-bearing sediments which are probably composed of the marine Imperial Formation.

This unexpectedly thick sequence of sediments (4000 feet) suggests that during the Tertiary the study area may have experienced massive influxes of sediments. One possibility is that the Whitewater River has in the past flowed into the Mission Creek Subbasin along the present course of Mission Creek. This resulted in an extremely thick sequence of well-graded materials being rapidly deposited into the down dropping basin. It is also possible that a lake existed within the basin during Late Tertiary geologic times resulting in the deposition of silt and clay beds. It may be the existence of these fine-grained deposits that causes the relatively high seismic velocities seen in the Late Tertiary sediments in the basin. At some time in the early Pleistocene, the Whitewater River was captured or altered its drainage and began to flow along its present course resulting in relatively smaller quantities of sediments being deposited within the Mission Creek Subbasin as opposed to the Whitewater Subbasin. The basin subsidence rate must also have decreased at approximately this time since the influx of sediment into the study area appears to be sufficient to keep the basin full and not allow a significant depression to develop.

The observed seismic velocity of over 10,000 ft/sec. for the semiwater-bearing zone indicates that the sediments at this depth are well lithified containing few pore spaces or fractures although those present should be saturated. These units would serve as poor aquifers because of their probable low porosity and permeability.

Nonwater-bearing Rocks. Comprising this group of materials are consolidated sedimentary rocks of middle Tertiary geologic age and crystalline basement rocks (bedrock) of pre-Tertiary age. For the most part, the consolidated sedimentary rocks are of limited areal extent, particularly in the northern portion of the Salton Trough. The only exposures of these rocks in the region are in the Indio Hills, Garnet Hill, and the foothills of the San Bernardino Mountains just west of the study area (Plate 7). Because of their

secondary porosity, low permeability, and structural complexity, these rocks are not capable of yielding water readily to wells. Moreover, because of their lithified and cemented character, their storage capacity is low and long-term sustained yield is unpredictable. For these reasons, these rocks are classified as nonwater-bearing and are not considered part of the ground water basin.

Included within these rocks are: the marine deposited Imperial Formation (Ti on Plate 7) of Lower Pliocene age which consists of fossiliferous shales, sandstones, and siltstones; and the Coachella Fonglomerate of Miocene age (Tc on Plate 7) which is composed of continentally-deposited, coarse-grained sandstones and conglomerates. No wells are known to extract water from these rocks in the study area.

Also, within the nonwater-bearing group are all pre-Tertiary crystalline igneous and metamorphic rocks. These rocks underlie the sedimentary rocks within the Salton Trough and are exposed in the San Bernardino and Little San Bernardino Mountains adjacent to the study area. Collectively, these crystalline rocks comprise the basement complex. No wells are known in the study area to extract water from these rocks. Porosity, permeability, and water-yielding ability of these crystalline rocks are extremely limited.

Within the basement complex is found an assemblage of gneisses and schists (metamorphic rocks) of pre-Cambrian age (p_{gn} on Plate 7) which have been intruded and metamorphosed by younger granitic rocks associated with the southern California batholith (gr) of probable Cretaceous geologic age.

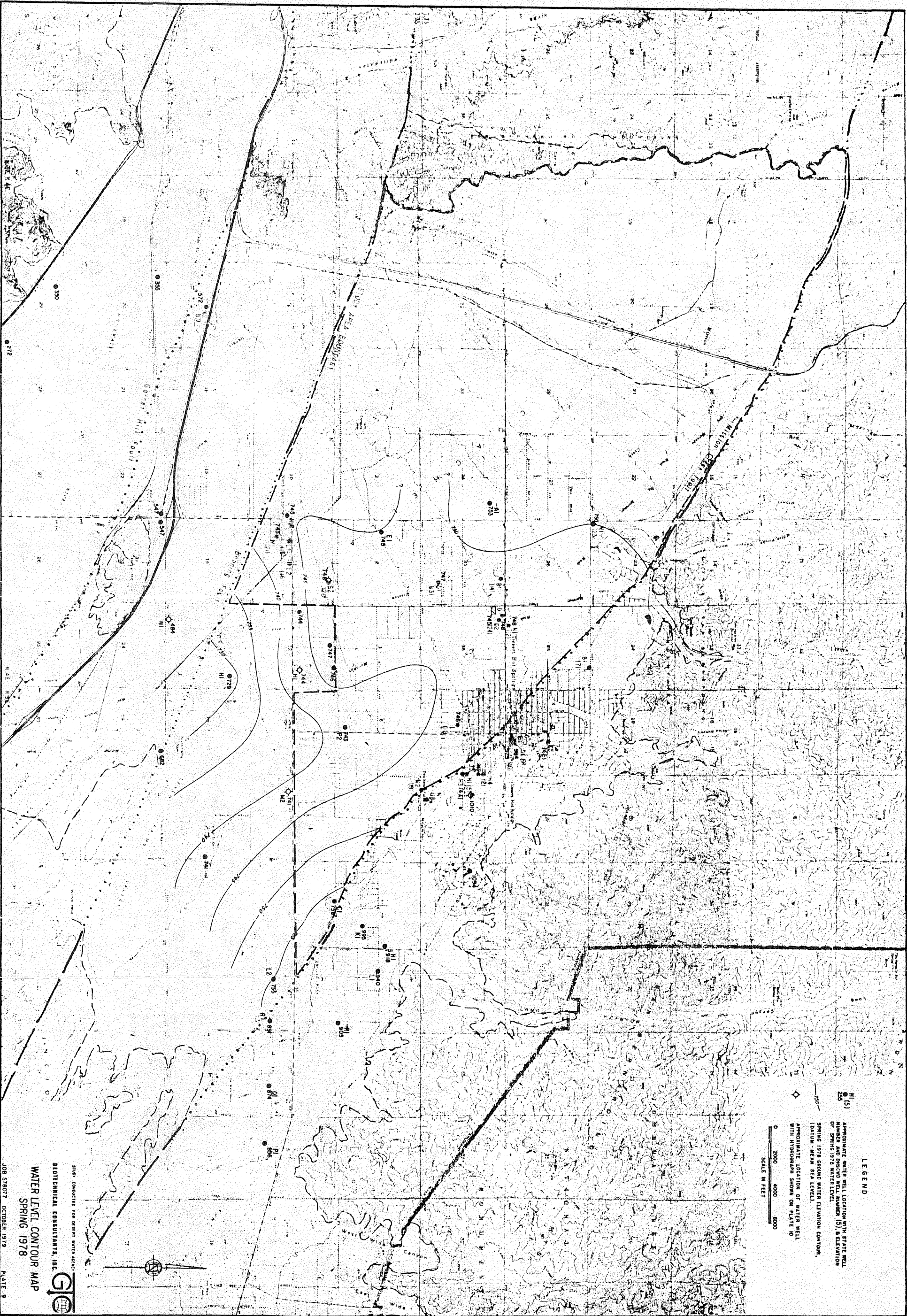
Seismic wave velocities for the nonwater-bearing sedimentary rocks appear to be approximately the same as those of the semiwater-bearing sediments or about 11,600 feet per second. The crystalline basement complex has a seismic velocity of over 17,000 ft/sec. and is clearly defined by the refraction profiles. Due to the arrangement of the seismic arrays and the placement of short points, the Banning Fault and the anomalous subsurface structure near

Devers Hill were only seen in the basement rocks. The gravity data was also used to clarify the subsurface structure of the basement complex which should be mirrored by the overlying sediments. The basement complex was found to exist at a maximum depth of over 7000 feet in the central portions of the study area.

Occurrence and Movement of Ground Water. Within the saturated zone, water exists in the pore spaces or voids between the individual sedimentary grains. For the study area, this intergranular water is believed to occur under water table conditions. This condition results from the relative coarseness of the sediments (as revealed by driller's logs), the method by which they were deposited, and the geologic history of the region, all of which preclude the possibility of areally extensive impermeable layers of clay that could result in confined aquifers and artesian wells.

The surface of the saturated sediments can be contoured to show the origin of basin waters and the direction these waters are moving. Nonpumping water level measurements obtained by District personnel during the Spring of 1978, were subsequently contoured. The resulting map, Plate 9 - Water Level Contour Map Spring 1978, reveals the elevation of the water table in the study area. Additional water level data for portions of the Desert Hot Springs and Garnet Hill Subbasins, was obtained from the Coachella Valley County Water District and for privately-owned wells in these subbasins, from the Riverside County Flood Control District.

The water level contours (Plate 9), indicate that the general direction of ground water movement is to the south. This trend closely parallels the variation in surface topography across the study area. The contours depicting the top of the water table, however, do not represent the top of the aquifer, which continues to the ground surface. Since almost the entire sequence



LEGEND

- WELL LOCATION WITH STATE WELL NUMBER AND OBSERVED WELL NUMBER (S) & ELEVATION OF SPRING 1978 WATER LEVEL
- SPRING 1978 GROUND WATER ELEVATION CONTOUR, (DATHUR - MEAN SEA LEVEL)
- APPROXIMATE LOCATION OF WATER WELL WITH HYDROGRAPH SHOWN ON PLATE 10
- SCALE IN FEET

STUDY CONDUCTED FOR RESIDENT WATER AGENCY
GEOTECHNICAL CONSULTANTS, INC. GPC
WATER LEVEL CONTOUR MAP
SPRING 1978



of water-bearing material below the water table is producible, we will, for the following discussion, treat the ground water regime as a single body.

The Spring, 1978 water table ranged between 735 and 753 feet in elevation and from 65 to 550 feet below ground level in the eastern portion of the study area. In the northwestern end of the subbasin, no recent water level data are available except for the drillers' logs from a few wells drilled in this part of the study area. From these logs, it is clear that there exists an ancestral channel of Mission Creek and that it is filled with at least 200 feet of alluvium where it enters the Upper Coachella Valley. The water levels at this end of the valley can be estimated today from the extrapolation of initial water levels recorded in these wells. This results in a ground water level of approximately 2000 feet elevation at the mouth of Mission Creek and less than 1100 feet elevation two miles south of Big Morongo Canyon where water level was not reached in a 300-foot well.

Along a line south of and paralleling the trace of the Mission Creek Fault, the ground water gradient significantly increases as it crosses into the northern end of the study area (Plate 8). From Dos Palmas Corners to north of 10th Avenue, the gradient is about 2.3 feet per mile while to the northwest, the ground water gradient is estimated at 300-400 feet per mile. We suggest this steep ground water gradient because the bedrock rises steeply from the basin to the northern edge of the study area. Further, due to the high porosity of the overlying water-bearing sediments, the water table mirrors the bedrock profile until it reaches the apparent "surface" of the ground water lake that fills the southeastern portion of the study area.

Zones of recharge may be inferred from shape of the contours on Plate 9. Re-entrant contours are present at the mouth of Long Canyon west of the Mission Creek Fault and so indicate a zone of recharge.



The sources of recharge for the Mission Creek Subbasin include: the San Bernardino Mountains through the drainage net of Mission Creek and its tributaries as well as the small channels and canyons along the eastern face of the mountains; the Little San Bernardino Mountains through the drainage networks of Big Morongo Canyon, Little Morongo Canyon and Long Canyon, and by the small channels and canyons along the western front of the mountains; inflow from the Desert Hot Springs Subbasin; and returns from sewage effluent and excess irrigation.

Unlike coastal regions and areas of greater precipitation, it is not likely that significant amounts of deep percolation of precipitation occur in this arid environment. Certainly, there would be deep percolation of precipitation if, in years of high rainfall, the requirements for evapo-transpiration and soil moisture deficiency were satisfied. However, according to DWR (1964, p. 106-107), in desert areas where average seasonal rainfall is less than 12 inches (Desert Hot Springs has five inches) deep percolation of precipitation is negligible. The quantitative appraisal of each of the above items of recharge to the study area is beyond the scope of this study.

Ground water barriers created by faults within the San Andreas fault zone are evident by inspection of Plate 9. These barriers are characterized by anomalies in the contour gradients and by the shape of the contours themselves on opposite sides of the Banning and Mission Creek faults. In each case, the region on the northerly side of each fault displays a higher ground water elevation relative to the regions on the southerly side.

The ground water barrier created by the Banning fault is not considered to be completely effective. Some subsurface flow appears to be moving southward across the fault from the Mission Creek Subbasin into the Garnet Hill Subbasin.



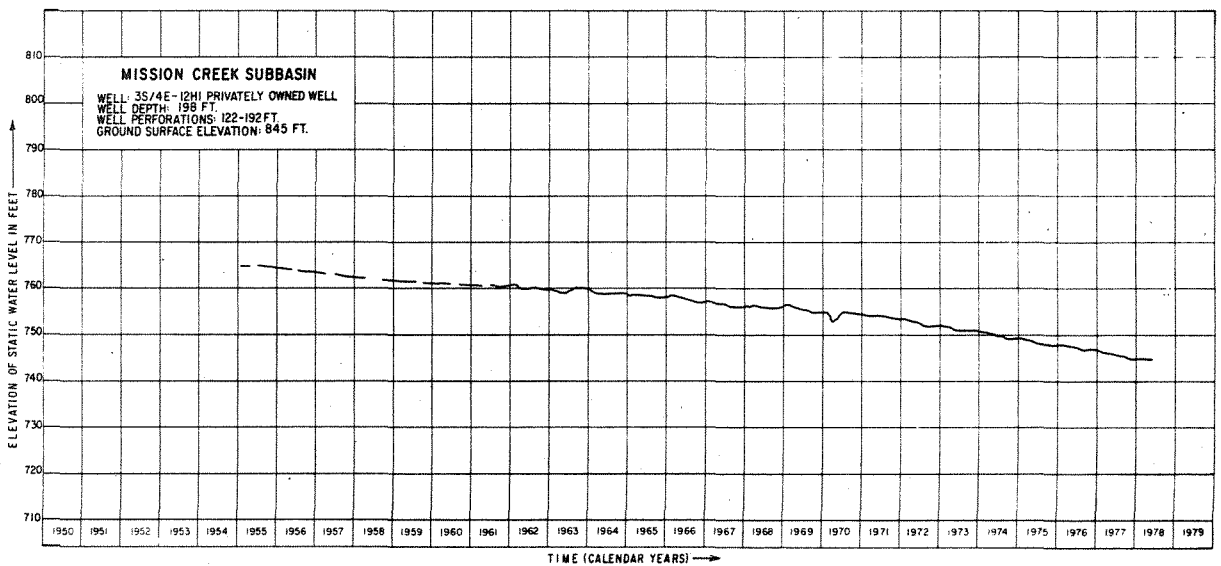
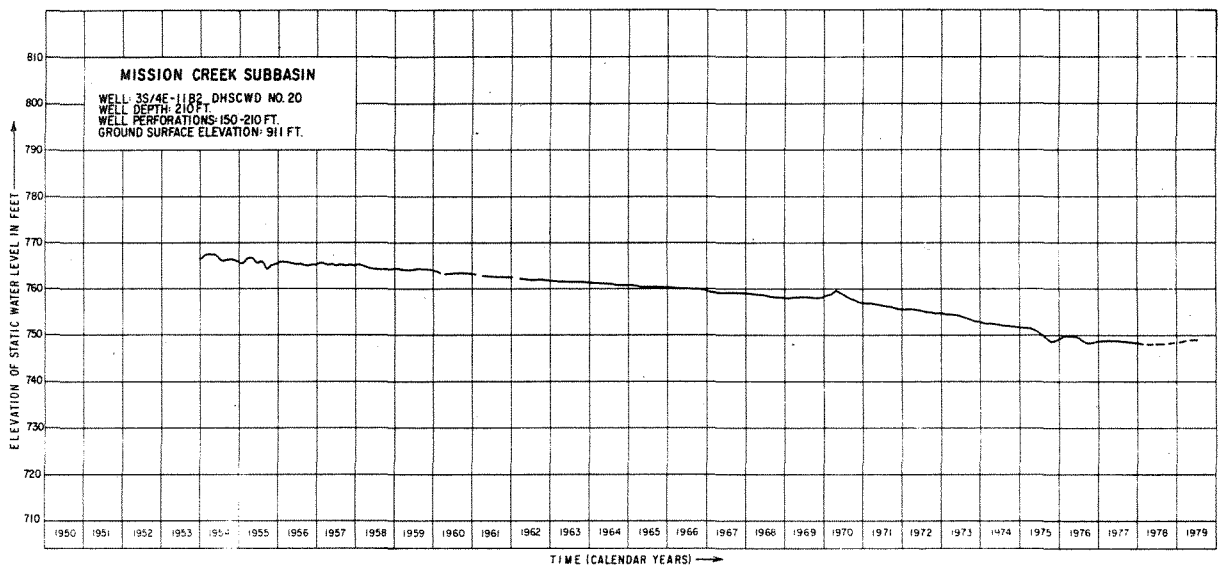
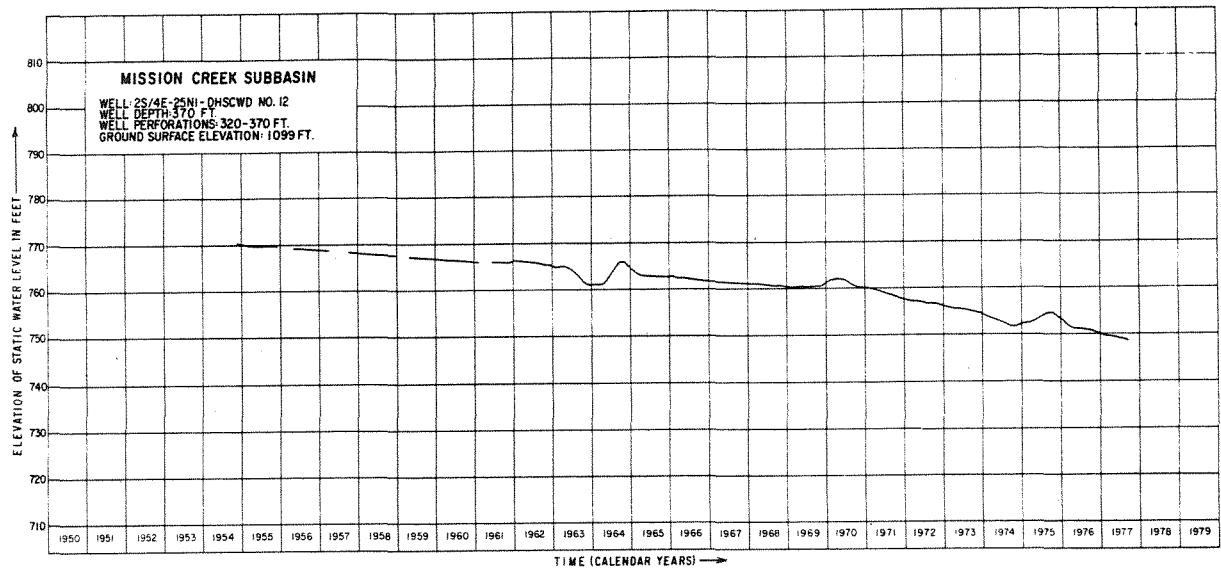
This is particularly evidenced by the ground water contours (Plate 9) in the vicinity of Seven Palms Ranch.

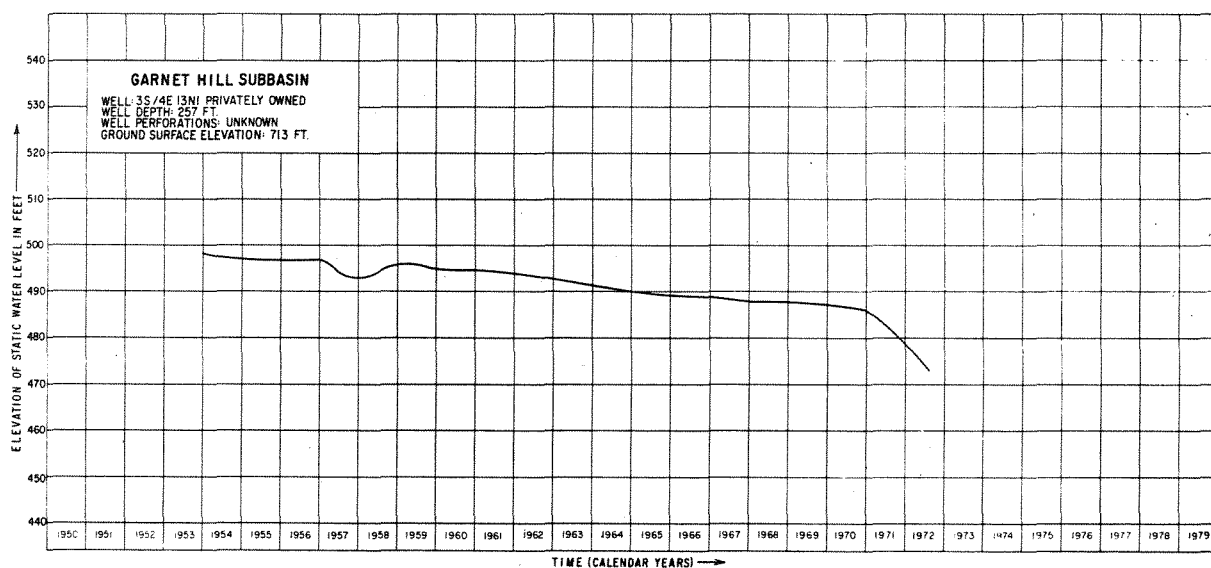
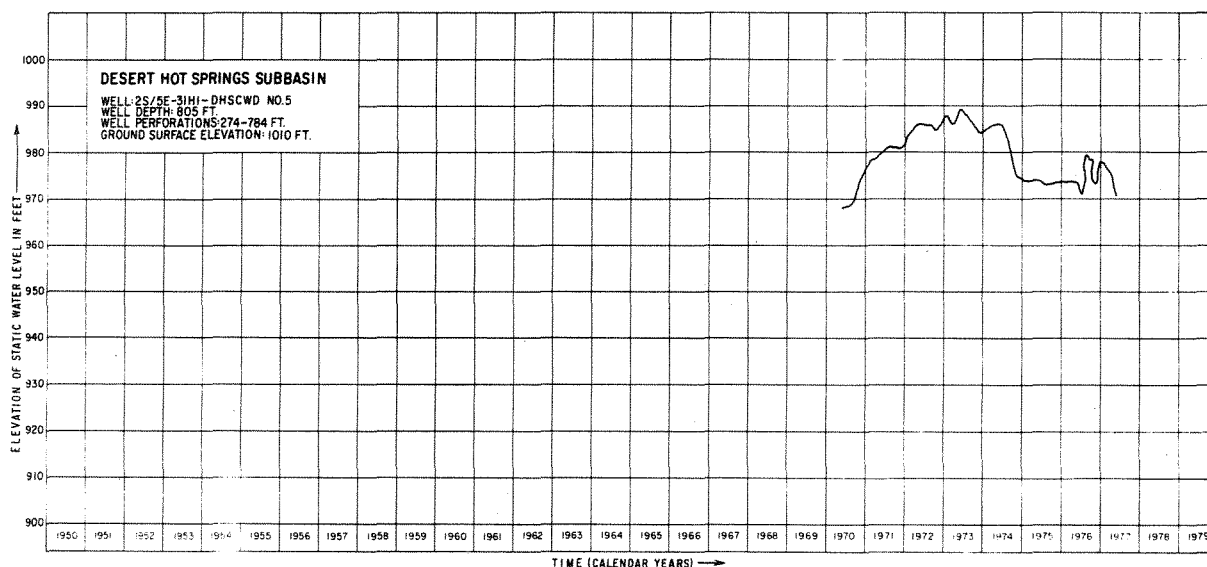
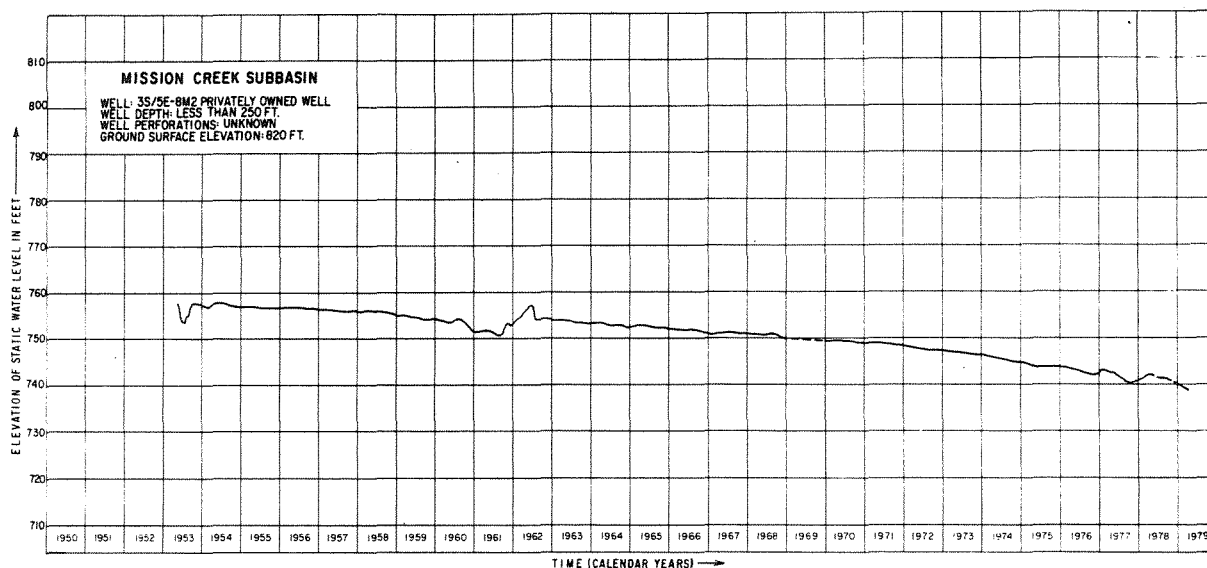
The Mission Creek Fault also creates a ground water barrier, although it too fails to be completely effective. On the basis of re-entrant contours where Dillon Road crosses the fault and on water quality data, it appears that the Mission Creek Fault between Miracle Hill and the Indio Hills allows a significant amount of subsurface flow to the southwest.

Total water level declines since the 1950's within the study area have amounted to, at most, 20 feet. The declines have averaged about one foot per year, with only slightly greater decreases beginning in 1970; the water levels are depicted on Plates 10.1 and 10.2 - Water Well Hydrographs.

Hydrographs for wells within the Desert Hot Springs Subbasin show many significant variations that can, in part, be correlated with the quantity of ground water extracted from that basin. The most reasonable explanation for why the Mission Creek Subbasin water levels fail to show the effects of variations in precipitation over the last 20 years may be that the ground water reservoir in the subbasin behaves like a lake and the ground water "streams" recharging the "lake" must travel sufficient distances through the sediments that annual variations are obscured. The result of the subbasin's apparent ability to "smooth" out any short-term variations is that the hydrographs may be interpreted as accurate indicators of long-term changes in ground water levels.

Hydrographs. Annual water levels have been plotted in the study area to study the continuous adjustment of ground water in storage to changes in recharge and discharge in selected wells. The resulting hydrographs for District well Nos. 12, 20 and for privately-owned wells 3S/4E-12H1 and 3S/5E-8M2, are depicted on Plates 10.1 and 10.2. District well No. 5 in the Desert Hot Springs Subbasin and privately-owned well 3S/4E-13N1 of the Garnet Hill Subbasin are also shown.







These wells were selected for analysis because they have a relatively long-term nonpumping water level record and they display water level information for both the study area and adjacent subbasins. In order to study water level fluctuations, individual hydrographs were compared to previously presented graphs of annual desert-floor precipitation (Plate 3), and of annual District ground water extractions (Plate 4).

The Mission Creek Subbasin hydrographs show little if any seasonal variations in the amount of ground water in storage in the study area. This would suggest that water levels in Mission Creek Subbasin do not directly depend upon the quantity of recent rainfall but instead fluctuate on the basis of long-term rainfall trends.

Wells within the Desert Hot Springs Subbasin, however, do exhibit short-term fluctuations of water levels and so can be said to respond quickly to seasonal variations of precipitation (See Plate 10.2). Wells in the Desert Hot Springs Subbasin also display a short-term response to ground water extractions as seen in the significantly lower ground water levels in 1969-1970 when approximately 900 acre-feet per year was extracted by the District. During 1971-1973 little water was taken from District wells in this subbasin and the hydrographs display a 20-foot rebound of the water table. Within the Mission Creek Subbasin, the effects of apparent increased extractions by the District from about 1970 to the present may be reflected in the slight steepening of the decreasing ground water gradient.

On all of the hydrographs plotted for wells within the study area, the gradient of ground water level decline, changes from an almost constant 0.65 feet per year from mid-1950 to 1970, to 1.2 feet per year from 1970 to the present. It is generally agreed that a significant wet cycle for southern California ended in 1945 and that since that time, the average precipitation has been less than the long-term average and so indicates a dry cycle.

It can therefore be maintained that declining water levels prior to 1970 are the result of the subbasin adjusting to the long-term (steady state) recharge-discharge balance in the ground water reservoir. Since 1970, however,



change in supply to the basin was the apparent increase in extractions by the District.

Review of the hydrographs on Plates 10.1 and 10.2 reveals the existence of occasional spurious water level readings which cannot be correlated with either extractions or climate. Such data (for example, in 1970 in well 3S/4E-12H1) are most likely caused by human error; that is, by changes in monitoring personnel or monitoring equipment, by modifications to the reference points or sounding tubes, or by reporting a non-pumping (static) water level while in reality a pumping or partial recovery level should have been reported.

Well Characteristics and Well Logs. Historical water level records, specific capacity data, boring log-well completion information and water quality data have been amassed where possible for the 11 wells which have been drilled for and/or operated by the Desert Hot Springs County Water District. Similar data for the privately-owned wells in the study area are meager. We have prepared Table 1 - Summary of Water Well Data, to permit rapid comparisons of pertinent data available for each District well in and near the study area and to synthesize important criteria relative to the future viability of these wells. The table shows and compares for 26 wells such variables as well depths, date of construction, casing completion data, original and Spring 1978 static water level data, original and 1978 specific capacity data, and general water quality data.

Particularly significant items on Table 1 are discussed as follows:

- a. Distance of bowls below top of perforations. Where pump bowls are placed below the top of perforations there is a tendency to increase corrosion or incrustation in the well. Also, the well can pump air if cascading water occurs. All of the active District wells within the study area show this type of bowl placement except No. 21. Pump bowl placement in well No. 21 is just at the top of the perforations. This could be a problem in 10 to 15 years if water levels continue to decline at their current rate.

DHSCWD SUMMARY OF WATER WELL DATA

TABLE 1

IDENTIFICATION DATA							CASING DATA - PERFORATIONS				WATER LEVEL DATA - DEPTHS				SPECIFIC CAPACITY DATA				WATER QUALITY DATA			THEORETICAL TRANSMISSIVITY	THEORETICAL PERMEABILITY	YIELD FACTOR
DHSCWD Well No.	DWR Well No.	Subbasin Location	Date Drilled	Well Depth (feet)	Boring Log	Well Status	Diameter (inches)	Zone (feet)	Total Length (feet)	Size (inches)	Original Static (feet)	Spring 1978 Static (feet)	Spring 1978 Pumping (feet)	Distance of Bowls Below Perforations (feet)	(Q/s) Original (gpm/ft)	(Q/s) 1978 or Latest (gpm/ft)	Percent Q/s Decline	Overall Plant Efficiency (percent)	TDS (mg/l)	TH as CaCO ₃ (mg/l)	Temp. (°F.)	$T = \frac{3500 Q_m}{S (2m-s)} \text{ (gpd/ft)}$	$P = T/m \text{ (gpd/ft}^2\text{)}$	$YF = \frac{Q}{m} \text{ (gpm/ft)}$
1	2S/5E-30Q1	Desert Hot Springs	1951(?)	190 or 260	no	abandoned	8	-	-	-	60	112	-	-	(1954) $\frac{94}{6.7} = 14$	(1958) $\frac{86}{18.4} = 4.7$	-	(1958) 47.8	-	-	86	26,300 approximate	526 approximate	1.9 approximate
2	-31H4	Desert Hot Springs	1940	122	yes	destroyed	-	55-110	55	5/16, mills knife	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-31H2	Desert Hot Springs	1951	119	yes	destroyed	10	46-55,80-100	29	5/16, mills knife	-	-	-	-	(1954) $\frac{168}{11.9} = 14.1$	-	-	-	-	-	-	29,600	1,021	5.8
4B	-30K1 or -30K5	Desert Hot Springs	1951	132	yes	destroyed	10	24-48,84-128	68	3/16, mills knife	-	-	-	-	(1954) $\frac{44}{16} = 2.7$	-	-	(1954) 27.1	-	-	-	5,500	81	0.6
5	-31H1	Desert Hot Springs	1949	805	yes	active	18	274-291,513-517 661-699,761-784	82	3/8	39 (1954)	-	-	114 above	(1954) $\frac{468}{85.5} = 5.5$	(1976) $\frac{173}{40.2} = 4.3$	22	(1976) 44.1	678	258	94	20,000	244	5.7
6	-30Q2	Desert Hot Springs	1955	204	yes	inactive, to be abandoned	10	80-100,140-160 176-195	59	1/4, mills knife & torch	80	-	-	104	$\frac{60}{4} = 15$	(1967) $\frac{133}{29.1} = 4.6$	69	27.1	879	359	88	27,200	461	1.0
7	2S/4E-25B1	Desert Hot Springs	1950	191	yes	abandoned	8	160-190	30	1/8, torch	153	-	-	104	$\frac{17}{0.5} = 34$	-	-	-	-	-	84	60,000	2,000	0.3
8	2S/5E-30Q5	Desert Hot Springs	1957	385	yes	active	10 and 8	80-195,260-290 365-395	175	1/4, mills knife & torch	82	121(?)	194(?)	100, well sands	$\frac{100}{4} = 25$	$\frac{221}{26.1} = 8.5$	66	54.6	771	341	84	44,300	253	0.6
9	-30Q6	Desert Hot Springs	1964	738	yes	abandoned	12 and 8	360-700	340	1/8, louvers	108	-	-	-	$\frac{525}{127} = 4.1$	(1974) $\frac{413}{79.6} = 5.2$	-27	62.7	716	90	102	8,900	26	1.5
10	-30Q7	Desert Hot Springs	1966	775	yes	active	12	250-304,360-700	394	3/32, louvers	-	153(?)	178(?)	40 above	$\frac{950}{95} = 10$	$\frac{540}{66.9} = 8.1$	19	48.2	690	245	95	11,000	28	2.4
11	2S/5E-31L1	Mission Creek	1954 or 1959	288	yes	abandoned	10	220-285	65	1/4, mills knife & torch	217	237	-	-	$\frac{75}{2} = 37$	-	-	-	731	216	90	66,700	1,025	1.2
12	2S/4E-25N1	Mission Creek	1954	370	yes	abandoned	8	320-370	50	5/32, torch	330	351	-	-	-	-	-	-	-	-	-	-	-	-
13	-35Q1	Mission Creek	1954	530	yes	abandoned	8	185-217,265-380	147	1/4	190	297	-	-	(1959) $\frac{192}{3.5} = 55$	-	-	-	-	-	-	97,200	661	1.3
14	-35B1	Mission Creek	1955	410	-	DHSCWD no longer owns	12	250-400	150	-	-	-	-	-	-	(1968) $\frac{72.3}{6.1} = 11.8$	-	53.1	445	240	76	21,200	-	0.5
15	3S/4E-11L1	Mission Creek	-	128	no	inactive, to be abandoned	8	-	-	-	-	-	-	-	55	Q = 16 gpm	-	-	277	106	79	-	-	-
16	-11L2	Mission Creek	1955	167	no	on standby	8	-	-	-	105 (1961)	-	-	-	(1961) $\frac{201}{10} = 20$	(1975) $\frac{57}{10} = 5.7$	72	19.3	396	166	80	39,100 approximate	782 approximate	-
17	-17K2	Garnet Hill	1970	660	yes	never used	12	-	-	-	-	-	-	-	Q = 5 gpm	-	-	-	-	-	-	-	-	-
18	2S/5E-32N1	Desert Hot Springs	-	-	-	partly destroyed	-	-	-	-	-	-	-	-	-	-	-	-	641	64	-	-	-	-
19	-32N2	Desert Hot Springs	1966	182	yes	abandoned	8	110-180	70	3/16, torch	64	-	-	-	$\frac{40}{4} = 10$	-	-	-	-	-	120	18,000	257	0.6
20	3S/4E-11B2	Mission Creek	1956	210	yes	active	7	150-210	60	1/8, torch	151	163	170	20	(1966) $\frac{25.7}{4} = 6.4$	$\frac{26}{12.2} = 2.1$	67	35.3	585	237	77	11,600	194	0.4
21	-11M1	Mission Creek	1963	302	yes	active	10	170-290	120	1/8, vertical slots	106 (1972)	114	116	bowls at top of perfs.	(1972) $\frac{432}{3.3} = 131$	$\frac{382}{4.2} = 91$	20	56.6	261	99	79	232,300	1,935	3.6
22	2S/4E-36D1	Mission Creek	1970	807	yes	active	14	390-780	390	1/8, full-flow louvers	352	351	365	160	$\frac{2300}{20} = 115$	$\frac{1181}{11.4} = 103.6$	31	61.0	411	202	82	206,500	530	5.9
23	-23N1	Mission Creek	1969	830	yes	active	12	526-830	304	-	526	-	-	154	$\frac{1100}{54} = 20.3$	$\frac{874}{14.7} = 59.3$	-192	60.3	426	220	72	39,100	129	3.6
24	-36D2	Mission Creek	1973	810	yes	active	14	400-790	390	1/8, louvers	352	347(?)	366	150	$\frac{2500}{15} = 166$	$\frac{1421}{11.5} = 123.6$	26	70.5	393	199	77	297,400	763	6.4
25	3S/3E-7M1	San Geronio Pass	1958	465	yes	active	16	330-455	125	3/16	315	324	325	90	(1972) $\frac{819}{24} = 34.1$	(1977) $\frac{181}{5.3} = 34.2$	0	34.3	303	158	-	66,100	528	6.6
26	3S/3E-8M1	San Geronio Pass	1928	575	yes	active	20	225-553	228	-	237 (1968)	224	225	155 to 175	(1975) $\frac{261}{1.5} = 174$	(1977) $\frac{251}{2.5} = 100.4$	42	60.6	228	102	-	305,500	1,340	1.1



b. Casing Data-Perforations-Size. Although not available for all wells, these data wherever given reveal the variable size of the perforations and the manner in which the openings were made (that is, whether they are vertical slots, hydraulic mills knife cuts, torch cut openings, or louvered shutter screens).

Specific capacity losses can more readily occur when well perforations are of the vertical slot or torch-cut or mills knife varieties. Such perforations are present in the older active District wells Nos. 20 and 21. In general, active agency wells drilled within the last 10 years were completed in the state-of-the-art method with louvered shutter screen casing containing openings of 1/8-inch in size.

c. Specific Capacity Data-Percent Decline. This column of Table 1 shows the percent decline in specific capacity between the original or earliest available gallons/ft of drawdown Q/S value and the 1978 or latest available data. Reasons for such declines can include: chemical or biological encrusting of the well perforations, in the gravel pack or on the adjacent formation walls; inaccurate monitoring of the well yield, static level or pumping level at the time of the test; and plugging of the gravel pack with fine-grained formation materials caused by continuous and long-term production without periodic surging.

The active wells within the study area that have demonstrated declines in specific capacity are well Nos. 20 (67 percent), 21 (20 percent), 22 (31 percent), and 24 (26 percent).

An increase in specific capacity was noted in active well No. 23 and is shown by the negative value of specific capacity percent decline. This means that the well is more efficient now than when first drilled and can occur through slowly improved development of the well and removal of drilling muds from coated producing zones. These coatings are only slowly removed from in and around the well bore by long-term pumpage and surging.



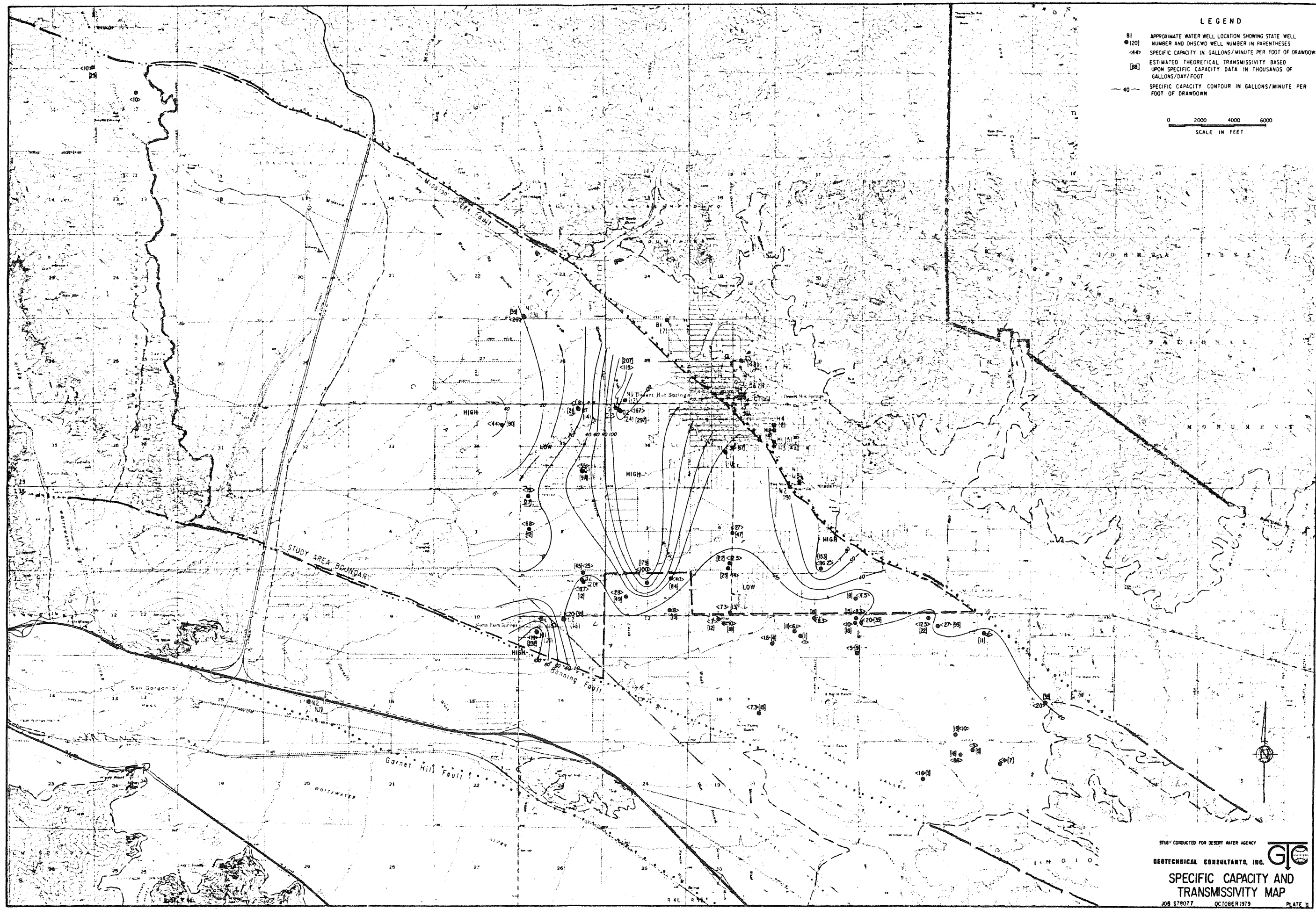
Changes in specific capacity can occur also where a small amount of drawdown is created in a well. Thereby, small errors in monitoring basic water level data can cause relatively large fluctuations in the calculated specific capacity.

d. Specific Capacity Data - 1978 Overall Plant Efficiency.

Active District wells within the study area display efficiencies between 35 and 71 percent in terms of overall plant efficiencies, as determined by 1978 Edison Company Tests. The most recent wells (Nos. 21, 22, 23, and 24) have overall efficiencies from 56-71 percent, which are generally considered average. Well No. 20, drilled in 1956, had an efficiency of only 35 percent combined with a 67 percent decline in specific capacity.

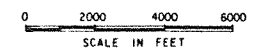
In order to gain a clearer understanding of the hydrologic nature of the Mission Creek Subbasin, the specific capacity for wells located within the basin have been plotted on Plate 11 - Specific Capacity and Transmissivity Map. From this plot, we see that there exists regions of generally higher and lower specific capacities. Since permeability is directly related to specific capacity, the contours on Plate 11 give us a reasonable approximation of what parts of the basin contain a greater sequence of highly permeable sediments. Although this data in part reflects the method with which the wells were drilled and completed, it is felt that general trends may be interpreted from the data.

This map indicates that there exists a region of relatively high specific capacity extending from North Palm Springs northeast to Desert Hot Springs and from there northwest perhaps to the San Bernardino Mountains. This region should be interpreted only as a statistical feature, delineating areas where high capacity wells presently exist and consequently areas where one would expect similar wells to be successful. The portion of the subbasin south of the study area appears to be a region of uniformly low specific capacity.



LEGEND

- (20) APPROXIMATE WATER WELL LOCATION SHOWING STATE WELL NUMBER AND OHSCWO WELL NUMBER IN PARENTHESES
- <44> SPECIFIC CAPACITY IN GALLONS/MINUTE PER FOOT OF DRAWDOWN
- [88] ESTIMATED THEORETICAL TRANSMISSIVITY BASED UPON SPECIFIC CAPACITY DATA IN THOUSANDS OF GALLONS/DAY/FOOT
- 40 — SPECIFIC CAPACITY CONTOUR IN GALLONS/MINUTE PER FOOT OF DRAWDOWN



SCALE IN FEET

STUDY CONDUCTED FOR DESERT WATER AGENCY
GEOTECHNICAL CONSULTANTS, INC.



SPECIFIC CAPACITY AND TRANSMISSIVITY MAP

Theoretical Aquifer Parameters. The water transmitting or hydraulic properties of aquifers are characterized by the aquifer coefficients of transmissivity and storativity. The permeability, which was derived from transmissivity, and the yield factor derived from specific capacity are additional parameters used to compare and quantify aquifer characteristics. Theoretical transmissivity, permeability and yield factors, for District wells are presented on Table 1.

Transmissivity is defined as the quantity of water, in gallons per day, that will flow through a vertical strip of the aquifer one foot wide extending the full saturated height of the aquifer under a hydraulic gradient of one foot per foot. The transmissivity calculated from an aquifer test in a well represents the transmissivity of all the aquifers penetrated and completed by the perforated casing in the well.

We have calculated theoretical transmissivity for all District wells and a few privately-owned wells having necessary specific capacity data. Our calculated values were used as a tool to locate areas in the study area having high transmissivity and to provide design values for determining well spacing for future wells (Plate 11). Transmissivity values from District wells varied from 5500 to 305,500 gallons per day per foot. They also generally fell into two transmissivity groups. Thus the 20,000 to 66,000 gallon per day range appear to be the shallower wells while those in the 200,000 to 300,000 gallons per day range seemed to be deeper.

Actual calculations of theoretical transmissivity are based on the modified Thiem formula which provides an empirical relationship between transmissivity and specific capacity. For the unconfined water table thought to exist within the study area, the relationship is: aquifer transmissivity (in gallons per day per foot of aquifer) $T = 3500 \frac{Q}{m \cdot s}$ (2m-s), where Q/s is the original specific capacity in the well with well yield, Q , in gallons per minute; and drawdown, s , in feet; and where m is the total aquifer thickness in feet. We have utilized the original specific capacity value as determined in the well (see Table 1).



Moreover, because we have used actual Q and s data from existing wells, the resulting T value for each well represents the transmissivity of the total length of aquifer for which the well was perforated.

An attempt was made to obtain water level drawdown and recovery data from District wells Nos. 12, 21, 22, and 24 during August of 1978 in order to develop the transmissivity of the basin sediments. Due to various operating and measuring problems, usable data was obtained only from wells Nos. 22 and 24 (Appendix B - Aquifer Tests and Field Data). These data provided transmissivity which varied from 1,500,000 to 1,800,000 gallons per day per foot in well 22 and 1,470,000 gallons per day per foot in well 24. These results are generally too high for the basin. Most data suggests a range of 200,000 to 300,000 gallons per day per foot. Recharge from nearby Mission Creek may have caused the test results to be high.

Using the calculated theoretical transmissivity values, theoretical permeabilities were developed (Table 1) by the formula $P=T/m$. In this equation permeability as P (gallons per day per square foot of aquifer), theoretical transmissivity as T , and the total length of perforations in the well (i.e., the length of the formation open to the well) as m (units in feet).

The third parameter, yield factor, is defined as the amount of water produced from each foot of perforated casing in the well or $Y_f = Q/m$ where Q is the original yield of the well and m is the length of screen. Such calculations eliminate the variation in the depth of the wells and afford a hydraulic element which can be used in the general comparison of wells and of the materials from which water is extracted by the wells regardless of plant capacity, well drawdown, or well depth. The factor can be used also in future well design criteria to help establish the amount of perforations required for any required well yield in any given area.

It should be noted that no accurate information is available to evaluate individual aquifer characteristics in the basin, but a general correlation



between the depth of a well and the magnitude of the aquifer parameters is possible. This correlation indicates that the deeper wells within the basin tend to have higher specific capacities, greater yields, and large theoretical transmissivities. The main implication of this is that the aquifer does not seem to deteriorate with depth within the water-bearing sediments.

Theoretical transmissivity values for District and selected private wells have been plotted on Plate 11 - Specific Capacity and Transmissivity Map. Due to extreme variability, these values do not give a clear picture of how these physical properties of the aquifers are distributed, either laterally or vertically. One reason for this is that these theoretical aquifer parameters are directly related to the specific capacities of the wells and as discussed previously, the manner in which the water wells were completed has a significant effect on the specific capacities the wells display.

Nevertheless, the contours of specific capacity (Plate 11) indicate the existence of regions with significantly higher Q/S values. If we assume that water well development has been relatively uniform over the basin, i.e., no area has a larger number of older shallower, or poorly completed wells, then the zones of high specific capacity on Plate 11 delineate areas where new wells are statistically more likely to have high specific capacities. High specific capacity is a good indicator of a highly porous and permeable aquifer. The implications of the contours on Plate 11 then is that there exists at depth a good aquifer beneath Mission Creek and the Morongo washes. This would be expected if coarse grained, poorly graded channel deposits existed at depth beneath the present stream courses.

Analysis of Storativity. The final hydraulic property of aquifers is the storage coefficient (S). The storage coefficient (also known as storativity) is defined as the volume of water in cubic feet that an aquifer releases from a saturated vertical column of the aquifer 1 foot square when the water table declines 1 foot. From this definition, the units of storativity

are: cubic feet per square foot per foot, which is a dimensionless quantity. Typically, the storage coefficient is expressed as a decimal or as a percent.

In water table aquifers such as exist in the study area, the storativity is a much larger value than in artesian or confined aquifers, such as exist farther to the south in the Coachella Valley. Typical magnitudes of storage coefficient are: about 0.1 to 0.3 in water table aquifers; and about 0.00001 to 0.001 in artesian aquifers (Lohman, 1972, p. 8-9). The differences in magnitude occurs because water is drained by gravity flow from the pore spaces between individual grains in the water table aquifer while in artesian conditions, the pore spaces remain saturated as the water level (piezometric or pressure surface) declines in response to pumping. As a result, the aquifer releases water from storage by compression of the aquifer and expansion of the water (Lohman, 1972, p. 8).

In unconfined water table conditions as in the study area, the storage coefficient can be considered to be equivalent to the specific yield of the materials being drained. Specific yield is defined as the ratio of the volume of water (in cubic feet) which can be drained by gravity to a unit volume of the saturated material (in cubic feet). The specific yield of a sediment is a physical property of the material and is readily determined in a soils laboratory; it is commonly expressed as a decimal or as a percent. Typical specific yields range between 0.03 (3 percent) for clay and other fine grained materials to 0.28 (28 percent) for sand and other well-sorted (poorly graded) coarse grained sediments.

At present, the only laboratory determinations of specific yield which exists for the Coachella Valley were conducted by the USGS in their artificial recharge study for the Whitewater River Subbasin (Tyley, 1973, p. 11 and 15). These data are for sediments to depths of 27 feet below ground surface near Windy Point and reveal specific yields on the order of 13 to 21 percent.



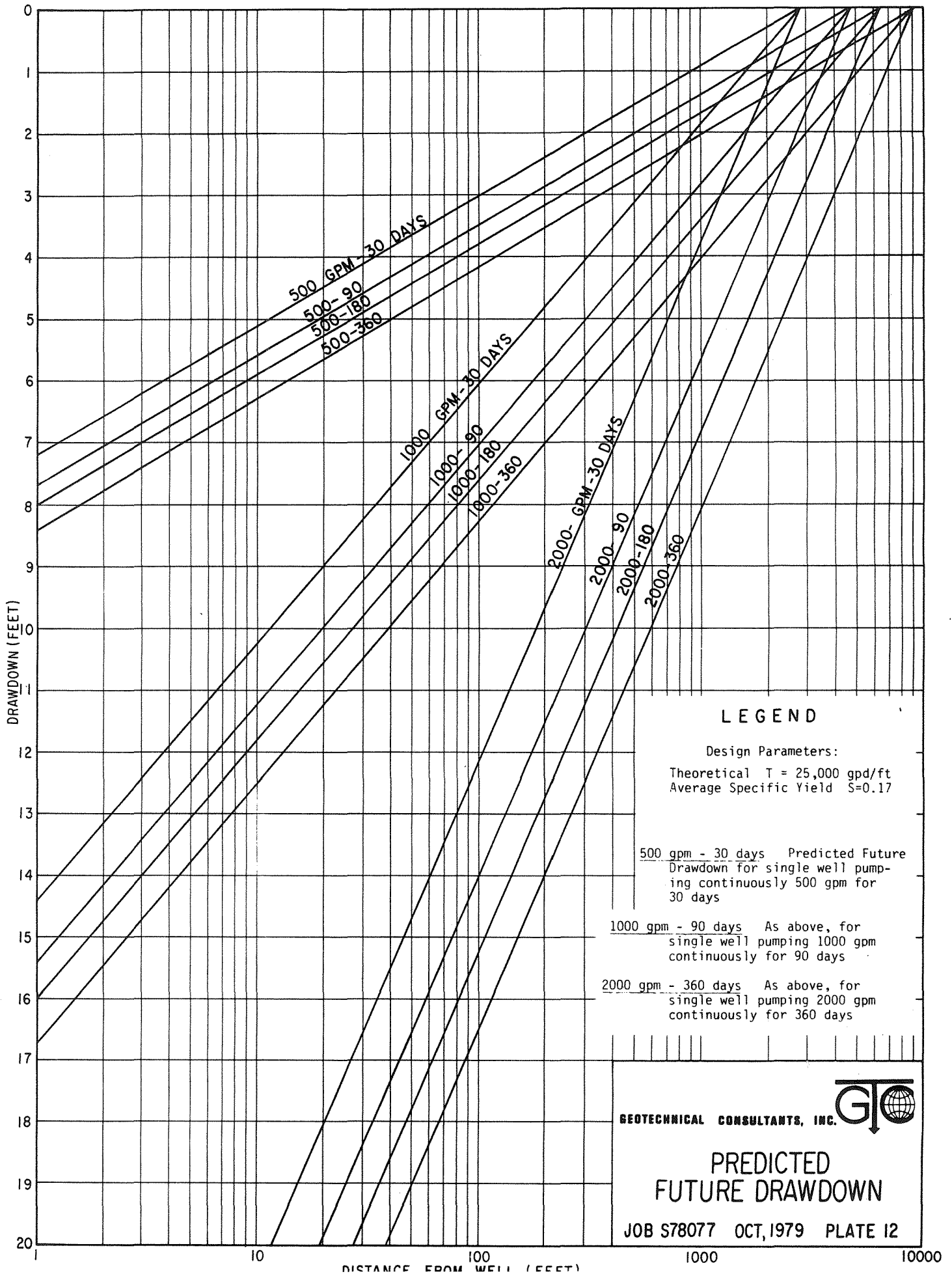
Because the depositional environment and grain size of these sediments is considered to be grossly similar to that in the sediments down to the base of fresh water, the specific yield of the underlying materials can be expected to be in the same general order of magnitude.

To assist the determination of storativity for the study area and because of the lack of both specific yield determinations and long-term aquifer tests, it was necessary to assign specific yield values to various earth materials as described on available drillers' logs. We have adapted specific yield values assigned by DWR (1964) to these logs.

Based upon these assignments and our calculations, we have determined an overall specific yield (storage coefficient) of 0.17 (17 percent). This value is considered reasonable and representative based on the descriptions of earth materials on the boring logs and upon the types of sediments present in the region and their method of deposition. Details of these calculations and the method of specific yield assignments are presented in Appendix C-Ground Water Storage.

Predicted Future Drawdown. Design parameters from which drawdown interference effects can be predicted have been generated and are presented on Plate 12 - Predicted Future Drawdown. The parameters were developed for $T = 125,000$ gpd/ft and $s = 0.17$ which represent the average theoretical transmissivity (refer to Table 1) and the overall storativity value (see previous section) of the study area.

The graph provides families of curves which indicate the theoretical drawdown created by a single pumping well pumping continuously at various rates (500, 1000, and 2000 gpm) for different periods of time (30, 90, 180 and 360 days). Drawdown created within the well itself and within other wells located at various radial distances outward from the pumping well can be determined from the curves on Plate 12.



For example, by referring to Plate 12, one could predict a drawdown of 14.4 feet if a well were pumped at 1000 gpm continuously for 30 days, while at an adjacent well at a distance of 1000 feet the interference effects would create a drawdown of approximately 2 feet. The maximum size of the radius of influence (the limit of the cone of influence (the limit of the cone of depression) for a well pumping at 1000 gpm for 30 days will be located 2800 feet from the pumping well. Such a broad flat cone of depression is indicative of highly transmissive and permeable sediments in a water table environment.

Although these data were prepared for a single pumping well, the individual curves in each family can be used to also reveal the mutual interference drawdown effects for any number of wells situated within overlapping zones of influence (cones of depression). For example, two wells each pumping 1000 gpm continuously for 90 days located 1000 feet apart will create a total drawdown of 8 feet (4 feet from each well) at a point 500 feet from both wells, i.e. halfway between the two wells. Drawdown in each well would be 19.5 feet, 14.5 feet created by that well plus 4 feet created by the adjacent well.

Referring to Plate 12, we notice that a well producing 1000 gpm continuously for 90 days will cause a drawdown of almost 5 feet in a well located 355 feet away. Such a situation exists between District well Nos. 22 and 24. Plate 12 also predicts a drawdown of almost 15 feet within a well if it also pumps 1000 gpm for 90 days. The expected total drawdown from Plate 11 in District Well Nos. 22 and 24 after 90 days of pumping 1000 gpm each is 20 feet.

However, only 15 feet of drawdown would be noticed during well tests unless both wells (Nos. 22 and 24) were simultaneously shut off for a reasonable length of time. Data indicates that these wells do not experience a full 15 feet of drawdown due to pumping, the reason for this is that Plate 12 is based upon basin averages and Well Nos. 22 and 24 have theoretical transmissivities over 200,000 gpd/ft and so display smaller drawdowns than the average basin well.

GEOHYDROLOGY

Ground Water in Storage. The ground water storage capacity is the volume of water that can be held in underground storage from the base of the water bearing to the ground surface. In the unconfined water table conditions that exist throughout the study area, storage capacity depends on the total volume of sedimentary material that is or can be saturated and the specific yield of that material. For the study area, calculations of water in storage were from the base of the water-bearing to the average 1978 water table.

The storage calculations (refer to Appendix C), were performed separately for the two parts of the study area depicted in Plate C-1. The study area was divided into these two units on the basis of ground water level gradients and degree of reliability of data. In storage Zone A, little is known about the water table, sediments or depth of the basin except from geophysical data. We have assumed a basin model where the bedrock rises quickly from the line separating the storage zones towards the northwest creating a ground water gradient of 300 to 400 feet per mile. Using a storage coefficient of 17 percent determined from data in Zone B, a value of 558,600 acre-feet of water in storage was determined. This volume should not be considered in total storage calculations since basin models of this storage zone could take many forms varying the storage volume significantly.

Within storage Zone B, the ground water level is practically horizontal with a maximum variation of 10 feet. Data in this zone is good and provides a relatively accurate picture of zonal storage and a volume of 890,000 acre-feet was determined.

Ground Water in Storage by Others. Previous determinations of ground water in storage for the Mission Creek Subbasin have been made by DWR (1964) and Bechtel (1967). Direct quantitative comparison between these studies and ours is difficult since our study area represents only the northwestern three-quarters of the Mission Creek Subbasin and both the ground water levels and



the maximum depths of saturated sediments we used differ from those used by the previous studies. The values obtained by DWR and Bechtel for the Mission Creek Subbasin are certainly within the same order of magnitude as the values we have calculated for ground water in storage.

Change in Ground Water in Storage. It is possible to calculate the change in ground water in storage by the specific yield method. This change in storage calculation is for the identical region used previously (see Plate C-1) comprised of the two storage zones. For our study, we have calculated the change in storage for the 23-year period for which we have water level data (1955-78).

It should be remembered that according to precipitation records, the last 41-year period was characterized by: a wet period between 1936 and 1946 wherein surplus water would have existed; and a dry period which began in 1947 and continues to the present, wherein deficient water supply conditions have existed (refer to a cumulative departure curve of precipitation for Beaumont presented in Tyley, 1974, Figure 15). Because the deficient water supply period has been longer than the prior surplus water supply period, the resultant water conditions in the region during our analysis period would have been expected to decline regardless of ground water extractions.

As indicated, utilizing the two storage zones (see Table C-1), the average water level change in each zone during the 23 years of record is multiplied by the average specific yield within the sediments. The resultant calculations suggest a total decline in storage of 71,200 acre-feet of water. On an annual basis, this total decline amounted to an average decline in storage of 2,400 acre-feet per year from 1955 to 1970 and 4,400 acre-feet per year from 1970 to 1978.

Both ground water extraction and the natural recharge-discharge balance are responsible for the decline. Data on Plate 4 indicates that there has been a total ground water extraction by the District of 12,992 acre-feet from the Mission Creek Subbasin through 1978. The volume of District extracted water represents about 18 percent of the total decline in storage.

The remaining 82 percent of the decline in storage could be attributed to ground water extraction by private wells, deficiencies in the natural recharge-discharge balance, and extractions by Coachella Valley County Water District outside the study area.

It is readily apparent that the extraction of ground water by the District does have a measurable impact upon basin ground water levels. However, this impact is not as large as the effect of insufficient recharge into the basin stemming from the lack of adequate rainfall and private or other agency pumping.

Change in Ground Water in Storage by Others. Only the DWR (1964, Plate 12) has calculated a decline in storage for the Mission Creek Subbasin within which the study area is located. For this region, the DWR calculated a net rise in storage of approximately 25,000 acre-feet for a 21-year base period of study, 1935-36 through 1956-57. From 1953 to 1957, however, they have indicated a decline of approximately 10,000 acre-feet.

Since the wet cycle ended in 1945, the eight year lag time before basin water levels began to decline may indicate the time required for the

basin to feel the effects of increased or decreased natural ground water recharge.

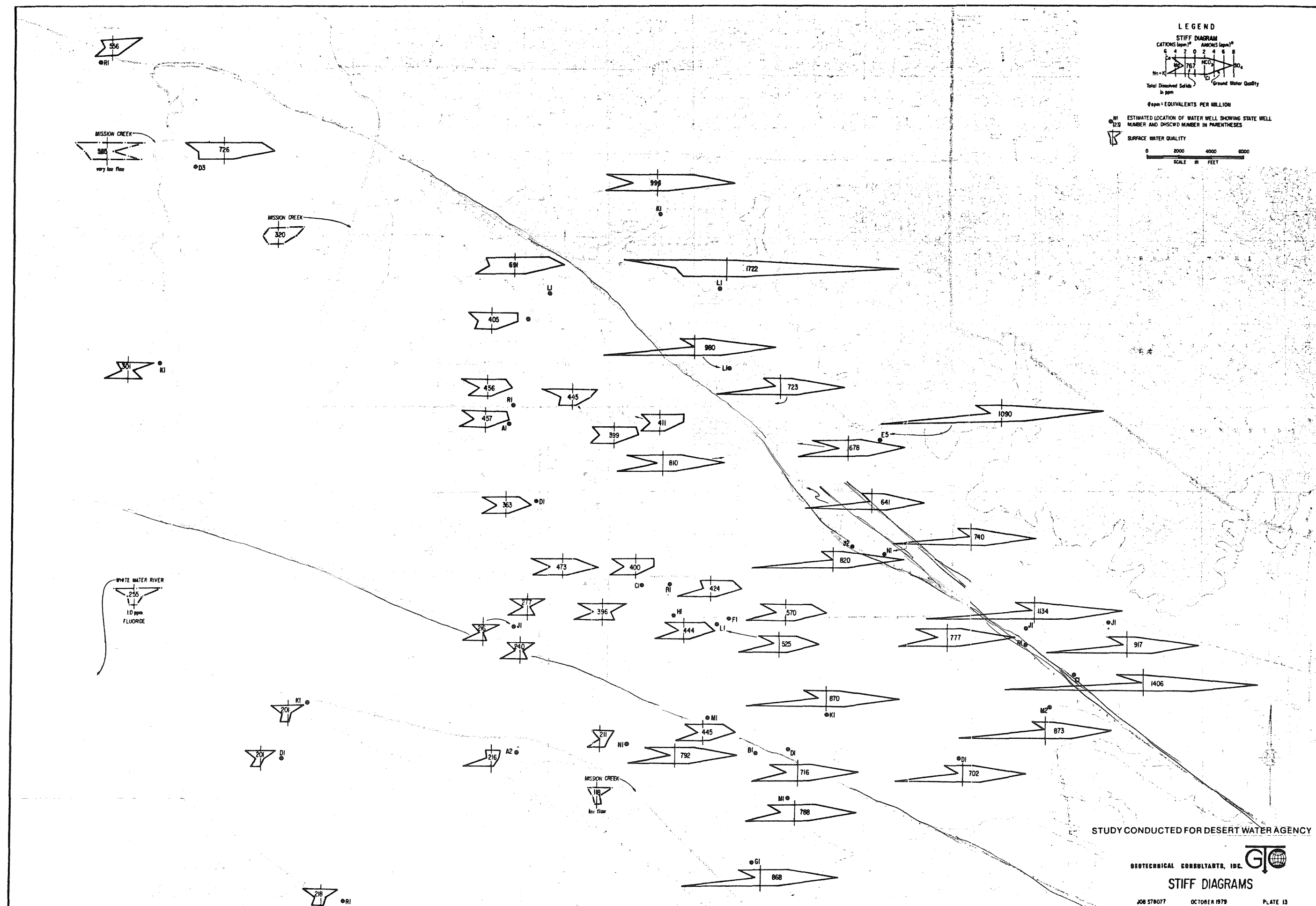
WATER QUALITY

General Statement. Variability of both the quantity and composition of dissolved solids within naturally occurring ground water within the Mission Creek Subbasin results in distinct regions of good to poor water quality. Ground water quality is a function of the source of the water, the type of water-bearing materials in which it occurs, hydrologic conditions governing the rates of ground water movement and recharge, well construction and abandonment techniques and the duration and rate of pumping immediately prior to sampling for analysis.

To study the quality of ground water, chemical analyses were reviewed as available from the files of the District, the Desert Water Agency, USGS, and the Riverside County Flood Control District. Independent selective sampling was conducted during this study in District and privately-owned wells in the study area. Results of these tests are incorporated in the following findings and are provided in Appendix B - Aquifer Tests and Field Data.

Because all wells are perforated for great lengths throughout water producing units, it is not possible to differentiate water quality within individual aquifers in the study area.

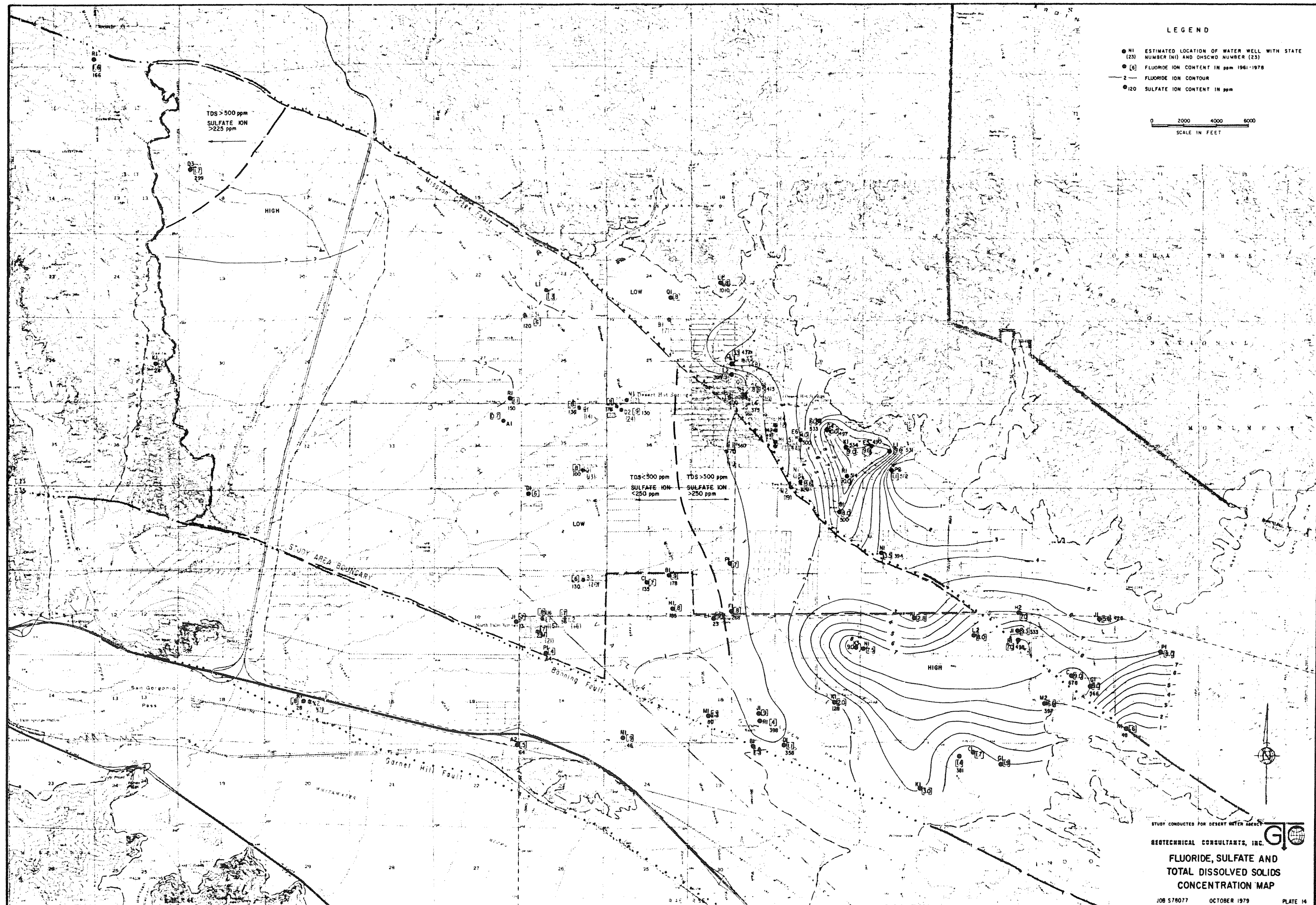
Chemical Character. To both graphically and areally depict the chemical character of ground water, representative water analyses have been plotted as stiff diagrams and displayed adjacent to the locations from which they were obtained as shown on Plate 13 - Stiff Diagrams. Each plot displays the relative amounts of the principal constituent cations (calcium, magnesium, and sodium plus potassium) and the constituent anions (sulfate, chloride, and bicarbonate plus carbonate) in equivalents per million. The total dissolved solids are also shown on the diagrams.



The most recent water quality data from District wells, several privately-owned wells, the Whitewater River at Whitewater, and Mission Creek at Indian Springs, Route 62, and Interstate 10, was used in the construction of the stiff diagrams. This information was also used to generate Plate 14 - Fluoride, Sulfate and Total Dissolved Solids Concentration Map.

The Mission Creek Subbasin may be divided into three regions on the chemistry of the ground waters: a sodium sulfate zone south and east of Desert Hot Springs; and a calcium-sodium bicarbonate-chloride zone near North Palm Springs; and a calcium-sodium bicarbonate-sulfate zone west of Desert Hot Springs and north of North Palm Springs.

The sodium-sulfate zone is characterized by unusually high quantities of sodium cations and sulfate anions. The water in this zone also contains unhealthful (greater than 1.4 ppm) amounts of fluoride, higher than recommended levels of sulfate (250 ppm), and high TDS concentrations. The high fluoride concentrations found in this zone have been previously identified and discussed in both the Bechtel (1967) and the DWR (1964) studies. It is thought that the presence of fluoride is related to deep seated tectonic processes, thermal water, near surface weathered igneous and metamorphic basement rock (Hem, 1959) or near surface volcanic rocks. None of these geologic conditions are directly associated with the fluorides in the Mission Creek Subbasin, however, all of the conditions apply to the Desert Hot Springs Subbasin to the northeast of the study area and separated from the area by the Mission Creek fault. It is therefore thought that the high fluoride concentrations seen in the southeastern portion of the study area are the result of a southward ground water leakage through the Mission Creek fault. Supporting evidence for this is: water level contours (Plate 9); and sulfate and TDS concentrations that mimic the fluoride contours. Sulfate and TDS concentrations within the Desert Hot Springs Subbasin are significantly higher than those southwest of the Mission Creek fault



LEGEND

- NI (23) ESTIMATED LOCATION OF WATER WELL WITH STATE NUMBER (NI) AND OHSCWD NUMBER (23)
- [6] FLUORIDE ION CONTENT IN ppm 1961-1978
- 2 — FLUORIDE ION CONTOUR
- 120 SULFATE ION CONTENT IN ppm

0 2000 4000 6000
SCALE IN FEET



and so the contours shown on Plate 14 show a definite trend of ground water leakage across the fault. The presence of sewage treatment facilities in this zone may in the long run contribute to increasing sulfate and TDS concentrations. At this time, there is no indication of the effect of the facility on the water quality.

The calcium-sodium bicarbonate-chloride ground water zone is represented exclusively by water wells located in North Palm Springs. This water is considered very good with low sulfate and TDS levels and moderate fluoride concentrations. The only chemically similar water is found in the Devils Garden well in the San Bernardino foothills just north of the study area. Calcium bicarbonate water is the principle type that drains from the San Bernardino and San Jacinto Mountains into the San Geronimo Pass Subbasin and the Palm Springs subarea of the Whitewater River Subbasin to the south of the study area. It may be that this zone, which is also distinguished by high specific capacity, is separated from the main portion of the Mission Creek Subbasin.

In order to segregate this area from the rest of the basin, a subsurface structure must exist approximately one mile from the paralleling of the Banning fault. Such a structure was observed in the geophysical data. Since the chemistry of the water within this small zone is so different from the water that is observed within the rest of the Mission Creek Subbasin, it is thought that this zone must either receive recharge from another source or the lithology of the aquifer must differ markedly from the rest of the basin. Since no obvious difference was noted in the rock types listed in the driller logs between wells in the North Palm Springs area and wells in the main part of the basin that do not show the low sulfate anomaly, it must be assumed that the ground water within the low-sulfate zone has a unique recharge source. Since it was observed that ground water in the foothills of the San Bernardinos resembles that found around North Palm Springs, it is suggested that this may be the origin of the low sulfate water.



The calcium-sodium sulfate-bicarbonate water zone represents the dominant water type within the study area. This water has moderate sulfate, TDS and fluoride concentrations and is in general of good quality. The significance of this ground water type is that it is pervasive from the northern end of the subbasin to the Seven Palms Ranch where Mission Creek crosses the Banning fault. Therefore, the anomalous water chemistry zones around North Palm Springs and in the southeastern portion of the Mission Creek Subbasin do represent areas wherein large scale variations in the geohydraulic nature of the reservoir or in the source of ground water recharge are indicated.

Surface water in Mission Creek bears little resemblance to ground water taken from the Mission Creek Subbasin. It is in general high in bicarbonate and very low in sulfates and sodium. Surface waters in general display high bicarbonate concentrations. As this water reaches the ground water, an increase in sodium is often associated with ion exchange phenomena between the water and clay minerals (Hem, 1959). Sulfates and high quantities of TDS are often found in basins associated with evaporites such as gypsum.

Water Quality Trends. No complete or long-term record of water quality is available for wells within the study area. Review of the available data though suggests that there has been no significant decline in water quality since the 1950's. This lack of decline was also seen in the DWR study, therefore, it appears that the region in general is not declining in quality due to production and urbanization within the Mission Creek Subbasin.



SUMMARY AND CONCLUSIONS

1.10 GENERAL

The study area lies within the Mission Creek Subbasin. It is hydro-geologically feasible for the Desert Hot Springs County Water District to develop additional ground water supplies from the Mission Creek Subbasin. However, only a relatively thin section of potentially water-bearing sediments was found. Ground water in storage in the study area was calculated at 890,000 acre-feet in the area where data is good and 558,600 acre-feet estimated from the poorly defined western portion of the study area.

Ground water levels have been declining since 1953 at fairly steady rates. Distinct areas of poor water quality exist within the ground water basin on the east side of the study area.

Two older District wells within the study area display reduced specific capacities. More recent District wells have been constructed utilizing state-of-the-art techniques indicating good plant efficiencies with good specific capacities.

Future ground water development is available in areas north of North Palm Springs and west of Desert Hot Springs. Future wells should maintain specified separations to avoid mutual drawdown. Construction of new District wells should be in accordance with current water well technology modified as necessary in the following recommendations.

1.20 AVAILABILITY OF BASIC DATA

The Desert Hot Springs County Water District has in the last ten years in cooperation with the Edison Company acquired important specific



capacity and plant efficiency information for District wells. The District also obtains pumping and nonpumping water level data.

Water quality data has not been obtained on a regular basis so that quality trends are not readily discernable.

A systematic and organized program for monitoring water quality information, water level data, and production characteristics in private wells does not exist at this time.

1.30 GEOLOGY, GEOPHYSICS AND STRUCTURE

Sections of Quaternary and Tertiary continental sediments have been deposited within the Upper Coachella Valley. In general, these sediments thicken rapidly towards the southeast along the axis of the Salton Trough.

Within the Mission Creek Subbasin it has been discovered through the use of geophysical techniques, that the total sequence of sedimentary rocks is much greater than anticipated. As much as 7000 feet of sediments overly granitic basement rocks. Basement materials begin to rise rapidly west of Indian Avenue. The sedimentary basin shallows rapidly, therefore, as one moves westward toward the San Bernardino Mountains.

Active faults belonging to the San Andreas system bound the Mission Creek Subbasin. These are the Mission Creek fault and the Banning fault.

Data also exists for the presence of a heretofore undetected geologic structure north of the Banning fault and approximately one mile north of North Palm Springs.

1.40. HYDROGEOLOGY

- 1.41 Water Bearing Sediments. Seismic refraction data indicates that only the upper 600 to 1100 feet of sediments in the study area appears



to be water-bearing. The rest of the sedimentary sequence has high seismic velocities and consequently poor water producing characteristics. This is considerably less than was previously believed.

Water-bearing sediments are younger, more permeable, more porous, less consolidated, less weathered, and less structurally deformed than all other materials in the region. These materials are composed of relatively coarse grained fan and river deposits of sand, silt, and boulders and cobbles of decomposed granitic rocks. Available data indicates no thick areally extensive layer of clay exists to confine the water table within the study area.

Data further indicates that there exists beneath the present Mission Creek and Morongo washes thick sequences of highly porous and permeable deposits. These sediments probably represent stream channel deposits of an ancient Mission Creek.

- 1.42 Occurrence and Movement of Ground Water. Ground water under water table conditions moves in a southerly direction across the study area. The water table gradient is only 2.3 feet per mile in the southeastern half of the study area. It must be at least 300-400 feet per mile in the northwestern half to reach recharge areas of Mission Creek. Indications are that the ground water within the southeastern portion of the study area can be characterized as a lake of ground water and that the water table to the northwest represents the ground water recharge from the San Bernardino Mountains.

Additional recharge comes from deep percolation of inflow from Mission Creek and the Big Morongo and Little Morongo washes as well as leakage across the Mission Creek fault south of Desert Hot Springs. Recharge of a possibly separate source around North Palm Springs can only be hypothesized as coming from the San Bernardino foothills to the west.



Ground water barriers created by the Mission Creek and Banning faults exists along the northeastern and southwestern boundaries of the study area. Also, a ground water barrier is thought to exist about one mile north of North Palm Springs paralleling the Banning fault. None of the fault barriers appear to be completely impermeable since ground water is seen to leak across them.

In general, ground water flow appears to follow the course of Mission Creek.

- 1.43 Water Level Fluctuations. Spring, 1978 depths to water ranges between 65 and 550 feet below ground surface from south to north across the study area.

Water levels have declined approximately 20 feet in the study area between the mid 1950's and Spring, 1978. The decline is the result of long-term deficiencies in precipitation and recharge since 1946 and possibly ground water extractions since 1970.

- 1.44 Hydrograph Trends. Water well hydrographs display a declining water table. Also revealed is that the decline trend almost doubled beginning in 1970 corresponding to the advent of significant well water extractions by the District.

The hydrographs are unusual in that they display no discernable seasonal variation. They do not respond to years of markedly higher or lower precipitation. This appears to be independent of well perforation depths. One must conclude that the ground water basin is somehow buffered from the recharge sources and that water levels within the basin reflect long-term averages of the recharge.



1.50 AQUIFER CHARACTERISTICS

- 1.51 Transmissivity, Specific Capacity. The theoretical transmissivities derived from wells within the study area are in general variable, ranging from 11,000 gdp/ft to over 290,000 gdp/ft. The theoretical permeabilities obtained from these T values are therefore also highly variable with a range of 100 to 1900 gdp/ft².

A more useful picture of aquifer characteristics was obtained through the use of specific capacity (Plate 11) and yield factor data. The yield factor data indicates that a region west of Desert Hot Springs and north of North Palm Springs has the potential of over three gallons per minute per foot of perforated casing within the aquifer. The high specific capacity region may represent coarse grained channel deposits beneath the present Mission Creek and Morongo Washes.

Deeper wells also appear to have higher specific capacities, theoretical transmissivities, and yield factors. This suggests that there are good aquifer materials to a depth of at least 800 feet.

1.60 GEOHYDROLOGY

- 1.61 Ground Water in Storage. Total ground water in storage as of 1978 is estimated at 890,000 acre-feet in storage Zone B and 558,600 acre-feet in storage Zone A (Appendix C).
- 1.62 Changes in Ground Water in Storage. Ground water levels have declined in the study area at least since 1955. The total decline is estimated at 71,200 acre-feet since 1955. This decline has averaged 2400 acre-feet per year from 1955 to 1970 and 4400 acre-feet per year from 1970 to 1978. The decline has occurred because the total seasonal water inflow has been exceeded by the sum of all surface and subsurface outflow.

The 71,200 acre-feet of ground water lost to the study area since 1955 represents 5 percent of the estimated ground water in storage as of Spring, 1978. The total extraction by the District from Mission Creek Subbasin to 1978 is 12,992 acre-feet.

1.70 WATER QUALITY

- 1.71 Chemical Character. Ground water in the study area may be divided into three basic types: calcium-sodium bicarbonate-sulfate; sodium-sulfate; and calcium-sodium bicarbonate-chloride. Surface flow in Mission Creek is variable depending upon where the sample is obtained but in general lacks the sulfate and sodium seen in the ground waters.

TDS concentrations of well waters average over 500 ppm east of Southwest Drive and in the far northwestern portion of the study area. TDS values of 250 ppm and less are seen in and around North Palm Springs. In general, the TDS levels average about 400 ppm in the central portion of the study area.

Sulfate and fluoride ion levels show similar distributions in the study area with the over 250 ppm sulfate region corresponding to that having over 500 ppm TDS. The high fluoride levels are found in areas near the Mission Creek fault and point to portions of the fault that leak from the Desert Hot Springs Subbasin into the Mission Creek Subbasin. The result of the water quality data is the definition of an area with poor quality ground water which should be avoided when placing new domestic water wells. This area is defined in the study area by the line that separates Range 4 east from Range 5 east.



The source of the poor quality water is the Desert Hot Springs Sub-basin. The hot waters found in this subbasin have dissolved various ions out of the granitic basement and sedimentary aquifer. The clay minerals associated with the Mission Creek fault zone may supply a significant amount of the sodium ions. High fluoride and TDS values in the northern portion of the study area may result from ground water coming out of the San Bernardino Mountains. That these waters do not reach the main basin area may be due to dilution and mixing with better quality recharge waters or precipitation.

- 1.72 Water Quality Trends. Water quality has not significantly declined in wells within the study area. This conclusion is admittedly based upon generally poor and short-term data. In some wells water quality as defined by TDS, F, and SO₄ levels has actually improved over the period of record and in other wells extreme deterioration of water quality is seen for a period of time. It is therefore difficult to tell if observed chemical variations of water chemistry through time are the result of ground water contamination, well casing decay, or measurement error.

1.80 DISTRICT WELLS

- 1.81 Pump Bowl Settings. Pump bowls are at or below the top of perforations in all active wells belonging to the District. Continued production with such settings can result in cascading water, air entrainment and an increased potential for incrustation and corrosion. These problems can be expected to intensify in the future if water levels continue to decline.



- 1.82 Casing Perforations. District wells that have been drilled in the last 10 years have in general been completed with louvered shutter screen casing which provides larger open areas, lower entrance velocities and greater well efficiency.
- 1.83 Specific Capacity Data. Declines in Q/S values have been detected in active well Nos. 20, 21, 22 and 24. No direct study was made to determine the causes of these declines so no definite conclusions can be drawn. Only well No. 20 and standby well No. 16 have specific capacities low enough to be considered as no longer viable.

An increase in the specific capacity of well No. 23 was noted. This indicates that the well required several years of pumping and surging to slowly remove drilling fluids and formation fines from the gravel pack and formation walls.

It should be realized that inaccurate monitoring of static and pumping levels can result in anomalous Q/S values. These values should be easily detectable, however, if long-term records and plots are kept of the specific capacity values.

RECOMMENDATIONS

2.10 GENERAL STATEMENT

Analysis of the existing data indicates that it is feasible for the District to construct new municipal water wells in areas north of North Palm Springs and west of Desert Hot Springs.



Abandonment of well Nos. 16 and 20 should also be considered.

The basin can sustain added production, however, water levels will continue to decline and the decline can be accentuated by added production.

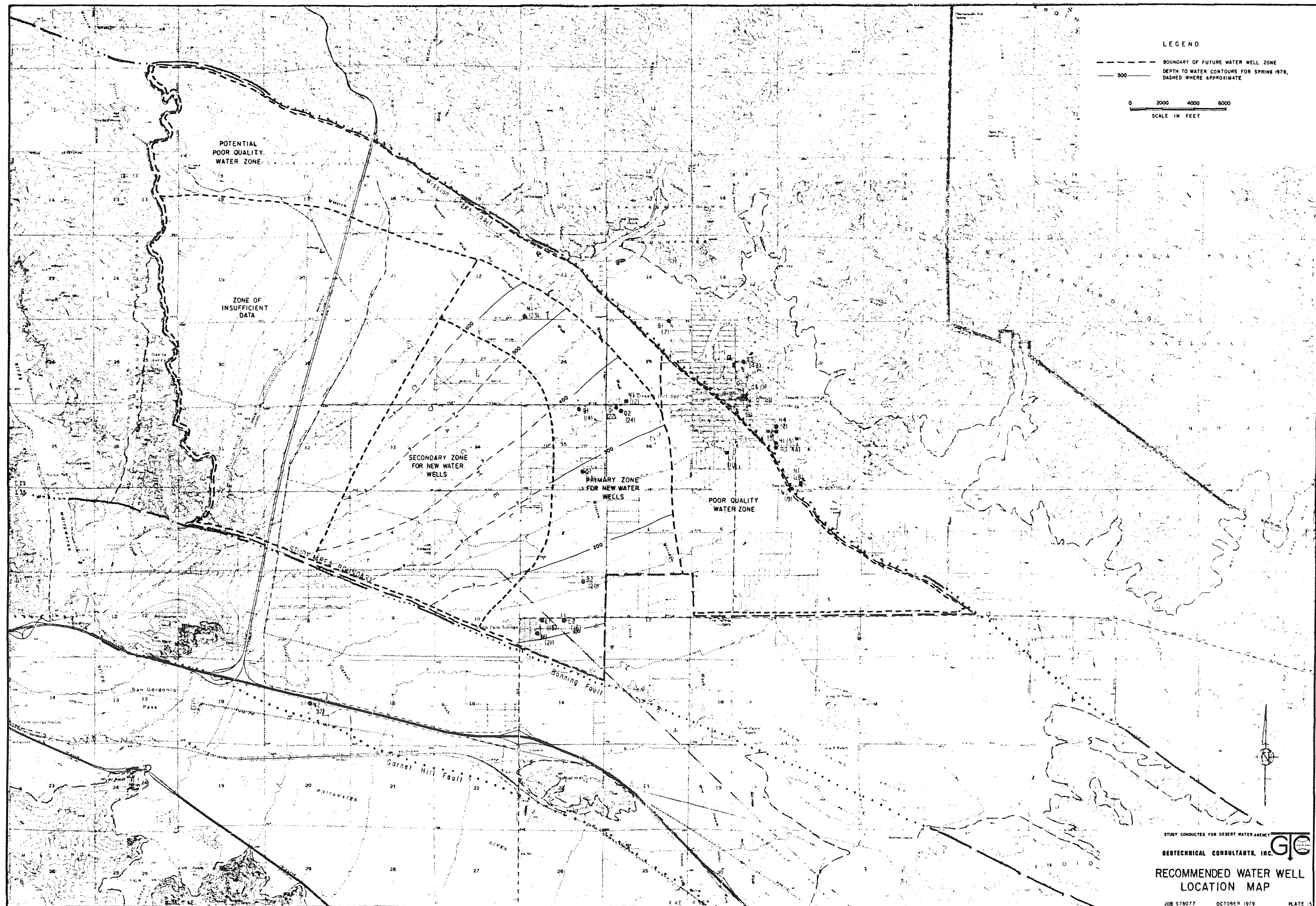
2.20 CONSTRUCTION OF NEW WELLS

2.21 Well Locations. Based upon the data, the construction of new wells should be restricted to areas north of North Palm Springs and west of Desert Hot Springs. To avoid areas of poor quality water, and regions with low permeabilities. Plate 15 - Recommended Water Well Location Map, depicts potential areas for new wells.

To maximize development of ground water, we recommend that well sites be selected which are aligned parallel to ground water contour lines. We recommend spacings of at least 1500 feet, based on available data, to minimize mutual drawdown interference.

To retard the escape of ground water from the basin, new wells should be located nearer the Banning fault. Even though ground water levels are very flat, the depth to ground water is shallowest at this area.

The Primary Zone for new water well placement represents a region where wells have historically found fair to good water quality, high yields, and thick sections of water-bearing sediments. Wells drilled in this region should be able to produce 1000 gpm of good quality water with only 10 to 20 feet of drawdown if they are drilled sufficiently deep and completed in a recommended manner.



LEGEND

--- BOUNDARY OF FUTURE WATER WELL ZONE
--- 500 --- DEPTH TO WATER CONTOURS FOR SPRING 1978,
DASHED WHERE APPROXIMATE

0 2000 4000 6000
SCALE IN FEET

STUDY CONDUCTED FOR DESERT WATER AGENCY
GEOTECHNICAL CONSULTANTS, INC. 
RECOMMENDED WATER WELL
LOCATION MAP



The Secondary Zone for new water well placement is in a region which has seen little in the way of water resources development. The region has been selected solely on potential and the extrapolation of known water level data, aquifer characteristics, and water quality information. It would be highly recommended that at least one test well be drilled to a depth of 800 to 1000 feet west of Dever's Hill in order to further understand this portion of the ground water basin.

Insufficient information exists at this time to recommend the drilling of wells in the far western part of the study area. It is thought on the basis of current geologic and geophysical data that the bedrock comes up rapidly towards the west and may result in a reduced sequence of water-bearing sediments. A deep test well located in this region would certainly answer many questions as to its potential.

It is recommended that no wells for the supply of domestic drinking water be drilled in either the known Poor Water Quality Zone or the Potential Poor Water Quality Zone. These areas have historically produced water containing potentially unhealthful concentrations of fluoride, sulfate, and TDS. These regions also lack high yield potential.

The Desert Hot Springs Subbasin and the area south and east of the study area in Mission Creek Subbasin are also considered poor areas for potential well sites. However, an area west of Morongo Wash, east of North Palm Springs and south of the study area in the Mission Creek Subbasin is considered good for potential well sites.

- 2.22 Well Design. We recommend that wells be drilled to depths of 800 to 1000 feet to take advantage of the full section of high yield aquifers that exist to this depth.



A well yield of 1500 gpm is suggested for the design. Bowls should be placed above the top of perforations.

We recommend the use of continuous wrap, wire-wound well screen in order to maximize casing open area, minimize water inlet velocity and increase yield factor. The well screen can be a low carbon steel because ground water within the Primary Zone for placement of new water wells has no strong tendency for either corrosion or incrustation.

Specific recommendations for screen slot size, gravel pack gradations, and precise casing sizes and placements should be provided upon analysis of the selected site and pilot hole data.

A reasonable dose of chlorine should be put into the water in the well each day during drilling. It is also recommended that all gravel-pack materials be sterilized prior to implacement. Before final disinfection of the well, it should be thoroughly cleaned of all foreign substances which can introduce bacteria into the well.

- 2.23 Well Specifications. We recommend slight modifications to the specifications and bid documents in an attempt to provide additional refinements in data collection, well development and testing procedures:

The additional refinements include:

- a. drill new wells with reverse rotary equipment using only if absolutely necessary, biodegradable drilling fluids; if the well must be drilled by rotary methods, use only biodegradable drilling fluids. We recommend that no clay-base drilling muds (bentonite, etc.) be used on new wells.



- b. utilize a geologist to geologically log drill cuttings and drill rates, and to obtain samples for grain-size analysis.
- c. conduct induction electric log surveys and gamma log surveys of the pilot boring; utilize the geologist to analyze the geologic log and both geophysical logs for determination of final ream depths and casing placements.
- d. provide for violent agitation of the screen and gravel pack by simultaneous high-velocity, horizontal jetting and pumping as the prime method of development.
- e. provide time in the bid documents for development, for well testing and for obtaining a step-drawdown curve and minimum 24-hour water level drawdown and recovery data.
- f. install two flexible neoprene-type tubings for permanent air lines and ensure they are carefully calibrated.

2.30 VIABILITY OF EXISTING WELLS

- 2.31 Well Abandonment. Abandonment of well Nos. 16 and 20 is recommended. These wells have had significantly greater reductions in specific capacities than other District wells.

Well abandonment should include removal of the pump and appurtenances. We do not recommend the complete destruction or filling of a well until its use as a data point has been evaluated. Abandoned wells may be useful



as permanent observation holes to monitor water levels and water quality. If electric log data is not available, a gamma log should be run on each well as it is taken out of service.

The attachments which complete this report are listed in the Table of Contents.

Respectfully submitted,

GEOTECHNICAL CONSULTANTS, INC.

A handwritten signature in black ink, appearing to read 'Richard C. Slade'.

Richard C. Slade
Engineering Geologist #929

A handwritten signature in black ink, appearing to read 'Robert T. Misen'.

Robert T. Misen
Engineering Geologist #658

RCS/RTM/MR:1m

REFERENCES CITED

- Bechtel Corporation, 1967, Comprehensive Water Resources Management Plan, 79 p.
- Biehler, Shawn, 1964, Geophysical Study of the Salton Trough of Southern California: Unpublished PhD Thesis, California Institute of Technology.
- Brown, J. S., 1923, The Salton Sea Region, California: U. S. Geological Survey Water Supply Paper 497, 283 p.
- Butler, S., 1957, Engineering Hydrology, Prentice-Hall, Inc. 356 p.
- California Department of Water Resources, 1964, Coachella Valley Investigation: Bulletin 108, 145 p.
- California Division of Mines and Geology, 1966, Geologic Map of California, Santa Ana Sheet.
- California Division of Mines and Geology, 1968, Geology of the Desert Hot Springs-Upper Coachella Valley Area, California, Special Report 94.
- French, J. J., 1974, Maps of San Geronio Pass-Upper Coachella Valley Area, California: U.S.G.S. Water Resources Division, Open-File.
- Healy, A. G., and Peck, E. L., 1964, Precipitation, Runoff, and Water Loss in the Lower Colorado River-Salton Sea Area: U. S. Geological Survey Professional Paper 486-B, 16 p.
- Lohman, S. W., 1972, Ground Water Hydraulic, U. S. Geological Survey: Professional Paper 708, 70 p.
- Mendenall, W. C., 1909, Ground Waters in the Indio Region, California: U. S. Geological Survey Water Supply Paper 225, 68 p.
- Mendenhall, W. C., 1909, Some Desert Watering Places in Southeastern California and Southwestern Nevada: U. S. Geological Survey Water Supply Paper 224, 40 p.
- Proctor, R., 1958, Geology of the Desert Hot Springs Area, Little San Bernardino Mountains, California: Unpublished M. A. Thesis, University of California at Los Angeles.



REFERENCES CITED
(continued)

- Riverside County Flood Control and Water Conservation District, 1976, Hydrogeologic Data for 1974-75 Season: Annual Report, 174 p.
- Todd, D., 1959, Ground Water Hydrology: John Wiley and Sons, Inc. Publishers, 336 p.
- Tyley, S. J., 1971, Analog Model Study of the Ground Water Basin of the Upper Coachella Valley, California: U. S. Geological Survey Open File Report, 89 p.
- Tyley, S. J., 1973, Artificial Recharge on the Whitewater River Area, Palm Springs, California: U. S. Geological Survey Open File Report, 51 p.
- Tyley, S. J., 1974, Analog Model Study of the Ground Water Basin of the Upper Coachella Valley, California: U. S. Geological Survey Water Supply Paper 2027, 77 p.
- U.O.P. - Johnson Division, 1966, Ground Water and Wells: Edward E. Johnson, Inc., Publisher, 440 p.
- Webb, 1964, Report on Testing Water Well No. 1 for The North Palm Springs County Water District: Albert A. Webb & Associates, p. 8.



APPENDIX A

GLOSSARY OF HYDROGEOLOGIC TERMS

Acre-Foot - A unit for measuring the volume of water and is equal to the quantity of water required to cover one acre to a depth of one foot; a total of 325,851 gallons or 43,560 cubic feet.

Alluvial Fan or Cone - A body of alluvial material deposited by a stream debouching from the region undergoing erosion above the apex of the cone.

Aquiclude - A formation which, although porous and capable of absorbing water slowly, will not transmit it fast enough to furnish an appreciable supply for a well or spring.

Aquifer - A geologic formation or structure that contains saturated permeable material and can transmit water in sufficient quantity to supply pumping wells or springs.

Aquifer Test - A test whereby drawdown and recovery levels are monitored in a well during and after pumping from which the hydraulic characteristics or aquifer parameters of transmissibility, storage, and permeability can be theoretically calculated.

Area of Influence - The area beneath which ground water or pressure surface contours are modified by pumping. The area influenced by the drawdown curve of a pumping well at a particular time.

Artesian - An adjective applied to ground water, or things connected with ground water, such as a well, underground basin, etc., where water is under pressure and will rise to a higher elevation if afforded an opportunity to do so.

Confined Ground Water - A body of ground water overlain by material sufficiently impermeable to sever free hydraulic connection or communication with overlying ground water except at the intake. Confined water moves in conduits under the pressure due to difference in head between intake and discharge areas of the confined water body. See also Artesian.

Consumptive Use - The amount of water used by the vegetative growth of a given area in transpiration or building of plant tissue and evaporated from adjacent soil. It also includes the evaporation of precipitation intercepted by vegetative growth or impervious areas, and the water evaporated in industrial processes or household uses. Evaporation and transpiration from land areas only, excluding evaporation from lakes and reservoirs.

Deep Percolation - The moisture which penetrates below the depth from which it may be used by plants; it represents that part of the water absorbed which exceeds the field capacity of the soil within the depth of root development. In this report, "deep percolation" is water which moves downward from the surface of the ground and reaches the water table.

Drainage Basin (Area) - An area whose runoff is more or less separate from the runoff for adjacent areas, so that it can be considered a distinct hydrologic unit.

Drainage Divide - The boundary line, along a topographic ridge separating two adjacent drainage basins (areas).

Drawdown - The amount of lowering of the static water level in a well by pumping; the difference (in feet) between the static and pumping levels in a well.

Driller's Log - A record of the types of earth materials encountered at various depths during a drilling of a well and as recorded by the driller or his crew.

Effluent Seepage - Flow from the ground water to the ground surface.

Evaporation - The process by which water passes from a liquid state, at temperatures below the boiling point, to vapor. The rate is expressed in depth of water removed per unit of time.

Evapotranspiration - Water withdrawn from a land area by evaporation from water surfaces and moist soil and by transpiration from plants.

Field Capacity - The maximum amount of capillary water that can be permanently retained in the soil or in a freely-drained root zone in opposition to the downward pull of gravity.

Formation - An assemblage of rock masses grouped together into a time unit that is convenient for field mapping or description.

Gravel Pack - In well construction, a several-inch thick thickness of gravel placed in the annular space between the casing and the drilled hole.

Ground Water - The water in the zone of saturation which moves under the control of the water table slope.

Ground Water Cascade - Descent of ground water on a steep hydraulic gradient to a lower and flatter water table slope. A cascade occurs when ground water flows over a sharp drop in the configuration of the nonwater-bearing rock forming the base of a free ground water body.

Ground Water Divide - The boundary of the cone of pumping depression which separates the area of influence and the area outside.

Ground Water, Free (Unconfined) - Unconfined water is found in the zone of saturation whenever the upper surface of the zone forms a water table under atmospheric pressure, free to rise and fall with changes in volume of stored water.

Ground Water Inventory - A detailed estimate of the amount of water added to the ground water reservoir of a given area (increment) balanced against estimates of amounts abstracted from the ground water reservoir (decrement) for any selected period of time.

Ground Water Mining - Pumping ground water from a basin where the safe yield is small, thereby extracting water directly from storage in excess of recharge.

Ground Water Mound - A mound-shaped addition to the ground water body built up by seepage, percolation, or recharge.

Hydrograph - A graphic plot of changes in the flow of water or in elevation of water level against time.

Hydrologic Equation - The water inventory equation where $\text{Inflow} = \text{Outflow} + \text{Change in Storage}$ during a given time period for a specific area.

Infiltration - Flow of water in a downward direction from ground surface through the soil zone toward the water table.

Observation Hole - A nonpumping well or hole completed with perforated casing used to monitor water levels or to obtain water samples for analysis via air lift methods.

Overdraft - Pumping in a ground water basin in excess of safe yield.

Perched Water - Water in a relatively small body supported above the main ground water body.

Percolation - The movement or flow of water through the interstices or the pores of a soil or other porous medium.

Percolation, Deep - The amount of water which passes through the soil and root zones and reaches the water table.

Period - A specified division or portion of time.

Average. An arithmetical average relating to a period other than a mean period.

Base. A period chosen for detailed hydrologic analysis because prevailing conditions of water supply and climate are approximately equivalent to mean conditions, and because adequate data for such hydrologic analysis are available.

Mean. A period chosen to represent conditions of water supply and climate over a long series of years.

Seasonal. Any 12-month period other than the calendar year. In this study, seasonal period is synonymous to the runoff period or water year, October 1 through September 30.

Permeability - The property of a material which permits appreciable movement of water through it when saturated and actuated by hydrostatic pressure of the magnitude normally encountered in natural subsurface water.

Permeability, Coefficient of - The rate of flow of a fluid through a cross section of a porous mass under a unit hydraulic gradient, at a temperature of 60 degrees F. The standard coefficient of permeability used in the hydrologic work of the U. S. Geological Survey is defined as the rate of flow of water at 60 degrees F, in gallons a day, through a cross section of one square foot, under hydraulic gradient of 100 percent.

Phreatophyte - A plant that habitually obtains its water supply from the zone of saturation, either directly or through the capillary fringe.

Porosity - The sum of specific yield and specific retention which is equivalent to the total void space in the material, expressed as a percentage of the total volume of the material.

Precipitation - The total measurable supply of water received directly from clouds as rain, snow, hail, and sleet; usually expressed as depth in a day, month, or year, and designated as daily, monthly, or annual precipitation.

Pumping Level - The level as measured from ground surface at which water stands in a well when pumping is in progress.

Recovery - The amount of rising of the water level in a well above the pumping level once the pumping has been terminated.

Rising Water - Ground water effluent which appears as surface flow in stream channels.

Runoff, Surface - That portion of runoff which flows to stream channels over the surface of the ground.

Safe Yield - The rate at which water can be pumped from wells year after year without decreasing ground water in storage to the point where pumping lift would become economically unfeasible or where water of poor quality would begin to intrude into the reservoir. The amount of water which can be withdrawn from a ground water basin over a long period of time without producing an undesired result. Determination of safe yield value requires analysis of water supply to the basin, economics of basin pumpage, quality of the ground water, and water rights in the basin.

"It should be apparent that safe yield cannot exceed the long-time mean annual water supply to the basin. Withdrawals exceeding this supply must come from storage within the aquifer. Such permanent depletion is often referred to as mining of ground water because of its analogy to mining of ores and petroleum. In most basins, the quantity of water in storages is many times the annual recharge or draft; therefore, in any one year, the draft can exceed the recharge without causing permanent depletion. But on a long-term basis, when a series of wet and dry years would tend to average out, the draft becomes an overdraft if the mean supply is exceeded." (Adapted from Todd, 1959.)

Specific Capacity - The yield or discharge of a well (in gallons per minute) per unit of drawdown (in feet). The ratio is affected by the type of well construction, its development, the type of well casing, and the age and condition of the well and pump.

Specific Conductance - The electrical conductivity of a water sample at 25° C expressed in micro-ohms per centimeter.

Specific Retention - As applied to water-bearing material, it is the ratio of the volume of water which will be retained by the material against the force of gravity, expressed as a percentage of the total volume of the material.

Specific Yield - As applied to water-bearing materials, it is the volume of water drained by the force of gravity from a saturated material over a reasonably long period of time, expressed as a percentage of the total volume of the saturated material.

Static Level - The distance from ground surface to the water level in a non-pumping well, outside the area of influence of any adjacent pumping well. This level registers one point on the water table in a water table well or one point on the pressure surface in a confined or artesian well.

Storage - Water artificially impounded in surface or underground reservoirs for future use.

Transmissivity - The characteristic property of the entire saturated portion of an aquifer to transmit water.

Transmissivity, Coefficient of - The field coefficient of permeability multiplied by the thickness, in feet, of the saturated part of the aquifer.

Transpiration - The quantity of water absorbed and transpired and used up directly on the building of plant tissue in a specified period of time.

Underflow - Relatively horizontal movement of water through saturated granular material under hydraulic gradients commonly developed underground.

Watershed - The topographic divide separating one drainage basin from another. Also means the entire drainage basin or catchment area.

Water Table - The upper surface of the body of free water which completely fills all openings in a granular material sufficiently pervious to permit percolation.

Well Interference - The drawdown effects created in a well by pumping from a nearby well.

Well Yield - The volume of water per unit time discharged from a well by pumping. Commonly measured in gallons per minute.

Year - Unless otherwise noted, the water year is from October 1 to September 30. The year 1928-29 is October 1, 1928, through September 30, 1929. The period 1929-57 is October 1, 1929 through September 30, 1957.

Zone of Aeration - The zone above the water table in which interstices are partly filled with air.

Zone of Saturation - The zone below the water table in which interstices are completely filled with ground water.

REFERENCE TO HYDROGEOLOGIC TERMS

Glossary - Water and Sewage Control Engineering, APHA, ASCE, AWWA, FSWA.

Glossary of Geology and Related Sciences, AGI, 2nd Edition, November, 1960.

Ground Water Basin Management, ASCE Manual of Engineering Practice, No. 40.

Meinzer, O. E., "Hydrology," 1942.

Muir, K. S., U. S. Geological Survey Water Supply Paper 1859-A, 1968.

Todd, D. K., "Ground Water Hydrology," 1959.

Tolman, C. F., "Ground Water," 1937.

TABLE A-1
GEOLOGIC TIME SCALE

ERA	PERIOD	EPOCH	Approximate Age in Millions of Years
CENOZOIC	Quaternary	Holocene(Recent)	0 - 0.02
		Pleistocene	0.02 - 3
	Tertiary	Pliocene	3 - 12
		Miocene	12 - 26
		Oligocene	26 - 38
		Eocene	38 - 54
		Paleocene	54 - 65
MESOZOIC	Cretaceous		65 - 135
	Jurassic		135 - 185
	Triassic		185 - 220
PALEOZOIC	Permian		220 - 600
	Penssylvanian		
	Mississippian		
	Devonian		
	Silurian		
	Ordovician		
	Cambrian		
PRE-CAMBRIAN			600

Note: Refer to the Geology Section in the text and to the Legend on the Geology Maps to relate rock formation names to the above geologic ages.

APPENDIX B

AQUIFER TESTING AND WATER QUALITY DATA

TERMINOLOGY

Aquifer tests, commonly referred to by the layman as "pump tests," involve either the lowering of the water level in a well (drawdown) or the rising of the water level in a well (recovery). These fluctuations in water levels, created by pumping the well, can be monitored in the well itself or in adjacent observation holes. Drawdown and recovery data collected during pump tests are then subjected to detailed analyses to determine the hydraulic characteristics of the subsurface materials.

The two principal aquifer characteristics determined from aquifer tests are the coefficients of transmissivity (T) and storage (S).

Once field data have been mathematically analyzed and field coefficients (T and S) determined, they are then utilized to determine theoretical, long-term drawdown conditions around the pumping well. Predictions can then be made of future well conditions in the same general area. These methods give much more accurate determinations of transmissivity than the specific capacity method shown in Table 1 of the text.

ANALYSIS OF DATA

Data collected during standard aquifer tests are typically analyzed by two methods: the Theis Non-Equilibrium Type Curve Solution and the Jacob Straight Line Solution.

Also, there are many variations of the above solutions which can be used to determine standard mathematical solutions requiring a constant well dis-

charge for the duration of the test. If this condition is not met, more emphasis should be placed on the analysis of recovery data rather than on the draw-down data.

Theis derived the non-equilibrium formula from the analogy between water flow conditions in an aquifer and the heat flow conditions in an equivalent thermal system. The formula is based on theoretical assumptions that are seldom, if ever present in nature. Principal assumptions about the aquifer include: isotropic properties, constant thickness, infinite areal extent, and no recharge. Deviation in the field from these theoretical assumptions can result in erroneous values for the coefficients. Graphs of actual field measurements versus time, plotted on log-log paper, are required for solution of the non-equilibrium formula.

The Jacob solution involves a straight line approximation for sufficiently small distances between the pumping well and the observation hole in which measurements are taken. Plots of field measurements versus time, on semi-logarithmic paper, are required for solution of the Jacob formula.

Values of storage coefficient can not be obtained solely from fluctuations of the water levels in the pumping well; to determine the S value, measurements in observation holes near the pumping well must be obtained.

Additional theoretical formulae, other than the Theis or Jacob solutions, can be used to verify the magnitude of the aquifer coefficients. One of these is the modified Thiem equation which is used to relate transmissivity to specific capacity (Q/s , units of gallons per minute per foot of drawdown, gpm/ft), where Q is well discharge in gpm and s is drawdown in feet. The theoretical relationship is $T = 3500 \frac{Q_m}{S(2m-s)}$ for water table conditions.

Data obtained from District well Nos. 12, 21, 22 and 24 are presented in the following pages with calculations of the aquifer parameters.

TEST AREA: Mission Creek Subbasin

GEOTECHNICAL CONSULTANTS, INC.

S78077

ENGINEERING GEOLOGY BRANCH

Plate B-1.2

AQUIFER TEST-FIELD TEST DATA

DATE 8/16/78

TEST AREA: Mission Creek Subbasin

Observation Hole No. <u>21</u>	Remarks:	Sheet <u>1</u> of <u>1</u>
M-Scope No. <u>3S/4E-11M1</u>		Observers <u>RCS</u>

Reference point is lower edge
of 2" tube on south side of pump
base

TYPE OF TEST

Recovery

[illegible]

TEST AREA: Mission Creek Subbasin

Observation Hole No. <u>22</u>	Remarks:	Sheet <u>1</u> of <u>1</u>
M-Scope No.		Observers

[illegible]

ENGINEERING GEOLOGY BRANCH
AQUIFER TEST-FIELD TEST DATA

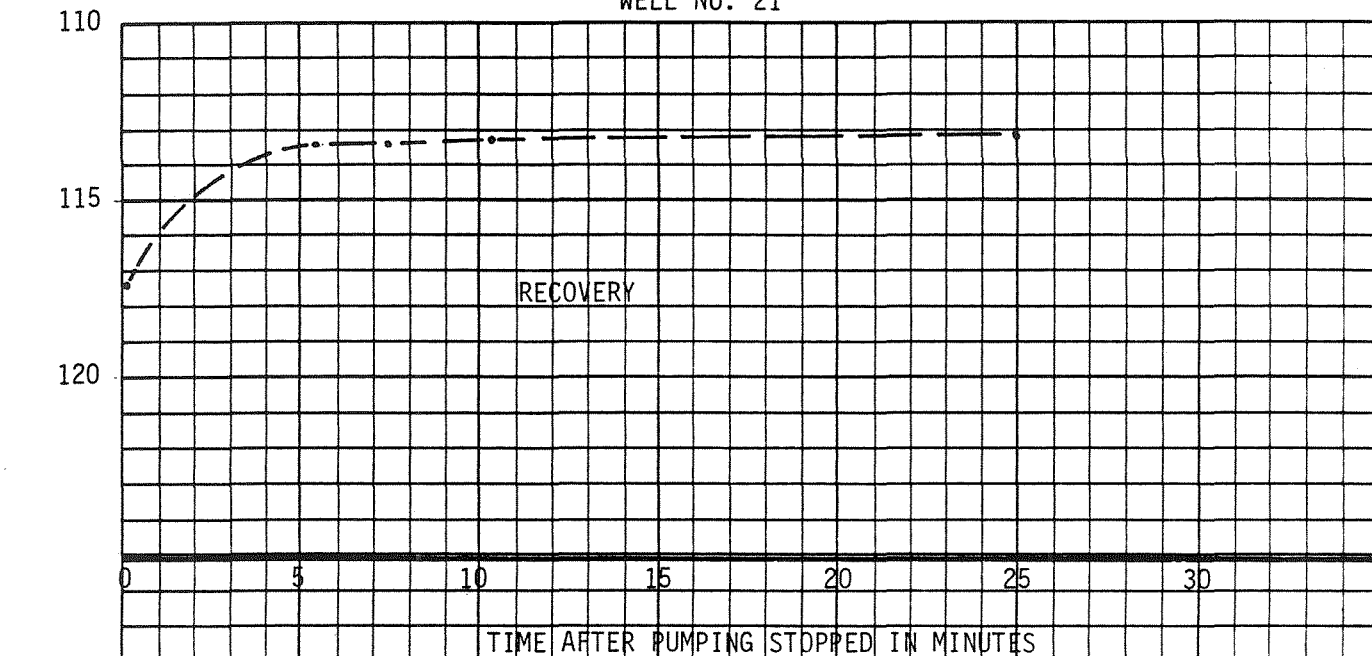
Plate B-1.4

DATE 8/14/78

Observation Hole No. <u>24</u>	Remarks: 24 is 355 ft. from well No. 22	Sheet <u>1</u> of <u>1</u>
M-Scope No. <u> </u>		Observers <u>RCS</u>

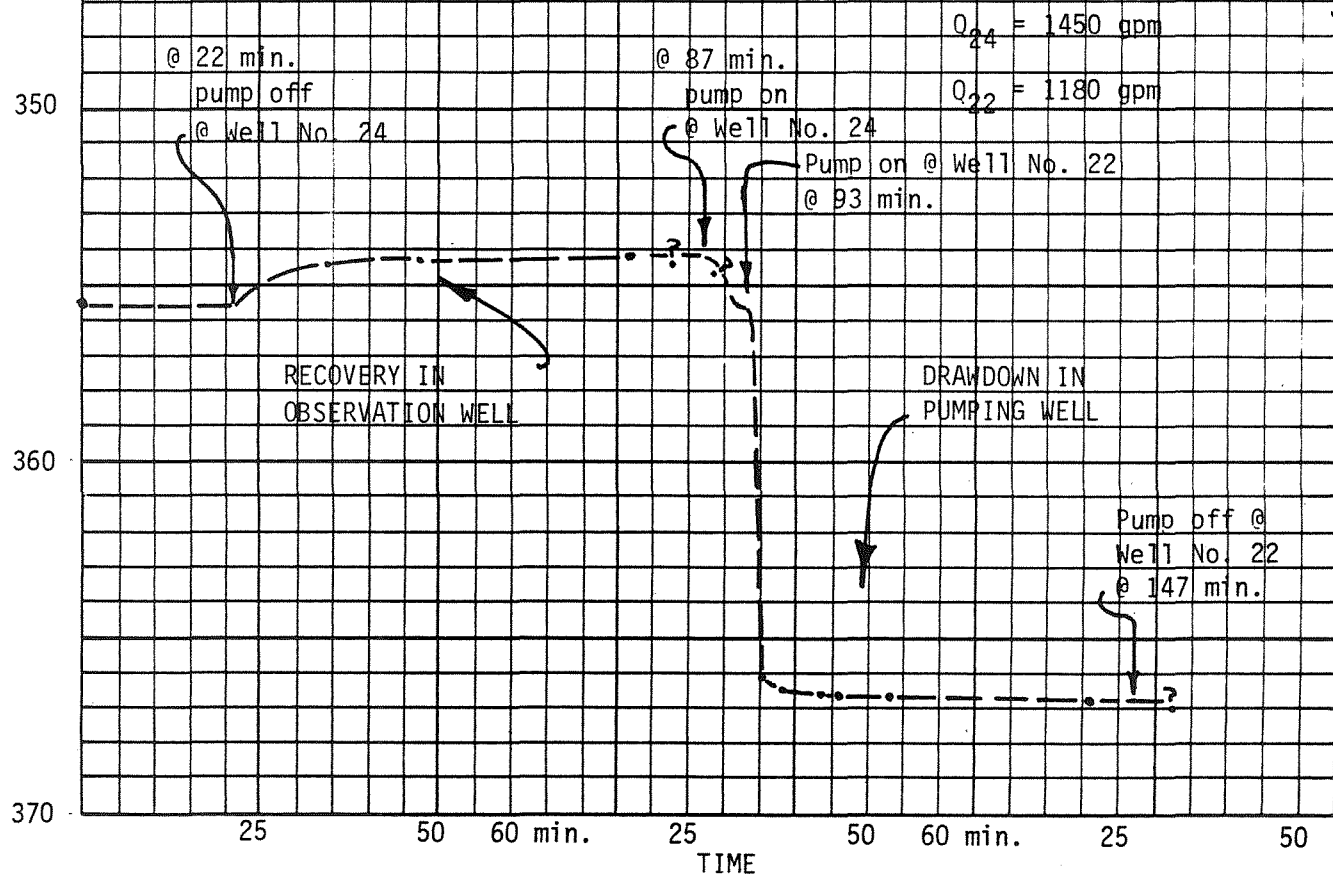
Time of Day	Elapsed Time		Depth to water from R.P. (ft)		Depth below static level. (ft)	Remarks:
	min.	sec.				
10:56	-		Pumping level = 361.17	ft. from lower side of		
			sounding tube on south side of pump, water sample taken	T=25°C		
8409	3550ft.	³				
8409	2000					
min 6/	1550ft.	³				
					PL = 361.17	
11:28	-		361.17		SL = 344.18	
11:30	-		361.17	pump off	drawdown s = 16.99ft.	
	-	30	344.18		16.99	
	1	-	345.43		15.74	$\frac{Q}{s} = \frac{1450}{16.77}$
	1	30	346.37		14.80	
	2	30	348.86		12.31	86 gpm/ft.
	3	-	349.60		11.57	
	4	-	349.62		11.55	
	5	-	349.67		11.50	
	6	-	349.60		11.57	
	8	-	349.54		11.63	
	10	-	349.50		11.67	
	28	-	349.39		11.78	
	30	-	349.38		11.79	
	50	-	349.33		11.84	
	60	-	349.33		11.84	
	62		pump on			

WELL No. 21

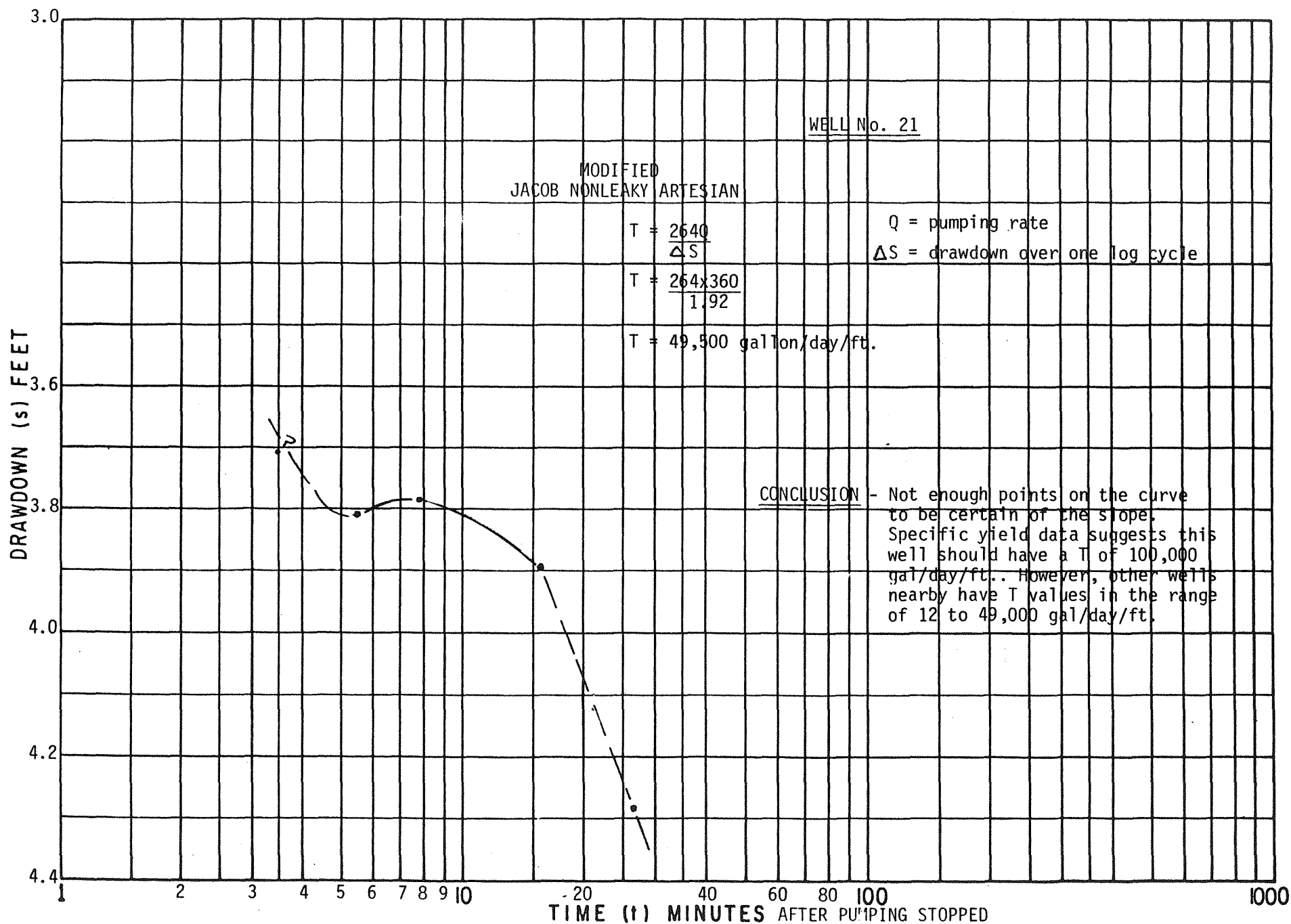


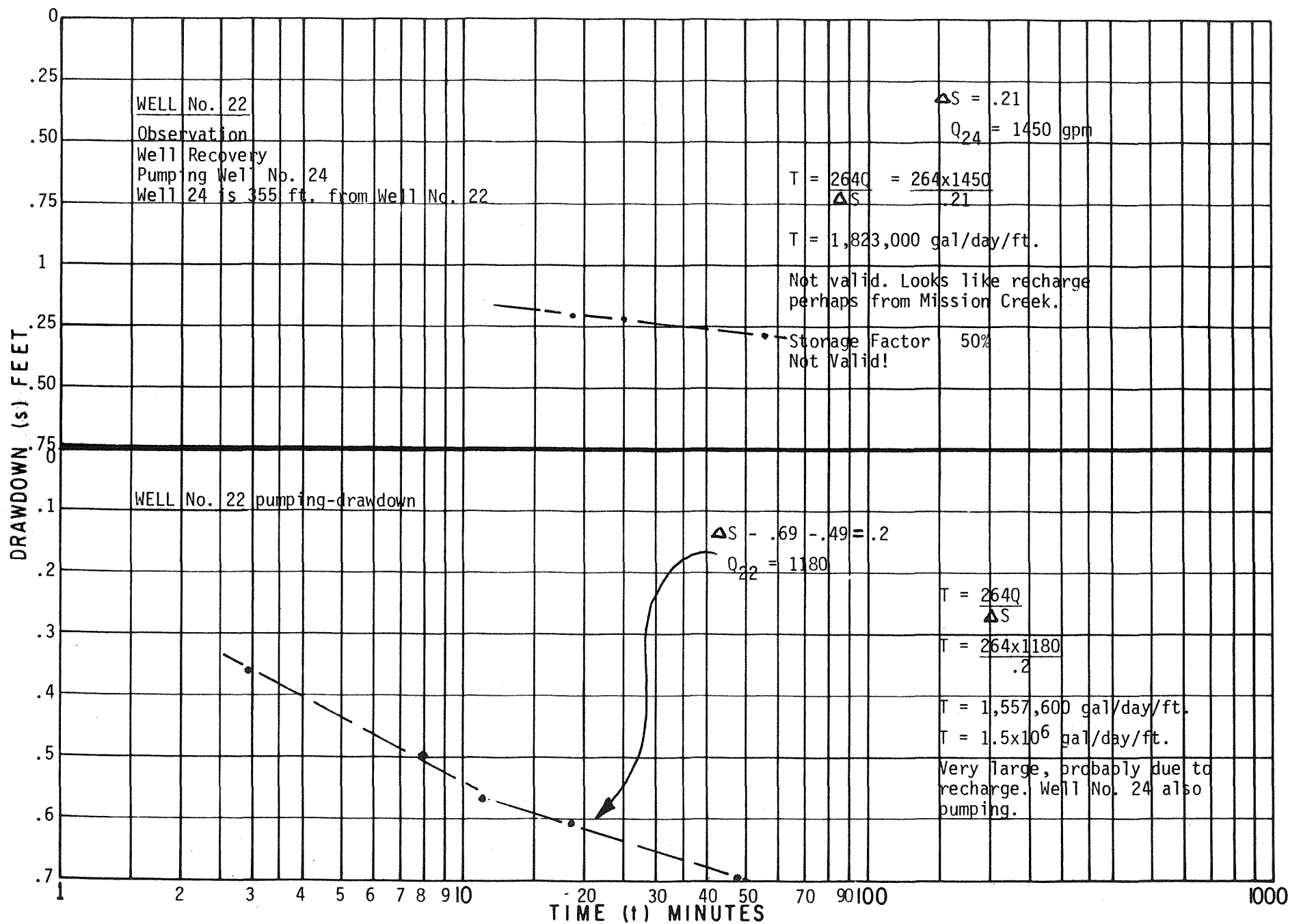
ELEVATION (in feet)

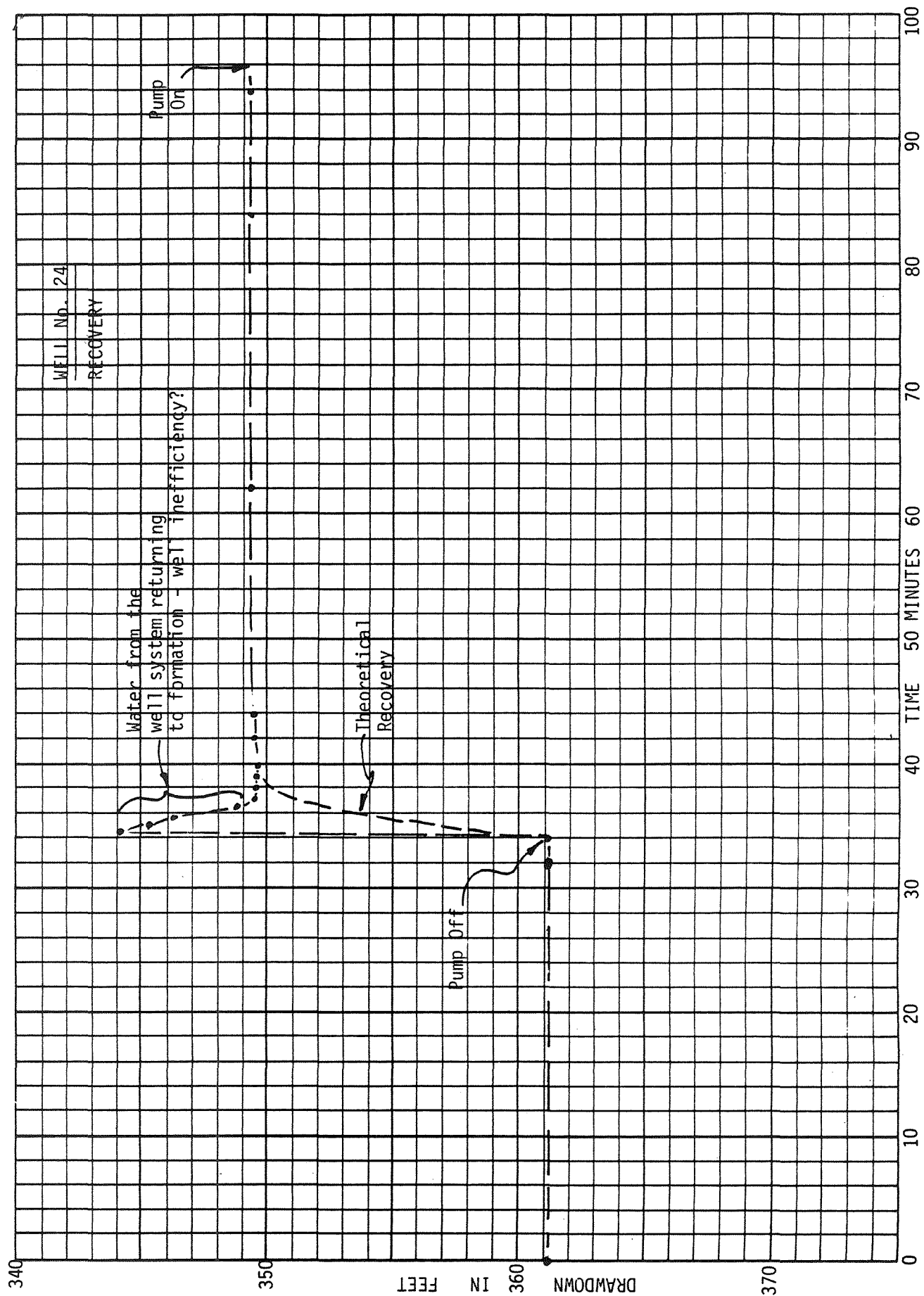
WELL No. 22

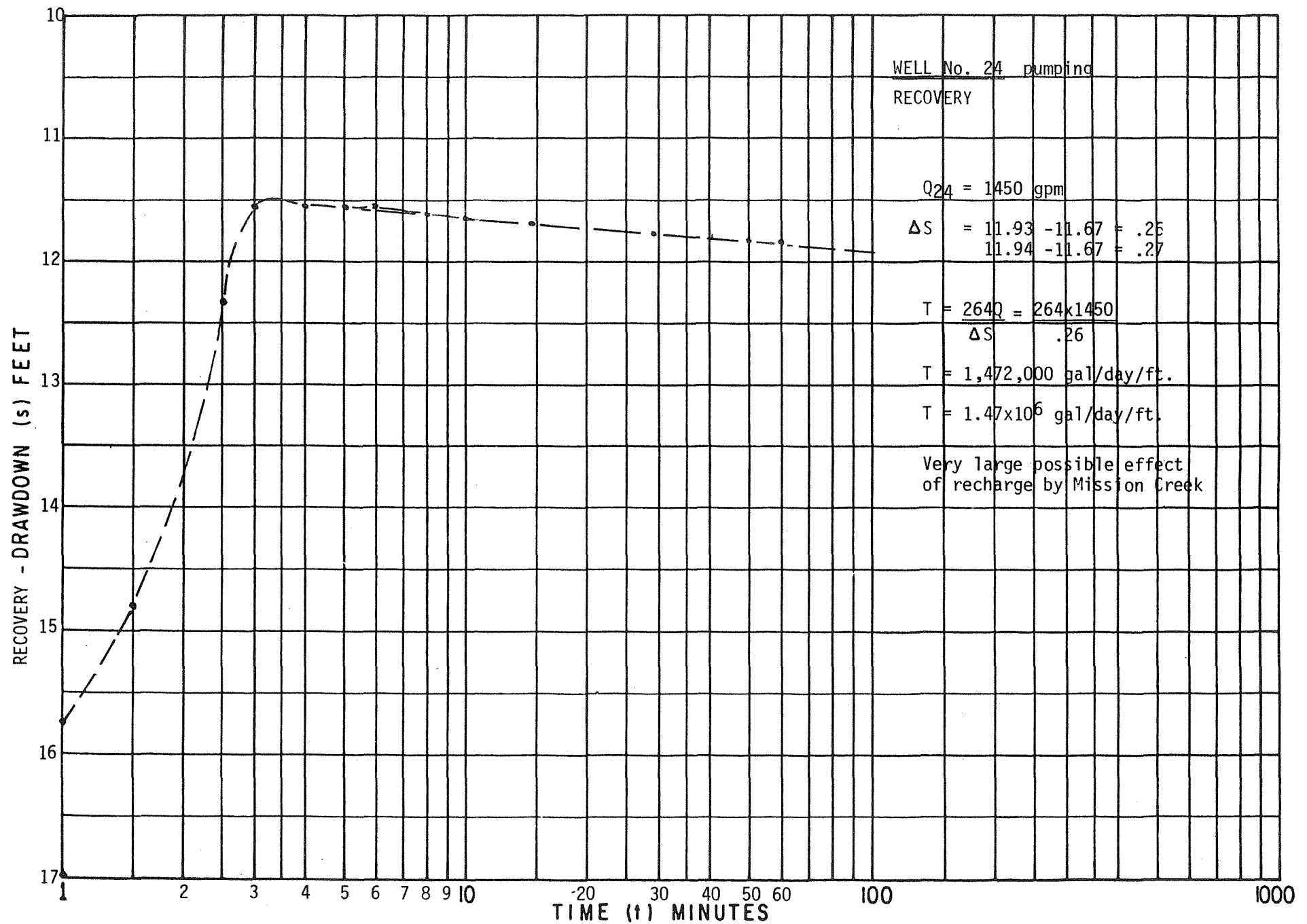


TIME









Clinical Laboratory of San Bernardino, Inc.

1595 N. D ST., SAN BERNARDINO, CA

PHONE (714) 883-3216

P. O. BOX 329, SAN BERNARDINO, CA 92402

S78077

Plate B-3.1

Stiff Plotted

GENERAL MINERAL ANALYSIS

SURVEYOR: Desert Hot Springs County Water Dist.

ADDRESS:

REPORT NO: 8 423

SAMPLING POINT: well 20 P L top of bowls
Temp. 25°C S 78077

ORDER NO: 1

DATE COLLECTED: 8 15 78 per RCS

CATIONS: %		PARTS PER MILLION epm		ANIONS: %		PARTS PER MILLION epi	
CALCIUM	45	69	3.44	ALKALINITY		nil	
MAGNESIUM	13	12.4	1.02	BICARBONATE	25	122	2.00
MANGANESE		less than .01		CARBONATE		nil	
POTASSIUM	3	8.6	0.22	CHLORIDE	12	35	0.99
SODIUM	39	70	3.05	SULFATE	62	235	4.89
			7.73	NITRATE (No ₃)	1	4	0.05
		PARTS PER MILLION					7.93
COPPER		less than .005		PERCENT SODIUM		39 %	
IRON		0.71		HYDROGEN ION ACTIVITY (Ph)		7.9	
ZINC		0.74		SPECIFIC CONDUCTANCE (Kx10-6)		805	
MBAS (Detergents)		less than .005					
TOTAL ALKALINITY AS CaCO ₃		100					
TOTAL HARDNESS AS CaCO ₃		220					
TOTAL DISSOLVED SOLIDS		473					
FLUORIDE		0.6					

REMARKS: CATIONS DONE BY ATOMIC ABSORPTION

DATE STARTED: 8 18 78

DATE COMPLETED: 8 21 78

CHEMIST:

Q. J. Kelly

Clinical Laboratory of San Bernardino, Inc.

1393 N. D ST., SAN BERNARDINO, CA

PHONE (714) 865-3218

P. O. BOX 329, SAN BERNARDINO, CA 92402

S78077

Plate B-3.2

Stiff Plotted

GENERAL MINERAL ANALYSIS

PURVEYOR: Desert Hot Springs County Water Dist.

ADDRESS:

REPORT NO: 8 424

SAMPLING POINT: well # 24 P L 361 Q 1450 gm
Temp. 25°C S 78077

ORDER NO: 2

DATE COLLECTED: 8 14 78 per RCS

CATIONS: %		PARTS PER MILLION epm		ANIONS: %		PARTS PER MILLION epm	
CALCIUM	38	50	2.50	ALKALINITY		nil	
MAGNESIUM	24	19	1.56	BICARBONATE	40	171	2.80
MANGANESE		less than .01		CARBONATE		nil	
POTASSIUM	3	6.7	0.17	CHLORIDE	6	15	0.42
SODIUM	36	55	2.39	SULFATE	54	180	3.75
			6.62	NITRATE (No ₃)		2	0.03
		PARTS PER MILLION					7.00
COPPER		less than .005		PERCENT SODIUM		36 %	
IRON		0.01		HYDROGEN ION ACTIVITY (Ph)		7.89	
ZINC		0.16		SPECIFIC CONDUCTANCE (Kx10 ⁻⁶)		705	
MDAS (Detergents)		less than .005					
TOTAL ALKALINITY AS CaCO ₃		140					
TOTAL HARDNESS AS CaCO ₃		198					
TOTAL DISSOLVED SOLIDS		411					
FLUORIDE		0.66					

REMARKS: CATIONS DONE BY ATOMIC ABSORPTION

DATE STARTED: 8 18 78

DATE COMPLETED: 8 21 78

CHEMIST:

@ J. L. H. S.

Clinical Laboratory of San Bernardino, Inc.

1885 N. D ST., SAN BERNARDINO, CA

PHONE (714) 883-3218

P. O. BOX 329, SAN BERNARDINO, CA 92402

S78077

Plate B-3.3

Stiff Plotted

GENERAL MINERAL ANALYSIS

PURVEYOR: Desert Hot Springs County Water Dist.

ADDRESS:

REPORT NO: 8 425

SAMPLING POINT: well # 10 P L est Q 775 g p m
Temp. 35° C S 78077

ORDER NO: 3

DATE COLLECTED: 8 15 78

CATIONS: %		PARTS PER MILLION epm		ANIONS: %		PARTS PER MILLION epm	
CALCIUM	20	44	2.20	ALKALINITY		nil	
MAGNESIUM	7	8.8	0.72	BICARBONATE	11	73	1.20
MANGANESE		less than .01		CARBONATE		nil	
POTASSIUM	2	9.8	0.25	CHLORIDE	19	75	2.12
SODIUM	71	176	7.66	SULFATE	70	375	7.81
			10.83	NITRATE (No ₃)	0	3	0.05
		PARTS PER MILLION				11.18	
COPPER		less than .005		PERCENT SODIUM		71 %	
IRON		less than .01		HYDROGEN ION ACTIVITY (Ph)		8.03	
ZINC		.08		SPECIFIC CONDUCTANCE (Kx10-6)		1300	
NDAS (Detergents)		less than .005					
TOTAL ALKALINITY AS CaCO ₃		60					
TOTAL HARDNESS AS CaCO ₃		145					
TOTAL DISSOLVED SOLIDS		723					
FLUORIDE		0.86					

REMARKS: CATIONS DONE BY ATOMIC ABSORPTION

DATE STARTED: 8 18 78

DATE COMPLETED: 8 21 78

CHEMIST:

A. J. Kelly

Clinical Laboratory of San Bernardino, Inc.

1999 N. D ST., SAN BERNARDINO, CA
PHONE (714) 853-3310
P.O. BOX 329, SAN BERNARDINO, CA 92402

S78077

Plate B-3.4

Stiff Plotted

GENERAL MINERAL ANALYSIS

SURVEYOR: Desert Hot Springs County Water Dist.

ADDRESS:

REPORT NO: 8 426

SAMPLING POINT: P L 550 Q 870 g p m
Temp. 22°C S 78077 well 23

ORDER NO: 4

DATE COLLECTED: 8 14 78 per RCS

CATIONS: %		PARTS PER MILLION epm		ANIONS: %		PARTS PER MILLION epm	
CALCIUM	43	57	2.84	ALKALINITY		nil	
MAGNESIUM	26	21	1.73	BICARBONATE	47	195	3.20
MANGANESE		less than .01		CARBONATE		nil	
POTASSIUM	2	6.8	0.17	CHLORIDE		14	0.39
SODIUM	29	44	1.91 6.65	SULFATE	6	155	3.23
				NITRATE (No ₃)	47	1	6.82
		PARTS PER MILLION					
COPPER		less than .005		PERCENT SODIUM		28 %	
IRON		less than .01		HYDROGEN ION ACTIVITY (Ph)		7.93	
ZINC		less than .005		SPECIFIC CONDUCTANCE (Kx10-6)		695	
MBAS (Detergents)		less than .005					
TOTAL ALKALINITY AS CaCO ₃		160					
TOTAL HARDNESS AS CaCO ₃		226					
TOTAL DISSOLVED SOLIDS		405					
FLUORIDE		0.8					

REMARKS: CATIONS DONE BY ATOMIC ABSORPTION

DATE STARTED: 8 18 78

DATE COMPLETED: 8 21 78

CHEMIST:

Q. J. [Signature]

Clinical Laboratory of San Bernardino, Inc.

1305 N. D ST., SAN BERNARDINO, CA
PHONE (714) 885-3210
P. O. BOX 329, SAN BERNARDINO, CA 92402

578077

Plate B-3.5

Stiff Plotted

GENERAL MINERAL ANALYSIS

PURVEYOR: Desert Hot Springs County Water Dist.

ADDRESS:

REPORT NO: 8 427

SAMPLING POINT: well # 21 Temp. 26° C S 78077
Q 360 gpm

ORDER NO: 5

DATE COLLECTED: 8 15 78 per RCS

CATIONS:	%	PARTS PER MILLION	epm	ANIONS:	%	PARTS PER MILLION	epm
CALCIUM	35	27	1.35	ALKALINITY		nil	
MAGNESIUM	9	4.2	.35	BICARBONATE	54	137	2.25
MANGANESE		less than .01		CARBONATE		nil	
POTASSIUM	3	4.5	0.12	CHLORIDE	19	27	0.76
SODIUM	53	48	2.09	SULFATE	26	52.5	1.09
			3.91	NITRATE (No ₃)	1	2	0.03
		PARTS PER MILLION					4.13
COPPER		less than .005		PERCENT SODIUM		54 %	
IRON		less than .01		HYDROGEN ION ACTIVITY (Ph)		8.08	
ZINC		0.3		SPECIFIC CONDUCTANCE (Kx10-6)		405	
MBAS (Detergents)		less than .005					
TOTAL ALKALINITY AS CaCO ₃		112					
TOTAL HARDNESS AS CaCO ₃		92					
TOTAL DISSOLVED SOLIDS		240					
FLUORIDE		0.62					

REMARKS: CATIONS DONE BY ATOMIC ABSORPTION

DATE STARTED: 8 18 78

DATE COMPLETED: 8 21 78

CHEMIST:

[Signature]

Clinical Laboratory of San Bernardino, Inc.

1395 N. D ST., SAN BERNARDINO, CA

PHONE (714) 883-3218

P. O. BOX 329, SAN BERNARDINO, CA 92403

S78077

Stiff Plotted

Plate B-3.6

GENERAL MINERAL ANALYSIS

PURVEYOR: Mission Lakes (Desert Hot Springs)

ADDRESS: Mission Lakes Country Club Well

SAMPLING POINT: # 3 Temp. 23° C S 78077
Q. 960 E P M

REPORT NO: 8 428

ORDER NO: 6

DATE COLLECTED: 8 15 78 per R C S

CATIONS: %		PARTS PER MILLION epm		ANIONS: %		PARTS PER MILLION ep	
CALCIUM	30	70	3.49	ALKALINITY		nil	
MAGNESIUM	28	39.5	3.25	BICARBONATE	35	249	4.08
MANGANESE		less than .01		CARBONATE		nil	
POTASSIUM	2	8.5	0.21	CHLORIDE	12	45	1.27
SODIUM	40	108	4.7	SULFATE	53	295	6.14
			11.65	NITRATE (No ₃)		3	0.05
		PARTS PER MILLION					11.54
COPPER		less than .005		PERCENT SODIUM		41 %	
IRON		less than .01		HYDROGEN ION ACTIVITY (Ph)		7.75	
ZINC		less than .005		SPECIFIC CONDUCTANCE (Kx10-6)		1195	
MBAS (Detergents)		less than .005					
TOTAL ALKALINITY AS CaCO ₃		204					
TOTAL HARDNESS AS CaCO ₃		330					
TOTAL DISSOLVED SOLIDS		691					
FLUORIDE		1.3					

REMARKS: CATIONS DONE BY ATOMIC ADSORPTION

DATE STARTED: 8 18 78

DATE COMPLETED: 8 21 78

CHEMIST: O. J. J. J.

1505 N. D ST., SAN BERNARDINO, CA
PHONE (714) 885-3210
P. O. BOX 320, SAN BERNARDINO, CA 92402

Plate B-3.7

GENERAL MINERAL ANALYSIS

REPORT NO: 8 429

ORDER NO: 7

REMARKS: CATIONS DONE BY ATOMIC ABSORPTION

DATE COMPLETED: 8 21 78

CHEMIST:

C. J. Lipp

Clinical Laboratory of San Bernardino, Inc.

1393 N. D ST., SAN BERNARDINO, CA

PHONE (714) 885-3218

P. O. BOX 329, SAN BERNARDINO, CA 92402

S78077

Plate B-3.8

Stiff Plotted

GENERAL MINERAL ANALYSIS

PURVEYOR: Desert hot springs county water dist.

ADDRESS:

REPORT NO: 8 430

SAMPLING POINT: well 22 P L 366 ft. Q 1180
Temp. 28°C S 78077

ORDER NO: 8

DATE COLLECTED: 8 14 78 per RCS

CATIONS: %		PARTS PER MILLION epm		ANIONS: %		PARTS PER MILLION epm	
CALCIUM	37	48	2.40	ALKALINITY		nil	
MAGNESIUM	24	18.8	1.55	BICARBONATE	45	185	3.0
MANGANESE		less than .01		CARBONATE		nil	
POTASSIUM	2	6.7	0.17	CHLORIDE	7	18	0.5
SODIUM	37	55	2.39	SULFATE	48	160	3.3
			6.51	NITRATE (No ₃)		1	6.8
		PARTS PER MILLION					
COPPER		less than .005		PERCENT SODIUM		37 %	
IRON		0.42		HYDROGEN ION ACTIVITY (Ph)		7.94	
ZINC		0.04		SPECIFIC CONDUCTANCE (Kx10-6)		695	
NBAS (Detergents)		less than .005					
TOTAL ALKALINITY AS CaCO ₃		152					
TOTAL HARDNESS AS CaCO ₃		190					
TOTAL DISSOLVED SOLIDS		399					
FLUORIDE		0.77					

REMARKS: CATIONS DONE BY ATOMIC ADSORPTION

DATE STARTED: 8 18 78

DATE COMPLETED: 8 21 78

CHEMIST:

E. J. Kelly

Clinical Laboratory of San Bernardino, Inc.

1395 N. D ST., SAN BERNARDINO, CA
PHONE (714) 885-3218
P. O. BOX 328, SAN BERNARDINO, CA 92408

S78077

Plate B-3.9

GENERAL MINERAL ANALYSIS

PURVEYOR: Desert Hot Springs

REPORT NO. 8 718

ADDRESS:

ORDER NO. 5

SAMPLING POINT: Mission Creek @ Hwy 62 Bridge

LAB NO. 5

DATE COLLECTED: 9 29 78

COLLECTED BY:

CATIONS:	MEQ/L	PPM	ANIONS:	MEQ/L	PPM
CALCIUM	1.4	28	HYDROXIDE		n11
MAGNESIUM	2.1	26	CARBONATE		n11
SODIUM	1.4	32	BICARBONATE	3.0	181
POTASSIUM	.2	8.4	CHLORIDE	.3	10
MANGANESE	.0	less than .01	SULFATE	2.1	100
			NITRATE (NO ₃)	.0	less than 1
			FLUORIDE	.0	0.52
TOTAL MEQ/L 5.1			TOTAL MEQ/L 5.4		
COPPER		less than .005	PERCENT SODIUM		27 %
IRON		less than .01	HYDROGEN ION ACTIVITY (pH)		8.61
ZINC		less than .005	SPECIFIC CONDUCTANCE (K ₁ 25)		500
MBAS (DETERGENTS)		less than .005			
TOTAL ALKALINITY AS CaCO ₃		148			
TOTAL HARDNESS AS CaCO ₃		165			
TOTAL DISSOLVED SOLIDS		320			

REMARKS:

DATE RECEIVED: 9 29 78

DATE STARTED: 10 2 78

DATE COMPLETED: 10 4 78

ALL ANALYSES DONE BY "STANDARD METHODS", (14TH ED.) OF APHA
OR EPA "METHODS FOR CHEMICAL ANALYSIS OF WATER AND WASTE."

CHEMIST:

[Signature]

TABLE B-1

OBSERVATIONS MADE DURING THE AQUIFER TESTS
(August 14 and August 16, 1978)

WELL No.	NOTE
20	Could hear cascading water. Water surface oily. Pumping level 205 ft. (Perforated 150 to 210 ft.)
21	Difficult to obtain water level. No effervescence at 375 gpm. Water surface very oily. Pumping level 117 ft. Rough static 113 ft.
22	Effervescence.
23	Effervescence. Water slightly milky.
24	Effervescence.(drilled 1973, bowls replaced 1977, water cloudy with sand, gravel pack has moved). Water slightly milky. Pumping level 361 ft.

TABLE B-2

TEMPERATURE DATA OBTAINED DURING THE AQUIFER TESTS
(measured during warm days)
(August 14 and August 15, 1978)

Well Number	Centigrade	Fahrenheit*	Subbasin
8	29 ⁰	84 ⁰	Desert Hot Springs
10	35 ⁰	95 ⁰	Desert Hot Springs
20	23 ⁰	73 ⁰	Mission Creek
21	26 ⁰	79 ⁰	Mission Creek
22	28 ⁰	82 ⁰	Mission Creek
23	22 ⁰	72 ⁰	Mission Creek
24	25 ⁰	77 ⁰	Mission Creek
Mission Lakes 2S/4E-23L	23 ⁰	73 ⁰	Mission Creek

* Degrees F=9/5 C+32



APPENDIX C

GROUND WATER STORAGE

GENERAL STATEMENT

Calculation of the ground water storage of the study area was based on determining the volume of the water-bearing sediments and the specific yields of those sediments.

The procedure for calculating storage involved the following:

1. Subdivision of the study area into two surface units representing a ground water storage zone;
2. Grouping of earth materials represented on well logs into categories;
3. Assignment of specific yield values to these categories of earth materials; and,
4. Computation of ground water storage.

The two ground water storage zones are shown on Plate C-1 - Ground Water Storage Zones. Zone A was defined in the western half of the basin where the ground water basin sediments are thought to thin rapidly to the west. Zone B represents the portion of the study area where ground water basin sediments thicken from east to west and the water level is practically horizontal.

In estimating the total volume of each zone, fault boundaries were assumed to be vertical, and basin bottom contours were generalized to form smooth gradients.

Classification of Materials. Factual data for determining the specific yield (or even porosity) of the deposits within the area are quite meager. The USGS in their study of artificial recharge plots in the Upper Coachella Valley (1973) provided the first and, to date, only laboratory-determined values for specific yield. Thus, for earth materials in their Windy Point study area, sediments within the upper 30 feet of ground surface displayed specific yields on the order of 13.0 to 21.3 percent (1973, p. 11-13). However, in their discussion, they indicated that these samples were likely disturbed due to the heavy pounding required to obtain the samples; such pounding might compact the sample causing reductions in the specific yield and porosity.

Therefore, the various earth materials shown on driller's logs in the study area were grouped into categories considered to have grossly similar porosities and specific yield values. Following the scheme adopted by Bulletin 108 of the California Department of Water Resources (1964), these categories were assigned a specific yield value developed by the DWR. A description of the materials, along with representative driller's terms and corresponding specific yield values are shown in Table C-1 - Selected Specific Yield Values. The actual values of specific yield used for each storage zone are shown in Table C-2 - Total Ground Water in Storage.

GROUND WATER STORAGE

Results of geophysical surveys conducted by Biehler (Appendix E), indicate that potentially water-bearing sediments extend to depths of only 800 to 1000 feet. The storage of each zone was then calculated as the product of the volume of saturated materials and its average specific yield. Summation of the storage in all zones provided the total ground water storage for the study area. As shown on Table C-2, the total ground water storage is 1.45×10^6 acre-feet as



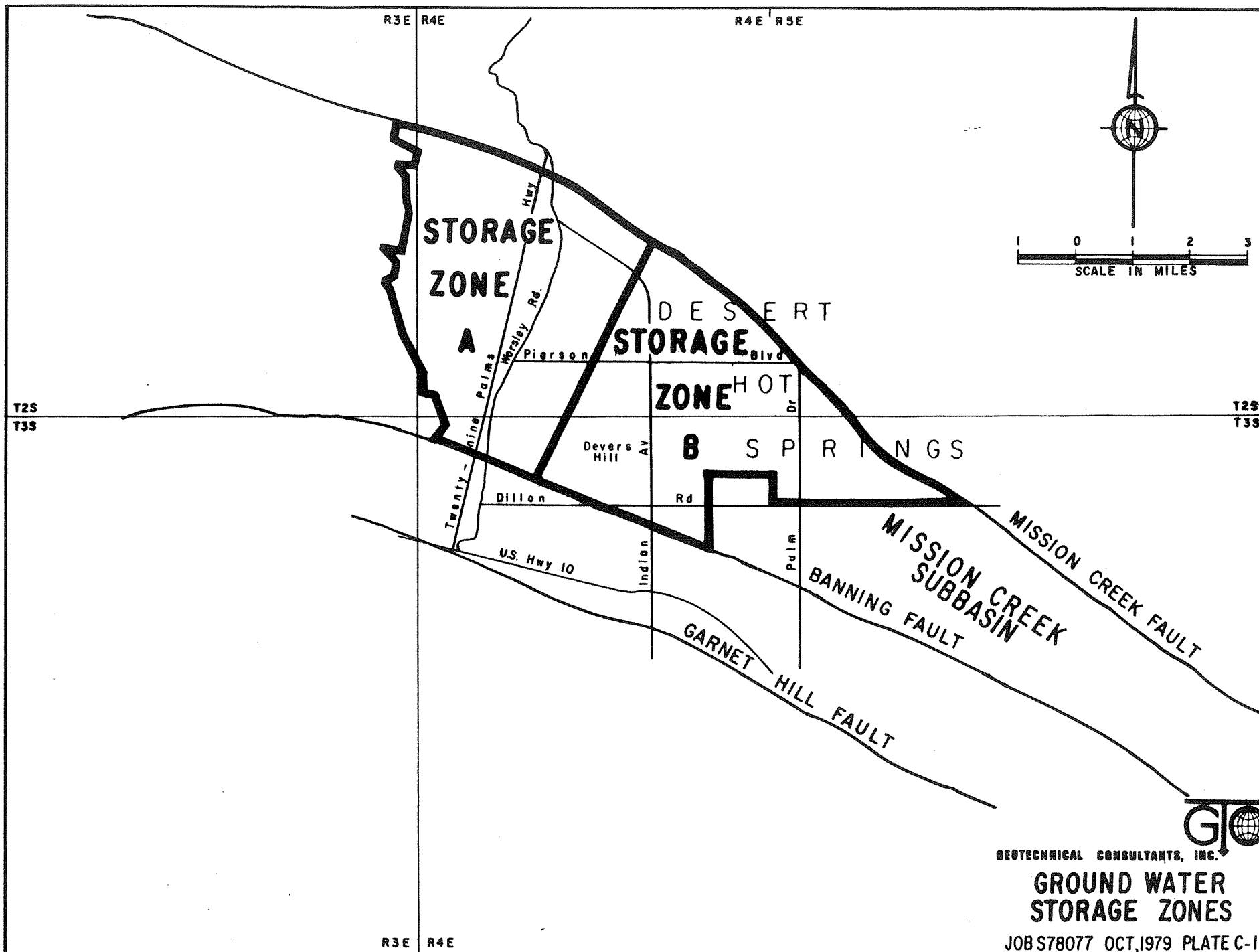
TABLE C-1
SELECTED SPECIFIC YIELD VALUES

Specific Yield Value	Description of Material	Representative terms used by drillers to describe material	
3 percent	Clay	Clay and silt Clay streak Gumbo Hard pack Hard shale	Ledge Shale and clay Shell Slum Sticky formation
5 percent	Clayey sand	Clay and sand Clay and sand streaks Clay and slummy sand Fine in and out Hill formation	Medium fine sand and shale streaks Medium fine shaley Medium fine to clay streaks Slime sand
7 percent	Clayey gravel	Cemented gravel Cemented rock Clay and gravel streaks Clay and rock	Conglomerate and shale Gravel and sand cemented Slummy gravel
10 percent	Silty sand	Clay and mix Coarse in and out In and out Medium in and out Sand and clay	Silty sand Slummy sand Surface soil Tight gravel Tight sand and gravel
18 percent	Fine sand	Blow sand Boulders Dirty sand Fine fair loose sand Fine sand	Hard packed sand Medium fine and pebbles Running sand Sand cutting type Sugar sand
22 percent	Gravel	Clear rock Coarse gravel Fairly coarse sand mixed with fine sand Free gravel Light white water gravel	Medium to conglomerate Rocky pebbles Sand and gravel Sand and rock Surface rocks
25 percent	Medium sand	Alluvial deposits Clean sand Dry wash sand Medium and coarse sand	Medium coarse and medium sand Sand Water Water Gravel
28 percent	Coarse sand	Coarse sand Fairly coarse sand	Match head gravel Medium coarse sand

Data adapted from DWR (1964, p. 72)

TABLE C-2TOTAL GROUND WATER IN STORAGE

Study Zone	Surface Area (acres)	Average Thickness of Sediments (feet)	Total Volume of Sediments (acre-feet)	Average Depth to Water (Spring 1978) (feet)	Average Thickness of Saturated Sediments (feet)	Total Volume of Saturated Sediments (acre-feet)	Average Specific Yield	Total Volume of Ground Water in Storage (acre-feet)
A	10,668	668	7,126,224	360	308	3,285,744	17%	558,576
B	10,796	845	9,122,620	360	485	5,236,060	17%	890,130
TOTAL	21,464	-	16,248,844	-	-	8,521,804	-	1,448,706



APPENDIX D

WATER WELL IDENTIFICATION SYSTEM

Several water well identification systems have been used in Riverside County to distinguish individual wells. The earliest system merely named a particular well after its owner or geographic location. The old Palm Springs Water Company utilized this method for its earliest well files; for example, the Araby Well or the Wheeler Well.

Later, as more wells were drilled, the well names were changed to well numbers. This system is still being used today by the Desert Hot Springs County Water District and, as new wells are drilled, they are numbered serially. At present, well numbers 1 through 26 have been drilled.

A more sophisticated system, and the one which is used in this report was devised by the U. S. Geological Survey. This system numbers a well according to the Township, Range, and Section subdivision of the Federal land survey. Each one-square-mile section is divided into 40-acre plots, lettered as shown below.

DI ●●D2

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

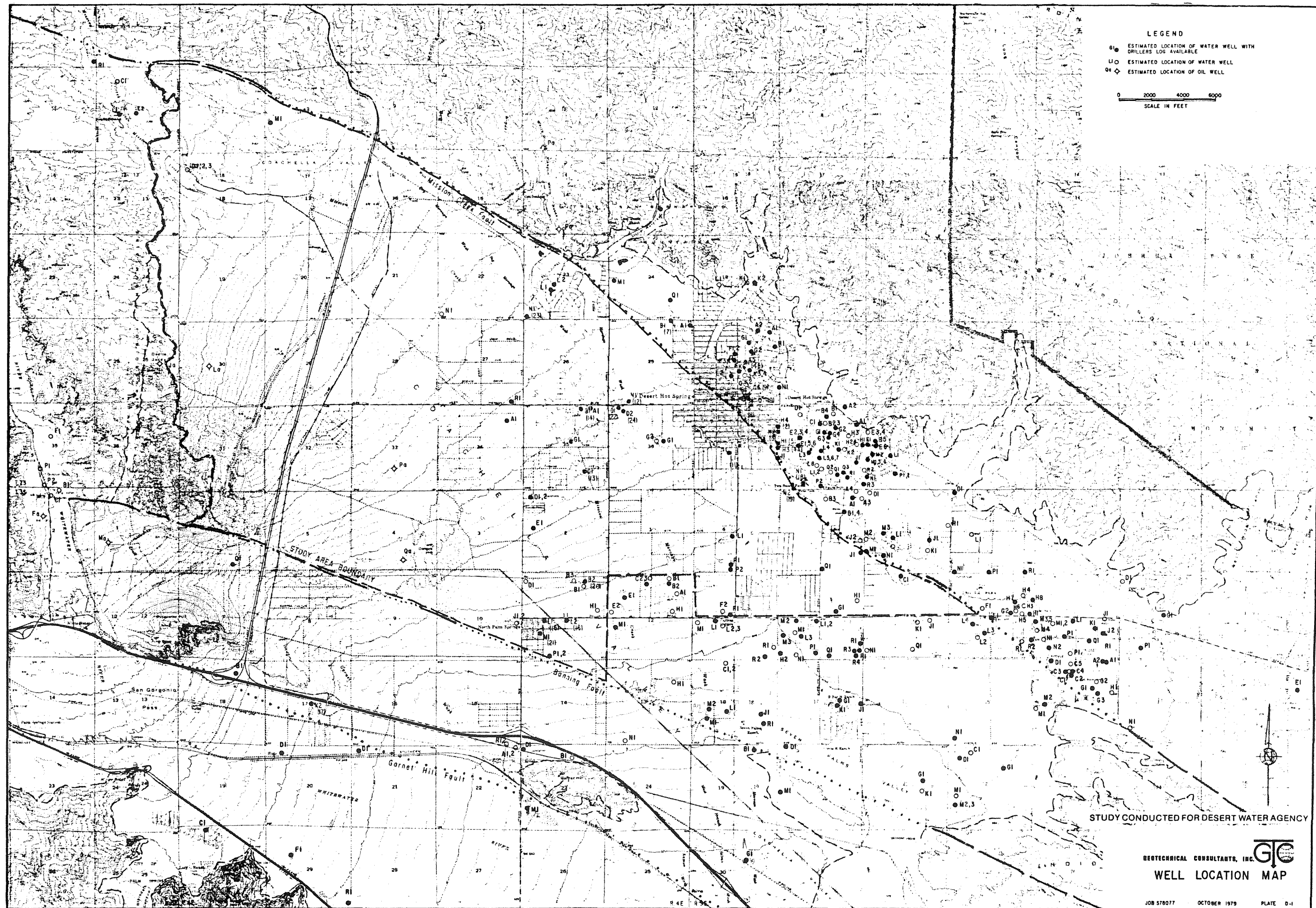
36

For example, for well number 2S/4E-36D2, the portion of the number preceding the slash (2S) indicates the township (2 South); the portion of the number between the slash and the hyphen is the range (4 East), the number between the hyphen and the letter indicates the section (36); and the letter indicates the 40-acre sub-division (D) of the section. New wells are numbered serially within each of the 40-acre tracts as indicated by the final digit (2). Hence, well 2S/4E-36D2 is the second well to be located in the northwest one-quarter of the northwest one-quarter of Section 36, Township 2 South, Range 4 East.

Oil wells in this report also are referenced to the Federal land survey system. They differ from water well numbers in that their final symbol is a letter, not a number as for water wells. Thus, an oil well designation would be 4S/4E-29Pa. New oil wells are lettered serially within each 40-acre tract.

All wells in this report are referenced to the San Bernardino Base Line and Meridian (SBRM).

Plate D-1 - Water Well Location Map has been prepared to illustrate the locations of known wells in the region and to identify if a driller's boring log exists for the well.





S78077

APPENDIX E

A GEOPHYSICAL INVESTIGATION OF
THE DESERT HOT SPRINGS AREA,
UPPER COACHELLA VALLEY, CALIFORNIA

Appendix E will be provided under separate cover.