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MCAS EL TORO
SSIC # 5090.3

PHASE II REPORT

ADDITIONAL INVESTIGATION AND REMEDIATION OF TRICHLOROETHYLENE CONTAMINATION IN THE VICINITY OF THE MARINE CORPS AIR STATION EL TORO

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ORANGE COUNTY WATER DISTRICT

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EXECUTIVE SUMMARY

The Orange County Water District constructed six 150-to 450-foot deep single-point monitoring wells in the fall of 1989, in addition to four previously installed multipoint wells. The purpose of the additional wells was to further define the extent of trichloroethylene contamination in the groundwater in the vicinity of the Marine Corps Air Station (MCAS) El Toro. Groundwater chemical data collected during OCWD's initial (Phase I) investigation were used by the U.S. Environmental Protection Agency to support the placement of contaminated areas, both on- and off-base, on the National Priorities (Superfund) List. Results of sampling the new wells and existing nearby irrigation wells indicate that the TCE plume extends at least to Culver Drive, about 3 miles northwest of the MCAS El Toro (see Figure 10). The southwestern boundary of the plume appears to be delineated by San Diego Creek, as evidenced by below-action level (5.0 ug/L) TCE concentrations. The highest TCE concentrations outside the Marine base continue to be found along Irvine Center Drive between Jeffrey Road and Sand Canyon Avenue. Well MCAS-3, located just outside the southwestern corner of MCAS El Toro, was found to contain TCE at 18 ug/L. This well was previously thought to be free of TCE in the Phase I investigation and was cited by the Marines as evidence that the off-base plume was separate from the on-base contamination. The additional hydrogeologic and water quality data collected support OCWD staff's earlier conclusion that the MCAS El Toro is the source of TCE in the Irvine area.

As a second task of its Phase II work, OCWD constructed a 1,200 gpm (maximum capacity) extraction well and VOC removal system as an interim means of groundwater contamination remediation. The treatment system, consisting of a rotary air stripper and a vapor-phase UV/ozone VOC destruct unit is designed for a maximum discharge of 700 gpm. Treated water is conveyed to Irvine Ranch Water District's reclaimed water system, used for agricultural and greenbelt irrigation. The extraction well's capture area is estimated to contain 80 percent of the upgradient area of the plume and approximately 500 to 1,000 feet downgradient from the well (see Figure 12). Subsequent monitoring of local piezometric levels during operation at this flow rate should refine this estimate. Future increases in pumping to the maximum rate of 1,200 gpm may be necessary to maximize TCE recovery until a regional groundwater cleanup program is implemented.

The proposed Irvine Desalter Project, consisting of a 7 MGD production wellfield and treatment system, may provide the basis for an ultimate water quality solution for the Irvine area. However, wells in addition to those planned will be necessary to effectively remove shallow VOC-laden groundwater directly beneath the MCAS El Toro. As the Irvine Desalter Project and the USMC's Remedial Investigation/Feasibility Study progress through their respective planning stages, joint efforts to clean up groundwater should be researched for potential economic benefits.

1. INTRODUCTION

This report describes and presents data collected during additional field investigations conducted by the Orange County Water District (OCWD) to further assess the extent of trichloroethylene (TCE) contamination of groundwater in the vicinity of the Marine Corps Air Station (MCAS) El Toro. In addition, this report describes the construction of the TCE pumpout project which consists of a high-capacity production well and wellhead treatment facility. This portion of the investigation, referred to here as Phase II, included the construction and sampling of six new monitoring wells and one production well from May 1989 through March 1990.

1.1 PREVIOUS INVESTIGATIONS

During routine water sampling in 1985, OCWD personnel detected the industrial solvent TCE in four Irvine-area production wells (TIC 35, TIC 47, TIC 55, and TIC 74). Concentrations of TCE found in wells TIC 35 and TIC 47 were two to ten times higher than the 5.0 micrograms per liter (ug/l) State drinking water standard, while concentrations detected in wells TIC 55 and TIC 74 were close to the 0.5 ug/l laboratory detection limit. As shown on Figure 1, well TIC 55 is located on the MCAS property, while wells TIC 35, TIC 47, and TIC 74 are located west of the base.

Subsequent field investigations conducted by OCWD included the construction and sampling of four multipoint monitoring wells, MCAS-1, -2, -3, and -7, and attempted rehabilitation and sampling of four inactive irrigation wells. Details and findings of this first phase of investigation were described in a report by OCWD (1989). As described in the report, three of the four monitoring wells were found to contain TCE concentrations in excess of the drinking water standard. The aquifer zones found to contain TCE range between 200 and 450 feet deep. The report concluded that the El Toro MCAS is the source of TCE in the Irvine area.

In addition to the OCWD study, the United States Marine Corps (USMC) conducted a subsurface investigation confined within the perimeter of the MCAS (USMC, 1989). The investigation included the construction and sampling of eight shallow monitoring wells and one multi-depth well cluster. Five of the eight monitoring wells and three of the five clustered wells were found to contain TCE. The USMC report disputes the findings of the OCWD study and suggests the existence of multiple TCE plumes and that "MCAS El Toro is a contributor to this contamination and not the sole source of contamination."

In February 1990, the U.S. Environmental Protection Agency (EPA) placed the MCAS El Toro on the National Priorities (Superfund) List. The USMC is presently preparing a comprehensive Remedial Investigation/Feasibility Study (RI/FS) Work Plan to conduct an extensive surface and subsurface investigation of previous waste storage and disposal sites, including five inactive landfills and approximately 300 underground storage tanks, at the El Toro MCAS as well as off-base areas known or suspected to be impacted by contaminants emanating from the base. Potential contaminants other than chlorinated solvents which will be investigated include heavy metals and petroleum hydrocarbons from on-base airplane refueling operations.

A technical review committee (TRC) headed by the U.S. EPA will review and comment on the draft RI/FS Work Plan when it is submitted by the USMC. A final work plan is scheduled to be completed in October 1990. The TRC consists of interested local and regional agencies, including the EPA, Orange County Health Care Agency (OCHCA), Santa Ana Regional Water Quality Control Board (RWQCB), California Department of Health Services, Irvine Ranch Water District (IRWD), The Irvine Company (TIC), City of Irvine, USMC and its contractors, and OCWD.

1.2 OBJECTIVES

The objectives of the Phase II OCWD investigation were as follows:

- Initiate an interim cleanup operation to stop or slow the northwestward migration of the TCE plume.

- Further investigate and define the lateral extent of the TCE plume, as this will impact the design of a comprehensive remediation program.

The area east of the Laguna Freeway, known as the Irvine Spectrum, was not included in the current OCWD study, because the USMC's RI/FS work plan will include extensive studies in this area.

1.3 SCOPE OF WORK

The scope of the Phase II investigation consisted of the following tasks:

- Drill and construct one groundwater production well (ET-1) to be used as a TCE recovery well.

- Perform aquifer tests, flowmeter surveys, and depth-specific water sampling in well ET-1. Aquifer transmissivity and storage coefficient values were estimated from the aquifer test data.

- Design and construct a wellhead VOC treatment facility and pipeline to convey extracted water to a reclaimed water line owned by IRWD.

- Drill and construct six single-point ground water monitoring wells (MCAS-4, -5, -6, -8, -9, and -10) at locations shown on Figure 1. A single-point monitoring well is defined here as having one or more perforated or screened intervals within a single aquifer; this is to distinguish these wells from the multipoint wells (MCAS-1, -2, -3, and -7) installed during the Phase I investigation.

- Measure piezometric levels and collect water samples in all new and existing monitoring wells. Water samples were analyzed for volatile organic compounds (VOCs) and inorganic compounds at the OCWD State-certified laboratory.

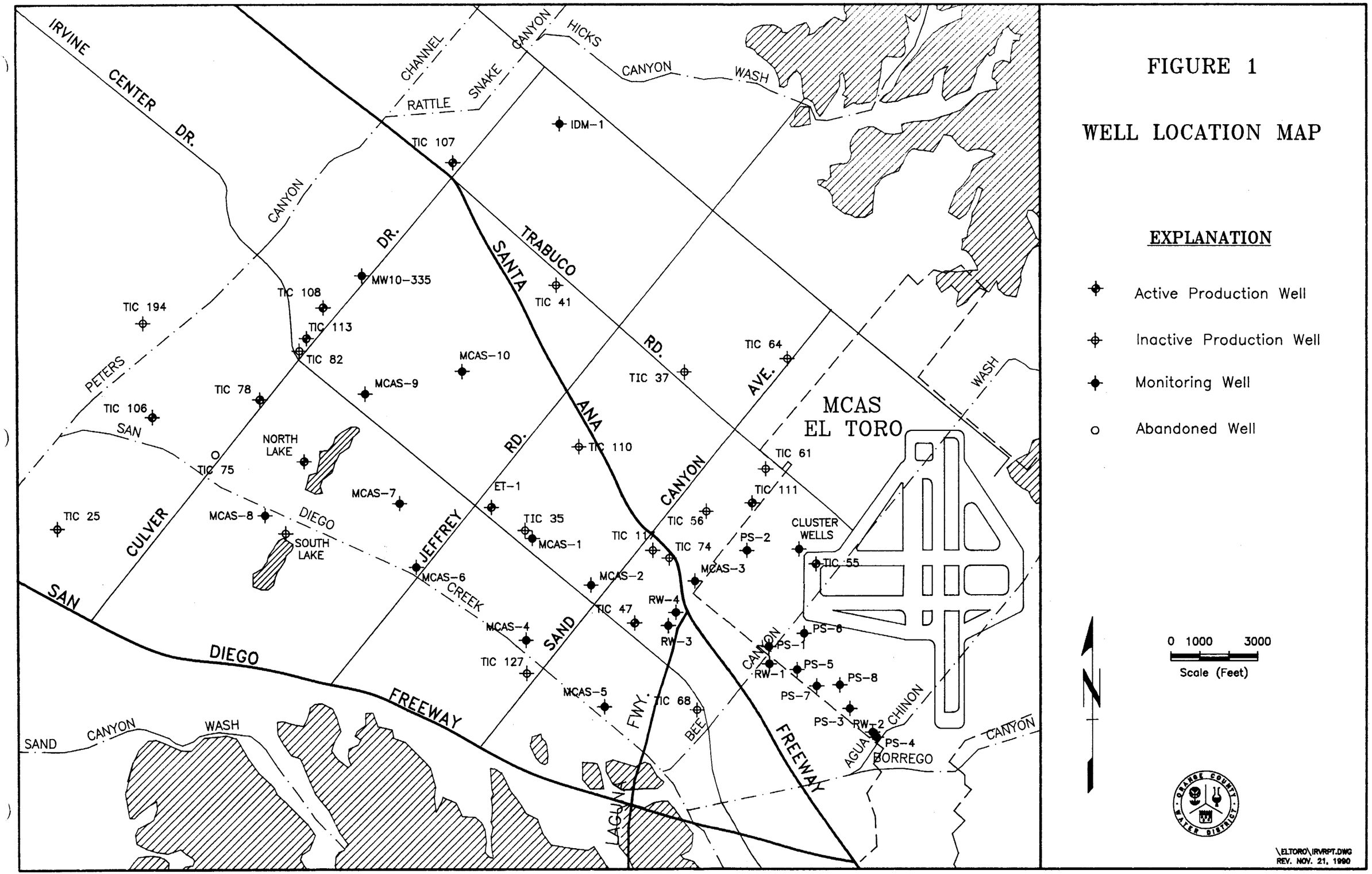
FIGURE 1
WELL LOCATION MAP
EXPLANATION
Active Production Well
Inactive Production Well
Monitoring Well
Abandoned Well
0 1000 3000
Scale (Feet)
N
MCAS
EL TORO
IRVINE CENTER DR.
CHANNEL
RATTLE
SNAKE
CANYON
HICKS
CANYON
WASH
CANYON
DR.
SANTA
TRABUCO
RD.
AVE.
ANA
RD.
CANYON
PETERS
SAN
DIEGO
CULVER
JEFFREY
CREEK
SAND
CANYON
FWY.
LAGUNA
BEE
CANYON
AGUA
CHINON
BORREGO
CANYON
WASH
SAND
CANYON
WASH
SAN
DIEGO
FREEWAY
FREEWAY
NORTH LAKE
SOUTH LAKE
CLUSTER WELLS
IDM-1
TIC 107
TIC 41
TIC 64
TIC 37
MW10-335
TIC 108
TIC 113
TIC 82
TIC 194
MCAS-10
MCAS-9
TIC 78
TIC 106
TIC 75
TIC 110
TIC 61
TIC 111
ET-1
TIC 35
MCAS-1
TIC 56
TIC 11
TIC 74
PS-2
MCAS-3
TIC 55
MCAS-7
MCAS-8
TIC 25
MCAS-6
MCAS-2
TIC 47
RW-4
RW-3
MCAS-4
TIC 127
PS-6
PS-1
PS-5
RW-1
PS-8
PS-7
PS-3
RW-2
PS-4
MCAS-5
TIC 68
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- Analyze the new hydrogeologic data collected during this investigation. Data analysis included the revision of geologic cross sections and TCE plume and piezometric contour maps.

- Prepare this report and recommend methods of evaluating the effectiveness of the interim TCE cleanup program.

2. FIELD INVESTIGATION

The purpose of the Phase II investigation was to initiate an interim groundwater extraction and treatment system and to delineate the southern and western lateral extent of the TCE plume. Data from the new and existing monitoring wells will be used to evaluate the effectiveness of the recovery system on slowing the migration of the TCE plume. The field data collection part of the investigation included borehole lithologic logging, water sampling, and aquifer testing of the production and monitoring wells. The following section describes these tasks.

Site access permission from property owners was obtained for all wells prior to commencement of field activities. Table 1 lists the type of site access document obtained or pending for wells constructed during this investigation.

2.1 PRODUCTION WELL CONSTRUCTION AND TESTING

As a first step toward remediation of the TCE plume, a production well, ET-1, was constructed near the northeast corner of Irvine Center Drive and Jeffrey Road (see Figure 1). This site was selected to maximize contaminated groundwater extraction and plume containment based on its location downgradient from wells
TIC 35 and MCAS-1, where the highest off-base TCE concentrations were detected.

2.1.1 Drilling and Soil Sampling

Between May and June 1989, well ET-1 was drilled, constructed, developed, and pump tested. A 30-inch diameter, mild steel conductor casing was installed inside a 36-inch diameter borehole from ground surface to a depth of 50 feet and grouted in place with cement. A 28-inch diameter boring was then continued to a total depth of 520 feet below ground surface (bgs) using reverse rotary drilling equipment. A hydrant adjacent to the site provided the water source. No bentonite mud or other drilling fluids were used as additives. An OCWD geologist collected samples of the drill cuttings at approximate 10-foot intervals as they were discharged from the borehole prior to entering the settling

Table 1. Well Site Access Summary

Well Number	Site Owner	Site Access Document	Status
MCAS-4	The Irvine Co.	Temp. Entry Permit	--
MCAS-5	The Irvine Co.	Temp. Entry Permit	--
MCAS-6	City of Irvine	Easement	pending
MCAS-8	Irvine Unified School Dist.	Easement	--
MCAS-9	City of Irvine	Easement	pending
MCAS-10	So. Calif. Edison	License Agreement	pending
ET-1	The Irvine Co.	Temp. Entry Permit	site purchase by IRWD pending

tank. Samples were then placed in labeled plastic bags. The field geologist maintained a log describing the lithology of the strata penetrated during drilling. Appendix A contains the boring logs and construction details of all wells drilled during the Phase II investigation.

Drilling rates averaged about 13 feet per hour, as the lithology varied from clay to sand and some gravel. Drill cuttings were placed on plastic liners, and fluids were stored in Baker tanks and tested to be nonhazardous for VOCs (EPA Method 8010/8020) prior to disposal on OCWD property in the City of Anaheim. Water was discharged to a storm drain adjacent to the well site in accordance with OCWD's NPDES permit.

2.1.2 Borehole Lithology

The sediments encountered while drilling well ET-1 consisted of unconsolidated clays and silts with interbedded sands and gravels. From ground surface to a depth of about 220 feet, the clay and silt layers appeared to be the predominant soil type. From 220 to 520 feet, the clay and silt beds were thinner with sand and gravel zones increasing in thickness. The sand layers were generally poorly sorted, ranging from fine-to coarse-grained, often with clay. Clays were generally plastic and contained sand. Sediment color was light to dark brown from ground surface to a depth of 350 feet. Below 350 feet the cuttings were gray, possibly indicating reduced groundwater chemical conditions.

2.1.3 Geophysical Logging

Geophysical logs run in the ET-1 borehole following drilling included point resistivity, 16- and 64-inch normal resistivity, spontaneous potential (SP), and caliper. The SP and resistivity logs were used with the boring log to interpret the depths of the various strata encountered. The electric logs indicated the presence of interbedded clays and silts with zones of more permeable sands and gravels throughout the total borehole depth. The depth interval between 400 and 500 feet appeared to contain fewer clay and silt zones. The electric log of well ET-1 is presented on Figure A1 in Appendix A.

The caliper log was used to measure the borehole diameter following drilling. This log revealed an oversized borehole diameter (greater than 42 inches, the maximum diameter of the caliper) from the bottom of the 30-inch diameter conductor (50 feet bgs) to a depth of approximately 325 feet. Below 325 feet, the borehole maintained a fairly constant 28-inch diameter. Because the driller replaced a 28-inch diameter drag bit with a 28-inch cluster cone bit at a depth of about 328 feet during drilling, OCWD staff believes that the enlarged borehole may be attributed to a faulty nozzle on the drag bit that created a horizontal "wash out" of the borehole. This problem did not occur after the bit was changed.

2.1.4 Well Design and Installation

Well ET-1 was designed after review of the lithologic and geophysical logs as well as the depths at which TCE was found in the existing multipoint monitoring wells (between 200 and 450 feet bgs). The zones selected for production in well ET-1 were in the interval between 220 to 490 feet bgs. Sixteen inch diameter wire-wrapped stainless steel screens with 0.050-inch wide slots were placed adjacent to selected aquifer zones. A 10-foot length of 16-inch diameter stainless steel blank casing was butt-welded to the bottom of the screen as a silt trap. The upper 220 feet of the well consisted of 16-inch diameter blank stainless steel casing (0.250-inch wall thickness). All joints of screen and casing were butt-welded. A 4-inch diameter stainless steel camera/sounding tube was installed in the annulus and welded on taper to the well casing between the depths of 187 and 197 feet. In addition, a 3-inch diameter mild steel gravel feed tube was set on the opposite side of the well casing from the camera tube in the annulus to a depth of 160 feet bgs.

The gravel pack consisted of size 4 x 8 All American "Well Rock", which was substituted for Monterey sand due to the latter product's unavailability. The gravel was emplaced through a tremie pipe to the annular depth interval between 150 and 520 feet. The remainder of the annulus was grouted to ground surface with a six-sack concrete mix.

During annular backfilling, the field geologist observed an oily substance in the displaced water in the annulus. The substance was whitish yellow and had the consistency of a

light-weight machine oil. Close inspection of the drill rig and ancillary equipment indicated that no apparent contamination had occurred from on-site equipment. A sample of the substance was collected on June 1 and submitted to Truesdail Laboratory (Tustin, California) for volatile organic analysis by EPA Methods 8010/8020. Because the oily substance resembled partially decomposed turbine pump lubricating oil, the analytical results were compared with laboratory results of pure turbine oil sampled from the oil drum which supplies the pump in well TIC 35. The laboratory results of both analyses are presented in Appendix B.

The constituents detected in the oily substance included acetone (73.4 ug/kg), ethyl benzene (8 ug/kg), and xylenes (13.1 ug/kg). Compounds detected in the lubricating oil at well TIC 35 included acetone, ethyl benzene, toluene, and xylenes. The similarities between the detected compounds support the probability that the oily substance is a residual of an abandoned irrigation well previously located near the present well site. The oily substance was not observed during subsequent test pumping of well ET-1 and is believed to reside at shallow depths above the screened interval. It is not anticipated that the oil will enter the well during future pumping.

2.1.5 Well Development

Development of well ET-1 was performed following well construction to remove fine sediment from the well casing and the gravel pack. Development consisted of swabbing and air-lifting using a 9-foot long swabbing tool. Sections of screen were swabbed 30 feet at a time until discharged water contained less than 10 milliliters per liter (ml/l) settleable solids. Following swabbing and air-lifting, the well was surged with a turbine pump until discharge water contained less than 1 ml/l settleable solids. The pump used during development and subsequent aquifer testing was a 6-stage, 8-inch diameter, diesel-powered, vertical turbine pump set at a depth of 174 feet bgs.

All development water and water produced during subsequent aquifer testing were discharged to a storm drain per monitoring requirements outlined in OCWD's NPDES Permit. Solids were allowed to settle out in 20,000-gallon Baker tanks prior to

discharging. In addition, VOCs were removed from the water prior to discharge by the use of an aeration tank equipped with a set of baffles and a perforated pipe attached to an air compressor. Representative water samples were submitted to the OCWD State-certified laboratory and analyzed to be less than 5 ug/l TCE and other VOCs prior to discharge.

2.1.6 Aquifer Testing

Aquifer testing consisted of a step-drawdown test followed by a constant discharge test. The purpose of the step-drawdown and constant discharge tests were to determine the well production capacity, to estimate TCE concentrations for treatment system design, and to evaluate the potential capture area of well ET-1. Discharge rates during both tests were measured using an in-line propeller meter at the wellhead.

The step-drawdown test was conducted on June 12 and 13, 1989, and included pumping at five discharge rates until drawdown in the well had generally stabilized. The static water level prior to pumping was approximately 32 feet bgs. Except for the last step, drawdown had stabilized for each flow rate within about 15 minutes. As shown on Figure 2, flow rates were increased from 300 to 1,600 gpm with corresponding drawdowns of 48 to 105 feet. The maximum test flow rate of 1,600 gpm produced a large increase in drawdown (decreased specific capacity) and is believed to exceed the optimal discharge rate of this well. The maximum specific capacity calculated during the step-drawdown testing was 16 gpm/ft at a discharge rate of 1,200 gpm.

The constant discharge test began about 30 hours after the step-drawdown test had ended. The depth to water in well ET-1 prior to the start of the constant discharge test was 62 feet bgs, indicating that the piezometric level was still slowly recovering. OCWD staff decided that the residual drawdown would not significantly affect the results of the constant discharge test, so pumping commenced on June 14 and continued for 48 hours. The flow rate was maintained between 1,100 and 1,200 gpm throughout the test.

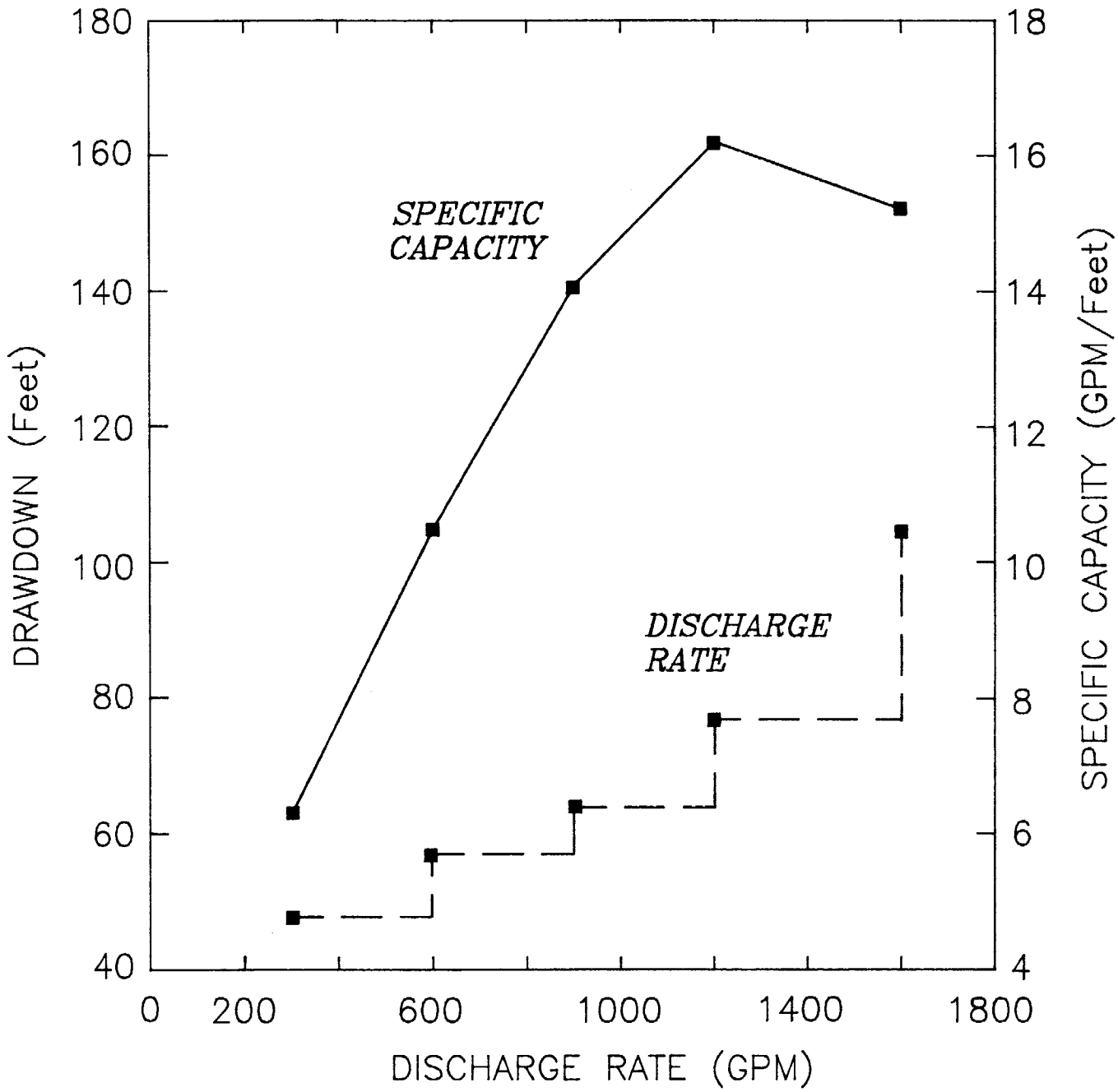

FIGURE 2 WELL ET-1 STEP DRAWDOWN TEST RESULTS

Water levels were measured frequently in the pumping well and in the two nearest observation wells MCAS-1 and MCAS-7. Well MCAS-7 is located 2,900 feet southeast of well ET-1, while well MCAS-1 is approximately 1,850 feet west of well ET-1. Measurements were made using electric sounders in wells ET-1 and MCAS-7 and with both an electric sounder and an electronic datalogger in well MCAS-7. Piezometric levels in multipoint wells MCAS-1 and MCAS-7 were monitored by opening the pumping ports between the depths of 220 and 490 feet to correspond with the screened interval of the pumping well. Total drawdown in the pumping well at the end of 48 hours was 60 feet. Total drawdowns observed in wells MCAS-1 and MCAS-7 were 4.8 and 1.7 feet, respectively.

Video and flowmeter surveys, as well as depth-specific and time-series water sampling, were conducted at well ET-1 during the constant discharge test. These activities are described in Sections 2.1.7 and 2.1.8.

At the end of pumping, recovery measurements were collected for a period of 24 hours and then less frequently for 10 additional days, at the end of which time it appeared that piezometric levels had generally reached static conditions. Data collected during the constant discharge and recovery tests are presented tabularly and graphically in Appendix C.

To estimate the aquifer hydraulic parameters, transmissivity (T) and storage coefficient (S), the drawdown data for pumping well ET-1 and observation wells MCAS-1 and MCAS-7 were analyzed. The methods employed were the Theis (1935) and Cooper-Jacob (1964) methods for pumping data and the Jacob (1963) recovery method for recovery data.

A summary of the T and S values found from the plots using the various methods is shown on Table 2. Transmissivity values ranged between 1,800 and 18,000 ft^2/day.

The T values calculated using the Jacob recovery method are consistently lower than those from the other methods. Well ET-1 data yielded the lowest T values, while well

Table 2. Well ET-1 Aquifer Test Results

WELL NUMBER	TEST	METHOD OF CALCULATION	STORAGE COEFFICIENT	TRANSMISSIVITY (ft^2/day)	HYDRAULIC CONDUCTIVITY (ft/day)	AQUIFER THICKNESS (ft)
ET-1	Constant Discharge	Theis	-------	4300	33	129
	Constant Discharge	Jacob-Cooper	-------	5400	42	129
	Recovery	Jacob Recovery	-------	1800	14	129
MCAS-1	Constant Discharge	Theis	0.0014	8000	38	209
	Constant Discharge	Jacob-Copper	0.0012	8000	38	209
	Recovery	Jacob Recovery	-------	5300	25	209
MCAS-7	Constant Discharge	Theis	0.0025	12600	54	232
	Constant Discharge	Jacob-Cooper	0.0017	18000	78	232
	Recovery	Jacob Recovery	-------	4300	19	232
-------	Constant Discharge	Distance Drawdown	0.0015	5400	28	190*

NOTES: The constant discharge pump test was conducted on 6/14-16/89.

Aquifer thickness was estimated by subtracting out the thickness of clay and silt layers within the total screened aquifer zone of each well.

Hydraulic conductivity values are based on the estimated aquifer thickness (hydraulic conductivity = transmissivity/aquifer thickness).

* For the distance drawdown method, the aquifer thickness is the arithmetic average of aquifer thickness for the 3 wells ET-1, MCAS-1, and MCAS-7.

MCAS-7 data yielded the highest T values, as may be expected from the thickening of the aquifer to the west. Storage coefficient values ranged from 0.001 to 0.0025, suggesting semi-confined or leaky aquifer conditions.

Hydraulic conductivity (K) was calculated by dividing T by the estimated aquifer thickness. The aquifer thickness at each well was estimated by subtracting out the thickness of clay and silt layers that lie within the total depth interval being pumped. Values of K ranged from 14 to 78 ft/day. This range is consistent with values estimated during earlier studies by OCWD (1989) and USMC (1989).

2.1.7 Video and Flowmeter Surveys

Color video and flowmeter surveys were conducted under pumping conditions approximately 24 hours into the constant discharge test. The purpose of the surveys was to ensure proper screen development and condition and to determine the depths where ground water was entering the well. The video survey indicated that the screen and welds were in good condition and showed no sediment entering the well during pumping at approximately 1,150 gpm.

Results of the flowmeter survey would provide the basis for determining the depths from which water samples be collected during pumping. The flowmeter log revealed that nearly half of the production occurred between the depth interval from 240 to 360 feet. The production percentage by depth is presented as follows:

Depth Interval (feet)	Percent of Total	Calculated Feet (gpm)	Flow Per Foot of Screen (gpm)
220 - 240	18	207	10.4
240 - 360	44	506	4.2
360 - 410	18	207	4.1
410 - 490	20	230	2.9

2.1.8 Water Sampling

Both depth-specific and time-series water samples were collected from well ET-1 during the constant discharge test. The water sampling results were necessary for the design of the water and air treatment system installed at the wellhead.

Four depth-specific samples were obtained using a down-hole sampler at depths of 200, 300, 390, and 440 feet. Because water flows upward inside the well casing during pumping, the "depth-specific" sample actually represents a composite sample of water from the screened interval between the sampler depth and the bottom of the screen (490 feet). The "200-foot" sample was collected to determine the cumulative VOC concentrations prior to entering the pump bowls. These samples were submitted to the OCWD laboratory and analyzed for halogenated and aromatic hydrocarbons using EPA Methods 601 and 602, as well as general minerals and trace metals. The sampler was washed with trisodium phosphate and rinsed with distilled water before collecting each sample.

As shown in Table 3A, TCE concentrations ranged from 40.1 ug/l at a depth of 200 feet to 88.7 ug/l at a depth of 440 feet. This supports previous multipoint well sampling findings that the highest TCE concentrations occur near the base of the fresh-water aquifer between the depths of 400 and 450 feet bgs.

Over the 48-hour pumping period, 15 time-series samples were collected from a spigot valve approximately six feet from the well. Table 3B presents the results of the time-series sampling. TCE was the only compound found above the State action level. Low concentrations of trans-1,2 DCE were also detected. Figure 3 illustrates the irregular, yet increasing, concentrations of both of these compounds over time. The level of TCE at the end of the 48-hour pump test was 42.9 ug/l. TCE concentrations in samples collected after 24 hours of pumping were very close to those detected in the 200-foot depth sample, indicating that almost no VOCs were lost between the pump intake and the discharge outlet.

Table 3A. Well ET-1 Depth-Specific Water Sample VOC Analyses

DEPTH (feet BGS)	TIME SINCE PUMP ON (minutes)	TCE (ug/l)	t-1,2 DCE (ug/l)
200	1530	40.1	2.1
300	1830	40.8	2.2
390	1860	64.8	4.4
440	1890	88.7	12.7

Table 3B. Well ET-1 Time Series Water Sample VOC Analyes

TIME SINCE PUMP ON (minutes)	FIELD EC (umhos/cm)	TCE (ug/l)	t-1,2 DCE (ug/l)
60	1330	13.7	ND
120	1315	14.0	ND
240	1305	17.7	TR
360	1276	24.6	1.0
480	1255	31.6	1.4
720	1239	23.4	1.2
960	1231	25.9	1.3
1200	1216	23.2	1.2
1440	1195	40.8	1.6
1680	1184	37.1	1.8
1920	1188	37.4	1.9
2160	1177	20.4	1.2
2400	1198	22.7	1.3
2640	1213	31.7	1.7
2880	1115	42.9	2.1

NOTES: umhos/cm = micromhos/centimeter; ug/l = micrograms/liter
TR = constituent detected below reportable limit (0.5 ug/l)
ND = Not Detected
Samples obtained 6/14/89 to 6/16/89 during 48-hour constant discharge pump test.
All depth-specific samples were obtained using a Welenco depth-specific sampler.

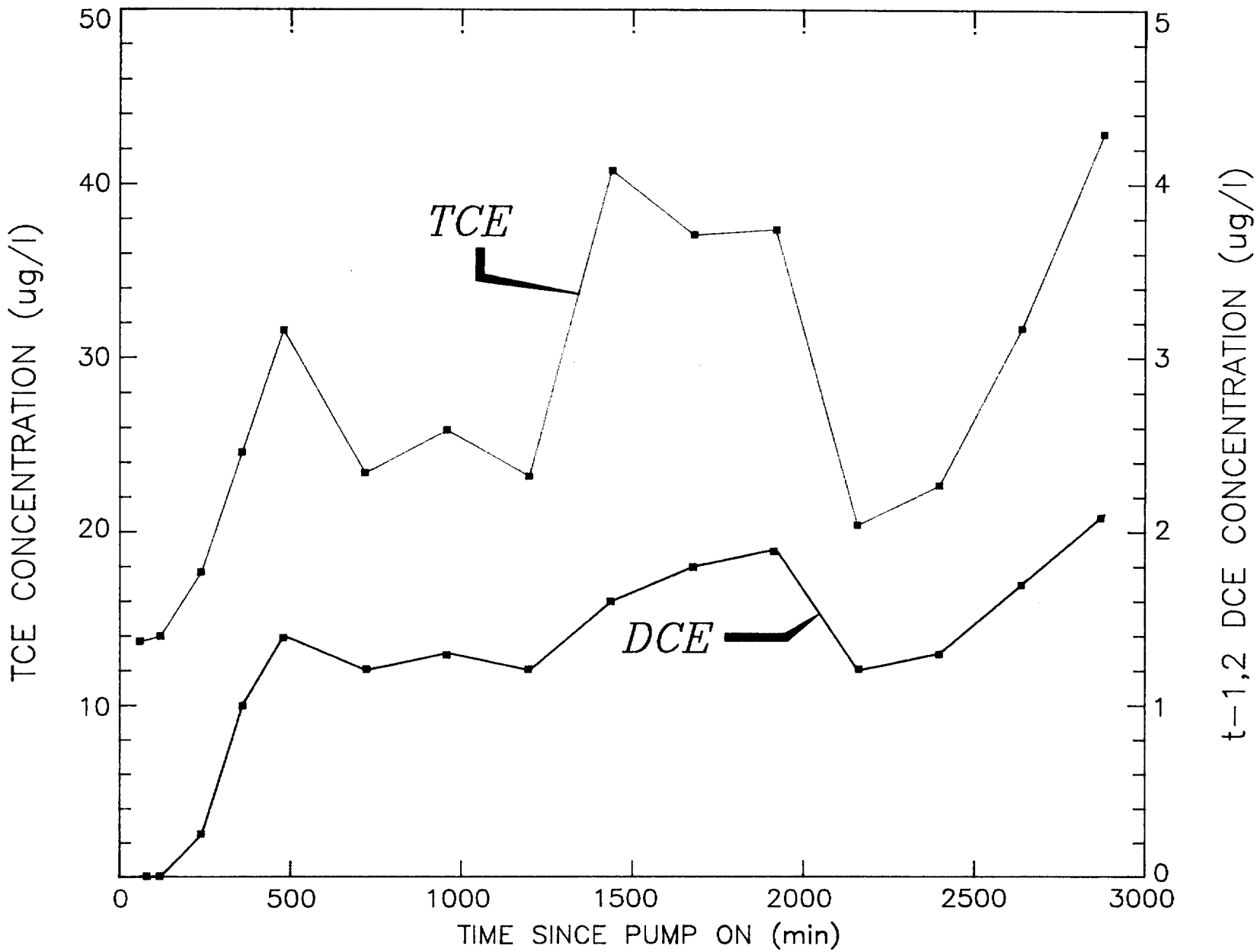

FIGURE 3 **WELL ET-1 TIME-SERIES VOC DATA**

JUNE 14-16, 1989

Electrical conductivity (EC) was measured frequently during the pump test using a field EC meter. Field EC values are shown on Figure 4, and indicate a decreasing trend over time. This same reverse trend, as compared with TCE, has been documented from previous sampling of nearby well TIC 35 (OCWD, 1989). Because higher TCE and lower EC values were found at deeper intervals, the time-series data demonstrate that water is increasingly drawn from deeper aquifer zones over pumping time.

2.2 MONITORING WELL CONSTRUCTION AND TESTING

Between August and October 1989, six monitoring wells (MCAS-4, -5, -6, -8, -9, and -10) were drilled and constructed by Beylik Drilling (La Habra, California) along San Diego Creek and near the most downgradient TCE-impacted wells, MCAS-7 and the North Lake well, to better define the extent of TCE in these areas. The wells were also located in areas with no existing wells to provide additional piezometric level data to better estimate groundwater flow directions in the vicinity of the plume.

2.2.1 Drilling and Soil Sampling

Six monitoring wells were drilled to depths ranging from 150 to 450 feet using an air rotary drill rig equipped with a pneumatic casing hammer. The borehole was progressed using a 3 5/8-inch diameter tricone bit and was simultaneously cased with 4-inch nominal diameter, mild steel casing. A geologist from the firm of Harding Lawson Associates (Tustin, California) was on site during all drilling, well construction, and sampling activities. The geologist collected cuttings samples at 10-foot intervals and maintained a log describing the lithology of the sediments encountered. Appendix A contains the boring logs and well construction details of the six monitoring wells.

Borings MCAS-4, -5, and -6 were terminated after it was determined that consolidated sediments had been penetrated. This contact was obvious in borings MCAS-4 and -5 where the driven casing could not be advanced beyond depths of 275 and 150 feet, respectively. Borings MCAS-8 and -9 were successfully drilled to their target depths of 430 and 450 feet respectively. Boring MCAS-10 was terminated after the casing could ot be driven beyond a depth of 390 feet due to heaving sand.

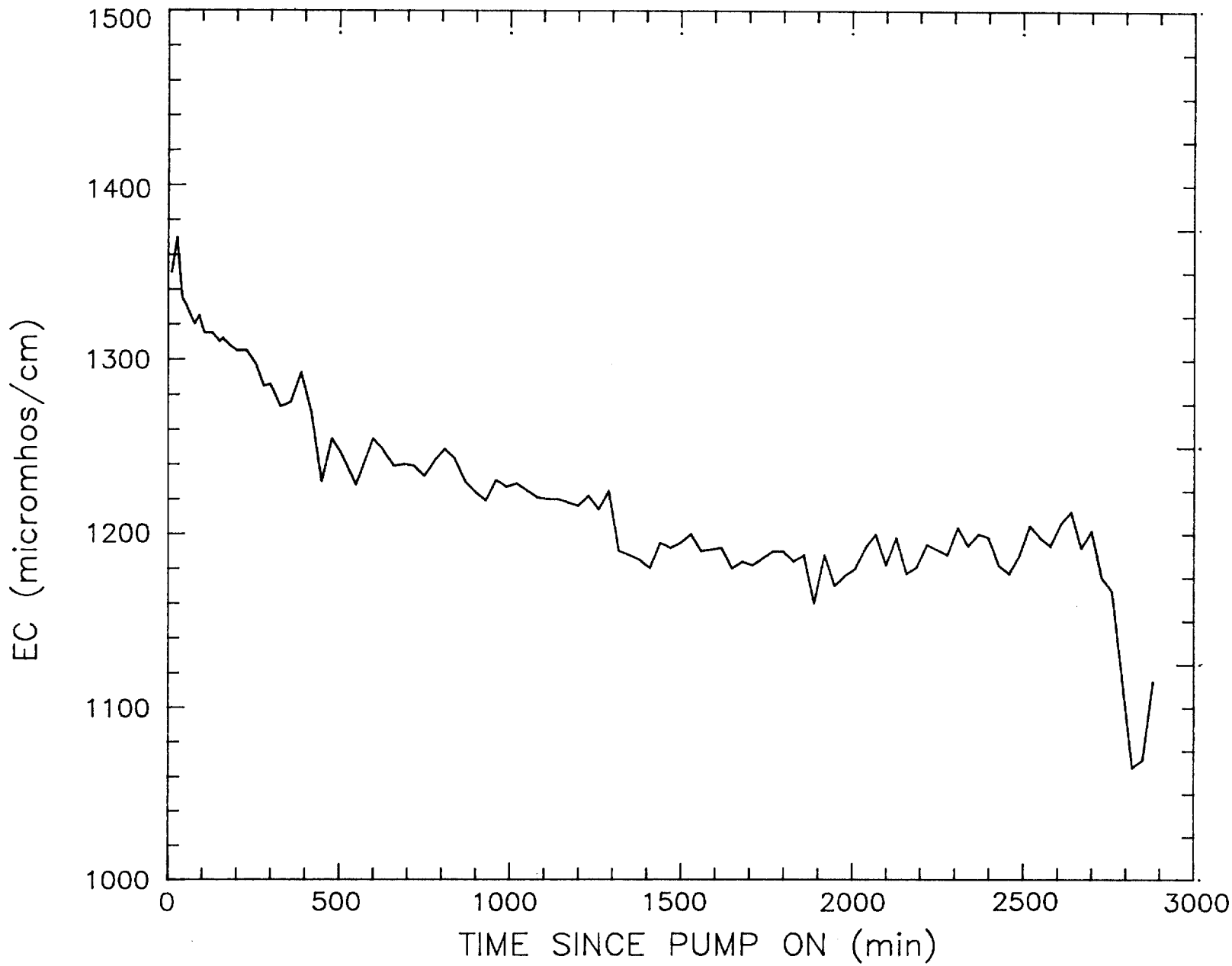

FIGURE 4 WELL ET-1 TIME-SERIES EC DATA
JUNE 14-16, 1989

All cuttings and formation fluids produced during drilling were contained in roll-off bins and tested to be nonhazardous for VOCs (EPA Method 601/602) prior to disposal on OCWD property in the City of Anaheim.

2.2.2 Borehole Lithology

Sediments encountered while drilling the six monitoring wells primarily consisted of unconsolidated interbedded clays and sands. A semi-consolidated sedimentary unit containing, fossiliferous siltstone and sandstone, was penetrated at depths of 250, 150, and 290 feet, in wells MCAS-4, -5, and -6, respectively, which are located along San Diego Creek. Similar units were documented at wells MCAS-1 and -7 (OCWD, 1989) and were attributed to the early Miocene Vaqueros Formation of marine origin (Singer, 1973; Miller and Tan, 1976). This formation outcrops in the San Joaquin Hills approximately 2,000 feet south of wells MCAS-4 and -5. No consolidated sediments were observed while drilling wells MCAS-8, -9, and -10.

The lithology from ground surface to 300 feet at wells MCAS-8, -9, and -10 was chiefly comprised of relatively low-permeability materials, including clay, sandy clay, and clayey sand. Below 300 feet, the predominant soil type was clean, fine- to medium-grained sands. These relatively high-permeability materials form the major water-bearing unit in this vicinity.

Evidence of the Irvine area's recent past as a shallow marine environment was further supported by the finding of abundant clam shell fragments between the depths of 340 and 350 feet while drilling well MCAS-9.

2.2.3 Well Design and Installation

The design and final completion of the six monitoring wells consisted of determining the depth interval of the casing to be perforated, perforating the casing, and installing an inner sleeve of slotted PVC casing to minimize sediment entry into the well through the perforations. The main design objective was to determine if TCE existed at each new well location.

Therefore, the well casings were perforated adjacent to aquifer zones estimated to most likely contain TCE, based on depth-specific water quality data from existing multipoint monitoring wells.

The perforated interval of each well casing was determined by reviewing the borehole log and by correlating with similar water-bearing units where TCE was detected in existing wells. A mechanical wheel perforator was used to punch four rows of 3/8" wide by 3/4" long slots, 90 degrees apart. Total perforated intervals ranged from 6 to 29 feet in the six wells, as detailed below:

Well Number	Perforated Interval Depth (feet)
MCAS-4	181-189, 204-208, 230-238
MCAS-5	142-148
MCAS-6	167-175, 187-197, 215-222
MCAS-8	392-410
MCAS-9	372-382, 400-409, 435-445
MCAS-10	355-375

To prevent fine-grained formation materials from entering the well through the perforations, a filter pack was installed inside the steel casing adjacent to each slotted interval. The filter pack consisted of double-wall PVC casing with 0.020-inch slots, filled with No. 3 Monterey sand in the annular space between the inner and outer PVC casings. This prefilter-packed casing, known as "pre-pack" casing. The inner and outer nominal diameters of this casing are 2 and 3 1/2 inches, respectively.

During perforating, prior to pre-pack casing installation, fine-grained formation sands created difficulties due to "heaving" inside the well casing. This occurrence was lessened by maintaining a head of water inside the well from the time of perforating until the pre-pack casing was installed. Nevertheless, some sand entered well MCAS-9 and covered some of the lowermost perforations before the pre-pack casing could be installed.

Subsequent pumping has indicated that this does not impair the well's sampling capability.

2.2.4 Water Sampling

Groundwater samples were collected from wells MCAS-4, -5, -6, -8, -9, and -10 between October 1989 and March 1990. The samples were collected after at least of four well volumes of water were removed from each well using an electric submersible pump with a flow rate of 5 to 7 gpm. Samples were obtained from the pump discharge at the wellhead and were retained in 40-ml glass vials for VOC analysis (EPA Methods 601/602) and in one-gallon plastic bottles for inorganic constituent analysis. All VOC sample vials were immediately placed in a cooler with ice and delivered to the OCWD laboratory.

As a check of the reliability of the pump discharge samples, a second set of water samples was collected from wells MCAS-4, -5, and -6 using a Teflon bailer immediately after the submersible pump was removed. Subsequent laboratory VOC analyses indicated equivalent or higher VOC concentrations in the pump discharge samples as compared to the bailer samples. Based on these results, OCWD staff concluded that the bailer samples provided equivalent or inferior quality results and discontinued this sampling method.

Tables B1 and B2 in Appendix B summarize results of the VOC and inorganic constituent analyses of samples collected from the six new monitoring wells. In addition, these tables present laboratory water quality analyses from the four multipoint wells (MCAS-1, -2, -3, and -7) and irrigation wells located in the study area.

2.2.5 Water Level Measurements

Monthly piezometric level measurements were taken at each measurement port in the four multipoint monitoring wells since they were constructed in 1988. Depth-specific piezometric levels in wells MCAS-1,-2, -3, and -7 from March 1989 to March 1990 are illustrated on Figures 5A through 5D. Piezometric levels in the study area were highest

FIGURE 5A. MCAS-1 PRESSURE PROFILE

1989-1990 PIEZOMETRIC LEVELS

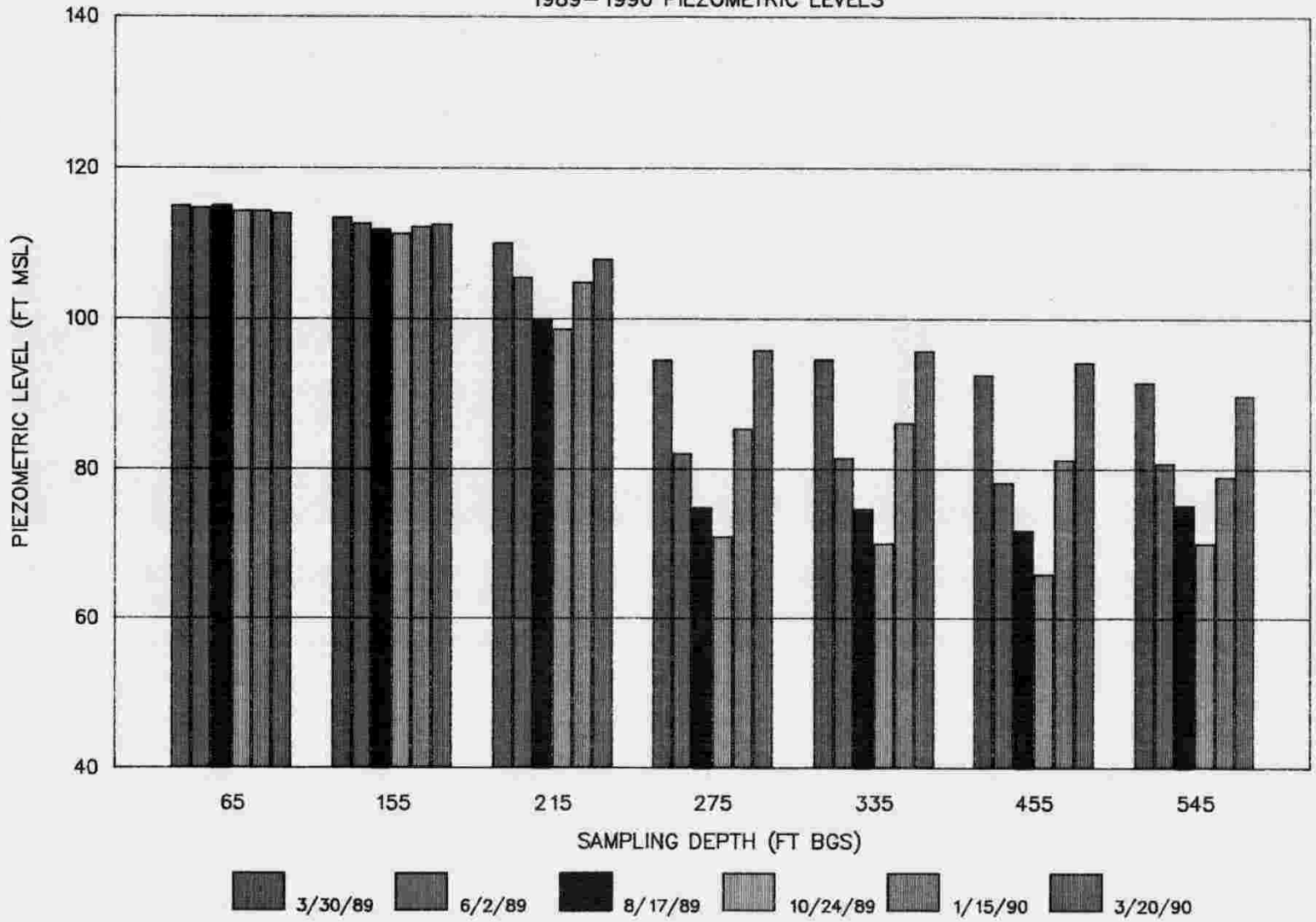

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FIGURE 5B. MCAS-2 PRESSURE PROFILE

1989-1990 PIEZOMETRIC LEVELS

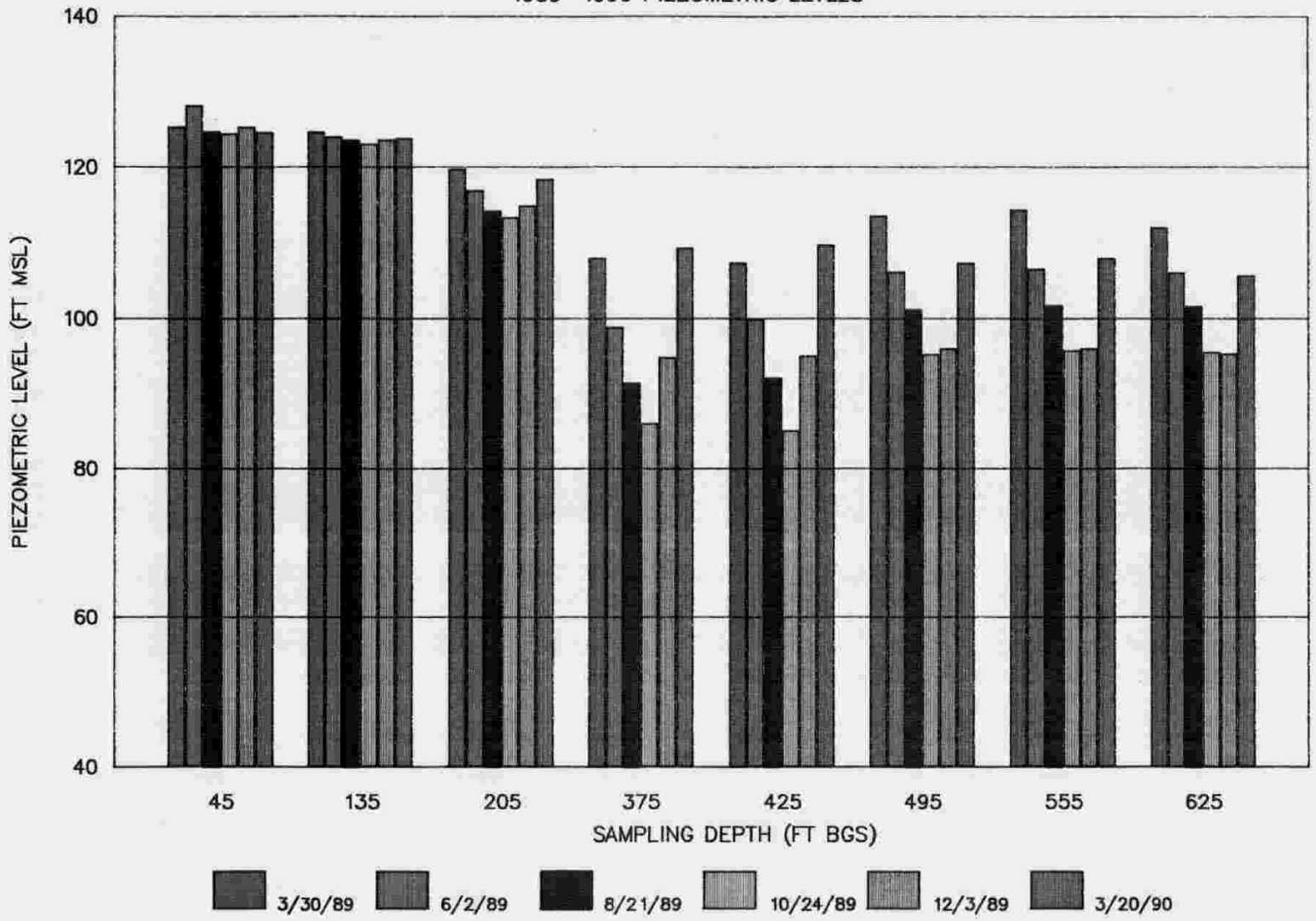

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FIGURE 5C. MCAS-3 PRESSURE PROFILE

1989-1990 PIEZOMETRIC LEVELS

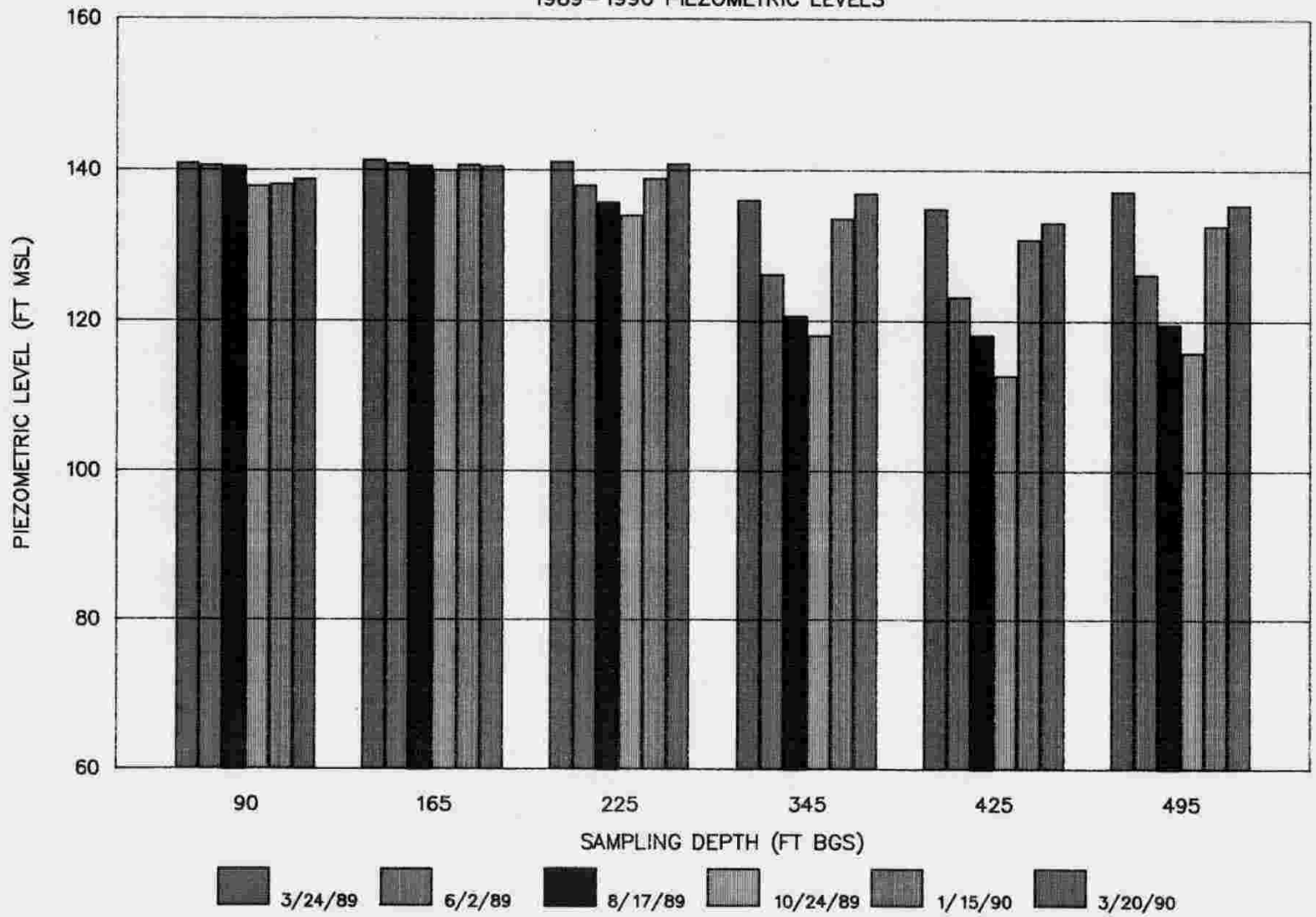
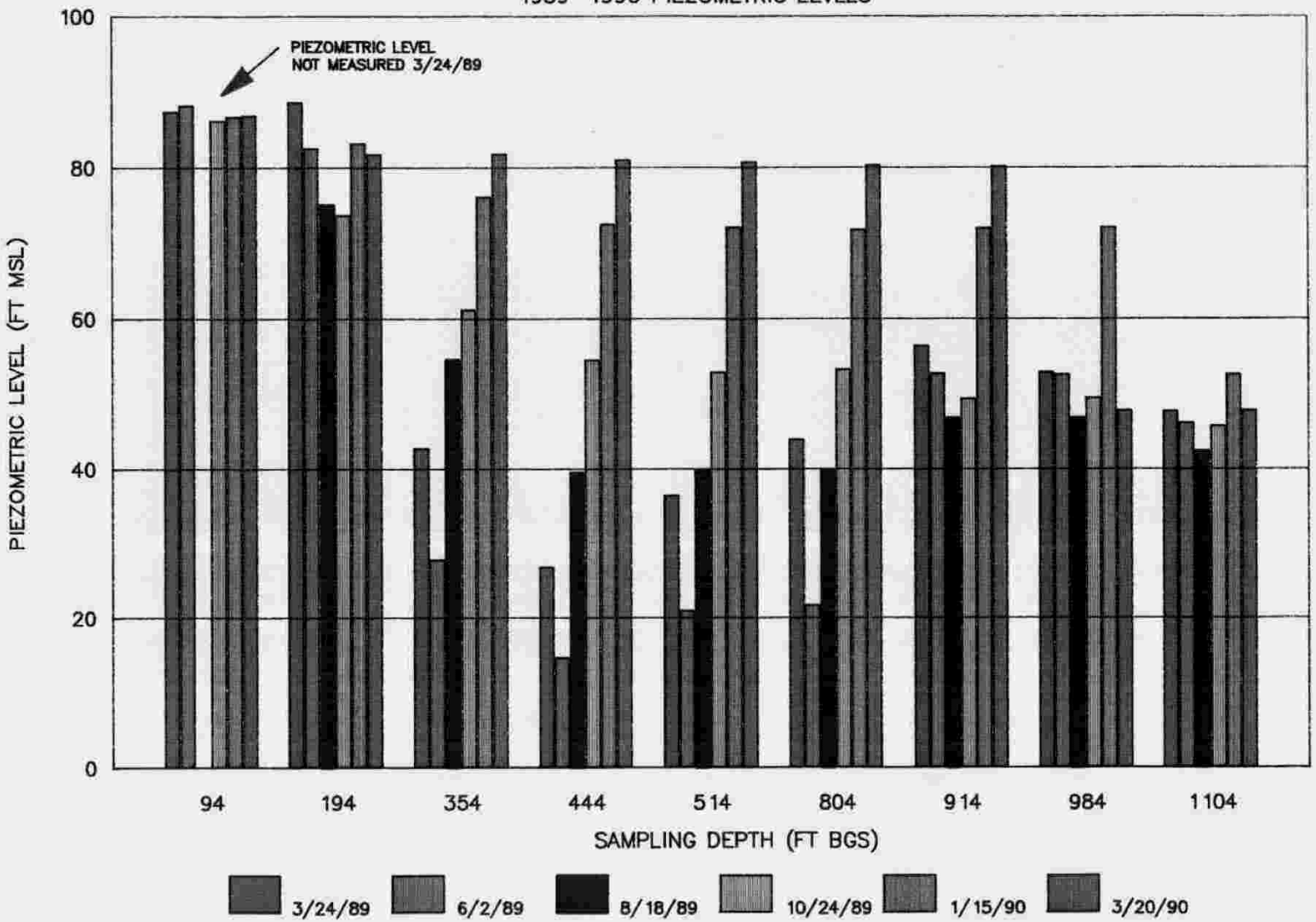


FIGURE 5D. MCAS-7 PRESSURE PROFILE

1989-1990 PIEZOMETRIC LEVELS



in March and lowest in October, corresponding to the beginning and end of the primary pumping season. Twenty-foot annual water level fluctuations were observed in wells MCAS-1,-2, and -3 between the depths of about 275 and 500 feet. Water levels within the uppermost 200 feet showed little change.

Piezometric levels measured in well MCAS-7 after June 1989 indicate anomalous data, as compared to the other multipoint wells. As shown on Figure 5D, the levels in well MCAS-7 rose substantially in August 1989 and increased through March 1990, by which time piezometric heads had risen over 40 feet above their March 1989 levels. Subsequent packer integrity testing in this well confirmed that some of the packers had failed and were evidently allowing piezometric levels from several aquifer zones to equilibrate inside the well. Representatives of Westbay Instruments (Vancouver, Canada), manufacturer of the packers, suggested that the relatively high groundwater temperatures (37 degrees Celsius) present in well MCAS-7 could have caused packer deterioration. Steps are being taken to remove the faulty packers, redevelop the well, and reinstall new packers that are less sensitive to high temperatures. The remaining three multipoint wells will be monitored closely for similar equipment malfunctions.

In October 1989, vertical head differences of over 40 feet between shallow (less than 200 feet deep) and deep (200 to 500 feet deep) aquifer zones were evident in wells MCAS-1 and -2. Vertical gradients become less pronounced as a result of decreased groundwater production in the late fall and winter months, as piezometric levels within the producing aquifer zones are allowed to recover.

Water level measurements were also taken in 30 study area wells (including the six new monitoring wells) in March 1990. With the exception of wells TIC 127 and MCAS-5 along San Diego Creek, these wells are screened or perforated in the main producing aquifer (from about 200 to 500 feet bgs). At the time of monitoring, several wells located near

Culver Drive were pumping, so piezometric levels at these wells were not available. Figure 6 presents a piezometric level contour map generated from the March 1990 water level measurements. March 1990 piezometric level data for all wells are tabulated in Table 4.

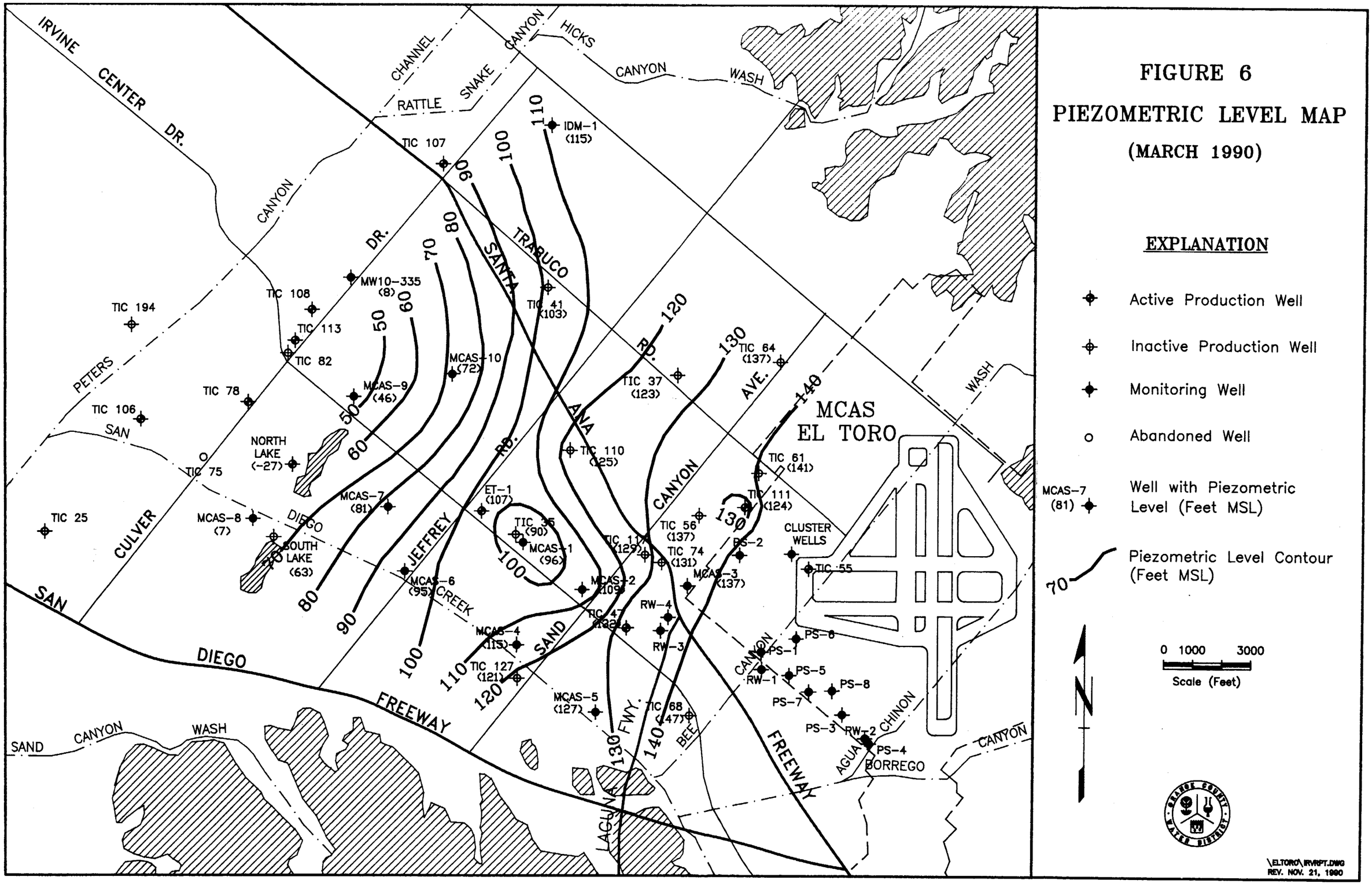


FIGURE 6
PIEZOMETRIC LEVEL MAP
(MARCH 1990)
EXPLANATION
Active Production Well
Inactive Production Well
Monitoring Well
Abandoned Well
MCAS-7 (81)
Well with Piezometric Level (Feet MSL)
70
Piezometric Level Contour (Feet MSL)
0 1000 3000
Scale (Feet)
N
MCAS EL TORO
IRVINE CENTER DR.
CHANNEL
RATTLE
SNAKE
CANYON
HICKS
CANYON
WASH
CANYON
DR.
TRABUCO
SANTA
ANA
RD.
AVE.
PETERS
CULVER
SAN
DIEGO
FREEWAY
JEFFREY
CREEK
SAND
CANYON
WASH
SAND
CANYON
WASH
LAGUNA
FWY.
BEE
CANYON
FREEWAY
AGUA
CHINON
CANYON
BORREGO
NORTH LAKE (-27)
SOUTH LAKE (63)
CLUSTER WELLS
TIC 194
TIC 106
TIC 25
TIC 78
TIC 108
TIC 113
TIC 82
TIC 75
TIC 107
TIC 41 (103)
TIC 64 (137)
TIC 37 (123)
TIC 110 (125)
TIC 61 (141)
TIC 111 (124)
TIC 56 (137)
TIC 74 (131)
TIC 55
TIC 35 (90)
TIC 47 (122)
TIC 127 (121)
TIC 68 (147)
IDM-1 (115)
MW10-335 (8)
MCAS-10 (72)
MCAS-9 (46)
MCAS-7 (81)
MCAS-8 (7)
MCAS-6 (95)
MCAS-4 (115)
MCAS-5 (127)
MCAS-2 (109)
MCAS-1 (96)
MCAS-3 (137)
ET-1 (107)
RW-4
RW-3
RW-1
RW-2
PS-1
PS-2
PS-3
PS-4
PS-5
PS-6
PS-7
PS-8
50
60
70
80
90
100
110
120
130
140
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Table 4. March 1990 Piezometric Level Data

WELL NUMBER	SCREENED INTERVAL RANGE (feet BGS)	GROUND SURFACE ELEVATION (feet MSL)	DATE MEASURED	DEPTH TO WATER (feet BGS)	PIEZOMETRIC HEAD ELEVATION (feet MSL)
ET-1	220 - 490	131	04/03/90	24.3	107
TIC 35	263 - 150	142	03/23/90	51.7	90
TIC 37	255 - 1305	220	03/23/90	97.1	123
TIC 41	266 - 1570	157	03/23/90	53.6	103
TIC 47	268 - 1107	182	03/23/90	50.3	132
TIC 56	336 - 647	239	03/23/90	102.0	137
TIC 61	248 - 694	284	03/23/90	143.3	141
TIC 64	310 - 540	271	03/23/90	134.2	137
TIC 68	274 - 403	203	03/23/90	56.0	147
TIC 74	210 - 705	201	03/26/90	70.1	131
TIC 83	261 - 402	184	03/23/90	51.3	132
TIC 110	182 - 1030	166	03/23/90	41.0	125
TIC 111	200 - 750	260	03/23/90	136.0	124
TIC 117	360 - 635	200	03/26/90	70.4	129
TIC 127	? - 100(?)	148	03/23/90	27.3	121
SOUTH LAKE	210 - 800	88	03/23/90	24.8	63
NORTH LAKE	370 - 890	91	03/30/90	118.4	-27
MCAS-1	330 - 340	144	06/20/90	47.8	96
MCAS-2	370 - 380	163	03/20/90	53.4	109
MCAS-3	340 - 350	218	03/21/90	80.5	137
MCAS-4	181 - 238	143	03/23/90	28.0	115
MCAS-5	142 - 148	161	03/23/90	34.7	127
MCAS-6	167 - 222	115	03/23/90	19.8	95
MCAS-7	510 - 520	102	03/20/90	20.8	81
MCAS-8	392 - 410	86	03/23/90	79.2	7
MCAS-9	372 - 445	78	03/23/90	31.9	46
MCAS-10	335 - 375	104	03/23/90	32.2	72
IDM-1	760 - 770	180	03/22/90	65.0	115
MW10-335	? - 335(?)	68	03/23/90	60.2	8
WELLS PUMPING - NO WATER LEVELS OBTAINED					
TIC-78	410 - 690		NA	NA	NA
TIC-107	430 - 980		NA	NA	NA
TIC-113	280 - 1080		NA	NA	NA

3. DATA ANALYSIS

This section presents analyses and interpretations of the data collected during the Phase II field investigation. Hydrogeologic and water quality data provided by the USMC from its monitoring wells were also used in the interpretations. Geologic cross sections and an estimated areal plume extent map have been constructed or revised from those presented in the Phase I Report based on hydrogeologic information collected from the new monitoring wells.

3.1 HYDROGEOLOGIC CONDITIONS

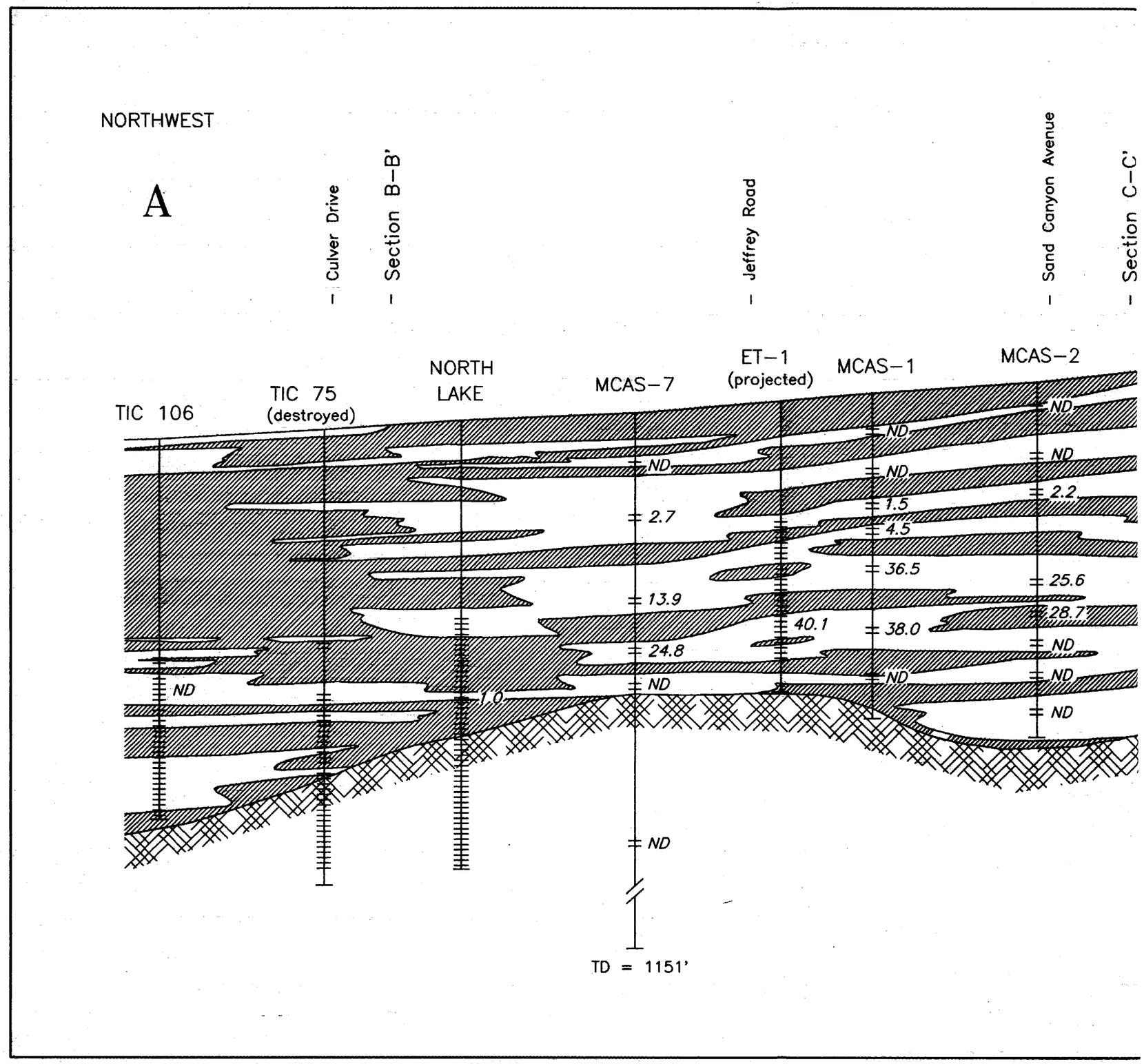
3.1.1 Aquifer Configuration

The predominant sediment types encountered in the Irvine subbasin consist of relatively low permeability silts and clays with thinner interbeds of sands and occasional gravels. Geologic cross sections (Figures 7, 8, and 9) illustrate the interpreted geometry of zones of coarser-grained sediments which appear to form elongated deposits aligned in the general direction of San Diego Creek. These higher permeability sediments, indicating possible former stream deposits, represent the dominant migration pathways of the VOCs.

The depth to bedrock, defined here as semiconsolidated siltstone, shale, or sandstone, averages 500 to 600 feet bgs along Irvine Center Drive which follows the approximate centerline of the TCE plume. However, the bedrock shallows sharply to the southwest to depths of 150 to 250 feet near wells MCAS-4 and -5 along San Diego Creek. In the northwestern most part of the study area along Culver Drive, the bedrock contact deepens to over 1,100 feet bgs.

3.1.2 Groundwater Production and Flow Direction

Approximately 10,000 acre-feet of groundwater were pumped from the Irvine subbasin in 1989, most of which was used for irrigation purposes. Active production wells in the vicinity of the TCE plume are listed with their 1989 pumpage totals in Table 5. Most groundwater production occurs during the summer months. The Irvine Company, owner


NORTHWEST
A
Culver Drive
Section B–B'
Jeffrey Road
Sand Canyon Avenue
Section C–C'
TIC 106
TIC 75
(destroyed)
NORTH
LAKE
MCAS–7
ET–1
(projected)
MCAS–1
MCAS–2
ND
ND
ND
2.7
13.9
24.8
ND
ND
1.0
ND
ND
1.5
4.5
36.5
40.1
38.0
ND
ND
ND
2.2
25.6
28.7
ND
ND
ND
TD = 1151'

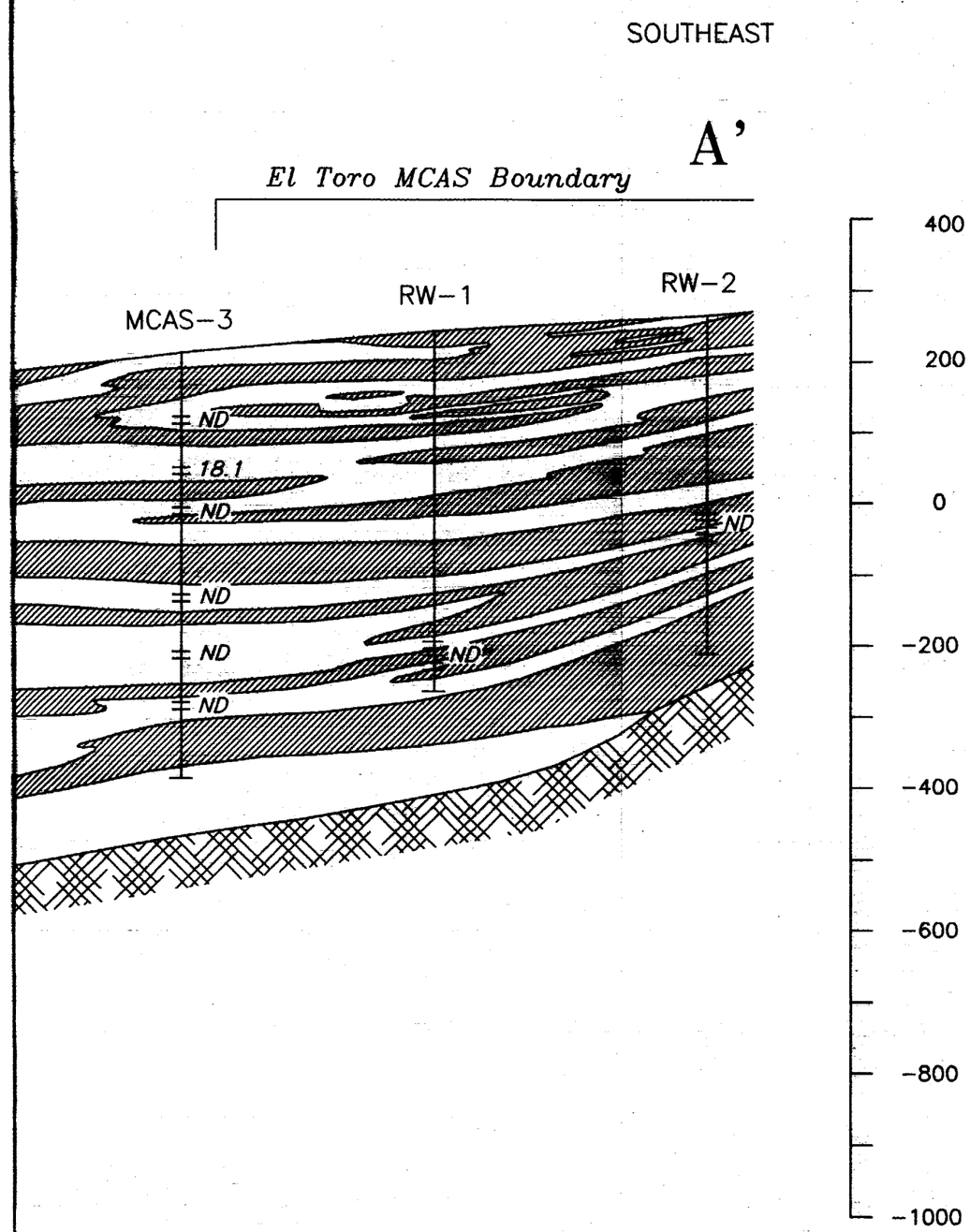


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FIGURE 7
GEOLOGIC CROSS SECTION A–A'

EXPLANATION

Unconsolidated High–Permeability Sediments

Unconsolidated Low–Permeability Sediments

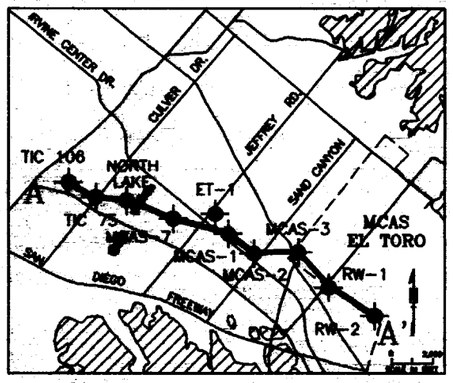
Semiconsolidated Low–Permeability Sediments

MCAS–3
8.2
Well with Screened Interval and TCE Concentration (mg/l)

ND = Not Detected
NT = Not Tested

0 2,000 4,000
Horizontal Scale (Feet)

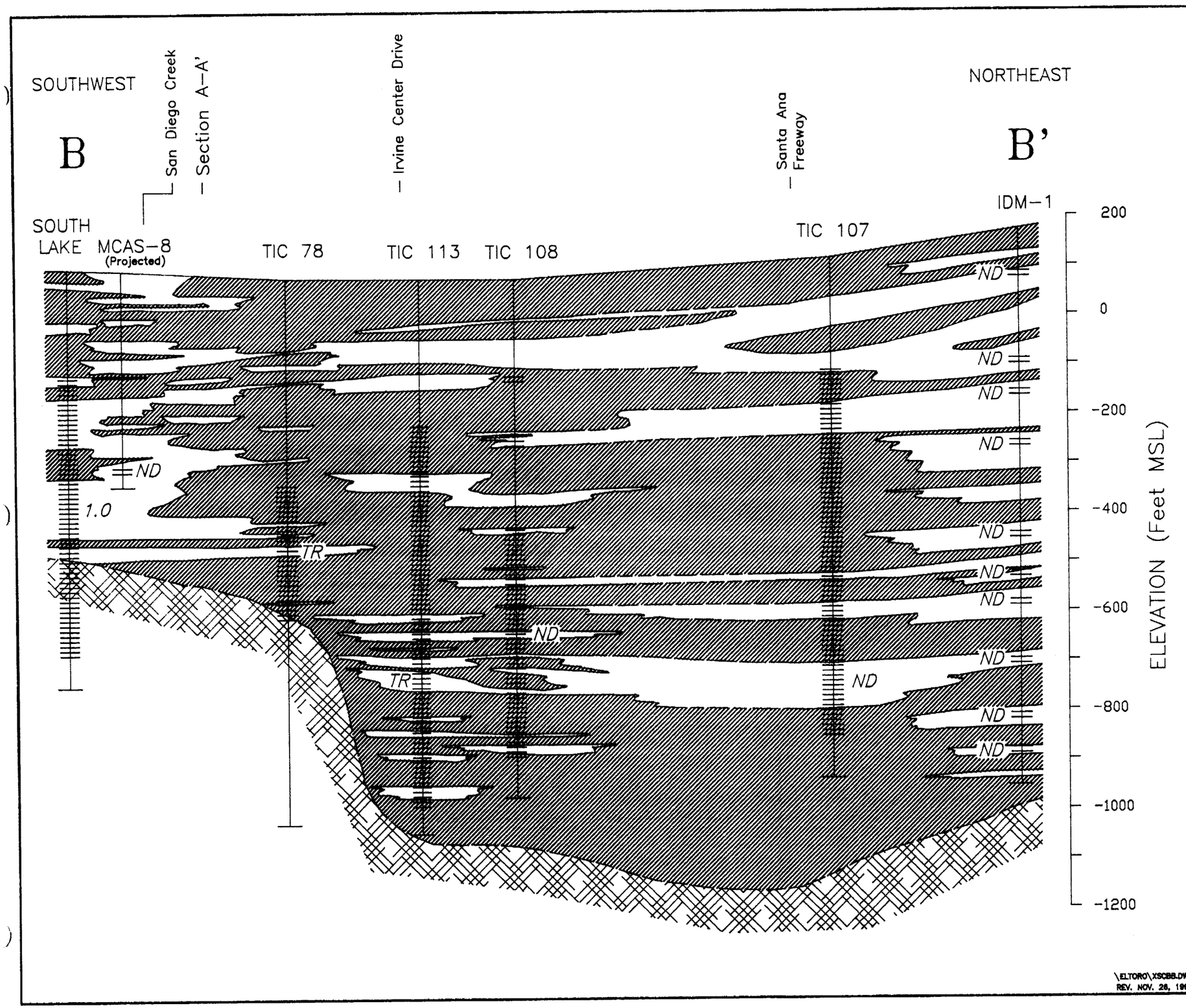
CROSS SECTION INDEX MAP



ORANGE COUNTY WATER DISTRICT

FIGURE 8

GEOLOGIC CROSS SECTION B–B'



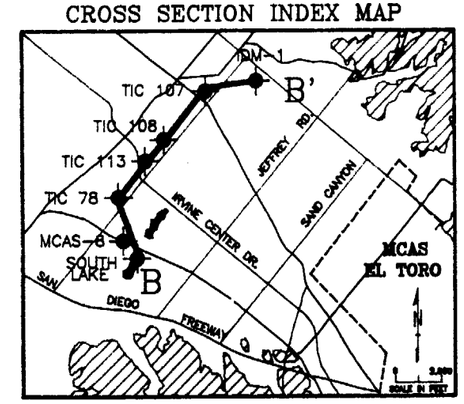
EXPLANATION

- Unconsolidated High–Permeability Sediments
- Unconsolidated Low–Permeability Sediments
- Semiconsolidated Low–Permeability Sediments
- MCAS–3 / 8.2 — Well with Screened Interval and TCE Concentration (mg/l)

ND = Not Detected
TR = Trace (< 0.5 mg/l)

0 2,000 4,000
Horizontal Scale (Feet)

CROSS SECTION INDEX MAP



ORANGE COUNTY WATER DISTRICT

20B

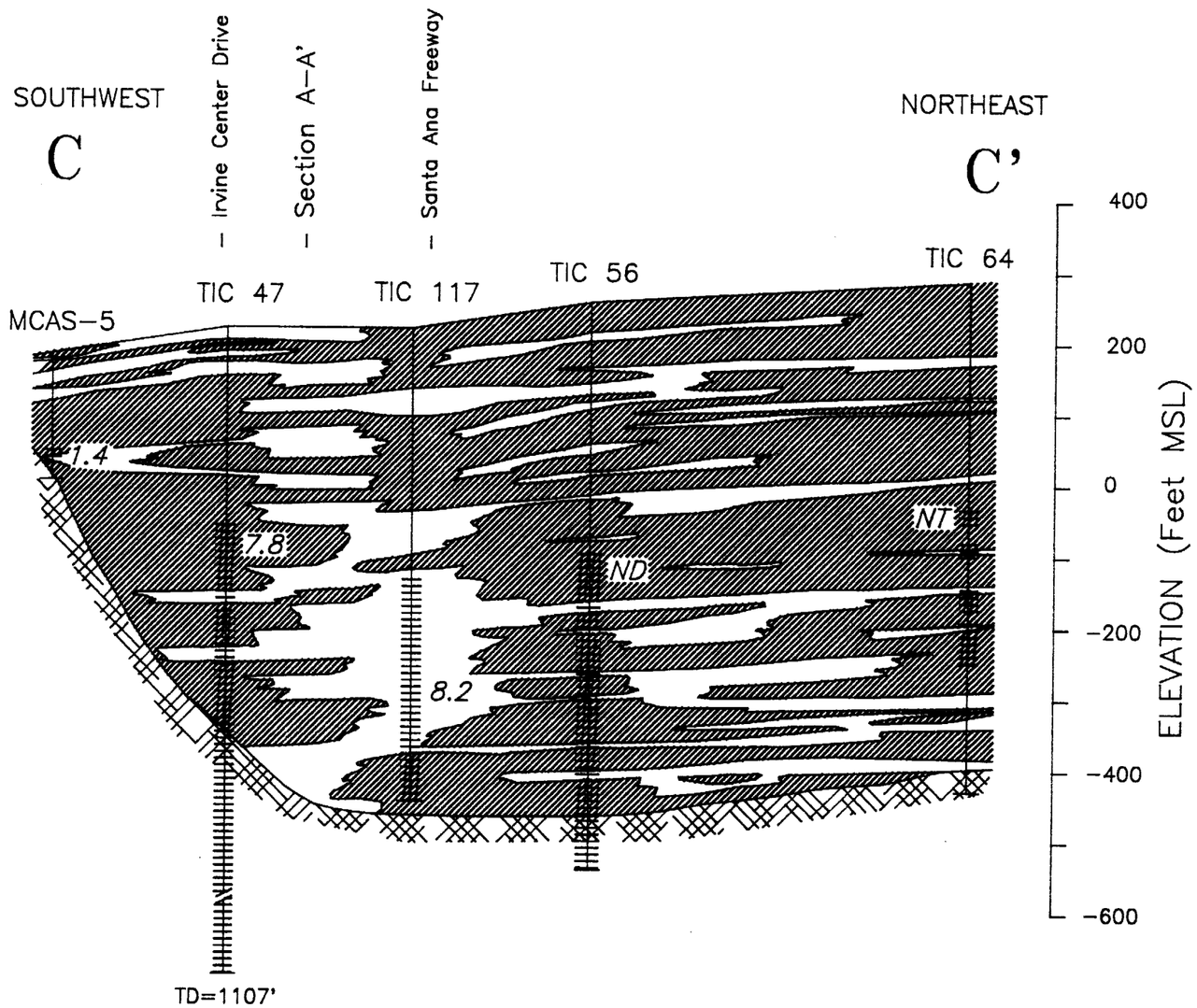


FIGURE 9

GEOLOGIC CROSS SECTION C–C'

EXPLANATION

Unconsolidated High–Permeability Sediments

Unconsolidated Low–Permeability Sediments

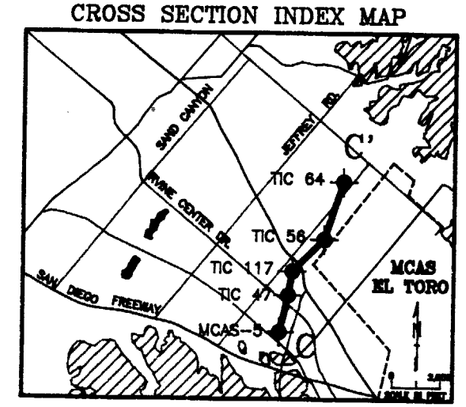
Semiconsolidated Low–Permeability Sediments

MCAS–3
8.2 Well with Screened Interval and TCE Concentration (mg/l)

ND = Not Detected
NT = Not Tested

0 2,000 4,000
Horizontal Scale (Feet)

CROSS SECTION INDEX MAP



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20C

Table 5. Study Area 1989 Groundwater Production

WELL NUMBER	TOTAL PRODUCTION (acre-feet)
TIC 47	388
TIC 55	437
TIC 78	422
TIC 106	76
TIC 107	873
TIC 108	1,617
TIC 110	28
TIC 111	473
TIC 113	1,421
NORTH LAKE	596
SUBTOTAL:	6,350
IRVINE AREA WELLS WEST OF STUDY AREA:	
TIC 73	3
TIC 109	1,260
TIC 112	1,527
TIC 114	209
TOTAL:	9,349

Source: The Irvine Company

20D

of most of the active wells in the study area, recently disconnected the power to wells TIC 35 and 110 due to their high salt content.

As shown on Figure 6, the general groundwater flow direction is to the northwest with an average gradient of 0.007. This gradient is essentially the same as the 0.008 value calculated from the 1988 water level data (OCWD, 1989). Although piezometric data were not available along Culver Drive, the large amount of pumpage there has probably maintained steeper gradients, and hence higher groundwater velocities in this area. Depressed water levels were measured in the vicinity of wells TIC 35 and TIC 111. The depression around well TIC 35 is not easily explained, because records show that this well was last pumped in January 1990. Experience from conducting aquifer pump tests at well TIC 35 has shown that piezometric level in this well was still several feet below its original level more than one week after the pump was turned off.

3.2 WATER SAMPLING RESULTS

3.2.1 General Minerals

Three groundwater hydrochemical facies were identified in the study area during the Phase I investigation (OCWD, 1989). Each facies occurs within a general depth interval and represents a distinct water quality type. Characteristics of the three facies are summarized as follows:

Facies	Depth Interval (feet)	TDS (mg/l)	TCE (ug/l)
1	< 200	1,500 - 3,100	ND - 18
2	200 - 500	500 - 1,500	ND - 89
3	> 500	1,500 - 2,200	ND

Facies 1 represents the shallow groundwater containing high TDS and nitrate concentrations probably resulting from past agricultural activities. Facies 2 represents the main producing aquifer containing relatively low TDS but high TCE concentrations. The

third and deepest facies represents water with highest TDS and no detectable TCE. The high TDS concentrations and more stable piezometric levels observed below a depth of about 500 feet may indicate that this facies represents relatively immobile groundwater where formation-derived minerals have accumulated.

3.2.2 Volatile Organic Compounds

VOCs detected in the off-base study area wells include the chlorinated compounds TCE, PCE, and DCE, as well as the petroleum hydrocarbons toluene, chlorobenzene, and ethyl benzene. By far, TCE is by far the most ubiquitous of the VOCs and occurs in the highest concentrations. Except in on-base well PS-3, PCE was generally detected in levels below 1 ug/l. Trans-1,2 DCE was found in wells MCAS-1, -2, and -7, and ET-1 in levels as high as 12 ug/l. OCWD staff believes that the low levels of toluene, ethyl benzene, and chlorobenzene, generally present at depths below 500 feet are, natural residual hydrocarbons leached from deep petroleum- or bitumen-bearing formations. Naturally occurring aromatic hydrocarbons were reported by Slain and Barker (1990) in similar low-groundwater velocity aquifers. Available VOC water quality analyses are summarized in Appendix B.

Aerial Extent of TCE

The areal extent of groundwater containing detectable levels of TCE was estimated based on water quality data from new and existing wells. Figure 10 presents the known areal extent of TCE with the most recent sampling results. The maximum TCE concentration identified in an off-base well was 88 ug/l in well ET-1. TCE was also found in four of the six single-point wells, with all concentrations less than the 5.0 ug/l State action level. TCE levels in the Woodbridge North Lake well have remained constant at about 1 ug/l over the last year.

Water samples collected in April 1990 from wells TIC 78 and TIC 113 along Culver Drive contained trace levels of TCE, indicating that the plume has continued its northwestward migration. Plume travel rates were estimated from when TCE was first detected in the North Lake well (November 1988) and in well TIC 78 (April 1990). Estimated average

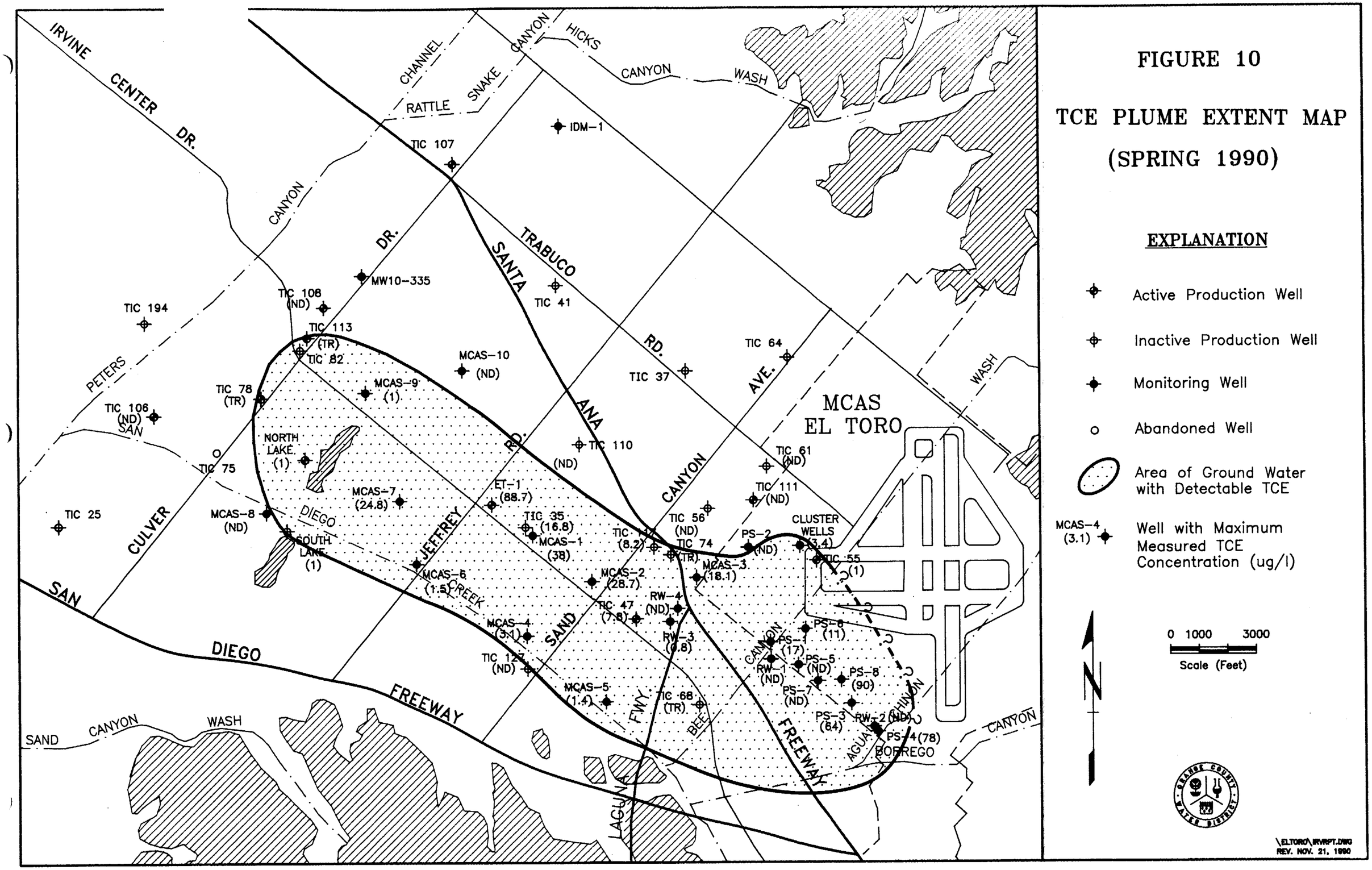
FIGURE 10
TCE PLUME EXTENT MAP
(SPRING 1990)
EXPLANATION
Active Production Well
Inactive Production Well
Monitoring Well
Abandoned Well
Area of Ground Water with Detectable TCE
MCAS-4 (3.1)
Well with Maximum Measured TCE Concentration (ug/l)
0 1000 3000
Scale (Feet)
N
MCAS EL TORO
IRVINE CENTER DR.
CHANNEL
RATTLE
SNAKE
CANYON
HICKS
CANYON
WASH
CANYON
DR.
SANTA
TRABUCO
RD.
ANA
RD.
AVE.
WASH
PETERS
CULVER
SAN
DIEGO
JEFFREY
CREEK
SAND
CANYON
CANYON
AGUA
CHINON
BEE
LAGUNA
FWY.
FREEWAY
FREEWAY
SAND
CANYON
WASH
CANYON
BORREGO
IDM-1
TIC 107
TIC 194
TIC 108 (ND)
MW10-335
TIC 113 (TR)
TIC 82
TIC 41
MCAS-10 (ND)
TIC 64
TIC 37
TIC 78 (TR)
MCAS-9 (1)
TIC 106 (ND)
NORTH LAKE (1)
TIC 75
TIC 110 (ND)
TIC 61 (ND)
TIC 111 (ND)
ET-1 (88.7)
MCAS-7 (24.8)
TIC 25
MCAS-8 (ND)
SOUTH LAKE (1)
TIC 35 (16.8)
MCAS-1 (38)
TIC 117 (8.2)
TIC 56 (ND)
TIC 74 (TR)
PS-2 (ND)
CLUSTER WELLS (3.4)
TIC 55 (1)
MCAS-6 (1.5)
MCAS-2 (28.7)
MCAS-3 (18.1)
TIC 47 (7.8)
RW-4 (ND)
MCAS-4 (3.1)
RW-3 (0.8)
PS-6 (11)
PS-1 (17)
RW-1 (ND)
PS-5 (ND)
PS-8 (90)
PS-7 (ND)
TIC 127 (ND)
MCAS-5 (1.4)
TIC 68 (TR)
PS-3 (64)
RW-2 (ND)
PS-4 (78)
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velocities over this distance ranged from 4 to 30 feet per day; however, notwithstanding local pumping effects, an average regional groundwater flow rate of between 1 and 4 feet per day reported by OCWD (1989) is still believed a valid estimate.

A TCE concentration of 18 ug/l was detected in multipoint well MCAS-3 at a depth of 165 feet. This well is located near the southwest corner of MCAS El Toro and had not shown any TCE for the first year and a half following its installation. The presence of TCE in this well may indicate that 1) a new plume has moved into this vicinity; 2) a "clean water wedge" within a large plume has migrated through and past the well; or 3) the well was not sufficiently developed, and ambient water quality equilibration was delayed.

Vertical Distribution of TCE

TCE was found between the depths of 200 and 450 feet west of Sand Canyon Avenue, which corresponds to the main producing aquifer in this area. The highest concentration, 88 ug/l, was detected in well ET-1 at a depth of 440 feet from a depth-specific sample collected during pumping. TCE concentrations greater than 20 ug/l were noted in wells MCAS-1 and -2 between the depths of 300 and 450 feet. Well MCAS-5, located along San Diego Creek, contained TCE at 1.4 ug/l at a depth of approximately 145 feet. The occurrence of TCE at a relatively shallow depth along San Diego Creek, supports the possibility that this and the other washes east of Sand Canyon Avenue historically acted as recharge areas for TCE-laden surface runoff from the Marine base.

Well RW-3, drilled by the USMC just west of the Laguna Freeway, reportedly contained 0.8 ug/l TCE and trace levels of PCE from a screened interval of 370 to 390 feet bgs. Shallow well RW-4, screened from 65 to 85 feet bgs and installed adjacent to RW-3, showed trace levels of PCE but no TCE. One or more future wells at this site screened intermediately between 100 and 300 feet bgs would have a higher probability of tapping aquifer zones with higher TCE concentrations.

The USMC installed and sampled two other deep wells, RW-1 and -2, adjacent to existing contaminated shallow wells along the MCAS southern perimeter. The screened depth

intervals of wells RW-1 and -2 are 430 to 470 feet and 270 to 310 feet, respectively. No TCE was detected in either well. These wells appear to provide a lower vertical limit of TCE contamination in this area, but a 200- to 300-foot thick stratigraphic interval remains between the deep and shallow wells in this area without any VOC information.

4. GROUNDWATER CONTAMINATION REMEDIATION

As an interim means of retarding the TCE plume migration, OCWD constructed a high-capacity extraction well (ET-1), a liquid- and vapor-phase VOC treatment system, and two discharge water pipelines near the corner of Jeffrey Road and Irvine Center Drive. The initial design flow rate of the well is 700 gpm. All water will be discharged to an IRWD reclaimed water pipeline that runs beneath Jeffrey Road. This pipeline transmits water to irrigated agricultural and greenbelt areas in and around the City of Irvine. Following initial startup testing in May and June 1990, the system is expected to be on-line almost continuously.

The original design of the VOC extraction system did not include water and air treatment equipment. OCWD received approval to construct and operate the extraction system without treatment from the RWQCB and the South Coast Air Quality Management District (SCAQMD) when it was calculated that the total emissions of VOCs would fall well below the SCAQMD's 1 lb/day limit. A sprinkler study conducted by OCWD (1989a) indicated that TCE losses to the atmosphere resulting from sprinkler and drip irrigation methods averaged approximately 97% and 42%, respectively. The study concluded that the use of untreated groundwater for irrigation purposes would cause no adverse impact on groundwater quality. A health risk assessment conducted by Med-Tox Associates, Inc. (1989) for OCWD indicated that the amount of VOCs that would be emitted to the atmosphere posed no significant health risks. Despite these findings, the City of Irvine requested that a water and air emissions treatment system be installed at the site at its expense. OCWD approved the request and redesigned the system to include liquid- and vapor-phase VOC removal equipment.

4.1 TCE PUMPOUT AND TREATMENT SYSTEM

As shown on Figure 11, the groundwater extraction and wellhead treatment system consists of a production well, liquid- and vapor-phase VOC treatment equipment, wet well and booster pump, and discharge pipelines connected to a reclaimed water line and a storm drain. The 16-inch diameter stainless steel production well, described in Section

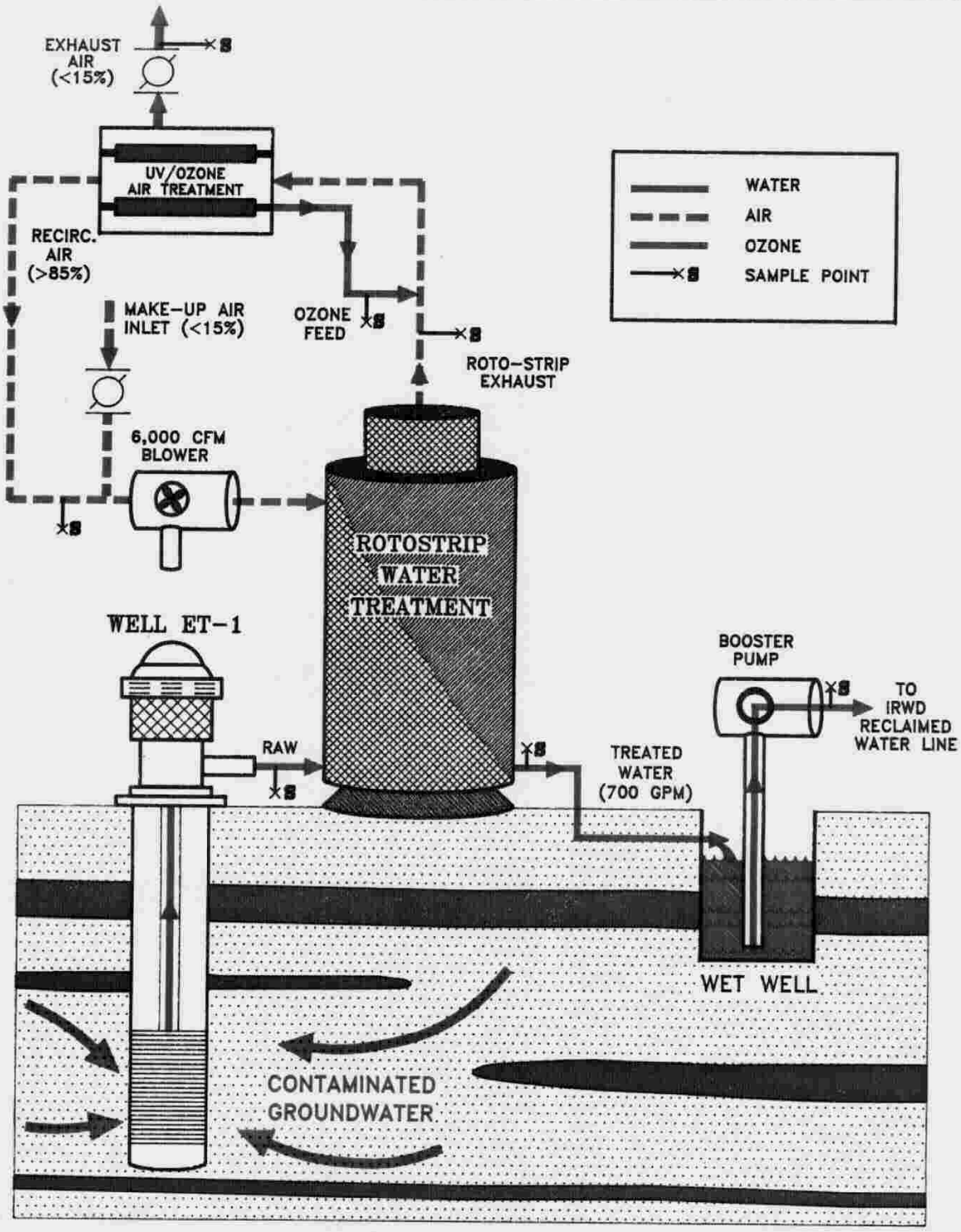

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FIGURE 11 TCE PUMPOUT AND TREATMENT SYSTEM

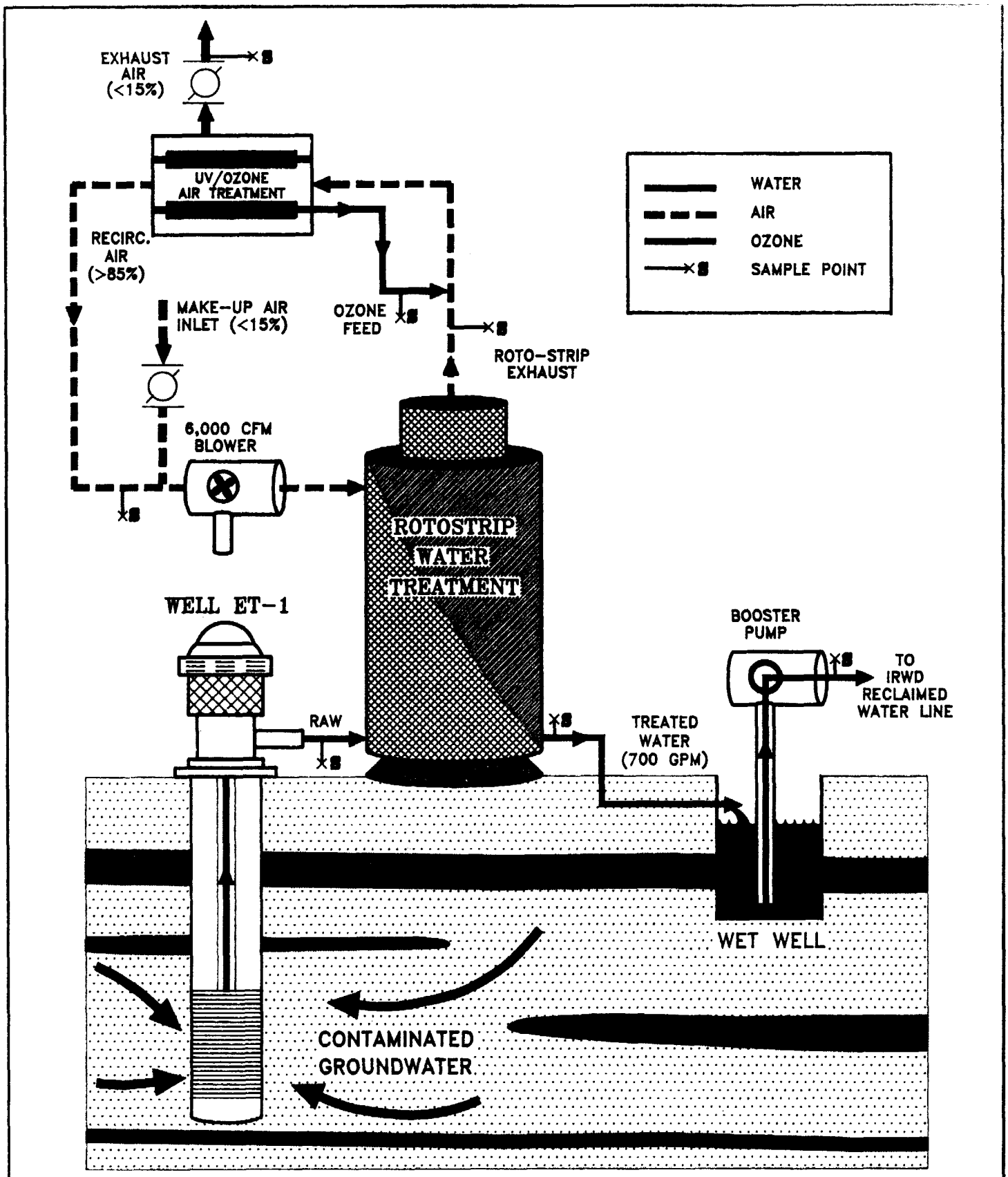

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FIGURE 11 TCE PUMPOUT AND TREATMENT SYSTEM

2.1, is equipped with an 5-stage, 10-inch diameter, vertical turbine pump and 100-hp electric motor. The pump intake is set at a depth of 170 feet bgs. The well, pump, motor, and pipelines have a maximum flow capacity of 1,200 gpm, but will initially be operated at 700 gpm, the maximum capacity of the water treatment unit.

Water discharged at the wellhead will flow into a stainless steel rotary air stripping, or "roto-strip", unit at a rate of 700 gpm. A roto-strip unit bypass valve may be opened to divert all or a portion of the discharge water directly to either the drain line connected to a nearby storm drain or to the reclaimed water line. Under normal operating conditions this valve will remain closed. The roto-strip unit is a two-phase (gas/liquid) mass transfer device consisting of a 6.5-foot diameter rotating drum, containing high surface area packing media. Water is sprayed onto the packing media inside the rotating drum and driven through the packing by centrifugal force. A 6,000-cfm blower will force air through the packing media counter currently to the water, thereby stripping off the VOCs from the water.

The treated water will flow by gravity from the roto-strip unit into a 2,000-gallon holding tank, or wet well, which is equipped with a vertical turbine booster pump and 100-hp variable frequency drive electric motor. The booster pump will pump the treated water into the reclaimed water line.

Valves and motors are connected to an on-site computerized motor control center (MCC) which is telemetered to IRWD's operations plant for remote operation. Electronic pressure transducers and transmitters are installed in the production well and wet well which can signal the MCC to automatically adjust the wet well pump flow rate or shut down the entire system if water levels fall below acceptable limits. The vapor-phase treatment equipment is designed to destroy VOCs in the exhaust air discharged from the roto-strip unit at a rate of 6,000 cfm. A stainless steel, ultraviolet light/ozone reactor, containing a bank of 16 UV light bulbs, is manifolded directly to the air exhaust of the roto-strip unit. The UV light bulbs create ozone which oxidizes the chlorinated VOCs, converting them into water, carbon dioxide, and hydrogen chloride. The UV/ozone unit

is designed to operate almost as a closed system in that it will recirculate approximately 85 percent of the treated air back into the roto-strip blower intake, which is ducted directly to the reactor chamber. The remaining 15 percent will be exhausted to the atmosphere.

Monitoring of the UV/ozone unit exhaust air will be performed in accordance with the SCAQMD requirements specified in OCWD's permit to construct this equipment. Constituents to be measured include carbon dioxide, hydrogen chloride, chlorinated hydrocarbons, total non-methane hydrocarbons, and ozone.

Estimated Well Capture Zone

OCWD designed the TCE pumpout and treatment system at Irvine Center Drive and Jeffrey Road as an interim measure to initiate cleanup of the area containing the highest TCE concentrations and to slow the northwestward migration of the TCE plume. The system is located within or slightly downgradient of the highest levels of TCE measured outside the MCAS El Toro. A preliminary analytical groundwater flow model run by OCWD indicates that this single extraction well will not capture the entire TCE plume (see Figure 12), which extends over one mile downgradient of well ET-1. The model indicated that well ET-1 would contain the majority of the upgradient plume and approximately 500 to 1,000 feet of the downgradient portion of the plume.

No computations were made to determine the length of time necessary for this single well to recover the upgradient portion of the plume, but OCWD staff believes that this could take many years. It is important to note that this well and most off-base extraction wells would be designed to remove deep TCE-laden groundwater, and that a comprehensive remediation program should include shallow extraction wells to remove contaminated groundwater where it occurs closer to its source on-base. If this is done, the time required to capture the upgradient portion of the plume will be significantly decreased.

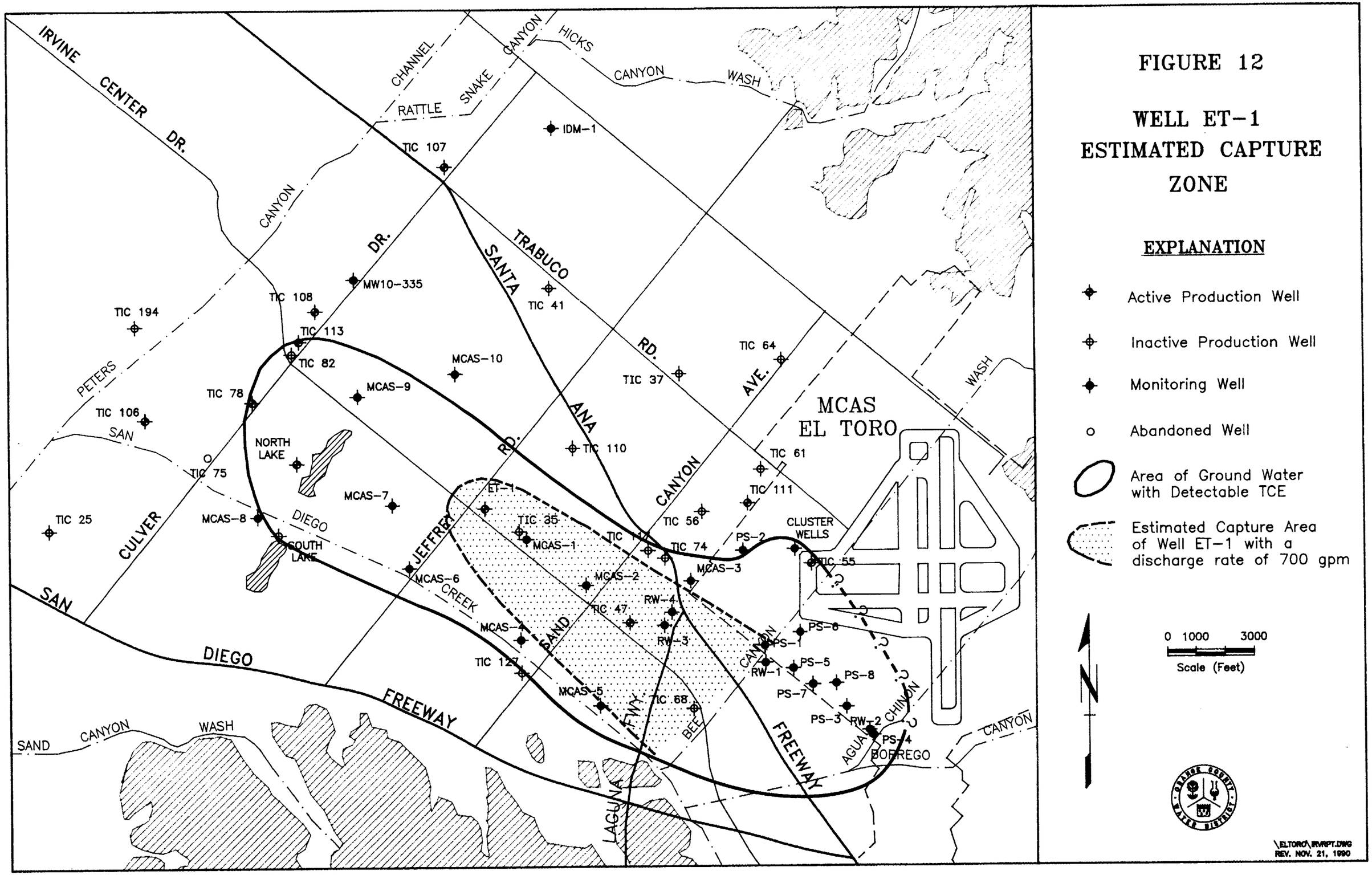
FIGURE 12
WELL ET-1
ESTIMATED CAPTURE
ZONE
EXPLANATION
Active Production Well
Inactive Production Well
Monitoring Well
Abandoned Well
Area of Ground Water with Detectable TCE
Estimated Capture Area of Well ET-1 with a discharge rate of 700 gpm
0 1000 3000
Scale (Feet)
N
MCAS
EL TORO
IRVINE CENTER DR.
PETERS CANYON CHANNEL
RATTLE SNAKE CANYON
HICKS CANYON WASH
SANTA ANA RD.
TRABUCO RD.
JEFFREY RD.
CULVER DR.
SAN DIEGO FREEWAY
SAND CANYON WASH
LAGUNA BEE FWY.
AGUA CHINON AVE.
BORREGO CANYON
NORTH LAKE
SOUTH LAKE
SAND CREEK
CLUSTER WELLS
IDM-1
TIC 107
MW10-335
TIC 108
TIC 113
TIC 82
TIC 194
TIC 78
TIC 106
TIC 75
TIC 25
MCAS-10
MCAS-9
MCAS-7
MCAS-8
MCAS-6
MCAS-4
MCAS-5
MCAS-1
MCAS-2
MCAS-3
ET-1
TIC 35
TIC 41
TIC 37
TIC 64
TIC 110
TIC 61
TIC 111
TIC 56
TIC 74
TIC 55
TIC 47
TIC 127
TIC 68
RW-4
RW-3
RW-1
RW-2
PS-1
PS-2
PS-3
PS-4
PS-5
PS-6
PS-7
PS-8
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4.2 IRVINE DESALTER PROJECT

Based on the above information, OCWD staff believes that additional extraction wells are necessary to contain and recover VOC-contaminated groundwater within a reasonable time period. Possible future remedial activities, including the construction of the Irvine Desalter Project, may result in a final groundwater remediation strategy.

Prior to the finding of TCE, historical water quality data indicated that the groundwater in the Irvine area was degraded with high concentrations of nitrate, TDS, and selenium largely due to past agricultural activities. Several years ago OCWD conceived of a project to extract and treat large volumes of groundwater from the Irvine area to provide a heretofore unusable local potable water supply. The Irvine Desalter Project, as now proposed, would consist of six to nine production wells, distribution pipelines, and a central water treatment facility which would treat about 7.0 to 8.5 MGD of groundwater, resulting in the production of about 6.5 MGD of potable water and 0.6 to 2.0 MGD of brine reject (Engineering-Science, 1990). The product water would be delivered to the IRWD potable water system. The brine would be discharged to and treated at the Fountain Valley Wastewater Treatment Plant operated by the County Sanitation Districts of Orange County. Well, pipeline, and facilities locations will be finalized, pending review of the Project Environmental Impact Report (Jones & Stokes Associates, 1990) and approval of funding assistance by several agencies, including the Metropolitan Water District of Southern California and the State Water Resources Control Board.

Because the groundwater containing high nitrates and TDS commingles with the TCE plume, the design of the Irvine Desalter, as originally planned, had to include the treatment of TCE-contaminated groundwater. Conversely, any future large-scale TCE plume extraction and treatment system undertaken by the USMC would likely include the treatment of nitrate and/or TDS before the water could be reinjected, pumped to storm channels, or used for potable or irrigation purposes. Therefore, a joint cleanup effort by OCWD and the USMC may constitute a cost-effective approach to a total groundwater remediation program.

OCWD developed a single-layer numerical groundwater flow model, based on the finite difference code "MODFLOW" by McDonald and Harbaugh (1983), to assess the drawdown effects of the desalter wellfield. Although not specifically generated to evaluate the potential TCE plume capture area, the piezometric levels calculated by the model indicate that the desalter wellfield and existing active irrigation wells would probably contain the deep TCE plume as far west as Culver Drive (see Figure 13). Shallower TCE-contaminated groundwater found on-base would not be readily recovered by the deep-screened desalter wells and, therefore, would need to be removed using additional shallow recovery wells. Further model runs, using a solute transport code, would be necessary before more definitive capture areas and total plume remediation time can be estimated.

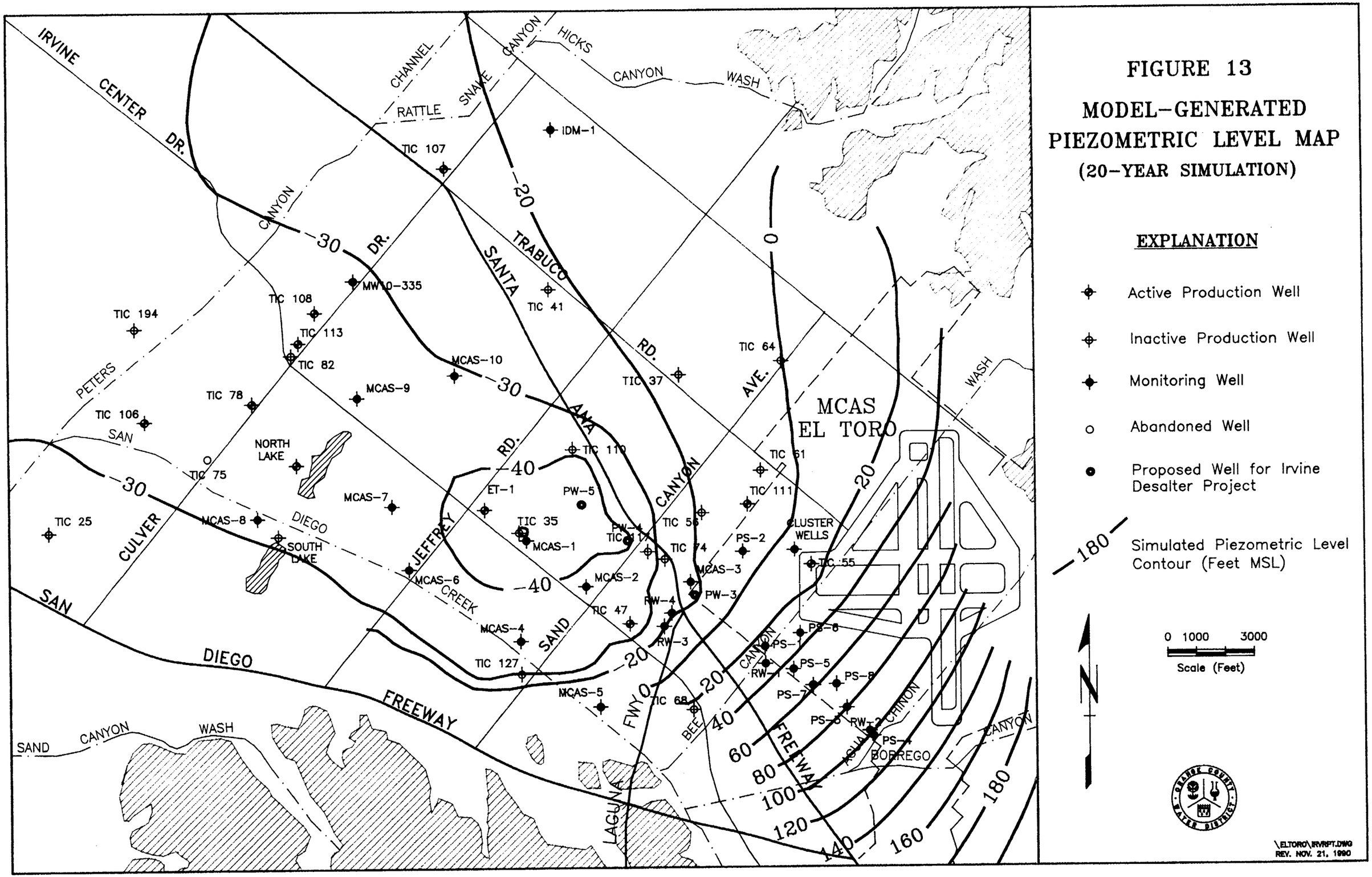
FIGURE 13
MODEL-GENERATED PIEZOMETRIC LEVEL MAP
(20-YEAR SIMULATION)
EXPLANATION
Active Production Well
Inactive Production Well
Monitoring Well
Abandoned Well
Proposed Well for Irvine Desalter Project
Simulated Piezometric Level Contour (Feet MSL)
0 1000 3000
Scale (Feet)
N
MCAS EL TORO
IRVINE CENTER DR.
CHANNEL
RATTLE SNAKE CANYON
HICKS CANYON WASH
SANTA ANA TRABUCO RD.
PETERS CANYON
SAN DIEGO FREEWAY
CULVER DR.
JEFFREY RD.
SAND CANYON
LAGUNA FWY
BEE CANYON
ASHBURN CHINON
BORREGO CANYON
SAND CANYON WASH
NORTH LAKE
SOUTH LAKE
CLUSTER WELLS
IDM-1
TIC 107
TIC 194
TIC 108
TIC 113
TIC 82
MW10-335
TIC 41
TIC 64
TIC 37
MCAS-10
MCAS-9
TIC 78
TIC 106
TIC 75
TIC 110
TIC 61
TIC 111
TIC 25
MCAS-8
MCAS-7
ET-1
PW-5
TIC 35
MCAS-1
TIC 56
TIC 74
PS-2
MCAS-3
PW-3
TIC 55
MCAS-6
MCAS-2
RW-4
TIC 47
MCAS-4
RW-3
TIC 127
MCAS-5
TIC 68
PS-6
PS-1
PS-5
RW-1
PS-7
PS-8
RW-2
PS-4
0
20
30
40
60
80
100
120
140
160
180

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5. FINDINGS AND CONCLUSIONS

OCWD installed six additional groundwater monitoring wells to better define the lateral extent of the TCE plume in the Irvine area. In addition, OCWD constructed a 1 MGD groundwater extraction and treatment system as an interim measure to begin groundwater cleanup and to retard further plume migration. Groundwater samples and piezometric levels were collected from the new wells and from existing multipoint monitoring wells and irrigation wells. The data were used to extend geologic cross sections and to update plume configuration and piezometric contour maps with the objective of better understanding the hydrogeologic characteristics of the study area. The USMC installed and sampled four single-point monitoring wells, and these data were incorporated into this report. Based on available data, the following findings were made:

- The TCE plume west of Sand Canyon Avenue is about one mile wide and is approximately bounded on its southern edge by San Diego Creek. This boundary corresponds to a shallowing of the bedrock (and thinning of the aquifer) noted in the new wells drilled along this drainage. The northern boundary is roughly parallel with, and about 2,000 feet north of, Irvine Center Drive.

- The TCE plume extends to Culver Drive, about 3 miles northwest of the MCAS El Toro, as evidenced by the recent finding of trace levels of TCE in irrigation wells TIC 78 and TIC 113. It is not known whether these wells will capture all ground water with TCE that passes Culver Drive. Plume travel time estimates between the North Lake well and the Culver Drive wells support earlier-estimated groundwater velocities of 1 to 4 feet per day.

- TCE was identified in wells MCAS-3 and RW-3 located in areas near the MCAS El Toro where no previous TCE was found. This was an area of contention during the Phase I investigation, when the USMC suggested that the absence of TCE in this well indicated that the plume off base was discontinuous with the plume on base.

- Geologic cross sections interpreted from borehole logs support previous indications of interconnected higher permeability sediments between 200 and 500 feet bgs which may act as preferential plume migration pathways both vertically and laterally.

- The estimated capture area of extraction well ET-1 encompasses most of the deep TCE plume upgradient of the well and extends about 500 to 1,000 feet

downgradient, leaving an unrecovered portion of the plume which contains TCE levels ranging from trace to 25 ug/l near Culver Drive.

Based on the findings of this investigation, the following conclusions were drawn by OCWD.

- Hydrogeologic and water quality data collected since the Phase I investigation support OCWD's earlier conclusion that the MCAS El Toro is the source of the TCE plume in the Irvine area.

- Both on- and off-base extraction wells, in addition to well ET-1, will be necessary to effectively recover TCE-contaminated groundwater. The Irvine Desalter Project may include sufficient deep-aquifer extraction wells to capture the TCE plume off base, but additional shallow wells will be necessary to recover shallow contaminated groundwater on-base.

6. RECOMMENDATIONS

The hydrogeologic data collected to date provide relatively well-defined lateral and vertical boundaries of the TCE plume in the Irvine area west of the Laguna Freeway. Recent meetings with the USMC to discuss the scope of their RI/FS Work Plan have indicated that the major focus of extensive hydrogeologic studies will be the Spectrum area east of the Laguna Freeway and the base itself. OCWD (1990) and other agencies provided comments and recommendations to the USMC after reviewing an initial draft of their Work Plan, which will not be discussed here in detail. A revised Work Plan is scheduled for final agency review in October 1990.

In summary, OCWD recommends that the areas beneath and adjacent to the base be sufficiently characterized to begin a timely groundwater remediation program that will include all known areas of VOC contamination. To this end, the following recommendations are made:

1. Quarterly well monitoring data should be collected and made available by the USMC for all wells installed by them. This recommendation was made in the Phase I investigation report, but only OCWD has been collecting regular water level and water quality data from its monitoring wells. A regular groundwater monitoring program is necessary to track plume movement and should be initiated by the USMC, even before the RI/FS officially begins.

2. The USMC should include in its RI/FS Work Plan the construction of at least one multipoint well (or cluster of wells) near the intersection of Irvine Center Drive and Culver Drive. In addition, aquifer tests should be conducted using this new well as an observation well while pumping well TIC 78 or TIC 113. The recent finding of TCE in wells TIC 78 and TIC 113 warrants the evaluation of whether these wells will capture the portion of the TCE plume not contained by well ET-1. The nearest multipoint monitoring well to Culver Drive is MCAS-7, 3/4 of a mile to the east. Because wells TIC 78 and TIC 113 are screened over large depth intervals, no depth-specific water quality data are available to identify whether higher TCE concentrations may exist in specific aquifer zones. A monitoring well, or set of wells, and adequate aquifer testing will help provide the data necessary to evaluate the rate of plume migration or containment in this area.

3. OCWD should continue to assess the effective capture areas of well ET-1 and other production wells within the TCE plume using data collected from existing wells as they are monitored in the future. This information could be used to modify proposed production well locations for the Irvine Desalter Project, if necessary.

4. The proposed Irvine Desalter should be considered as a possible treatment facility of groundwater extracted at or near MCAS El Toro when a larger-scale interim or final groundwater remedial program is developed for that area. A cooperative groundwater remedial program in the Irvine area between OCWD, IRWD, and the USMC would have economic advantages by combining, rather than duplicating, facilities construction, operation, and maintenance activities.

7. REFERENCES

Cooper, H.H., Jr. and C.E. Jacob (1964), A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well-Field History, Trans. Am. Geophys. Union, Vol. 27, pp. 526-534.

Engineering-Science, Inc. (1990), Facility Plan and Project Report - Irvine Desalter (DRAFT); prepared for Orange County Water District.

Jacob, C.E. (1963), Recovery Method for Determining the Coefficient for Transmissivity, USGS Water Supply Paper 1536I.

Jones & Stokes Associates, Inc. (1990), Irvine Desalter Project - Final Environmental Impact Report; prepared for Orange County Water District.

McDonald, M.G. and A.W. Harbaugh (1983), A Modular Three Dimensional Finite-Difference Ground-Water Flow Model, U.S. Geological Survey.

Med-Tox Associates, Inc. (1989), Public Health Risk Assessment for the OCWD/IRWD Proposed Trichloroethylene Containment Program, Irvine, California; prepared for Orange County Water District.

Miller, Russell, V. and Siang S. Tan (1976), Geology and Engineering Geologic Aspects of the South Half Tustin Quadrangle, Orange County, California, Calif. Div. of Mines and Geology, Special Report 126.

Orange County Water District (1989), Phase I Report - Investigation of Trichloroethylene Contamination in the Vicinity of the El Toro Marine Corps Air Station.

Orange County Water District (1989a), Results of an Investigation of TCE Removal During Sprinkler and Drip Irrigation in the Irvine Area.

Orange County Water District (1990), Letter to Lt.(jg) Michael Rehor, MCAS El Toro, Dated Jan. 11, 1990; Subject: Comments on MCAS El Toro Off-Station RI Work Plan.

Singer, John A. (1973), Geohydrology and Artificial-Recharge Potential of the Irvine Area, Orange County, California, USGS Open File Report 73-264.

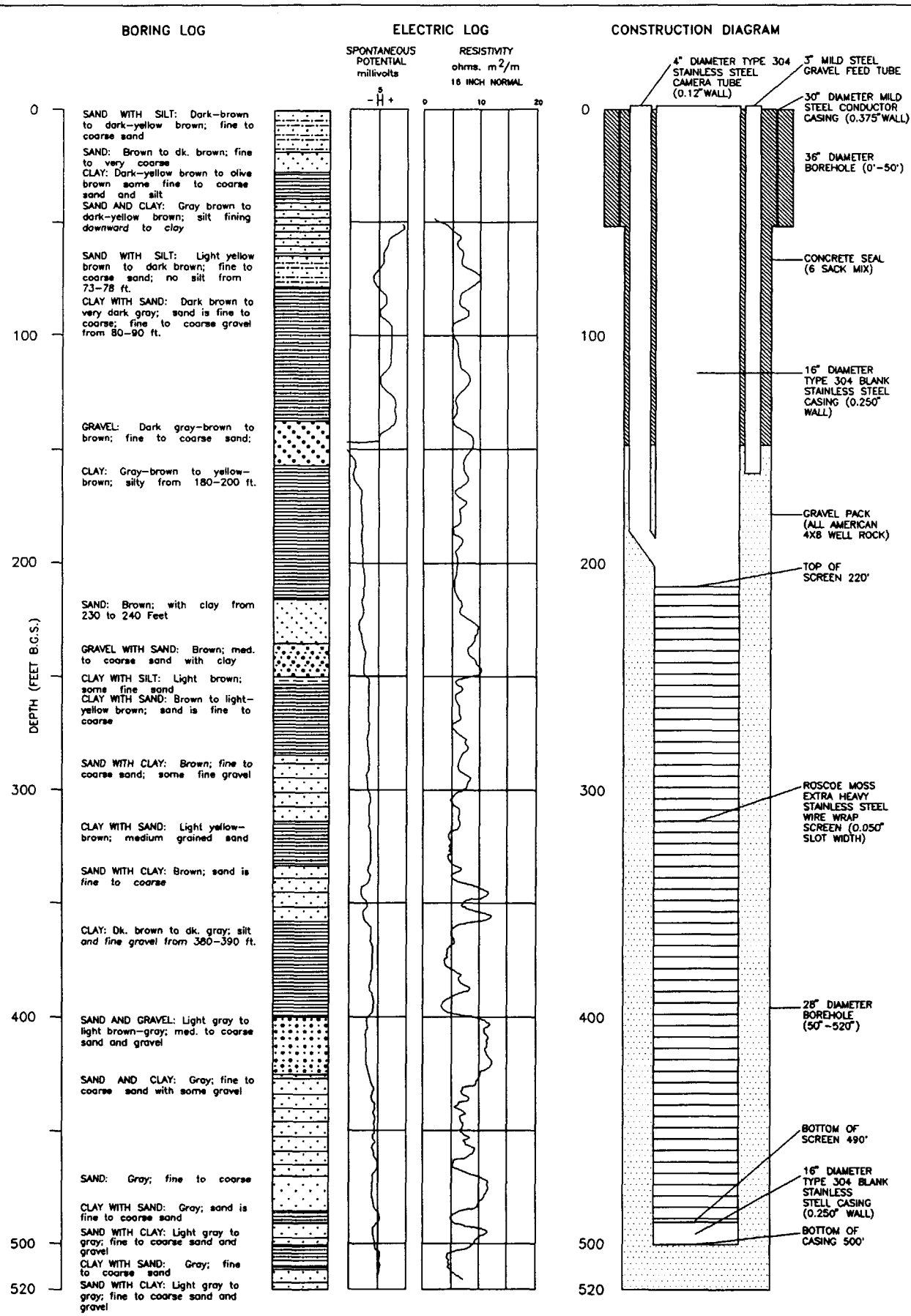
Slain, David D. and James F. Barker (1990), The Detection of Naturally Occurring BTX during a Hydrogeologic Investigation, Groundwater Monitoring Review, Vol. 10, No. 2 pp. 89-94.

Theis, C.V. (1935), The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Ground Water Storage, Trans. Am. Geophys. Union, Vol. 16, pp. 519-524.

U.S. Marine Corps (1989), MCAS El Toro Perimeter Investigation Interim Report; prepared by James M. Montgomery Consulting Engineers, Inc. under the Installation Restoration Program by the San Diego Branch, Western Division Naval Facilities Engineering Command, San Diego.

APPENDIX A

BORING LOGS AND WELL CONSTRUCTION DETAILS



ET-1 BORING/ELECTRIC LOG & CONSTRUCTION DIAGRAM

MAJOR DIVISIONS				TYPICAL NAMES
COARSE-GRAINED SOILS (MORE THAN HALF IS LARGER THAN No. 200 SIEVE)	GRAVELS (MORE THAN HALF COARSE FRACTION IS LARGER THAN No. 4 SIEVE SIZE)	CLEAN GRAVELS WITH LITTLE OR NO FINES	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES
			GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES
		GRAVELS WITH OVER 12% FINES	GM	SILTY GRAVELS, POORLY GRADED GRAVEL-SAND-SILT MIXTURES
			GC	CLAYEY GRAVELS, POORLY GRADED GRAVEL-SAND-CLAY MIXTURES
	SANDS (MORE THAN HALF COARSE FRACTION IS SMALLER THAN No. 4 SIEVE SIZE)	CLEAN SANDS WITH LITTLE OR NO FINES	SW	WELL-GRADED SANDS, GRAVELLY SANDS
			SP	POORLY GRADED SANDS, GRAVELLY SANDS
		SANDS WITH OVER 12% FINES	SM	SILTY SANDS, POORLY GRADED SAND-SILT MIXTURES
			SC	CLAYEY SANDS, POORLY GRADED SAND-CLAY MIXTURES
FINE-GRAINED SOILS (MORE THAN HALF IS SMALLER THAN No. 200 SIEVE)	SILTS AND CLAYS (LIQUID LIMIT 50% OR LESS)		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS, OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC CLAYS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS (LIQUID LIMIT GREATER THAN 50%)		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS

■ – "Undisturbed" S&H or Shelby tube sample

▨ – Bulk or classification sample

▨ – Standard Penetration Test sample

▤ – No sample recovered

I – Core sample

Blows/ft – Blows required to drive sampler 12 inches with a 140-pound hammer falling 30 inches. Blow counts for S&H samplers are converted to approximate "equivalent" SPT N values (N = 0.5 X S&H blows per foot)

HC Odor – Hydrocarbon Odor

- No – No Odor
- Lo – Slight Odor
- Md – Moderate Odor
- Sg – Strong Odor

PID – Photoionization Detector reading (10.2-electron-volt lamp, calibrated using a benzene standard)

OVA – Organic Vapor Analyzer (flame ionization detector) calibrated using a methane standard

* – Sample submitted for chemical analysis

** – Based on HLA Temporary Bench Mark (TBM) shown on Plate 2. Assumed elevation = 100.00'.

KEY TO BORING LOG

Harding Lawson Associates
Engineers and Geoscientists

SOIL CLASSIFICATION CHART
& KEY TO BORING LOG
Orange County Water District
Irvine, California

PLATE 1

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

ROCK2

I **CONSOLIDATION OF SEDIMENTARY ROCKS;** usually determined from unweathered samples. Largely dependent on cementation.

U = unconsolidated
P = poorly consolidated
M = moderately consolidated
W = well consolidated

II **BEDDING OF SEDIMENTARY ROCKS**

Splitting Property	Thickness (Feet)	Stratification
Massive	Greater than 4.0	Very thick bedded
Blocky	2.0 to 4.0	Thick bedded
Slabby	0.2 to 2.0	Thin bedded
Flaggy	0.05 to 0.2	Very thin bedded
Shaly or platy	0.01 to 0.05	Laminated
Papery	Less than 0.01	Thinly laminated

III **FRACTURING**

Intensity	Size of Pieces (Feet)
Very little fractured	Greater than 4.0
Occasionally fractured	1.0 to 4.0
Moderately fractured	0.5 to 1.0
Closely fractured	0.1 to 0.5
Intensely fractured	0.05 to 0.1
Crushed	Less than 0.05

IV **HARDNESS**

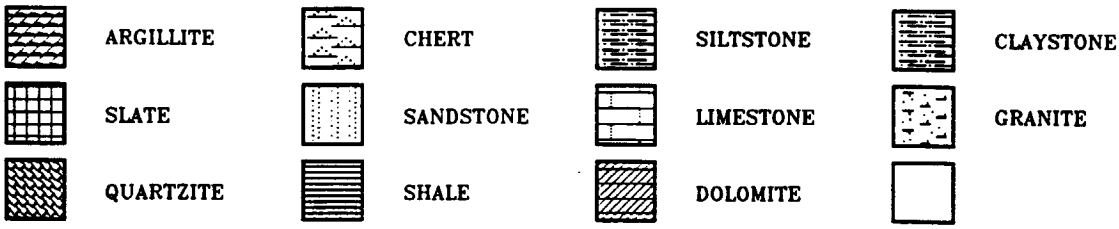
1. **Soft** – Reserved for plastic material alone.
2. **Low hardness** – Can be gouged deeply or carved easily with a knife blade.
3. **Moderately hard** – Can be readily scratched by a knife blade; scratch leaves a heavy trace of dust and is readily visible after the powder has been blown away.
4. **Hard** – Can be scratched with difficulty; scratch produces little powder and is often faintly visible.
5. **Very hard** – Cannot be scratched with knife blade; leaves a metallic streak.

V **STRENGTH**

1. **Plastic** or very low strength.
2. **Friable** – Crumbles easily by rubbing with fingers.
3. **Weak** – An unfractured specimen of such material will crumble under light hammer blows.
4. **Moderately strong** – Specimen will withstand a few heavy hammer blows before breaking.
5. **Strong** – Specimen will withstand a few heavy ringing hammer blows and will yield with difficulty only dust and small flying fragments.
6. **Very strong** – Specimen will resist heavy ringing hammer blows and will yield with difficulty only dust and small flying fragments.

VI **WEATHERING** – The physical and chemical disintegration and decomposition of rocks and minerals by natural processes such as oxidation, reduction, hydration, solution, carbonation, and freezing and thawing.

D. **Deep** – Moderate to complete mineral decomposition; extensive disintegration; deep and thorough discoloration; many fractures, all extensively coated or filled with oxides, carbonates, and/or clay or silt.
M. **Moderate** – Slight changes or partial decomposition of minerals; little disintegration; cementation little to unaffected; moderate to occasionally intense discoloration; moderately coated fractures.
L. **Little** – No megascopic decomposition of minerals; little or no effect on normal cementation; slight and intermittent, or localized discoloration; few stains on fracture surfaces.
F. **Fresh** – Unaffected by weathering agents; no disintegration or discoloration; fractures usually less numerous than joints.



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PHYSICAL PROPERTIES CRITERIA FOR ROCK DESCRIPTIONS
Orange County Water District
Irvine, California

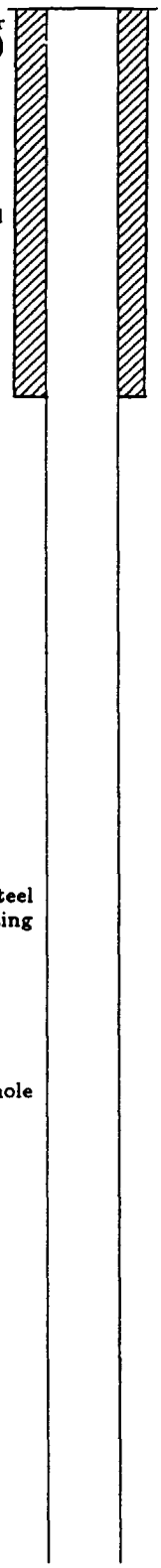
PLATE 2

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 9/21/89



Depth ft | Sample

0 — DARK GRAY-BROWN CLAY (CL)
dry, with trace of fine-grained sand

10 — GRAY-BROWN SANDY CLAY (CL)
dry to slightly moist, fine- to medium-grained sand

color change to dark gray-brown

20 — color change to brown

BROWN SAND (SP)
dry to moist, fine grained, with some medium to coarse grained

GRAY-BROWN CLAY (CL)
dry to moist, with trace of very fine-grained sand

30 — water level measured on 10/23/89

color change to tan-brown, with trace of fine-grained sand

40 — no recovery

BROWN SILTY SAND (SM)
very fine to fine grained, with clay

BROWN SAND (SP)
fine to medium grained, with some clay

50 — with trace of silt, little or no clay

BROWN SANDY CLAY (CL)
fine-grained sand

60 — color change to light brown

BROWN CLAYEY SAND (SC)
fine grained, with silt

70 — fine to medium grained

LIGHT BROWN SAND (SP)
fine to medium grained

80

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Log of Boring MCAS- 4 (sheet 1 of 5)

Orange County Water District
Irvine, California

PLATE **3**

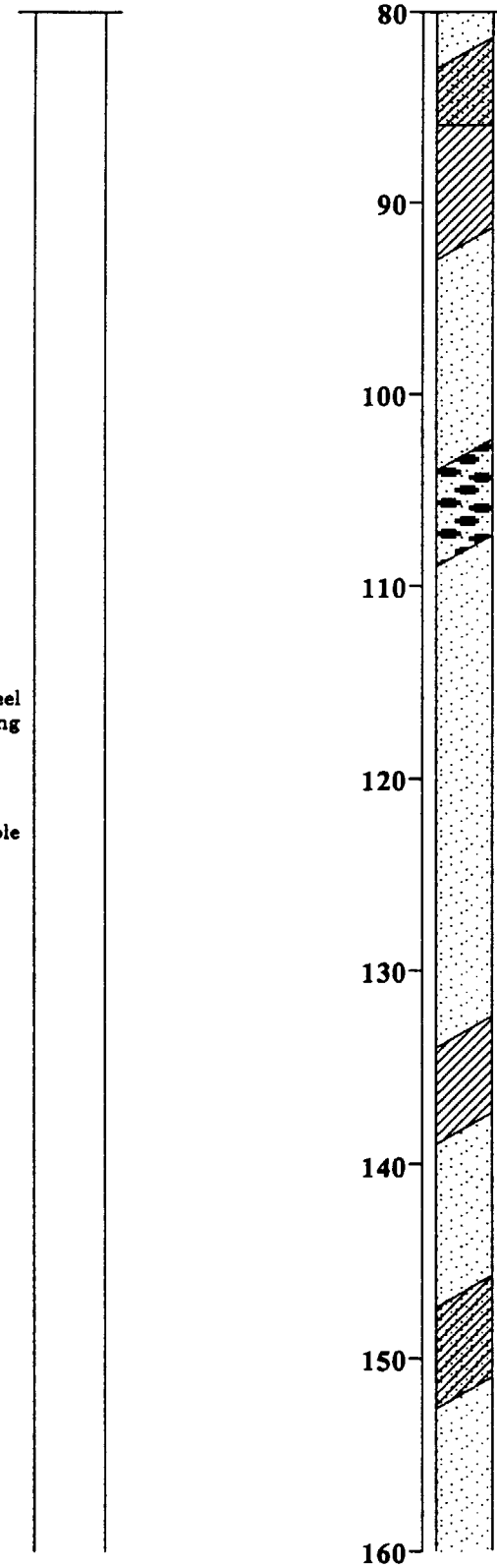
DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 9/21/89

Depth ft | Sample



BROWN CLAYEY SAND (SC)
fine to medium grained

BROWN SANDY CLAY (CL)
fine grained

BROWN SAND (SP)
fine to coarse grained, with subangular gravel and trace of silt

DARK BROWN SANDY GRAVEL (GP)
with medium- to coarse-grained sand, subangular gravel

BROWN SAND (SP)
fine grained, with trace of subangular gravel and trace of silt

color change to light brown, little or no fines

with some silt

fine- to medium-grained sand and trace of gravel

no gravel

BROWN SANDY CLAY (CL)
fine grained

LIGHT BROWN SAND (SP)
fine to medium grained, with trace of silt

LIGHT BROWN CLAYEY SAND (SC)
fine to medium grained

LIGHT BROWN SAND (SP)
fine to coarse grained, with some angular to subangular gravel, quartz-rich, trace of silt

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Log of Boring MCAS- 4 (sheet 2 of 5)

Orange County Water District
Irvine, California

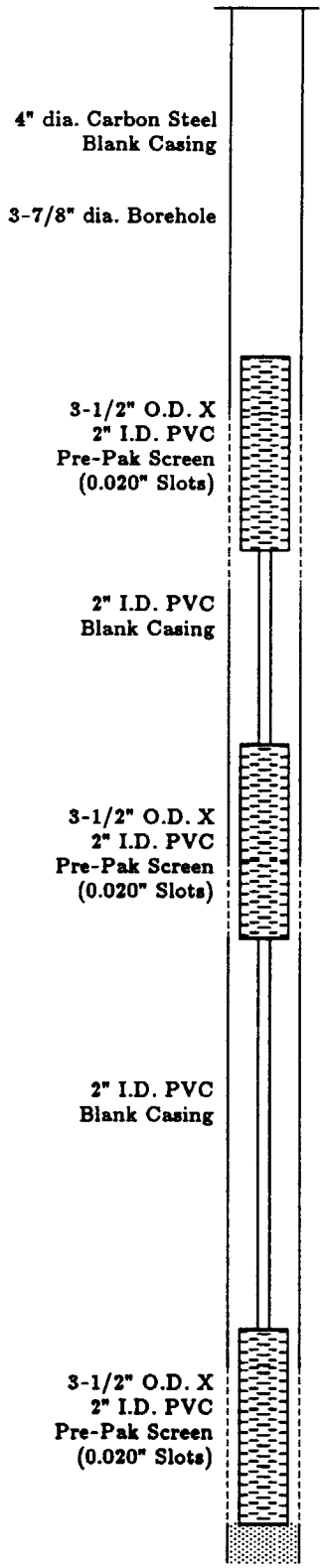
PLATE **3a**

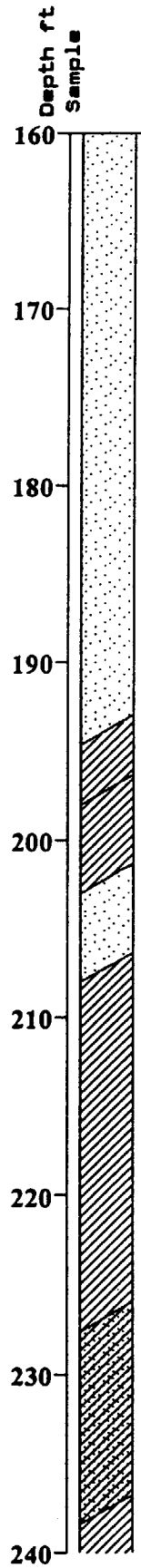
DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 9/21/89





fine to medium grained, with trace of gravel

subangular to subrounded gravels

color change to light gray-brown

color change to light orange-brown, with trace of clay

color change to light brown

BROWN CLAY (CL)
with fine-grained sand

BROWN SANDY CLAY (CL)
fine grained

LIGHT GRAY-BROWN SAND (SP)
fine grained, with trace of clay

LIGHT BROWN SANDY CLAY (CL)
fine grained

color change to medium brown

color change to brown

LIGHT BROWN CLAYEY SAND (SC)
fine grained

LIGHT BROWN SANDY CLAY (CL)
fine grained

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Log of Boring MCAS- 4 (sheet 3 of 5)

Orange County Water District
Irvine, California

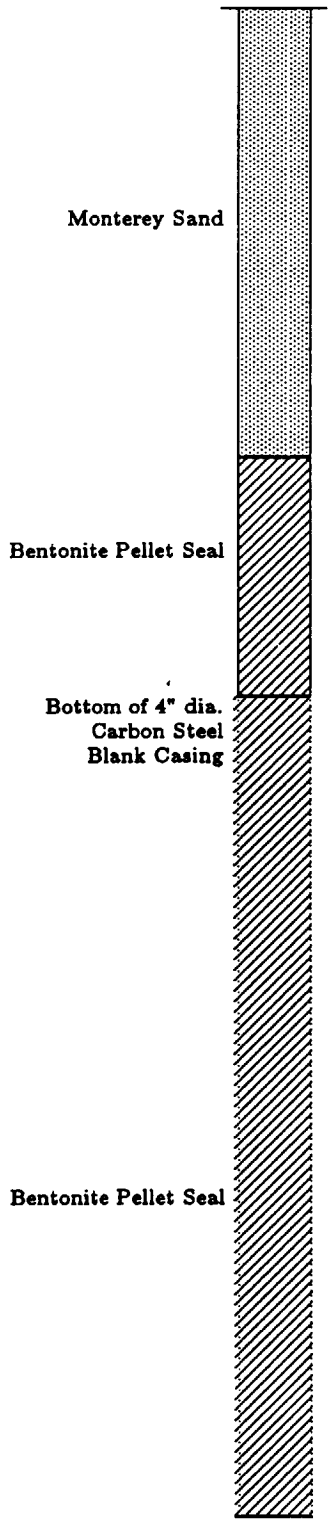
PLATE **3b**

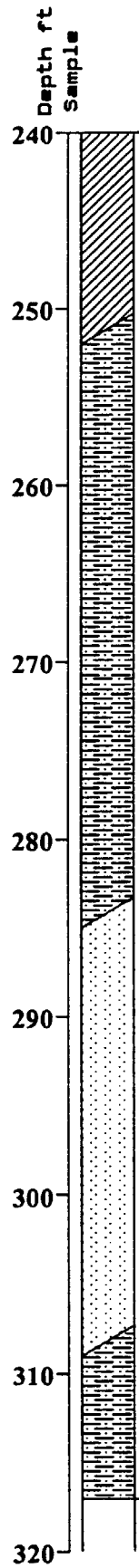
DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 9/21/89





trace of medium-grained sand

no recovery

LIGHT YELLOW-BROWN SANDY SILTSTONE
low hardness, friable, moderate weathering

with clay

color change to yellow-brown, friable, moderate to deep weathering, with clay

no recovery

YELLOW-GRAY SILTY SANDSTONE
low hardness, moderately strong, fine grained, little weathering

color change to gray-green, moderately hard, moderately strong, little weathering, fossiliferous (gastropod)

LIGHT GRAY-BROWN SILTSTONE
with clay, low hardness, weak, moderate weathering, fossiliferous (gastropod)

LIGHT BROWN SANDY SILTSTONE
moderately hard, moderately strong, little weathering

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Log of Boring MCAS- 4 (sheet 4 of 5)

Orange County Water District
Irvine, California

PLATE **3c**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Depth ft | Sample

Equipment Air Rotary

Elevation NA Date 9/21/89

320

330

340

350

360

370

380

390

400

Boring terminated at 317.0 feet.
Steel casing driven to 275.25 feet in a 3-7/8-inch-diameter borehole.
Ground water encountered at approximately 37.0 feet during drilling.
Steel casing perforated with a mechanical wheel perforator.
Boring converted to ground-water observation well on 10/21/89.

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Log of Boring MCAS- 4 (sheet 5 of 5)

Orange County Water District
Irvine, California

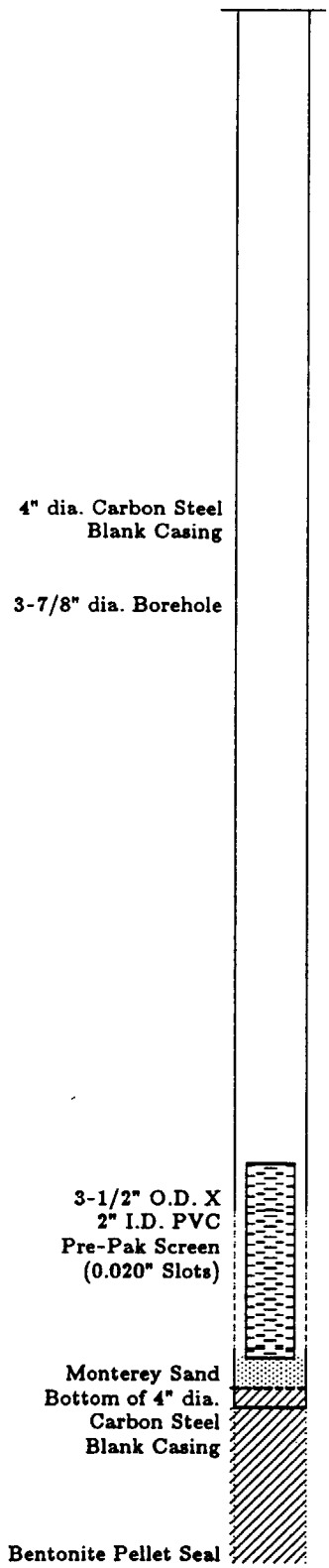
PLATE **3d**

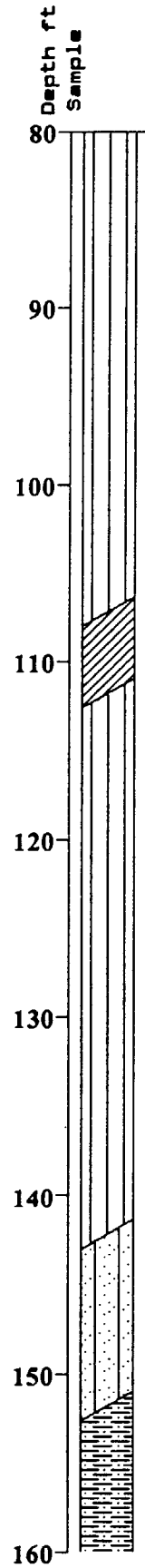
DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 9/18/89





color change to light brown

color change to yellow-brown, no clay

trace of fine-grained sand

LIGHT GRAY CLAY (CL)
moist, with silt

LIGHT YELLOW-BROWN SILT (ML)
moist, with trace of very fine-grained sand

color change to yellow-brown, with very fine-grained sand

YELLOW-BROWN SILTY SAND (SM)
fine to medium grained, with trace of clay

WEATHERED GRAY CLAYEY SILTSTONE

GRAY SILTSTONE

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Log of Boring MCAS- 5 (sheet 2 of 3)

Orange County Water District
Irvine, California

PLATE **4a**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 9/18/89

Depth ft

Sample

Bentonite Pellet Seal

160

170

180

190

200

210

220

230

240

Boring terminated at 177.0 feet.
Steel casing driven to 152.0 feet in a 3-7/8-inch-diameter borehole.
Ground water encountered at approximately 57.0 feet during drilling.
Steel casing perforated with a mechanical wheel perforator.
Boring converted to ground-water observation well on 10/19/89.

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Log of Boring MCAS- 5 (sheet 3 of 3)

Orange County Water District
Irvine, California

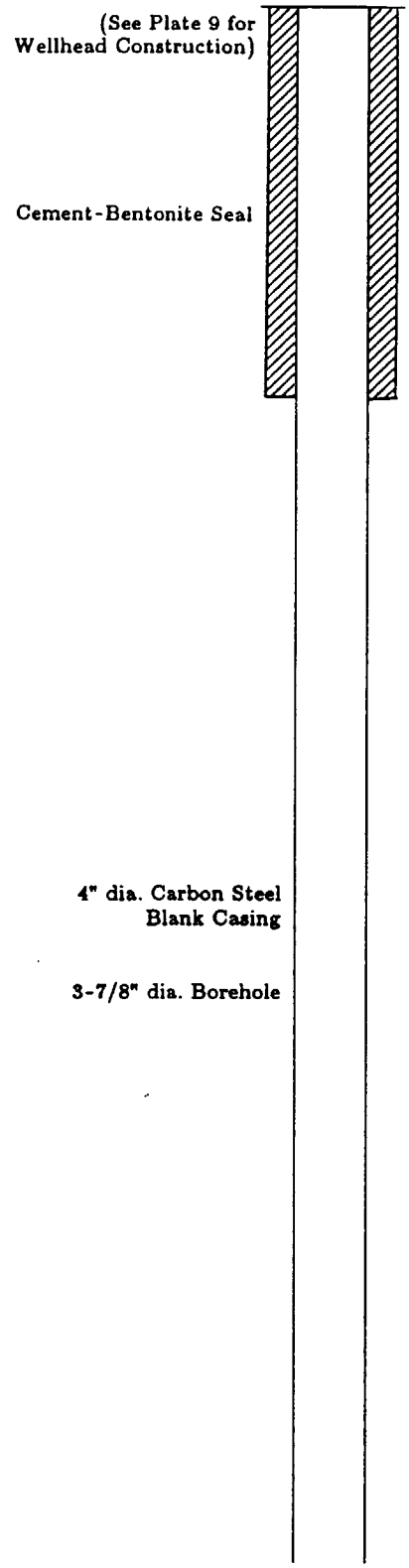
PLATE **4b**

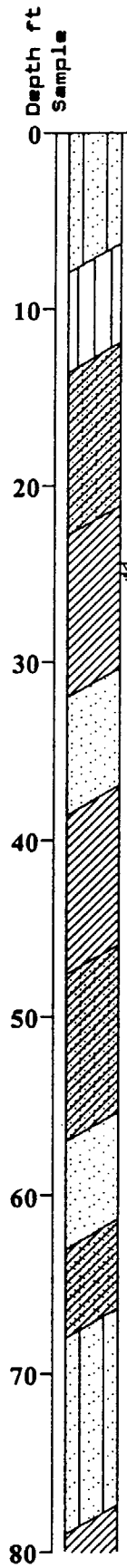
DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 9/25/89





DARK BROWN SILTY SAND (SM) [FILL]
dry, fine grained, with some angular gravel, with clay

DARK BROWN SANDY SILT (ML)
fine-grained sand, with some clay

LIGHT BROWN CLAYEY SAND (SC)
fine grained, with some silt

BROWN SANDY CLAY (CL)
slightly moist, fine-grained sand, low plasticity

water level measured on 10/28/89

LIGHT RED-BROWN SAND (SP)
moist, fine grained, trace of medium-grained sand, with silt

BROWN SANDY CLAY (CL)
moist, fine-grained sand

DARK BROWN CLAYEY SAND (SC)
moist, fine grained, cohesive

with silt

fine to medium grained

BROWN SAND (SP)
wet, fine grained, with some medium grained, with clay

BROWN CLAYEY SAND (SC)
wet, fine grained

BROWN SILTY SAND (SM)
very wet, fine grained, with some clay

BROWN SANDY CLAY (CL)
wet, fine-grained sand, with some silt,

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Log of Boring MCAS- 6 (sheet 1 of 6)

Orange County Water District
Irvine, California

PLATE **5**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 9/25/89

Depth ft

Sample

4" dia. Carbon Steel Blank Casing

3-7/8" dia. Borehole

80

low plasticity

90

slightly mottled

100

up to 30% sand content

BROWN SANDY GRAVEL (GP)
gravel subangular, quartzite, 5-20 mm diameter

110

BROWN SAND (SP)
wet, fine to medium grained (60% medium, 40% fine), quartz grains predominate

120

130

BROWN CLAY (CL)
wet, some fine-grained sand disseminated, medium plasticity, with sand

BROWN SANDY CLAY (CL)
moist, fine grained

140

BROWN SAND (SP)
wet, fine to medium grained (70% fine, 25% medium), angular to subrounded sand grains

150

BROWN CLAYEY SAND (SC)
very moist, fine-grained sand, cohesive

160

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Log of Boring MCAS- 6 (sheet 2 of 6)

Orange County Water District
Irvine, California

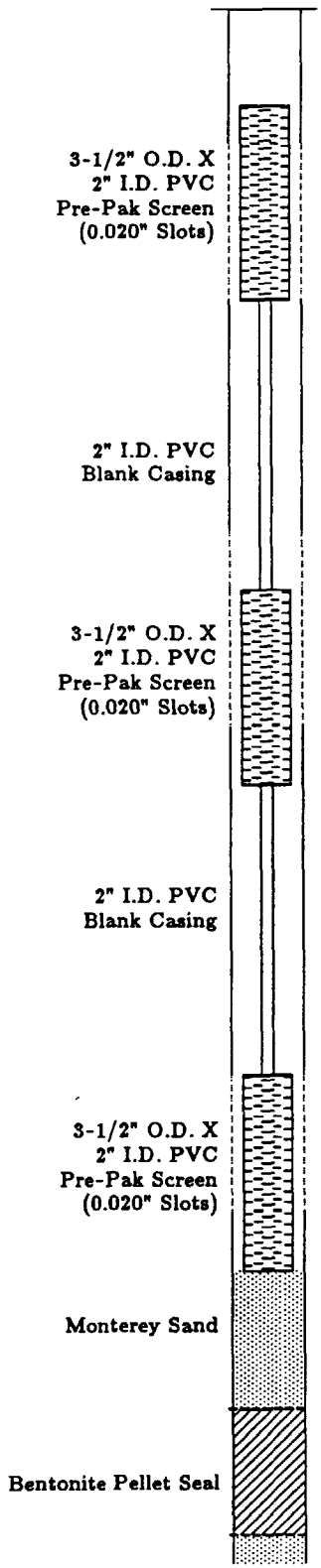
PLATE **5a**

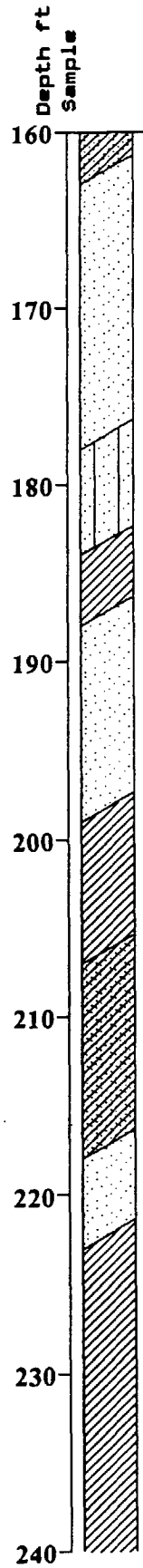
DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 9/25/89





LIGHT BROWN SAND (SP)
fine to medium grained

with 5-10% silt

LIGHT BROWN SILTY SAND (SM)
fine grained, with some clay

GRAY SANDY CLAY (CL)
fine grained, with silt

LIGHT GRAY SAND (SP)
fine grained, with some medium grained

fine and medium grained, subangular to subrounded

GRAY SANDY CLAY (CL)
fine to medium grained, low plasticity

color change to light gray, fine grained

GRAY CLAYEY SAND (SC)
fine grained

trace of angular, monoclastic gravel of siltstone

no gravel

LIGHT GRAY SAND (SP)
fine grained

GRAY SANDY CLAY (CL)
fine grained

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Log of Boring MCAS- 6 (sheet 3 of 6)

Orange County Water District
Irvine, California

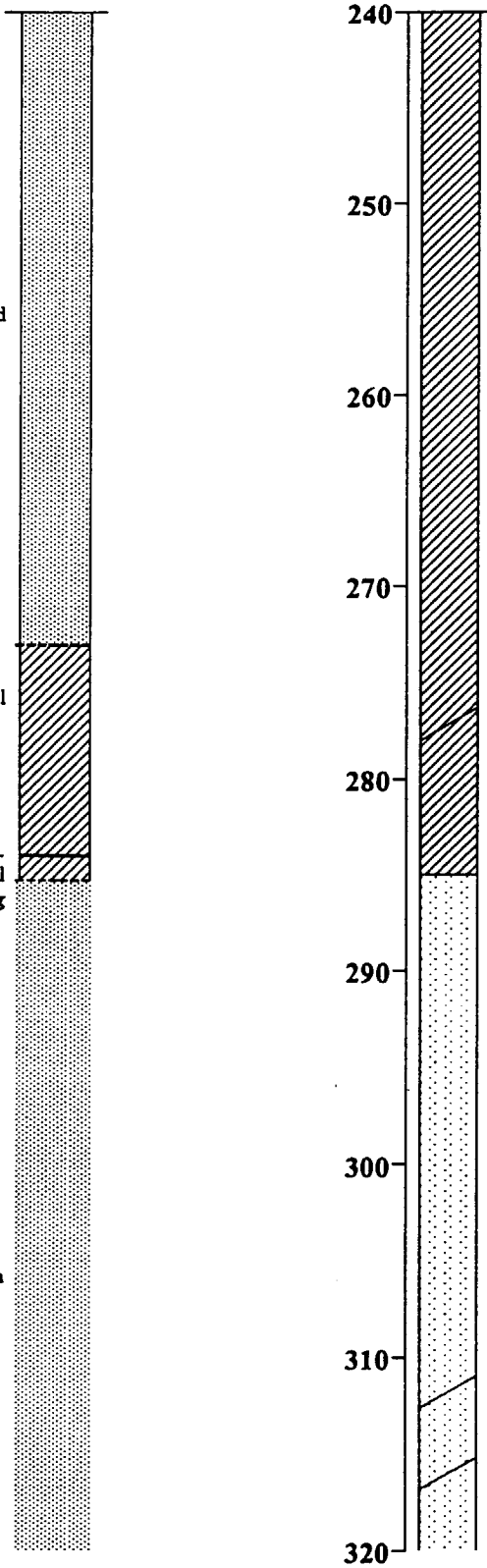
PLATE **5b**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 9/25/89



trace of angular to subangular gravel

GRAY TO BLUE-GRAY CLAY (CL)
with trace of fine-grained sand, angular to subangular

LIGHT GRAY QUARTZ SANDSTONE
low hardness, weak, moderate weathering, fine grained, well sorted, rounded subspherical

more lithic

color change to gray-brown, lithic quartz arenite

BROWN CLAYEY SANDSTONE
low hardness, weak, moderate weathering

GRAY-BROWN SANDSTONE (QUARTZ ARENITE, SLIGHTLY LITHIC)
fine grained, low hardness, weak, moderate

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Log of Boring MCAS- 6 (sheet 4 of 6)

Orange County Water District
Irvine, California

PLATE 5c

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 9/25/89

Depth ft

Sample

Monterey Sand/Slough

320 weathering

330 slightly lithic

340

350

lithic

color change to light gray

360

with silt

370

380

with angular fragments of gray siltstone

390 <5% fragments of siltstone

10-20% siltstone

400

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Log of Boring MCAS- 6 (sheet 5 of 6)

Orange County Water District
Irvine, California

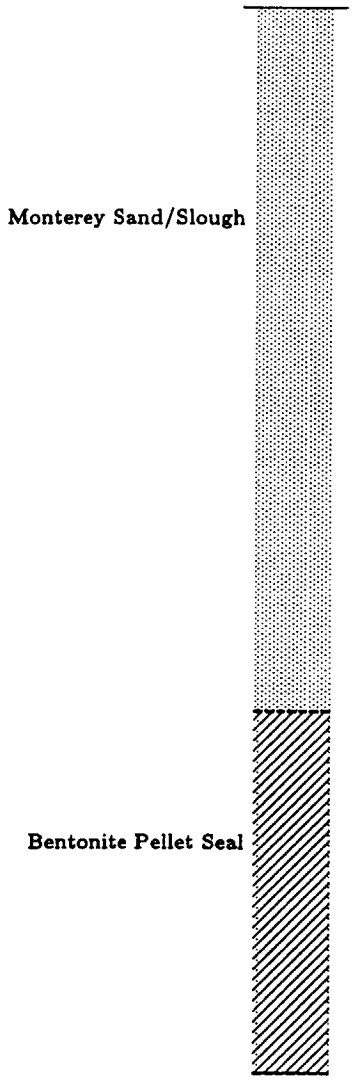
PLATE **5d**

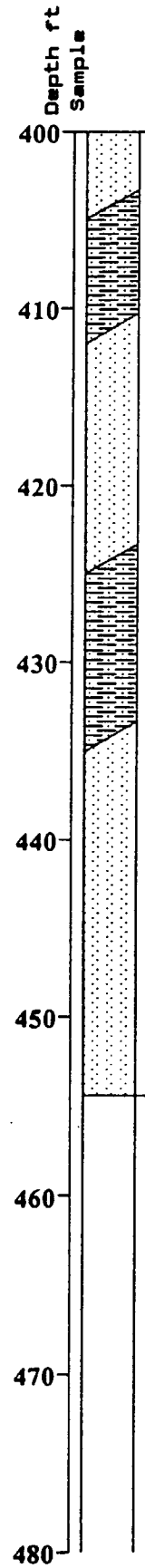
DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 9/25/89





<5% siltstone

70% siltstone fragments and 30% sandstone, increasing induration

90% sandstone

no recovery

siltstone with trace (10-20%) sandstone

sandstone with 20-30% siltstone

Boring terminated at 454.5 feet.
Steel casing driven to 285.3 feet in a 3-7/8-inch-diameter borehole.
Ground water encountered at approximately 58.5 feet during drilling.
Steel casing perforated with a mechanical wheel perforator.
Boring converted to ground-water observation well on 10/27/89.

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Log of Boring MCAS- 6 (sheet 6 of 6)

Orange County Water District
Irvine, California

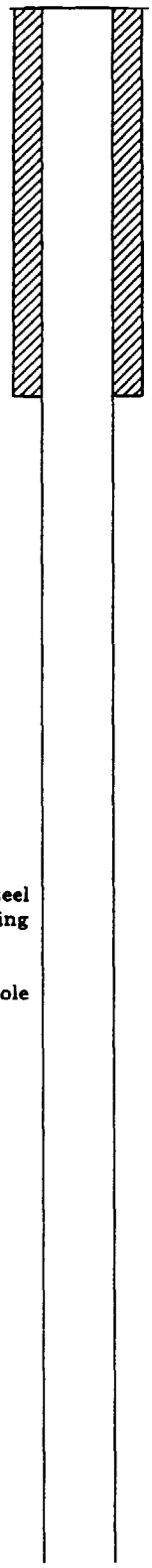
PLATE **5e**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 9/14/89



Depth ft | Sample

0

BROWN SILTY SAND (SM)
dry to slightly moist, fine grained, rootlets

no recovery

no recovery

10

BROWN CLAYEY SAND (SC)
moist, fine grained

no recovery

20

BROWN SILTY SAND (SM)
moist, fine grained, with clay

30

BROWN CLAYEY SAND (SC)
moist, fine grained

40

MEDIUM DARK BROWN SANDY CLAY (CL)
moist, fine-grained sand

BROWN SAND (SP)
moist, medium grained, trace of coarse-grained sand, with subangular gravel

50

no recovery

no recovery

60

BROWN SANDY CLAY (CL)
moist to very moist, fine grained, with trace of medium-grained sand

70

BROWN CLAYEY SAND (SC)
moist, fine grained

80

BROWN SANDY CLAY (CL)

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Log of Boring MCAS- 8 (sheet 1 of 6)

Orange County Water District
Irvine, California

PLATE **6**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 9/14/89

Depth ft

Sample

4" dia. Carbon Steel Blank Casing

3-7/8" dia. Borehole

80

moist, fine-grained sand

90

BROWN SAND (SP)
wet, fine to medium grained, trace of clay

BROWN CLAYEY SAND (SC)
wet, fine to medium grained

100

BROWN CLAY (CL)
wet, with fine- to medium-grained sand (10%), low plasticity
water level measured on 11/3/89

110

fine- to medium-grained sand (15-20%)

TAN SILTY SAND WITH CLAY (SM)
fine to medium grained

TAN SANDY CLAY (CL)
fine-grained sand, trace of medium-grained sand, subrounded, low plasticity

120

130

color change to brown, with fine- to medium-grained sand

LIGHT BROWN SAND (SP)
fine to medium grained, with some clay

140

10% coarse-grained sand

150

160

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Log of Boring MCAS- 8 (sheet 2 of 6)

Orange County Water District
Irvine, California

PLATE **6a**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 9/14/89

Depth ft | Sample

4" dia. Carbon Steel Blank Casing

3-7/8" dia. Borehole

160

color change to light gray-brown, 5-10% clay

BROWN-GRAY CLAY (CL)
with fine- to medium-grained sand

170

GRAY SAND (SP)
fine grained, micaceous

180

GRAY CLAYEY SAND (SC)
fine grained

190

GRAY SAND (SP)
fine grained, trace of medium grained

200

with trace of silt

GRAY SANDY CLAY (CL)
with fine-grained sand, medium plasticity

GRAY SAND (SP)
fine grained with medium grained, sand 70% quartz grains

210

GRAY SILTY SAND (SM)
fine grained, with trace of medium-grained sand

GRAY SANDY CLAY (CL)
fine-grained sand, low to moderate plasticity

220

230

240

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Log of Boring MCAS- 8 (sheet 3 of 6)

Orange County Water District
Irvine, California

PLATE 6b

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 9/14/89

Depth ft | Sample

240

250

LIGHT GRAY SAND (SP)
medium grained, with angular gravel

GRAY CLAYEY SAND (SC)
fine to medium grained

260

minor clay content (5-10%)

270

15-20% clay

280

4" dia. Carbon Steel Blank Casing

3-7/8" dia. Borehole

trace of gravel (No. 4 sieve to 1/2-inch diameter) subangular

GRAY SILTY SAND (SM)
fine grained

290

LIGHT GRAY SAND (SP)
fine grained, quartz-rich

LIGHT GRAY SANDY SILT (ML)
fine grained

300

GRAY CLAYEY SAND (SC)
fine to coarse grained

310

fine to medium grained

BROWN SANDY CLAY (CL)
fine grained, sand lenses, low plasticity

320

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Log of Boring MCAS- 8 (sheet 4 of 6)

Orange County Water District
Irvine, California

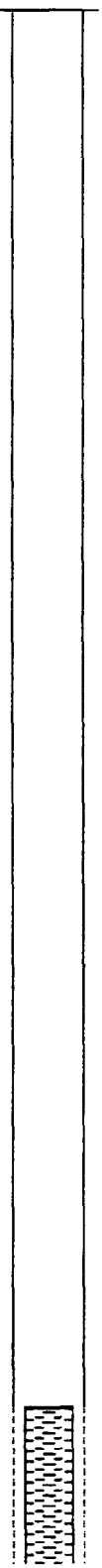
PLATE 6c

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 9/14/89



Depth ft
Sample

320
330
340
350
360
370
380
390
400

LIGHT GRAY SAND (SP)
fine grained

fine to medium grained

70% medium grained

trace of subangular gravel

GRAY SANDY CLAY (CL)
fine grained

LIGHT GRAY SAND (SP)
medium grained, 90% quartz grains, subangular

70% fine grained, 20% medium grained

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Log of Boring MCAS- 8 (sheet 5 of 6)

Orange County Water District
Irvine, California

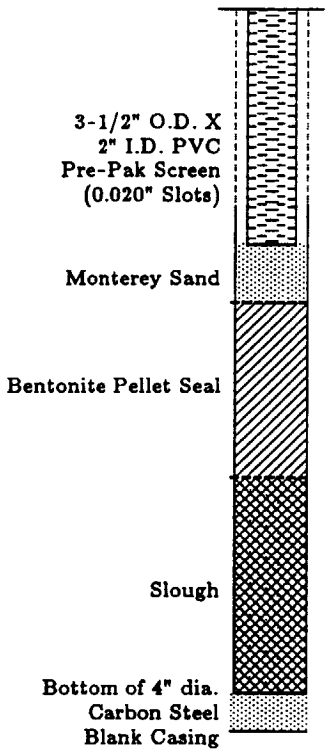
PLATE 6d

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 9/14/89



Depth ft

Sample

400

410

420

430

440

450

460

470

480

2-5% coarse grained

medium grained, angular

trace of coarse grained

GRAY SILTY SAND (SM)
very fine grained, with fragments of gray siltstone
GRAY SAND (SP)
fine grained

Boring terminated at 437.0 feet.
Steel casing driven to 435.0 feet in a 3-7/8-inch-diameter borehole.
Ground water encountered at approximately 60.0 feet during drilling.
Steel casing perforated with a mechanical wheel perforator.
Boring converted to ground-water observation well on 11/2/89.

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Log of Boring MCAS- 8 (sheet 6 of 6)

Orange County Water District
Irvine, California

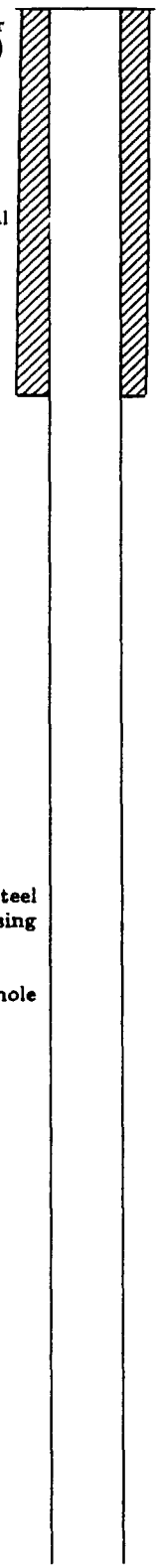
PLATE **6e**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 10/5/89



Depth ft	Sample	
0		DARK BROWN CLAY (CL) [FILL] wet, with rootlets
		very moist
10		color change to mottled dark brown to tan-brown possibly perched ground water encountered color change to light brown
		with trace of fine-grained sand
20		no recovery
		no recovery
30		color change to light brown, wet, with some fine- to medium-grained sand
40		no recovery
		BROWN SANDY CLAY (CL) wet, fine grained
50		
		water level measured on 10/26/89
		BROWN CLAYEY SAND (SC) wet, fine grained
60		
		BROWN SILTY SAND (SM) very moist, fine grained
70		with trace of medium- and coarse-grained sand
		fine grained
		BROWN CLAY (CL) moist, with some fine-grained sand
80		

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Log of Boring MCAS- 9 (sheet 1 of 6)

Orange County Water District
Irvine, California

PLATE **7**

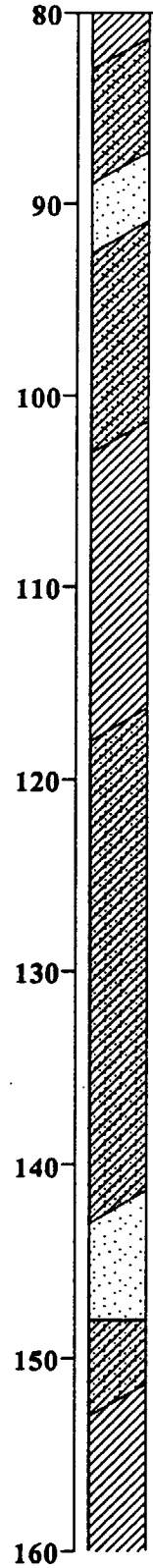
DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 10/5/89

Depth ft
Sample



BROWN CLAYEY SAND (SC)
slightly moist, fine grained

LIGHT BROWN SAND (SP)
dry, fine grained

BROWN CLAYEY SAND (SC)
dry, fine grained

with calcareous nodules

BROWN SANDY CLAY (CL)
moist to wet, fine grained, with some medium grained

BROWN CLAYEY SAND (SC)
moist, fine grained, with silt

4" dia. Carbon Steel Blank Casing

3-7/8" dia. Borehole

with trace of medium-grained sand

LIGHT BROWN SAND (SP)
moist, fine grained, with trace of silt

BROWN CLAYEY SAND (SC)
moist, fine grained

BROWN SANDY CLAY (CL)
moist, fine grained

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Log of Boring MCAS- 9 (sheet 2 of 6)

Orange County Water District
Irvine, California

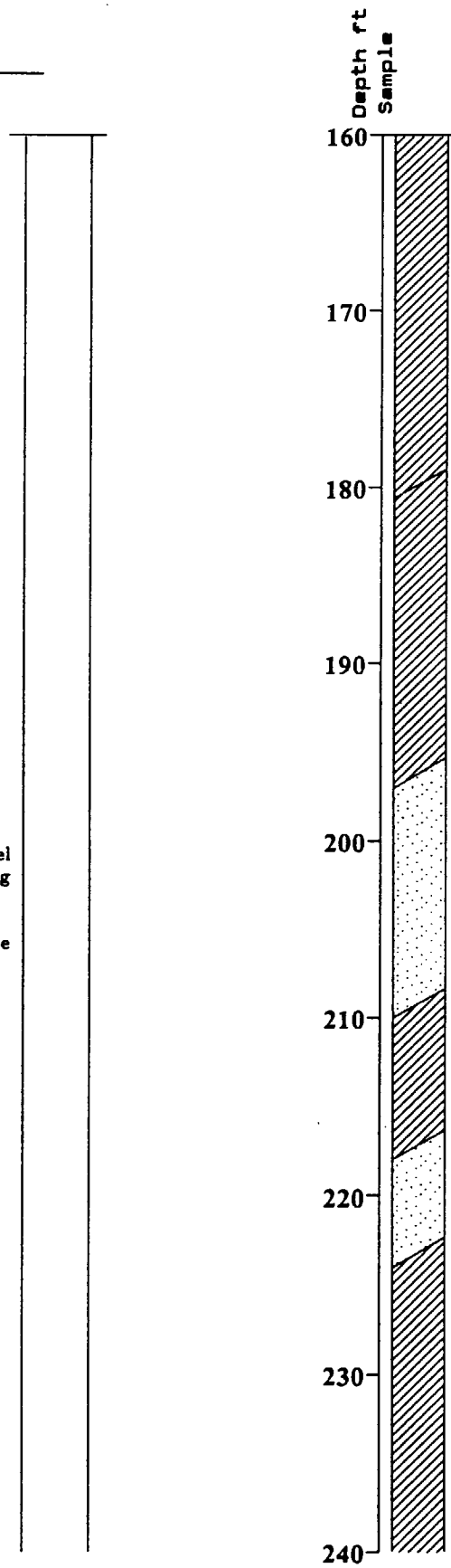
PLATE **7a**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 10/5/89



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Log of Boring MCAS- 9 (sheet 3 of 6)

Orange County Water District
Irvine, California

PLATE **7b**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 10/5/89

Depth ft

Sample

4" dia. Carbon Steel Blank Casing

3-7/8" dia. Borehole

240

12-25% sand, fine grained

GRAY-BROWN CLAYEY SAND (SC)
fine grained

250

GRAY-BROWN SANDY CLAY (CL)
fine grained

260

LIGHT BROWN CLAYEY SAND (SC)
fine grained

270

BROWN SANDY CLAY (CL)
with some very fine to fine-grained sand, with calcareous nodules

BROWN CLAYEY SAND (SC)
fine to medium grained

280

BROWN SANDY CLAY (CL)
fine-grained sand

LIGHT GRAY-BROWN SAND (SP)
fine grained, with trace of angular to subangular gravel

290

BROWN CLAYEY SAND (SC)
fine and coarse grained, with angular gravel, calcareous fragments of cemented fine-grained sand

300

GRAY SAND (SP)
fine to coarse grained, with trace of gray siltstone fragments

GRAY CLAY (CL)
with trace of fine-grained sand

310

LIGHT GRAY SAND (SP)
fine grained, with clay, trace of calcareous fragments of cemented fine-grained sand

320

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Log of Boring MCAS- 9 (sheet 4 of 6)

Orange County Water District
Irvine, California

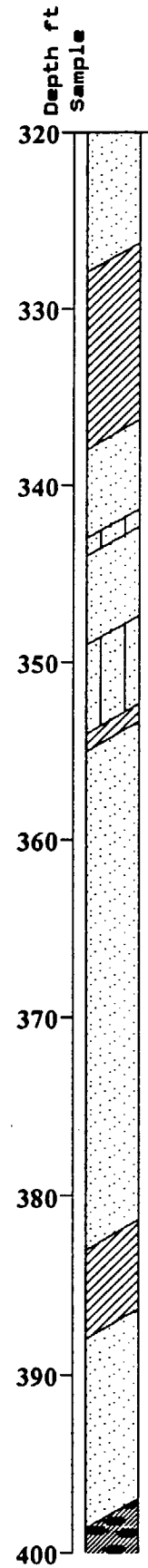
PLATE **7c**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 10/5/89



4" dia. Carbon Steel Blank Casing

3-7/8" dia. Borehole

3-1/2" O.D. X 2" I.D. PVC Pre-Pak Screen (0.020" Slots)

2" I.D. PVC Blank Casing

GRAY SANDY CLAY (CL)
fine-grained sand

gravels of subangular sandstone

high plasticity, little or no sand

GRAY SAND (SP)
fine to medium grained, quartz-rich, with some clay, with seashell fragments and whole shells

GRAY SILTY SAND (SM)
fine grained

LIGHT GREEN-BROWN SAND (SP)
fine grained, quartz-rich, with some seashell fragments
color change to brown

BROWN SILTY SAND (SM)
fine grained, with some clay

LIGHT GRAY-BROWN SANDY CLAY (CL)
fine grained, with trace of medium grained

LIGHT BROWN SAND (SP)
fine to medium grained, with trace of clay, with calcareous fragments of cemented sand

color change to brown, with clay

color change to light brown, with some angular to subrounded gravel

with medium-grained sand and trace of subangular gravel (passing 1/2-inch sieve)

BROWN CLAY (CL)
with fine-grained sand

LIGHT BROWN SAND (SP)
fine to medium grained, with some clay

subangular to subrounded sand grains

LIGHT BROWN CLAYEY GRAVEL (GC)
with medium- to coarse-grained sand, angular to

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Log of Boring MCAS- 9 (sheet 5 of 6)

Orange County Water District
Irvine, California

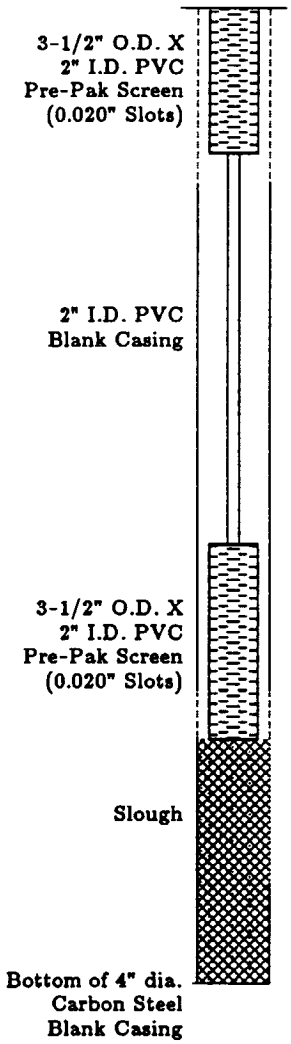
PLATE **7d**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 10/5/89



Depth ft	Sample	
400		subangular gravel
		LIGHT BROWN SAND (SP)
		fine to medium grained, with trace of clay
		medium to coarse grained, rounded sand, with trace of subangular gravel (passing 1/2-inch sieve)
410		medium grained
		BROWN SANDY CLAY (CL)
		fine to medium grained
420		color change to light brown
		LIGHT BROWN SAND (SP)
		fine grained, with trace of subrounded gravel, with trace of clay
		LIGHT BROWN CLAYEY SAND (SC)
430		fine grained
		LIGHT GRAY-BROWN SAND (SP)
		fine grained, with some silt
		with trace of subangular to subrounded gravel
440		
		color change to light brown, medium grained, with trace of subangular gravel
450		fine to medium grained, with some clay
		Boring terminated at 450.0 feet.
		Steel casing driven to 450.0 feet in a 3-7/8-inch-diameter borehole.
		Perched ground water encountered at approximately 12.0 feet during drilling.
		Ground water encountered at approximately 97.5 feet during drilling.
460		Steel casing perforated with a mechanical wheel perforator.
		Boring converted to ground-water observation well on 10/25/89.
470		
480		

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Log of Boring MCAS- 9 (sheet 6 of 6)

Orange County Water District
Irvine, California

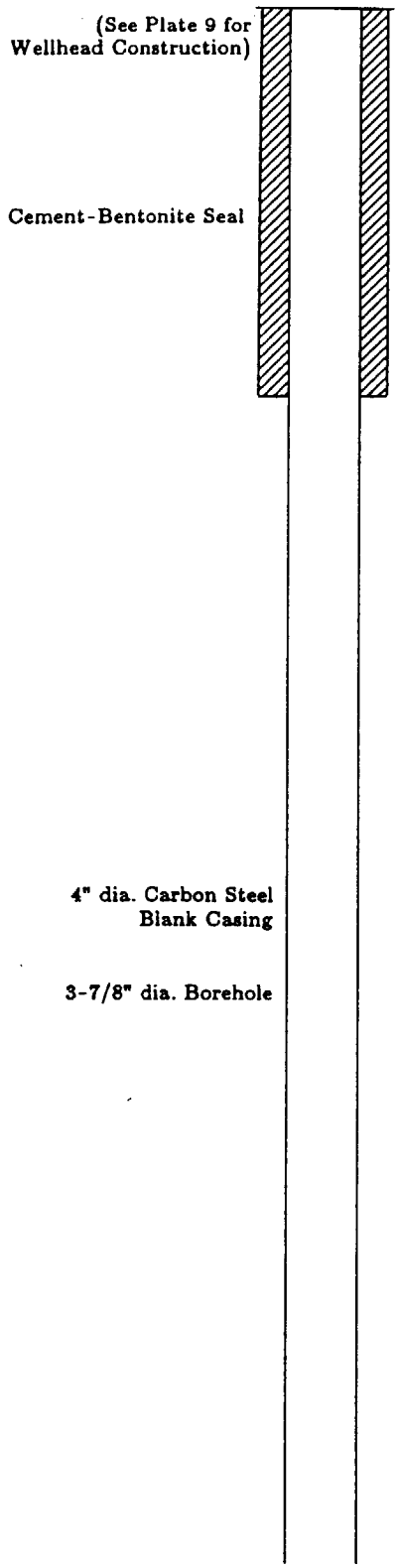
PLATE **7e**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 10/17/89



Depth ft | Sample

0

DARK BROWN CLAY (CL)
with trace of fine- to medium-grained sand
BROWN CLAYEY SAND (SC)
fine grained

10

20

no recovery

no recovery

30

40

no recovery

no recovery

no recovery

50

BROWN SANDY CLAY (CL)
fine grained, with trace of medium- to coarse-grained sand

no recovery

60

water level measured on 11/6/89
no recovery

BROWN CLAYEY SAND (SC)
fine grained

70

no recovery
LIGHT BROWN SAND (SP)
fine grained

80

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Log of Boring MCAS-10 (sheet 1 of 5)

Orange County Water District
Irvine, California

PLATE **8**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 10/17/89

Depth ft | Sample

4" dia. Carbon Steel Blank Casing

3-7/8" dia. Borehole

80

LIGHT BROWN CLAYEY SAND (SC)
fine grained, with angular to subangular gravel

90

no gravel
LIGHT BROWN SILTY SAND (SM)
fine grained, with some clay

BROWN CLAYEY SAND (SC)
fine grained, with trace of medium grained, with trace of subangular gravel

100

LIGHT BROWN SAND (SP)
fine to medium grained, with trace of subangular gravel

BROWN SILTY SAND (SM)
fine grained, with minor clay, with trace of subangular gravel

110

LIGHT GRAY-BROWN CLAYEY SAND (SC)
fine grained, with trace of medium grained, with trace of subangular gravel

120

no recovery
LIGHT BROWN SANDY CLAY (CL)
fine grained, with trace of medium-grained sand, with trace of subangular gravel

LIGHT BROWN SAND (SP)
fine to medium grained, with trace of subangular gravel

130

LIGHT BROWN GRAVELLY SAND (SP)
medium to coarse grained, angular to subangular gravel, with clay

140

minor gravel
LIGHT BROWN CLAYEY SAND (SC)
fine grained, with some medium grained

150

fine grained
BROWN SANDY CLAY (CL)
fine to medium grained, trace of coarse grained

LIGHT BROWN SAND (SP)
fine grained, with minor clay

160

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Log of Boring MCAS-10 (sheet 2 of 5)

Orange County Water District
Irvine, California

PLATE **8a**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 10/17/89

Depth ft | Sample

4" dia. Carbon Steel Blank Casing

3-7/8" dia. Borehole

160

BROWN CLAYEY SAND (SC)
fine grained

LIGHT BROWN SANDY CLAY (CL)
fine grained

170

color change to light gray-brown, with trace of medium-grained sand

180

color change to light brown, fine-grained sand

190

LIGHT BROWN CLAYEY SAND (SC)
fine to medium grained

BROWN SAND (SP)
fine to medium grained, with trace of subangular gravel
no recovery

200

color change to gray-brown, no gravel

210

with minor clay

220

LIGHT BROWN SANDY CLAY (CL)
fine to medium grained

LIGHT BROWN SAND (SP)
predominantly medium grained, with some fine grained

230

DARK BROWN AND LIGHT BROWN CLAY (CL)
laminated, with trace of fine-grained sand, high plasticity

LIGHT BROWN SAND (SP)
fine to medium grained

240

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Log of Boring MCAS-10 (sheet 3 of 5)

Orange County Water District
Irvine, California

PLATE 8b

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 10/17/89

Depth ft | Sample

240

LIGHT GRAY-BROWN SANDY CLAY (CL)
fine grained

250

260

LIGHT BROWN SAND (SP)
fine grained, with minor clay

270

fine to medium grained

280

4" dia. Carbon Steel Blank Casing

3-7/8" dia. Borehole

290

minor angular gravel

300

LIGHT GRAY-BROWN CLAYEY SAND (SC)
fine grained, trace of coarse-grained sand, clasts composed of fine-grained quartz arenite

LIGHT BROWN-GRAY CLAY (CL)
with some fine- to medium-grained sand

310

LIGHT BROWN SAND (SP)
fine grained

320

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Log of Boring MCAS-10 (sheet 4 of 5)

Orange County Water District
Irvine, California

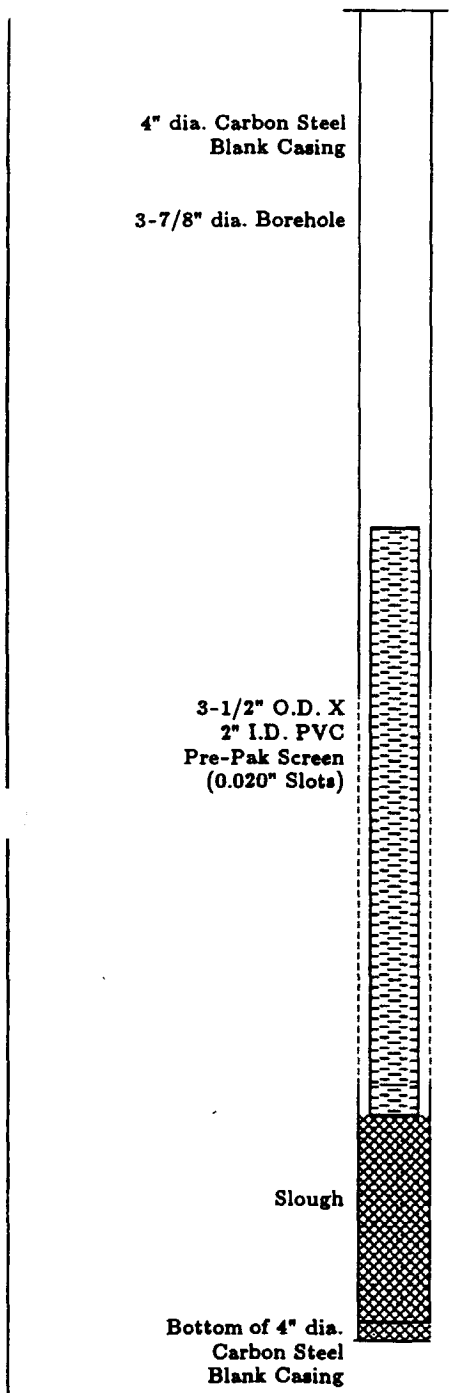
PLATE 8c

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

Top of Casing NA

Equipment Air Rotary

Elevation NA Date 10/17/89



Depth ft	Sample	Description
320		no recovery
		color change to light gray-brown, medium grained, with trace of gravel
330		fine and medium grained
		TAN CLAYEY SAND (SC) fine grained
340		
350		LIGHT BROWN SANDY GRAVEL (GP) angular to subangular gravel, fine- to coarse-grained sand, with minor clay
		LIGHT BROWN SAND (SP) fine to medium grained, with trace of coarse grained, with minor clay
360		
		trace of subangular gravel
370		
		color change to light gray
380		color change to light brown
		predominantly fine grained
390		Boring terminated at 389.0 feet. Steel casing driven to 388.4 feet in a 3-7/8-inch-diameter borehole. Ground water encountered at 16.5 feet during drilling. Steel casing perforated with a mechanical wheel perforator. Boring converted to ground-water observation well on 11/6/89.
400		

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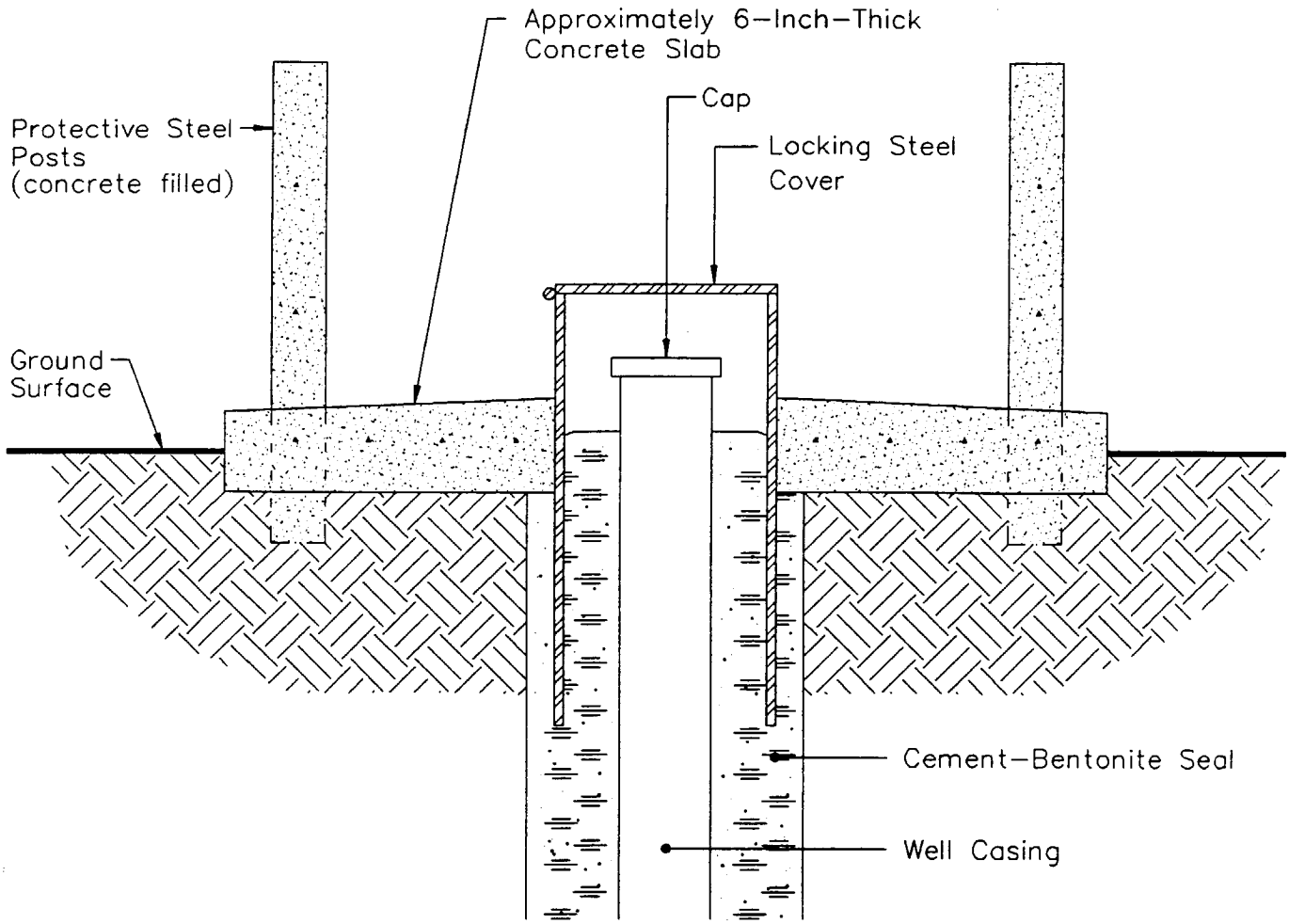
Log of Boring MCAS-10 (sheet 5 of 5)

Orange County Water District
Irvine, California

PLATE **8d**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

18\9859054\LSC



WELLHEAD DETAIL

	Bentonite-Cement Grout
	Blank Carbon Steel Casing
	Bentonite Seal
	Filter Sand
	Slotted PVC Casing
	Slough

	Bentonite Grout

KEY TO WELL DETAIL (ON LOGS OF BORINGS)

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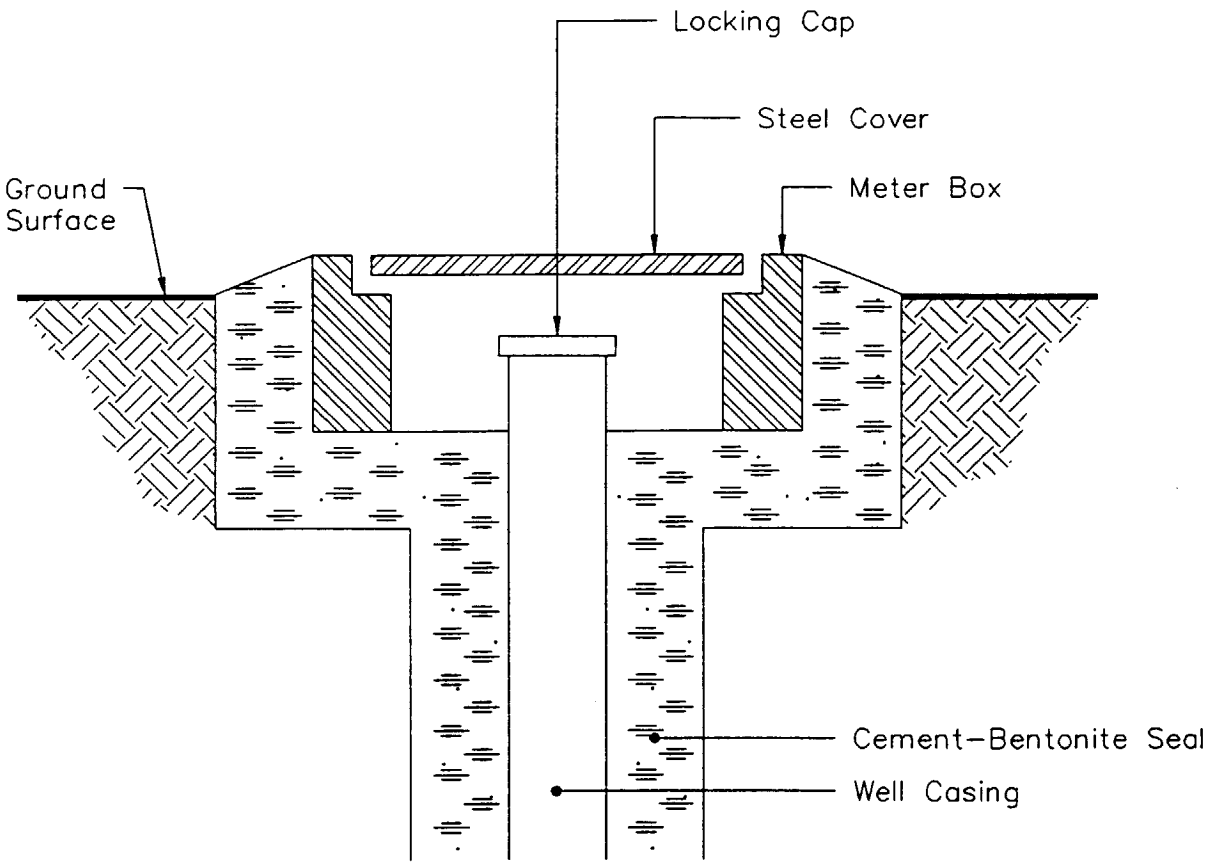
ABOVEGROUND WELLHEAD DETAIL
Orange County Water District
Irvine, California

PLATE
9

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
JTL	9859,054.11		11/89		

859054\MTRBOX



WELLHEAD DETAIL

	Bentonite-Cement Grout		Bentonite Grout
	Blank Carbon Steel Casing		
	Bentonite Seal		
	Filter Sand		
	Slotted PVC Casing		
	Slough		

KEY TO WELL DETAIL (ON LOGS OF BORINGS)

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BELOW GROUND WELLHEAD DETAIL
Orange County Water District
Irvine, California

PLATE
10

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
HK	9859,054.11		11/89		

APPENDIX B

WATER QUALITY ANALYSIS SUMMARY TABLES

Table B1. Water Sample Analyses Showing Those VOCs Found Above Reportable Limits

Date Printed: 08/09/90

Well No.	Sample/ Screen Depth (feet)	Date Sampled	EC	TCE	PCE	trans-1,2 DCE	1,1,1 TCA	CCl4	Chloroform	Chloro-benzene	Ethyl-benzene	Toluene
Monitoring Wells Constructed and Sampled by OCWD:												
MCAS-1	65	01/04/89	2191	ND	ND	ND	TR*	ND	2.0	ND	ND	TR*
		02/06/89	2329	ND	ND	ND	ND	ND	2.0	ND	ND	ND
		05/05/89	2323	ND	ND	ND	ND	ND	2.1	ND	ND	ND
		10/19/89	2110	ND	ND	ND	ND	ND	1.5	ND	ND	ND
		02/08/90	NT	ND	ND	ND	ND	ND	1.0	ND	ND	ND
	155	01/04/89	2905	ND	ND	ND	TR*	ND	ND	ND	ND	TR*
		02/06/89	3050	ND	ND	ND	ND	ND	ND	ND	ND	ND
		05/05/89	2952	ND	ND	ND	ND	ND	ND	ND	ND	ND
		10/19/89	2970	ND	ND	ND	ND	ND	ND	ND	ND	ND
		02/08/90	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND
	215	01/04/89	1871	1.8	ND	ND	TR*	ND	ND	ND	ND	TR*
		02/06/89	1973	1.5	ND	ND	ND	ND	ND	ND	ND	ND
		05/05/89	2009	1.6	ND	ND	ND	ND	ND	ND	ND	ND
		10/19/89	1950	1.3	ND	ND	ND	ND	ND	ND	ND	ND
		02/08/90	NT	1.5	ND	ND	ND	ND	ND	ND	ND	ND
	275	01/04/89	1713	4.8	ND	ND	TR*	ND	TR	ND	ND	TR*
		02/06/89	1178	5.2	ND	ND	ND	ND	TR	ND	ND	ND
		05/05/89	1694	8.1	ND	ND	ND	ND	TR	ND	ND	ND
		10/19/89	1800	3.8	ND	ND	ND	ND	ND	ND	ND	ND
		02/08/90	NT	4.5	ND	ND	ND	ND	ND	ND	ND	ND
	335	01/04/89	NT	34.6	ND	TR	ND	ND	TR	ND	ND	ND
		02/06/89	NT	39.1	ND	TR	ND	ND	0.5	ND	ND	ND
		05/05/89	1316	47.5	ND	TR	ND	ND	TR	ND	ND	ND
		10/19/89	1580	17.7	ND	ND	ND	ND	ND	ND	ND	ND
		02/08/90	NT	36.5	ND	ND	ND	ND	ND	ND	ND	ND

Notes : All units in micrograms/liter, except for Electrical Conductivity, which is in micromhos/centimeter.
TR = constituent detected below reportable limit
ND = Not Detected; NT = Not Tested

Well No.	Sample/ Screen Depth (feet)	Date Sampled	EC	TCE	PCE	trans-1,2 DCE	1,1,1 TCA	CCl4	Chloroform	Chloro-benzene	Ethyl-benzene	Toluene
	455	01/04/89	1477	45.1	ND	1.4	ND	ND	TR	ND	ND	ND
		02/06/89	1189	51.9	ND	1.8	ND	ND	TR	ND	ND	ND
		05/05/89	1162	46.1	ND	1.9	ND	ND	ND	ND	ND	ND
		10/19/89	1240	30.0	ND	ND	ND	ND	ND	ND	ND	ND
		02/08/90	NT	38.0	ND	3.3	ND	ND	ND	ND	ND	ND
	545	01/04/89	2550	TR	ND	ND	ND	ND	0.7	TR	ND	ND
		02/06/89	2534	ND	ND	ND	ND	ND	0.5	TR	ND	ND
		05/05/89	2420	ND	ND	ND	ND	ND	TR	TR	ND	ND
		10/19/89	2260	ND	ND	ND	ND	ND	ND	0.5	ND	ND
		02/08/90	NT	ND	ND	ND	ND	ND	ND	TR	ND	ND
MCAS-2	45	12/27/88	2732	ND	ND	ND	ND	ND	ND	ND	ND	ND
		02/07/89	2900	ND	ND	ND	ND	ND	ND	ND	ND	ND
		05/03/89	2904	ND	ND	ND	ND	ND	ND	ND	ND	ND
		10/17/89	2820	ND	ND	ND	ND	ND	ND	ND	ND	ND
		03/13/90	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND
	135	12/27/88	3939	ND	ND	ND	ND	ND	ND	ND	ND	ND
		02/07/89	3943	ND	ND	ND	ND	ND	ND	ND	ND	ND
		05/03/89	4211	ND	ND	ND	ND	ND	ND	ND	ND	ND
		10/17/89	4140	ND	ND	ND	ND	ND	ND	ND	ND	ND
		03/13/90	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND
	205	12/27/88	1699	1.4	ND	ND	ND	ND	ND	ND	ND	ND
		02/07/89	1810	1.8	TR	ND	ND	ND	ND	ND	ND	ND
		05/03/89	1839	2.0	TR	ND	ND	ND	ND	ND	ND	ND
		10/17/89	1800	3.0	TR	ND	ND	ND	ND	ND	ND	ND
		03/13/90	NT	2.2	ND	ND	ND	ND	ND	ND	ND	ND
	375	12/27/88	1280	34.6	ND	ND	ND	ND	TR	ND	ND	ND
		02/16/89	1376	28.5	ND	ND	ND	ND	TR	ND	ND	ND
		05/03/89	1384	32.2	TR	ND	ND	ND	TR	ND	ND	ND
		10/17/89	1390	37.2	TR	ND	ND	ND	TR	ND	ND	ND
		03/13/90	NT	25.6	ND	ND	ND	ND	TR	ND	ND	ND

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ND = Not Detected; NT = Not Tested

Well No.	Sample/ Screen Depth (feet)	Date Sampled	EC	TCE	PCE	trans-1,2 DCE	1,1,1 TCA	CCl4	Chloroform	Chloro-benzene	Ethyl-benzene	Toluene
	425	12/27/88	1172	38.9	ND	0.6	ND	ND	ND	ND	ND	ND
		02/08/89	1256	37.0	ND	0.5	ND	ND	ND	ND	ND	ND
		05/03/89	1273	33.9	ND	TR	ND	ND	ND	ND	ND	ND
		10/10/89	1310	51.9	ND	0.5	ND	ND	ND	ND	ND	ND
		03/13/90	NT	28.7	ND	TR	ND	ND	ND	ND	ND	ND
	495	12/27/88	2437	ND	ND	ND	ND	ND	ND	ND	ND	ND
		02/08/89	2807	ND	ND	ND	ND	ND	ND	ND	ND	ND
		05/03/89	2614	ND	ND	ND	ND	ND	ND	ND	ND	ND
		10/10/89	2130	ND	ND	ND	ND	ND	ND	ND	ND	ND
		03/13/90	NT	ND	ND	ND	ND	ND	ND	TR	0.6	ND
	555	12/27/88	3033	ND	ND	ND	ND	ND	ND	ND	ND	0.5
		02/08/89	3371	ND	ND	ND	ND	ND	ND	ND	ND	ND
		05/03/89	3340	ND	ND	ND	ND	ND	ND	0.6	ND	TR
		10/10/89	3460	ND	ND	ND	ND	ND	ND	1.0	ND	TR
		03/13/90	NT	ND	ND	ND	ND	ND	ND	1.0	0.7	0.5
	625	12/27/88	2609	ND	ND	ND	ND	ND	ND	TR	ND	0.9
		02/08/89	2918	ND	ND	ND	ND	ND	ND	0.6	0.9	0.6
		05/03/89	2904	ND	ND	ND	ND	ND	ND	0.7	1.0	TR
		10/10/89	2450	ND	ND	ND	ND	ND	ND	0.7	1.3	TR
		03/13/90	NT	ND	ND	ND	ND	ND	ND	0.8	1.2	TR
MCAS-3	90	12/06/88	2606	ND	ND	ND	ND	ND	2.8	ND	ND	ND
		01/30/89	2750	ND	ND	ND	ND	ND	2.1	ND	ND	ND
		04/13/89	2682	ND	ND	ND	ND	ND	2.1	ND	ND	ND
		10/10/89	2930	ND	ND	ND	ND	ND	1.6	ND	ND	ND
		02/09/90	NT	ND	ND	ND	ND	ND	1.1	ND	ND	ND
		03/13/90	NT	ND	ND	ND	ND	ND	0.8	ND	ND	ND
	165	12/06/88	1929	ND	ND	ND	ND	ND	0.7	ND	ND	ND
		01/30/89	2036	ND	ND	ND	ND	ND	TR	ND	ND	ND
		04/13/89	2131	ND	ND	ND	ND	ND	TR	ND	ND	ND
		10/10/89	2210	6.8	ND	ND	ND	ND	1.0	ND	ND	ND
		02/09/90	NT	14.6	ND	ND	ND	ND	0.5	ND	ND	ND
		03/13/90	NT	18.1	TR	ND	ND	ND	TR	ND	ND	ND

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ND = Not Detected; NT = Not Tested

Well No.	Sample/ Screen Depth (feet)	Date Sampled	EC	TCE	PCE	trans-1,2 DCE	1,1,1 TCA	CCl4	Chloroform	Chloro-benzene	Ethyl-benzene	Toluene
	225	12/06/88	1260	ND	ND	ND	ND	ND	ND	ND	ND	ND
		01/30/89	1240	ND	ND	ND	ND	ND	ND	ND	ND	ND
		04/13/89	1140	ND	ND	ND	ND	ND	ND	ND	ND	ND
		10/09/89	1270	ND	ND	ND	ND	ND	ND	ND	ND	ND
		02/09/90	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND
		03/13/90	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND
	345	12/06/88	1041	ND	ND	ND	TR	ND	ND	ND	ND	ND
		01/30/89	1013	ND	ND	ND	ND	ND	ND	ND	ND	ND
		04/13/89	1073	ND	ND	ND	ND	ND	ND	ND	ND	ND
		10/09/89	1050	ND	ND	ND	ND	ND	ND	ND	ND	ND
		02/09/90	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND
	425	12/06/88	1203	ND	ND	ND	ND	ND	ND	ND	ND	ND
		01/30/89	1013	ND	ND	ND	ND	ND	ND	ND	ND	ND
		04/13/89	1044	ND	ND	ND	ND	ND	ND	ND	ND	ND
		10/09/89	1190	ND	ND	ND	ND	ND	ND	ND	ND	ND
		02/09/90	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND
	495	12/06/88	1203	ND	ND	ND	ND	ND	ND	ND	ND	ND
		01/30/89	1215	ND	ND	ND	ND	ND	ND	ND	ND	ND
		04/13/89	1265	ND	ND	ND	ND	ND	ND	ND	ND	ND
		10/09/89	1220	ND	ND	ND	ND	ND	ND	ND	ND	ND
		02/09/90	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND
MCAS-4	181-238	10/23/89	1320	3.1	ND	ND	ND	ND	5.8	ND	ND	ND
		02/23/90	1330	3.1	ND	ND	ND	ND	ND	ND	ND	ND
MCAS-5	142-148	10/19/89	1430	1.2	ND	ND	ND	ND	TR	ND	ND	ND
		03/07/90	1380	1.4	ND	ND	ND	ND	ND	ND	ND	ND
MCAS-6	167-222	10/28/89	1150	2.2	ND	ND	ND	ND	TR	TR	ND	ND
		03/09/90	1050	1.5	ND	ND	ND	ND	ND	ND	ND	ND
MCAS-7	94	10/17/88	3210	ND	ND	ND	ND	ND	ND	ND	ND	ND
		11/30/88	3294	ND	ND	ND	ND	ND	ND	ND	ND	ND
		01/20/89	3211	ND	ND	ND	ND	ND	ND	ND	ND	ND
		05/04/89	3480	ND	ND	ND	ND	ND	ND	ND	ND	ND

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Well No.	Sample/ Screen Depth (feet)	Date Sampled	EC	TCE	PCE	trans-1,2 DCE	1,1,1 TCA	CCl4	Chloroform	Chloro-benzene	Ethyl-benzene	Toluene
	194	10/17/88	NT	3.0	ND	ND	ND	ND	ND	ND	ND	ND
		11/30/88	1203	2.6	ND	ND	ND	ND	ND	ND	ND	ND
		01/20/89	1141	3.2	ND	ND	ND	ND	ND	ND	ND	ND
		05/04/89	1190	2.7	ND	ND	ND	ND	ND	ND	ND	ND
	354	10/17/88	1195	20.0	ND	TR	ND	ND	ND	ND	ND	ND
		11/30/88	1076	24.8	ND	0.5	ND	ND	ND	ND	ND	ND
		01/20/89	1003	19.8	ND	TR	ND	ND	ND	ND	ND	ND
		05/04/89	1860	13.9	ND	ND	ND	ND	ND	ND	ND	ND
	444	10/17/88	1050	19.4	ND	4.1	ND	ND	ND	ND	ND	ND
		11/30/88	1036	19.7	ND	4.2	ND	ND	ND	ND	ND	ND
		01/19/89	1005	23.6	ND	4.1	ND	ND	ND	ND	ND	ND
		05/04/89	1090	24.8	ND	5.3	ND	ND	ND	ND	ND	ND
	514	10/17/88	3000	ND	ND	ND	ND	ND	ND	ND	ND	ND
		11/30/88	2797	ND	ND	ND	TR	ND	ND	ND	ND	TR
		01/18/89	2500	ND	ND	ND	ND	ND	ND	ND	ND	ND
		05/04/89	2300	ND	ND	ND	ND	ND	ND	ND	ND	ND
	804	10/17/88	3242	ND	0.6	ND	ND	ND	ND	0.6	ND	0.8
		11/30/88	3112	ND	0.7	ND	0.6	ND	ND	ND	TR	0.7
		01/19/89	2964	ND	TR	ND	ND	ND	ND	0.7	ND	ND
		05/04/89	2370	ND	ND	ND	ND	ND	ND	ND	ND	TR
	914	10/17/88	2468	ND	0.8	ND	ND	ND	ND	ND	TR	TR
		11/30/88	2244	ND	0.8	ND	TR	ND	ND	ND	TR	0.6
		01/19/89	2305	ND	TR	ND	ND	ND	ND	ND	ND	ND
		05/04/89	2280	ND	0.6	ND	ND	ND	ND	ND	TR	ND
	984	10/17/88	3194	ND	0.7	ND	ND	ND	ND	ND	TR	0.9
		11/30/88	3093	ND	0.6	ND	TR	ND	ND	TR	TR	0.8
		01/19/89	2974	ND	0.5	ND	TR	ND	ND	TR	ND	TR
		05/04/89	3100	TR	TR	ND	ND	ND	ND	ND	0.9	TR

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Well No.	Sample/ Screen Depth (feet)	Date Sampled	EC	TCE	PCE	trans-1,2 DCE	1,1,1 TCA	CCl4	Chloroform	Chloro-benzene	Ethyl-benzene	Toluene
	1104	10/17/88	3049	ND	0.7	ND	ND	ND	ND	ND	0.8	1.0
		11/30/88	2892	ND	0.5	ND	TR	ND	ND	TR	0.9	0.7
		01/18/89	2866	ND	TR	ND	ND	ND	ND	TR	0.7	TR
		05/04/89	2950	ND	TR	ND	ND	ND	ND	TR	1.0	TR
MCAS-8	392-410	11/03/89	NT	ND	ND	ND	ND	ND	3.0	ND	ND	0.9
		02/06/90	1570	ND	ND	ND	ND	ND	TR	ND	ND	1.6
MCAS-9	372-445	10/27/89	721	TR	ND	ND	ND	ND	1.8	TR	ND	ND
		02/12/90	722	1.0	ND	ND	ND	ND	ND	ND	ND	ND
MCAS-10	355-375	11/07/89	NT	ND	ND	ND	ND	ND	9.7	ND	ND	ND
		01/31/90	1250	ND	ND	ND	ND	ND	ND	ND	ND	ND
Recovery Well Constructed and Sampled by OCWD:												
ET-1	200	06/15/89	1230	40.1	ND	2.1	ND	ND	TR	ND	ND	ND
	300	06/15/89	1210	40.8	ND	2.2	ND	ND	ND	ND	ND	ND
	390	06/15/89	1190	64.8	ND	4.4	ND	ND	TR	ND	ND	ND
	440	06/15/89	1130	88.7	ND	12.7	ND	ND	ND	ND	ND	ND
Monitoring Wells Constructed and Sampled by USMC:												
RW-1	430-470	09/11/89	1380	ND	ND	ND	ND	ND	ND	ND	ND	ND
RW-2	270-310	09/11/89	1120	ND	ND	ND	ND	ND	ND	ND	ND	ND
RW-3	370-390	09/11/89	1320	0.8	0.1	ND	ND	ND	0.1	ND	ND	ND
RW-4	65-85	09/11/89	2590	ND	0.4	ND	ND	ND	ND	ND	ND	ND
PS-1	102?-122	12/15/88	NT	19	ND	ND	ND	0.3	ND	0.3	ND	ND
		01/22/89	3080	17	ND	ND	ND	0.4	ND	ND	ND	ND
PS-2	103?-133	12/16/88	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND
		01/22/89	NT	ND	ND	ND	ND	ND	0.2	ND	ND	ND

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Well No.	Sample/ Screen Depth (feet)	Date Sampled	EC	TCE	PCE	trans-1,2 DCE	1,1,1 TCA	CCl4	Chloroform	Chloro- benzene	Ethyl- benzene	Toluene
PS-3	102?-122	12/13/88	NT	33	24	ND	ND	ND	ND	ND	ND	ND
		01/23/89	1440	64	81	ND	ND	0.4	12	ND	ND	ND
PS-4	98?-118	01/22/89	NT	78	48	ND	ND	ND	3.1	ND	ND	ND
PS-5	106?-126	01/23/89	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND
PS-6	130?-150	01/23/89	NT	11	0.4	ND	ND	1.3	7.7	ND	ND	ND
PS-7	106?-126	01/23/89	NT	ND	ND	ND	ND	ND	0.1	ND	ND	ND
PS-8	125?-145	01/23/89	NT	90	ND	ND	ND	2.0	4.0	ND	ND	ND
DW-135	115-135	07/15/88	NT	5.0	ND	ND	ND	56	11	ND	ND	ND
		09/22/88	NT	7.0	ND	ND	ND	61	14	ND	ND	ND
		01/20/89	NT	3.4	ND	ND	ND	45	11	ND	ND	ND
DW-250	215-250	07/15/88	NT	ND	ND	ND	ND	8.0	ND	ND	ND	ND
		09/22/88	NT	ND	ND	ND	ND	15	ND	ND	ND	ND
		01/20/89	NT	ND	ND	ND	ND	3.1	ND	ND	ND	ND
DW-350	310-350	07/15/88	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND
		09/22/88	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND
		01/20/89	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND
DW-450	420-450	07/15/88	NT	0.1	ND	ND	ND	ND	ND	ND	ND	ND
		09/22/88	NT	2.5	ND	ND	ND	ND	0.3	ND	ND	ND
		01/20/89	NT	0.2	ND	ND	ND	ND	ND	ND	ND	ND
DW-540	490-540	07/15/88	NT	0.4	ND	ND	ND	ND	0.1	ND	ND	ND
		09/22/88	NT	0.3	ND	ND	ND	ND	ND	ND	ND	ND
		01/21/89	NT	0.4	ND	ND	ND	ND	ND	ND	ND	ND
Monitoring Wells Constructed by Gregg & Assoc. (1986, 1987)												
CN-2	75-95	05/12/89	2240	ND	ND	ND	ND	ND	ND	ND	ND	ND
CN-5	70-90	05/11/89	3192	ND	ND	ND	ND	ND	ND	ND	ND	ND

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ND = Not Detected; NT = Not Tested

Well No.	Sample/ Screen Depth (feet)	Date Sampled	EC	TCE	PCE	trans-1,2 DCE	1,1,1 TCA	CCl4	Chloroform	Chloro- benzene	Ethyl- benzene	Toluene
CN-12 (destroyed)	60-80	05/22/89	2116	ND	ND	ND	ND	ND	ND	ND	ND	ND
CN-13 (destroyed)	60-80	05/22/89	1740	ND	ND	ND	ND	ND	ND	ND	ND	ND
WP-MW1 (destroyed)	75-95	03/13/87	NT	5	19	ND	ND	ND	3	ND	ND	34
WP-MW2 (destroyed)	75-95	03/13/87	NT	2	1	ND	ND	ND	ND	ND	ND	1
WP-MW3 (destroyed)	73-93	03/13/87	NT	ND	ND	ND	ND	ND	ND	ND	ND	3
WP-MW4 (destroyed)	80-100	03/13/87	NT	3	ND	ND	ND	ND	2	ND	ND	4
Active and Inactive Production Wells:												
TIC 35	263-1503	07/22/85	1294	11.4	TR	ND	ND	ND	ND	ND	ND	ND
		06/18/86	1725	15.9	ND	ND	ND	ND	ND	ND	ND	ND
		09/16/86	1385	27.8	ND	TR	ND	ND	ND	ND	ND	ND
		05/15/87	1392	31.8	ND	0.6	ND	ND	ND	ND	ND	ND
		04/15/88	1596	21.0	ND	TR	ND	ND	0.9	ND	ND	ND
		05/27/88	1475	35.1	ND	0.6	ND	ND	TR	ND	ND	ND
		09/09/88	1493	33.1	ND	0.8	ND	ND	TR	ND	ND	ND
		12/09/88	NT	30.4	ND	0.7	ND	ND	TR	ND	ND	ND
		01/16/89	1700	21.7	ND	ND	ND	ND	TR	ND	ND	ND
		05/15/89	NT	16.8	ND	ND	ND	ND	ND	ND	ND	ND
		07/31/89	1920	16.8	ND	ND	ND	ND	TR	ND	ND	ND
TIC 47	268-1107	06/17/85	NT	10.1	TR	ND	ND	ND	ND	ND	ND	ND
		06/24/85	NT	9.8	ND	ND	ND	ND	ND	ND	ND	ND
		09/17/85	1461	8.4	ND	ND	ND	ND	ND	ND	ND	ND
		09/30/85	1499	7.9	ND	ND	ND	ND	ND	ND	ND	ND
		10/01/85	1499	8.7	ND	ND	ND	ND	ND	ND	ND	ND
		10/24/85	1601	9.0	ND	ND	ND	ND	ND	ND	ND	ND

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TR = constituent detected below reportable limit
ND = Not Detected; NT = Not Tested

Well No.	Sample/ Screen Depth (feet)	Date Sampled	EC	TCE	PCE	trans-1,2 DCE	1,1,1 TCA	CCl4	Chloroform	Chloro-benzene	Ethyl-benzene	Toluene
		06/18/86	1468	9.5	ND	ND	ND	ND	ND	ND	ND	ND
		09/16/86	1463	6.7	ND	ND	ND	ND	ND	ND	ND	ND
		04/13/87	1687	3.8	ND	ND	ND	ND	ND	ND	ND	ND
		03/16/88	1438	4.4	ND	ND	ND	ND	ND	ND	ND	ND
		05/10/88	1376	6.6	ND	ND	ND	ND	ND	ND	ND	ND
		08/31/88	1355	5.6	ND	ND	ND	ND	ND	ND	ND	ND
		09/09/88	1365	7.6	ND	ND	ND	ND	ND	ND	ND	ND
		05/15/89	NT	6.5	ND	ND	ND	ND	ND	ND	ND	ND
		07/31/89	1460	7.8	ND	ND	ND	ND	ND	ND	ND	ND
TIC 55	300-496	07/22/85	1004	TR	TR	ND	ND	ND	ND	ND	ND	ND
		09/17/85	999	TR	ND	ND	ND	ND	ND	ND	ND	ND
		10/24/85	1028	TR	ND	ND	ND	ND	ND	ND	ND	ND
		04/13/87	1002	0.7	ND	ND	ND	ND	ND	ND	ND	ND
		05/28/87	1020	0.9	ND	ND	ND	ND	ND	ND	ND	ND
		08/08/88	1114	TR	ND	ND	ND	ND	ND	ND	ND	ND
		12/88	NT	1.0-1.4	TR	ND	ND	ND	TR	ND	ND	ND
TIC 56	336-647	07/22/85	2019	ND	ND	ND	ND	ND	ND	ND	ND	ND
		10/13/89		ND	ND	ND	ND	ND	ND	ND	ND	ND
TIC 61	248-694	10/24/89	2250	ND	ND	ND	ND	ND	ND	ND	ND	2.5
TIC 68	274-403	05/06/88	612	0.6	ND	ND	ND	ND	ND	ND	ND	ND
		02/07/89	1262	TR	ND	ND	ND	ND	ND	ND	ND	ND
TIC 74	210-280?	11/20/86	1170	ND	ND	ND	ND	ND	ND	ND	ND	ND
		12/14/87	1691	TR	ND	ND	ND	ND	ND	ND	ND	ND
		12/14/87	1197	0.6	ND	ND	ND	ND	ND	ND	ND	ND
		01/31/89	1176	TR	ND	ND	ND	ND	ND	ND	ND	ND
		12/12/89	NT	TR	ND	ND	ND	ND	ND	ND	ND	ND

Notes : All units in micrograms/liter, except for Electrical Conductivity, which is in micromhos/centimeter.
TR = constituent detected below reportable limit
ND = Not Detected; NT = Not Tested

Well No.	Sample/ Screen Depth (feet)	Date Sampled	EC	TCE	PCE	trans-1,2 DCE	1,1,1 TCA	CCl4	Chloroform	Chloro-benzene	Ethyl-benzene	Toluene
TIC 78	410-690	07/08/85	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND
		03/04/87	831	ND	ND	ND	ND	ND	ND	ND	ND	ND
		08/07/87	810	ND	ND	ND	ND	ND	ND	ND	ND	ND
		07/26/88	775	ND	ND	ND	ND	ND	ND	ND	ND	ND
		11/03/88	768	ND	ND	ND	ND	ND	ND	ND	ND	ND
		06/29/89	824	ND	ND	ND	ND	ND	ND	ND	ND	ND
		04/13/90	NT	TR	ND	ND	ND	ND	ND	ND	ND	ND
TIC 83 (destroyed)	261-402	02/14/89	1230	9.1	TR	ND	ND	ND	ND	ND	ND	ND
TIC 106	405-715	07/09/86	668	ND	ND	ND	ND	ND	ND	ND	ND	ND
		12/30/86	4076	ND	ND	ND	ND	ND	ND	ND	ND	ND
		06/20/88	556	ND	ND	ND	0.9	ND	ND	ND	ND	ND
										ND	ND	
TIC 107	230-980	07/22/86	1135	ND	ND	ND	ND	ND	ND	ND	ND	ND
		05/10/88	1087	ND	ND	ND	ND	ND	ND	ND	ND	ND
TIC 108	200-960	07/22/86	982	ND	ND	ND	ND	ND	ND	ND	ND	ND
		04/13/87	1070	ND	ND	ND	ND	ND	ND	ND	ND	ND
		06/20/88	1076	ND	ND	ND	TR	ND	ND	ND	ND	ND
		06/29/89	971	ND	ND	ND	ND	ND	ND	ND	ND	ND
		04/13/90	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND
TIC 110	182-1030	07/08/85	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND
		09/16/86	1640	ND	ND	ND	ND	ND	ND	ND	ND	ND
		08/07/87	1245	ND	ND	ND	ND	ND	ND	ND	ND	ND
		08/31/88	2323	ND	ND	ND	ND	ND	ND	ND	ND	ND
		11/04/88	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND
		07/31/89	2550	ND	ND	ND	ND	ND	ND	ND	ND	ND
TIC 111	200-750	07/22/85	1187	ND	ND	ND	ND	ND	ND	ND	ND	ND
		09/16/86	1286	ND	ND	ND	ND	ND	ND	ND	ND	ND
		08/07/87	1902	ND	ND	ND	ND	ND	ND	ND	ND	ND
		07/26/88	1244	ND	ND	ND	ND	ND	ND	ND	ND	ND
		07/31/89	1470	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes : All units in micrograms/liter, except for Electrical Conductivity, which is in micromhos/centimeter.
TR = constituent detected below reportable limit
ND = Not Detected; NT = Not Tested

Well No.	Sample/ Screen Depth (feet)	Date Sampled	EC	TCE	PCE	trans-1,2 DCE	1,1,1 TCA	CCl4	Chloroform	Chloro-benzene	Ethyl-benzene	Toluene
TIC 113	280-1080	08/11/86	1192	ND	ND	ND	ND	ND	ND	ND	ND	ND
		04/13/87	1028	ND	ND	ND	ND	ND	ND	ND	ND	ND
		05/28/87	1113	ND	ND	ND	ND	ND	ND	ND	ND	ND
		07/31/89	1178	ND	ND	ND	ND	ND	ND	ND	ND	ND
		04/13/90	NT	TR	ND	ND	ND	ND	ND	ND	ND	ND
TIC 117	360-635	02/07/86	1027	ND	ND	ND	ND	ND	ND	ND	ND	ND
		10/13/87	1997	ND	ND	ND	ND	ND	ND	ND	ND	ND
		12/13/89	1980	8.2	ND	ND	ND	ND	1.2	ND	ND	ND
TIC 127	?-100?	03/07/89	1268	ND	ND	ND	ND	ND	ND	ND	ND	ND
North Lake	370-890	07/08/85	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND
		09/16/86	1662	ND	ND	ND	ND	ND	ND	ND	ND	ND
		10/08/87	1581	ND	ND	ND	ND	ND	ND	ND	ND	ND
		11/02/88	1020	0.9	ND	ND	ND	ND	ND	ND	ND	ND
		11/09/88	NT	0.7	ND	ND	ND	ND	ND	ND	ND	ND
		04/10/89	1145	1.3	ND	ND	ND	ND	ND	ND	ND	ND
		12/07/89	1390	1.3	ND	ND	ND	ND	ND	ND	ND	ND
		04/13/90	NT	1.0	ND	ND	ND	ND	ND	ND	ND	ND
		05/11/90	NT	1.3	ND	ND	ND	ND	ND	ND	ND	ND
South Lake	210-800	06/07/89	1110	1.0	ND	ND	ND	ND	ND	ND	ND	ND
		07/07/89	1120	1.0	ND	ND	ND	ND	ND	ND	ND	ND
		04/24/90	1010	0.9	ND	ND	ND	ND	ND	ND	ND	ND

Notes : All units in micrograms/liter, except for Electrical Conductivity, which is in micromhos/centimeter.
TR = constituent detected below reportable limit
ND = Not Detected; NT = Not Tested

Table B2. Water Sample Inorganic Constituent Analyses

Date Printed: 08/10/90

Well No.	Sample/ Screen Depth (feet)	Sample Date	GENERAL MINERALS (concentrations in milligrams/liter)											METALS (concentrations in micrograms/liter)											
			HCO3	Ca	Cl	Mg	NO3-N	K	Na	SO4	TDS	EC	pH	Al	As	Ba	Cd	Cr	Cu	Fe	Pb	Mn	Se	Ag	Zn
Monitoring Wells Constructed and Sampled by OCWD:																									
MCAS-1	65	02/06/89	529	NT	132	48	14	2.2	287	517	1616	2330	7.8	22	9.1	86	(0.1)	3.8	15	14	4.0	31	(5.0)	(0.1)	90
		10/19/89	499	163	141	42	13	(0.1)	302	532	1520	1990	7.5	46	33	57	0.2	21	3.4	91	(1.0)	1.7	7.1	0.2	344
	155	02/07/89	334	340	430	106	27	3.6	158	779	2590	2994	7.4	23	14	92	(0.1)	(1.0)	(1.0)	7.9	(1.0)	15	15	(0.1)	(50)
		10/19/89	361	357	392	99	26	1.5	200	727	2470	2840	7.5	82	42	76	0.7	109	7.1	1500	(1.0)	43	33	0.1	114
	215	02/07/89	207	180	344	49	14	3.7	172	324	1270	2035	7.4	11	(5.0)	79	0.3	(1.0)	1.4	16	NT	85	NT	(0.1)	NT
		10/19/89	175	191	389	46	16	1.5	200	366	1460	2000	7.3	123	27	167	6	443	177	11	(1.0)	120	10	0.2	52
	275	02/07/89	234	154	270	43	11	4.7	148	302	1420	1780	7.5	57	(5.0)	112	0.1	16	5.5	270	(1.0)	150	5.1	(0.1)	(50)
		10/19/89	213	178	303	47	13	1.5	165	326	1280	1810	7.4	178	(5.0)	121	0.9	131	7.3	2270	(1.0)	57	8.4	0.2	(50)
	335	02/07/89	229	103	153	28	7.1	3.6	134	222	908	1316	7.7	14	(5.0)	66	0.1	(1.0)	2.0	17	(1.0)	95	(5.0)	(0.1)	(50)
		10/19/89	243	150	245	40	6.5	2.4	162	299	1100	1620	7.3	35	(5.0)	85	0.8	59	10	831	(1.0)	260	(5.0)	0.4	(50)
	455	02/06/89	217	74	132	30	(0.1)	4.7	126	208	788	1240	7.7	86	(5.0)	83	(0.1)	9.1	9.5	370	4.0	298	(5.0)	(0.1)	55
		10/19/89	191	106	175	26	(0.1)	1.5	138	227	818	1260	7.3	58	(5.0)	66	1	12	4.4	1320	(1.0)	279	(5.0)	0.1	(50)
	545	02/06/89	279	181	329	72	7.7	7.4	260	603	1760	2570	7.4	46	5.8	148	0.7	42	45	960	11	1100	(5.0)	(0.1)	180
		10/19/89	323	191	316	54	0.6	4.8	270	519	1610	2270	6.8	368	(5.0)	87	(0.1)	19	5.6	1580	(1.0)	1920	5.8	0.2	(50)
MCAS-2	45	02/16/89	425	169	417	54	31	1.8	348	430	1970	2780	7.7	0.5	(5.0)	75	(0.1)	4.3	(1.0)	(1.0)	(1.0)	42	17	(0.1)	(50)
		10/17/89	287	190	457	59	28	0.9	330	459	1880	2710	7.8	46	5.1	61	0.4	11	6.2	138	(1.0)	12	(5.0)	(0.1)	(50)
	135	02/16/89	254	518	862	121	29	4.3	216	767	3120	3998	7.4	0.9	(5.0)	98	(0.1)	14	(1.0)	(1.0)	(1.0)	85	54	(0.1)	(50)
		10/17/89	208	516	933	119	31	0.6	275	830	3140	4110	7.5	60	(5.0)	102	33	89	7.2	601	(1.0)	40	61	0.6	(50)
	205	02/16/89	208	148	274	36	12	3.4	176	293	1190	1727	7.7	3.7	(5.0)	70	(0.1)	2.5	2.6	(1.0)	(1.0)	10	(5.0)	(0.1)	85
		10/17/89	200	149	278	40	12	3.3	172	307	1170	1720	8.0	40	(5.0)	75	0.3	8	7.9	36	(1.0)	2.7	9.4	0.5	(50)
	375	02/16/89	227	95	162	25	7.3	3.1	160	221	898	1319	7.7	6.1	(5.0)	74	(0.1)	4.3	(1.0)	18	(1.0)	44	8.0	(0.1)	50
		10/17/89	221	96	172	27	8.6	2.4	165	237	882	1360	7.7	124	5.2	64	0.3	7.6	4.6	133	(1.0)	4.8	(5.0)	0.3	(50)
	425	02/08/89	228	66	134	26	2.7	5.8	147	193	814	1210	7.9	120	6.3	63	(0.1)	11	3.6	260	(1.0)	34	(5.0)	(0.1)	(50)
		10/10/89	229	87	147	23	2.7	2.8	154	211	822	1230	7.6	269	5.5	64	0.4	19	7.5	3.9	(1.0)	56	49	0.2	73
	495	02/08/89	269	137	450	44	4.1	9.3	384	501	1810	2656	7.6	19	5.8	91	(0.1)	29	3.8	560	1.7	550	16	(0.1)	65
		10/10/89	201	55	337	17	(0.1)	4	388	424	1320	2090	7.3	58	(5.0)	44	0.2	24	1.6	22	(1.0)	135	6.4	0.4	73
	555	02/08/89	240	190	596	48	6.8	8.9	467	649	2200	3205	7.5	44	7.8	87	0.3	28	1.0	1000	NT	640	25	(0.1)	60
		10/10/89	281	142	576	42	(0.1)	8	555	648	2210	3350	7.4	96	(5.0)	56	0.3	48	7.7	8	(1.0)	220	5.6	0.4	73
	625	02/08/89	195	170	528	50	(0.1)	9.7	345	518	1870	2745	6.9	46	5.2	89	(0.1)	140	8.6	3500	2.8	1600	(5.0)	(0.1)	85
		10/10/89	195	93	431	24	(0.1)	7	404	402	1490	2370	6.6	47	(5.0)	60	0.2	48	2.8	9.2	(1.0)	1700	7.3	0.6	114

Notes : Units for electrical conductivity (EC) are micromhos/centimeter.
( ) indicates constituents not detected above enclosed detection limit
* indicates data obtained from Irvine Ranch Water District; all other data from OCWD
NT = Not Tested

Well No.	Sample/ Screen Depth (feet)	Sample Date	GENERAL MINERALS (concentrations in milligrams/liter)											METALS (concentrations in micrograms/liter)											
			HCO3	Ca	Cl	Mg	NO3-N	K	Na	SO4	TDS	EC	pH	Al	As	Ba	Cd	Cr	Cu	Fe	Pb	Mn	Se	Ag	Zn
MCAS-3	90	01/30/89	254	244	251	68	22	4.3	283	814	2072	2770	8.1	17	12	121	(0.1)	1.8	19	31	(1.0)	38	12	(0.1)	65
		10/10/89	254	282	265	76	25	3.6	300	899	2230	2930	7.8	19	5.5	88	0.3	23	2.6	0.4	(1.0)	70	(5.0)	0.6	94
	165	01/30/89	102	217	340	70	23	4.3	142	447	1562	2100	8.1	18	6.4	116	(0.1)	3.0	6.9	15	(1.0)	5.2	7.4	(0.1)	(50)
		10/09/89	174	235	350	70	21	3.3	132	440	1710	2210	7.3	278	(5.0)	133	1.2	6.6	19	2310	2.9	136	(5.0)	0.3	271
	225	01/30/89	178	98	180	24	23	2.6	128	120	768	1270	8.0	11	5.4	130	(0.1)	5.3	10	27	(1.0)	13	(5.0)	(0.1)	(50)
		10/09/89	181	98	180	24	21	1.8	126	123	822	1270	7.4	58	5.2	125	0.4	18	5.3	100	(1.0)	5.7	43	0.1	62
	345	01/30/89	222	82	116	24	3.7	2.9	95	122	658	1040	8.2	27	6.4	89	(0.1)	2.2	11	17	(1.0)	11	(5.0)	(0.1)	(50)
		10/09/89	214	85	123	24	4.3	1.8	98	146	688	993	7.4	244	5.6	83	0.4	18	4	814	(1.0)	26	11	0.2	73
	425	01/30/89	234	78	96	22	1.9	3.1	114	162	656	1030	8.2	14	6.1	67	(0.1)	(1.0)	11	28	(1.0)	12	(5.0)	(0.1)	(50)
		10/09/89	245	102	135	28	0.9	2.1	108	186	782	1130	7.3	51	(5.0)	79	0.4	15	4.7	1000	(1.0)	82	5.4	0.3	83
	495	01/30/89	221	92	157	24	2.4	2.6	135	186	772	1230	8.2	18	5.2	70	(0.1)	4.4	5.2	130	(1.0)	15	(5.0)	(0.1)	60
		10/09/89	206	92	153	23	2.4	1.8	132	189	804	1170	7.4	38	7.1	61	0.5	2.5	11	3380	(1.0)	67	7.4	0.2	94
MCAS-4	181-238	10/23/89	180	106	153	20	4.8	(0.1)	142	205	886	1320	7.2	49	14	66	0.2	23	5.5	820	(1.0)	146	(5.0)	0.6	150
		02/23/90	188	94	156	27	3.9	2	129	232	996	1330	7.2	(1.0)	(5.0)	45	(0.1)	(1.0)	(1.0)	21	(1.0)	81	(5.0)	0.2	(50)
MCAS-5	142-148	10/19/89	211	108	206	17	11	0.6	157	186	912	1410	7.7	45	(5.0)	120	0.3	4.6	2.7	100	1.6	81	6.9	0.1	52
		03/07/90	53	61	182	21	11	1.8	147	179	896	1380	7.4	(1.0)	(5.0)	50	0.1	2.8	(1.0)	310	1.2	120	(5.0)	(0.5)	(50)
MCAS-6	167-222	10/28/89	198	94	143	10	4	(0.1)	120	163	722	1150	7.2	100	12	172	0.3	2.1	56	102	(1.0)	264	(5.0)	0.5	(50)
		03/09/90	196	100	141	16	4	3.8	112	124	668	1050	7.4	38	9.2	140	0.1	2.2	11	860	(1.0)	220	(5.0)	0.4	(50)
MCAS-7	94	01/20/89	204	346	545	97	38	3.1	224	638	2560	3330	7.5	18	6.2	92	(0.1)	(1.0)	6.4	29	(1.0)	0.6	5.1	3.6	(50)
	194	01/20/89	217	100	151	23	0.1	3.2	105	166	870	1190	7.6	18	6.6	51	(0.1)	(1.0)	7.3	10	(1.0)	15	(5.0)	2.0	(50)
	354	01/20/89	203	65	122	17	3.1	3.8	119	126	650	1030	7.7	9.2	7.2	59	(0.1)	(1.0)	5.0	6.4	(1.0)	107	(5.0)	2.0	(50)
	444	01/20/89	196	77	137	17	(0.1)	2.7	109	132	670	1050	7.6	27	7.2	92	(0.1)	(1.0)	15	41	(1.0)	140	(5.0)	1.8	(50)
	514	01/18/89	263	123	343	42	(0.1)	10	394	612	1720	2590	7.6	41	11	89	(0.1)	(1.0)	27	554	(1.0)	204	(5.0)	3.6	228
	804	01/19/89	390	124	416	34	(0.1)	12	530	668	2030	3090	7.6	69	10	117	(0.1)	(1.0)	7.1	282	(1.0)	543	(5.0)	3.6	65
	914	01/19/89	311	62	239	18	(0.1)	9.6	416	534	1480	2260	7.8	87	12	66	(0.1)	2.6	16	210	(1.0)	186	(5.0)	3.0	(50)
	984	01/19/89	363	141	443	38	(0.1)	12	495	671	2070	3070	7.3	95	8	90	(0.1)	(1.0)	22	2160	(1.0)	850	(5.0)	3.8	(50)
	1104	01/18/89	355	196	434	44	(0.1)	12	401	632	2034	2950	6.8	120	12	113	(0.1)	5.4	13	3280	(1.0)	883	(5.0)	3.9	(50)
MCAS-8	392-410	02/06/90	201	27	399	5.4	(0.1)	2.4	296	(0.5)	860	1570	7.9	(1.0)	(5.0)	263	(0.1)	6.6	(1.0)	1282	(1.0)	60	(5.0)	0.9	(50)

Notes : Units for electrical conductivity (EC) are micromhos/centimeter.
( ) indicates constituents not detected above enclosed detection limit
* indicates data obtained from Irvine Ranch Water District; all other data from OCWD
NT = Not Tested

Well No.	Sample/ Screen Depth (feet)	Sample Date	GENERAL MINERALS (concentrations in milligrams/liter)											METALS (concentrations in micrograms/liter)											
			HCO3	Ca	Cl	Mg	NO3-N	K	Na	SO4	TDS	EC	pH	Al	As	Ba	Cd	Cr	Cu	Fe	Pb	Mn	Se	Ag	Zn
MCAS-9	372-438	10/26/89	166	53	51	7.6	0.5	(0.1)	78	120	454	698	7.5	48	6.7	76	0.2	4	3.5	113	(1.0)	238	(5.0)	0.4	52
		02/09/90	186	52	51	14	1.0	2.2	80	123	536	722	7.3	(1.0)	(5.0)	46	0.4	153	(1.0)	1180	(1.0)	80	(5.0)	0.1	(50)
MCAS-10	355-375	01/31/90	227	78	99	34	2.3	2.9	119	245	826	1250	7.4	(4)	5.2	22	0.6	16	(0.09)	962	(1.0)	110	(5.0)	(0.1)	(50)
Recovery Well Constructed and Sampled by OCWD:																									
ET-1	200	06/15/89	201	112	155	27	6.3	2.3	107	194	808	1230	7.5	11	8.7	82	0.4	1.6	(1.0)	18	1.6	44	(5.0)	(0.1)	(50)
	300	06/15/89	203	102	145	25	5.8	2.3	113	180	756	1210	7.3	10	8.3	82	0.4	2.2	2.3	54	1.9	54	(5.0)	(0.1)	(50)
	390	06/15/89	216	99	137	25	4.8	2.1	113	180	734	1190	7.3	8.8	9.0	84	0.3	2.4	(1.0)	11	1.4	87	(5.0)	(1.0)	(50)
	440	06/15/89	208	91	122	20	(0.1)	2.1	118	182	690	1130	7.4	48	9.2	91	0.2	4.5	0.5	85	2.4	175	(5.0)	(0.1)	(50)
Monitoring Wells Constructed and Sampled by USMC:																									
RW-1	430-470	09/07/89	243	94	170	24	3.1	3.0	162	211	850	1380	7.3	NT	NT	NT	NT	NT	(50)	1300	NT	(50)	NT	NT	(50)
RW-2	270-310	09/11/89	217	85	149	16	11	2.7	132	117	670	1120	7.9	NT	NT	NT	NT	NT	(50)	5500	NT	80	NT	NT	80
RW-3	370-390	09/12/89	200	72	180	18	8.8	3.4	182	144	790	1320	7.5	NT	NT	NT	NT	NT	(50)	820	NT	60	NT	NT	(50)
RW-4	65-85	09/13/89	449	250	328	60	30	2.1	225	375	1650	2590	7.5	NT	NT	NT	NT	NT	(50)	530	NT	(50)	NT	NT	(50)
PS-1	102?-122	01/22/89	194	380	691	100	30	5.9	140	480	1950	3080	7.5	NT	NT	NT	NT	NT	15	1200	NT	410	NT	NT	270
PS-2	103?-133	01/22/89	140	560	840	230	70	5.4	260	1430	3500	4540	7.2	NT	NT	NT	NT	NT	15	640	NT	180	260	NT	80
PS-3	102?-122	01/23/89	316	140	234	39	14	4.0	130	119	840	1440	7.4	NT	NT	NT	NT	NT	13	410	NT	320	NT	NT	43
PS-4	98?-118	01/23/89	347	160	339	42	13	3.4	150	76	1000	1710	7.1	NT	NT	NT	NT	NT	(9.0)	380	NT	440	(1)	NT	33
PS-5	106?-126	01/23/89	237	240	314	69	44	3.2	90	309	1300	2060	7.2	NT	NT	NT	NT	NT	10	250	NT	71	11	NT	110
PS-6	130?-150	01/22/89	231	180	342	62	24	5.0	160	334	1250	2050	7.5	NT	NT	NT	NT	NT	19	720	NT	290	42	NT	22
PS-7	106?-126	01/23/89	358	74	55	23	9.4	4.4	100	86	510	905	7.7	NT	NT	NT	NT	NT	10	150	NT	71	(1)	NT	17
PS-8	125?-145	01/22/89	219	140	242	48	17	7.0	100	165	910	1520	7.5	NT	NT	NT	NT	NT	(9.0)	810	NT	670	6	NT	130
DW-135	115-135	01/21/89	237	230	349	140	27	3.2	180	770	1750	2690	7.4	NT	NT	NT	NT	NT	(9.0)	1000	NT	42	64	NT	430
DW-250	215-250	01/20/89	235	61	81	29	3.1	3.1	90	148	570	920	7.9	NT	NT	NT	NT	NT	(9.0)	8100	NT	50	4	NT	890
DW-350	310-350	01/20/89	273	76	66	24	1.6	2.9	85	153	580	965	7.6	NT	NT	NT	NT	NT	23	5600	NT	150	3	NT	240
DW-450	420-450	01/20/89	273	84	68	26	5.1	2.8	90	148	580	940	7.7	NT	NT	NT	NT	NT	(9.0)	2200	NT	47	4	NT	220
DW-540	490-540	01/21/89	272	80	85	28	7.1	2.5	98	148	630	990	7.8	NT	NT	NT	NT	NT	(9.0)	470	NT	(14)	4	NT	780

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NT = Not Tested

Date Printed: 08/10/90

Well No.	Sample/ Screen Depth (feet)	Sample Date	GENERAL MINERALS (concentrations in milligrams/liter)											METALS (concentrations in micrograms/liter)											
			HCO3	Ca	Cl	Mg	NO3-N	K	Na	SO4	TDS	EC	pH	Al	As	Ba	Cd	Cr	Cu	Fe	Pb	Mn	Se	Ag	Zn
Monitoring Wells Constructed by CDM (1985) and Sampled by OCWD:																									
MW10-115	?-115?	02/26/90	279	43	133	9.2	(0.1)	5.4	309	315	1090	1612	8.3	(1.0)	38	2.9	(0.1)	(1.0)	(1.0)	1.2	(1.0)	17	(5.0)	0.4	(50)
MW10-210	?-210?	02/22/90	308	139	40	(0.1)	(0.1)	6	109	308	774	2050	11.9	331	(5.0)	68	(0.1)	(1.0)	(1.0)	(1.0)	(1.0)	(0.1)	(5.0)	(0.1)	(50)
MW10-335	?-335?	02/22/90	296	68	59	36	(0.1)	3.5	134	251	808	1120	7.7	(1.0)	15	31	(0.1)	(1.0)	(1.0)	3.2	(1.0)	33	(5.0)	(0.1)	(50)
Monitoring Wells Constructed by Gregg & Assoc. (1986, 1987)																									
CN-2	75-95	05/12/89	103	253	489	64	18	3	150	374	1572	2240	7.4	10	5.1	39	(0.1)	3.2	1.9	7.8	33	3.8	20	(0.1)	(50)
CN-5	70-90	05/11/89	161	383	716	100	62	3	173	377	2690	3192	7.1	10	(5.0)	83	0.1	7.7	2.1	(1.0)	4.6	11	19	(0.1)	(50)
CN-12 (destroyed)	60-80	05/22/89	202	230	302	50	63	1.4	168	259	1596	2116	7.1	(1.0)	7.9	29	(0.1)	24	1.4	(1.0)	4.6	2.9	11	(0.1)	(50)
CN-13 (destroyed)	60-80	05/22/89	223	222	355	52	57	2.2	208	284	1740	2303	7.9	(1.0)	6.9	24	(0.1)	7.4	2.2	3.3	2.3	1.4	7.5	(0.1)	(50)
WP-MW1 (destroyed)	75-95	03/13/87	NT	NT	NT	NT	NT	NT	NT	NT	736	NT	7.2	NT	(2)	30	1.1	(10)	(20)	NT	(2)	NT	(2)	(50)	(2)
WP-MW2 (destroyed)	75-95	03/13/87	NT	NT	NT	NT	NT	NT	NT	NT	864	NT	7.5	NT	2	100	0.8	(10)	(20)	NT	(2)	NT	(2)	(50)	(2)
WP-MW3 (destroyed)	73-93	03/13/87	NT	NT	NT	NT	NT	NT	NT	NT	790	NT	7.4	NT	2	60	1.2	(10)	(20)	NT	(2)	NT	(2)	(50)	(2)
WP-MW4 (destroyed)	80-100	03/13/87	NT	NT	NT	NT	NT	NT	NT	NT	1120	NT	7.4	NT	2	140	1.1	(10)	(20)	NT	(2)	NT	(2)	(50)	(2)
Active and Inactive Production Wells:																									
TIC 35	263-1503	*9/85	239	102	180	29	8.0	3.0	134	238	961	1300	7.5	NT	NT	NT	NT	NT	NT	10	NT	10	NT	NT	NT
		*1/86	258	143	205	40	11	4.0	142	257	1097	1540	8.0	NT	NT	NT	NT	NT	20	20	NT	20	NT	NT	60
		*02/17/87	287	174	248	43	12	4.0	179	300	1188	1700	7.9	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
		03/10/88	NT	157	244	41	13	3.2	154	306	1190	1900	7.6	11	(5.0)	100	0.8	1.6	1.5	250	(1.0)	2.5	9.8	0.2	(50)
		05/27/88	208	124	222	31	10	3.2	146	272	1040	1470	8.0	NT	NT	NT	NT	NT	NT	8.8	NT	(0.1)	13	NT	NT
		07/31/89	221	168	292	42	6.7	2.9	162	202	1320	1790	8.0	1.2	11	NT	(0.1)	5.1	(1.0)	155	(1.0)	5.9	14	0.2	(50)
TIC 47	268-1107	06/17/85	200	112	200	27	9.5	2.9	156	230	985	1450	7.4	NT	(5.0)	41	0.4	1.1	2.6	17	(1.0)	0.6	(5.0)	(0.1)	(100)
		06/18/86	201	113	210	25	11	3.4	158	210	960	1480	7.9	NT	(5.0)	56	0.2	(1.0)	2.4	9.3	(1.0)	0.8	(5.0)	0.4	(100)
		*02/17/87	275	114	195	26	9.5	3.0	179	195	964	1400	7.9	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
		05/10/88	196	109	202	22	9.8	2.8	162	224	940	1410	7.4	12	(5.0)	43	(0.1)	2.6	1.3	14	(1.0)	0.6	(5.0)	0.6	(50)
		*08/22/88	305	96	195	22	7.7	3.0	145	144	951	1500	8.0	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
		07/31/89	196	102	196	24	9.3	2.6	168	219	952	1340	8.2	3.4	10	107	(0.1)	6	(1.0)	21	(1.0)	3.1	9.6	3.4	(50)
		05/14/90	212	112	207	26	11	3.4	164	220	960	1419	7.1	(1.0)	(5.0)	30	(0.1)	(1.0)	(1.0)	(1.0)	(1.0)	(0.1)	(5.0)	0.8	(50)

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NT = Not Tested

Well No.	Sample/ Screen Depth (feet)	Sample Date	GENERAL MINERALS (concentrations in milligrams/liter)											METALS (concentrations in micrograms/liter)											
			HCO3	Ca	Cl	Mg	NO3-N	K	Na	SO4	TDS	EC	pH	Al	As	Ba	Cd	Cr	Cu	Fe	Pb	Mn	Se	Ag	Zn
TIC 55	300-496	*9/85	259	76	83	24	6.1	2.0	84	155	710	900	7.5	NT	NT	NT	NT	NT	NT	10	NT	10	NT	NT	NT
		*05/13/86	305	94	106	28	5.2	3.0	89	75	685	1010	7.7	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
		05/28/87	221	91	80	26	6.8	2.2	87	167	682	1020	7.6	61	(5.0)	48	(0.1)	2.5	1.4	67	1.2	1.9	8.7	0.2	(100)
		*08/22/88	305	90	117	32	7.7	3.0	101	155	833	1270	8.1	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
		05/09/90	234	106	88	34	7.6	3.0	74	164	660	1030	7.3	(1.0)	(5.0)	40	1.3	3.2	(1.0)	(1.0)	2.4	(0.1)	9.2	0.2	(50)
TIC 56	336-647	*03/07/85	286	157	150	66	27	2.8	128	391	1152	1800	7.3	NT	NT	NT	NT	NT	NT	10	NT	10	NT	NT	NT
		*09/03/85	279	105	110	41	12	3.0	108	274	832	1300	7.4	NT	NT	NT	NT	NT	NT	10	NT	10	NT	NT	NT
		*01/22/87	298	186	180	79	38	4.0	153	463	NT	2060	7.7	NT	NT	NT	NT	NT	(20)	(20)	NT	(20)	NT	NT	50
		*02/17/87	305	192	177	86	36	4.0	179	489	1465	2090	7.9	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
TIC 68	274-403	02/07/89	167	81	181	20	3.6	2.8	153	203	1000	1224	7.4	29	(5.0)	75	(0.1)	2.8	4.3	450	(1.0)	47	(5.0)	(0.1)	420
TIC 78	410-690	*9/85	117	43	113	10	0.25	2.0	122	90	498	800	7.7	NT	NT	NT	NT	NT	NT	20	NT	80	NT	NT	NT
		*05/13/86	262	50	106	10	(0.1)	3.0	120	48	569	840	7.4	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
		*02/17/87	120	52	96	11	(0.1)	3.0	120	74	545	790	8.5	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
		11/03/88	193	45	95	11	(0.1)	2.6	111	77	496	817	8.3	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
TIC 83 (destroyed)	261-402	02/14/89	188	72	168	18	10	2.7	167	182	824	1270	7.4	150	(5.0)	74	(0.1)	2.7	3.6	3800	3.8	55	(5.0)	(0.1)	120
TIC 106	405-715	*03/21/85	181	15	28	3.8	(0.1)	2.0	79	53	320	500	8.0	NT	NT	NT	NT	NT	NT	90	NT	30	NT	NT	NT
		07/29/85	192	6.3	137	4.4	2.6	1.4	158	7.0	NT	NT	8.4	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
		*12/30/85	185	11	90	2.5	0.1	1.2	128	25	384	600	7.8	NT	NT	NT	NT	NT	NT	140	NT	10	NT	NT	NT
		*04/09/86	185	14	50	2.7	(0.1)	1.6	94	47	320	500	7.9	NT	NT	NT	NT	NT	NT	360	NT	30	NT	NT	NT
		*02/17/87	183	26	18	6.1	(0.1)	3.0	74	181	391	440	8.3	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
		*08/22/88	214	18	50	3.7	(0.1)	2.0	87	43	392	570	8.2	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
TIC 107	230-980	*9/85	349	55	85	28	0.29	4.0	142	211	875	1200	7.7	NT	NT	NT	NT	NT	NT	40	NT	180	NT	NT	NT
		*05/13/86	415	68	120	30	(0.1)	4.0	150	115	827	1150	8.2	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
		*02/17/87	336	74	88	39	(0.1)	4.0	179	234	869	1200	8.4	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
		*08/22/88	396	56	92	30	(0.1)	4.0	138	125	824	1220	8.4	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
TIC 108	200-960	*11/04/85	305	54	65	22	0.20	2.6	112	170	640	1000	7.4	NT	NT	NT	NT	NT	NT	40	NT	40	NT	NT	NT
		*12/30/85	315	62	70	23	0.41	3.1	121	188	704	1100	7.5	NT	NT	NT	NT	NT	NT	80	NT	40	NT	NT	NT
		*04/09/86	307	67	65	24	0.36	3.1	117	211	704	1100	7.8	NT	NT	NT	NT	NT	NT	420	NT	50	NT	NT	NT
		*02/17/87	293	76	82	32	(0.1)	3.0	170	190	756	1030	8.2	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
		*08/22/88	336	56	81	20	(0.1)	4.0	112	110	709	1040	8.3	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
TIC 110	182-1030	*9/85	264	137	255	56	9.5	4.0	156	395	1309	1900	7.4	NT	NT	NT	NT	NT	NT	10	NT	NT	NT	NT	NT
		*05/13/86	336	147	258	54	5.6	5.0	161	195	1136	1710	7.6	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
		*02/17/87	244	165	266	64	11	5.0	200	417	1308	1870	8.3	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
		11/03/88	213	164	300	74	16	4.6	184	438	1450	2150	8.0	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
		07/31/89	188	174	344	80	26	4.4	225	564	1800	2330	8.1	84	6.2	98	(0.1)	76	(1.0)	362	(1.0)	18	61	0.5	(50)

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Well No.	Sample/ Screen Depth (feet)	Sample Date	GENERAL MINERALS (concentrations in milligrams/liter)											METALS (concentrations in micrograms/liter)											
			HCO3	Ca	Cl	Mg	NO3-N	K	Na	SO4	TDS	EC	pH	Al	As	Ba	Cd	Cr	Cu	Fe	Pb	Mn	Se	Ag	Zn
TIC 111	200-750	*01/21/85	286	99	115	39	5.9	5.4	122	240	832	1300	7.7	NT	NT	NT	NT	NT	NT	30	NT	60	NT	NT	NT
		*03/07/85	286	100	109	38	6.0	2.5	117	240	832	1300	7.4	NT	NT	NT	NT	NT	NT	10	NT	20	NT	NT	NT
		*09/03/85	295	88	115	34	4.4	3.1	118	260	832	1300	7.4	NT	NT	NT	NT	NT	NT	10	NT	10	NT	NT	NT
		*12/30/85	293	99	120	35	5.6	2.7	124	255	832	1300	7.4	NT	NT	NT	NT	NT	NT	10	NT	10	NT	NT	NT
		*04/09/86	293	95	105	34	5.6	2.9	114	268	832	1300	7.5	NT	NT	NT	NT	NT	NT	330	NT	20	NT	NT	NT
		*02/17/87	305	108	114	43	5.4	4.0	150	264	915	1280	8.0	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
		*08/22/88	305	94	120	35	4.5	3.0	115	172	872	1370	8.2	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
		07/31/89	256	106	135	42	5.6	3.2	154	301	990	1400	8.1	11	10	58	(0.1)	4.9	(1.0)	62	(1.0)	70	17	0.3	(50)
		05/03/90	250	114	136	44	4.4	3.4	121	252	878	1340	7.5	(1.0)	(5.0)	36	1.1	2.7	(1.0)	(1.0)	(1.0)	66	11	0.6	(50)
TIC 113	280-1080	08/11/86	239	88	96	30	1.4	3.3	120	258	808	1190	7.9	14	5.0	38	0.5	(1.0)	(1.0)	66	(1.0)	43	(5.0)	(0.1)	(100)
		05/28/87	232	77	87	26	1.2	3.1	120	223	744	1080	7.9	45	6.2	77	0.4	(1.0)	5.2	40	(1.0)	34	(5.0)	0.5	(100)
		*8/22/88	305	88	120	30	0.11	4.0	124	185	852	1320	8.2	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
TIC 117	360-635	02/07/86	NT	NT	NT	NT	0.9	NT	NT	NT	591	1060	8.4	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
		12/13/89	191	204	257	57	28	3.1	128	446	1438	1980	7.6	19	6.8	16	3.4	2.9	4.8	243	6.4	6.4	31	1.7	(50)
TIC 127	?-100?	03/07/89	164	88	176	5.0	4.7	2.3	148	204	790	1094	7.3	2400	(5.0)	NT	NT	3.4	NT	2300	5.1	NT	(5.0)	NT	(50)
North Lake	370-890	11/02/88	182	52	185	12	(0.1)	3.0	150	73	630	1080	7.9	NT	NT	NT	NT	NT	NT	2000	NT	204	NT	NT	NT
South Lake	210-800	06/07/89	203	95	143	21	0.2	2.6	112	162	708	1100	8.1	165	(5.0)	110	(0.1)	2.8	(1.0)	940	1.2	46	(5.0)	0.2	(50)
		04/24/90	210	94	137	20	(0.1)	2.7	112	155	688	1010	7.5	32	15	17	(0.1)	(1.0)	(1.0)	890	(1.0)	50	(5.0)	0.2	(50)

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( ) indicates constituents not detected above enclosed detection limit
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NT = Not Tested

REPORT

TRUESDAIL LABORATORIES, INC.

CHEMISTS - MICROBIOLOGISTS - ENGINEERS
RESEARCH - DEVELOPMENT - TESTING

14201 FRANKLIN AVENUE
TUSTIN, CALIFORNIA 92680
AREA CODE 714 • 730-6239
AREA CODE 213 • 225-1564
CABLE: TRUELABS

CLIENT: **Orange County Water District**
P. O. Box 3800
Fountain Valley, Califpornia 92728
Attention: Roy Herndon

DATE: December 14, 1988

RECEIVED: December 9, 1988

SAMPLE: **Pump Oil: TIC-35**
Purchase Order Number 28877

LABORATORY NO. 31515
Date Analyzed: December 13

INVESTIGATION: **Purgeable Organics (Volatiles) by EPA 601/602 GC - HECD and GC - PID**

RESULTS

Constituent	Approximate Detection Limit*	Concentration (ug/kg)**
Acetone	5.0 ug/l	9,100
Benzene	5.0 ug/l	ND
Bromodichloromethane	5.0 ug/l	ND
Bromoform	5.0 ug/l	ND
Bromomethane	5.0 ug/l	ND
Carbon Tetrachloride	5.0 ug/l	ND
Chlorobenzene	5.0 ug/l	ND
Chloroethane	5.0 ug/l	ND
2-Chlorethyvinyl ether	5.0 ug/l	ND
Chloroform	5.0 ug/l	ND
Chloromethane	5.0 ug/l	ND
bis (2-Chloroethyl) ether	5.0 ug/l	ND
Dibromochloromethane	5.0 ug/l	ND
1,2-Dichlorobenzene	5.0 ug/l	ND
1,3-Dichlorobenzene	5.0 ug/l	ND
1,4-Dichlorobenzene	5.0 ug/l	ND
Dichlorodifluoromethane	5.0 ug/l	ND
1,1-Dichloroethane	5.0 ug/l	ND
1,2-Dichloroethane	5.0 ug/l	ND
1,1-Dichloroethene	5.0 ug/l	ND
trans-1,2-Dichloroethene	5.0 ug/l	ND
1,2-Dichloropropane	5.0 ug/l	ND

This report applies only to the sample or samples investigated and is not necessarily indicative of the quality or condition of apparently identical or similar products. As a mutual protection to clients the public and these Laboratories this report is submitted and accepted for the exclusive use of the client to whom it is addressed and upon the condition that it is not to be used, in whole or in part, in any advertising or publicity matter without prior written authorization from these Laboratories.

TRUESDAIL LABORATORIES, INC.

Laboratory Number . .515
Orange County Water District
Pump Oil: TIC-35 per EPA 601/602

Constituent	Detection Limit*	Concentration ug/kg**
cis-1,3-Dichloropropene	5.0 ug/l	ND
trans-1,3-Dichloropropene	5.0 ug/l	ND
Ethyl Benzene	5.0 ug/l	320
Methylene Chloride	5.0 ug/l	ND
Methyl Ethyl Ketone	5.0 ug/l	ND
Methyl Isobutyl Ketone	5.0 ug/l	ND
1,1,2,2-Tetrachloroethane	5.0 ug/l	ND
Tetrachloroehtene	5.0 ug/l	ND
Toluene	5.0 ug/l	4,500
1,1,1-Trichloroethane	5.0 ug/l	ND
1,1,2-Trichloroethane	5.0 ug/l	ND
Trichloroethene	5.0 ug/l	ND
Trichlorofluoromethane	5.0 ug/l	40.7
Vinyl Chloride	5.0 ug/l	ND
Xylenes	5.0 ug/l	1,100

* Detection limits may vary with the type of sample and with the concentrations of other species present.

** ND = Not Detected, below the detection limit.

Respectfully submitted,

TRUESDAIL LABORATORIES,INC.

Gregory W. Everett,
Project Manager

REPORT

TRUESDAIL LABORATORIES, INC.

CHEMISTS - MICROBIOLOGISTS - ENGINEERS
RESEARCH — DEVELOPMENT — TESTING

14201 FRANKLIN AVENUE
TUSTIN, CALIFORNIA 92680
AREA CODE 714 • 730-6239
AREA CODE 213 • 225-1564
CABLE: TRUELABS

CLIENT **Orange County Water District**
10500 Ellis Avenue
Fountain Valley, California 92708
Attention: Nira Yamachika

DATE June 2, 1989

RECEIVED June 1, 1989

SAMPLE EF1 (oily foam)

LABORATORY NO. 32775-1

INVESTIGATION

Purgeable Organics (Volatiles) by EPA 8010-8020
GC-HECD and GC-PID

RESULTS

Constituent	Detection * Limit (ug/kg)	Concentration** Micrograms/Kilogram
Acetone	5.0	73.4
Benzene	5.0	ND
Bromodichloromethane	5.0	42.9
Bromoform	5.0	ND
Bromomethane	5.0	ND
Carbon Tetrachloride	5.0	ND
Chlorobenzene	5.0	ND
Chloroethane	5.0	ND
2-Chloroethyl vinyl ether	5.0	ND
Chloroform	5.0	32.1
Chloromethane	5.0	ND
bis (2-Chloroethyl) ether	5.0	ND
Dibromochloromethane	5.0	18.7
1,2-Dichlorobenzene	5.0	ND
1,3-Dichlorobenzene	5.0	ND
1,4-Dichlorobenzene	5.0	ND
Dichlorodifluoromethane	5.0	ND
1,1-Dichloroethane	5.0	ND
1,2-Dichloroethane	5.0	ND
1,1-Dichloroethene	5.0	ND
trans-1,2-Dichloroethene	5.0	ND
1,2-Dichloropropane	5.0	ND

* Detection limits may vary with the type of sample and with the concentrations of other species present.

** ND = Not detected, below detection limit.

This report applies only to the sample, or samples, investigated and is not necessarily indicative of the quality or condition of apparently identical or similar products. As a mutual protection to clients, the public and these Laboratories, this report is submitted and accepted for the exclusive use of the client to whom it is addressed and upon the condition that it is not to be used, in whole or in part, in any advertising or publicity matter without prior written authorization from these Laboratories.

Orange County Water District
Laboratory Number 32775-1
Page Two

Constituent	Detection * Limit (ug/kg)	Concentration** Micrograms/Kilogram
cis-1,3-Dichloropropene	5.0	ND
trans-1,2-Dichloroethene	5.0	ND
Ethyl Benzene	5.0	8.0
Methylene Chloride	5.0	ND
Methyl Ethyl Ketone	5.0	ND
Methyl Isobutyl Ketone	5.0	ND
1,1,2,2-Tetrachloroethane	5.0	ND
Tetrachloroethene	5.0	ND
Toluene	5.0	ND
1,1,1-Trichloroethane	5.0	ND
1,1,2-Trichloroethane	5.0	ND
Trichloroethene	5.0	ND
Trichlorofluoromethane	5.0	ND
Vinyl Chloride	5.0	ND
Xylenes	5.0	13.1

* Detection limits may vary with the type of sample and with the concentrations of other species present.

** ND = Not detected, below detection limit.

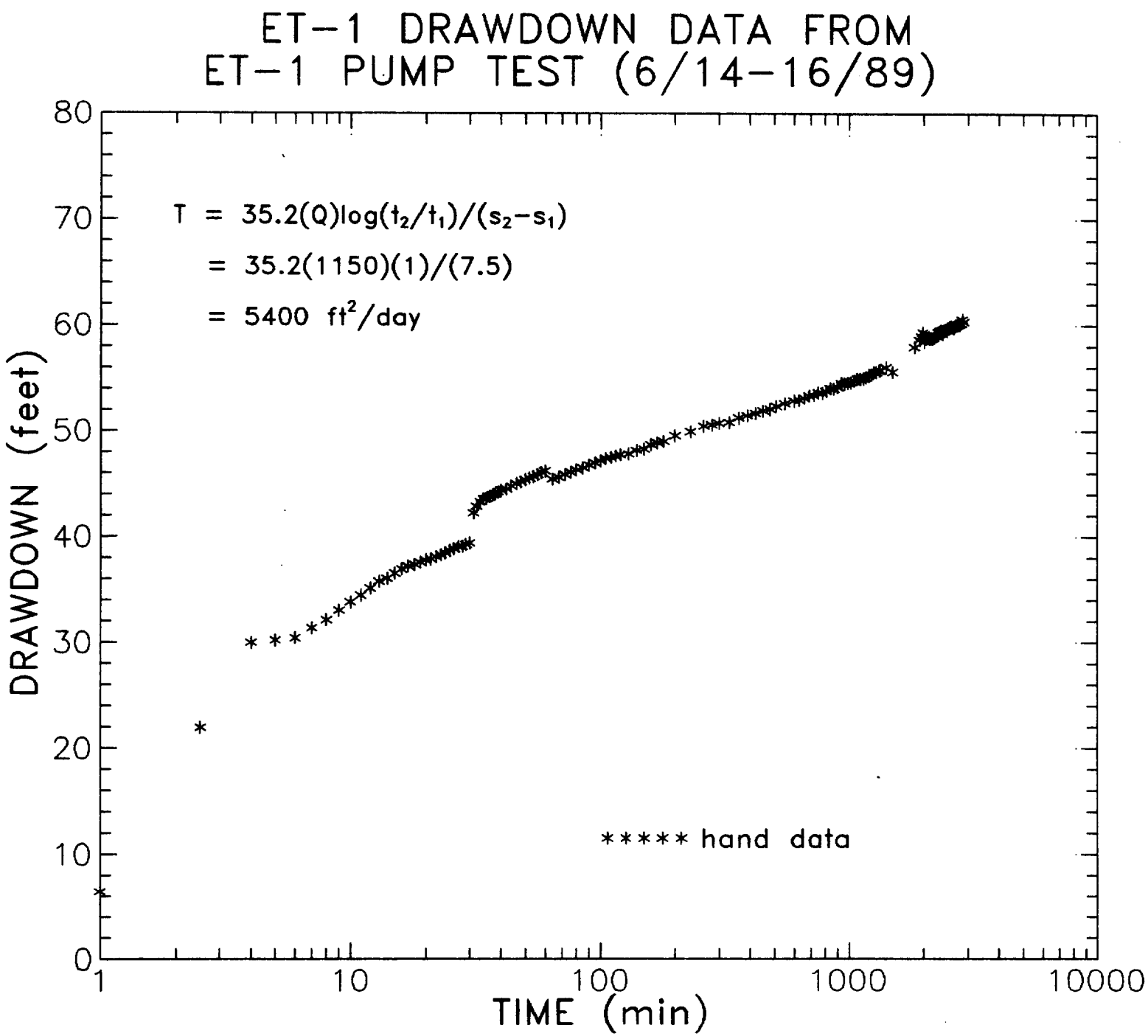
Respectfully submitted,
TRUESDAIL LABORATORIES, INC.

Julia Nayberg

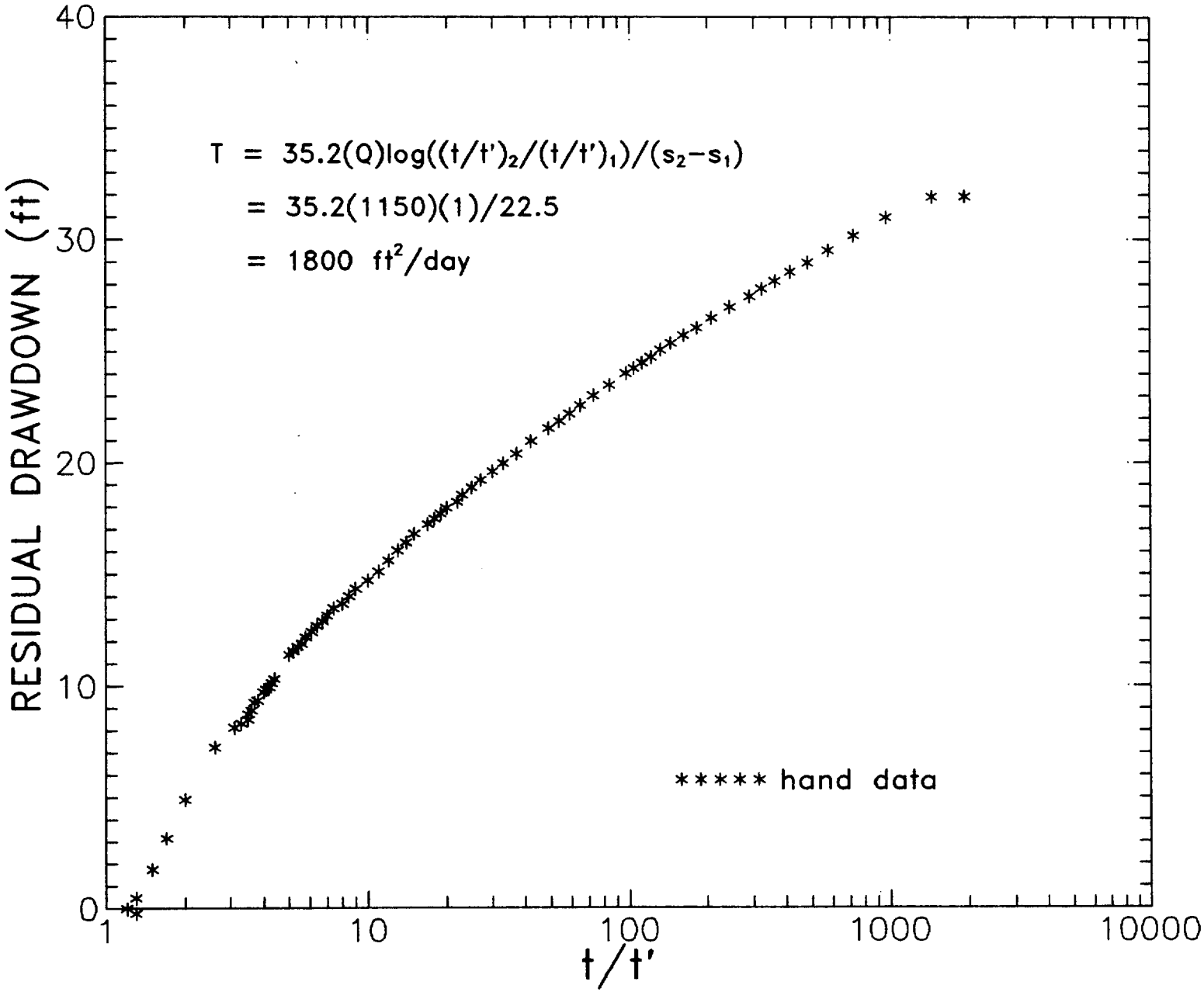
Julia Nayberg, Manager
Inorganic Chemistry

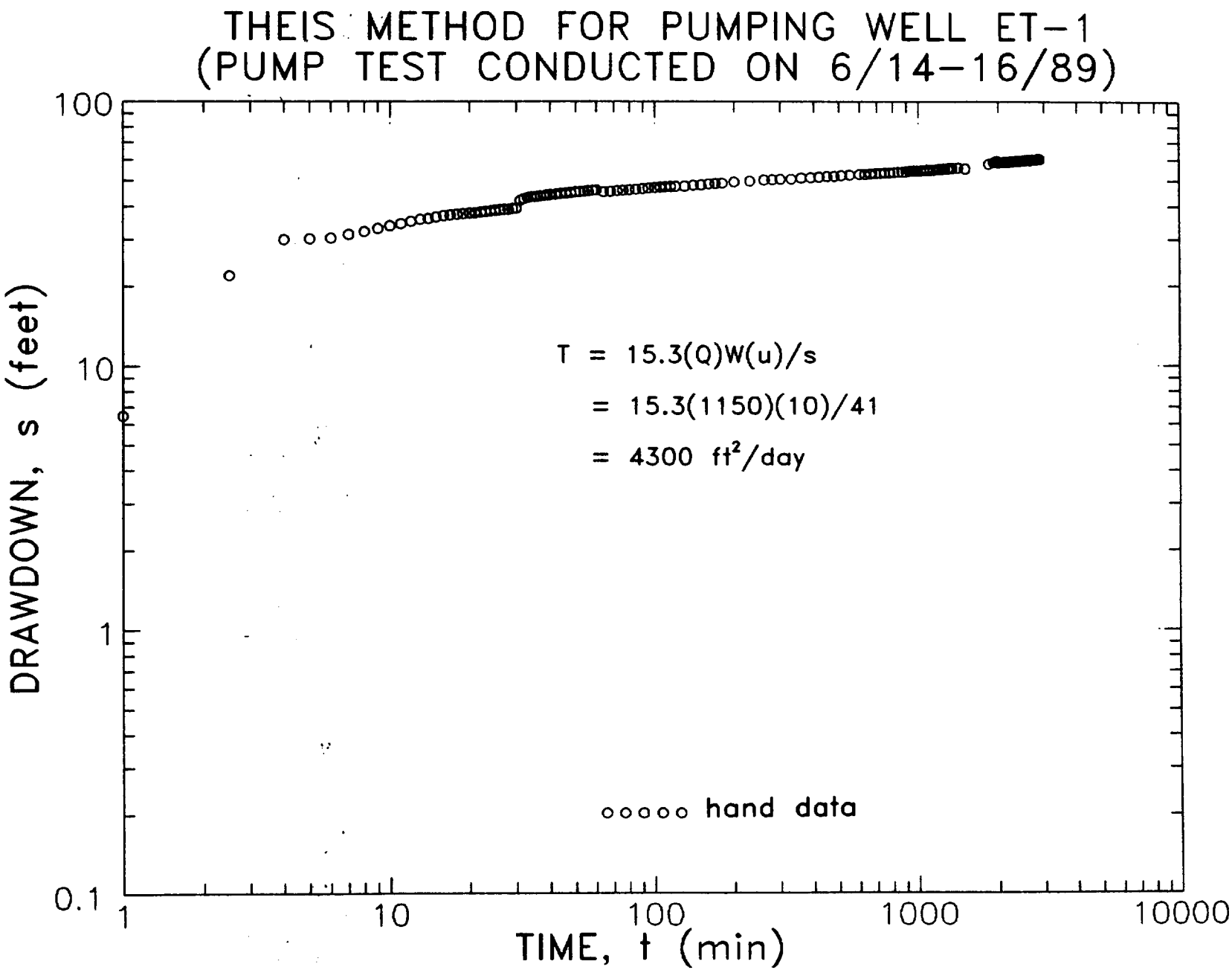
APPENDIX C

AQUIFER TEST DATA AND ANALYSES

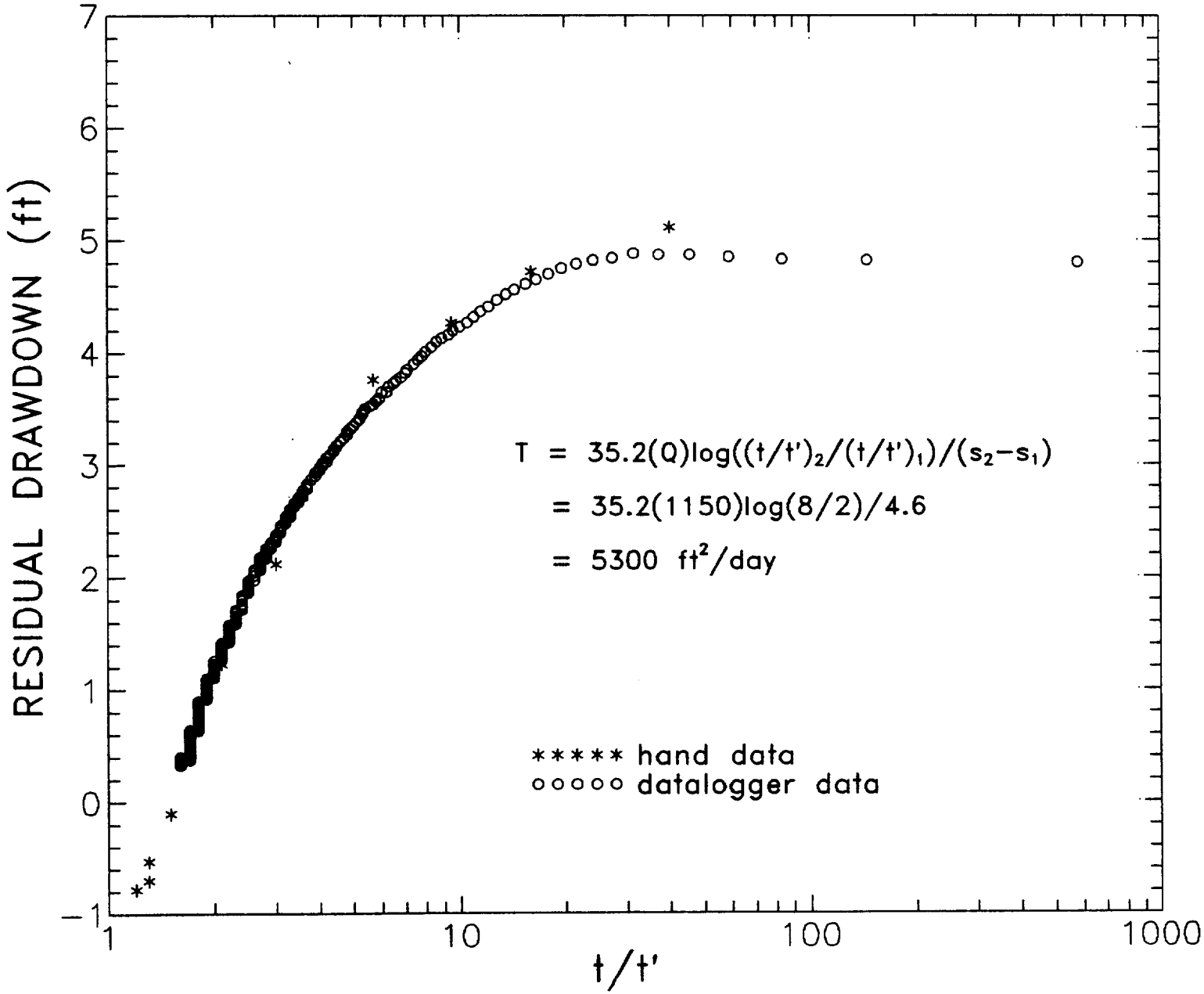

ET-1 DRAWDOWN DATA FROM
ET-1 PUMP TEST (6/14-16/89)
T = 35.2(Q)log(t2/t1)/(s2-s1)
= 35.2(1150)(1)/(7.5)
= 5400 ft2/day
***** hand data
DRAWDOWN (feet)
TIME (min)
0
10
20
30
40
50
60
70
80
1
10
100
1000
10000

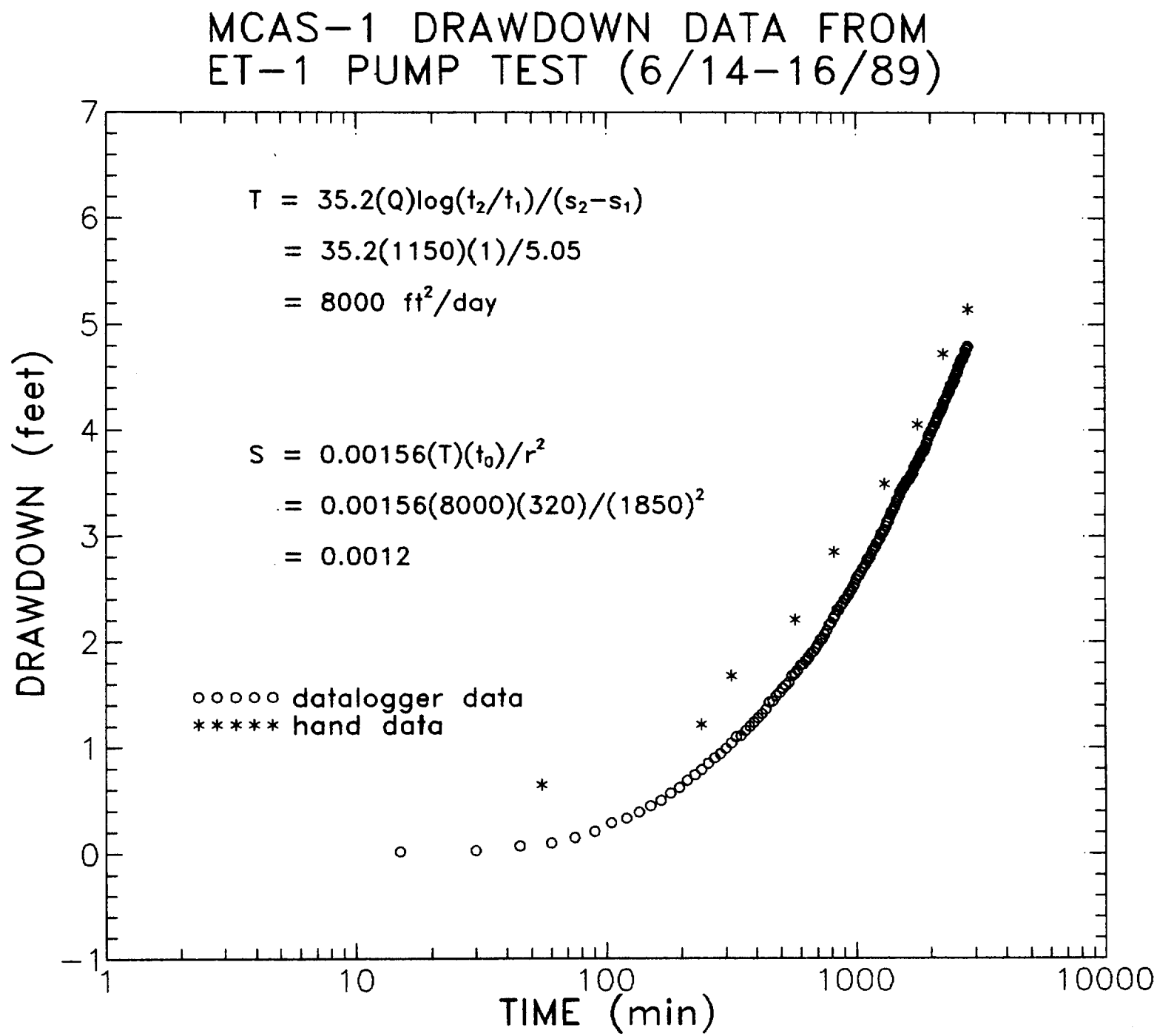
ET-1 RECOVERY DATA FROM ET-1 PUMP TEST (6/14-16/89)



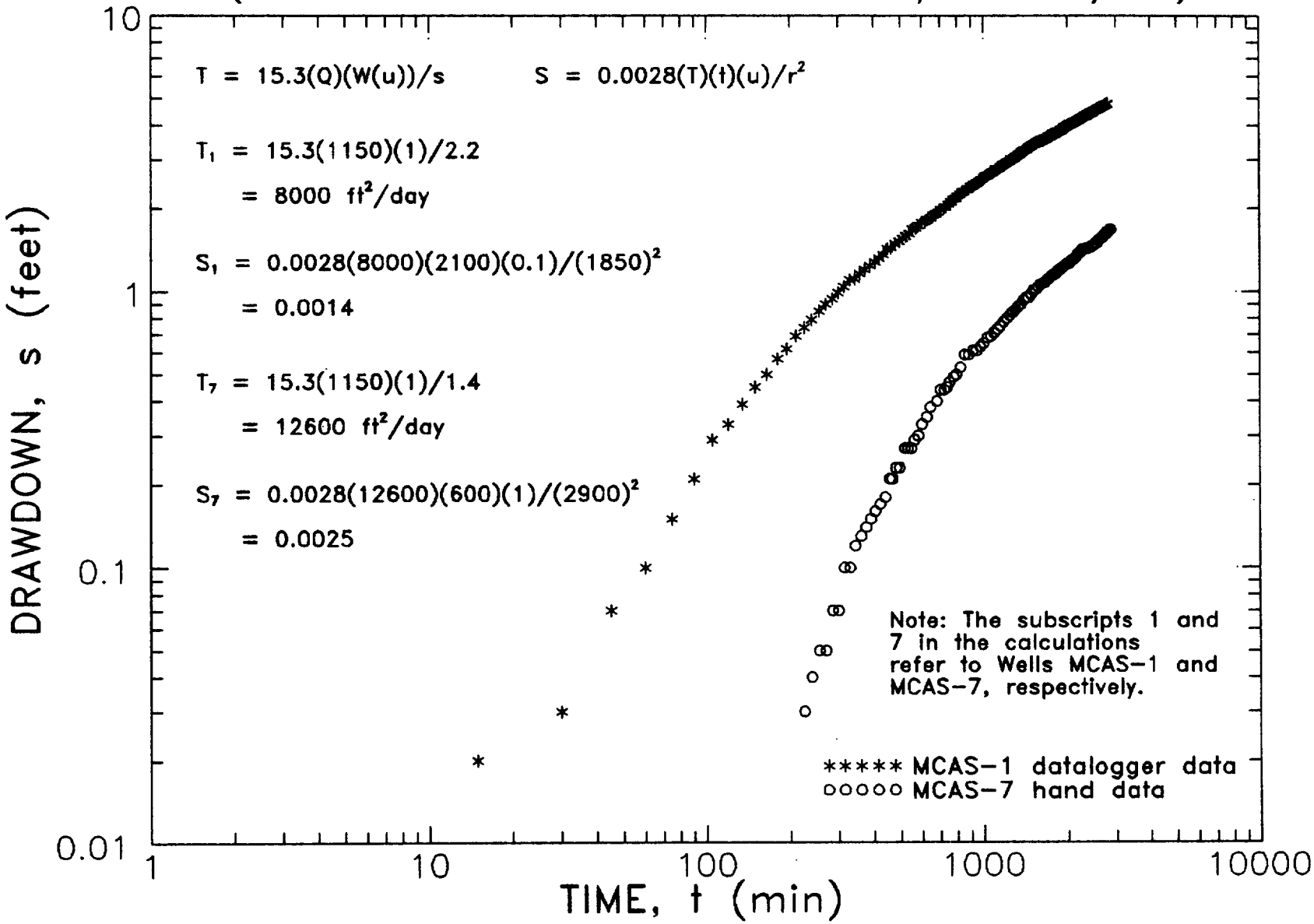

THEIS METHOD FOR PUMPING WELL ET-1
(PUMP TEST CONDUCTED ON 6/14-16/89)
DRAWDOWN, s (feet)
100
10
1
0.1
1
10
100
1000
10000
TIME, t (min)
T = 15.3(Q)W(u)/s
= 15.3(1150)(10)/41
= 4300 ft²/day
hand data

MCAS-1 RECOVERY DATA FROM ET-1 PUMP TEST (6/14-16/89)

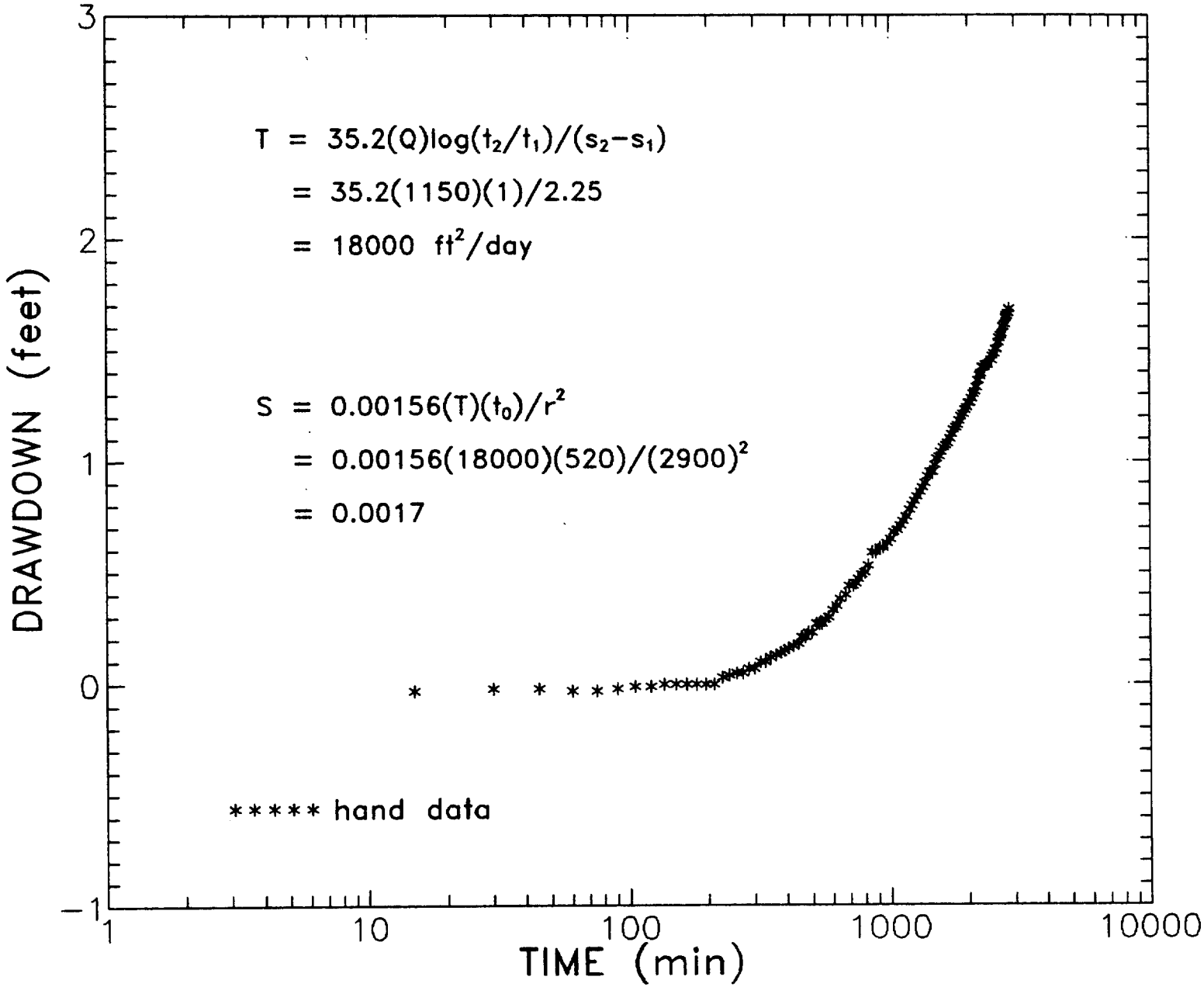



MCAS-1 DRAWDOWN DATA FROM
ET-1 PUMP TEST (6/14-16/89)
T = 35.2(Q)log(t2/t1)/(s2-s1)
= 35.2(1150)(1)/5.05
= 8000 ft2/day
S = 0.00156(T)(t0)/r2
= 0.00156(8000)(320)/(1850)2
= 0.0012
ooooo datalogger data
***** hand data
DRAWDOWN (feet)
TIME (min)
7
6
5
4
3
2
1
0
-1
1
10
100
1000
10000

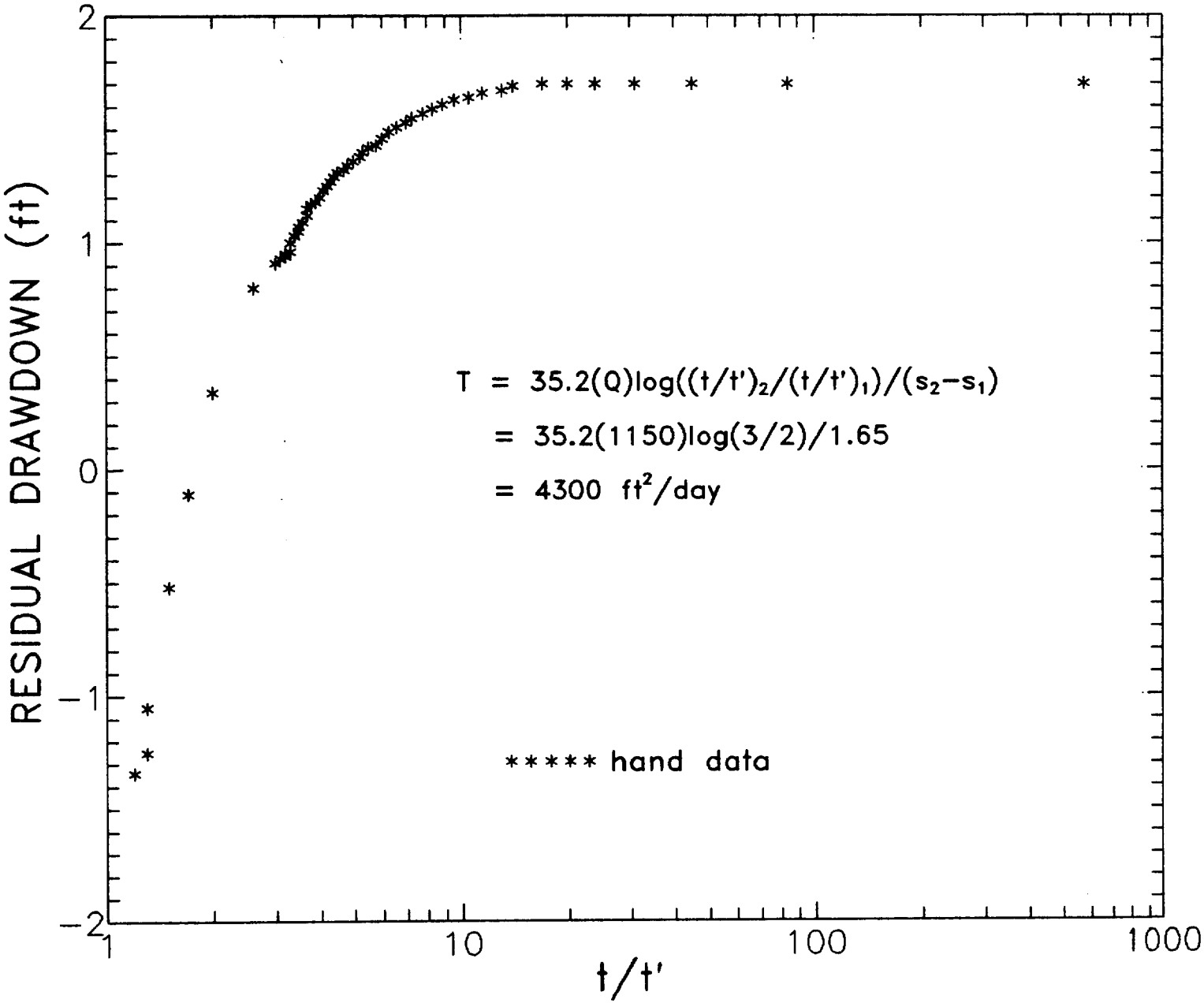
THEIS METHOD FOR MCAS-1 AND MCAS-7 (PUMP TEST CONDUCTED ON 6/14-16/89)



MCAS-7 DRAWDOWN DATA FROM ET-1 PUMP TEST (6/14-16/89)



MCAS-7 RECOVERY DATA FROM ET-1 PUMP TEST (6/14-16/89)



DISTANCE-DRAWDOWN DATA FROM WELLS ET-1, MCAS-1, MCAS-7 (ET-1 PUMP TEST: 6/14-16/89)

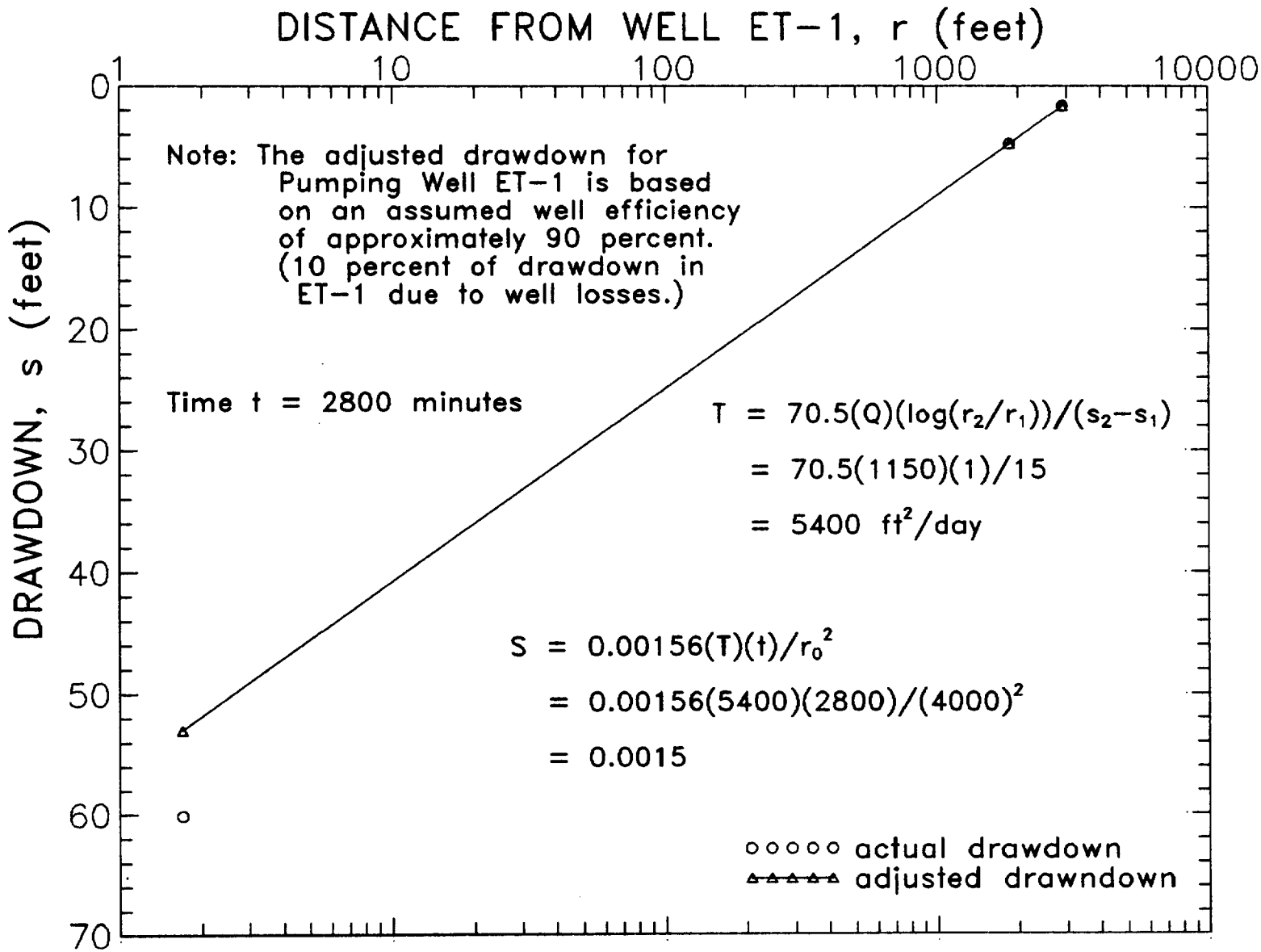


Table C1. ET-1 Aquifer Test Data

Test performed on 6-14-89 through 6-16-89.
Static water level = 57.45 feet BGS (6-27-89).
Pumping rate of Well ET-1 = 1150 gpm Date Printed: 08/13/90

Time Since Pump On, t (min)	Drawdown (feet)	Flowrate (gpm)	Time Since Pump Off, t' (min)	t/t'	Residual Drawdown (feet)
1	6.47	500	1.5	1928	31.92
2.5	21.95	900	2	1446	31.90
4	30.00	1000	3	964	30.98
5	30.22	1000	4	724	30.17
6	30.42	1000	5	579	29.50
7	31.37	1000	6	483	28.96
8	32.13	1000	7	414	28.55
9	33.02	1000	8	362	28.14
10	33.83	1000	9	322	27.81
11	34.45	1000	10	290	27.46
12	35.14	1000	12	243	26.99
13	35.78	1000	14	207	26.50
14	36.06	1000	16	182	26.06
15	36.53	1000	18	162	25.72
16	36.95	1000	20	145	25.37
17	37.20	1000	22	132	25.07
18	37.37	1000	24	121	24.75
19	37.58	1000	26	112	24.49
20	37.80	1000	28	104	24.25
21	37.89	1000	30	97	24.01
22	38.11	1100	35	84	23.48
23	38.30	1100	40	73	23.01
24	38.47	1100	45	65	22.58
25	38.70	1100	50	59	22.19
26	38.84	1100	55	54	21.86
27	39.07	1100	60	49	21.53
28	39.09	800	70	42	20.97
29	39.27	800	80	37	20.39
30	39.41	800	90	33	19.97
31	42.22	1200	100	30	19.59
32	42.85	1200	110	27	19.20
33	43.28	1200	120	25	18.87
34	43.55	1200	130	23	18.54
35	43.57	1200	140	22	18.23
36	43.76	1200	150	20	17.96
37	43.92	1200	160	19	17.71
38	44.01	1200	170	18	17.46
39	44.21	1200	180	17	17.22
40	44.38	1200	200	15	16.80
42	44.50	1200	220	14	16.41
44	44.75	1200	240	13	16.05
46	44.99	1200	270	12	15.60
48	45.15	1200	300	11	15.11
50	45.37	1100	330	10	14.72
52	45.51	1100	360	9	14.35
54	45.66	1100	390	8.5	14.01
56	45.85	1100	420	8	13.68
58	46.05	1100	450	7.4	13.49
60	46.20	1100	480	7	13.16
64	45.40	1100	510	6.7	12.90
68	45.60	1100	540	6.4	12.70
72	45.85	1100	570	6.1	12.43
76	46.07	1200	600	5.8	12.18
80	46.30	1200	630	5.6	11.89
85	46.48	1200	660	5.4	11.76
90	46.74	1200	690	5.2	11.56
95	46.98	1200	720	5	11.40
100	47.15	1200	840	4.4	10.31

Table C1. ET-1 Aquifer Test Data

Date Printed: 08/13/90

Time Since Pump On, t (min)	Drawdown (feet)	Flowrate (gpm)	Time Since Pump Off, t' (min)	t/t'	Residual Drawdown (feet)
100	47.15	1200	840	4.4	10.31
105	47.36	1200	870	4.3	10.13
110	47.50	1200	900	4.2	9.95
115	47.62	1200	930	4.1	9.85
120	47.74	1200	960	4	9.72
130	47.81	1200	1020	3.8	9.35
140	48.15	1200	1080	3.7	9.26
150	48.26	1200	1110	3.6	8.90
160	48.70	1200	1140	3.5	8.74
170	48.87	1200	1200	3.5	8.50
180	49.01	1200	1230	3.3	8.31
200	49.53	1180	1260	3.1	8.13
230	49.93	1180	1800	2.6	7.25
260	50.45	1180	3020	2	4.90
280	50.57	1180	4250	1.7	3.16
300	50.73	1150	5670	1.5	1.75
330	50.81	1150	8590	1.3	0.48
360	51.24	1150	10040	1.3	-0.23
390	51.45	1150	16130	1.2	0.00
420	51.68	1150			
450	51.91	1150			
480	52.05	1150			
510	52.32	1150			
550	52.60	1150			
600	52.87	1150			
630	52.91	1150			
660	53.12	1150			
690	53.35	1150			
720	53.38	1150			
750	53.61	1150			
780	53.60	1150			
810	53.78	1150			
840	54.02	1150			
870	53.99	1150			
900	54.14	1150			
930	54.52	1150			
960	54.50	1150			
990	54.56	1150			
1020	54.62	1150			
1050	54.73	1150			
1080	54.95	1150			
1110	54.95	1150			
1140	54.97	1150			
1170	55.07	1150			
1200	55.21	1150			
1230	55.33	1150			
1260	55.57	1150			
1290	55.56	1150			
1320	55.73	1150			
1340	55.72	1150			
1410	56.02	1150			
1500	55.58	1150			
1840	57.93	1150			
1920	58.63	1150			
1950	58.97	1170			
1980	59.32	1180			
2010	58.46	1180			
2040	58.77	1200			
2070	58.82	1180			
2100	58.88	1180			
2130	58.79	1180			

Remarks: Pump off at t = 2890 min.

At t=2870 min,
pH=7.2, water temp=25 C.

Water levels measured manually
with an electric sounder.

Water levels were still recovering
(from step drawdown test) when this
aquifer test began (t=0).

umhos/cm = micromhos/centimeter

Table C1. ET-1 Aquifer Test Data

Date Printed: 08/13/90

Time Since Pump On, t (min)	Drawdown (feet)	Flowrate (gpm)	Time Since Pump Off, t' (min)	t/t'	Residual Drawdown (feet)
2160	58.76	1180			
2190	58.83	1180			
2220	59.00	1180			
2250	59.02	1180			
2280	59.34	1180			
2310	59.45	1180			
2340	59.52	1180			
2370	59.19	1180			
2400	59.43	1180			
2430	59.48	1180			
2460	59.58	1180			
2490	59.69	1180			
2520	59.77	1180			
2550	59.86	1180			
2580	59.89	1180			
2610	59.82	1180			
2640	59.75	1180			
2670	59.92	1180			
2700	60.05	1180			
2730	60.02	1180			
2760	60.12	1180			
2790	60.13	1190			
2820	60.17	1190			
2850	60.57	1190			
2880	60.32	1190			

Table C2. MCAS-1 Data From Aquifer Test of Well ET-1

Test performed on 6/14/89 through 6/16/89.
Depth to water = 44.15 feet BGS (6-27-89).
Pumping rate of Well ET-1 = 1150 gpm
Distance from pumping well = 1850 feet

Date Printed: 08/13/90

DATALOGGER DATA

Time Since Pump On, t (min)	Drawdown (feet)	Time Since Pump Off, t' (min)	t/t'	Residual Drawdown (feet)
0	0.00	5	579.0	4.80
15	0.02	20	145.5	4.82
30	0.03	35	83.6	4.83
45	0.07	50	58.8	4.85
60	0.10	65	45.5	4.87
75	0.15	80	37.1	4.87
90	0.21	95	31.4	4.88
105	0.29	110	27.3	4.84
120	0.33	125	24.1	4.82
135	0.39	140	21.6	4.79
150	0.45	155	19.6	4.75
165	0.50	170	18.0	4.70
180	0.57	185	16.6	4.65
195	0.62	200	15.5	4.61
210	0.69	215	14.4	4.56
225	0.74	230	13.6	4.52
240	0.79	245	12.8	4.47
255	0.85	260	12.1	4.41
270	0.90	275	11.5	4.37
285	0.94	290	11.0	4.32
300	0.99	305	10.5	4.27
315	1.04	320	10.0	4.23
330	1.10	335	9.6	4.20
345	1.11	350	9.3	4.16
360	1.16	365	8.9	4.13
375	1.20	380	8.6	4.10
390	1.24	395	8.3	4.05
405	1.28	410	8.0	4.01
420	1.32	425	7.8	3.97
435	1.36	440	7.6	3.94
450	1.43	455	7.4	3.90
465	1.44	470	7.1	3.85
480	1.49	485	7.0	3.82
495	1.52	500	6.8	3.78
510	1.56	515	6.6	3.75
525	1.59	530	6.5	3.73
540	1.62	545	6.3	3.70
555	1.68	560	6.2	3.65
570	1.70	575	6.0	3.65
585	1.73	590	5.9	3.59
600	1.78	605	5.8	3.57
615	1.79	620	5.7	3.54
630	1.82	635	5.6	3.53
645	1.85	650	5.4	3.50
660	1.89	665	5.3	3.47
675	1.91	680	5.3	3.45
690	1.94	695	5.2	3.41
705	1.98	710	5.1	3.38
720	2.02	725	5.0	3.35
735	2.03	740	4.9	3.32
750	2.07	755	4.8	3.30
765	2.11	770	4.8	3.27
780	2.16	785	4.7	3.24
795	2.18	800	4.6	3.21
810	2.22	815	4.5	3.18
825	2.25	830	4.5	3.17
840	2.30	845	4.4	3.14
855	2.30	860	4.4	3.12
870	2.34	875	4.3	3.09
885	2.36	890	4.2	3.06
900	2.40	905	4.2	3.03

HAND DATA

Time Since Pump On, t (min)	Drawdown (feet)	Time Since Pump Off, t (min)	t/t'	Residual Drawdown (feet)
55	0.65	75	40.0	5.11
240	1.22	190	16.0	4.72
315	1.68	340	9.5	4.27
570	2.21	610	5.7	3.76
820	2.85	1475	3.0	2.12
1310	3.49	2660	2.1	1.23
1780	4.05	4240	1.7	0.54
2240	4.72	5660	1.5	-0.10
2810	5.14	8580	1.3	-0.53
		10030	1.3	-0.70
		16120	1.2	-0.78

Remarks: Pump off at t=2890 min.

Table C2. MCAS-1 Data From Aquifer Test of Well ET-1

Date Printed: 08/13/90

DATALOGGER DATA					HAND DATA				
Time Since Pump On, t (min)	Drawdown (feet)	Time Since Pump Off,t' (min)	t/t'	Residual Drawdown (feet)	Time Since Pump On, t (min)	Drawdown (feet)	Time Since Pump Off, t (min)	t/t'	Residual Drawdown (feet)
915	2.41	920	4.1	3.02					
930	2.44	935	4.1	3.00					
945	2.47	950	4.0	2.97					
960	2.49	965	4.0	2.95					
975	2.52	980	3.9	2.93					
990	2.55	995	3.9	2.90					
1005	2.59	1010	3.9	2.90					
1020	2.62	1025	3.8	2.87					
1035	2.63	1040	3.8	2.87					
1050	2.66	1055	3.7	2.83					
1065	2.69	1070	3.7	2.81					
1080	2.71	1085	3.7	2.79					
1095	2.73	1100	3.6	2.77					
1110	2.78	1115	3.6	2.74					
1125	2.78	1130	3.6	2.72					
1140	2.80	1145	3.5	2.71					
1155	2.83	1160	3.5	2.69					
1170	2.87	1175	3.5	2.67					
1185	2.88	1190	3.4	2.66					
1200	2.90	1205	3.4	2.63					
1215	2.93	1220	3.4	2.63					
1230	2.95	1235	3.3	2.60					
1245	2.97	1250	3.3	2.58					
1260	3.02	1265	3.3	2.56					
1275	3.02	1280	3.3	2.54					
1290	3.04	1295	3.2	2.54					
1305	3.06	1310	3.2	2.52					
1320	3.09	1325	3.2	2.50					
1335	3.13	1340	3.2	2.48					
1350	3.14	1355	3.1	2.46					
1365	3.17	1370	3.1	2.44					
1380	3.20	1385	3.1	2.43					
1395	3.23	1400	3.1	2.40					
1410	3.24	1415	3.0	2.38					
1425	3.26	1430	3.0	2.37					
1440	3.28	1445	3.0	2.36					
1455	3.33	1460	3.0	2.34					
1470	3.33	1475	3.0	2.32					
1485	3.36	1490	2.9	2.31					
1500	3.38	1505	2.9	2.31					
1515	3.42	1520	2.9	2.28					
1530	3.43	1535	2.9	2.27					
1545	3.46	1550	2.9	2.26					
1560	3.46	1565	2.8	2.25					
1575	3.48	1580	2.8	2.23					
1590	3.50	1595	2.8	2.21					
1605	3.52	1610	2.8	2.20					
1620	3.52	1625	2.8	2.18					
1635	3.53	1640	2.8	2.17					
1650	3.54	1655	2.7	2.18					
1665	3.56	1670	2.7	2.16					
1680	3.58	1685	2.7	2.15					
1695	3.59	1700	2.7	2.13					
1710	3.63	1715	2.7	2.11					
1725	3.65	1730	2.7	2.09					
1740	3.66	1745	2.7	2.07					
1755	3.68	1760	2.6	2.07					
1770	3.70	1775	2.6	2.06					
1785	3.72	1790	2.6	2.05					
1800	3.72	1805	2.6	2.02					
1815	3.73	1820	2.6	2.02					
1830	3.77	1835	2.6	2.02					
1845	3.79	1850	2.6	1.98					

Table C2. MCAS-1 Data From Aquifer Test of Well ET-1

Date Printed: 08/13/90

DATALOGGER DATA					HAND DATA				
Time Since Pump On, t (min)	Drawdown (feet)	Time Since Pump Off,t' (min)	t/t'	Residual Drawdown (feet)	Time Since Pump On, t (min)	Drawdown (feet)	Time Since Pump Off, t (min)	t/t'	Residual Drawdown (feet)
1860	3.79	1865	2.5	1.97					
1875	3.80	1880	2.5	1.97					
1890	3.82	1895	2.5	1.95					
1905	3.84	1910	2.5	1.93					
1920	3.87	1925	2.5	1.91					
1935	3.88	1940	2.5	1.90					
1950	3.91	1955	2.5	1.88					
1965	3.95	1970	2.5	1.88					
1980	3.95	1985	2.5	1.87					
1995	3.96	2000	2.4	1.84					
2010	3.99	2015	2.4	1.82					
2025	4.00	2030	2.4	1.80					
2040	4.01	2045	2.4	1.80					
2055	4.04	2060	2.4	1.80					
2070	4.04	2075	2.4	1.77					
2085	4.07	2090	2.4	1.76					
2100	4.08	2105	2.4	1.75					
2115	4.10	2120	2.4	1.74					
2130	4.12	2135	2.4	1.72					
2145	4.15	2150	2.3	1.71					
2160	4.15	2165	2.3	1.69					
2175	4.16	2180	2.3	1.69					
2190	4.18	2195	2.3	1.66					
2205	4.19	2210	2.3	1.66					
2220	4.21	2225	2.3	1.64					
2235	4.23	2240	2.3	1.62					
2250	4.24	2255	2.3	1.63					
2265	4.27	2270	2.3	1.61					
2280	4.28	2285	2.3	1.59					
2295	4.29	2300	2.3	1.59					
2310	4.31	2315	2.2	1.58					
2325	4.32	2330	2.2	1.56					
2340	4.35	2345	2.2	1.54					
2355	4.35	2360	2.2	1.53					
2370	4.37	2375	2.2	1.52					
2385	4.39	2390	2.2	1.51					
2400	4.42	2405	2.2	1.50					
2415	4.41	2420	2.2	1.49					
2430	4.42	2435	2.2	1.47					
2445	4.43	2450	2.2	1.47					
2460	4.46	2465	2.2	1.45					
2475	4.47	2480	2.2	1.44					
2490	4.49	2495	2.2	1.44					
2505	4.51	2510	2.2	1.43					
2520	4.52	2525	2.1	1.42					
2535	4.53	2540	2.1	1.40					
2550	4.54	2555	2.1	1.40					
2565	4.56	2570	2.1	1.38					
2580	4.60	2585	2.1	1.38					
2595	4.60	2600	2.1	1.37					
2610	4.62	2615	2.1	1.36					
2625	4.63	2630	2.1	1.35					
2640	4.65	2645	2.1	1.33					
2655	4.67	2660	2.1	1.31					
2670	4.66	2675	2.1	1.31					
2685	4.67	2690	2.1	1.31					
2700	4.68	2705	2.1	1.29					
2715	4.70	2720	2.1	1.28					
2730	4.71	2735	2.1	1.28					
2745	4.73	2750	2.1	1.27					
2760	4.76	2765	2.0	1.26					
2775	4.76	2780	2.0	1.26					
2790	4.77	2795	2.0	1.23					

Table C2. MCAS-1 Data From Aquifer Test of Well ET-1

Date Printed: 08/13/90

DATALOGGER DATA					HAND DATA				
Time Since Pump On, t (min)	Drawdown (feet)	Time Since Pump Off, t' (min)	t/t'	Residual Drawdown (feet)	Time Since Pump On, t (min)	Drawdown (feet)	Time Since Pump Off, t (min)	t/t'	Residual Drawdown (feet)
2805	4.79	2810	2.0	1.22					
		2825	2.0	1.21					
		2840	2.0	1.21					
		2855	2.0	1.20					
		2870	2.0	1.19					
		2885	2.0	1.18					
		2900	2.0	1.17					
		2915	2.0	1.16					
		2930	2.0	1.15					
		2945	2.0	1.14					
		2960	2.0	1.15					
		2975	2.0	1.13					
		2990	2.0	1.12					
		3005	2.0	1.13					
		3020	2.0	1.11					
		3035	2.0	1.11					
		3050	1.9	1.10					
		3065	1.9	1.09					
		3080	1.9	1.09					
		3095	1.9	1.07					
		3110	1.9	1.07					
		3125	1.9	1.05					
		3140	1.9	1.05					
		3155	1.9	1.04					
		3170	1.9	1.03					
		3185	1.9	1.03					
		3200	1.9	1.02					
		3215	1.9	1.01					
		3230	1.9	1.00					
		3245	1.9	1.01					
		3260	1.9	0.99					
		3275	1.9	0.97					
		3290	1.9	0.97					
		3305	1.9	0.96					
		3320	1.9	0.95					
		3335	1.9	0.95					
		3350	1.9	0.95					
		3365	1.9	0.93					
		3380	1.9	0.92					
		3395	1.9	0.92					
		3410	1.8	0.90					
		3425	1.8	0.88					
		3440	1.8	0.88					
		3455	1.8	0.87					
		3470	1.8	0.86					
		3485	1.8	0.86					
		3500	1.8	0.86					
		3515	1.8	0.84					
		3530	1.8	0.83					
		3545	1.8	0.82					
		3560	1.8	0.81					
		3575	1.8	0.81					
		3590	1.8	0.79					
		3605	1.8	0.78					
		3620	1.8	0.78					
		3635	1.8	0.77					
		3650	1.8	0.76					
		3665	1.8	0.74					
		3680	1.8	0.74					
		3695	1.8	0.74					
		3710	1.8	0.73					
		3725	1.8	0.71					
		3740	1.8	0.70					

Table C2. MCAS-1 Data From Aquifer Test of Well ET-1

Date Printed: 08/13/90

DATALOGGER DATA					HAND DATA				
Time Since Pump On, t (min)	Drawdown (feet)	Time Since Pump Off, t' (min)	t/t'	Residual Drawdown (feet)	Time Since Pump On, t (min)	Drawdown (feet)	Time Since Pump Off, t (min)	t/t'	Residual Drawdown (feet)
		3755	1.8	0.69					
		3770	1.8	0.68					
		3785	1.8	0.68					
		3800	1.8	0.66					
		3815	1.8	0.66					
		3830	1.8	0.64					
		3845	1.8	0.64					
		3860	1.7	0.64					
		3875	1.7	0.64					
		3890	1.7	0.62					
		3905	1.7	0.60					
		3920	1.7	0.61					
		3935	1.7	0.60					
		3950	1.7	0.59					
		3965	1.7	0.58					
		3980	1.7	0.57					
		3995	1.7	0.57					
		4010	1.7	0.57					
		4025	1.7	0.56					
		4040	1.7	0.55					
		4055	1.7	0.53					
		4070	1.7	0.53					
		4085	1.7	0.53					
		4100	1.7	0.52					
		4115	1.7	0.52					
		4130	1.7	0.50					
		4145	1.7	0.50					
		4160	1.7	0.48					
		4175	1.7	0.48					
		4190	1.7	0.47					
		4205	1.7	0.46					
		4220	1.7	0.46					
		4235	1.7	0.45					
		4250	1.7	0.45					
		4265	1.7	0.43					
		4280	1.7	0.42					
		4295	1.7	0.43					
		4310	1.7	0.41					
		4325	1.7	0.40					
		4340	1.7	0.40					
		4355	1.7	0.40					
		4370	1.7	0.40					
		4385	1.7	0.40					
		4400	1.7	0.40					
		4415	1.7	0.39					
		4430	1.7	0.40					
		4445	1.7	0.38					
		4460	1.6	0.38					
		4475	1.6	0.40					
		4490	1.6	0.37					
		4505	1.6	0.36					
		4520	1.6	0.37					
		4535	1.6	0.36					
		4550	1.6	0.35					
		4565	1.6	0.34					
		4580	1.6	0.34					
		4595	1.6	0.33					
		4610	1.6	0.33					

Table C3. MCAS-7 Data From Aquifer Test at Well ET-1

Test performed on 6-14-89 through 6-16-89
Depth to water = 20.26 feet BGS (6-27-89)
Pumping rate of Well ET-1 = 1150 gpm
Distance from pumping well ET-1 = 2900 feet

Date Printed: 08/13/90

Time Since Pump On, t (min)	Drawdown (feet)	Time Since Pump Off, t' (min)	t/t'	Residual Drawdown (feet)
0	0.00	5	579	1.70
0	0.00	5	579	1.70
15	-0.03	35	84	1.70
30	-0.02	65	45	1.70
45	-0.02	95	31	1.70
60	-0.03	125	24	1.70
75	-0.03	155	20	1.70
90	-0.02	185	17	1.70
105	-0.01	215	14	1.69
120	-0.01	245	13	1.67
135	0.00	275	11.5	1.66
150	0.00	305	10.5	1.64
165	0.00	335	9.6	1.63
180	0.00	365	8.9	1.61
195	0.00	395	8.3	1.59
210	0.00	425	7.8	1.57
225	0.03	455	7.3	1.55
240	0.04	485	7	1.53
255	0.05	515	6.6	1.51
270	0.05	545	6.3	1.49
285	0.07	575	6	1.46
300	0.07	605	5.8	1.43
315	0.10	635	5.5	1.42
330	0.10	665	5.3	1.40
345	0.12	695	5.2	1.38
362	0.13	725	5	1.36
378	0.14	755	4.8	1.34
391	0.15	785	4.7	1.32
406	0.16	815	4.5	1.31
423	0.17	845	4.4	1.29
441	0.18	875	4.3	1.27
457	0.21	905	4.2	1.25
468	0.21	935	4.1	1.23
482	0.23	965	4	1.20
498	0.23	995	3.9	1.18
518	0.27	1025	3.8	1.17
533	0.27	1055	3.7	1.15
548	0.27	1085	3.7	1.12
564	0.29	1115	3.6	1.09
581	0.30	1145	3.5	1.07
600	0.33	1175	3.5	1.05
623	0.35	1205	3.4	1.03
644	0.38	1235	3.3	1.00
678	0.40	1265	3.3	0.96
698	0.44	1295	3.2	0.95
723	0.44	1325	3.2	0.94
738	0.45	1355	3.1	0.93
754	0.47	1385	3.1	0.93
778	0.49	1415	3	0.91
798	0.50	1820	2.6	0.80
823	0.53	3030	2	0.34
853	0.59	4260	1.7	-0.11
883	0.59	5680	1.5	-0.52
913	0.61	8600	1.3	-1.05
943	0.61	10050	1.3	-1.25
973	0.63	16140	1.2	-1.34
1003	0.65			
1033	0.68			

Table C3. MCAS-7 Data From Aquifer Test at Well ET-1

Date Printed: 08/13/90

Time Since Pump On, t (min)	Drawdown (feet)
1063	0.69
1093	0.71
1123	0.73
1153	0.75
1183	0.78
1213	0.80
1243	0.82
1273	0.84
1303	0.86
1333	0.88
1363	0.90
1393	0.93
1423	0.95
1453	0.95
1483	0.98
1513	1.01
1543	1.02
1573	1.04
1603	1.06
1633	1.07
1663	1.08
1693	1.10
1723	1.12
1753	1.14
1783	1.15
1813	1.16
1843	1.18
1873	1.20
1903	1.21
1933	1.23
1963	1.24
1993	1.26
2023	1.26
2053	1.28
2083	1.30
2113	1.31
2143	1.33
2173	1.36
2203	1.38
2233	1.39
2263	1.42
2293	1.42
2323	1.43
2353	1.43
2443	1.45
2473	1.47
2503	1.48
2533	1.50
2563	1.50
2593	1.53
2623	1.55
2653	1.56
2683	1.57
2713	1.60
2743	1.61
2773	1.64
2803	1.65
2833	1.66
2863	1.68

Time Since Pump Off, t' (min)	t/t'	Residual Drawdown (feet)

Remarks: Pump off at t = 2890 min.

Water levels measured manually with an electric sounder.