Staal, Gardner & Dunne, Inc.

Consulting Engineers and Geologists

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HYDROGEOLOGIC INVESTIGATION

CARMEL RIVER AQUIFER COASTAL PORTION

MONTEREY COUNTY, CALIFORNIA

FOR

MONTEREY PENINSULA WATER
MANAGEMENT DISTRICT

MAY 1989

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INTRODUCTION

GENERAL STATEMENT

Presented in this report are the principal findings, conclusions, and recommendations developed as part of a hydrogeologic investigation of the coastal portion of the Carmel River Aquifer near Carmel in Monterey County, California. Geophysical techniques and the construction of test holes and monitoring wells were used to define basin geometry, refine estimates of ground water in storage, and to quantify the existence and potential for seawater intrusion in the western-most coastal portion of the aquifer system.

The location of the study area is shown on Figure 1 - Site Location Map, and includes an approximate 360 acre area straddling the Carmel River situated between U.S. Highway 1 and the Carmel Bay.

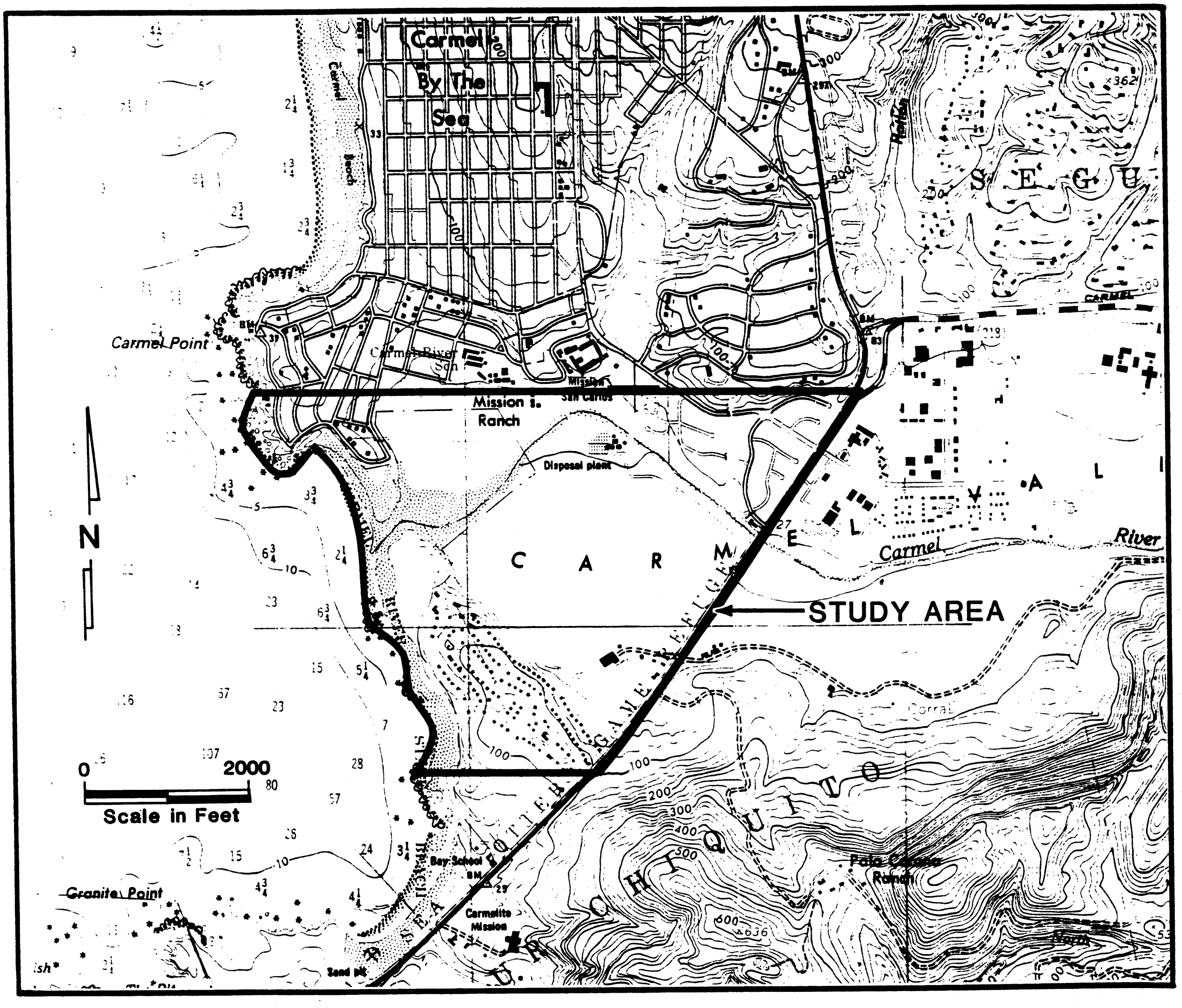
PURPOSE AND SCOPE

This study constitutes an analysis of the existing hydrogeologic conditions at the mouth of the Carmel Valley, and assesses the feasibility of, and impacts associated with, additional well production capacity in the coastal portion of the Carmel Valley alluvial aquifer. Additional municipal well production capacity in the coastal portion of the Carmel Valley (i.e., the lowest three miles of the alluvial aquifer, referred to by Monterey Peninsula Water Management District [District] staff as aquifer subunit 4) is being studied by the District as a possible component to the major reservoir project alternatives being considered. Results of this investigation will be utilized to assist in the analysis of alternatives for the District's New Water Supply Project Supplemental Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS), which is presently in preparation.

Previous geologic investigations have suggested that the Cypress Point fault is present near the mouth of the Carmel River mouth (Logan, 1983), and may constitute a subsurface barrier to seawater intrusion. This study represents an effort to verify the existence of this fault barrier, to establish

FIGURE 1

SITE LOCATION MAP



SOURCE: USGS 7.5 QUADRANGLE, MONTEREY, 1947, REV. 1983.

the presence of seawater intrusion, if any, within the coastal portion of the aquifer, and to assess the sensitivity of the aquifer to seawater intrusion under various scenarios of pumping stress to assist in the analysis alternatives as part of the District's water supply augmentation objectives.

The District authorized Staal, Gardner & Dunne, Inc. (SGD) to conduct a hydrogeologic investigation of the coastal Carmel River Aquifer pursuant to a scope of work contained in a letter of proposal dated November 8, 1988. The scope of work was further refined through discussions with Mr. Joe Oliver, District Geohydrologist. As performed, our work included:

1) Collection and review of readily available data including previous reports of the area and water well and geotechnical boring logs.

2) Performance of a geophysical survey of the study area utilizing both reflection and refraction seismic techniques as well as electromagnetic conductivity soundings to further define the subsurface geometry of the basin and river mouth. The geophysical surveys were performed by The Geophysics Group of San Diego, California.

3) Drilling and geologic logging of five test holes to provide geologic data and control for geophysical interpretations.

4) Drilling, geologic logging, and completion of three clusters of monitoring wells (a total of nine wells) to obtain water level and water quality data.

5) Collection and analysis of water quality samples from each of the monitoring wells constructed.

6) Preparation of this report documenting the field program and presenting findings, recommendations, and conclusions arising from the study.

With this report we have included a number of figures and plates. Plate 1 - Hydrogeologic Map, presents a compilation of available geologic and geophysical data and structural contours of the buried bedrock surface. Plate 2 - Regional Geologic Map, presents the regional geology of the study area. Plate 3 - Hydrogeologic Sections, presents sections developed from the various borings. Plate 4 - Water Level Contours Map - Spring 1989, depicts the current water table configuration. Appendix A - Supporting Geotechnical Data, contains geologic and geophysical logs, while Appendix B - Report of The Geophysics Group entitled "A Geophysical Investigation to Map the Depth and Configuration Granitic Bedrock Beneath the Lower Carmel River Valley, Carmel, California," includes the report prepared by The Geophysics Group. Water quality data are contained in Appendix C - Water Quality Data. Appendix D - Storage Calculations, contains storage calculations while Appendix E - Alternative Analysis, contains an analysis of the proposed alternative.

The references utilized in the performance of this study are listed at the end of this report.

BACKGROUND

The coastal portion of the Carmel River aquifer has previously been studied as part of several larger basin-wide investigations. The California Department of Water Resources (DWR) conducted an investigation of the Carmel River aquifer system as part of their Zone 11 Investigation (1974). The DWR study consisted of a preliminary investigation of both the Seaside and Carmel Valley aquifer systems with the major focus on the Carmel Valley aquifer. The study provided of evaluation of the aquifer system by defining basin geometry, aquifer storage capacity, and surface/ground water interaction. The study also addressed the lower basin's susceptibility to seawater intrusion and included limited seismic refraction profiling to delineate the subsurface geometry of the basin at Carmel River Beach. The report concluded that no conclusive physical evidence existed in support of a barrier and therefore the aquifer was susceptible to seawater intrusion. However, no evidence of seawater intrusion within the aquifer was identified at the time.

The most definitive study of the Carmel River aquifer system was prepared by Logan (1983) for the District. This study defined bedrock geometry throughout the length of the aquifer, evaluated the total storage capacity of the basin, and estimated the hydraulic parameters of the aquifer. In addition Logan suggested the presence of a significant subsurface scarp along the extension of the Cypress Point fault near the mouth of the Carmel River.

Although the concept of this uplifted block as a barrier to seawater intrusion was discussed, this conclusion was not formally presented in the Logan report due to the lack of supporting subsurface data.

Concurrently, although separately, with Logan's investigation, the United States Geological Survey (USGS) conducted an investigation of the Carmel Valley alluvial aquifer which resulted in the development of a two-dimensional, finite element, digital model of the ground water basin (USGS, 1984). The model simulated flow conditions throughout the aquifer system based on historic data. The model however was cumbersome and difficult to utilize, and a second model was subsequently constructed utilizing the Trescott-Pinder computer code. This second model was calibrated to the 1975-77 drought period, a period of limited recharge and moderate demand. In subsequent simulations utilizing increased demand, however the model does not accurately replicate aquifer response. This limitation in the model is believed to primarily be the result of incorrect aquifer parameters and a lack of understanding of the nature of interactive flow between the underlying bedrock and the alluvial deposits.

In addition to the basin-wide investigation on the Carmel Valley aquifer, several geotechnical and hydrogeologic studies have been conducted in the coastal portion of the Carmel River aquifer. The study area includes the site of the Carmel Sanitary District (CSD) and, as such, significant geotechnical exploration efforts (Michael David Obele and Associates, 1969;, Harding-Lawson Associates, 1978; 1981) have been undertaken as part of the continued expansion and upgrading of the wastewater treatment plant. Although most of the borings associated with these investigations have been to a relatively shallow depth, they do provide lithologic descriptions of the upper 50 feet of sediments and represent a significant improvement from the available water well drillers logs. These exploratory borings as well as a number of temporary piezometers also provide useful water level data.

A limited although similar hydrogeologic investigation of the coastal Carmel Valley aquifer was performed by Hydro-Search, Inc. of Reno, Nevada, for Cal-Am in September 1981 (Hydro-Search, Inc., 1981). The study was to delineate the bedrock geometry, identify alluvial materials encountered, and to locate the fresh water/seawater interface. The study consisted of the drilling and logging of six borings on Carmel River Beach. Unfortunately, due to hole stability and other problems, the drilling program was not entirely successful and therefore only limited data were collected. Additionally, the exact locations of the completed boring are only approximately known due to poor documentation. Data collected during this study did however identify the presence of saline water underlying Carmel Beach and provided for an interpretation of the bedrock geometry across the beach.

FIELD EXPLORATION

General Statement. The field exploration program was designed to define the bedrock geometry and the nature, magnitude, and orientation of the postulated buried fault scarp. The exploration program consisted of geophysical surveys, exploratory drilling, and monitoring well construction.

Geophysical Exploration. The geophysical exploration program consisted of both seismic and electromagnetic (EM) methods and was performed by The Geophysics Group of San Diego, California. The seismic methods utilized included both reflection and refraction. Reflection methods were utilized to obtain a detailed interpretation of the buried bedrock surface. Refraction methods were utilized to provide velocity data to allow for the conversion of travel time to depth in the reflection profiles. During the course of the study, a total of approximately 1,400 linear feet of seismic line data was collected. The location of each of the lines is shown on Plate 1.

In addition to the seismic methods utilized, EM methods were utilized to verify the seismic data and to allow collection of subsurface data in areas in which the more intrusive reflection and refraction methods were infeasible or not and not allowed. The EM survey utilized two conductive coils which induce a current within the underlying materials. The relative strength of the current is measured at a receiving coil and provides an average conductivity value for the underlying earth materials between the two coils. The greater the separation of the coils the greater the total depth of measurement. Coil spacings utilized in this survey were approximately 33, 65, and 131 feet (10, 20, and 40 meters) which corresponded to a maximum depth of measurement of approximately 49, 98 and 196 feet (15, 30, and 60 meters), respectively.

Approximately 1,800 linear feet of EM data were collected. The location of the EM survey lines are also shown on Plate 1.

A full report documenting methodologies, equipment, and geophysical interpretations prepared by The Geophysics Group is included as Appendix B.

Exploratory Drilling. The purpose of the exploratory drilling program was to verify and supplement the geophysical interpretations and consisted of the drilling of five test holes and the drilling and completion of three clusters of three monitoring wells within the study area. All of the test holes and one of the monitoring wells within each cluster were logged by a field geologist and drilled to the bedrock underlying the alluvial deposits. In addition, monitoring well MW-2D was geophysically logged. The locations of the test holes were established to verify seismic and EM geophysical data and are shown on Plate 1. Also shown on Plate 1 are the locations of other wells or test borings which provide useable data. The lithologic and geophysical logs are in Appendix A.

Nine monitoring wells were completed as part of the investigation to provide water level and water quality data for the study area. The wells were completed in clusters of three, each consisting of a deep (D), middle (M), and shallow (S) zone monitor. The deep monitor at each location was perforated immediately above the bedrock contact. The shallow well was perforated within the first significant permeable zone while the middle well was perforated in a permeable zone intermediate between the shallow and deep monitors.

All of the exploratory drilling was conducted by direct rotary methods and utilized an organic polymer as a drilling fluid (Revert). The wells were constructed in 6-inch diameter boreholes and consisted of 2-inch diameter PVC casing with 10 feet of perforations. The perforated interval consisted of horizontally slotted 2-inch diameter PVC casing with 0.040-inch slots. Each well was gravel packed with No. 3 Monterey Sand to just above the perforated interval and provided with a 3-foot-thick low permeability seal of bentonite pellets. The remaining annular space was then backfilled with gravel to a depth of 20 feet. A cement grout sanitary seal was then placed from a depth of 20 feet to the ground surface under permit and inspection by the County of Monterey Environmental Health Department. After construction of the wells, each well was developed by pumping until discharge was clear. Approximately 150 gallons was produced from each well during development.

FINDINGS

AREA OF INVESTIGATION

Physical Setting. The study area consists of a 360-acre area located between U.S. Highway 1 and the Pacific Ocean. The area is roughly bisected by the Carmel River. Physiographically, the area consists of a broad coastal valley approximately 3,000 feet wide, formed as a result of recent meanders of the Carmel River. Immediately adjacent to the shoreline the broad east-west trending valley has been disrupted by a northwest-trending granitic ridge which separates the larger inland area from the coastline. The granitic ridge has been breached by river erosion forming a relatively narrow opening of approximately 500 feet wide at the mouth of the river.

The geology of the area has been previously described by Lawson (1893), Bowen (1965; 1969), and Clark (1974; 1984; 1989). The project area consists of an alluvial river valley filled with as much as 200 feet of relatively coarse grained alluvial deposits which onlap to the north on older alluvium and Tertiary sedimentary volcanic rocks. The Cypress Point fault trends northwesterly through the project area and juxtaposes Santa Lucia granite to the west against the alluvial deposits to the east. The upthrown granitic block constitutes the southern boundary of the study area. Clark (1974) suggested movement on the Cypress Point fault occurred prior to the Quaternary age. McKittrick (1988) has correlated coastal terraces with estimated ages of 700,000 years before present across the fault, supporting the conclusion of Clark. Plate 2 reproduces the most recent work of Clark (1989).

Aquifer System. The study area consists of the coastal and most westerly portion of the Carmel Valley Aquifer system (area designated by the District as Aquifer Subunit No. 4). The Carmel Valley Aquifer is a narrow strip aquifer approximately 13 miles in length and averaging 3,000 feet in width. The aquifer is comprised of up to 200 feet of coarse-grained alluvium deposited in a canyon formed by the ancestral Carmel River. In the area east of the study area the alluvial deposits are underlain by shale assigned to the Monterey Formation (Logan, 1983). As shown on Plate 3, the study area itself is underlain by the Santa Lucia Granite. Although limited quantities of ground water undoubtedly occur in these rocks, for purposes of this study they constitute the effective base of fresh water.

Lithologic log and aquifer test data (Logan, 1983) suggest that water in the aquifer system occurs under unconfined or water table conditions. Ground water movement is essentially east to west, although locally ground water movement can be influenced by pumping stress.

Basin Geometry. Geologic and geophysical data collected as part of this study as well as readily available drillers logs were utilized to construct elevation contours on the top of the buried bedrock surface. Contours were constructed by interpolation between data points and interpretation in those areas with little or poor control. At the eastern boundary of the study area near Highway 1 the contours previously constructed by Logan (1983) were utilized. The resulting contours are presented on Plate 1 and reveal that the eastern portion consists of a relatively broad basin with a maximum depth in excess of 200 feet. In the northern portion of the basin the bedrock surface slopes gently toward the paleochannel of the Carmel River which trends through the center of the basin. The bedrock surface extending to the south forms a relatively flat surface conforming to an average approximate elevation of -100 feet. This surface is interrupted to the south by an abrupt change in slope, consistent with the extension of the Cypress Point fault.

In the extreme coastal portion of the basin, the subsurface geometry is interrupted by uplift associated with the Cypress Point fault. This uplift has elevated granite by possibly as much as 100 feet and has reduced the width of the basin at this location from approximately 3,000 feet to a small erosional channel of less than 500 feet in width and approximately 110 feet in depth (refer to Plate 2). The depth of the erosional channel is consistent with the inferred or estimated incisement of most coastal streams during the Pleistocene epoch as a result of a lower sea level (Schwartz, 1986).

GROUND WATER STORAGE

Specific Yield. The volume of ground water in storage in the study area can be estimated as the product of the volume of saturated alluvium within the basin and the specific yield of the sediments comprising the alluvium. The specific yield of a sediment is the volume of water that will drain from a saturated sediment by gravity and is predominately a function of pore size. The average specific yield of the materials comprising the entire Carmel River aquifer has been estimated as part of the investigations by DWR, Logan, and the USGS. Each of these previous investigations utilized the so-called "Well Log Method" of Evenson (1962) which involves the assignment of a specific yield for each of the types of sediments encountered in a lithologic log and the calculation of a weighted average of the specific yield for the lithologic section encountered at that location. An average specific yield for the area being studied is then calculated from the weighted specific yields.

The DWR (1974) utilized 16 well logs and derived an average specific yield for the sediments comprising the Carmel Valley alluvial aquifer of 23.59 percent. They suggested, however, that this value was likely lower in the coastal portion of the valley. Logan (1983), utilizing 149 logs, derived a mean value for the portion of aquifer west of Scarlett Narrows of 20 percent, and a mean value east of Scarlett Narrows of 23 percent, supporting the premise that finer grained materials in the western portion of the aquifer have a lower specific yield. Through calibration of the digital model the USGS (1974) derived storage coefficients (equivalent to specific yield in unconfined aquifers) ranging from 9 to 20 percent with an average of 19 percent. The best calibration of the model with the historic data was achieved by utilizing a specific yield value of approximately 10 percent for the coastal portion of the basin.

The test holes and monitoring wells drilled as part of this study added substantially to the number of available lithologic logs within the coastal portion of the basin. When combined with the previously existing drillers logs and geotechnical boring logs, the total number of logs available for estimating specific yield in the study area is 24. Each of the available logs was analyzed and in each the total footage of sediment type logged was assigned to one of five classes either clay (CL), silt (ML), silty sand (SM), clean sand (SW), or gravel (GW). Based on the assignment of a specific yield and percentage of that class of sediment on each log, a weighted specific yield was calculated and a specific yield for each location estimated. The resulting specific yield values were then averaged to estimate a specific yield for the study area. The results of the analysis are present below in Table 1 - Specific Yield Calculations - Coastal Carmel River Aquifer.

Review of Table 1 reveals that specific yield values for the wells within the study area range from 11 to 25 percent and average 20 percent. Several of the wells utilized in the average, specifically Hydro-Search wells Nos. CB-1 and CB-1', are not believed to be representative since they are of very shallow depth and encounter only sand, therefore displaying very high specific yields. In addition, Table 1 also reveals that the three logs shown as Monterey Peninsula Water Management District [MPWMD] MW-2D and TH-3, and PG&E Anode reflect specific yield values within the northern portion of the study area which are substantially lower (an average of 14 percent vs. 22 percent) than the southern portion. The lower specific yield values in the northern portion of the basin are likely the result of recurrent overbank depositional episodes consisting of fine grained and organically rich sediments in this portion of the basin. The occurrence of these sediments is likely due to geomorphic constraints imposed by the upthrown granitic block to the west that has influenced the location of the active river channel and prevented significant scour in this area.

Although significant differences in specific yield values for the northern and southern portions of the basin exist, we believe that until additional data are available an average value of 20 percent is a reasonable value for specific yield in this portion of the aquifer system. This value is consistent with the value utilized by Logan (1983) for Subunit No. 4.

Water Level Data. Upon completion of the field work, water level data were collected from the new monitoring wells and all accessible wells in

TABLE 1

SPECIFIC YIELD CALCULATIONS - COASTAL CARMEL RIVER AQUIFER

		CLAY		SILT		SILTY SAND		CLEAN SAND		GRAVEL		
WELL NAME	TOTAL ALLUVIAL THICKNESS (feet)	TOTAL THICKNESS (feet)	WEIGHTED SPECIFIC YIELD AT 2%	TOTAL THICKNESS (feet)	WEIGHTED SPECIFIC YIELD AT 8%	TOTAL THICKNESS (feet)	WEIGHTED SPECIFIC YIELD AT 21%	TOTAL THICKNESS (feet)	WEIGHTED SPECIFIC YIELD AT 25%	TOTAL THICKNESS (feet)	WEIGHTED SPECIFIC YIELD AT 23%	WELL SPECIFIC YIELD (%)
MPWMD MW-1D	89.0	3.00	0.001	9.00	0.008		0.000	66.0	0.185	11.0	0.028	0.223
MPWMD MW-2D	154.0	5.00	0.001	57.00	0.030		0.000	77.0	0.125	15.0	0.022	0.178
MPWMD MW-3D	130.0	8.00	0.001	46.00	0.028		0.000	70.0	0.135	6.0	0.011	0.175
MPWMD TH-1	150.0	5.00	0.001	21.00	0.011		0.000	105.0	0.175	19.0	0.029	0.216
MPWMD TH-2	86.0	7.00	0.002	27.00	0.025		0.000	44.0	0.128	4.0	0.011	0.165
MPWMD TH-3	114.0	6.00	0.001	53.00	0.037		0.000	50.0	0.110	5.0	0.010	0.158
MPWMD TH-4	161.5	8.00	0.001	38.00	0.019		0.000	105.0	0.163	11.0	0.016	0.198
MPWMD TH-5	172.0	11.00	0.001	79.00	0.037		0.000	74.0	0.108	10.0	0.013	0.159
HS CB-1	19.0		0.000		0.000	2.00	0.022	17.0	0.224		0.000	0.246
HS CB-1'	19.0		0.000		0.000		0.000	19.0	0.250		0.000	0.250
HS CB-2	95.0	2.00	0.000	12.00	0.010	53.00	0.117	12.0	0.032		0.000	0.159
HS CB-3	102.0		0.000	15.00	0.012	61.00	0.126	29.0	0.071		0.000	0.208
HS CB-4	50.0		0.000		0.000	17.00	0.071	33.0	0.165		0.000	0.236
HS CB-4'	81.0		0.000	2.00	0.002	54.00	0.140	25.0	0.077		0.000	0.219
CSD#2	130.0	10.00	0.002		0.000	11.00	0.018	68.0	0.131	41.0	0.073	0.223
H/L'81 No. 1	61.00		0.000	10.00	0.013	8.00	0.028	43.00	0.176		0.000	0.217
H/L'81 No. 2	50.00	1.00	0.000	15.00	0.024	11.00	0.046	21.00	0.105		0.000	0.176
H/L'81 No. 3	50.00		0.000	2.00	0.003	12.00	0.050	36.00	0.180		0.000	0.234
H/L'81 No. 4	45.00		0.000	12.00	0.021	18.00	0.084	14.00	0.078		0.000	0.183
H/L'81 No. 5	52.00		0.000	12.00	0.018	16.00	0.065	24.00	0.115		0.000	0.198
H/L'81 No. 6	50.00		0.000	22.00	0.035	5.00	0.021	28.00	0.140		0.000	0.196
Har/Law No.2	21.0		0.000		0.000	7.00	0.070	14.0	0.167		0.000	0.237
Odello #3	103.0	3.00	0.001		0.000	10.00	0.020	60.0	0.146	30.0	0.067	0.234
PGE Anode	44.0	27.00	0.012		0.000		0.000	17.0	0.097		0.000	0.109

AVERAGE SPECIFIC YIELD: 20.0%

the study area. The data reveal water levels in the study area are presently (March/April 1989) at an average elevation of approximately +4.0 feet across the study area, and range from an elevation of approximately +3.3 feet as measured in the monitoring well (MW-3) on the beach to approximately +5.2 feet in the Odello "Sanitary" well (TI6S/R1N-13L3) located immediately east of the Carmel Sanitary District Treatment Plant. The water level data reveals a seaward gradient extending from the Odello "Sanitary" well west to the beach. However, a landward gradient extends from this same well to the Odello "East Side Abandoned" well (T16S/R1W-13R1) located approximately 1,700 feet to the east across U.S. Highway 1. This reversal is also supported by recent water level data collected by the District during a Caltrans geotechnical investigation near Highway 1 bridge. This reversal in the seaward gradient reflects a seasonal pumping trough present to the east. Available water level data are presented in Table 2 - Summary of Well Data, Coastal Carmel River Aquifer. The inferred water table surface is presented on Plate 3.

Review of geotechnical and drillers logs reveal that water levels in the study area have been higher in the past. Geotechnical logs from Harding-Lawson Associates' November 1981 C.S.D. Treatment Plant Expansion investigation indicate water level elevations averaging approximately +7.5 feet, approximately 3 feet higher than current conditions. For purposes of storage calculations this report has utilized the current water level data.

Volume of Ground Water in Storage. The total volume of ground water in storage is the product of basin storage and specific yield. The volume of the basin was calculated from the structural contours shown on Plate 1 through the use of a planimeter. From these data, an estimated basin volume was at approximately 38,500 acre-feet. Calculations are included in Appendix D -Storage Calculations. Utilizing an average specific yield of 20 percent and a basin storage volume of 38,500, the total volume of ground water in storage below sea level was estimated at approximately 7,700 acre-feet. Correspondingly, the total volume of ground water in storage above sea level was calculated by planimetering the ground water surface presented on Plate 2, resulting in an estimate of 320 acre-feet. Based on water level data from 1981, the volume of ground water in storage above sea level at that time may have been on the order of 400 to 500 acre-feet.

TABLE 2

SUMMARY OF WELL DATA, CARMEL RIVER AQUIFER - COASTAL UNIT

STATE WELL NO.	WELL NAME	ELEV. (feet)	TOTAL DEPTH (feet)	DEPTH TO BEDROCK (feet)	FORMATION ON BOTTOM	ELEVATION OF BASE OF FRESH WATER (feet)	DEPTH TO WATER 3/89 (feet)	ELEV. OF WATER 3/89 (feet)	Cluster Average
T16S/R1W-13L	Odello (Sanitary)	15.2	?	?	?	15.2	10	5.2	
T16S/R1W-13L3	CSD#2	16.5	130	N	Qal	N	11.9	4.6	
T16S/R1W-13L	MPWMD MW-3S	15.5	65	N	N	N	10.6	4.9	
T16S/R1W-13L	MPWMD MW-3M	15.5	110.0	N	N	N	10.6	4.9	
T16S/R1W-13L	MPWMD MW-3D	15.5	132	130	GRANITE	-114.5	10.2	5.3	5.0
T16S/R1W-13M	MPWMD TH-4	10.0	166	161.5	GRANITE	-151.5	--	--	
T16S/R1W-13M	MPWMD TH-3	7.0	118	114	BASALT	-107	--	--	
T16S/R1W-13M	Hard/Law No.2	5.0	21	N	Qal	N	--	--	
T16S/R1W-13M	MPWMD MW-2S	7.1		N	N	N	3	4.1	
T16S/R1W-13M	MPWMD MW-2M	7.1		N	N	N	3.2	3.9	
T16S/R1W-13M	MPWMD MW-2D	7.1	160.0	154.0	GRANITE	-146.9	3.3	3.8	3.9
T16S/R1W-13N	MPWMD TH-5	9.0	176.0	172.0	GRANITE	-163	--	--	
T16S/R1W-13Q3	Odello (HIGHWAY)	16.5	110.0	103.0	GRANITE	-86.5	12.8	3.7	
T16S/R1W-13R1	Odello (E. SIDE ABN)	20.86	121.0	121.0	GRANITE	-100.14	17.3	3.56	
T16S/R1W-14H1	PGE Anode	11.0	120.0	44.0	GRANITE	-33	--	--	
T16S/R1W-14J	HS CB-1	23.0	23.0	19.0	GRANITE	4	--	--	
T16S/R1W-14J	HS CB-4*	4.1	50.0	N	Qal	N	--	--	
T16S/R1W-14J	HS CB-4'*	7.1	81.0	N	Qal	N	--	--	
T16S/R1W-14J	HS CB-2	15.9	95.0	79.0	GRANITE	-63.1	--	--	
T16S/R1W-14J	HS CB-3*	11.1	150.0	102.0	GRANITE	-90.9	--	--	
T16S/R1W-14J	MPWMD TH-1	6.0	150.0	150.0	GRANITE	-144	--	--	
T16S/R1W-14J	HS CB-1'	21.0	20.0	19.0	GRANITE	2	--	--	
T16S/R1W-14J	MPWMD MW-1S	10.0	30.0	N	N	N	6.3	3.7	
T16S/R1W-14J	MPWMD MW-1M	10.0	54.0	N	N	N	6.9	3.1	
T16S/R1W-14J	MPWMD MW-1D	10.0	89.0	89	GRANITE	-79	6.8	3.2	3.3
T16S/R1W-24D	MPWMD TH-2	10.5	94.0	86	GRANITE	-75.5	--	--	
T16S/R1W-13Q	Cal Trans	11.0					7.43	3.57	

HS=HYDRO-SEARCH, INC.
* Accurate location of boring not possible
N Not encountered

WATER QUALITY

General Statement. Water quality samples were collected from the monitoring wells constructed as part of this project and analyzed for electrical conductivity, chloride, and bicarbonate ion concentrations. The water quality data are presented below in Table 3 - Coastal Carmel River Aquifer, Summary of Water Quality Data. Complete laboratory reports are included in Appendix C.

TABLE 3

CARMEL RIVER AQUIFER COASTAL UNIT
WATER QUALITY DATA

	WELL NUMBER								
Constituent	MW-1S	MW-1M	MW-1D	MW-2S	MW-2M	MW-2D	MW-3S	MW-3M	MW-3D
Electrical Conductivity (μmhos/cm)	9,600	25,000	6,000	930	720	860	1,100	870	840
Chloride (mg/l)	3,500	11,000	2,100	124	76	104	144	96	100
Bicarbonate (mg/l)	260	160	200	272	216	204	247	232	220
Chloride/Bicarbonate ratio (meg/l)	23.46	119.8	18.3	0.79	0.61	0.88	1.02	0.65	0.79

The water quality data indicate high conductivity and elevated chloride/bicarbonate ion ratios in water samples collected from monitoring well cluster MW-1, located approximately 375 feet from the shoreline. These data suggest the past or current presence of saline or brackish ground water at this location. The presence of seawater intrusion at this location is discussed further below.

The water quality data obtained from monitoring well clusters MW-2 and MW-3, located respectively 1,400 and 3,400 feet from the shoreline, show no evidence of seawater intrusion. Water quality data from these wells reveal the water to be of good to excellent quality. Chloride/bicarbonate ratios from monitoring well cluster MW-2 and MW-3 are, while slightly elevated, are comparable with general range of values displayed in other samples from Carmel Valley aquifer which range from 0.2 to 0.6 (MPWMD, 1989). The elevated levels in this portion of the basin are likely due to the lack of recent recharge resulting in longer ground water residence time. Some minor degradation of water quality is apparent in well MW-3S, as indicted by the elevated chloride ion concentrations. This degradation is likely the result of agricultural return flow from the adjacent artichoke field.

SEAWATER INTRUSION

General Statement. In coastal alluvial aquifers that discharge directly to the ocean, the fresh and saline ground water interface occurs as a landward sloping zone of diffusion where saline ground water, due to its greater density, underlies fresh ground water. The location of this interface, relative to the shoreline, is a dynamic relationship and is a function of aquifer materials, aquifer geometry, and the volume of subsurface outflow. Seawater intrusion is commonly defined as a condition where this fresh water-saline water interface has moved significantly landward.

Physical Setting. The Carmel River alluvial aquifer is susceptible to seawater intrusion due to the subsurface outcrop and exposure of the aquifer to seawater within Carmel Bay and the coarse- to medium-grained and therefore highly conductive nature of the alluvial sediments. Water level data collected by the District indicate good hydraulic communication with the ocean as evidenced by tidal fluctuation in the MPWMD MW-1 monitoring wells. Although the Carmel Valley aquifer is in hydraulic communication with the ocean, some protection from intrusion is provided by the restricted flow path created by the breached fault block which reduces aquifer cross-section are from approximately 600,000 ft^2 to approximately 35,000 ft^2 (based on channel width of 500 feet and average depth of 70 feet).

Existing Conditions. The water quality data from MW-1 suggests the current or past presence of saline ground water at this location. Geophysical data from the EM lines also suggest substantially higher pore fluid conductivities underlying the beach area west of Seismic Line 2. Application of the Ghyben-Herzberg principle (Fetter, 1988) at the location of the well cluster MW-1 would predict the depth of the fresh water/seawater interface at a elevation of approximately -150 feet, based on a water level of +3.3 feet. However, the sediments comprising the aquifer at this location are highly transmissive and the tidal fluctuation measured in monitoring well cluster MW-1 exceeds 0.4 feet both of which likely contribute to a wide zone of diffusion associated with the interface. Of interest is the relatively low conductivity of the sample collected from the well MW-1D when compared with the conductivity of the sample from well MW-1M which is perforated at a shallower depth. This apparent anomaly is likely a function of the lower permeability of the aquifer materials at depth when compared with the upper portion of the aquifer. This reduced permeability has possibly reduced the width of the fresh water/seawater interface by reducing flow velocities.

Alternative Simulation. In order to assess the impacts of increased extractions in the lower aquifer, a simple numerical model was constructed using the THEIS 2 software developed by Koch (1982). The simulation utilized a single production well was located approximately 8,000 feet from the shoreline in the central portion of the basin. Two image wells were placed at equal distance from the respective basin boundaries as the simulated production well to simulate no-flow boundary effects. Hydraulic conductivity, aquifer thickness, and storativity values were taken from Logan (1983). Values of 2,000 gpd/ft^2, 200 feet, and 20 percent were utilized, respectively. Discharge from the simulated well occurred at a continuous rate of 620 gallons per minute, corresponding to an anticipated annual production 1,000 acre-feet (Oliver, 1989). A simulation period of two years was utilized to simulate a two year drought cycle. The simulation, although simplified, projected drawdown effects at the shoreline from the proposed well of approximately 1-foot after a two year period of continuous pumping. This effect would rapidly decay if pumping were terminated. The results of the simulation are presented in Appendix E - Alternative Simulation.

Utilizing the results of the simulation, the location of the saline wedge was calculated utilizing the Glover Equation (Glover, 1984). The location of the wedge was calculated for three scenarios consisting of current water levels (+3.3 at MW-1), and water elevations of +2.0 and +1.0 feet. The results are presented in Table 4 - Glover Equation Solutions, Location of Seawater Wedge, Carmel River Mouth and shown graphically on Figure 2A and 2B - Diagrammatic Sketch Seawater Intrusion Front - Carmel River Aquifer. Continuous outflow was

TABLE 4

GLOVER EQUATION SOLUTIONS
LOCATION OF SEAWATER WEDGE
CARMEL RIVER MOUTH

Distance from Shoreline "x" (feet)	Depth Below Sea Level "z"		
	Case 1	Case 2	Case 3
0	21.9	12.9	6.7
25	55.0	38.3	25.0
50	68.7	48.8	32.5
100	88.1	63.7	43.3
200	115.2	84.7	58.4
300	136.6	100.8	70.1
400 (Location of MW-1)	154.4	114.5	79.9
450	162.4	120.6	84.3
Unit Discharge ft^3/sec	0.0017	0.001	0.00052
Gradient ft/ft	0.008	0.0047	0.0023
MW-1 Water Level	+3.3	+2.0	+1.0

calculated using the gradients listed on Table 3 and a hydraulic conductivity of 2,000 gpd/ft^2 (Logan, 1983).

Review of Table 4 and Figure 2A and 2B reveal that the toe of the seawater wedge is located within the underlying granite under both current and low water level conditions. Hence, seawater intrusion is likely restricted to movement in a zone of diffusion within a fairly narrow area.

FIGURE 2A

DIAGRAMMATIC SKETCH SEAWATER INTRUSION FRONT - CARMEL RIVER AQUIFER

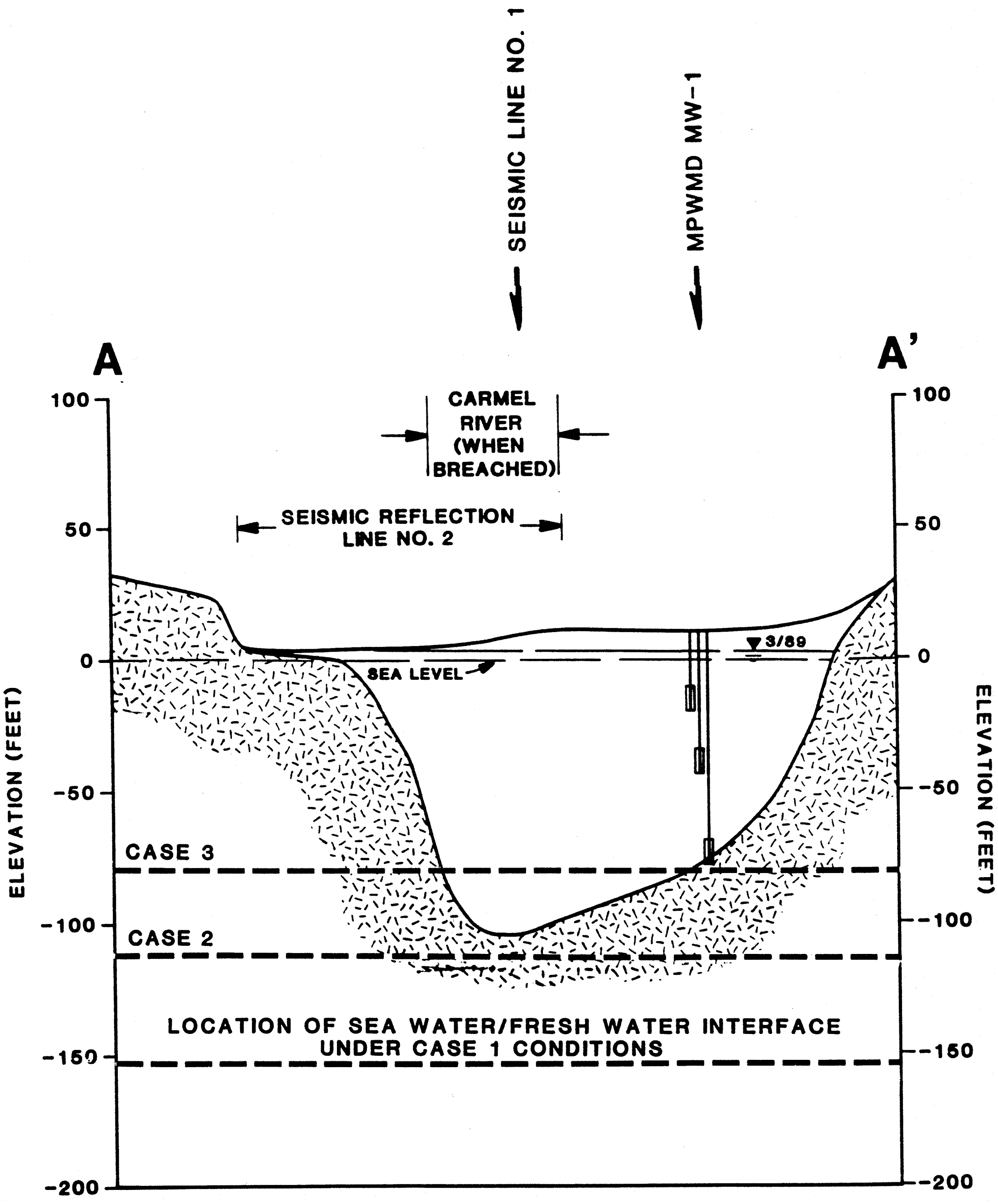
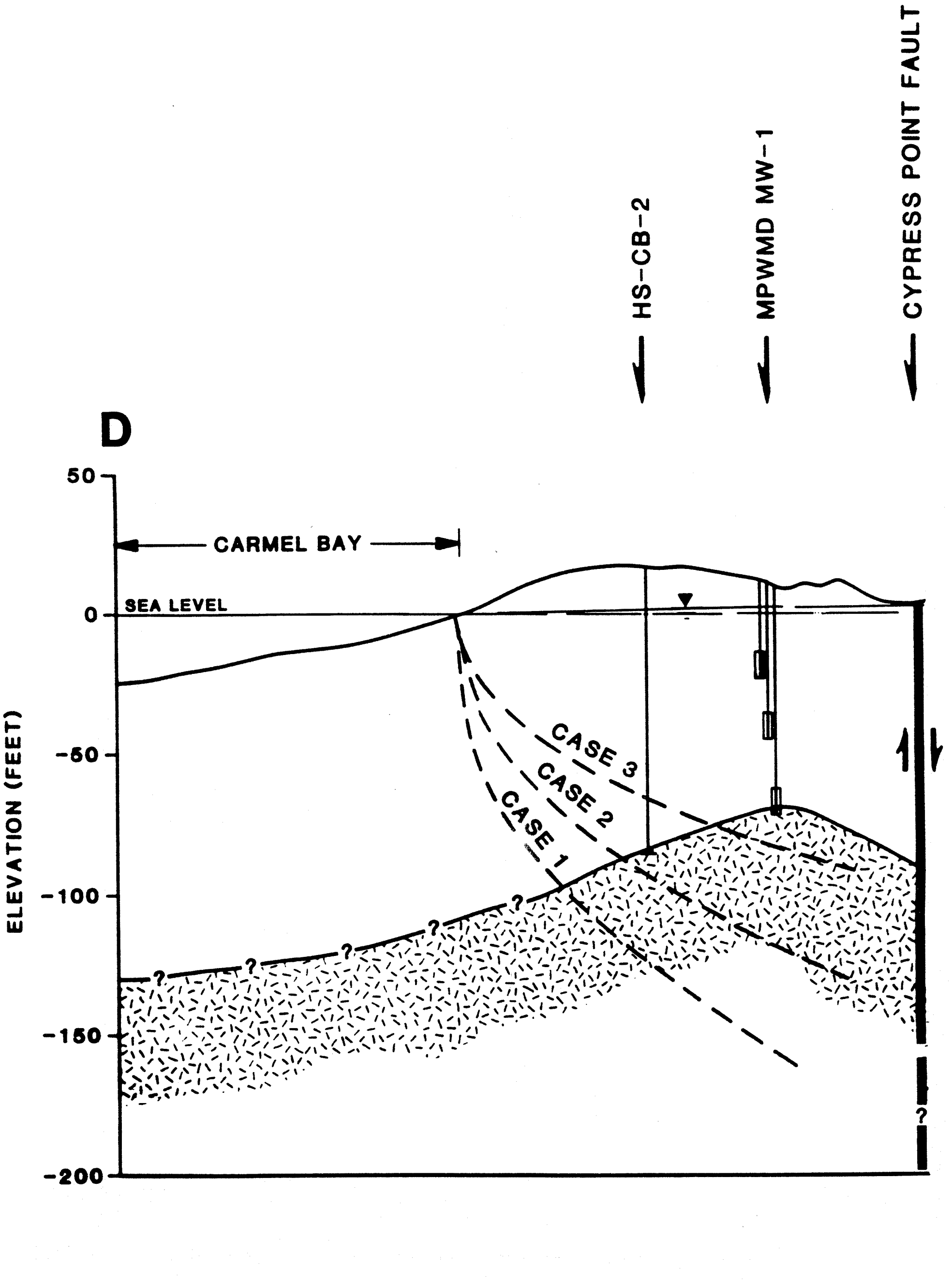


FIGURE 2B

DIAGRAMMATIC SKETCH SEAWATER INTRUSION FRONT - CARMEL RIVER AQUIFER



CONCLUSIONS AND RECOMMENDATIONS

1.0 GENERAL STATEMENT

Based on the above findings, we conclude that a defined and managed program of increased extractions from the coastal portion of the Carmel River Aquifer System is feasible. If properly managed, such extraction will not contribute to seawater intrusion. Proper management will require a monitoring program to confirm the conclusions of this report and monitor the position of the seawater wedge. In addition, we conclude that as a result of the relatively shallow and narrow bedrock channel breaching the uplifted Cypress Point fault block, the Cypress Point fault does provide some degree of protection from seawater intrusion.

2.0 BASIN GEOMETRY

Geologic and geophysical data developed as part of the study reveal the basin to be substantially broader and deeper than previously believed, therefore containing a greater volume of alluvial deposits. Significant to the increased volume is the relatively flat bedrock surface that abuts the projection of the Cypress Point fault in the southern portion of the basin. Also significant is the incised paleochannel of the Carmel River which exceeds 200 feet in depth.

3.0 CYPRESS POINT FAULT

Geologic and geophysical data suggest that the Cypress Point fault extends across the river mouth and trends along the granite bluff that borders the artichoke field on the south. The fault displays vertical offset of at least 100 feet and juxtaposes granite against alluvium within the study area. Geophysical and borehole data indicate however that the uplifted fault block has been breached to an approximate elevation of -110 feet by the erosive action of the ancestral Carmel River and reveals a narrow erosional channel which provides direct subsurface hydraulic communication with Carmel Bay. The activity of the Cypress Point fault was not a part of this investigation.

4.0 GROUND WATER IN STORAGE

Total ground water in storage in the study area is approximately 8,000 acre-feet both above and below sea level. Of this amount, approximately 300 acre-feet of ground water is currently in storage above sea level in the study area. Available data suggests that storage above sea level can be as much as 500 acre-feet during wetter periods.

5.0 SEAWATER INTRUSION

Water quality data from the monitoring wells located on Carmel River State Beach display high conductivity and elevated chloride ions concentrations. These data suggest the current or past presence of saline ground water at this location. Application of the Glover Equation Solution to the hydrogeologic system predicts the depth of the seawater/freshwater interface to be below the granitic basement. Evidence of saline ground water detected in the monitor wells likely represents a wide zone of diffusion associated with tidal fluctuations.

6.0 IMPACTS OF INCREASED EXTRACTIONS

The proposal alternative involves increased ground water extractions from the aquifer at a location approximately 8,000 feet from the shoreline. Numerical modeling predicts that a extraction well at this location with an annual demand of 1,000 acre-feet will result in a drawdown of approximately 1.1 feet at the shoreline. Based on solutions of the Glover Equation the location of the seawater wedge is relatively insensitive to this magnitude of water level decline, as a result of the relatively shallow depth to bedrock underlying the portion of the aquifer in hydraulic communication with the ocean. Therefore, increased extractions are not likely to induce seawater intrusion.

Although increased extractions in the lower portion of the aquifer system will likely not significantly affect the position of the seawater/freshwater interface, increased extractions will lower water levels in the area upgradient from the lagoon. Since available data suggests that the lagoon is likely partially supported by ground water discharge, the diminished head in this area may reduce the volume of ground water discharge and thus change the salinity of the lagoon water. A change in the salinity of lagoon water could impact the lagoon habitat. In addition, lower water levels will likely effect the riparian habitat and lower pumping levels of private pumpers in the area. These impacts could possibly be mitigated by establishment of injection wells or a grout curtain to create a coastal barrier. These concerns and mitigations are outside our scope of work but will need to be addressed as part of the EIR for this alternative.

7.0 CLOSURE

This report has been prepared for the exclusive use of the Monterey Peninsula Water Management District for specific application to the coastal portion of the Carmel River aquifer in Monterey County, California. The findings, conclusions, and recommendations presented herein were prepared in accordance with generally accepted hydrogeologic engineering practices. No other warranty, express or implied, is made.

The analyses and recommendations submitted in this report are based, in part, on data obtained from geophysical data and drill holes. The nature and extent of variations in the actual availability of ground water in the study area may not become evident until after project construction and the aquifer is subject to pumping stress. If significant variations appear, it will be necessary to reevaluate the recommendations of this report.

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

Respectfully submitted,

STAAL, GARDNER & DUNNE, INC.

Martin B. Feeney
Engineering Geologist 1454

David A. Gardner
Engineering Geologist 969

MBF:DAG:av/27

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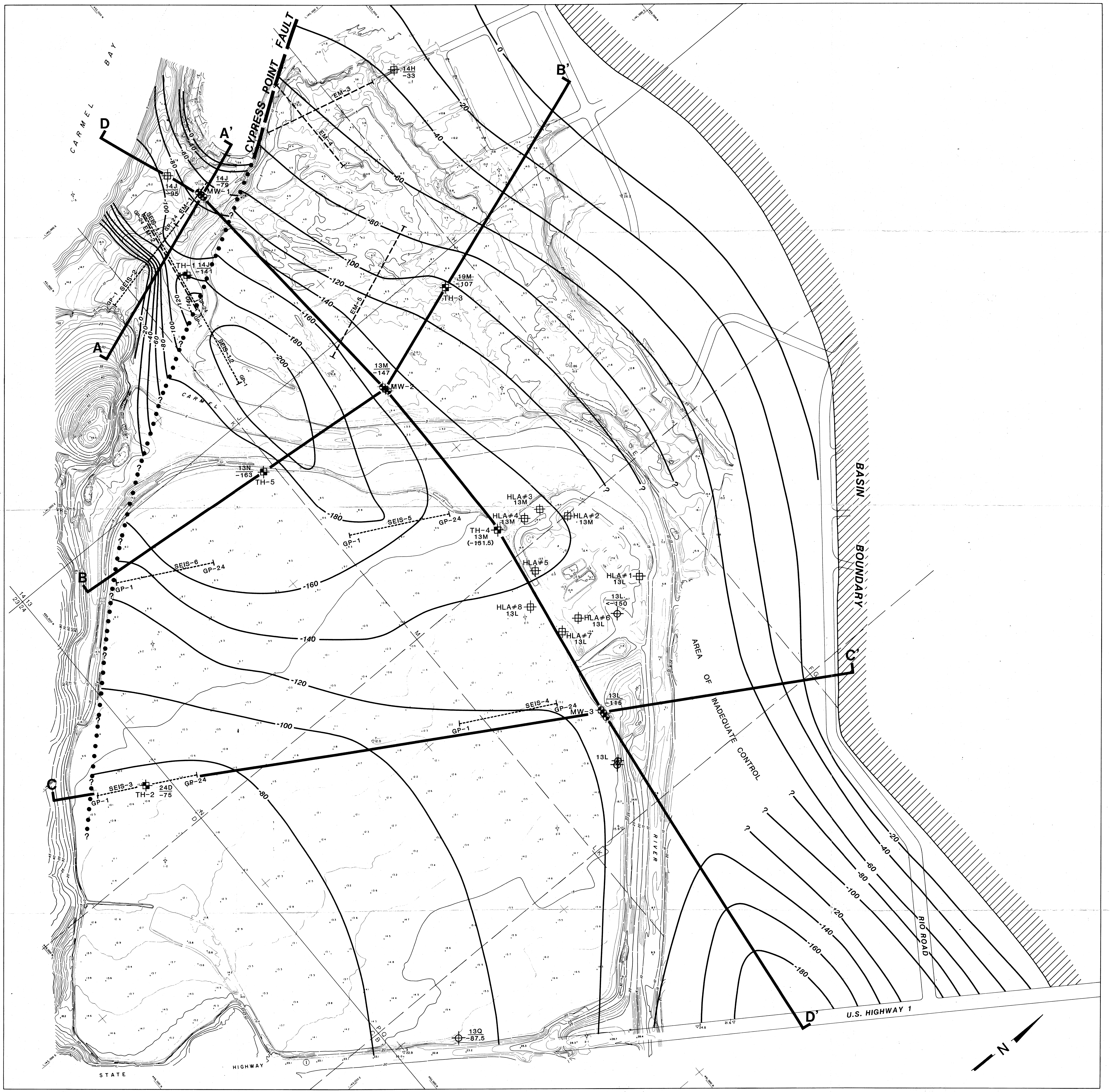


0 200 400 600 800 1000
Scale in Feet

LEGEND

▬ ▬ ● ● ● ?	FAULT, DASHED WHERE APPROXIMATELY LOCATED, DOTTED WHERE CONCEALED OR INFERRED, QUERIED WHERE UNCERTAIN
MW-3 ◈ 13L/-115	APPROXIMATE LOCATION OF MONITORING WELL WITH ELEVATION OF BEDROCK SURFACE AS SHOWN
⌖ 13Q/-18.5	APPROXIMATE LOCATION OF WATER WELL WITH ELEVATION OF BEDROCK SURFACE AS SHOWN
TH-1 ⊞ 14J/-95	GEOLOGIC TEST HOLE CONSTRUCTED AS PART OF THIS STUDY WITH ELEVATION OF BEDROCK SURFACE AS SHOWN
⊞ 14H/-33	GEOTECHNICAL BORING PERFORMED BY OTHERS WITH ELEVATION OF BEDROCK SURFACE AS SHOWN
-60	LINE OF EQUAL ELEVATION ON BURIED BEDROCK SURFACE
SEIS-2 GP-1 GP-24	GEOPHYSICAL SEISMIC LINE WITH GEOPHONE LOCATIONS
EM-5	GEOPHYSICAL ELECTROMAGNETIC LINE
A A'	LINE OF HYDROGEOLOGIC SECTION

TOPOGRAPHIC MAP OF
CARMEL RIVER MOUTH
FOR
PHILIP WILLIAMS & ASSOCIATES

CONTOUR INTERVAL ONE FOOT

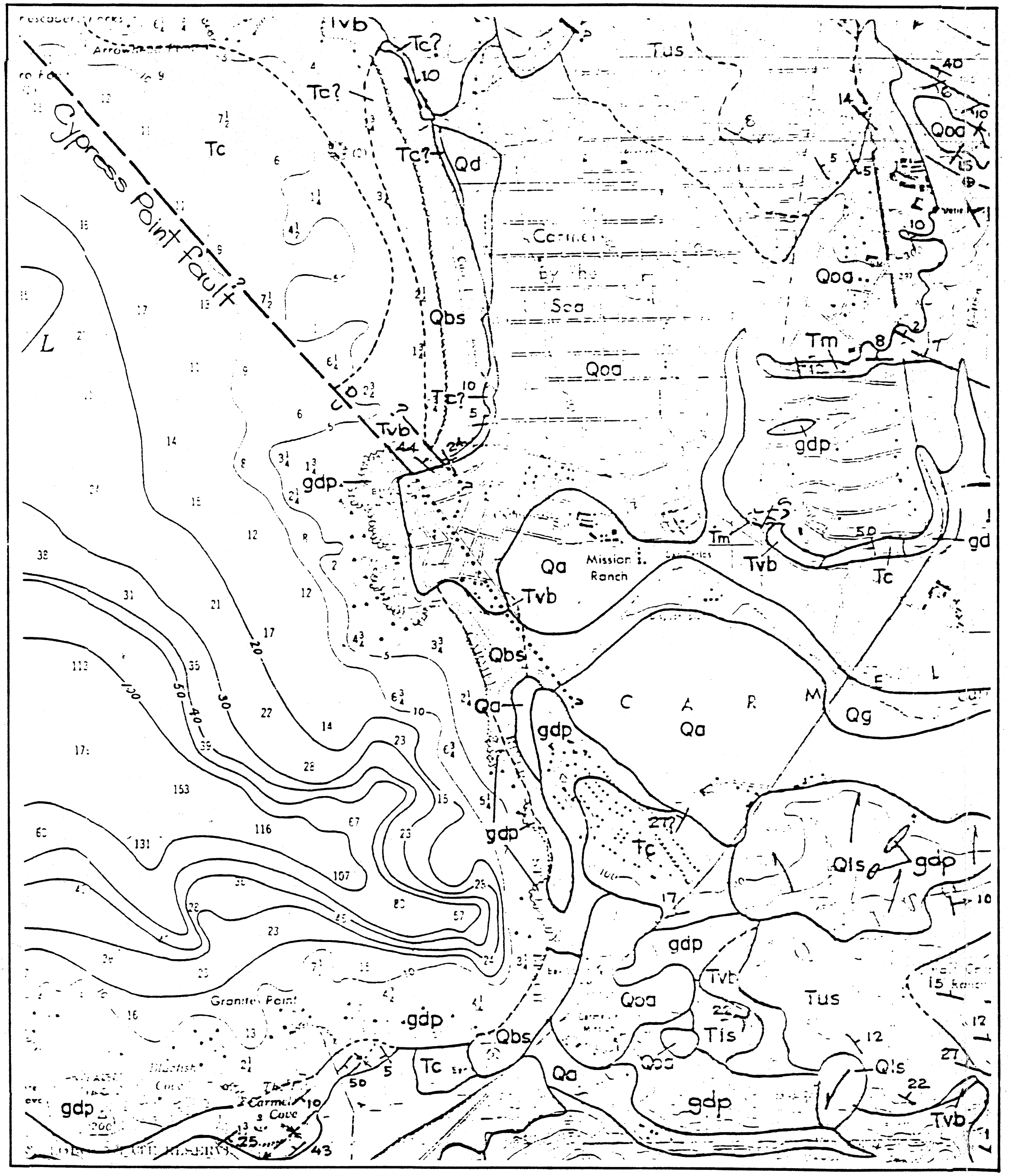
	DATE OF PHOTOGRAPHY	JOB NO.	SHEET	OF
Towill, Inc. 608 HOWARD STREET, SAN FRANCISCO CALIFORNIA 94105	SEPTEMBER 13, 1988	8556	1	1

HYDROGEOLOGIC MAP
WITH STRUCTURAL CONTOURS ON BURIED BEDROCK SURFACE

For: MONTEREY PENINSULA WATER MANAGEMENT DIST.

88152 May 1989 Plate 1

SGD *Staal, Gardner & Dunne, Inc.*
Consulting Engineers and Geologists



GEOLOGY FROM CLARK ET AL (1974, 1989).

DESCRIPTION OF MAP UNITS

	SURFICIAL SEDIMENTS
Qbs	Beach sand; near Carmel Beach includes (near-shore) sands just offshore
Qg	River sand and gravel
Qd	Dune sand
Qa	Alluvium
Qls	LANDSLIDE DEBRIS Some or parts of some may be very young and possibly actively moving. Half arrows show direction of downslope movement
	OLDER SURFICIAL SEDIMENTS (DISSECTED)
Qod	Older dune sand
Qoa	Older alluvium and terrace gravel and sand; at Monterey contains Pholas-bored pebbles at base and into underlying Monterey Shale
Qm	Marine terrace sand and gravel
Qar	AROMAS SAND (Pleistocene) Aromas Red Sands of Allen (1946) and Bowen (1965). Nonmarine; yellowish-brown to grayish-orange fine sand
QTp	PASO ROBLES FORMATION (Pliocene(?) and Pleistocene) Old alluvium deposited in a valley. Light-gray gravel, sand, and clay
QTs	*SEDIMENTARY DEPOSITS Seismic characteristics suggest poorly bedded sands and gravels; stratigraphic position unknown
Ts	*SEDIMENTARY ROCKS Mudstone and coarse-grained, arkosic sandstone; marine; middle or late Tertiary
Tsm	SANTA MARGARITA(?) SANDSTONE (Miocene) Marine and brackish-marine, white, friable, fine- to coarse-grained, arkosic sandstone; upper Miocene, possibly lower Pliocene
	MONTEREY SHALE (Miocene) Siliceous marine deposits
Tmd	Diatomite (Canyon del Rey Diatomite Member of Bowen, 1965), white, soft, punky, commonly silty; Delmontian Stage1/ (type) of Kleinpell (1938), upper Miocene
Tm	Siliceous shale (Aquajito Shale Member of Bowen, 1965), light-brown to white, hard, brittle, platy; Mohnian Stage, upper Miocene
Tml	Semi-siliceous shale, thin-bedded, yellowish-brown, foraminiferal; includes interbedded yellowish-brown siltstone; Luisian Stage, middle Miocene
Tss	MARINE SANDSTONE Buff to light-gray, friable arkosic sandstone; locally pebbly; in San Jose Canyon area contains interbedded conglomerate; middle Miocene; possibly in part upper anc lower Miocene
Tus	Sandstone as above, upper part (mapped as Los Laureles Sandstone Member of Monterey Formation by Bowen, 1965)
Tvb	Volcanic rocks. Flows and flow-breccias of basalt and basaltic andesite (carmeloite of Lawson, 1893)
Tls	Sandstone as above, lower part (mapped as Los Tularcitos Member of Chamisal Formation by Bowen, 1965)
Trc	RED BEDS OF ROBINSON CANYON Robinson Canyon Member of Chamisal Formation of Bowen (1965). Terrestrial; red to gray arkosic sandstone, siltstone, and conglomerate; middle and possibly lower Miocene
Tc	CARMELO FORMATION OF BOWEN (1965) (Paleocene) Carmelo Series of Lawson (1893); marine; interbedded sandstone, siltstone, mudstone, and cobble-pebble conglomerate
Tcg	Cobble and boulder conglomerate, mostly of granitic detritus
	GRANITIC ROCKS Light-gray crystalline rocks composed of about 2/3 feldspars, 1/3 quartz, and small amounts of biotite and hornblende; age, Cretaceous(?)
gdp	granodiorite, porphyritic
gd	Granodiorite
*qd	Quartz diorite
ms	METAMORPHIC ROCKS Biotite schist-gneiss and mixtures of granitic rocks

REGIONAL GEOLOGY MAP

For: MONTEREY PENINSULA WATER MANAGEMENT DIST.

88152 **May 1989** **Plate 2**

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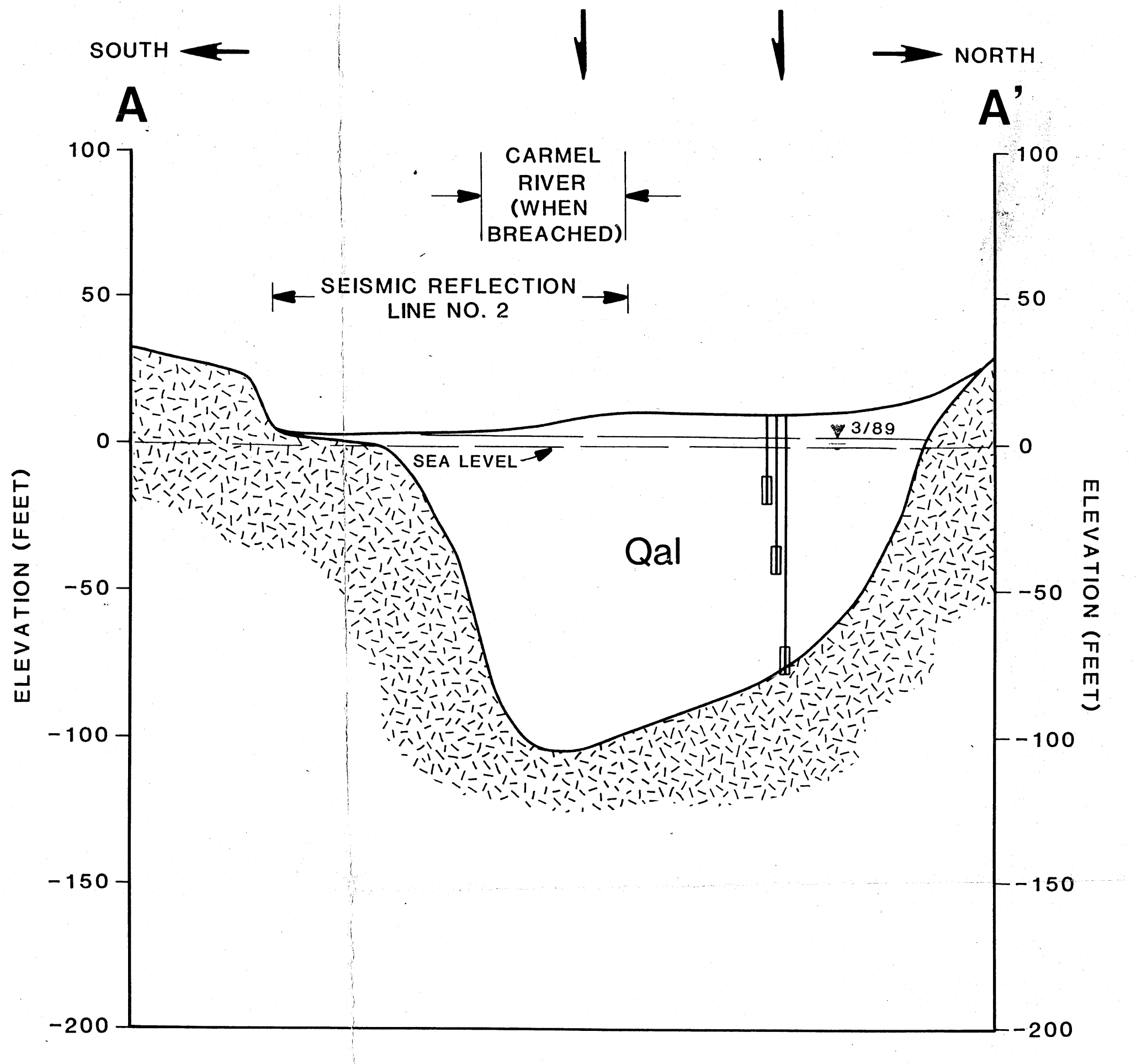
Consulting Engineers and Geologists

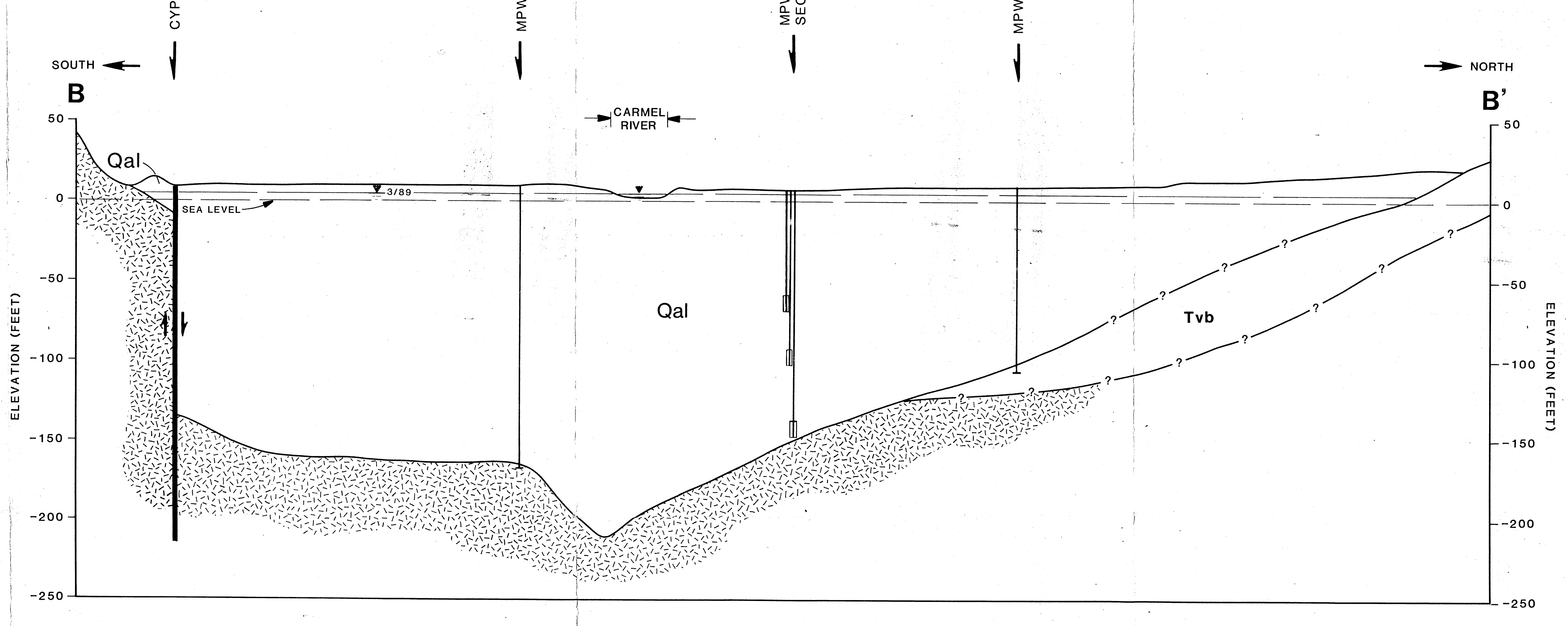
HYDROGEOLOGIC SECTIONS

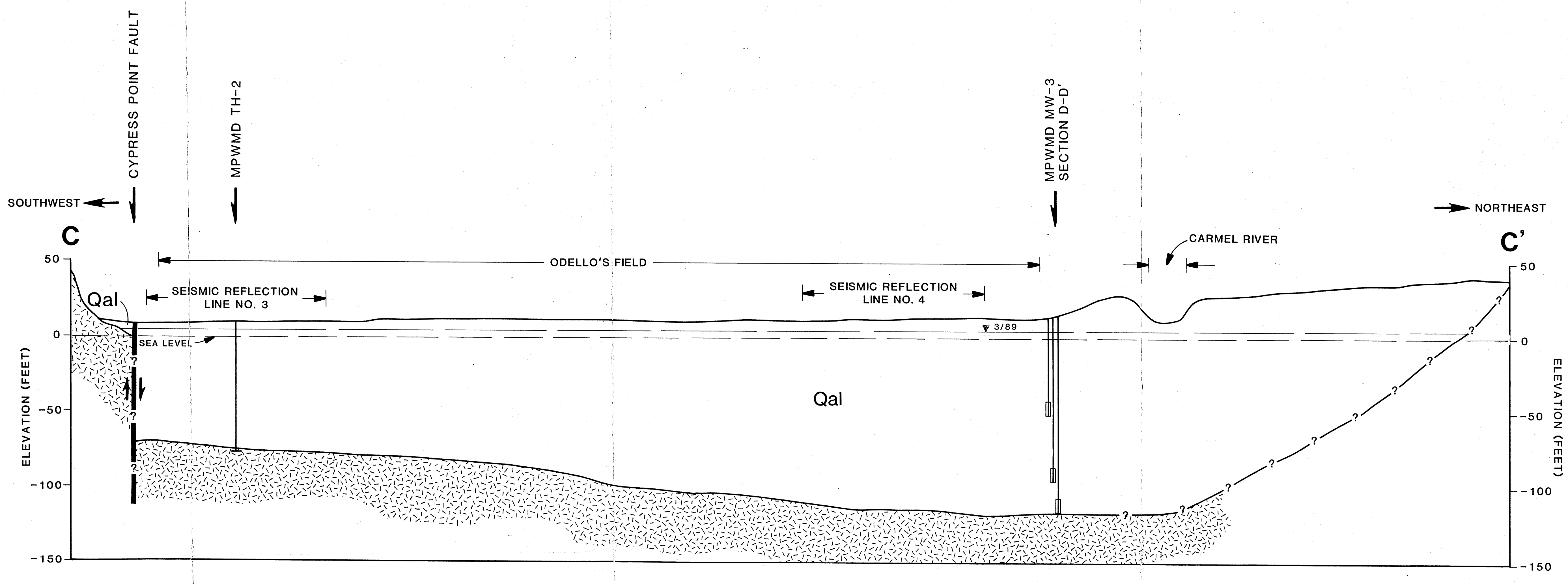
For: MONTEREY PENINSULA WATER MANAGEMENT DIST.

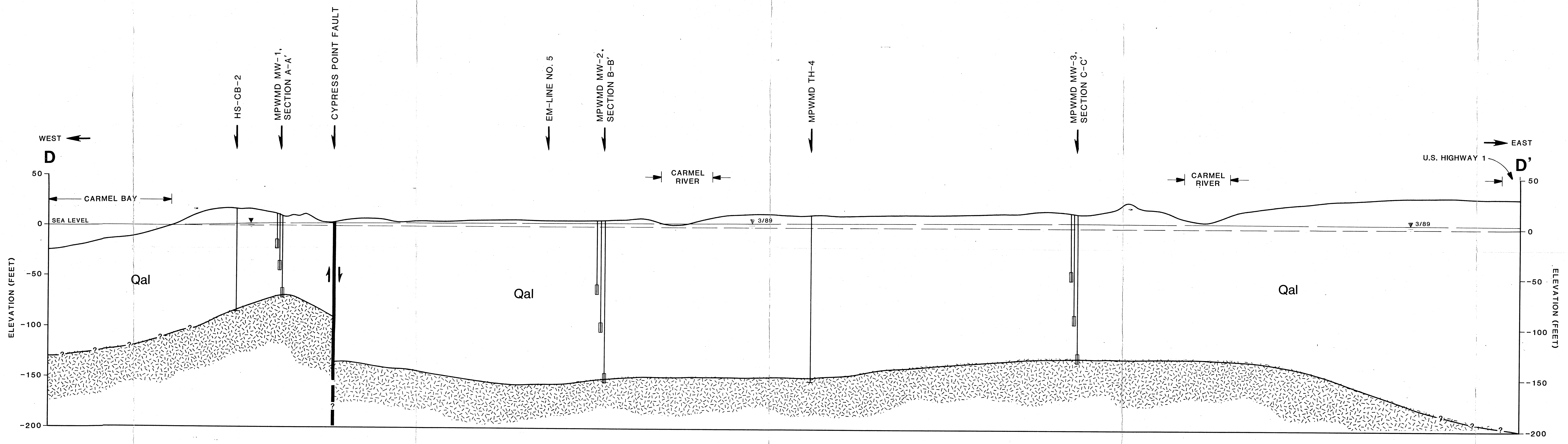
88152 May 1989 Plate 3

Staal, Gardner & Dunne, Inc.
Consulting Engineers and Geologists



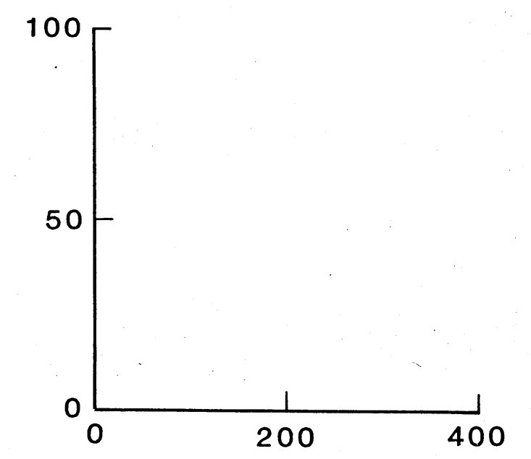






LEGEND

Qal	ALLUVIUM
Tvb	OLIGOCENE BASALT OF LAWSON (1893)
▨	SANTA LUCIA GRANITE
▯	LOCATION OF TEST HOLE OR MONITORING WELL, PERFORATIONS INDICATED IF KNOWN
▼ 3/89	WATER LEVEL ELEVATION



Scale in Feet
Vertical Exaggeration = 4x

LEGEND

▬ ▬ • • •? FAULT, DASHED WHERE APPROXIMATELY LOCATED, DOTTED WHERE CONCEALED OR INFERRED, QUERIED WHERE UNCERTAIN

⊕ APPROXIMATE LOCATION OF MONITORING WELL WITH WATER LEVEL DATA AS SHOWN

⊕ 3.7 APPROXIMATE LOCATION OF WATER WELL WITH WATER LEVEL DATA AS SHOWN

⇦ DIRECTION OF GROUND WATER FLOW

—1.0— LINE OF EQUAL ELEVATION OF GROUND WATER SURFACE

N

0 200 400 600 800 1000

Scale in Feet

TOPOGRAPHIC MAP OF
CARMEL RIVER MOUTH
FOR
PHILIP WILLIAMS & ASSOCIATES

CONTOUR INTERVAL ONE FOOT

Towill, inc. 608 HOWARD STREET, SAN FRANCISCO CALIFORNIA 94105	DATE OF PHOTOGRAPHY	JOB NO.	SHEET	OF
	SEPTEMBER 13, 1988	8556	1	1

WATER LEVEL CONTOUR MAP
MARCH/APRIL 1989
COASTAL CARMEL VALLEY AQUIFER

For: MONTEREY PENINSULA WATER MANAGEMENT DIST.

88152 May 1989 Plate 4

SGD *Staal, Gardner & Dunne, Inc.*
Consulting Engineers and Geologists

APPENDIX A

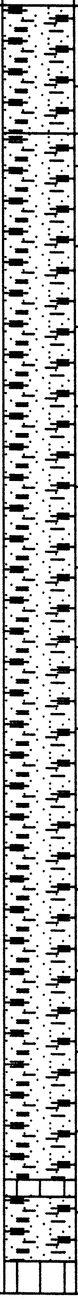
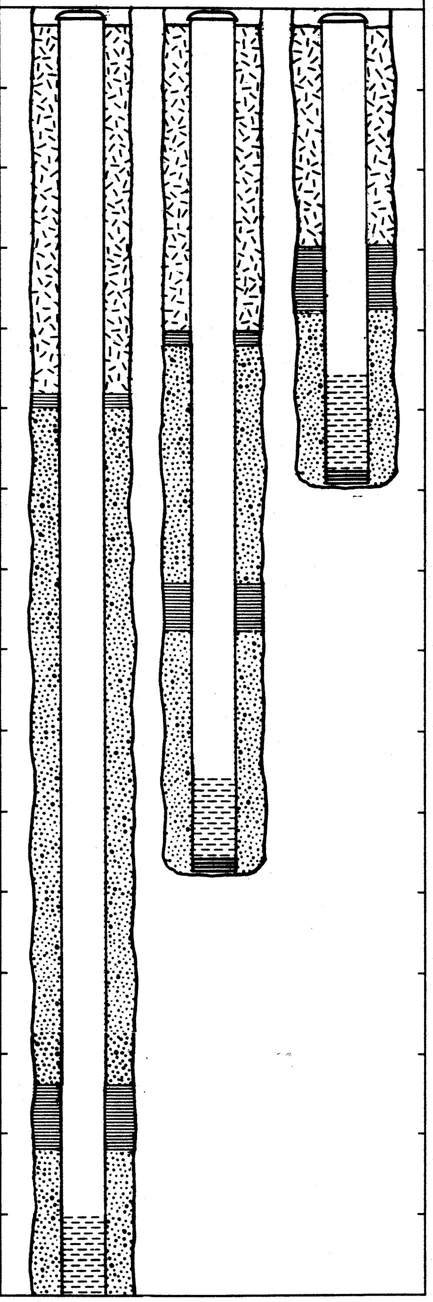
SUPPORTING GEOTECHNICAL DATA

LOG OF MONITORING WELL

JOB NO. : 88152
PROJECT : MPWMD, Lower Carmel River
LOCATION: Carmel River State Beach
DRILLING METHOD: Rotary Wash/Revert 6

LOGGED BY : M. S. Burke
DRILLED BY: Pitcher Drilling Co.
TIME START: 1140 3/1/89
TIME STOP : 1300 3/2/89

MONITORING WELL NO.: MW-1
DRILLING DATE : 3/1/89
DATUM : MSL
REFERENCE EL. : 10.0 feet (approx.)

ELEVATION (FEET)	DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	PHOTOIONIZATION DETECTOR (PPM)	MONITORING WELL SCHEMATIC
10						**BEACH SAND (Qs)** SAND (SW), grayish brown, loose, moderately well graded, fine- to coarse- predominately medium-grained, subrounded to subangular, damp		
	5							
0	10					**ALLUVIUM (Qal)** SAND (SW), brownish gray, well graded, fine- to coarse-grained, subangular, granitic, abundant mica, minor fine granitic gravel		
	15							
-10	20							
	25							
-20	30							
	35					predominantly coarse-grained, common fine subrounded to subangular granitic gravel		
-30	40							
	45							
-40	50							
	55					dark gray, moderately well graded, fine- to coarse- with abundant fine-grained material, abundant mica		
-50	60							
	65							
-60	70							
	75					minor gray, silty clay lenses		
-70								

SHEET 1 OF 2

LEGEND TO LOGS ON PLATE A-2

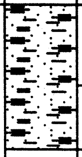
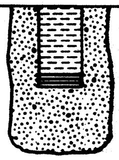
PLATE A-1.1

LOG OF MONITORING WELL

JOB NO. : 88152
PROJECT : MPWMD, Lower Carmel River
LOCATION: Carmel River State Beach
DRILLING METHOD: Rotary Wash/Revert 6

LOGGED BY : M. S. Burke
DRILLED BY: Pitcher Drilling Co.
TIME START: 1140 3/1/89
TIME STOP : 1300 3/2/89

MONITORING WELL NO.: MW-1
DRILLING DATE : 3/1/89
DATUM : MSL
REFERENCE EL. : 10.0 feet (approx.)

ELEVATION (FEET) DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	PHOTOIONIZATION DETECTOR (PPM)	MONITORING WELL SCHEMATIC
70 85					coarser grained sand refusal on granite		

Bottom of drill hole at a depth of 89 feet.
Refusal on top of granite at a depth of 89 feet.
Drill hole completed as a monitoring well to a depth of 85 feet.
Adjacent drill holes to depths of 54 and 30 feet completed as monitoring wells as part of well cluster.

SHEET 2 OF 2

LEGEND TO LOGS ON PLATE A-2

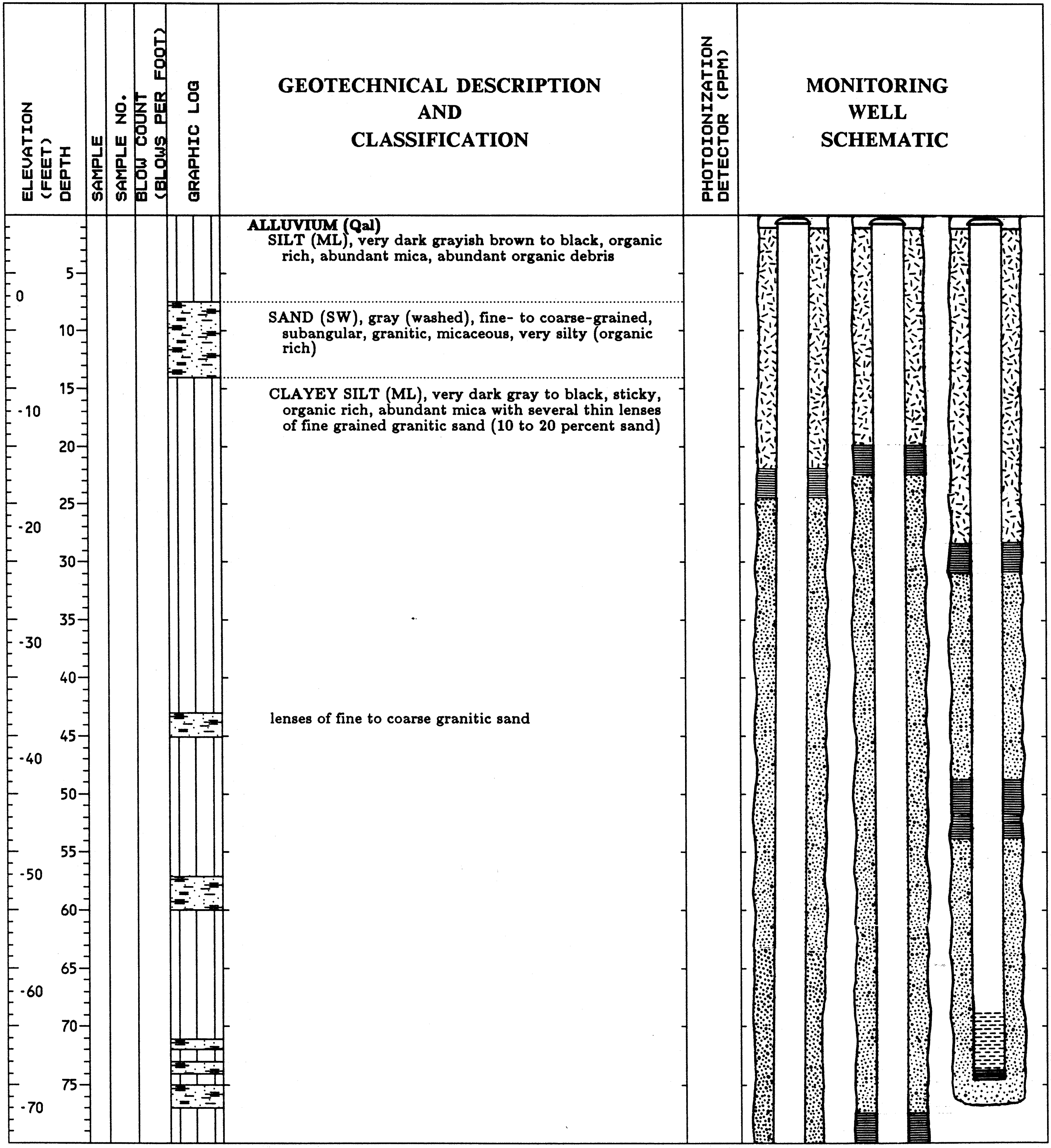
PLATE A-1.1

LOG OF MONITORING WELL

JOB NO. : 88152
PROJECT : MPWMD, Lower Carmel River
LOCATION: Mission Ranch, Carmel
DRILLING METHOD: Rotary Wash/Revert 6

LOGGED BY : M. S. Burke
DRILLED BY: Pitcher Drilling Co.
TIME START: 1100 3/6/89
TIME STOP : 1700 3/7/89

MONITORING WELL NO.: MW-2
DRILLING DATE : 3/6/89
DATUM : MSL
REFERENCE EL. : 7.0 feet (approx.)



ALLUVIUM (Qal)

SILT (ML), very dark grayish brown to black, organic rich, abundant mica, abundant organic debris

SAND (SW), gray (washed), fine- to coarse-grained, subangular, granitic, micaceous, very silty (organic rich)

CLAYEY SILT (ML), very dark gray to black, sticky, organic rich, abundant mica with several thin lenses of fine grained granitic sand (10 to 20 percent sand)

lenses of fine to coarse granitic sand

SHEET 1 OF 2

LEGEND TO LOGS ON PLATE A-2

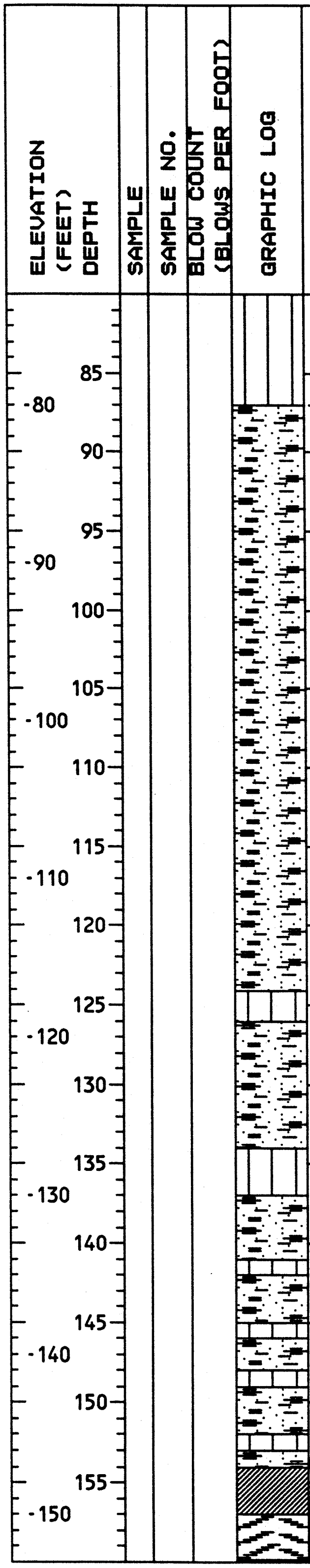
PLATE A-1.2

LOG OF MONITORING WELL

JOB NO. : 88152
PROJECT : MPWMD, Lower Carmel River
LOCATION: Mission Ranch, Carmel
DRILLING METHOD: Rotary Wash/Revert 6

LOGGED BY : M. S. Burke
DRILLED BY: Pitcher Drilling Co.
TIME START: 1100 3/6/89
TIME STOP : 1700 3/7/89

MONITORING WELL NO.: MW-2
DRILLING DATE : 3/6/89
DATUM : MSL
REFERENCE EL. : 7.0 feet (approx.)



GEOTECHNICAL DESCRIPTION AND CLASSIFICATION

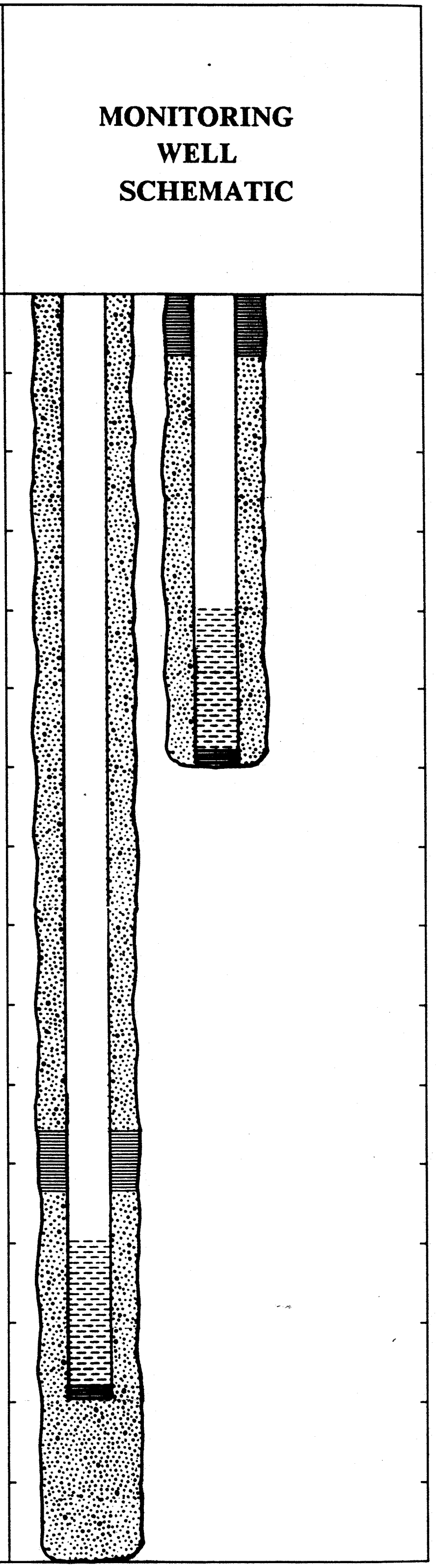
SAND (SW), gray (washed), fine- to coarse-grained, subangular, granitic, abundant mica, common fine granitic gravel and gravel fragments, minor volcanics in sedimentary gravel, common thin lenses of organic rich silt (20 to 25 percent)

SANTA LUCIA QUARTZ DIORITE (gr), extremely weathered
SILTY CLAY (CL), olive gray, common quartz fragments and mafic minerals, spongy

GRANITE (Rx), slightly weatered to fresh, extremely hard

Bottom of drill hole at a depth of 160 feet.
Refusal at 160 feet interpretted as top of fresh granite surface.
Drill hole completed as a monitoring well to a depth of 150 feet.
Adjacent drill holes to depths of 77 and 110 feet completed as monitoring wells as part of cluster.

PHOTOIONIZATION DETECTOR (PPM)



SHEET 2 OF 2

LEGEND TO LOGS ON PLATE A-2

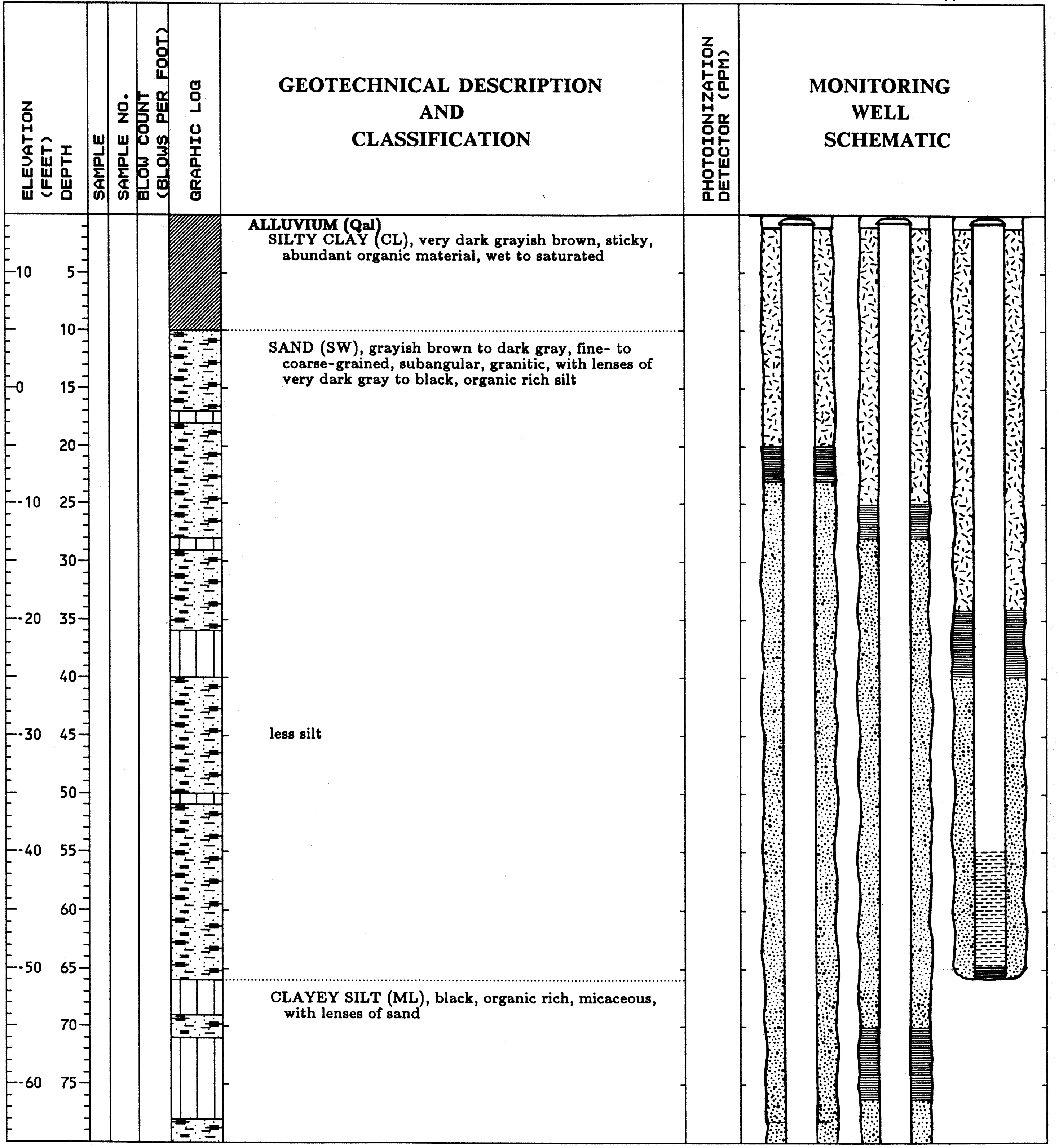
PLATE A-1.2

LOG OF MONITORING WELL

JOB NO. : 88152
PROJECT : MPWMD, Lower Carmel River
LOCATION: Odello Artichoke Field
DRILLING METHOD: Rotary Wash/Revert 6

LOGGED BY : M. S. Burke
DRILLED BY: Pitcher Drilling Co.
TIME START: 1400 3/9/89
TIME STOP : 1300 3/10/89

MONITORING WELL NO.: MW-3
DRILLING DATE : 3/9/89
DATUM : MSL
REFERENCE EL. : 15.0 feet (approx.)



ALLUVIUM (Qal)
SILTY CLAY (CL), very dark grayish brown, sticky, abundant organic material, wet to saturated

SAND (SW), grayish brown to dark gray, fine- to coarse-grained, subangular, granitic, with lenses of very dark gray to black, organic rich silt

less silt

CLAYEY SILT (ML), black, organic rich, micaceous, with lenses of sand

SHEET 1 OF 2

LEGEND TO LOGS ON PLATE A-2

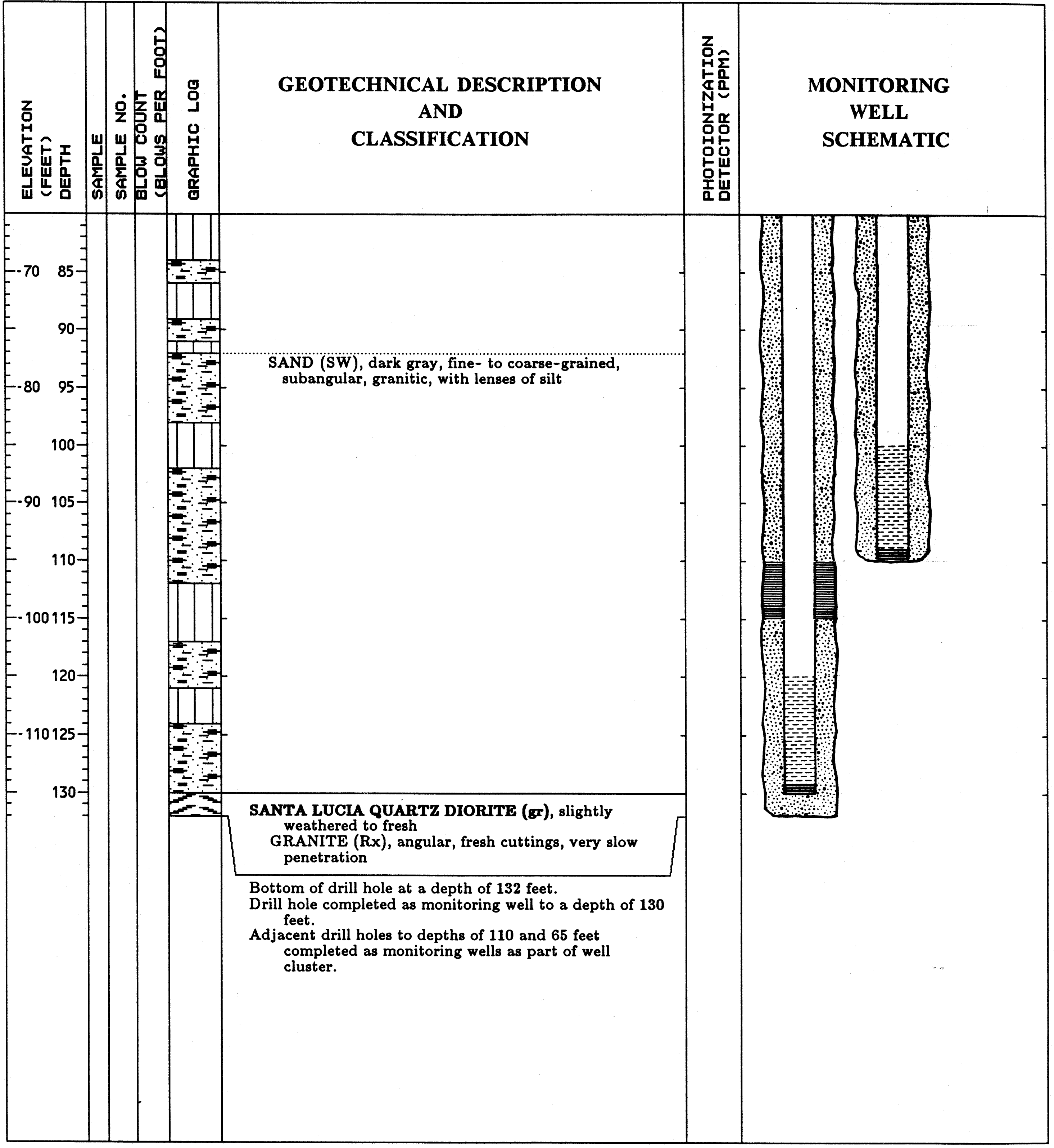
PLATE A-1.3

LOG OF MONITORING WELL

JOB NO. : 88152
PROJECT : MPWMD, Lower Carmel River
LOCATION: Odello Artichoke Field
DRILLING METHOD: Rotary Wash/Revert 6

LOGGED BY : M. S. Burke
DRILLED BY: Pitcher Drilling Co.
TIME START: 1400 3/9/89
TIME STOP : 1300 3/10/89

MONITORING WELL NO.: MW-3
DRILLING DATE : 3/9/89
DATUM : MSL
REFERENCE EL. : 15.0 feet (approx.)



SAND (SW), dark gray, fine- to coarse-grained, subangular, granitic, with lenses of silt

SANTA LUCIA QUARTZ DIORITE (gr), slightly weathered to fresh
GRANITE (Rx), angular, fresh cuttings, very slow penetration

Bottom of drill hole at a depth of 132 feet.
Drill hole completed as monitoring well to a depth of 130 feet.
Adjacent drill holes to depths of 110 and 65 feet completed as monitoring wells as part of well cluster.

LEGEND TO LOGS ON PLATE A-2

LOG OF DRILL HOLE

JOB NO. : 88152
PROJECT : MPWMD, Lower Carmel River
LOCATION: Carmel River State Beach
DRILLING METHOD: Rotary Wash/Revert 5

LOGGED BY : M. S. Burke
DRILLED BY: Pitcher Drilling Co.
TIME START: 1340 3/2/89
TIME STOP : 1550 3/2/89

DRILL HOLE NO.: TH-1
DRILLING DATE : 3/2/89
DATUM: MSL
REFERENCE EL. : 6.0 feet (approx.)

ELEVATION (FEET)	DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	Atterberg Limits LIQUID LIMIT (%)	Atterberg Limits PLASTIC LIMIT (%)	TORVANE (TSF)	POCKET PENETROMETER (TSF)	ADDITIONAL TESTS
						BEACH SAND (Qs) SAND (SW), brown, fine- to coarse-grained but predominantly medium, subangular to subrounded							
0	5												
	10					**ALLUVIUM (Qal)** SAND (SW), grayish brown, fine- to coarse-grained, subangular to subrounded, granitic, abundant mafic minerals including bialite, minor fine granitic gravel							
-10	15												
	20												
-20	25					gray to dark gray							
	30												
-30	35												
	40												
-40	45												
	50												
-50	55												
	60					finer grained							
-60	65					CLAYEY SILT (ML), black, organic rich, abundant mica, very sticky							
	70												
-70	75					SAND (SW), brownish gray, fine- to coarse-grained, subangular, granitic, with minor subangular, fine granitic gravel, few subrounded volcanic gravel with lenses of silt							

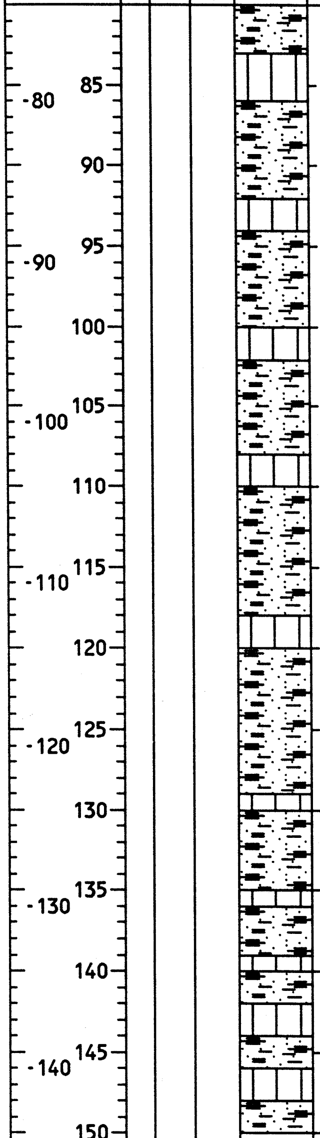
LEGEND TO LOGS ON PLATE A-2

LOG OF DRILL HOLE

JOB NO. : 88152
PROJECT : MPWMD, Lower Carmel River
LOCATION: Carmel River State Beach
DRILLING METHOD: Rotary Wash/Revert 5

LOGGED BY : M. S. Burke
DRILLED BY: Pitcher Drilling Co.
TIME START: 1340 3/2/89
TIME STOP : 1550 3/2/89

DRILL HOLE NO.: TH-1
DRILLING DATE : 3/2/89
DATUM: MSL
REFERENCE EL. : 6.0 feet (approx.)



ELEVATION (FEET) DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	Atterberg Limits LIQUID LIMIT (%)	Atterberg Limits PLASTIC LIMIT (%)	TORVANE (TSF)	POCKET PENETROMETER (TSF)	ADDITIONAL TESTS
130					silty							
140					abundant lenses of organic rich silt							
150					Bottom of drill hole at a depth of 150 feet. Refusal at 150 feet interpretted as top of granite. Drill hole backfilled.							

SHEET 2 OF 2

LEGEND TO LOGS ON PLATE A-2

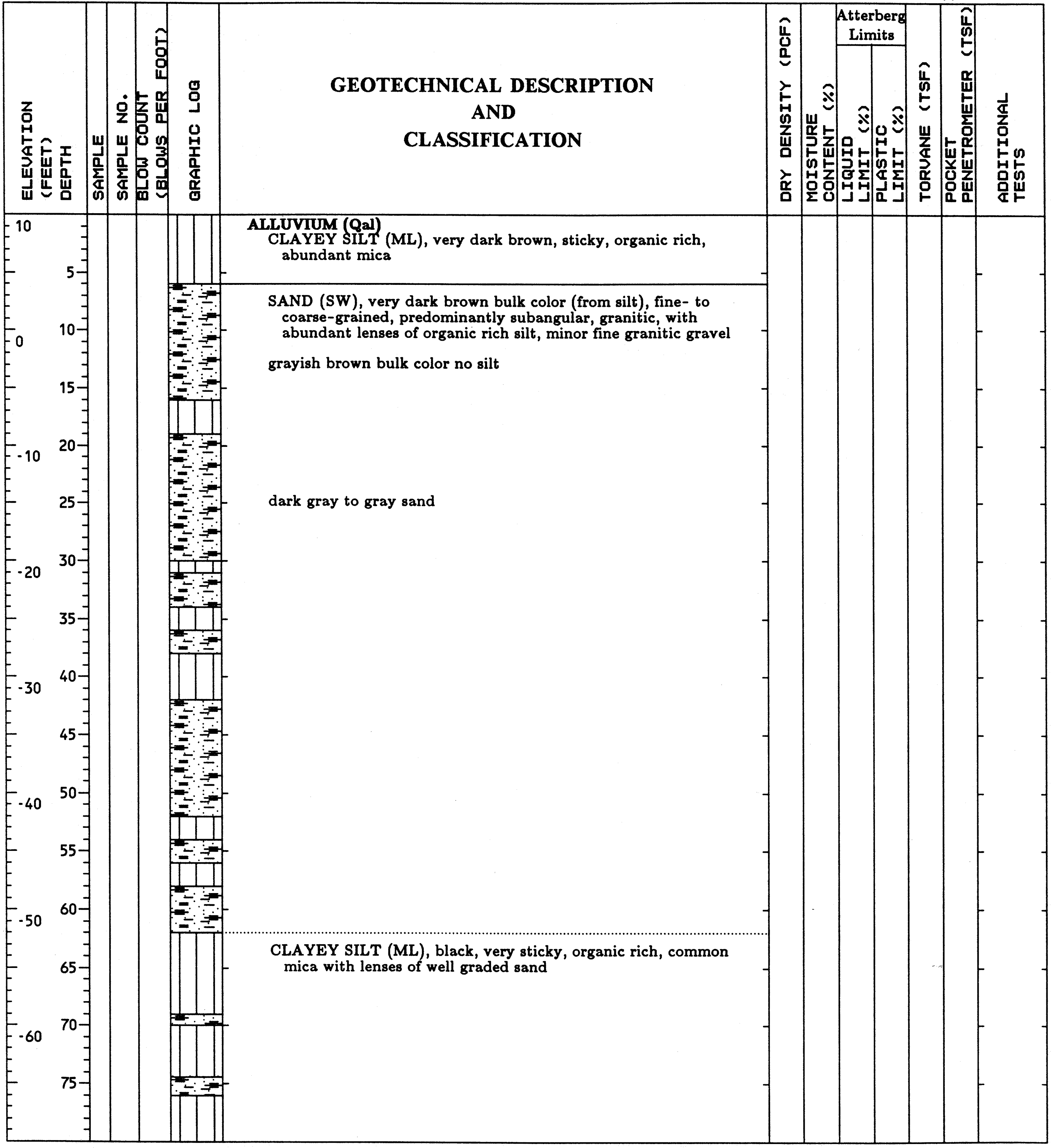
PLATE A-1.4

LOG OF DRILL HOLE

JOB NO. : 88152
PROJECT : MPWMD, Lower Carmel River
LOCATION: Odello Artichoke Field
DRILLING METHOD: Rotary Wash/Revert 5

LOGGED BY : M. S. Burke
DRILLED BY: Pitcher Drilling Co.
TIME START: 0800 3/3/89
TIME STOP : 0940 3/3/89

DRILL HOLE NO.: TH-2
DRILLING DATE : 3/3/89
DATUM: MSL
REFERENCE EL. : 11.0 feet (approx.)



GEOTECHNICAL DESCRIPTION AND CLASSIFICATION

ALLUVIUM (Qal)

CLAYEY SILT (ML), very dark brown, sticky, organic rich, abundant mica

SAND (SW), very dark brown bulk color (from silt), fine- to coarse-grained, predominantly subangular, granitic, with abundant lenses of organic rich silt, minor fine granitic gravel

grayish brown bulk color no silt

dark gray to gray sand

CLAYEY SILT (ML), black, very sticky, organic rich, common mica with lenses of well graded sand

SHEET 1 OF 2

LEGEND TO LOGS ON PLATE A-2

LOG OF DRILL HOLE

JOB NO. : 88152
PROJECT : MPWMD, Lower Carmel River
LOCATION: Odello Artichoke Field
DRILLING METHOD: Rotary Wash/Revert 5

LOGGED BY : M. S. Burke
DRILLED BY: Pitcher Drilling Co.
TIME START: 0800 3/3/89
TIME STOP : 0940 3/3/89

DRILL HOLE NO.: TH-2
DRILLING DATE : 3/3/89
DATUM: MSL
REFERENCE EL. : 11.0 feet (approx.)

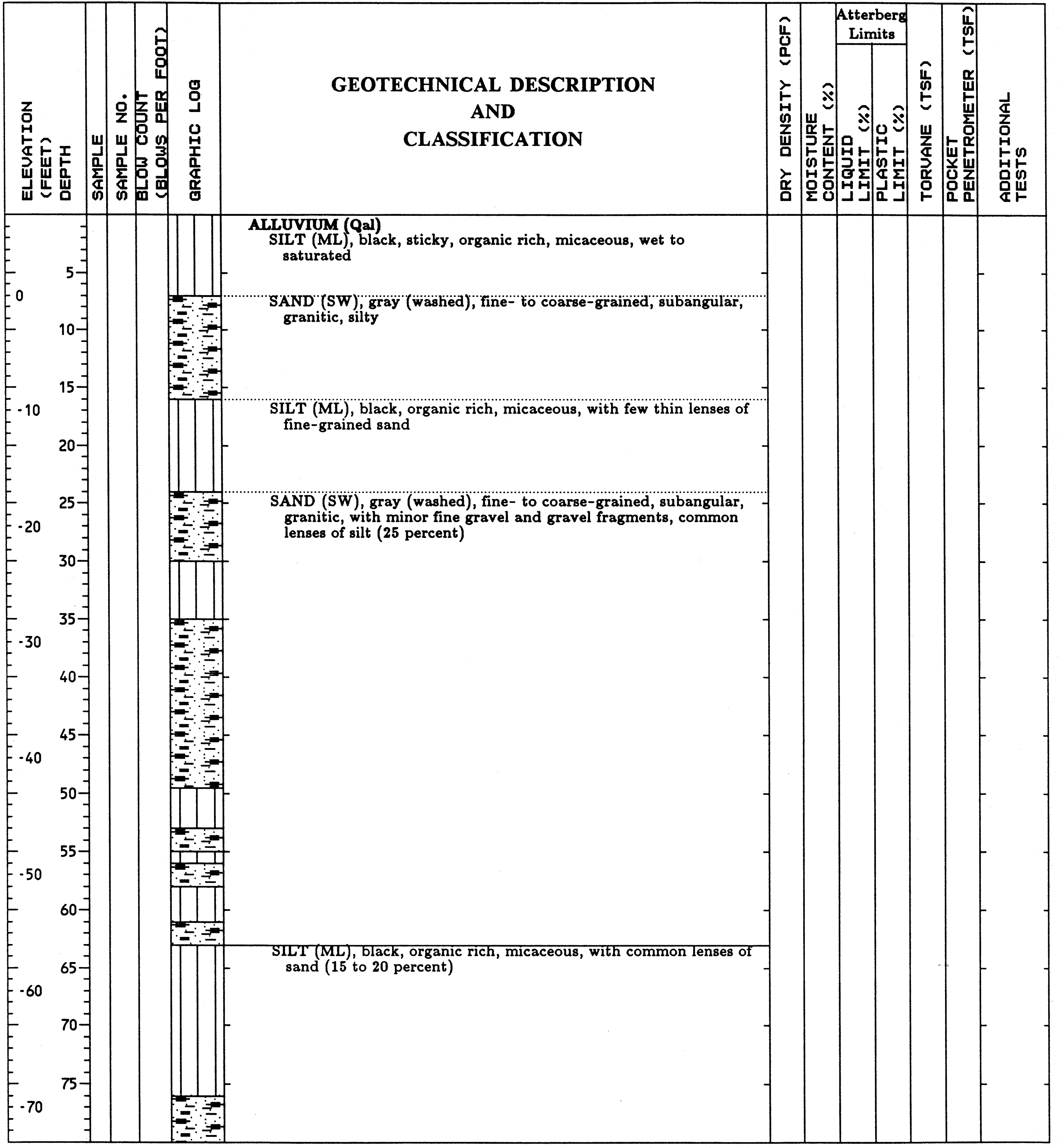
ELEVATION (FEET) DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	Atterberg Limits		TORVANE (TSF)	POCKET PENETROMETER (TSF)	ADDITIONAL TESTS
								LIQUID LIMIT (%)	PLASTIC LIMIT (%)			
-70												
85				▨	CLAY (CH), bluish olive, stiff, abundant mica							
				▨	**SANTA LUCIA QUARTZ DIORITE (gr)**, extremely weathered CLAY (CH) dark olive, micaceous, remnant granite structure							
90 -80				▨	GRANITE (Rx), fresh, extremely hard, angular cuttings							
					Bottom of drill hole at a depth of 94 feet. Drill hole backfilled.							

LOG OF DRILL HOLE

JOB NO. : 88152
PROJECT : MPWMD, Lower Carmel River
LOCATION: Mission Ranch, Carmel
DRILLING METHOD: Rotary Wash/Revert 6

LOGGED BY : M. S. Burke
DRILLED BY: Pitcher Drilling Co.
TIME START: 0930 3/6/89
TIME STOP : 1220 3/6/89

DRILL HOLE NO.: TH-3
DRILLING DATE : 3/6/89
DATUM: MSL
REFERENCE EL. : 7.0 feet (approx.)



GEOTECHNICAL DESCRIPTION AND CLASSIFICATION

ALLUVIUM (Qal)

SILT (ML), black, sticky, organic rich, micaceous, wet to saturated

SAND (SW), gray (washed), fine- to coarse-grained, subangular, granitic, silty

SILT (ML), black, organic rich, micaceous, with few thin lenses of fine-grained sand

SAND (SW), gray (washed), fine- to coarse-grained, subangular, granitic, with minor fine gravel and gravel fragments, common lenses of silt (25 percent)

SILT (ML), black, organic rich, micaceous, with common lenses of sand (15 to 20 percent)

SHEET 1 OF 2

LEGEND TO LOGS ON PLATE A-2

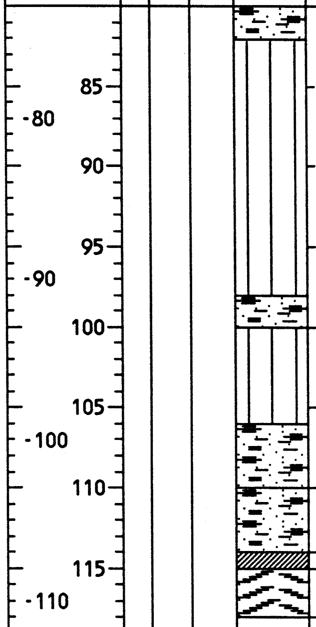
LOG OF DRILL HOLE

JOB NO. : 88152
PROJECT : MPWMD, Lower Carmel River
LOCATION: Mission Ranch, Carmel
DRILLING METHOD: Rotary Wash/Revert 6

LOGGED BY : M. S. Burke
DRILLED BY: Pitcher Drilling Co.
TIME START: 0930 3/6/89
TIME STOP : 1220 3/6/89

DRILL HOLE NO.: TH-3
DRILLING DATE : 3/6/89
DATUM: MSL
REFERENCE EL. : 7.0 feet (approx.)

ELEVATION (FEET) DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	Atterberg Limits LIQUID LIMIT (%)	Atterberg Limits PLASTIC LIMIT (%)	TORVANE (TSF)	POCKET PENETROMETER (TSF)	ADDITIONAL TESTS
					CLAY (CL), olive gray, abundant mica							
					UNNAMED VOLCANICS (Tvb) BASALT (Rx), dark red, very hard, with common olive minerals, aphanitic texture							
					Bottom of test hole at a depth of 118 feet. Drill hole backfilled.							



SHEET 2 OF 2

LEGEND TO LOGS ON PLATE A-2

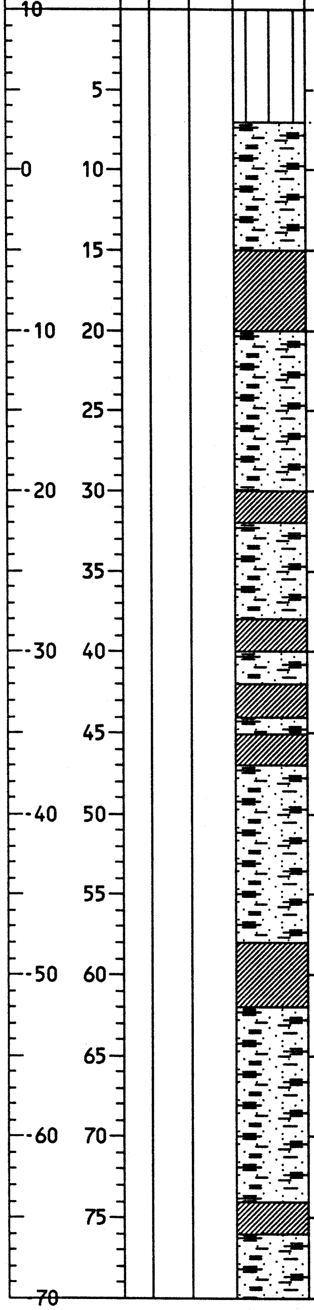
PLATE A-1.6

LOG OF DRILL HOLE

JOB NO. : 88152
PROJECT : MPWMD, Lower Carmel River
LOCATION: Odello Artichoke Field near CTP
DRILLING METHOD: Rotary Wash/Revert 6

LOGGED BY : M. S. Burke
DRILLED BY: Pitcher Drilling Co.
TIME START: 0900 3/8/89
TIME STOP : 1300 3/8/89

DRILL HOLE NO.: TH-4
DRILLING DATE : 3/8/89
DATUM: MSL
REFERENCE EL. : 10.0 feet (approx.)

ELEVATION (FEET) DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	Atterberg Limits LIQUID LIMIT (%)	Atterberg Limits PLASTIC LIMIT (%)	TORVANE (TSF)	POCKET PENETROMETER (TSF)	ADDITIONAL TESTS
					**ALLUVIUM (QaL)** CLAYEY SILT (ML), very dark brown to black, sticky, common organic material SAND (SW), grayish brown, well graded, subangular with lenses of brownish gray to dark gray clay CLAY (CL), very dark gray to black, organic rich, abundant mica, very silty SAND (SW), brownish gray, fine- to coarse-grained, subangular, granitic, abundant mica, with common lenses of black, organic rich, micaceous silt (20- to 30-feet at 15 percent) more silt (35- to 45-feet at 50 percent) less silt (45- to 60-feet at 10 percent) black silt finer grained sand, predominately fine- to medium-grained, with common lenses of silt (65- to 103-feet at 15 to 20 percent)							

LEGEND TO LOGS ON PLATE A-2

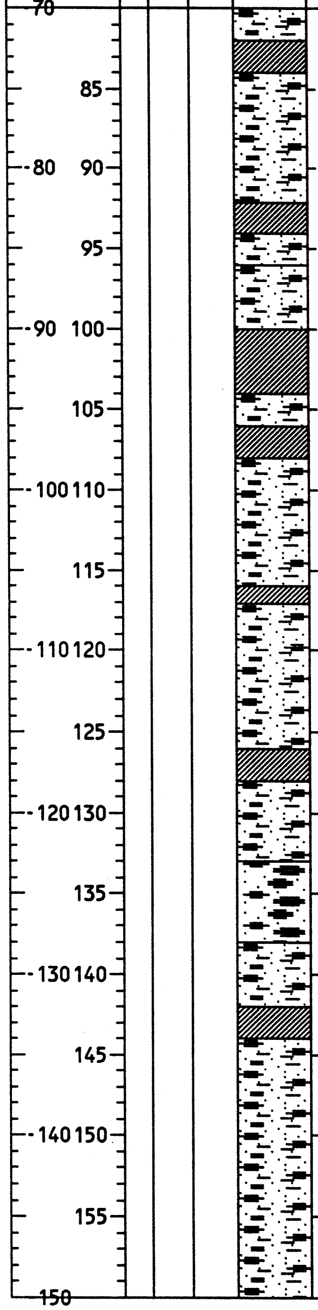
LOG OF DRILL HOLE

JOB NO. : 88152
PROJECT : MPWMD, Lower Carmel River
LOCATION: Odello Artichoke Field near CTP
DRILLING METHOD: Rotary Wash/Revert 6

LOGGED BY : M. S. Burke
DRILLED BY: Pitcher Drilling Co.
TIME START: 0900 3/8/89
TIME STOP : 1300 3/8/89

DRILL HOLE NO.: TH-4
DRILLING DATE : 3/8/89
DATUM: MSL
REFERENCE EL. : 10.0 feet (approx.)

ELEVATION (FEET) DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	Atterberg Limits LIQUID LIMIT (%)	Atterberg Limits PLASTIC LIMIT (%)	TORVANE (TSF)	POCKET PENETROMETER (TSF)	ADDITIONAL TESTS



more silt

coarser sand

coarser grained

lense of coarse-grained granitic sand and fine- to medium-granitic gravel

138- to 148-feet at 40 percent

coarse grained

wood fagments (tree?)

SHEET 2 OF 3

LEGEND TO LOGS ON PLATE A-2

PLATE A-1.7

LOG OF DRILL HOLE

JOB NO. : 88152
PROJECT : MPWMD, Lower Carmel River
LOCATION: Odello Artichoke Field near CTP
DRILLING METHOD: Rotary Wash/Revert 6

LOGGED BY : M. S. Burke
DRILLED BY: Pitcher Drilling Co.
TIME START: 0900 3/8/89
TIME STOP : 1300 3/8/89

DRILL HOLE NO.: TH-4
DRILLING DATE : 3/8/89
DATUM: MSL
REFERENCE EL. : 10.0 feet (approx.)

ELEVATION (FEET) DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	Atterberg Limits LIQUID LIMIT (%)	Atterberg Limits PLASTIC LIMIT (%)	TORVANE (TSF)	POCKET PENETROMETER (TSF)	ADDITIONAL TESTS
150												
165					**SANTA LUCIA QUARTZ DIORITE (GR)**, extremely weathered CLAY (CL), olive brown, micaceous, remnant grantic structure GRANITE (Rx), fresh, very hard, angular cuttings							

Bottom of drill hole at a depth of 166 feet.
Refusal on top of granite at a depth of 160 feet.
Drill hole backfilled.

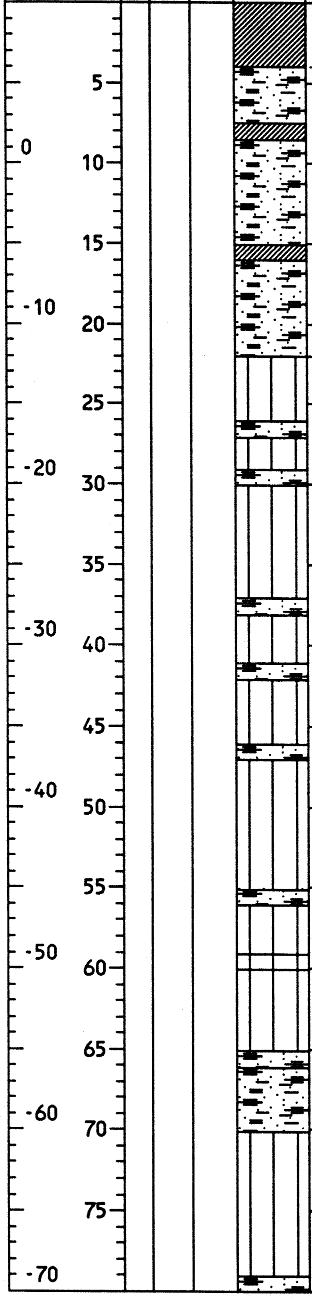
LEGEND TO LOGS ON PLATE A-2

LOG OF DRILL HOLE

JOB NO. : 88152
PROJECT : MPWMD, Lower Carmel River
LOCATION: West Odello Artichoke Field
DRILLING METHOD: Rotary Wash/Revert 5

LOGGED BY : M. S. Burke
DRILLED BY: Pitcher Drilling Co.
TIME START: 1400 3/10/89
TIME STOP : 1600 3/10/89

DRILL HOLE NO.: TH-5
DRILLING DATE : 3/10/89
DATUM: MSL
REFERENCE EL. : 9.0 feet (approx.)

ELEVATION (FEET) DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	Atterberg Limits LIQUID LIMIT (%)	Atterberg Limits PLASTIC LIMIT (%)	TORVANE (TSF)	POCKET PENETROMETER (TSF)	ADDITIONAL TESTS
					**ALLUVIUM (Qal)** SILTY CLAY (CL), dark grayish brown, sticky, abundant organic material SAND (SW), dark gray, fine- to coarse-grained, subangular, granitic, with lenses of silty clay and clyey sitl (15- to 20-percent) lenses of clayey silt CLAYEY SILT (ML), black, organic rich, micaceous, with few, then lenses of sand (25- to 40-feet at <10 percent) more sand (40- to 46-feet at 20 percent) less sand (46- to 55-feet <10 percent) thin sand lenses (55- to 70-feet at 10 percent) 70- to 85-feet at 10 to 15 percent							

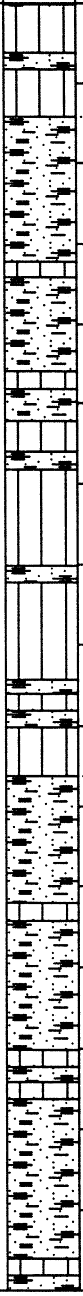
LEGEND TO LOGS ON PLATE A-2

LOG OF DRILL HOLE

JOB NO. : 88152
PROJECT : MPWMD, Lower Carmel River
LOCATION: West Odello Artichoke Field
DRILLING METHOD: Rotary Wash/Revert 5

LOGGED BY : M. S. Burke
DRILLED BY: Pitcher Drilling Co.
TIME START: 1400 3/10/89
TIME STOP : 1600 3/10/89

DRILL HOLE NO.: TH-5
DRILLING DATE : 3/10/89
DATUM: MSL
REFERENCE EL. : 9.0 feet (approx.)

ELEVATION (FEET)	DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	Atterberg Limits		TORVANE (TSF)	POCKET PENETROMETER (TSF)	ADDITIONAL TESTS
									LIQUID LIMIT (%)	PLASTIC LIMIT (%)			
	85												
-80	90					SAND (SW), dark gray, fine- to coarse-grained, subangular, granitic, with fine subangular granitic gravel, few thine lenses of clayey silt (88- to 89-feet at 20 percent)							
	95												
-90	100					98 to 105 feet at 40 percent silt							
	105												
-100	110					CLAYEY SILT (ML), black, organic rich, micaeous, with few thin layers of sand							
	115												
-110	120												
	125												
-120	130					SAND (SW), dark gray, fine- to coarse-grained, subangular, granitic, with mica fine granitica gravel, lenses of clayey silt (130 to 150 feet at 25 percent)							
	135												
-130	140												
	145					more silt							
-140	150					less silt (150 to 160 feet at 15 to 20 percent)							
	155												
-150													

SHEET 2 OF 3

LEGEND TO LOGS ON PLATE A-2

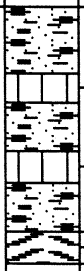
PLATE A-1.8

LOG OF DRILL HOLE

JOB NO. : 88152
PROJECT : MPWMD, Lower Carmel River
LOCATION: West Odello Artichoke Field
DRILLING METHOD: Rotary Wash/Revert 5

LOGGED BY : M. S. Burke
DRILLED BY: Pitcher Drilling Co.
TIME START: 1400 3/10/89
TIME STOP : 1600 3/10/89

DRILL HOLE NO.: TH-5
DRILLING DATE : 3/10/89
DATUM: MSL
REFERENCE EL. : 9.0 feet (approx.)

ELEVATION (FEET) DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	Atterberg Limits LIQUID LIMIT (%)	Atterberg Limits PLASTIC LIMIT (%)	TORVANE (TSF)	POCKET PENETROMETER (TSF)	ADDITIONAL TESTS
165												
-160 170					lenses of brown silt							
175					**SANTA LUCIA QUARTZ DIORITE (gr)** GRANITE (Rx), fresh, extremely hard, angular, fresh cutting							

Bottom of drill hole at a depth of 176 feet.
Drill hole backfilled.

SHEET 3 OF 3

LEGEND TO LOGS ON PLATE A-2

PLATE A-1.8

LEGEND TO LOGS

TERMS AND SYMBOLS

SAMPLE

SAMPLE TYPES ARE INDICATED AS FOLLOWS:

■ UNDISTURBED

⊡ UNSUCCESSFUL ATTEMPT

◩ STANDARD PENETRATION

☒ DISTURBED

BLOW COUNT

THE NUMBER OF HAMMER BLOWS REQUIRED TO DRIVE THE SAMPLER THE LAST 12 INCHES.

SYMBOL	HAMMER WEIGHT (POUNDS)	DROP HEIGHT (INCHES)	HAMMER TYPE
7			
(3)			
[6]			
④			
□			
⬡5			

WATER LEVEL	WATER INFLOW	HEAVY CAVING	LIGHT CAVING
▼	≡	⌒⌒	⌒⌒

ADDITIONAL TESTS

UC- UNCONFINED COMPRESSION

TD- TRIAXIAL COMPRESSION, DRAINED

TU- TRIAXIAL COMPRESSION, UNDRAINED

TDy- TRIAXIAL COMPRESSION, DYNAMIC

GS- GRAIN SIZE DISTRIBUTION

SE- SAND EQUIVALENT

SG- SPECIFIC GRAVITY

CP- COMPACTION

C- CONSOLIDATION

DS- DIRECT SHEAR

PM- PERMEABILITY

EX- EXPANSION INDEX

R- R VALUE

CBR- CALIFORNIA BEARING RATIO

pH- HYDROGEN ION CONCENTRATION

RS- RESISTIVITY

CL- CHLORIDE

SU- SULPHATE

PA- PALEONTOLOGIC ANALYSIS

WP- WATER PRESSURE

PMt- PRESSUREMETER

AS- AGRICULTURAL SUITABILITY

(UNIFIED SOIL CLASSIFICATION AND PLASTICITY CHART ON REVERSE)

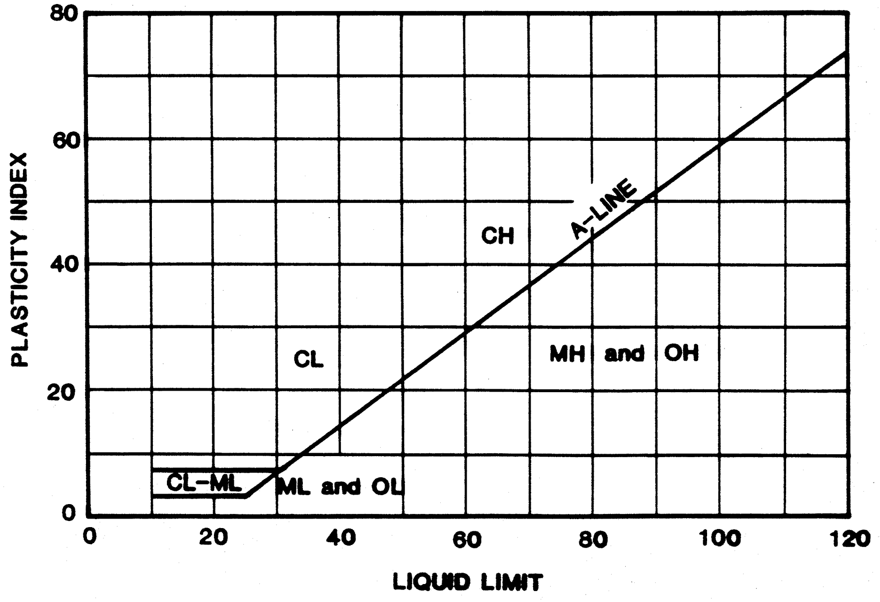
UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISION			GROUP SYMBOL	DESCRIPTION	GRAPHIC LOG
COARSE GRAINED SOILS OVER 50% BY WEIGHT COARSER THAN NO. 200 SIEVE SIZE	GRAVELLY SOILS OVER 50% OF COARSE FRACTION LARGER THAN NO. 4 SIEVE SIZE	CLEAN GRAVELLY SOILS LITTLE OR NO FINES	GW	WELL GRADED GRAVELS OR GRAVEL-SAND MIXTURES	▒
			GP	POORLY GRADED GRAVELS OR GRAVEL-SAND MIXTURES	▓
		GRAVELLY SOILS WITH FINES OVER 12% FINES	GM	SILTY GRAVELS OR POORLY GRADED GRAVEL-SAND-SILT MIXTURES	▥
			GC	CLAYEY GRAVELS OR POORLY GRADED GRAVEL-SAND-CLAY MIXTURES	▨
	SANDY SOILS OVER 50% OF COARSE FRACTION SMALLER THAN NO. 4 SIEVE SIZE	CLEAN SANDY SOILS LITTLE OR NO FINES	SW	WELL GRADED SANDS OR GRAVELLY SANDS	░
			SP	POORLY GRADED SANDS OR GRAVELLY SANDS	░
		SANDY SOILS WITH FINES OVER 12% FINES	SM	SILTY SANDS OR POORLY GRADED SAND-SILT MIXTURES	▥
			SC	CLAYEY SANDS OR POORLY GRADED SAND-CLAY MIXTURES	▨
FINE GRAINED SOILS OVER 50% BY WEIGHT FINER THAN NO. 200 SIEVE SIZE	SILTY AND CLAYEY SOILS LIQUID LIMIT LESS THAN 50		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, OR LEAN CLAYS	▨
			OL	ORGANIC CLAYS OR ORGANIC SILTY CLAYS OF LOW PLASTICITY	▥
	SILTY AND CLAYEY SOILS LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, OR ELASTIC SILTS	▥
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, OR FAT CLAYS	▨
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, OR ORGANIC SILTS	▨
HIGHLY ORGANIC SOILS			PT	PEAT OR OTHER HIGHLY ORGANIC SOIL	≋

Soil color based on Munsell Soil Color Chart

PLASTICITY CHART

USED FOR CLASSIFICATION OF FINE GRAINED SOILS



GEO-HYDRO-DATA

INCORPORATED

ELECTRIC WELL LOG

COMPANY MONTEREY PENINSULA WATER MANAGEMENT DISTRICT
WELL MW-3
FIELD CARMEL
COUNTY MONTEREY
STATE CA.

COMPANY MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

WELL MW-3

FIELD CARMEL

COUNTY MONTEREY STATE CALIFORNIA

LOCATION
LOWER CARMEL RIVER VALLEY

Sec.___ Twp.___ Rge.___

TYPE LOG
SP
PR
6' LAT

Permanent Datum GROUND LEVEL Elev.___

Log Measured From G.L. ___ Ft. Above Perm. Datum

Drilling Measured From G.L.

Elev.: K. B.___

D. F.___

G. L.___

Date	9 Mar 89		
Run No.	one		
Depth — Driller	132 ft.	ft.	ft.
Depth — GHD	132 ft.	ft.	ft.
Btm. Log Inter.	132 ft.	ft.	ft.
Top Log Inter.	11 ft.	ft.	ft.
Casing — Driller	in. @ ft.	in. @ ft.	in. @ ft.
Casing — GHD	ft.	ft.	ft.
Bit Size	6 in. to 132 ft.	in. to ft.	in. to ft.
Bit Size	in. to ft.	in. to ft.	in. to ft.
Bit Size	in. to ft.	in. to ft.	in. to ft.
Type Fluid in Hole	clay-gel		
Source of Sample	ditch		
PPM TDS	200		
Fluid Level	full ft.	ft.	ft.
Dens. / Visc.			
pH / Fluid Loss	ml	ml	ml
Rm @ Meas. Temp.	@ °F	@ °F	@ °F
Rmf @ Meas. Temp.	@ °F	@ °F	@ °F
Rmc @ Meas. Temp.	@ °F	@ °F	@ °F
Time Since Circ.	1/2 hr.	hr.	hr.
Logging Speed	30 ft./min.	ft./min.	ft./min.
Tool Type and No.	combo 4		
Unit No.	4		
Location	Tehachapi		
Invoice No.	6147		
Recorded By	Jim Bet, Associate Geologist		
Witnessed By	Mike, Staal, Gardner & Dunne		
other			

P. O. Box 418 Tehachapi, California 93561 (805) 822-6875

Fold Here

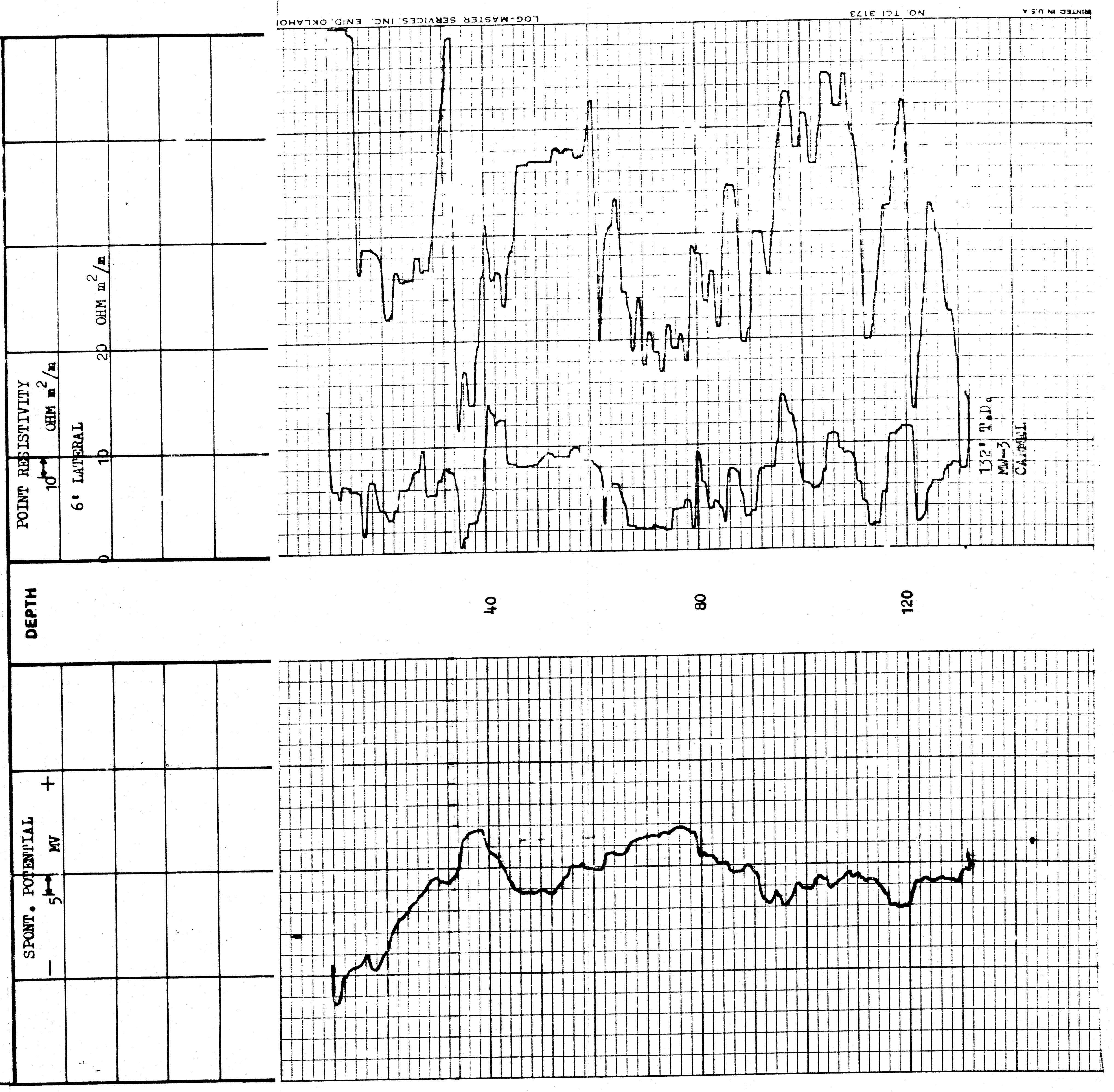
SCALE CHANGES			
Type Log	Depth	Scale Up Hole	Scale Down Hole

REMARKS: STAAL, GARDNER & DUNNE
MONTEREY, CA.

DRILL METHOD: STANDARD ROTARY

DRILLED BY: PITCHER DRILLING
PALO ALTO, CA.

All interpretations are opinions based on inferences from electrical or other measurements and we cannot, and do not guarantee the accuracy or correctness of any interpretations, and we shall not be liable or responsible for any loss, costs, damages or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Clause 6 of our General Terms and Conditions as set out in our current Price Schedule.



APPENDIX B

REPORT OF THE GEOPHYSICS GROUP ENTITLED "A GEOPHYSICAL INVESTIGATION TO MAP THE DEPTH AND CONFIGURATION GRANITIC BEDROCK BENEATH THE LOWER CARMEL RIVER VALLEY, CARMEL, CALIFORNIA"

4636 Mission Gorge Place, Suite 200
San Diego, CA 92120, USA
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The Geophysics Group

A GEOPHYSICAL INVESTIGATION TO MAP THE DEPTH AND CONFIGURATION OF GRANITIC BEDROCK BENEATH THE LOWER CARMEL RIVER VALLEY, CARMEL, CALIFORNIA

FINAL REPORT

Prepared For
STAAL, GARDNER & DUNNE, INC.
121 North Fir Street, Suite F
Ventura, California 93001

by
THE GEOPHYSICS GROUP
4636 Mission Gorge Place, Suite 200
San Diego, California 92120

March, 1989

Comprising Albireo Ltd. & Exploration Geothermics

A GEOPHYSICAL INVESITGATION TO MAP THE DEPTH AND CONFIGURATION OF GRANITIC BEDROCK BENEATH THE LOWER CARMEL RIVER VALLEY, CARMEL, CALIFORNIA

Prepared For

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THE GEOPHYSICS GROUP

March, 1989

Phillip A Walen

Phillip A. Walen
Project Geophysicist, Registration # GP917

Edward P. Gustafson

Edward P. Gustafson
Chief Geophysical Analyst

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Plate I: Base Map (in pocket). THIS PLATE IS NOT INCLUDED WITHIN THIS APPENDIX. GEOPHYSICAL LINES ARE SHOWN ON SGD PLATE 1 - HYDROGEOLOGIC MAP.

A GEOPHYSICAL INVESTIGATION TO MAP THE DEPTH AND CONFIGURATION OF GRANITIC BEDROCK BENEATH THE LOWER CARMEL RIVER VALLEY, CARMEL CALIFORNIA

EXECUTIVE SUMMARY

A geophysical investigation using seismic and electromagnetic methods was performed over the period of February 14 through 21, 1989 by The Geophysics Group for Staal, Gardner and Dunne, Inc., over the costal portions of the Carmel River valley. The study focused on mapping the configuration of granitic bedrock, with particular attention directed towards detecting subsurface structure that might indicate vertical separation along the Cypress Point fault which crosses the study area.

The geophysical data indicate a relatively shallow alluvial basin with thicknesses from less than 10 feet below the southern portion of the Carmel State Beach to 200 to 250 feet below the central portion of the project area. The geophysical data show no clear evidence of vertical separation across the Cypress Point fault, although there is seismic evidence of a significant change in bedrock slope east of the suspected trace of the fault.

A deeply-incised bedrock channel occurs beneath the northern portion of the beach study area. The southern edge of the channel is marked by a steeply-dipping boundary between the granite (to the south) and alluvial material. Electromagnetic, seismic, and drill-hole data suggests that the channel probably extends to the north end of the beach parking lot. Granite appears in outcrop approximately 100 feet to the north of the parking lot. Electromagnetic data indicate that the channel may be acting as a conduit for sea water intrusion, which may be confirmed by the observation of high water conductivities in monitoring well MW-1D located at the southern end of the parking lot (M. Feeney, pers. comm.). Geophysical data suggest that the intrusion is presently confined to the western portions of the beach area. Granite velocities of 8300 ft/s, measured directly on outcrop, indicate that the material is highly weathered, and may allow hydraulic connection between fresh and salt water. However, electromagnetic data suggest that this is not occurring through the shallow bedrock beneath the southern portions of the beach area.

1.0 INTRODUCTION

This final report covers the work performed by The Geophysics Group for Staal, Gardner and Dunne, Inc. (SG&D), during the period of February 14 - 21, 1989. The field area was the costal portion of the Carmel River Valley, immediately south of the city of Carmel, CA (Figure 1). Seismic and electromagnetic surveys were conducted according to the scope of work outlined in Part II of the contract agreement dated February 13, 1989. Field data acquisition was carried out by staff of The Geophysics Group, and supervised by Mr. Martin B. Feeney, Project Hydrogeologist and representative for SG&D. References to data and information made available to The Geophysics Group by Mr. Feeney on a personnal communications basis will be indicated in this report by (MBF).

The seismic survey layout was modified from the original field plan which called for three parallel 500-foot traverses across the inferred trace of the Cypress Point fault. At the time of the project, standing bodies of water, dense vegetation, and wet, marshy conditions precluded access, with seismic gear, to much of the survey area. Electromagnetic profiles were occupied in areas of interest in which seismic data were unobtainable.

The geophysical surveys were designed to determine the geometry of the granitic bedrock, for use in defining boundary conditions for future groundwater modeling of the Carmel River Valley Aquifer.

2.0 DATA ACQUISITION AND FIELD METHODS

2.1 Seismic Survey

2.1.1 Equipment, Energy Sources, and Recording Procedures.

Seismic reflection and refraction data were collected using an ABEM Terraloc Mark III 24-channel signal-enhancement seismograph using 100 Hz geophones. The signal-enhancement feature of this instrument allowed signals from repeated shots to be stacked, thus improving the signal-to-noise ratio. This option proved useful on seismic lines 1 and 2, where both cultural and natural noise was severe.

Data were recorded over record lengths of 100 and 200 ms, and stored digitally on 3.5 inch disks in MS-DOS format. A 100 Hz high-pass analog filter was used during most of the survey to reduce low-frequency noise and ground roll. Hard copy prints of each seismogram were made in the field on 21 cm thermal paper using the Terraloc printer. Copies of these recordings are included in Appendix A.

Two sources of seismic energy were used during this investigation; 1) sledge hammer impacts on a steel plate placed on the ground, and 2) 8 gauge industrial blanks fired by a Betsy Seisgun. In general, both methods produced sufficient energy to provide good reflection recordings from most shotpoints. Over the beach areas where loose, dry sand resulted in poor source coupling, both reflected and refracted arrivals were weak and

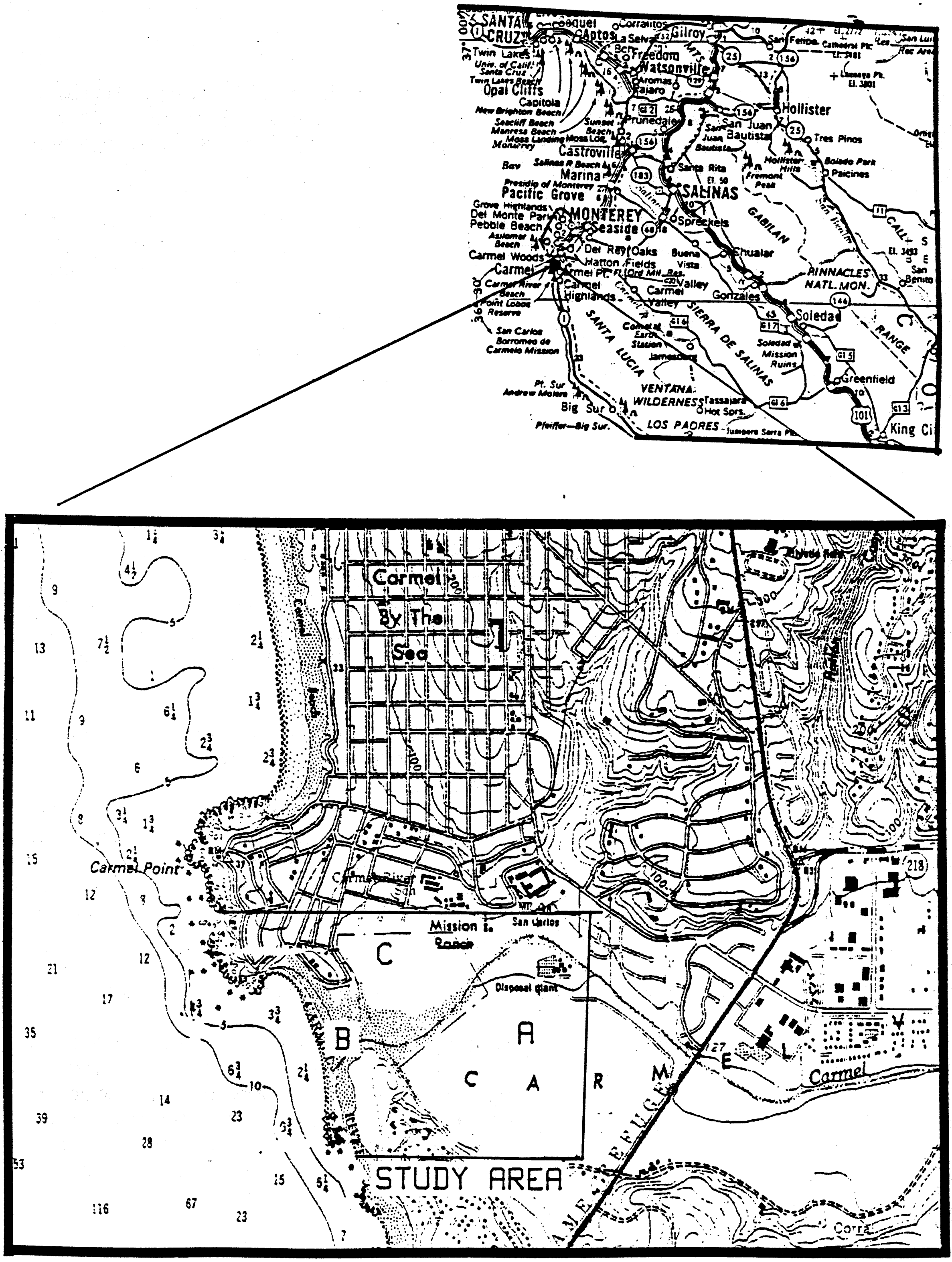

Fig. 1: Site location map. Geographical areas discussed in the text are indicated by letters. A) Artichoke Field Area, B) Carmel State Beach Area, C) Northwest Floodplain Area.

difficult to discern at distances greater than about 350 feet. Signals from multiple shots were stacked to improve the signal-to-noise ratio. However, the best records were produced with a single 8 gauge shot placed at or below the watertable or within firm, moist material.

When using energy sources of this type, the beginning of the seismograph record is initiated by a switch (attached to the hammer) that generates a trigger pulse on impact. During the field test, the trigger switch was found to be intermittent, and was replaced by a geophone trigger. This method uses the output of a geophone, placed near the shotpoint, to trigger the recorder. Because the response time of the geophone varied somewhat for each shotpoint, a time correction factor needed to be applied to some of the records to adjust time zero, particularly for shots located in the loose beach sand.

2.1.2 Preliminary Field Tests

The first two days of the field project were devoted to preliminary field tests, calibration, and orientation. The purpose of the tests was to evaluate on-site noise conditions (particularly the effects of surf noise), and to select survey parameters for production work. Specific parameters evaluated during this phase included; geophone spacing, filter and gain settings, recording time, optimum offset and the effective penetration of the seismic energy sources.

Unfortunately, the field testing program coincided with another project scheduled for the same time period by the California Department of Fish and Game. Bulldozers were working in the immediate vicinity in an effort to open a channel through the beach area. As a result, some testing and production time was lost because of the noise generated by the bulldozers and curious onlookers present in the vicinity of the geophones. Despite this interference, sufficient data were collected and evaluated to determine that adequate reflection data could be obtained at the site and would be useful in accomplishing the goals of the survey.

2.1.3 Conventional 24-channel Reversed Reflection/Refraction Spreads

Conventional 24-channel reflection recordings were obtained on all seismic lines. Annotated sample raw recordings are included in Figures 2 and 3, and the raw recordings for all seismic lines are in Appendix A. Double-reversed coverage was accomplished by placing a shotpoint at the center of the spread, and two additional shotpoints at each end. Additional shotpoints were established at various locations along the spread as needed. These data provided the primary means for calculating velocities and depths to key reflecting horizons.

A typical seismic line contained one spread of 24 geophones, placed at 20-foot intervals. Lines 1 (Spread 1) and 2 were also surveyed with a 230-foot spread using a 10-foot geophone spacing, for the purposes of constructing the optimum offset records. It was determined that the 10-foot spacing spreads did not offer significant improvement over the 20-foot spacing spreads, therefore a 20-foot spacing was maintained throughout the rest of the survey.

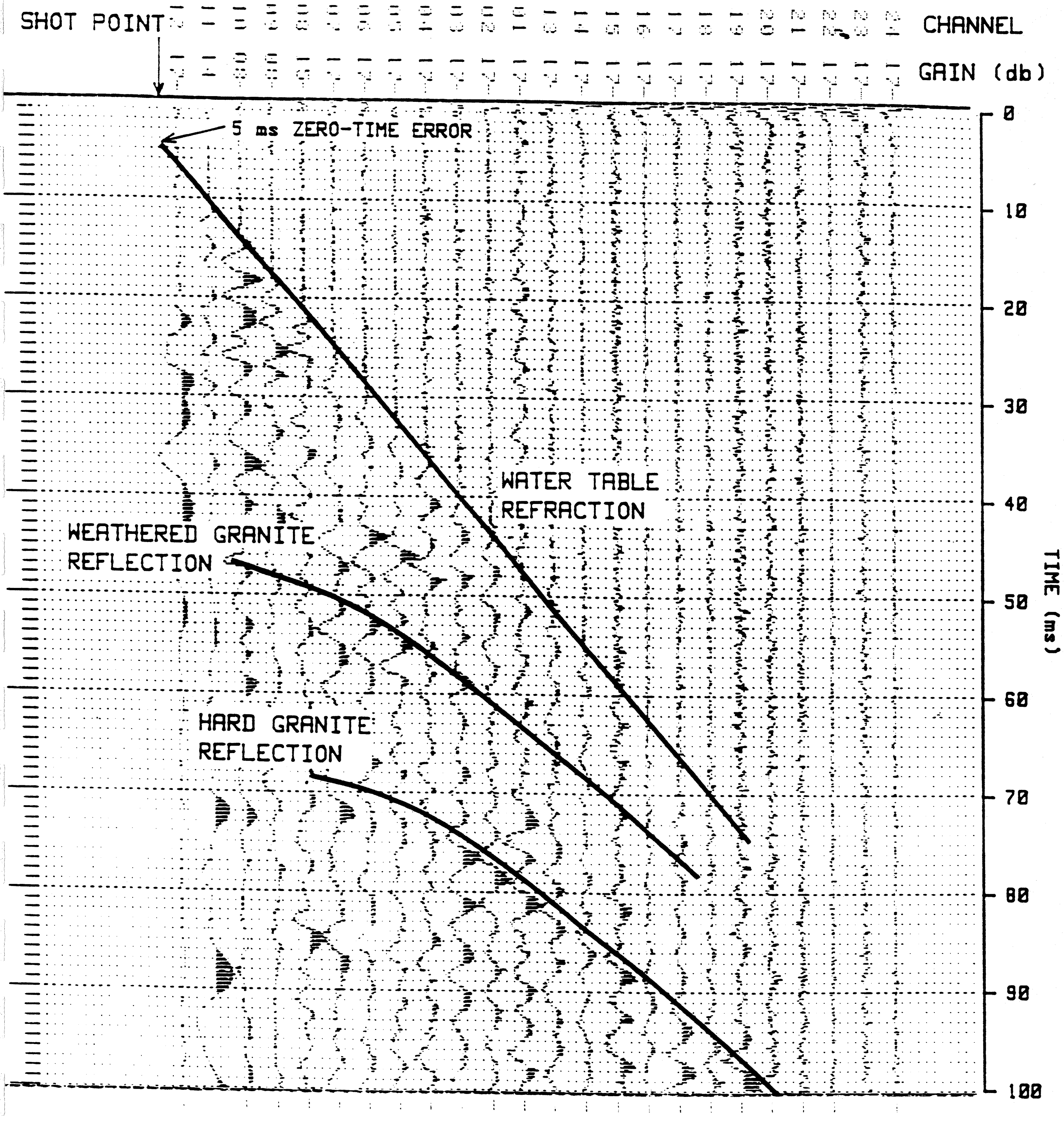

Fig. 2: Sample raw reflection record from the Carmel State Beach area. Data are for Line 1, Spread 1, shotpoint -10 ft. Trace separation is 20 ft. East is to the left. This is an example of a relatively noisy record.

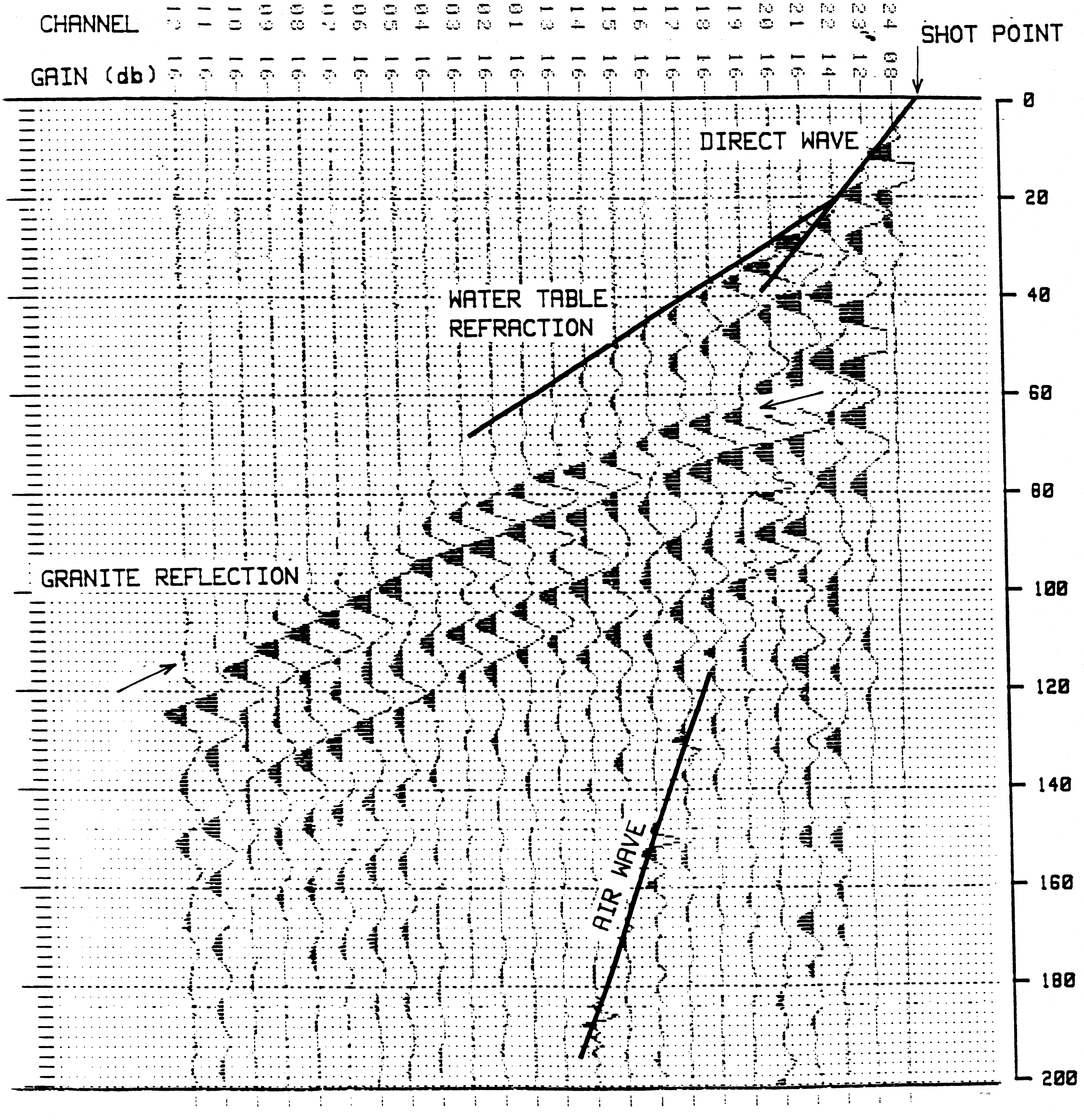

Fig. 3: Sample raw reflection record from the Artichoke Field area. Data are for Line 4, shotpoint 470 ft. South is to the left. This is an example of a relatively noise-free record.

Direct P-wave events and refraction first-arrivals were also present on the reflection records, and were recognized as high-amplitide first-breaks on the near-shot traces. The refraction data were used to determine near-surface alluvium velocities, static and triggering time corrections, water-table depths, and bedrock velocities in areas with shallow overburden.

2.1.4 Optimum Offset Profiles

In the optimum offset method, reflection events are recorded at fixed shot-geophone spacings across the entire spread. By using an optimum spacing, reflections can be observed on the records with a minimum of interference from ground roll, direct waves, or refracted events (the optimum window). Common offset gathers were produced by moving the source at regular intervals along the profile and using the lock memory function of the seismograph to freeze traces within the optimum window.

One purpose of the experimental phase of the survey was to determine the optimum source-geophone offset. In the case of seismic Line 1, Spread 1 there was an imprecision in the optimum offset of around 10 feet. Consequently, three traces (at offsets of 30, 40 and 50 ft) were saved per shot, the shot interval being 30 feet. While this did not affect the quality of the data (and subsequent interpretation), it did result in changes of the amplitude of the same reflection events on adjacent traces.

The following parameters were used for acquisition of the optimum-offset data:

Line 1: Geophone spacing - 10 ft
Shot/Geophone Offset - 30, 40, 50 ft
Shot Spacing - 30 ft

Line 2: Geophone spacing - 10 ft
Shot/Geophone Offset - 60, 70, 80 ft
Shot Spacing - 30 ft

2.2 Electromagnetic Survey

Electromagnetic (EM) measurements were acquired along five profiles in the study area (Plate I). The EM data were taken to extend interpretations based on the seismic data acquired along Lines 1 and 2 in the Carmel State Beach area, and to estimate bedrock depths in the northwest corner of the Carmel River floodplain.

2.2.1 Description of the EM method and Equipment

A Geonics Ltd. EM-34XL Terrain Conductivity Meter (EM-34) was used to acquire the EM data. With this instrumentation, a time-varying magnetic field is generated by a source (Tx) coil. This source field causes a system of electric currents to flow in the subsurface area under investigation. The strength of this current system depends on the electrical conductivity of the material. These currents, in turn, generate a secondary magnetic field which is detected by a receive (Rx) coil at the surface. The instrument is calibrated to provide direct apparent conductivity readings at Tx-Rx separations of 10 m (32.8 ft), 20m (65.6 ft), and 40 m (131.2 ft).

The depth of investigation of the EM-34 depends on a number of geologic conditions, but a crude estimate can be made on the basis of the Tx-Rx coil separations and orientations. Table I lists the nominal depths if investigation of the EM-34 (McNeill, 1980).

Table 1: Nominal depths of investigation of the EM-34 system.

Intercoil Spacing (meters)	- Nominal Depth of Investigation - Horizontal Dipole	Vertical Dipole
10	7.5 m (24.6 ft)	15 m (49.2 ft)
20	15 m (49.2 ft)	30 m (98.4 ft)
40	30 m (98.4 ft)	60 m (197 ft)

2.2.2 EM Data Reduction Procedures

Bedrock depths along EM lines 3, 4, and 5 were determined by interpolation of regression lines through the 20 m and 40 m spacing measurements, plotted as a function of known depth to bedrock (Figure 4). The justification for employing this procedure is as follows. In the absence of significant lateral variation in the conductivity of the subsurface, the apparent conductivity obtained at a given Tx-Rx coil separation is a function of the true conductivity and thickness of the alluvial section overlying relatively resistive bedrock. If we make the further assumptions that the true subsurface conductivity does not vary appreciably with lateral position, and that the EM fields penetrate the entire alluvial section, then the observed apparent conductivity is a function only of the depth to bedrock. These assumptions appeared to be valid, in general, for the data along EM Lines 3, 4, and 5. Sections of profile data which were characterized by significant lateral variations in apparent conductivity (suggesting shallow variations in true conductivity) were not used for depth estimation.

This procedure was not applicable to Lines 1 and 2 in the beach area, because the assumptions outlined above were not valid, particularly the assumption of laterally homogeneous conductivity.

3.0 SEISMIC DATA REDUCTION AND VELOCITY DETERMINATION

3.1 Refraction Analysis

Reduction of the refraction data was acomplished by measuring first-

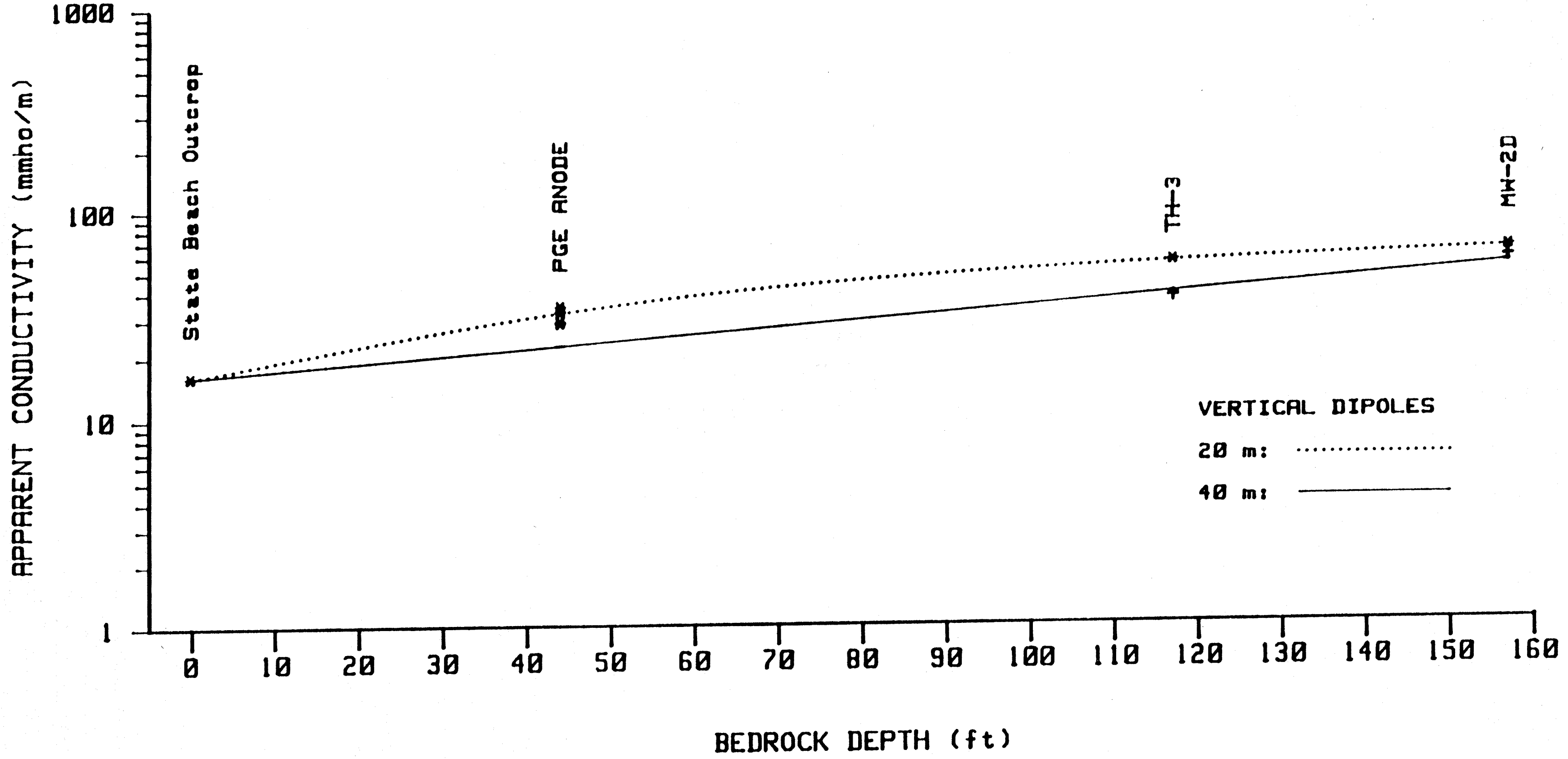

Fig. 4: Interpolation functions used to estimate bedrock depths from the 20 m and 40 m separation EM-34 data in the northwest floodplain area.

arrival times on the seismic records and performing a standard time-distance analysis. Direct arrival times were used to determine triggering time lag corrections and velocities of the material above the watertable.

Refractor velocities were determined using two different methods.

1) Apparent velocities from each shotpoint were determined from the inverse slope of the best-fit line through the travel times plotted as a function of distance from the shotpoint. True velocity was estimated from the apparent velocities using the formula

$$V_{true} = 2(V_u \times V_d)/(V_u + V_d)$$

where

V_u is the apparent up-dip velocity, and

V_d is the apparent down-dip velocity.

2) The second set of calculations were performed by computer using Program SIPT1 (Scott, 1977). This program uses the Hobson-Overton formula:

$$V = \frac{\sum^{n} \Delta x_i^2 - (\sum^{n} \Delta x_i)^2/n}{\sum^{n} \Delta x_i \Delta t_i - (\sum^{n} \Delta x_i)(\sum^{n} \Delta t_i)/n}$$

where V is the desired refraction velocity, Δt_i is the time difference between arrivals at the ith geophone from two shots on opposite ends of the spread, Δx_i is the difference in distance from geophone i to the two shotpoints, and n is the number of geophones used in the calculation.

Both of the methods described above were used to determine bedrock velocities along the southern portion of seismic Line 2, where weathered granite was sufficiently near the surface to produce a refraction arrival at the shot-geophone spacings used. In addition, the velocity of the weathered granite was measured directly on outcrop.

The following table summarizes the velocity determinations based on direct or refraction measurements.

Table 2: Direct-wave and Refraction Velocity Estimates

Material Type	Velocity (ft/s)
Dry Beach Sand	1000 - 1600
Dry Silt/Fines	1500 - 1800
Saturated Sand/Silt	4200 - 6200
Granite (refraction)	7900 - 8500
Granite (outcrop)	8300

3.2 Reflection Analysis

The x^2-t^2 method was used in the reduction of the seismic reflection data. With this technique, t^2 is plotted as a function of x^2, where t is the record time of a reflection event at a given geophone, and x is the distance from the geophone to the shotpoint. The average velocity to the reflector (straight-ray assumption) is given by formula

$$V_{ave}^2 = 1/m ,$$

where m is the slope of the best-fit straight line through the points. The depth Z of the reflector beneath the shotpoint can be estimated using the formula

$$Z = t_0 V_{ave}/2 ,$$

where t_0 is the $x = 0$ intercept the best fit line.

Once the average velocities above a reflector had been determined using the above techniques, the depth to the reflector was calculated from the picked reflection event times using the formula

$$Z(x/2) = \sqrt{\frac{V^2 t^2}{4} - \frac{x^2}{4}}$$

where x is the distance from the shot to the geophone, Z(x/2) is the reflector depth at the location x/2 (halfway between the shot and the geophone), V is the average velocity above the reflector, and t is the record time of the reflection event.

A reflection event coming from a dipping reflector falls along a hyperbola with an apex shifted in the up-dip direction from the shotpoint. An estimate of the reflector dip can be obtained by fitting shifted hyperbolas to the obverved events. This procedure was used to corroborate the general dip of the reflecting interfaces determined using the above procedures.

4.0 DISCUSSION AND INTERPRETATION OF RESULTS

The following discussion summarizes the interpretations of the seismic and EM data. Interpretative cross sections based on seismic measurements, are provided in Figures 7 through 12, and represent an integration of all seismic data gathered during the survey, including standard reflection, refraction, and optimum-offset data. Attempts to completely characterize all possible reflectors evident in the seismic records were beyond the scope of this project. The focus of the interpretations was on identifying 1) the water table interface, 2) the depth to the top of the granite, and 3) the depth to the top of unweathered granite.

4.1 Carmel State Beach Area

4.1.1. Seismic Survey

The optimum-offset time sections for seismic Lines 1 (Spread 1) and 2 are shown in Figures 5 and 6, respectively. Depth interpretations based on the standard reflection records for Lines 1 and 2 are shown in Figures 7 and 8. All records indicated the presence of two deep reflectors. The upper reflector is interpreted to be the top of the weathered granite which forms an erosional unconformity with the overlying units. The deeper horizon is a strong reflector and is interpreted as the base of the weathered rock, beneath which the granite is hard and less fractured.

A shallow reflector was observed within the alluvium at depths of 60-80 ft below the northern portions of Line 2 and the western portion of Line 1, Spread 1, and appears to correlate with the top of a silty, clayey sand bed. This reflector shows up clearly in the optimum-offset section.

The occurrence of a weathered granite layer appears to be confined to the beach area of the survey, where the bedrock is relatively shallow. This may be the result of greater exposure to air and sea water, which would tend to increase the rate of chemical decomposition. The thickness of the weathered layer varies from 50-60 feet below the west end of Line 1, decreasing to the east to a thickness of about 30 feet beneath the eastern end of Line 1, Spread 1. No evidence of significant weathering was seen along Line 1, Spread 2, which suggests that the weathered zone has thinned to a thickness such that it is not discernable on the seismic records.

The bedrock profile beneath Line 1, Spread 2 shows a distinct change in slope, relative to the sub-horizontal granite surface beneath Spread 1. While this change in slope does occur in the general vicinity of the inferred location of the Cypress Point fault, there is no compelling seismic evidence that it is a direct result of the presence of the fault. Small step-like features in the bedrock surface beneath the eastern end of Spread 1 may also be associated with the fault, and, in fact, are closer to its inferred trace.

A veneer of beach sand covers shallow weathered granite beneath the south half of Line 2. Refraction analysis indicates an irregular interface at depths of less than 10 feet. The granite cropping out in the bluff immediately south of Line 2 is fractured and weathered, and its surface, where it disappears beneath the sand, is quite irregular. Near the center of Line 2, bedrock dips sharply to the north, forming the southern boundary of a channel. North of this boundary, depths to the base of the channel range from 80 to 110 feet. Borehole data (MW-1D, MBF) north of the north end of Line 2 suggests that the channel is at least 400 feet wide, and extends beneath the beach parking lot. Granite crops out again at the Arnoc house just north of the parking lot.

At the intersection of Lines 1 and 2, there is a discrepancy in the depth to weathered granite of about 30 feet. We feel that the depth indicated by the records from Line 1 are more accurate, since the traverse was made roughly parallel to the axis of the channel. The horizon provided by the Line 2 records is considered less reliable because of the diffraction problems associated with a non-specular reflecting interface.

4.1.2 EM Survey

Pseudosections of the EM data along seismic Line 1, Spread 1, are shown in Figure 13. The vertical and horizontal dipole data show a general increase in conductivity at the eastern portions of the profile, which is consistent with a shallowing of the watertable in this area. At the west end of the profile the vertical dipole apparent conductivities begin to increase, and the horizontal dipole values begin to flatten out. The seismic bedrock reflector, on the other hand, appears to be at a roughly constant elevation in this area, and it is doubtful that the EM response is representative of a change in the watertable depth. We thus conclude that this conductivity increase is due to an increase in the conductivity of the pore fluid, probably due to increasing salinity.

The same behavior can be seen in the EM data along Line 2 (Figure 14). North of location 400 ft (roughly at the intersection of Lines 1 and 2), there is an increase in both the 20 m and 40 m apparent conductivities, representing an increase in the pore-fluid conductivity, whereas the decrease in the 10 m apparent conductivities are likely due to the fact that the watertable in this area is becoming deeper, relative to the surface.

Barring significant changes in the porosity of the subsurface materials, the observed increase in apparent conductivity can be explained by changes in the salinity of the groundwater. This is supported by observation high salinity at a depth of around 60 feet in MW-1D (MBF). The conductive zone in the northwestern beach survey area probably represents an area of sea water intrusion.

Another conductive zone occurs beneath locations 100 to 200 ft along Line 2. The fact that the anomaly extends to the surface suggests that it may represent a shallow local increase in conductivity. As the granite approaches the surface to the south, the conductivity values decrease, indicating that the granite is relatively free of saline water.

Bedrock profiles for EM Lines 3, 4, and 5 in the northwest floodplain area are shown in Figures 15, 16, and 17, respectively. Bedrock depths were available near each end of Line 3 (outcrop at the Arnoc house on the southwest end, and 44 ft at the PGE ANODE well at the northeast end). The bedrock depth profile along Line 3 shows evidence of a channel beneath location 200 ft, and a terrace roughly beneath location 400 ft.

EM Line 4 trended roughly east-west from the intersection of Carmelo and 17th street. There is evidence of a channel between locations 100 ft and 200 ft, and a gradual increase in bedrock depth to the east into the floodplain.

EM Line 5 trended roughly north-south, and ran sub-parallel and roughly 70 feet to the west of the western boundary fence of the Eastwood Ranch. Bedrock depths were available from two wells in the vicinity of the line; TH-3 (projecting to location 380 ft) and TH-4 (projecting to location 700 ft). Interpreted bedrock depths indicate a possible terrace out to location 150 ft, south of which there is an increase to a depth of 160 ft, below location 600 ft. An abrupt decrease in apparent conductivity values south of location 700 ft may reflect a change in porosity or fluid conductivity. The southern end of the line is roughly 200 feet from the present course of the Carmel River. Although the EM data alone are not conclusive, the decrease in conductivity may reflect either a zone of flushing of the groundwater by the relatively fresh water of the Carmel River, or a resistive anomaly, of the kind often seen flanking conductive anomalies, indicating the proximity of more porous, and therefore conductive, material.

In general, the apparent conductivities along EM Lines 3, 4, and 5 were significantly lower than those over the northwest portions of Lines 1 and 2. This suggests that if sea water intrusion is occurring in the beach area, it has not yet reached the area of the floodplain.

4.2 Artichoke Field Area

The quality of the reflection data collected along seismic Lines 3 through 6 is, in general, very good. The lines were located near the perimeter of the artichoke field where moist, firm soil provided good coupling with the energy source. The records in this area are characterized by one strong bedrock reflector, which suggests that weathering along this interface is insignificant. Basin depths below this area varied from about 110 ft below Line 3 to 180 ft below the south end of line 5. In general the alluvial fill becomes thicker toward the western portion of the field (see Figures 9 through 12).

5.0 SUMMARY AND CONCLUSIONS

The geophysical program described in this report was successful in determining the granitic bedrock configuration beneath the traverses, and, to some extent, the relative groundwater conductivity in areas where EM data were taken. To a large extent, this success was due to the fact that two types of geophysical data were measured (acoustic velocity and electrical conductivity) and that nearby ground truth was available.

The optimum-offset seismic reflection records were, in our opinion, not a significant enhancement over the standard reflection data sets. They did provide, however, a synoptic view of the sequence of reflectors in the subsurface with a minimum of processing. We consider these sections, in their own merit, to be quite acceptable in light of the field conditions in the Carmel State Beach area. Furthermore, it was established that the optimum offset is 50 ft over areas where the bedrock depth is on the order of 100 ft, and 80 to 100 ft over areas where bedrock depth is in the area of 150 to 200 ft. This information will be useful if further optimum offset work is needed in the area.

The following conclusions may be drawn on the basis of the geophysical data.

1) A relatively shallow alluvial basin underlies the lower Carmel River

Valley and reaches a maximum depth of 200 to 250 feet beneath the central portion of the survey area.

2) The granitic bedrock has been uplifted to the west along the Cypress point fault, relative to the east. However, the portion of this uplifted block south of and beneath the Carmel State Beach parking lot has been breached by a paleochannel of the Carmel River. The base of the channel is at an elevation of 70 to 100 feet below mean sea level and is underlain by 40 to 60 feet of weathered and fractured granite. Under these conditions, it is reasonable to assume that the potential for hydraulic connection between the bay and the Carmel River Valley Aquifer may extend to depths of 150 ft below sea level.

3) The EM data suggest that, although the potential for hydraulic connection exists, the shallow granite beneath the southern beach study area is not serving as an avenue for sea water intrusion. On the other hand, there is EM evidence of intrusion through the incised channel along the northern portions of the beach area. The EM data suggests that the intrusion has not progressed into the Carmel River floodplain east of the beach parking lot.

4) There is no compelling seismic evidence of a significant buried scarp or vertical bedrock separation along the Cypress Point fault in the area of its inferred trace.

ACKNOWLEDGEMENTS

We would like to thank Staal Gardner and Dunne, Inc. for inviting us to perform this work. Particular thanks are due Martin Feeney, Senior Hydrogeologist for SG&D, for his guidance and assistance in the field during the geophysical survey.

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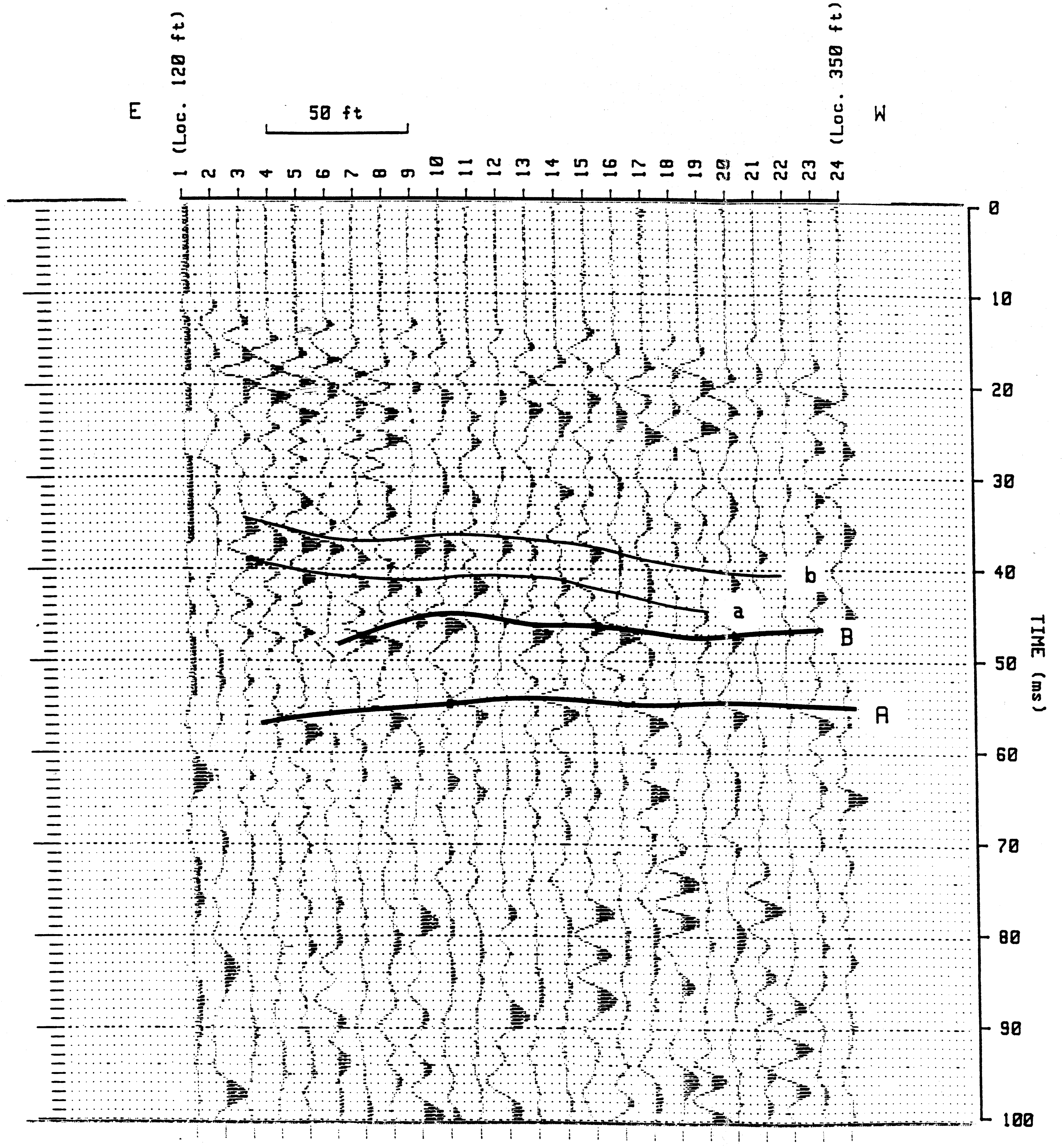
Scott, J. H., 1977, A seismic refraction inverse modeling program for batch computer systems: USGS Open File Report 77-365, 108 p.



CARMEL STATE BEACH AREA
LINE 1, SPREAD 1
OPTIMUM OFFSET SECTION

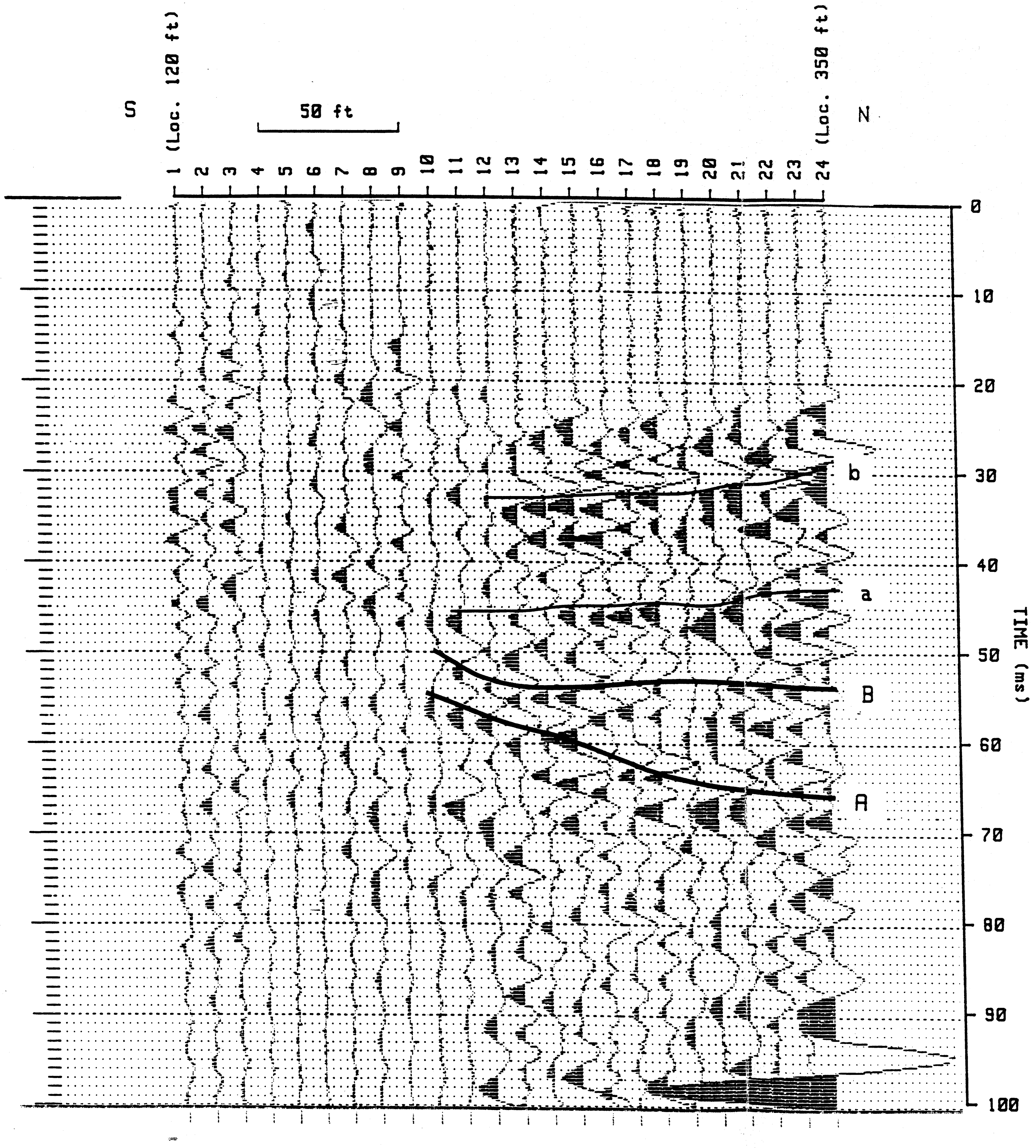
EXPLANATION OF REFLECTION EVENTS...

A - Hard Granite Reflection
B - Weathered Granite Reflection
a,b - Intra-alluvial reflectors

NOTES:

1) Geophone spacing: 10 ft
2) Horizontal locations are distances west of GP-1, Line 1, Spread 1, 20-foot reflection line.
3) Offsets: 30, 40, 50 ft (three-trace gather)
4) Energy source: hammer/plate
5) Display: Averaged variable area

Fig. 5: Optimum offset reflection time section for Line 1, Spread 1. Trace separation is 10 ft.



CARMEL STATE BEACH AREA
LINE 2
OPTIMUM OFFSET SECTION

EXPLANATION OF REFLECTION EVENTS...

A - Hard Granite Reflection
B - Weathered Granite Reflection
a,b - Intra-alluvial reflectors

NOTES:

1) Geophone spacing: 10 ft
2) Horizontal locations are distances north of GP-1, Line 2, 20-foot reflection line.
3) Offsets: 60, 70, 80 ft (three-trace gather:
4) Energy source: hammer/plate
5) Display: Averaged variable area

Fig. 6: Optimum offset reflection time section for Line 2. Trace separation is 10 ft.

Notes for Figures 7 through 12 (see following pages)

1) Interfaces are solid where well-constrained by the seismic reflection data, dotted where inferred.

2) Geophone locations at 20-foot spacings are indicated by ticks along the surface.

3) Elevations are in feet below mean sea level.

4) Shotpoint locations are indicated by "*".

5) Known bedrock depths are indicated by a horizontal bar on the drillhole symbols.

6) The watertable is indicated by a "∇".

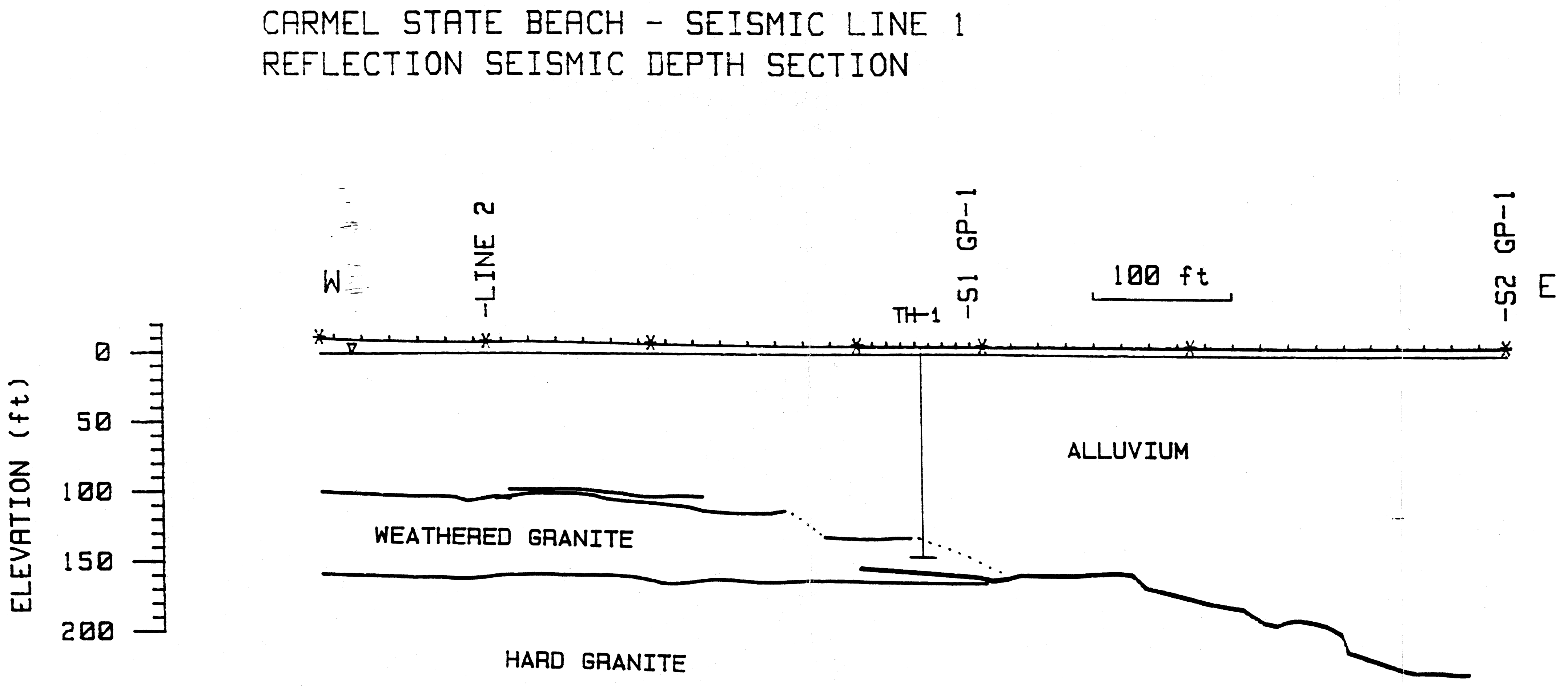


Fig. 7: Interpreted depth section for seismic Line 1.

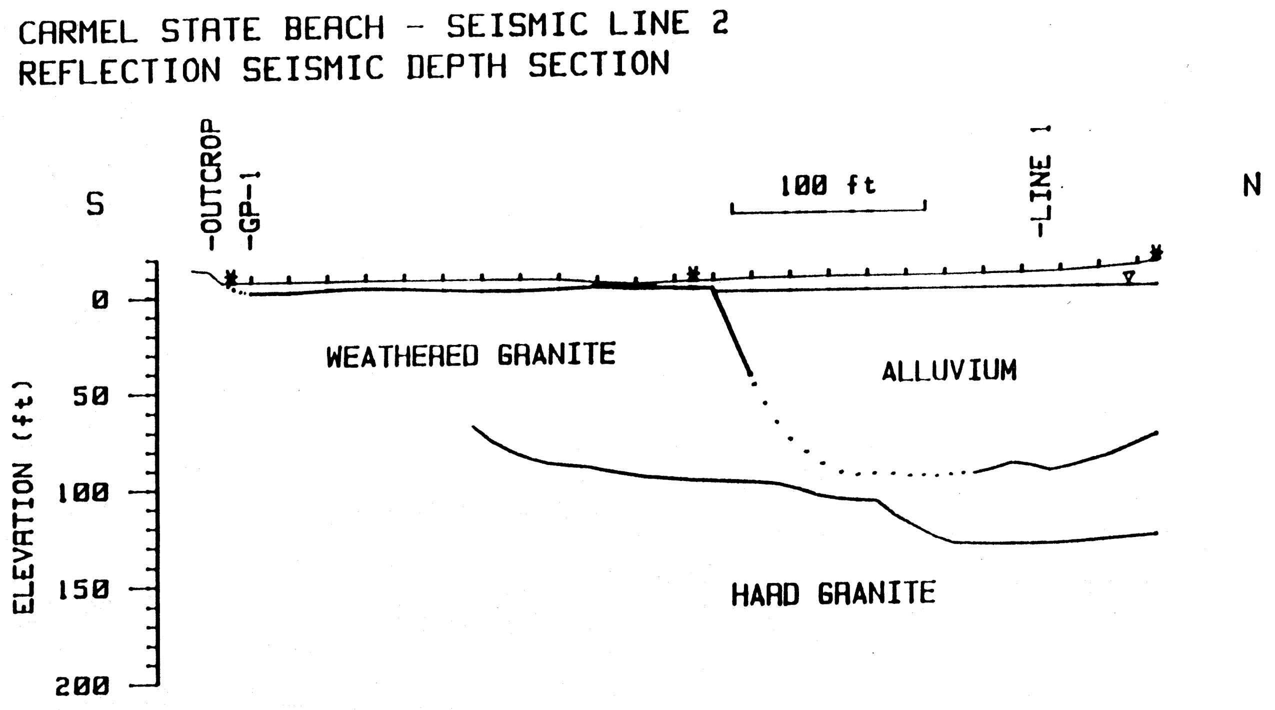


Fig. 8: Interpreted depth section for seismic Line 2.

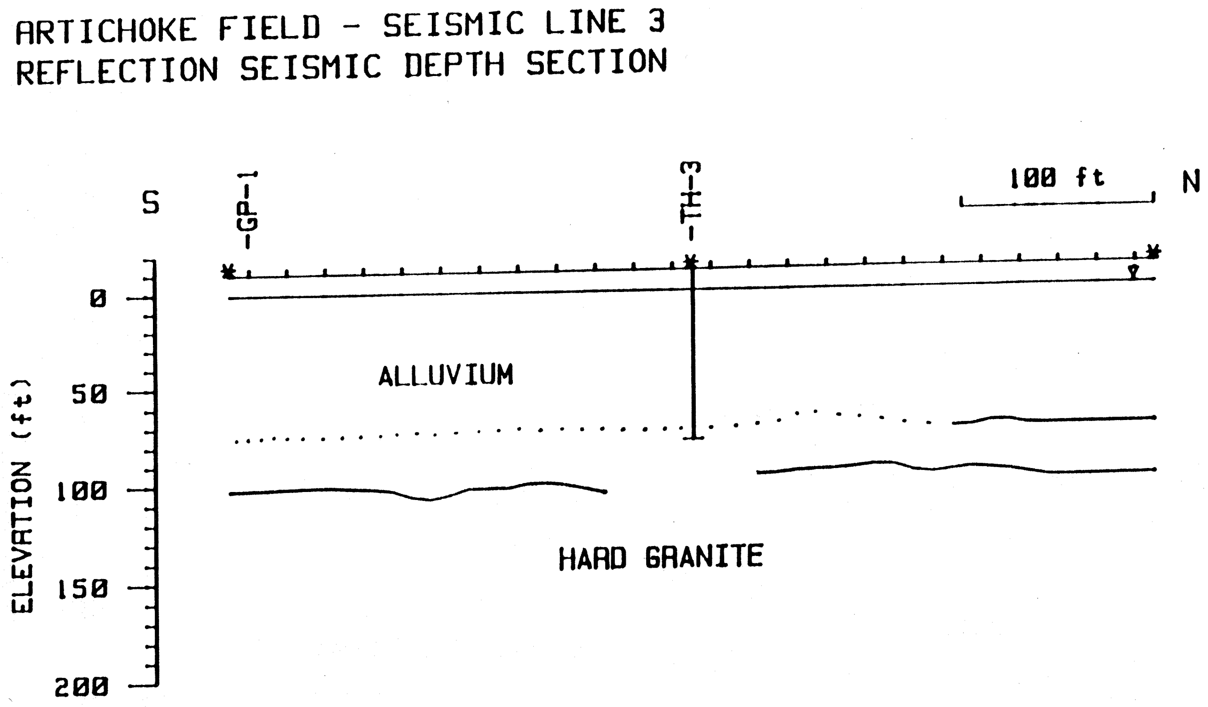


Fig. 9: Interpreted depth section for seismic Line 3.

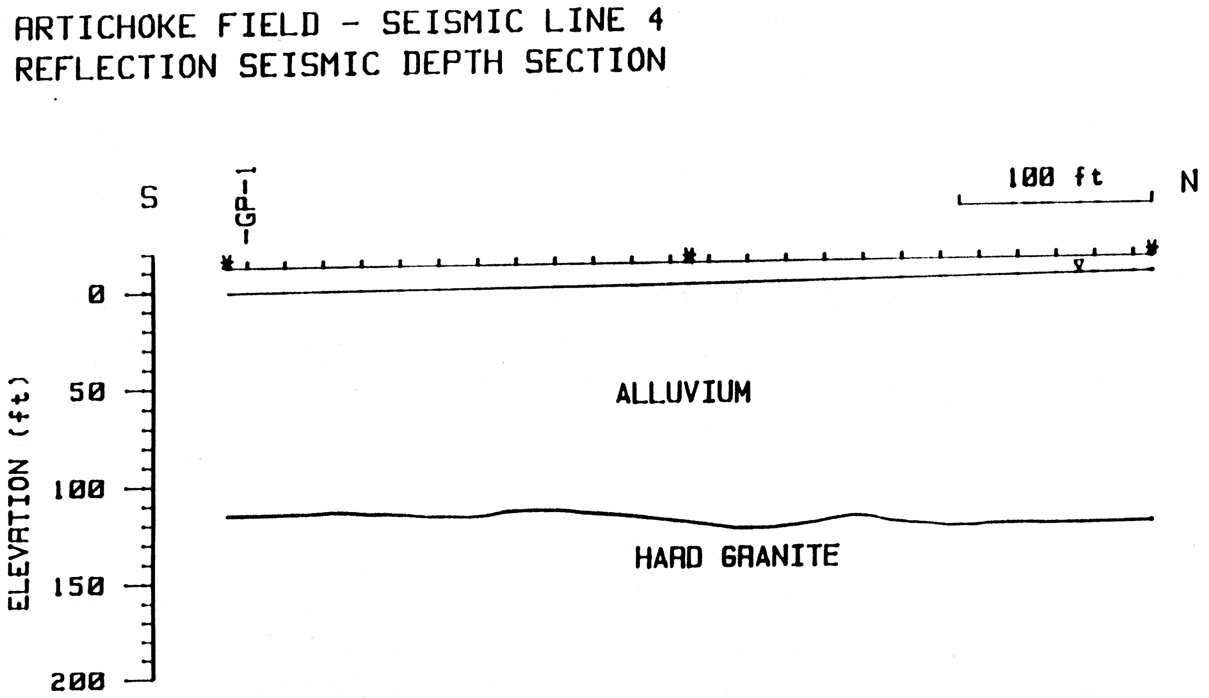


Fig. 10: Interpreted depth section for seismic Line 4.

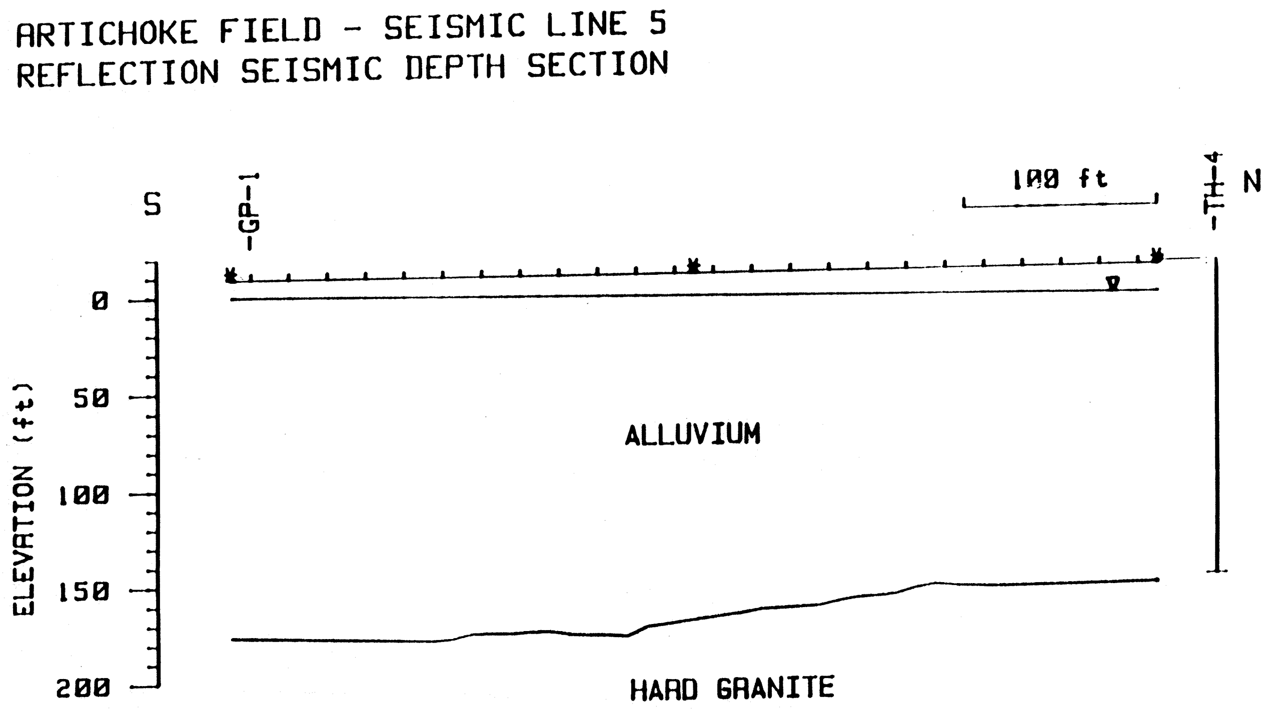


Fig. 11: Interpreted depth section for seismic Line 5.

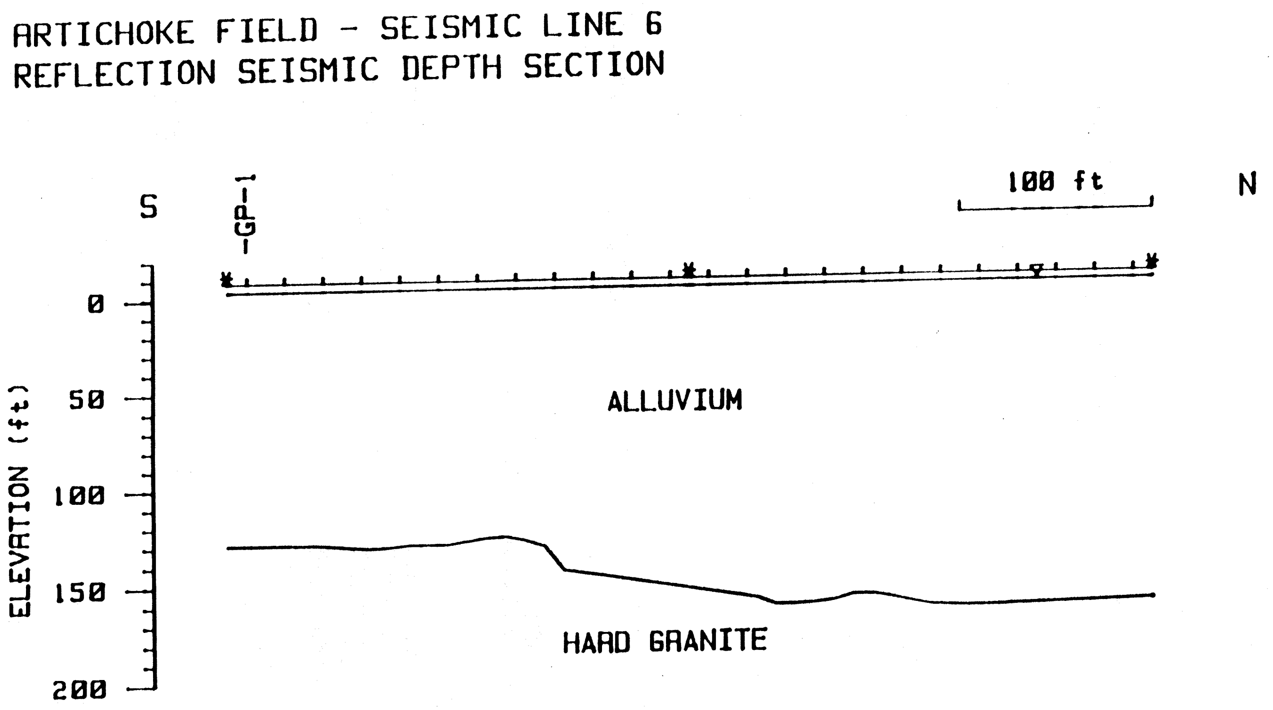


Fig. 12: Interpreted depth section for seismic Line 6.

CARMEL STATE BEACH AREA
EM LINE 1 PSEUDOSECTIONS

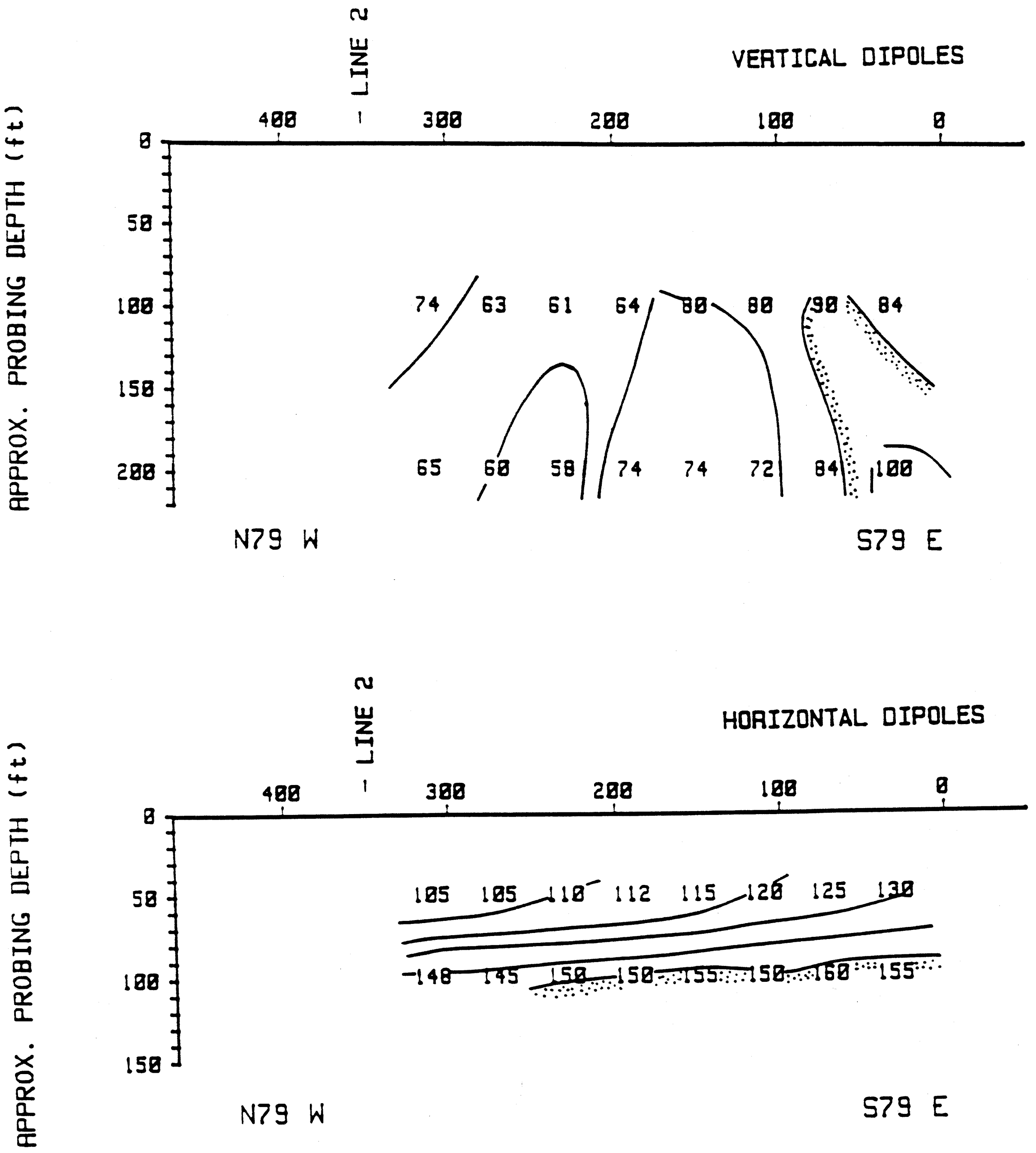
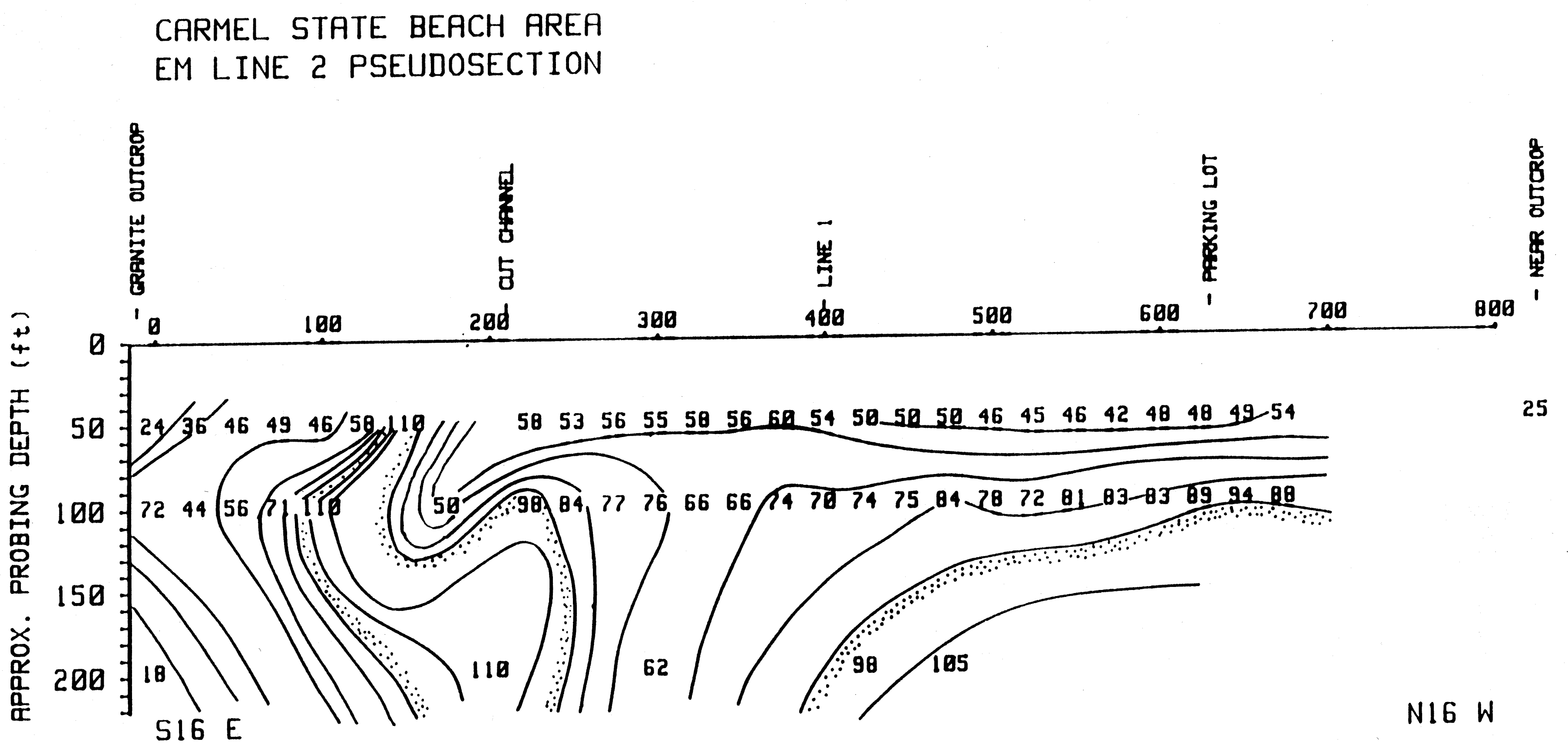


Fig. 13: EM pseudosections along seismic Line 1. Location 0 corresponds to GP-1, Line 1, Spread 1. The stippled areas outline regions of anomalously high apparent conductivity. Apparent conductivity values are in mmho/m. Contour interval is 10 mmho/m.



NOTES: 1) Vertical dipole apparent conductivity values in mmho/m
2) Contour interval: 10 mmho/m
3) All distances in ft
3) Horizontal location 0 corresponds to seismic Line 2, GP-1

Fig. 14: EM pseudosection along seismic Line 2. Stippled areas outline regions of anomalously high apparent conductivity.

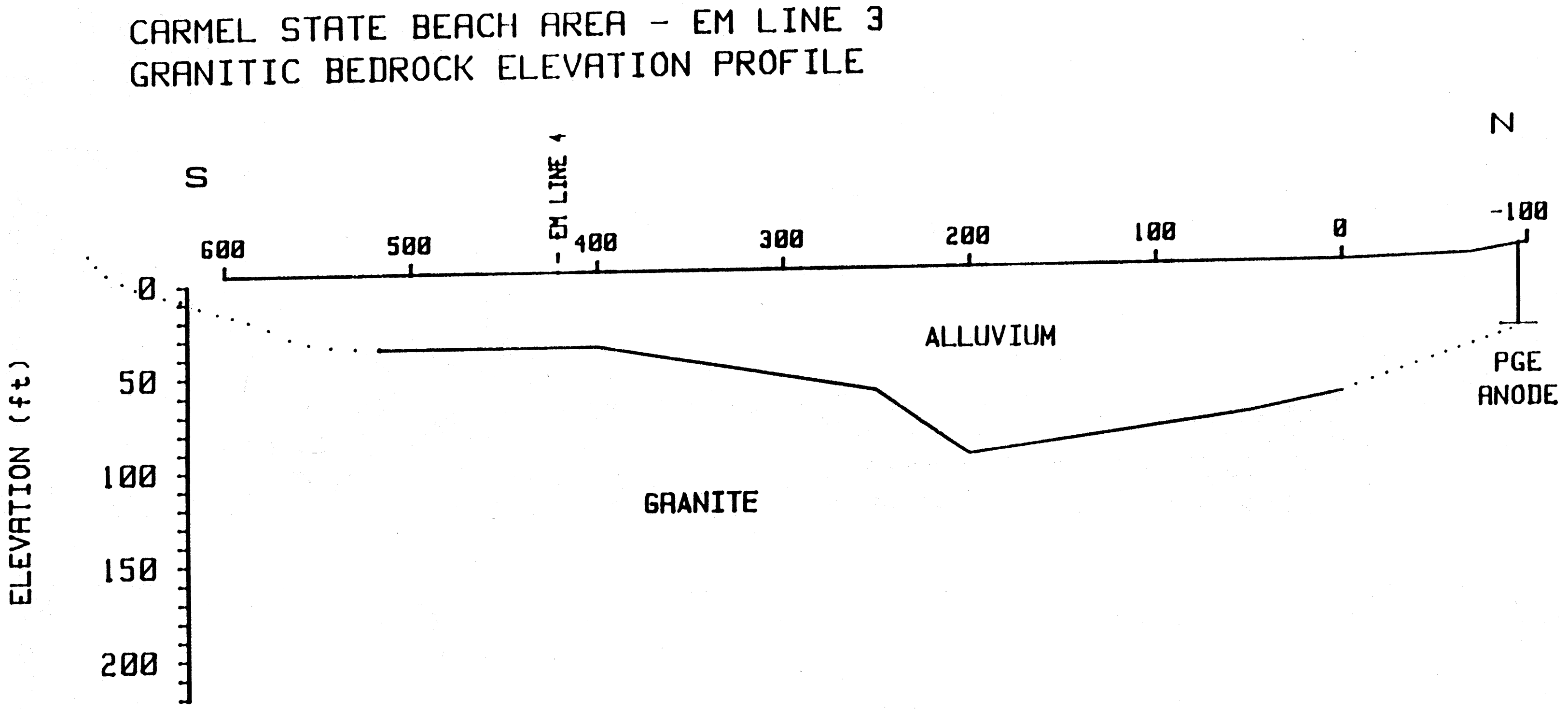


Fig. 15: Bedrock elevation profile along EM Line 3. Dotted areas indicate inferred bedrock depth. Known granite position is indicated by a horizontal bar at the bottom of the drillhole symbol.

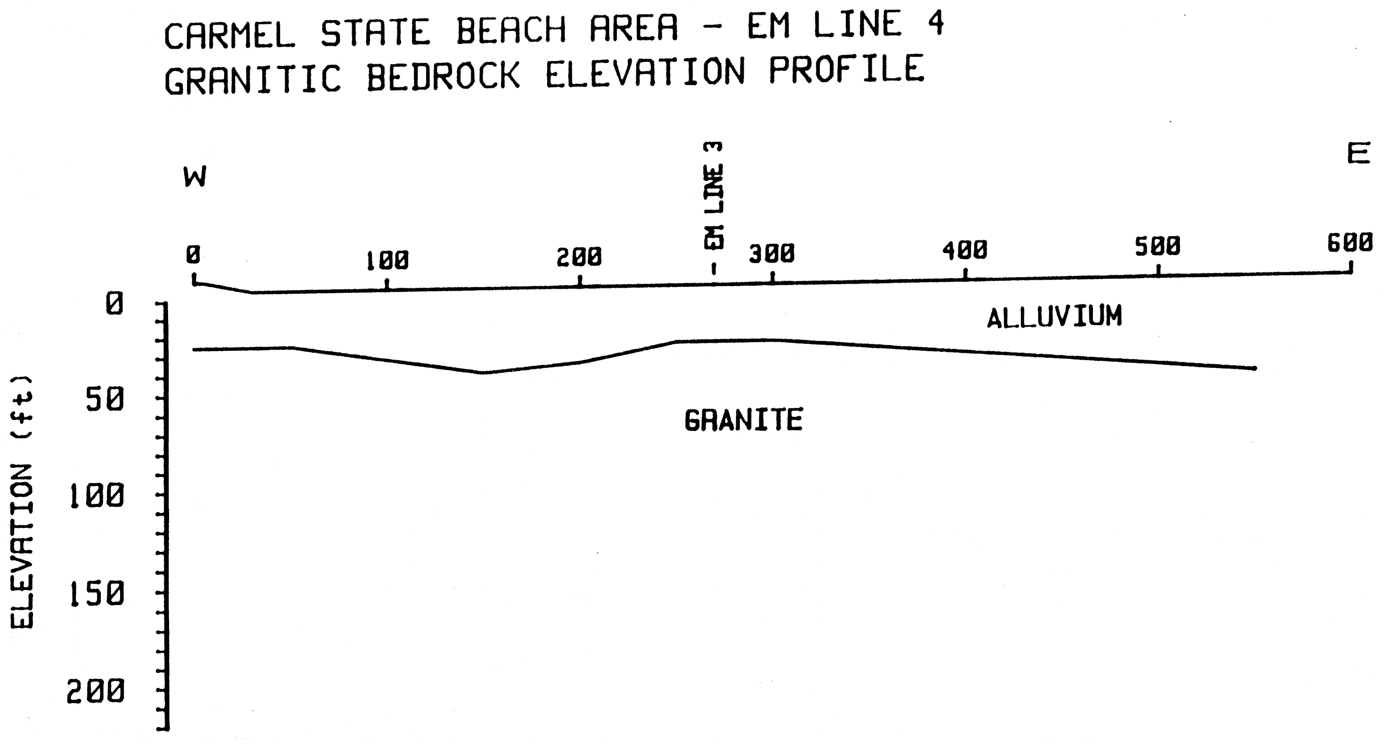


Fig. 16: Bedrock elevation profile along EM Line 4.

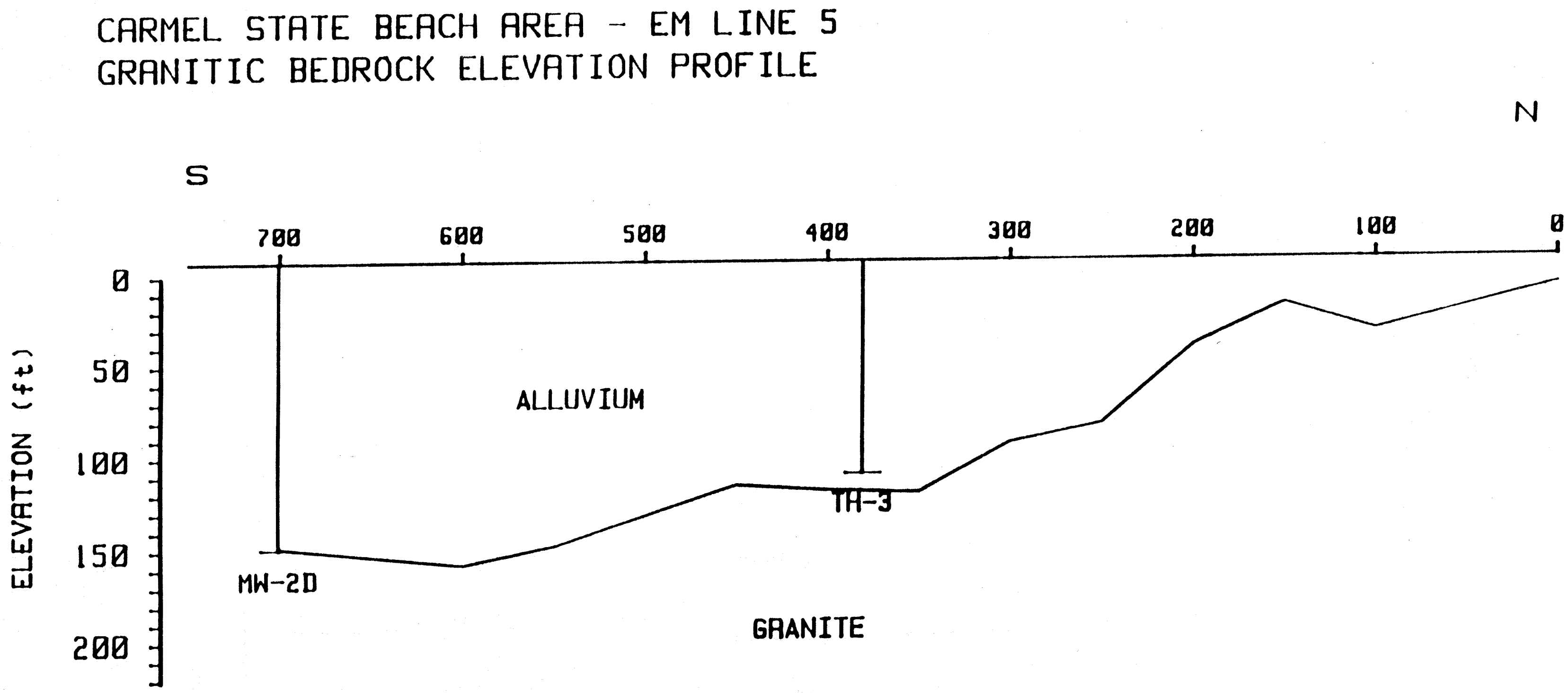


Fig. 17: Bedrock elevation profile along EM Line 5. Known granite positions are indicated by a horizontal bar at the bottom of the drillhole symbols.

APPENDIX A

Reflection Record Sections

RAW REFLECTION RECORD SECTIONS

The following reflection record sections are the raw field data from which the reflection and refraction event times were picked. The record identifications are included at the top of each page. The snotpoint designation is the distance (in feet) between the shotpoint (SP) and geophone number 1 (GP-1). In all cases, GP-1 corresponds to the leftmost trace on the record. The individual traces are separated by 20 feet.

The following parameters appear in the header:

Date:	Date in yymmdd format
Time:	Time in hh:mm format
Shot pos:	Distance (ft) between the shotpoint and GP-1
Layout start:	Location of GP-1
Layout end:	Location of GP-24
Record time:	Length of record in ms
Analog filter:	cutoff frequency (Hz) of input low-pass filter

T. CORR. +2.0

LINE 1, SPREAD 1, SP -10

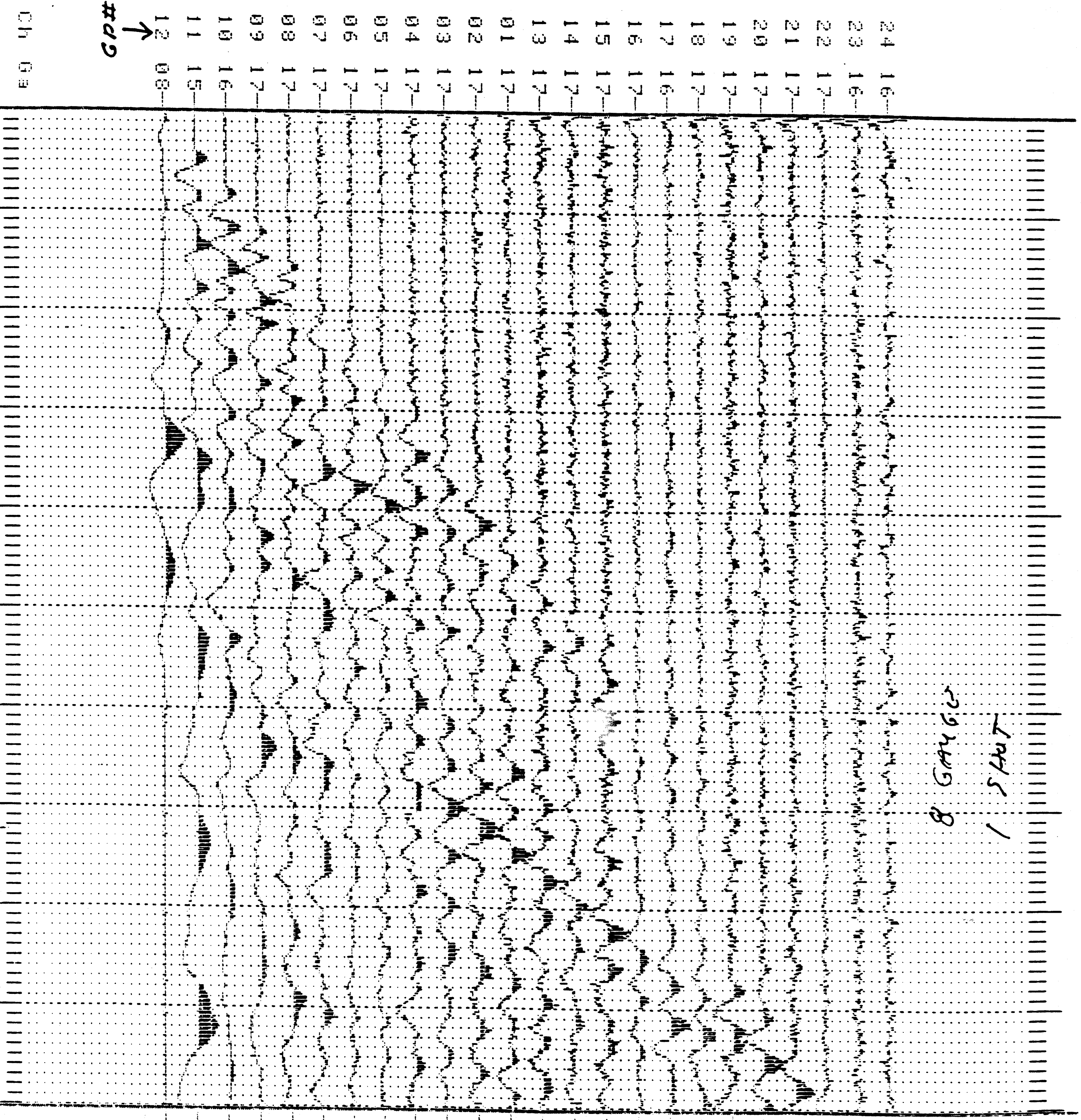
ABEM Terraloc Seismic System Record-000111 Date-890215 Time-13:05

Shot pos.: 0-10.0 Layout start: 00.0 Layout end: 460.0

Profile No.: 000906 Note: 0000900-0007 Operator: 000007

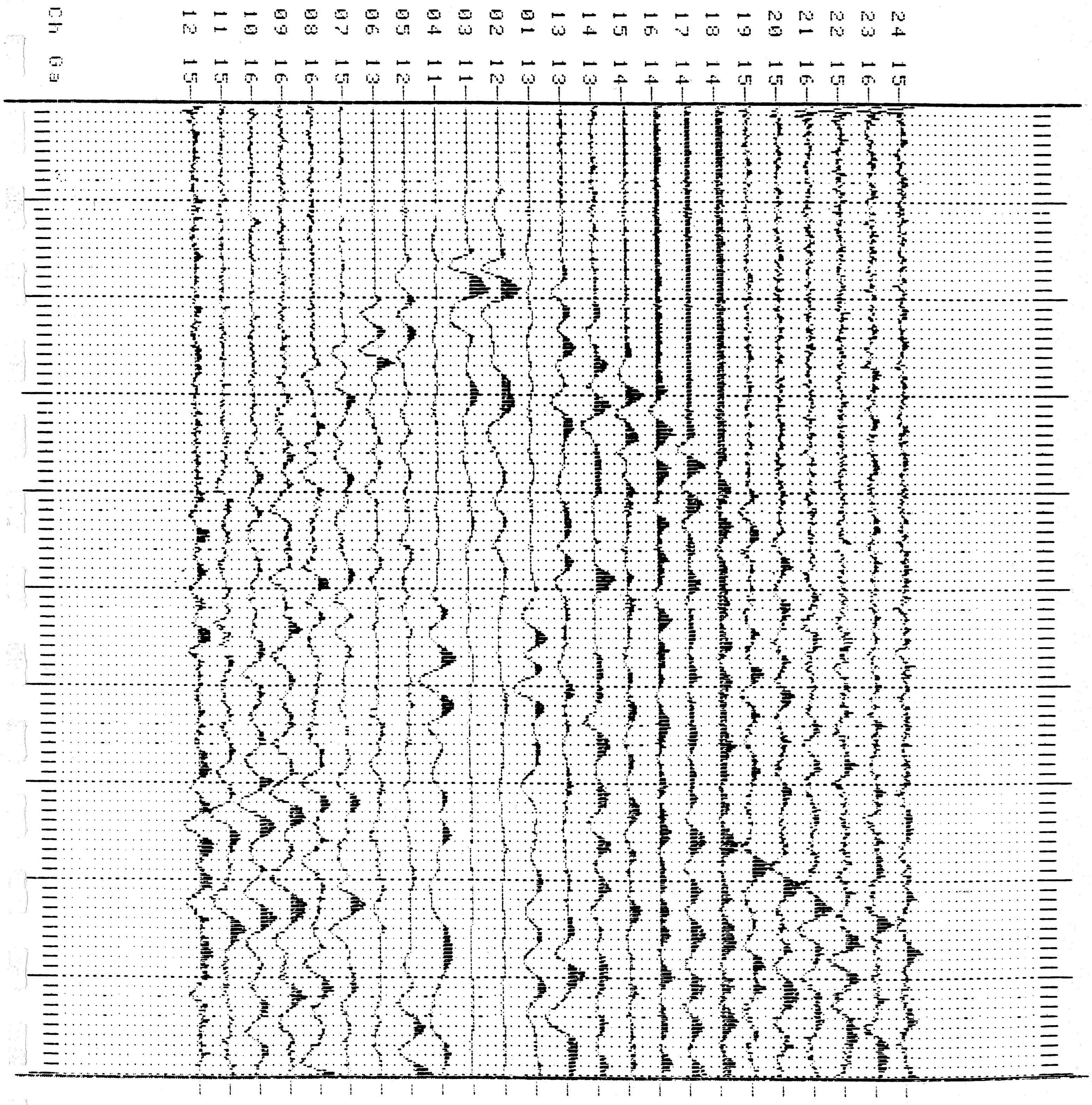
Record time: 100 ms Delay time: 0000 ms Analog filter: 200

Display mode: Normal. Low-cut: Off Hz High-cut: Off Hz Shots: 001



LINE 1, SPREAD 1, SP 210

ABEM Terraloc Seismic System   Record-000111   Date-890215   Time-11:39
Shot pos.: 0210.0   Layout start: 00.0   Layout end: 460.0
Profile No.: 000902   Note: 0000900-0003   Operator: 000007
Record time: 100 ms   Delay time: 0000 ms   Analog filter: 200
Display mode: Normal,   Low-cut: Off Hz   High-cut: Off Hz   Shots: 006



LINE 1, SPREAD 1, SP230

ABEM Terraloc Seismic System Record-000111 Date-890215 Time-13:20

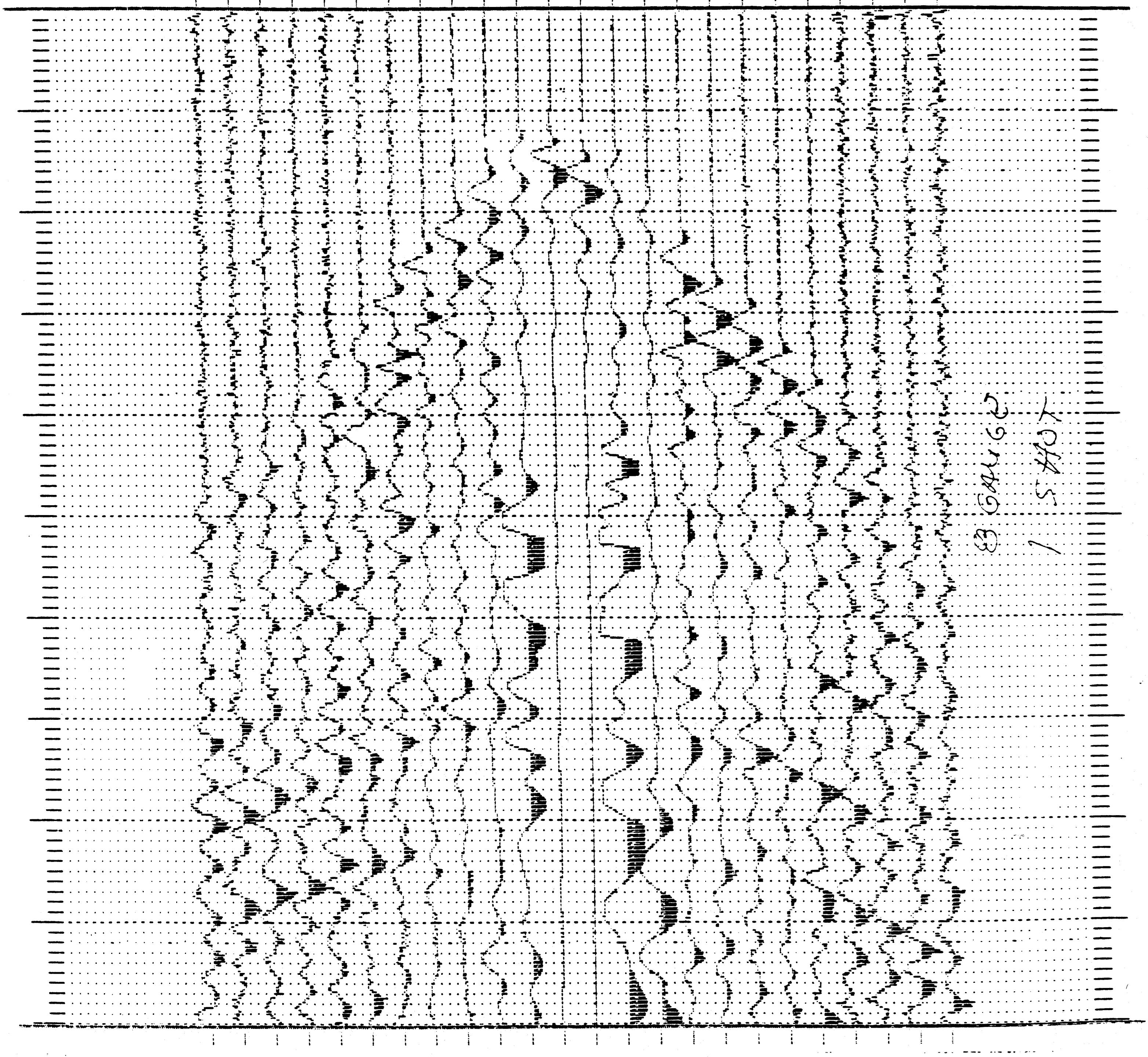
Shot pos,: 230 Layout start: 00,0 Layout end: 460,0

Profile No,: 000907 Note: 0000900-0008 Operator: 000007

Record time: 100 ms Delay time: 0000 ms Analog filter: 200

Display mode: Normal, Low-cut: Off Hz High-cut: Off Hz Shots: 001

Ch	12	11	10	09	08	07	06	05	04	03	02	01	13	14	15	16	17	18	19	20	21	22	23	24
dB	17	17	17	17	17	17	17	17	17	17	15	08	08	15	16	17	17	17	17	17	17	17	17	17



8 GAUGE
1 SHOT

LINE 1, SPREAD 1, SP 250

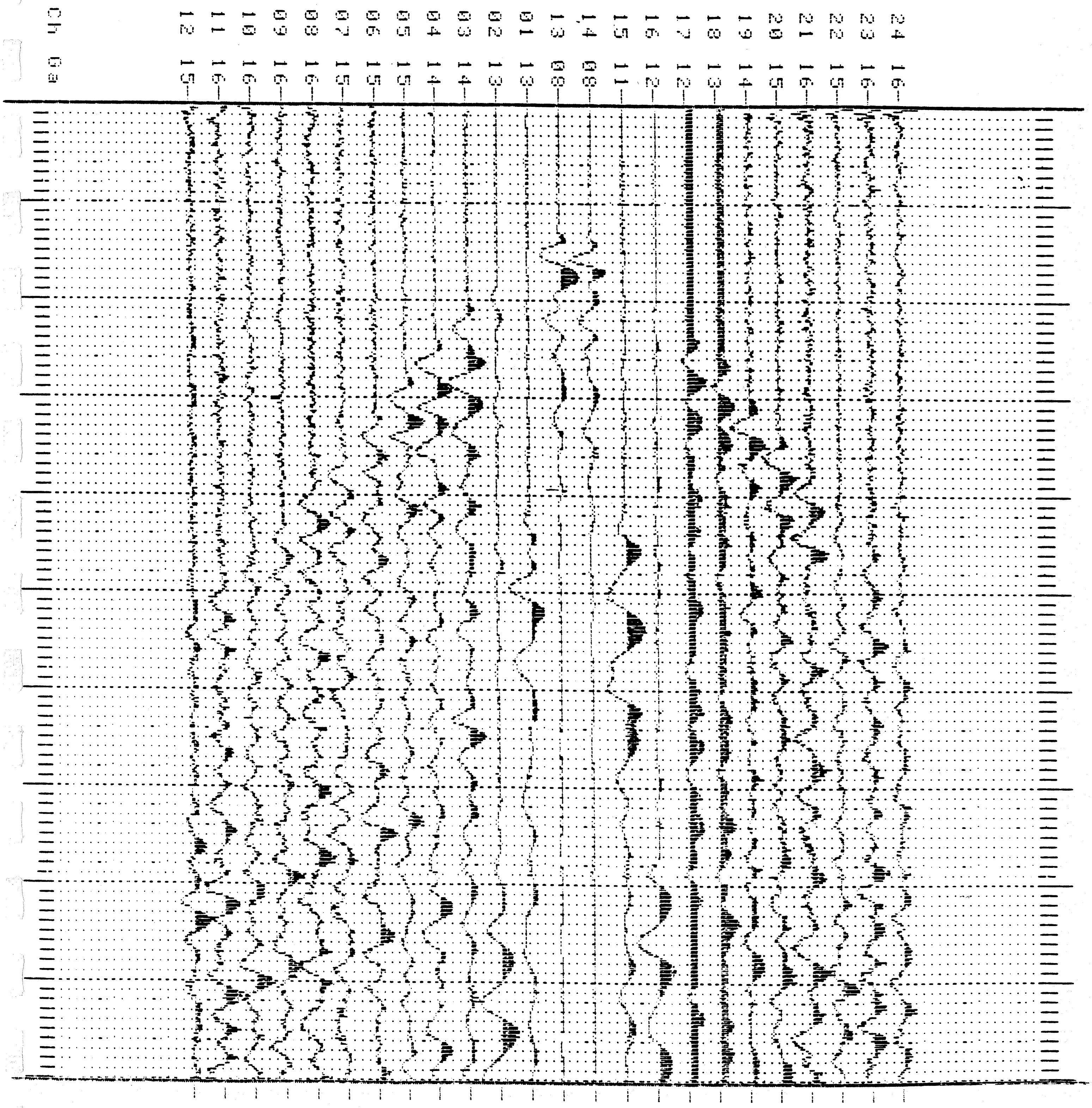
ABEM Terraloc Seismic System Record-000111 Date-890215 Time-11:59

Shot pos,: 250 Layout start: 00,0 Layout end: 460,0

Profile No,: 000903 Note: 0000900-0004 Operator: 000007

Record time: 100 ms Delay time: 0000 ms Analog filter: 200

Display mode: Normal, Low-cut: Off Hz High-cut: Off Hz Shots: 004



LINE 1, SPREAD 1, SP 370

ABEM Terraloc Seismic System   Record-000111   Date-890215   Time-12:10

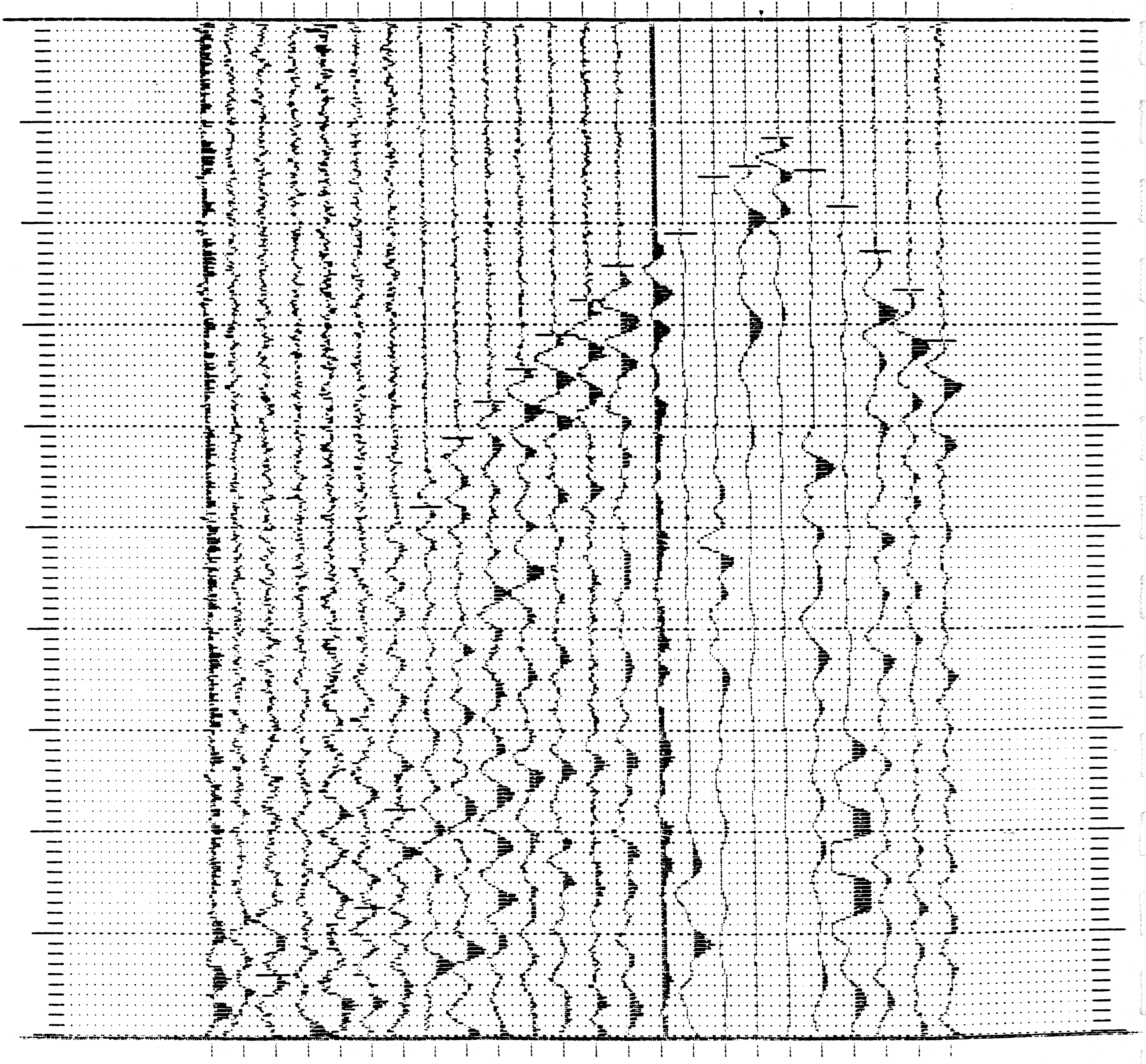
Shot pos.:   0370,0   Layout start: 00,0   Layout end: 460,0

Profile No.:   000904   Note: 0000900-0005   Operator: 000007

Record time: 100 ms   Delay time: 0000 ms   Analog filter: 200

Display mode: Normal,   Low-cut: Off Hz   High-cut: Off Hz   Shots: 005

Ch	12	11	10	09	08	07	06	05	04	03	02	01	13	14	15	16	17	18	19	20	21	22	23	24
G	15	16	16	16	16	16	16	16	16	16	16	16	15	15	13	14	13	09	09	13	16	15	16	16



LINE 1, SPREAD 1, SP 470

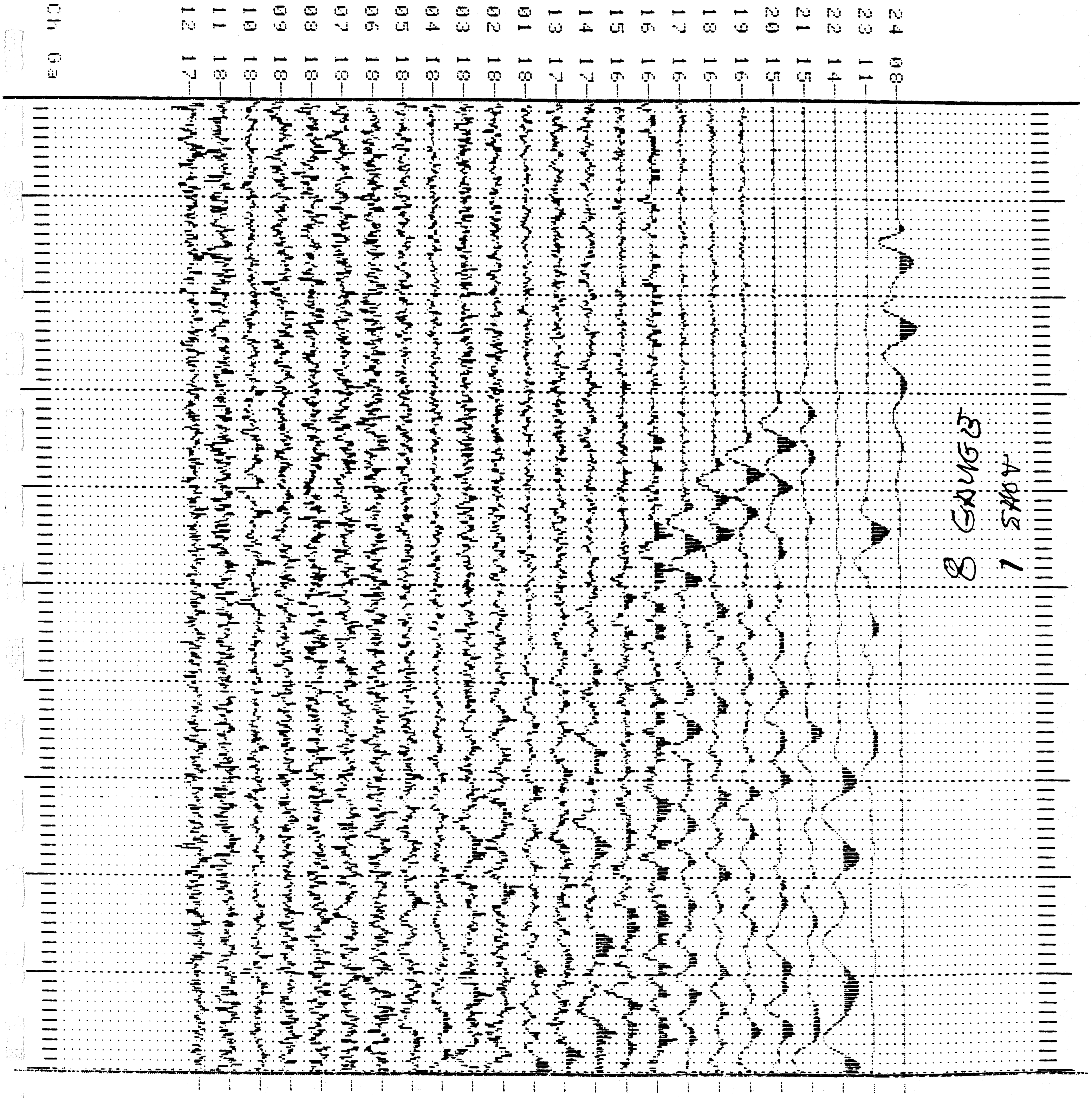
ABEM Terraloc Seismic System Record-000111 Date-890215 Time-12:41

Shot pos.: 0470.0 Layout start: 00.0 Layout end: 460.0

Profile No.: 000905 Note: 0000900-0005 Operator: 000007

Record time: 100 ms Delay time: 0000 ms Analog filter: 200

Display mode: Normal, Low-cut: Off Hz High-cut: Off Hz Shots: 001



LINE 1, SPREAD 2, SP 0

ABEM Terraloc Seismic System   Record-000122   Date-890217   Time-13:43

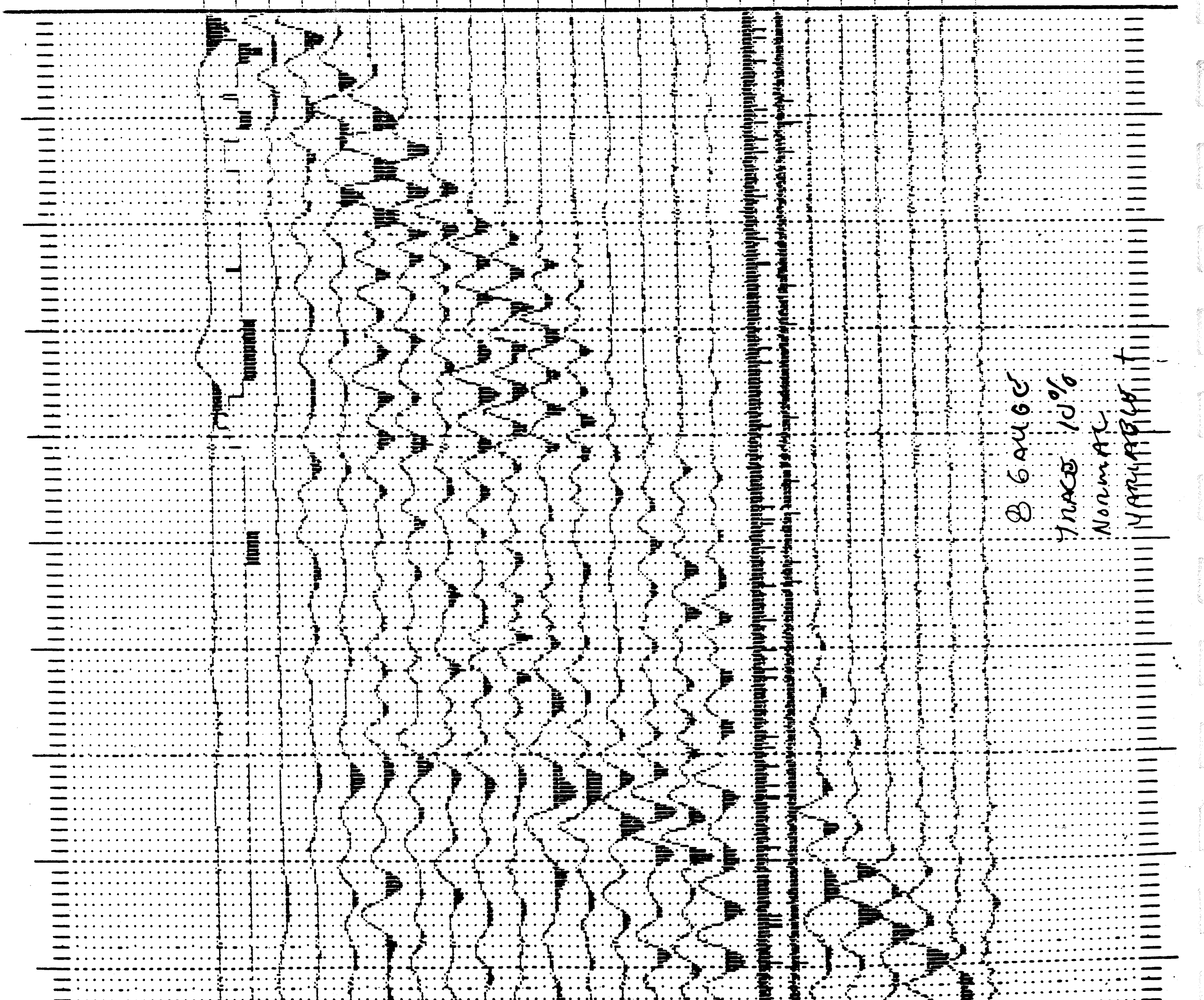
Shot pos.: 000.00   Layout start: 00.0   Layout end: 460.0

Profile No.: 212000   Note: 0000021-0000   Operator: 000007

Record time: 100 ms   Delay time: 0000 ms   Analog filter: 100

Display mode: Normal.   Low-cut: Off Hz   High-cut: Off Hz   Shots: 001

Ch	12	11	10	09	08	07	06	05	04	03	02	01	13	14	15	16	17	18	19	20	21	22	23	24
Ga	06	06	10	12	14	16	16	16	16	16	15	15	15	16	16	16	16	16	17	17	17	17	17	17

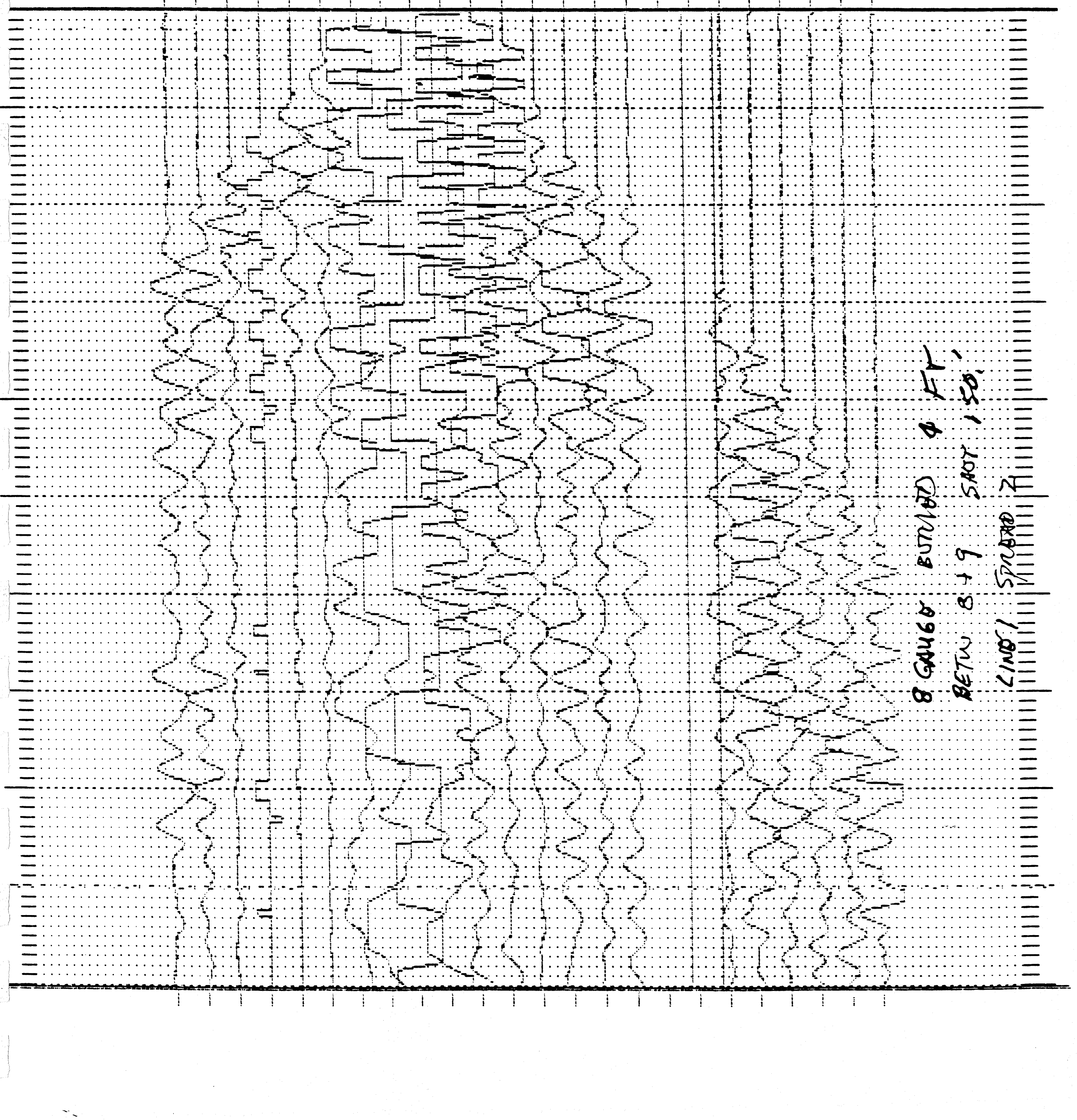


8 GAUGE
TRACE 10%
NORMAL
VARIABLE

LINE 1, SPREAD 2, SP 150

```
ABEM Terraloc Seismic System         Record-000120   Date-890217   Time-12:53
Shot pos.:         150.00     Layout start:    00.0         Layout end:       460.0
Profile No.:       212000     Note:       0000021-0000      Operator:         000007
Record time:       100 ms     Delay time:      0000 ms      Analog filter:    100
Display mode: Normal,         Low-cut: Off Hz   High-cut: Off Hz       Shots: 001
```

Ch	12	11	10	09	08	07	06	05	04	03	02	01	13	14	15	16	17	18	19	20	21	22	23	24
G	15	15	12	08	08	12	15	16	16	16	16	16	14	15	15	15	15	14	16	17	17	17	17	17



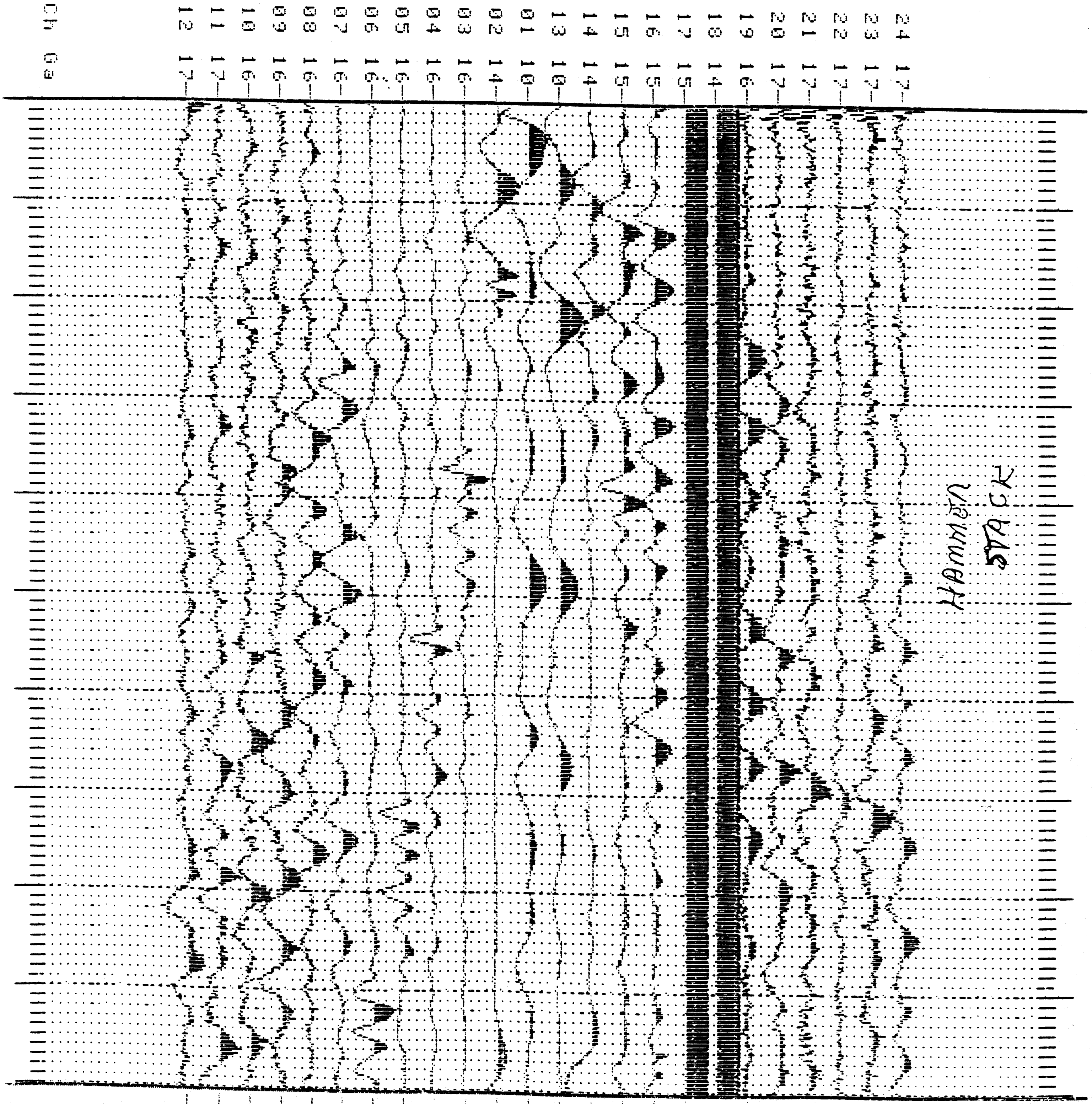
8 GAUGE BURIED 4 FT
BETW 8 + 9 SHOT 150'
LINE 1 SPREAD 2

LINE 1, SPREAD 2, SP 230

ABEM Terraloc Seismic System   Record-000117   Date-890217   Time-11:55

Shot pos.:	0230.0	Layout start:	00.0	Layout end:	460.0
Profile No.:	212000	Note:	0000021-0000	Operator:	000007
Record time:	100 ms	Delay time:	0000 ms	Analog filter:	100

Display mode: Normal,   Low-cut: Off Hz   High-cut: Off Hz   Shots: 004



Hammer

5kg CK

LINE 1, SPREAD 2, SP 470

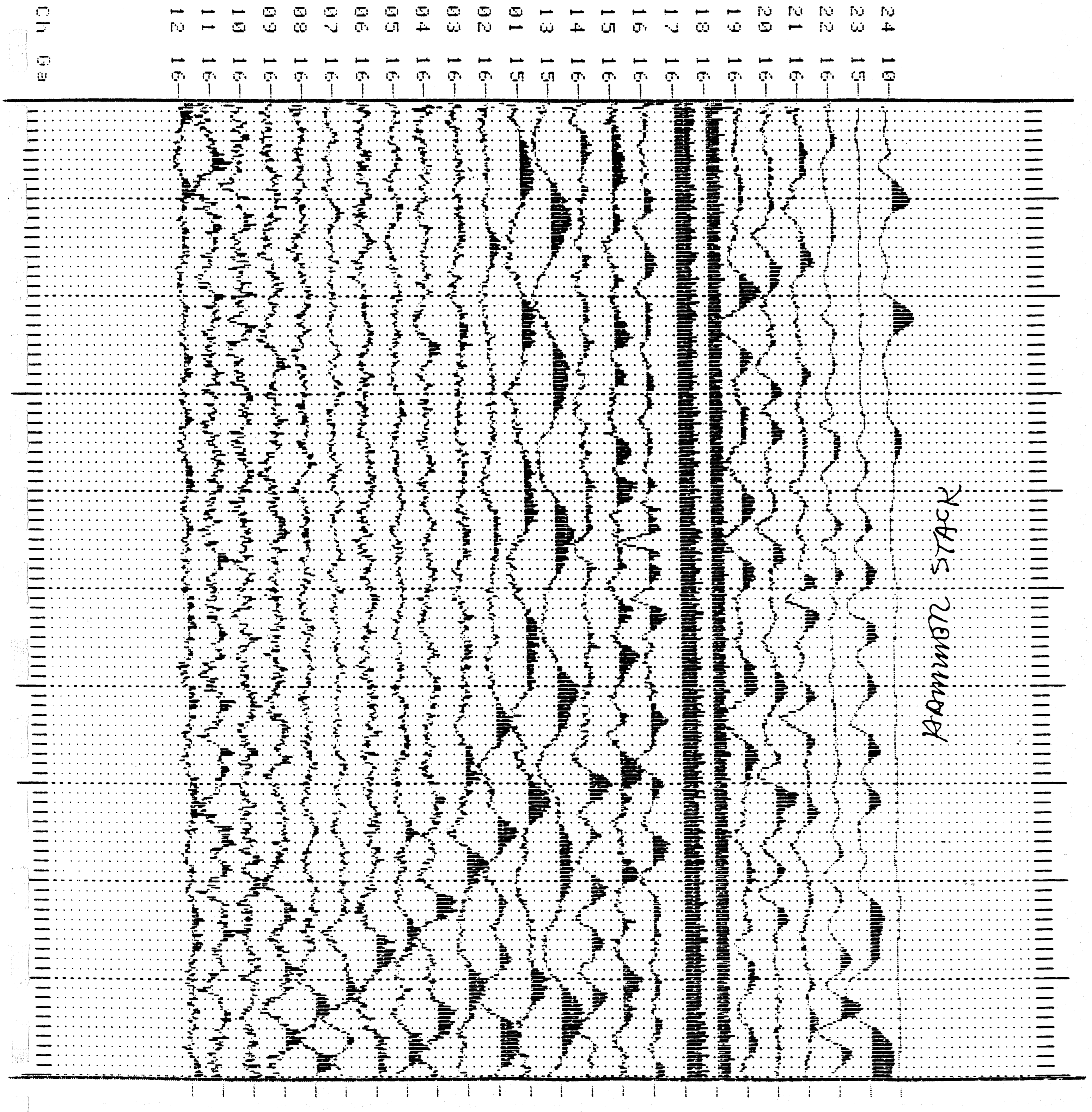
ABEM Terraloc Seismic System Record-000122 Date-890217 Time-13:28

Shot pos.: 470,00 Layout start: 00,0 Layout end: 460,0

Profile No.: 212000 Note: 0000021-0000 Operator: 000007

Record time: 100 ms Delay time: 0000 ms Analog filter: 100

Display mode: Normal, Low-cut: Off Hz High-cut: Off Hz Shots: 005



Common STACK

LINE 2, SP -10

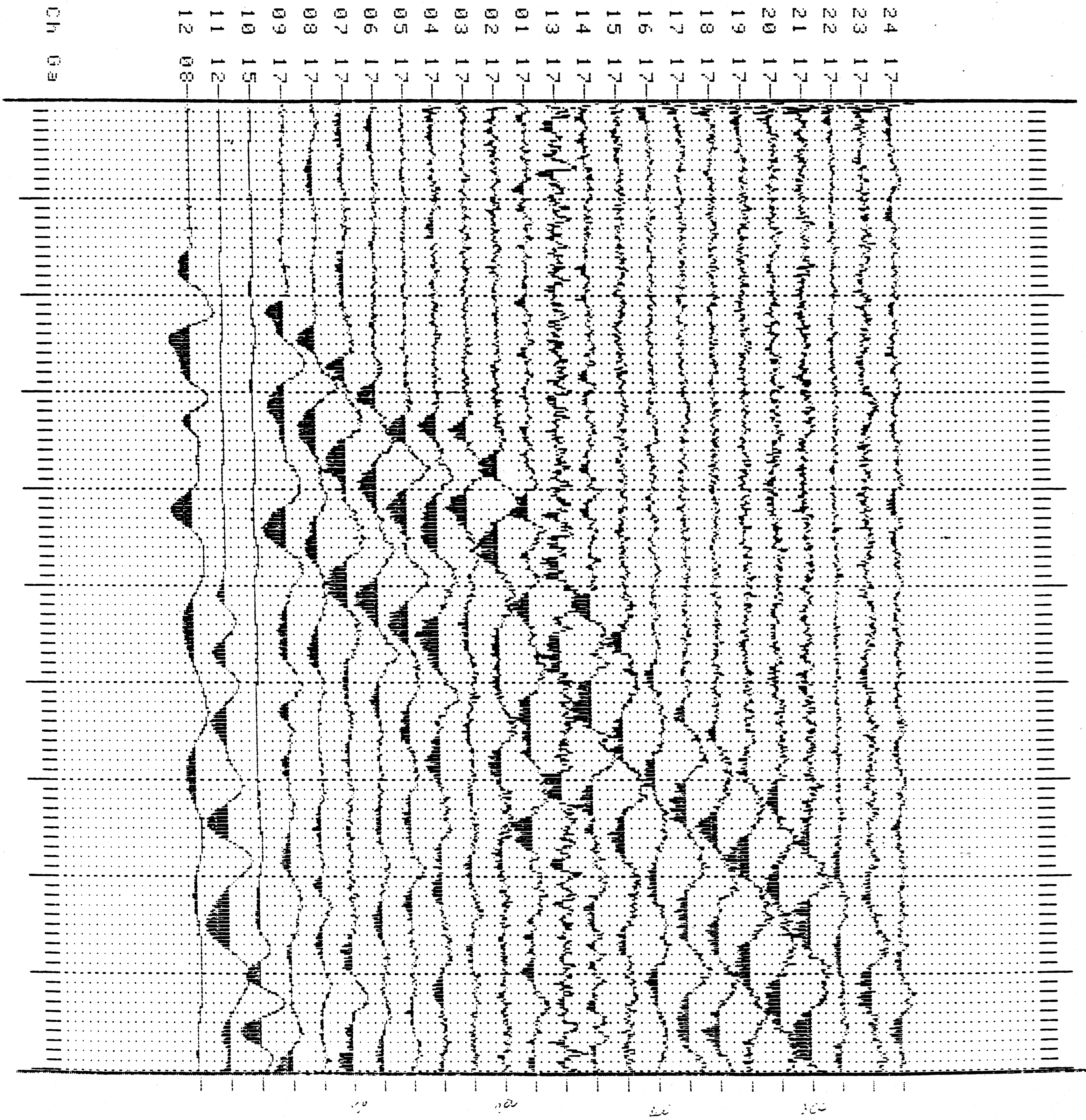
ABEM Terraloc Seismic System Record-000114 Date-890216 Time-10:45

Shot pos.: 0-10.0 Layout start: 00.0 Layout end: 460.0

Profile No.: 022000 Note: 0000002-2000 Operator: 000007

Record time: 100 ms Delay time: 0000 ms Analog filter: 100

Display mode: Normal, Low-cut: Off Hz High-cut: Off Hz Shots: 004



LINE 2, SP 110

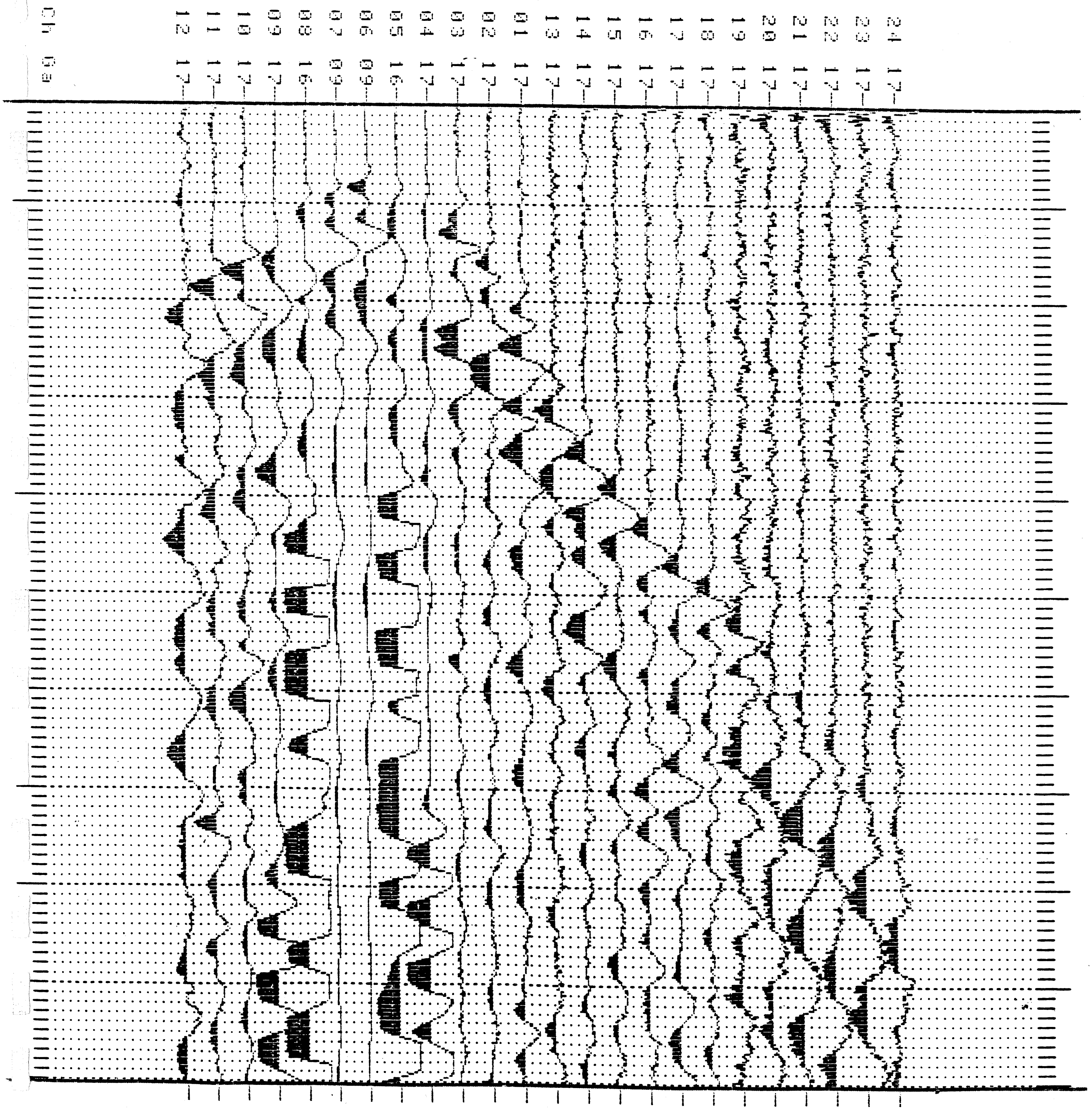
ABEM Terraloc Seismic System Record-000115 Date-890216 Time-11:23

Shot pos.: 110.0 Layout start: 00.0 Layout end: 460.0

Profile No.: 022000 Note: 0000002-2000 Operator: 000007

Record time: 100 ms Delay time: 0000 ms Analog filter: 100

Display mode: Normal, Low-cut: Off Hz High-cut: Off Hz Shots: 003



LINE 2, SP 230

ABEM Terraloc Seismic System   Record-000113   Date-890216   Time-10:30
Shot pos.: 0230.0   Layout start: 00.0   Layout end: 460.0
Profile No.: 022000   Note: 0000002-2000   Operator: 000007
Record time: 100 ms   Delay time: 0000 ms   Analog filter: 100
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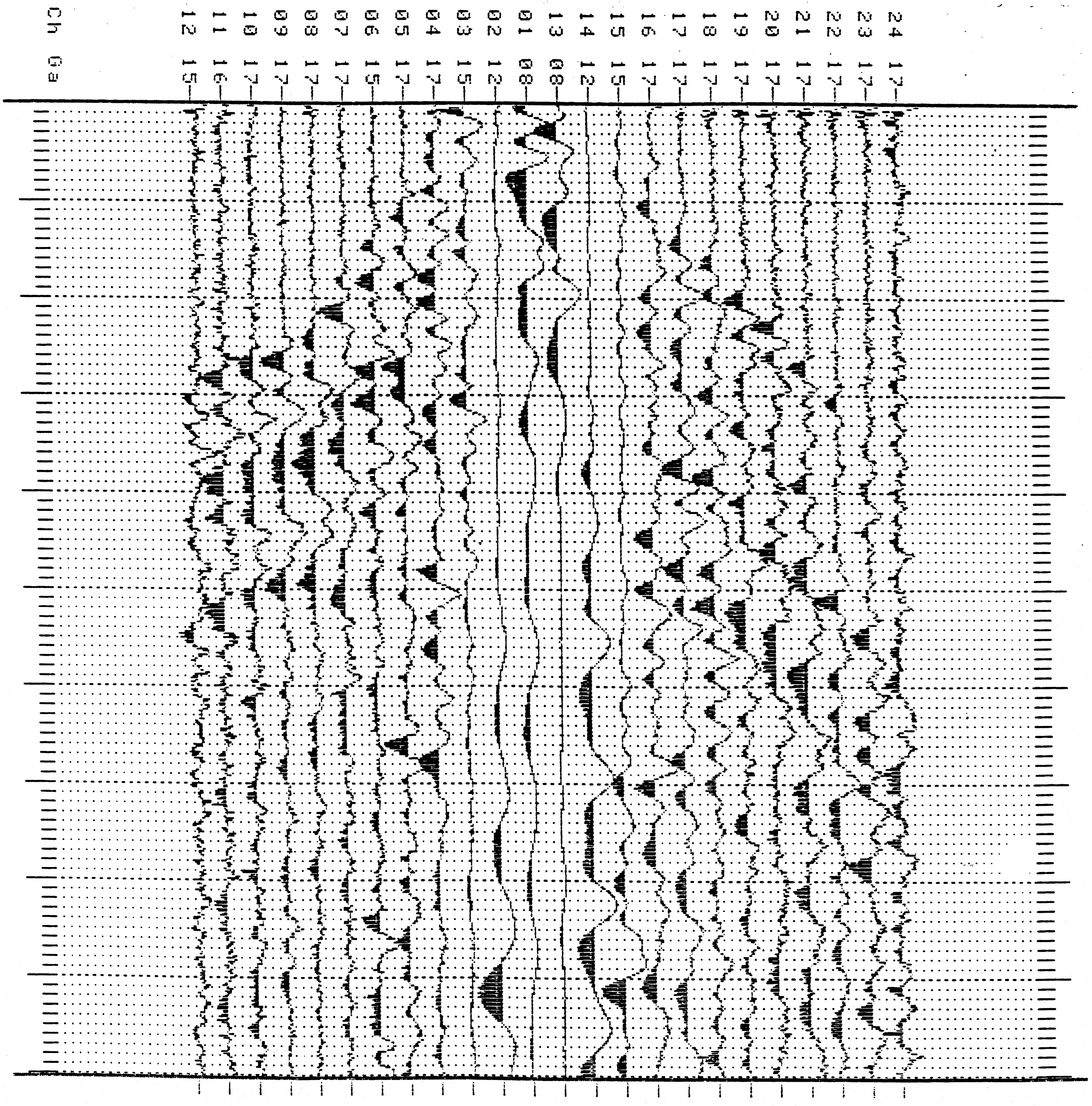


LINE 2, SP 350

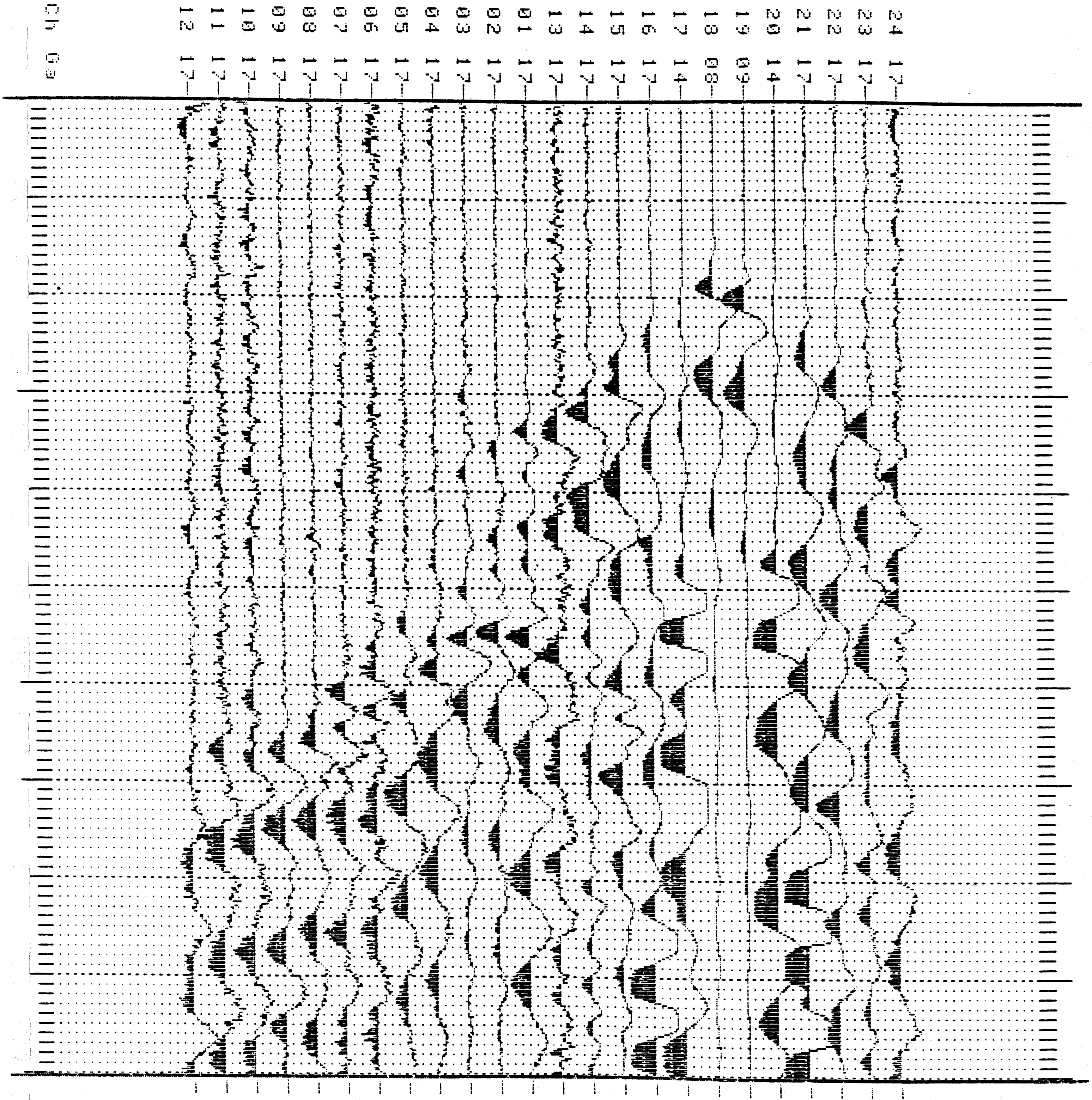
ABEM Terraloc Seismic System   Record-000115   Date-890216   Time-11:06

Shot pos.:   0350.0   Layout start: 00.0   Layout end: 460.0

Profile No.:   022000   Note: 0000002-2000   Operator: 000007

Record time: 100 ms   Delay time: 0000 ms   Analog filter: 100

Display mode: Normal.   Low-cut: Off Hz   High-cut: Off Hz   Shots: 004



50 100 150 200

LINE 2, SP 470

```
ABEM Terraloc Seismic System          Record-000115  Date-890216  Time-10:57
Shot pos.:        0470.0    Layout start:   00.0        Layout end:     460.0
Profile No.:      022000    Note:      0000002-2000     Operator:       000007
Record time:      100 ms    Delay time:      0000 ms    Analog filter:  100
Display mode: Normal.       Low-cut: Off Hz   High-cut: Off Hz    Shots: 005
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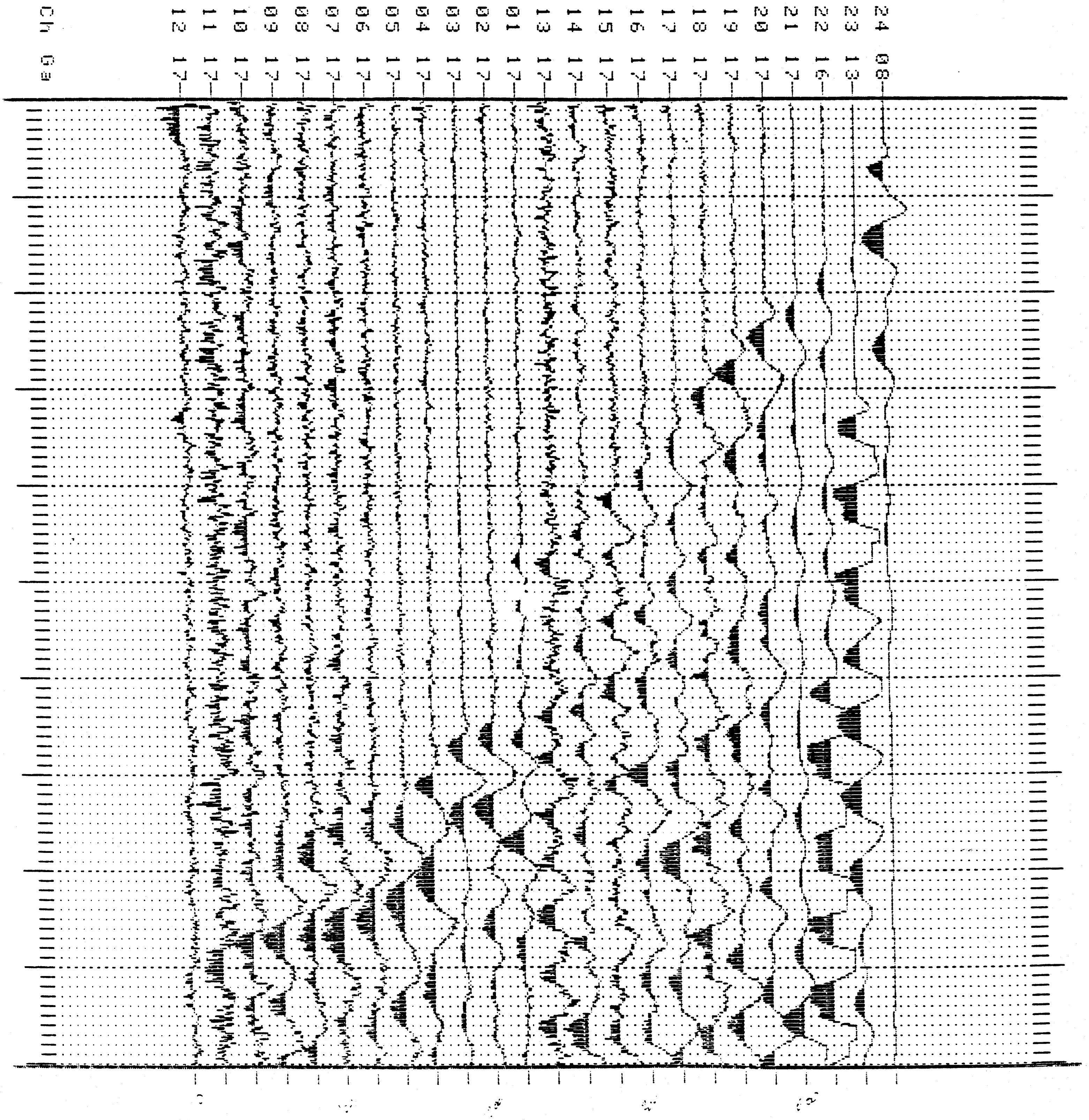
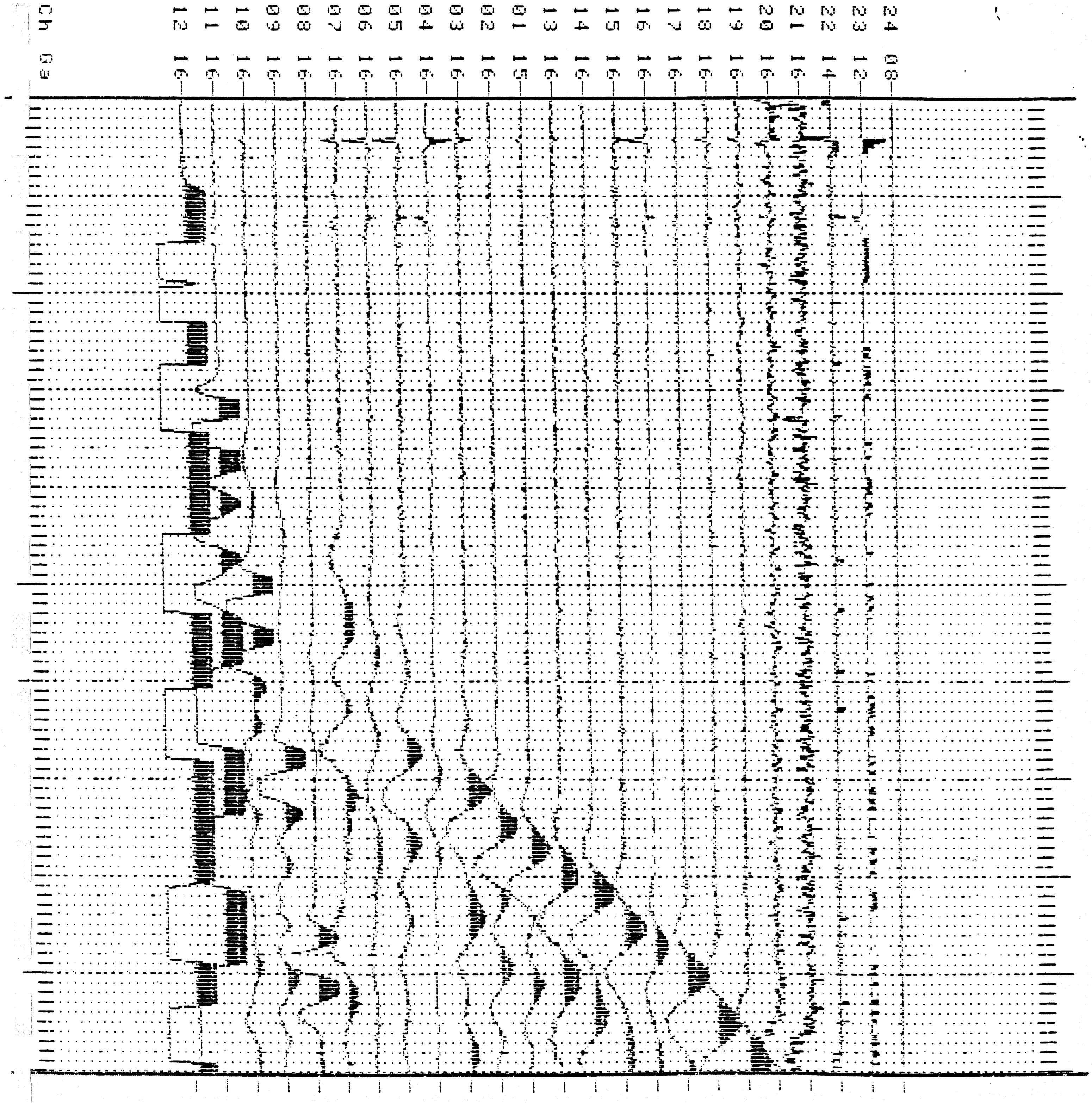


LINE 3, SP -10

ABEM Terraloc Seismic System Record-000125 Date-890218 Time-10:46
Shot pos.: 0-10.0 Layout start: 00.0 Layout end: 460.0
Profile No.: 032000 Note: 0000003-2000 Operator: 000007
Record time: 100 ms Delay time: 0000 ms Analog filter: 100
Display mode: Normal, Low-cut: Off Hz High-cut: Off Hz Shots: 001



LINE 3, SP 230

ABEM Terraloc Seismic System Record-000124 Date-890218 Time-10:31

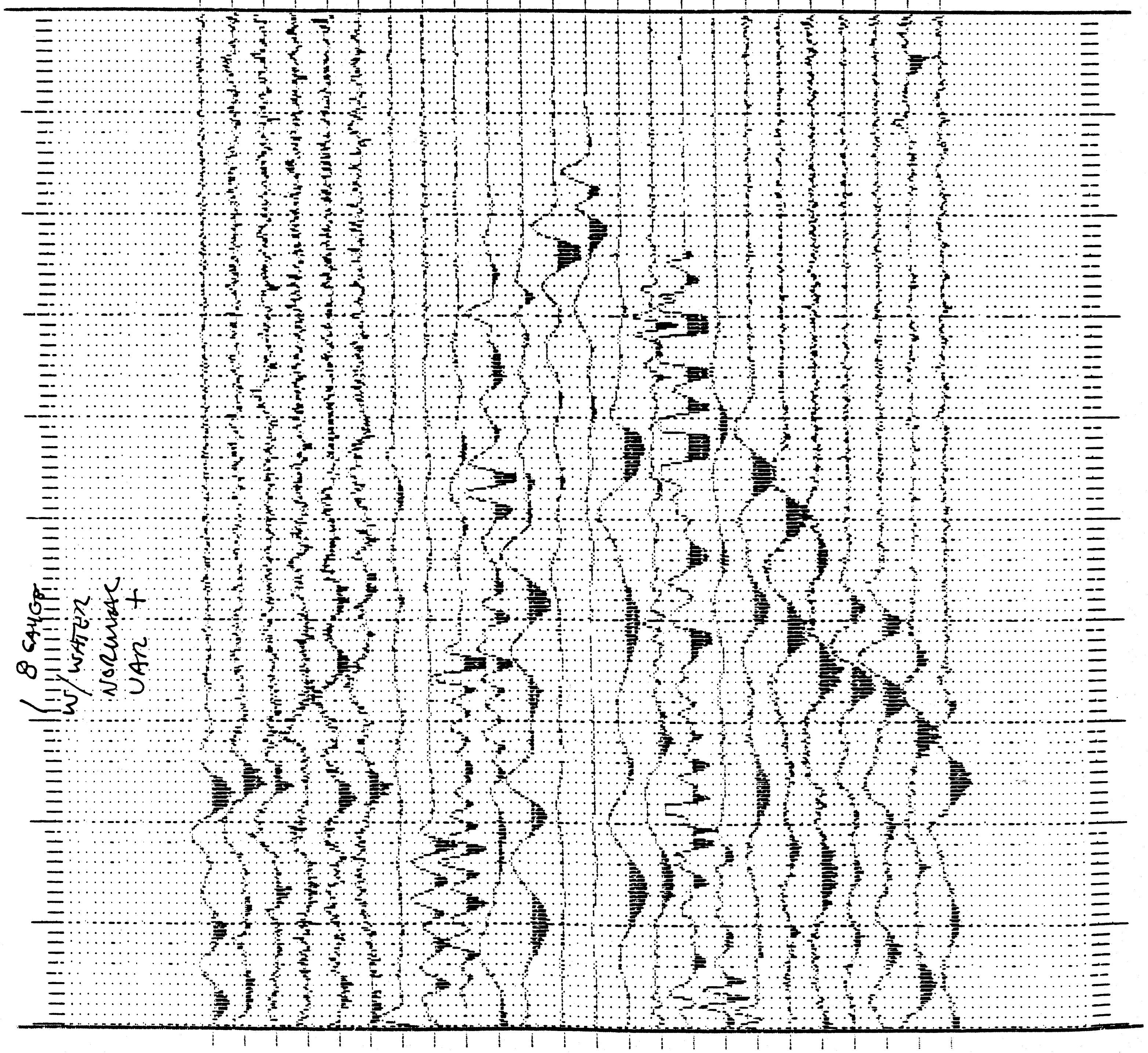
Shot pos.: 230.0 Layout start: 00.0 Layout end: 460.0

Profile No.: 032000 Note: 0000003-2000 Operator: 000007

Record time: 100 ms Delay time: 0000 ms Analog filter: 100

Display mode: Normal, Low-cut: Off Hz High-cut: Off Hz Shots: 001

Ch	12	11	10	09	08	07	06	05	04	03	02	01	13	14	15	16	17	18	19	20	21	22	23	24
dB	16	16	16	16	16	16	16	16	16	15	12	08	08	12	14	16	16	16	16	16	16	16	16	16



8 GAUGE W/WATER NORMAL + UAN

LINE 3, SP 470

ABEM Terraloc Seismic System   Record-000125   Date-890218   Time-11:01

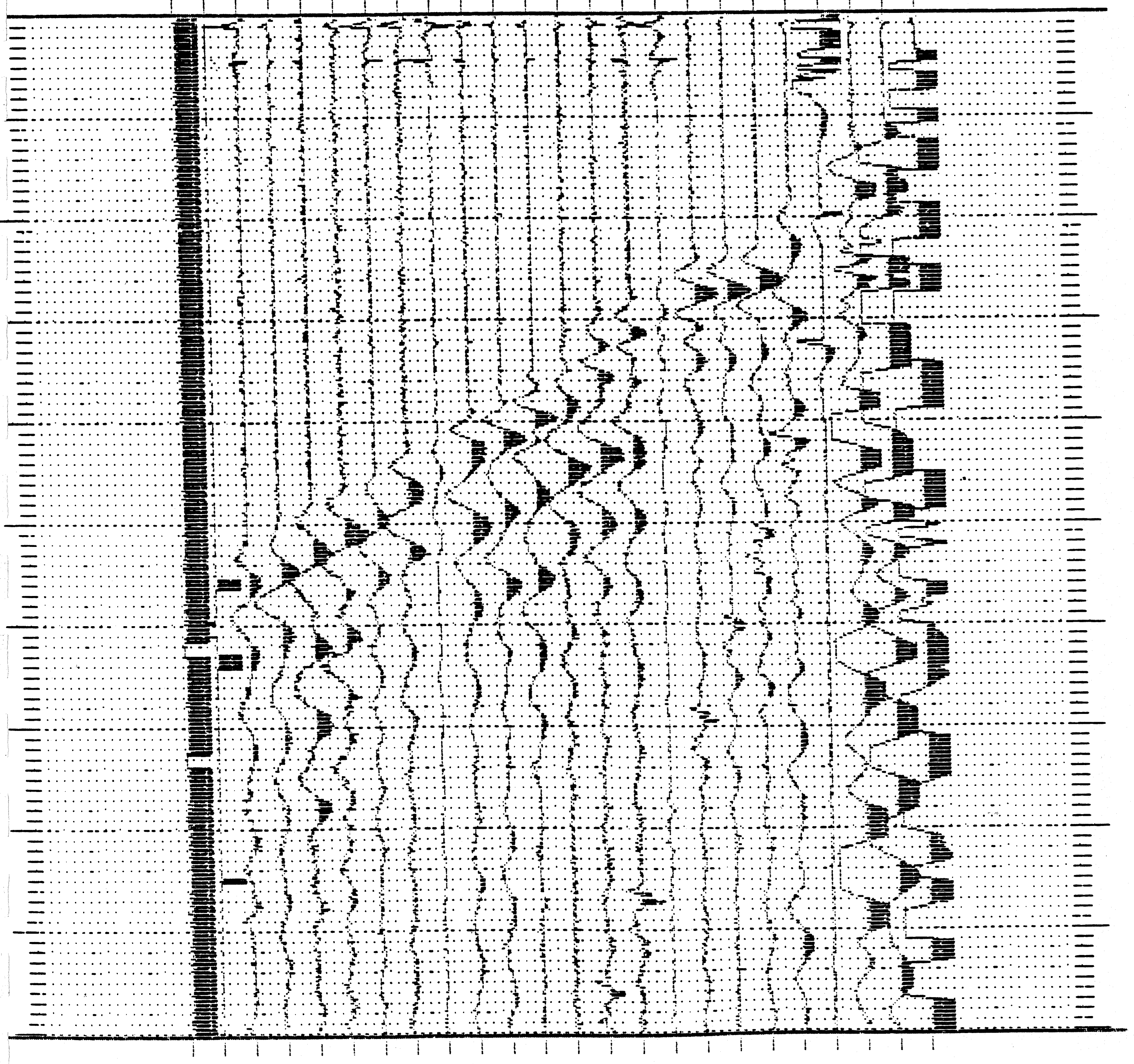
Shot pos.:   0470,0   Layout start: 00,0   Layout end: 460,0

Profile No.:   032000   Note: 0000003-2000   Operator: 000007

Record time: 200 ms   Delay time: 0000 ms   Analog filter: 100

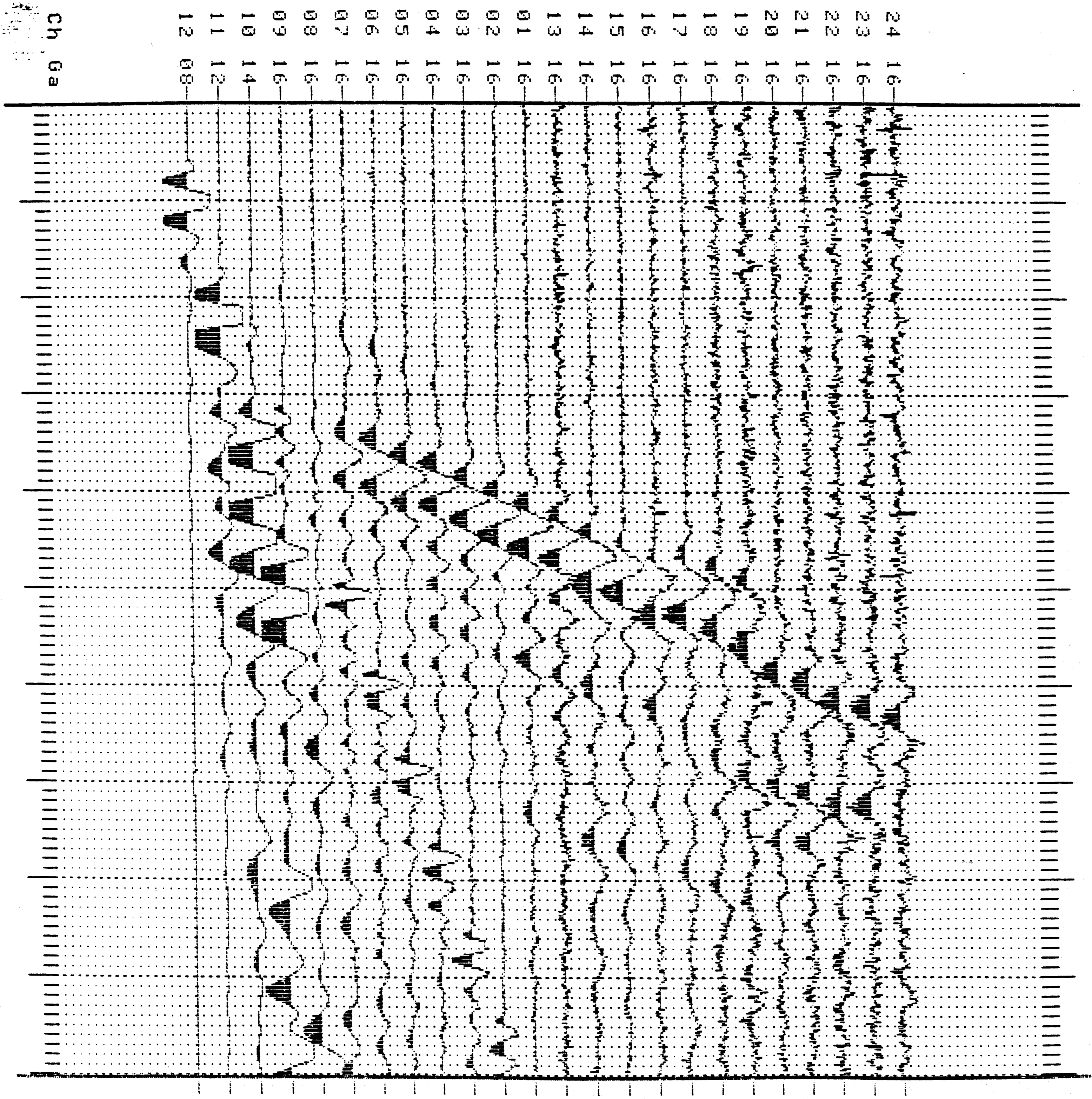
Display mode: Normal,   Low-cut: Off Hz   High-cut: Off Hz   Shots: 001

Ch	12	11	10	09	08	07	06	05	04	03	02	01	13	14	15	16	17	18	19	20	21	22	23	24
Ga	08	12	14	16	16	16	16	16	16	16	16	15	16	16	16	16	16	16	16	16	16	16	16	16



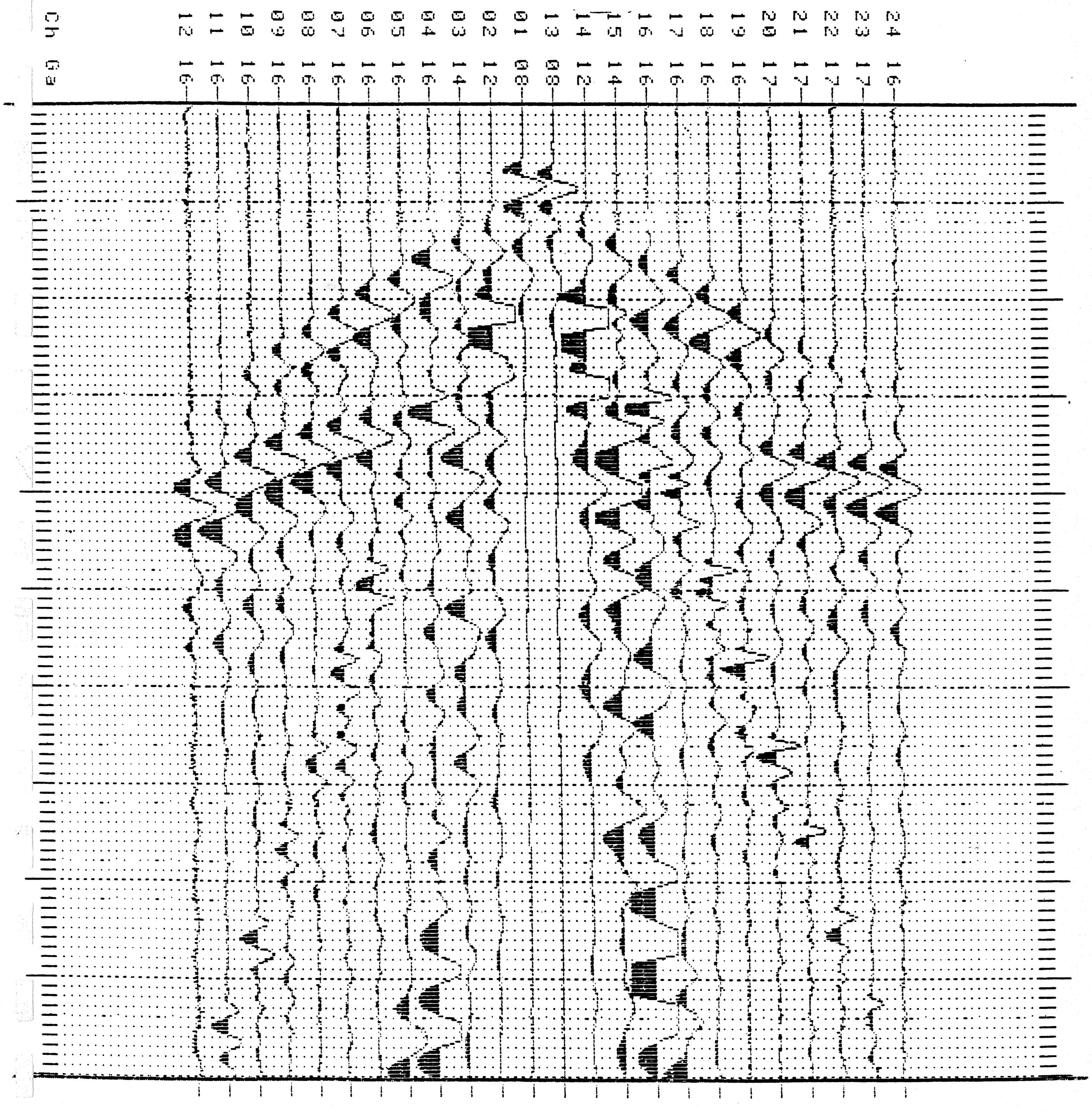
LINE 4, SP -10

ABEM Terraloc Seismic System Record-000127 Date-890220 Time-10:10
Shot pos.: 0-10.0 Layout start: 00.0 Layout end: 460.0
Profile No.: 042000 Note: 9900004-2000 Operator: 000007
Record time: 200 ms Delay time: 0000 ms Analog filter: 100
Display mode: Normal. Low-cut: Off Hz High-cut: Off Hz Shots: 001



LINE 4, SP 230

```
ABEM Terraloc Seismic System        Record-000126   Date-890220   Time-09:50
Shot pos.:       0230.0    Layout start:    00.0      Layout end:       460.0
Profile No.:     042000    Note:       9900004-2000   Operator:         000007
Record time:     200 ms    Delay time:      0000 ms   Analog filter:    100
Display mode: Normal,      Low-cut: Off Hz    High-cut: Off Hz     Shots: 001
```



LINE 4, SP 470

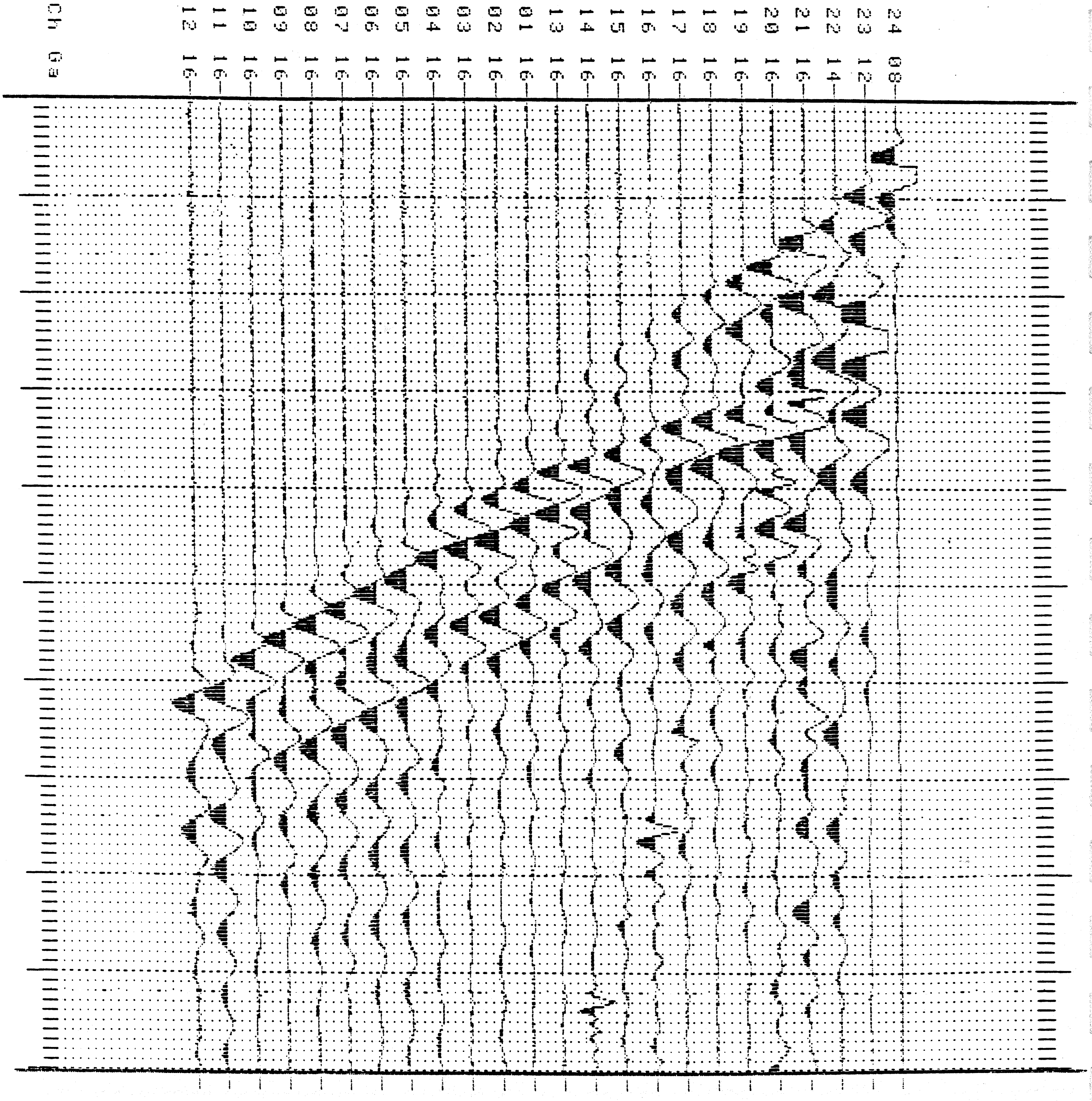
ABEM Terraloc Seismic System Record-000128 Date-890220 Time-10:28

Shot pos.: 0470.0 Layout start: 00.0 Layout end: 460.0

Profile No.: 042000 Note: 9900004-2000 Operator: 000007

Record time: 200 ms Delay time: 0000 ms Analog filter: 100

Display mode: Normal. Low-cut: Off Hz High-cut: Off Hz Shots: 001



LINE 5, SP -10

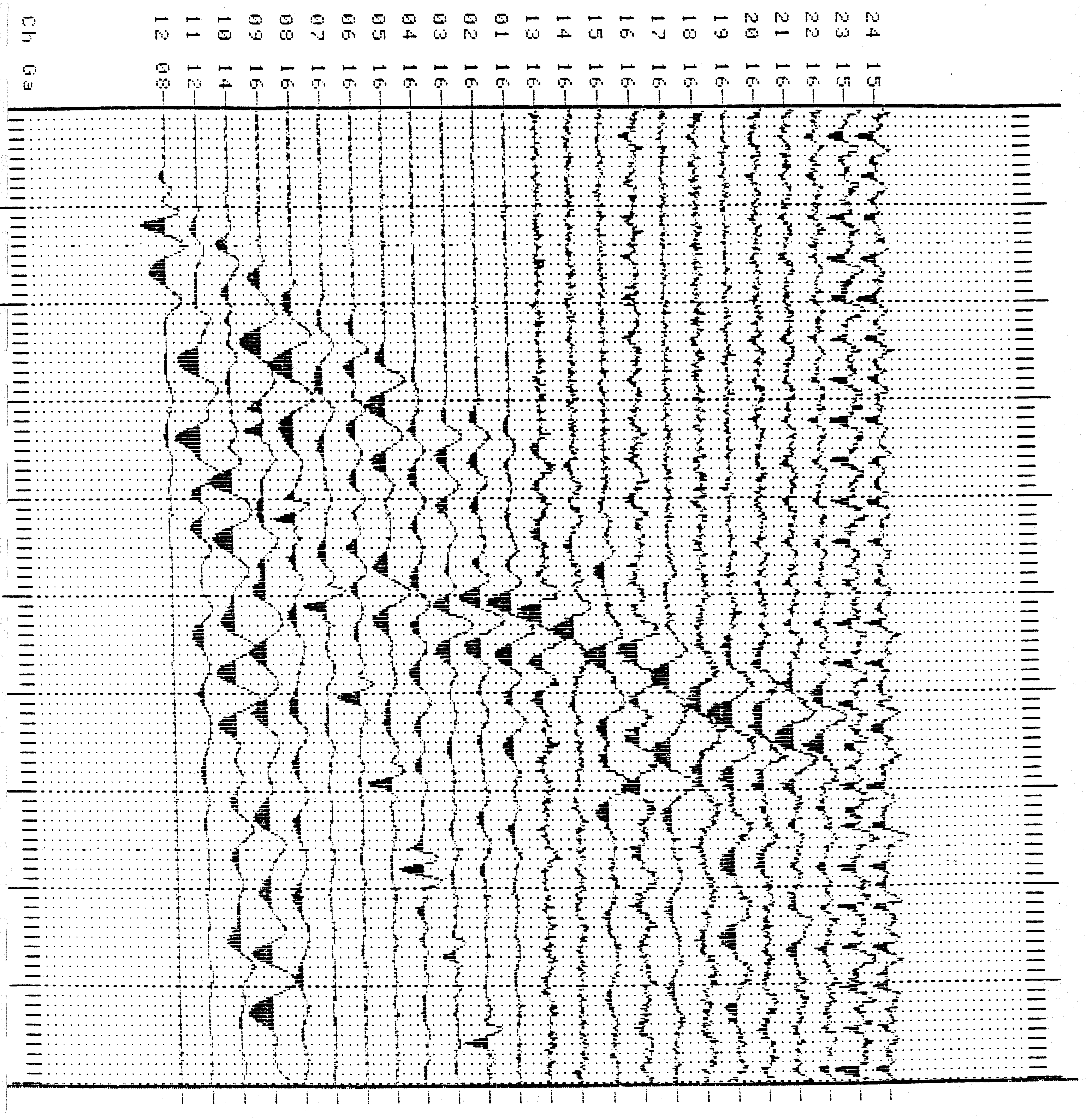
ABEM Terraloc Seismic System Record-000131 Date-890220 Time-12:12

Shot pos.: 0-10.0 Layout start: 00.0 Layout end: 460.0

Profile No.: 052000 Note: 9900005-2000 Operator: 000007

Record time: 200 ms Delay time: 0000 ms Analog filter: 100

Display mode: Normal. Low-cut: Off Hz High-cut: Off Hz Shots: 001



LINE 5, SP 230

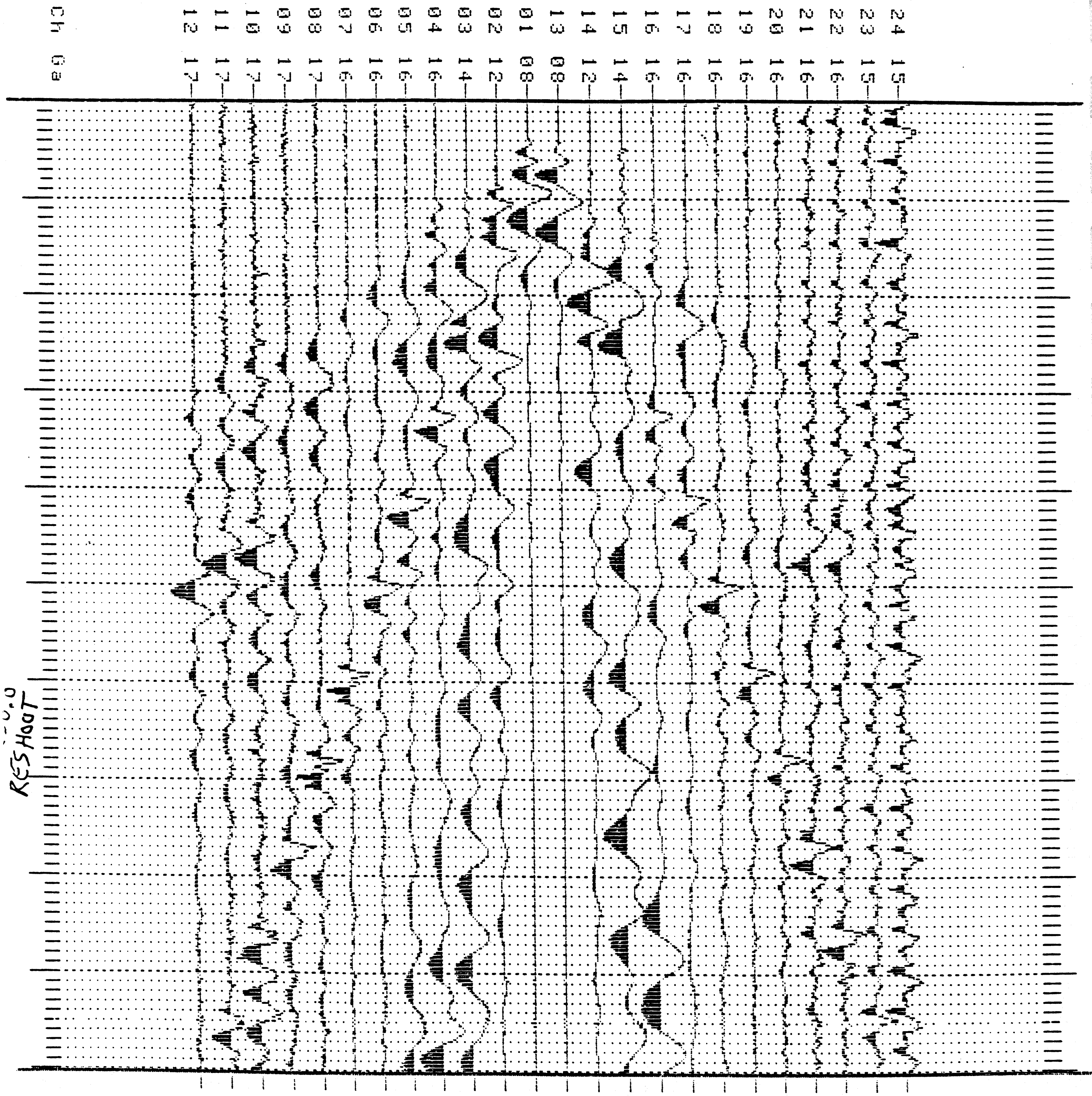
ABEM Terraloc Seismic System   Record-000130   Date-890220   Time-11:59

Shot pos.: 0230.0   Layout start: 00.0   Layout end: 460.0

Profile No.: 052000   Note: 9920005-2000   Operator: 000007

Record time: 200 ms   Delay time: 0000 ms   Analog filter: 100

Display mode: Normal.   Low-cut: Off Hz   High-cut: Off Hz   Shots: 001



RESHOOT

LINE 5, SP 350

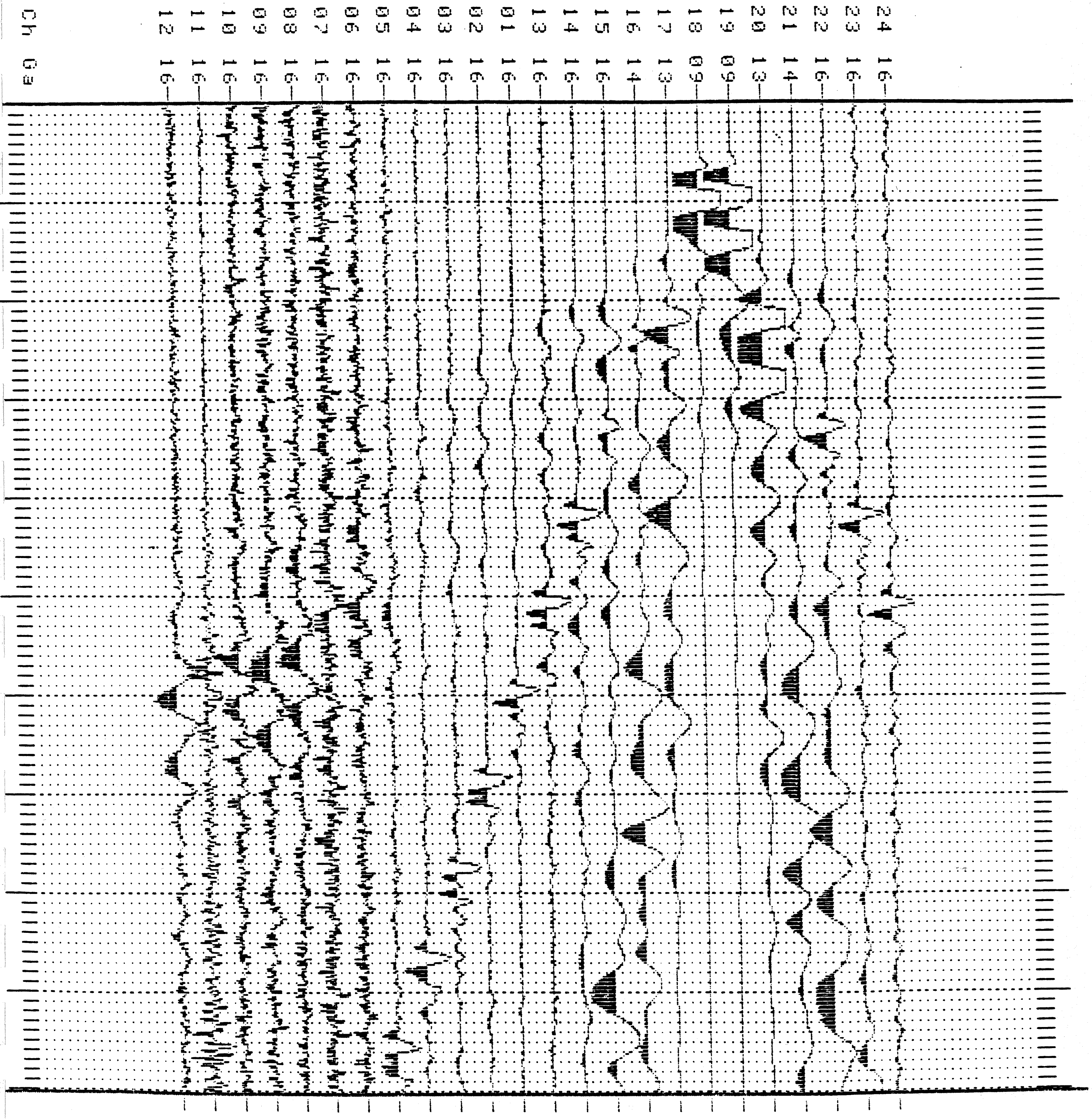
ABEM Terraloc Seismic System Record-000133 Date-890220 Time-13:22

Shot pos.: 0350.0 Layout start: 00.0 Layout end: 460.0

Profile No.: 052000 Note: 9900005-2000 Operator: 000007

Record time: 200 ms Delay time: 0000 ms Analog filter: 100

Display mode: Normal. Low-cut: Off Hz High-cut: Off Hz Shots: 001



LINE 5, SP 470

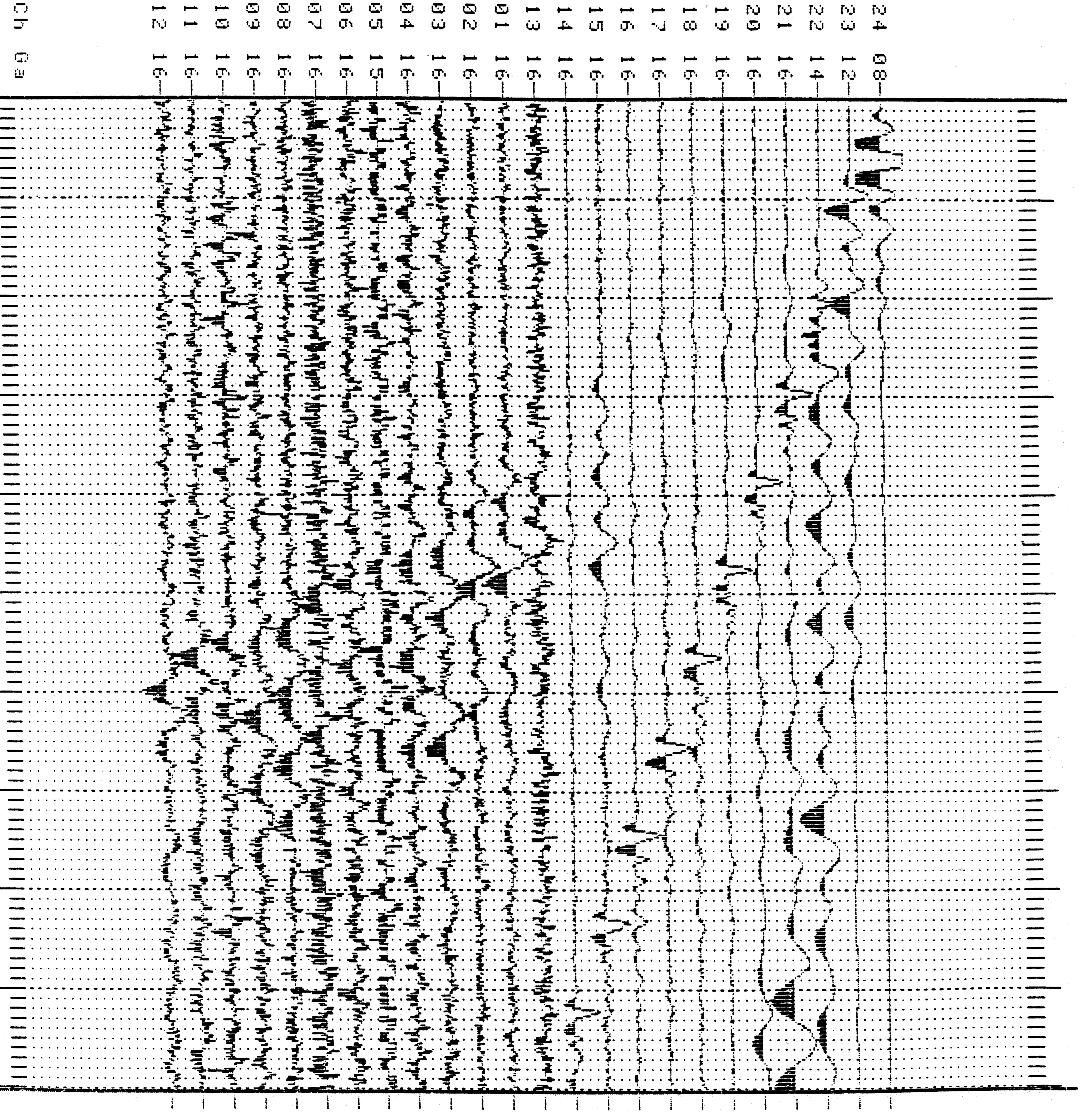
ABEM Terraloc Seismic System   Record-000132   Date-890220   Time-12:45

Shot pos.:   0470.0   Layout start: 00.0   Layout end: 460.0

Profile No.:   052000   Note: 9900005-2000   Operator: 000007

Record time: 200 ms   Delay time: 0000 ms   Analog filter: 100

Display mode: Normal,   Low-cut: Off Hz   High-cut: Off Hz   Shots: 001



LINE 6, SP -10

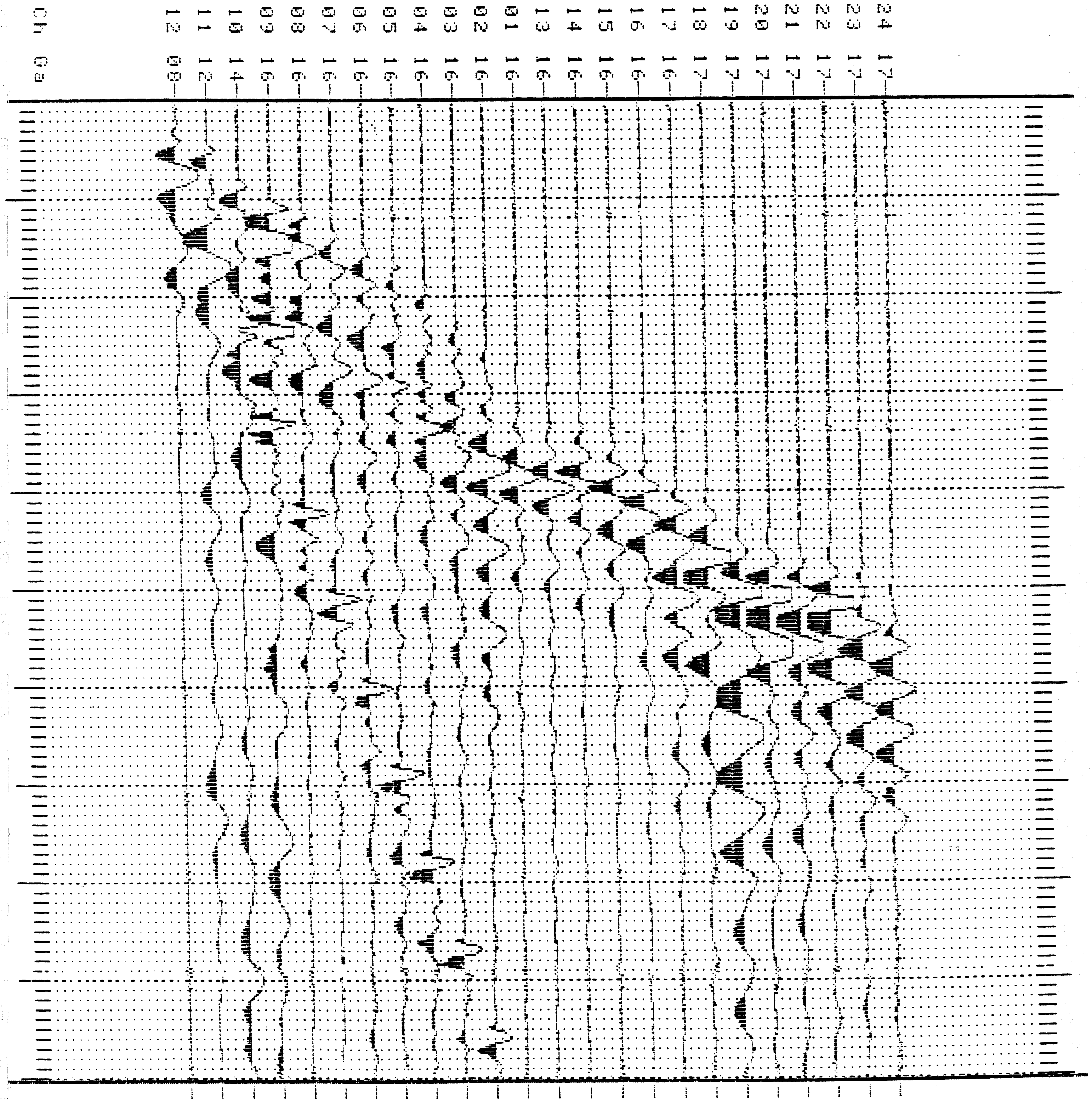
ABEM Terraloc Seismic System Record-000135 Date-890220 Time-15:27

Shot pos.: 0-10.0 Layout start: 00.0 Layout end: 460.0

Profile No.: 062000 Note: 9900006-2000 Operator: 000007

Record time: 200 ms Delay time: 0000 ms Analog filter: 100

Display mode: Normal, Low-cut: Off Hz High-cut: Off Hz Shots: 001



LINE 6, SP 230

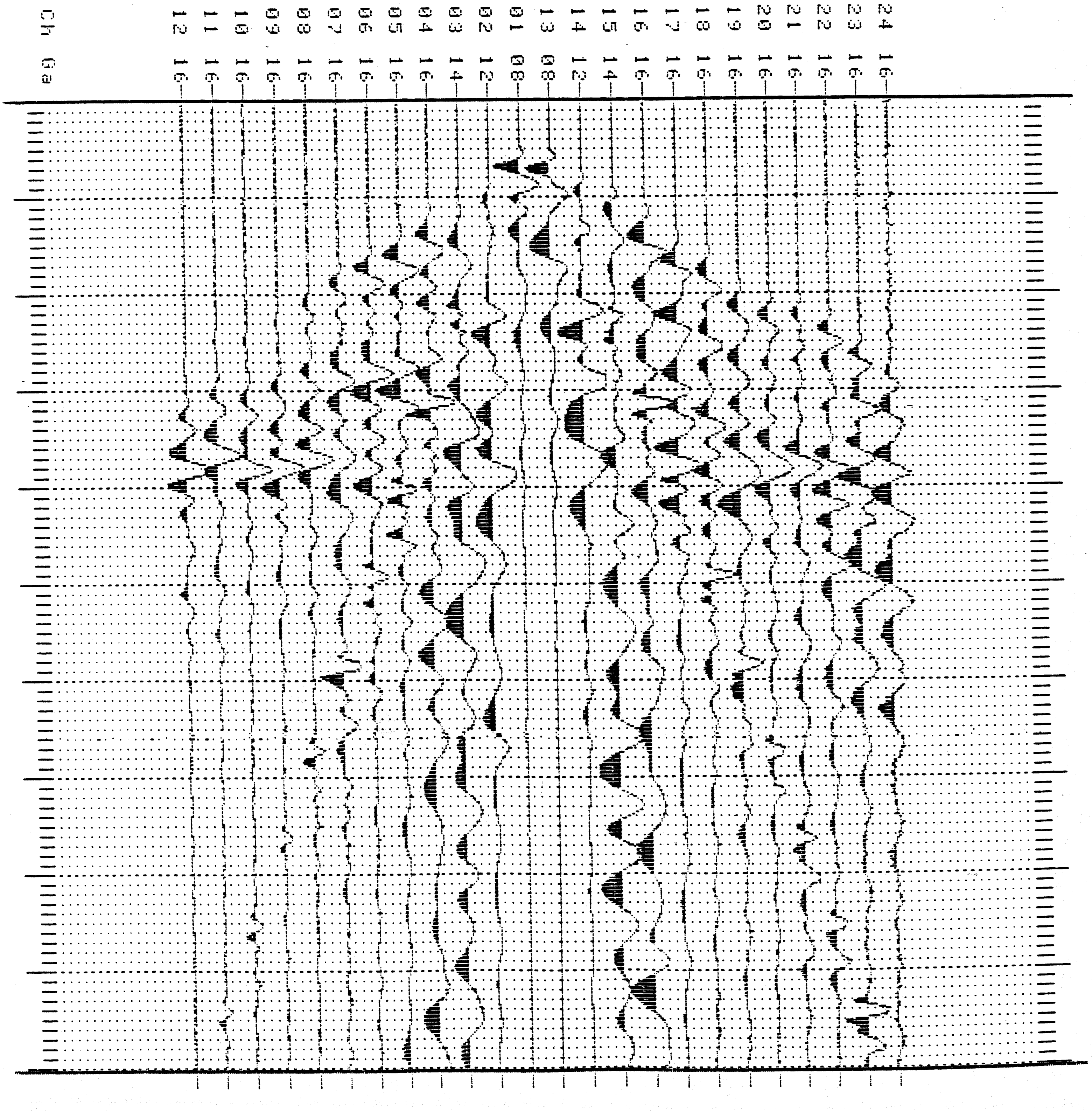
ABEM Terraloc Seismic System Record-000134 Date-890228 Time-15:13

Shot pos,: 0230,0 Layout start: 00,0 Layout end: 460,0

Profile No,: 062000 Note: 9900006-2000 Operator: 000007

Record time: 200 ms Delay time: 0000 ms Analog filter: 100

Display mode: Normal, Low-cut: Off Hz High-cut: Off Hz Shots: 001



LINE 6, SP 470

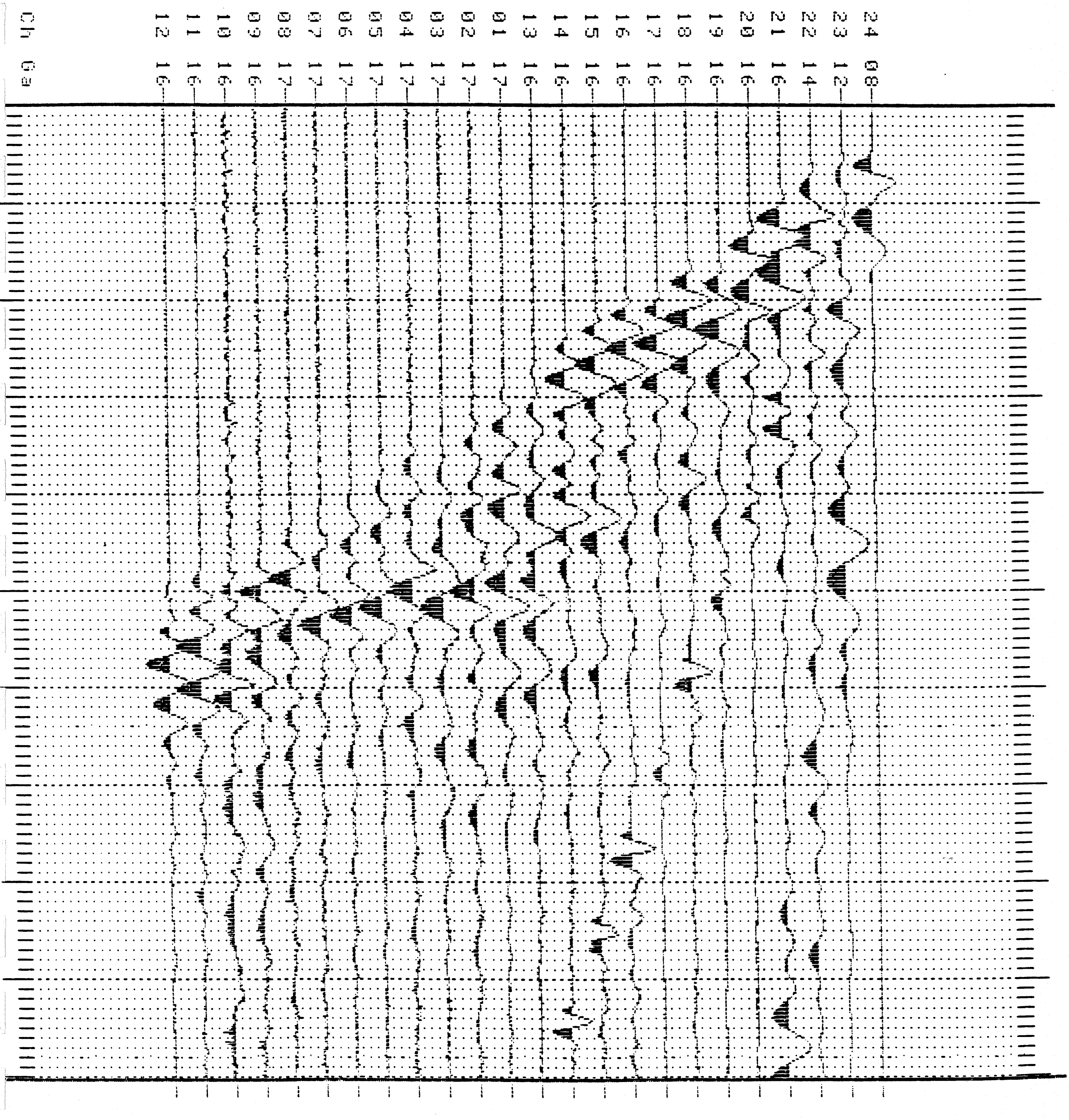
ABEM Terraloc Seismic System   Record-000136   Date-890220   Time-15:39

Shot pos.:   0470.0   Layout start: 00.0   Layout end: 460.0

Profile No.:   062000   Note: 9900006-2000   Operator: 000007

Record time: 200 ms   Delay time: 0000 ms   Analog filter: 100

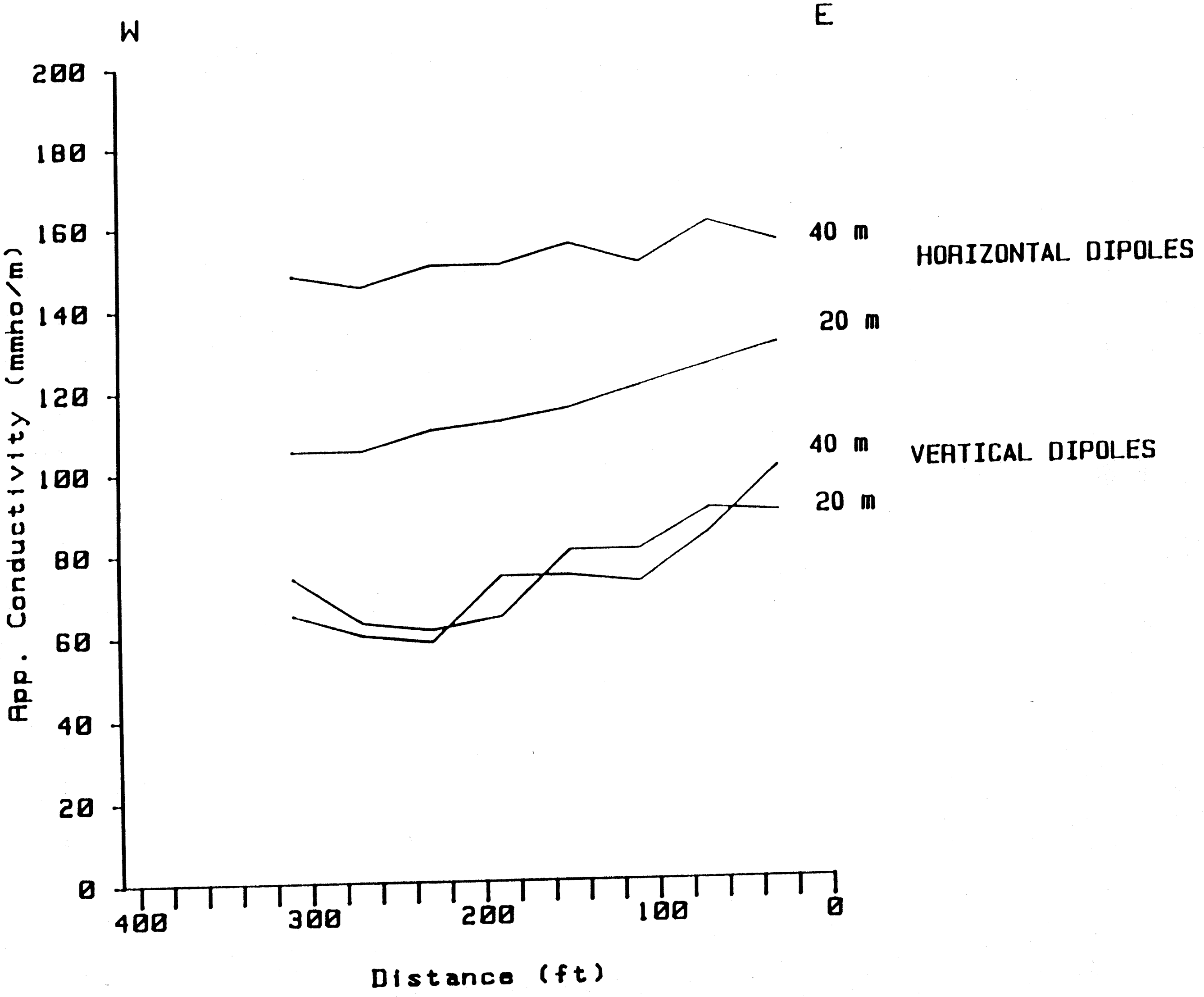
Display mode: Normal,   Low-cut: Off Hz   High-cut: Off Hz   Shots: 001



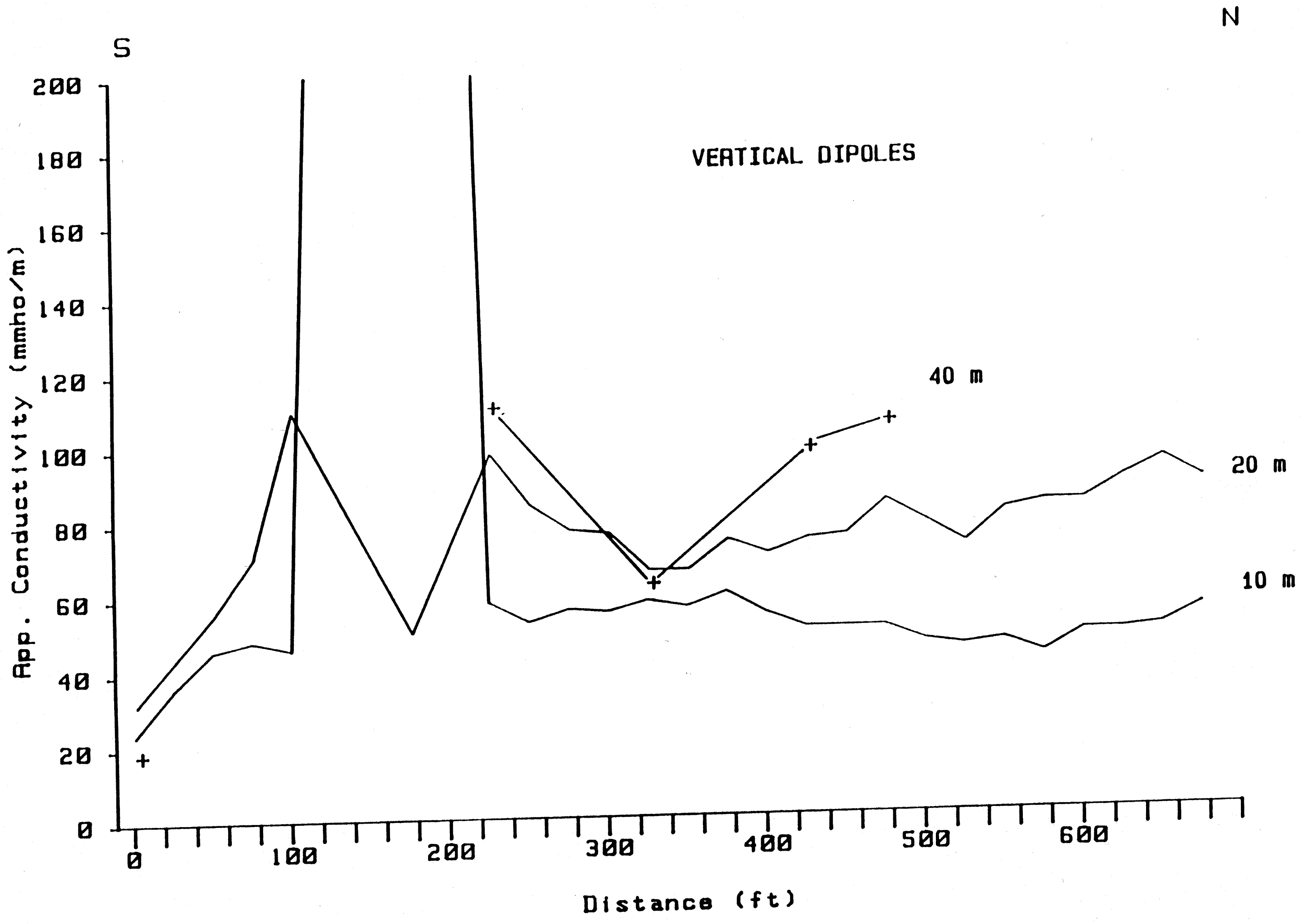
APPENDIX B

EM Data Profiles

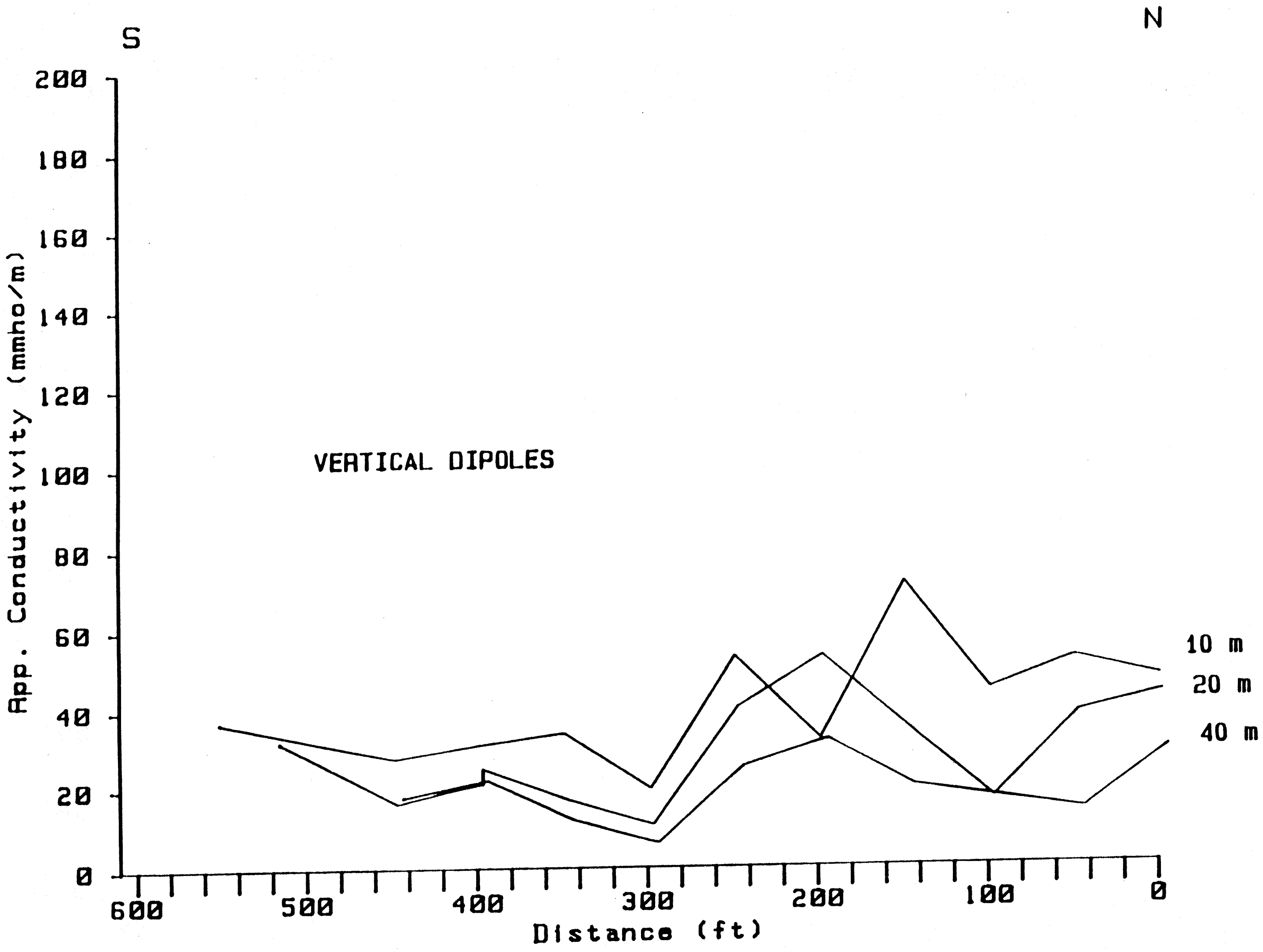
CARMEL STATE BEACH AREA
EM DATA: LINE 1



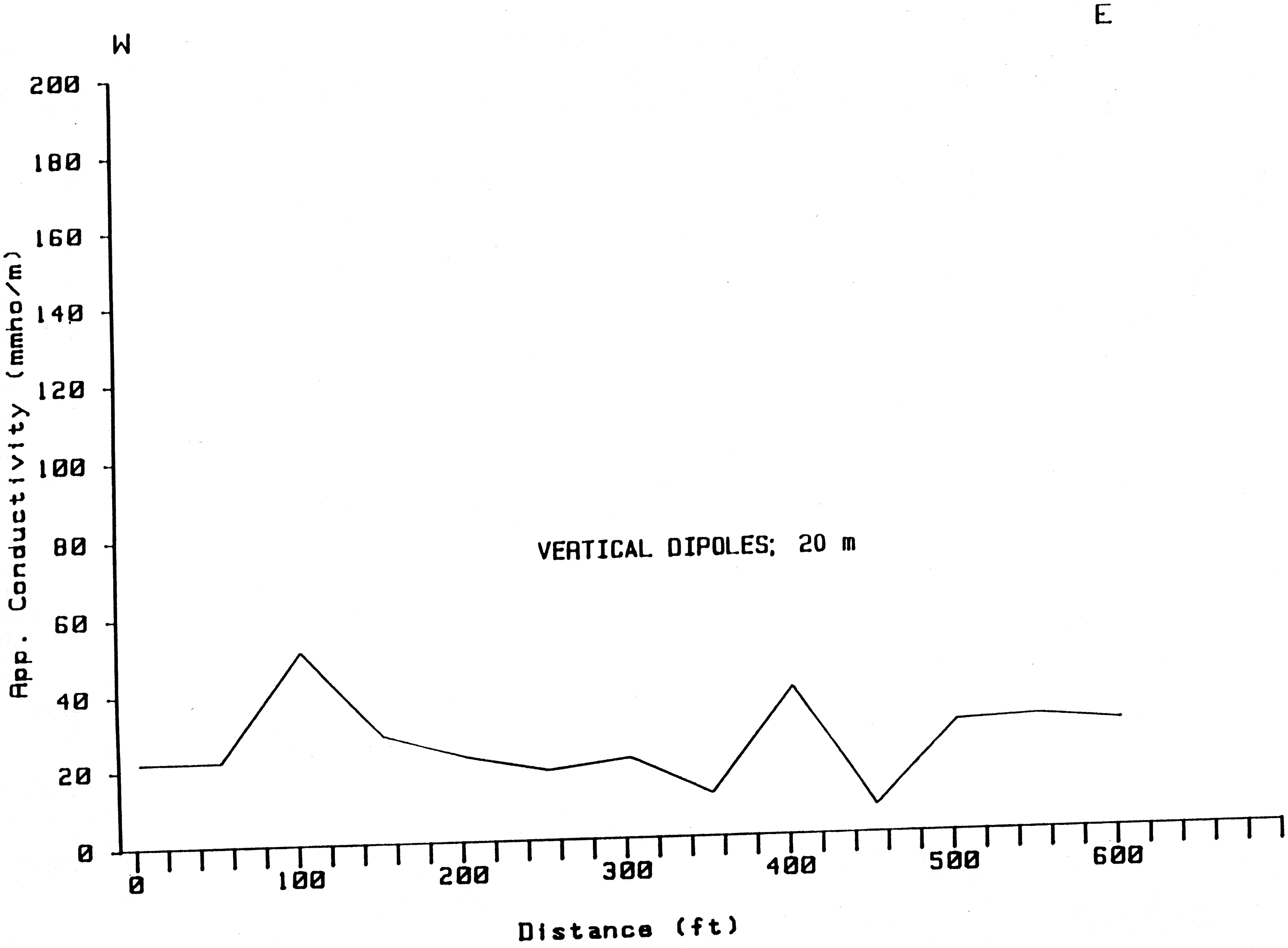
CARMEL STATE BEACH AREA
EM DATA: LINE 2



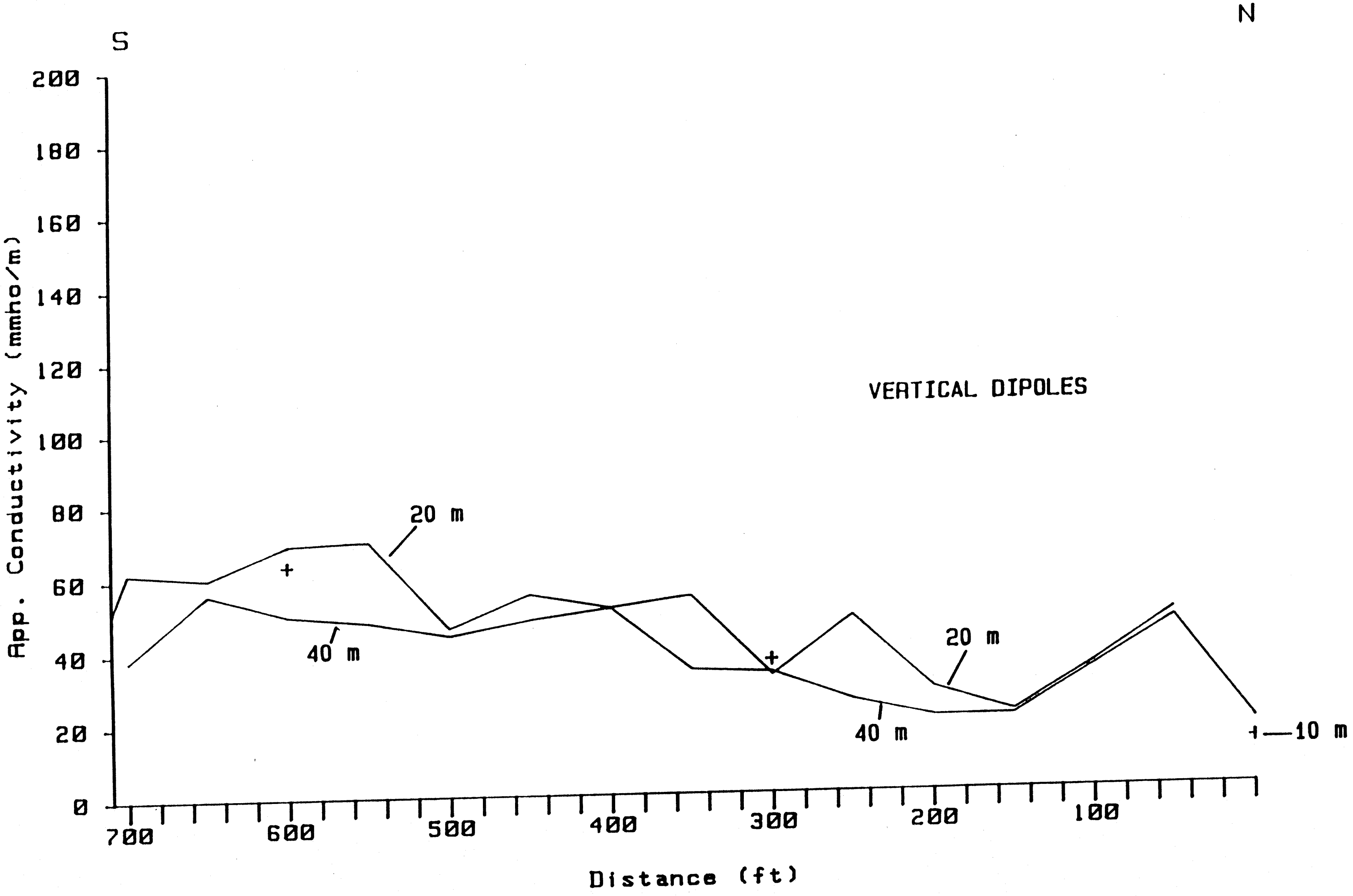
CARMEL STATE BEACH AREA (NORTHWEST FLOODPLAIN)
EM DATA: LINE 3



CARMEL STATE BEACH AREA (NORTHWEST FLOODPLAIN)
EM DATA: LINE 4



CARMEL STATE BEACH AREA (NORTHWEST FLOODPLAIN)
EM DATA: LINE 5



APPENDIX C

Logistics Summary

Logistics Summary

DATE	ACTIVITY
2/13/89	E. Gustafson (EG), P. Goupillaud (PG) and P. Walen (PW) mobilize from San Diego to Carmel.
2/14/89	Meet with client in AM, look over field area. Calibrate equipment on seismic Line 1, Spread 1. Bulldozer and spectators in vicinity.
2/15/89	Complete calibration, reflection, and common-offset measurements on Line 1, Spread 1. Bulldozer in vicinity in AM. Spectators in vicinity throughout the day.
2/16/89	Complete standard reflection and common-offset measurements on Line 2.
2/17/89	PG returns to San Diego. Complete Line 1, Spread 2.
2/18/89	Complete seismic Line 3, EM along Lines 1 and 2.
2/19/89	Complete EM Lines 3, 4, and 5.
2/20/89	Complete seismic Lines 4, 5, and 6.
2/21/89	EG and PW return to San Diego.

APPENDIX C

WATER QUALITY DATA

WATER TESTING
AND
CONSULTING LABORATORY
3825 SANTA CLAUS LANE
CARPINTERIA, CA 93013
Telephone (805) 684-3301

March 20, 1989

Staal, Gardner & Dunne, Inc.
121 N. Fir Street, Suite F
Ventura, CA 93001

WATER ANALYSIS
RE: CARMEL RIVER STATE BEACH

Attention: Martin Feeney

Following are the analytical results of nine(9) water samples received from Scott Brown on March 13, 1989.

Source Carmel River State Beach(lower), MPWMD
Sample Collected by Michael Burke
Sample Bottle Used WTCL 1-L plastic
Date Analysis Completed March 17, 1989

Sample Description	WTCL LAB NO.	Electrical Conductivity	Bicarbonate ppm as $CaCO_3$	Chloride ppm as Cl
Carmel River, MW-1D, 3/7/89	89291	6000	200	2100
Carmel River, MW-1M, 3/7/89	89292	25,000	160	11,000
Carmel River, MW-1S, 3/7/89	89293	9600	260	3500
Mission Ranch, MW-2D, 3/9/89	89294	860	204	104
Mission Ranch, MW-2M, 3/9/89	89295	720	216	76
Mission Ranch, MW-2S, 3/9/89	89296	930	272	124
Odello Field, MW-3D, 3/11/89	89297	840	220	100
Odello Field, MW-3M, 3/11/89	89298	870	232	96
Odello Field, MW-3S, 3/11/89	89299	1100	247	144

Reference in the methods of analysis is attached in this report. If there are any questions regarding this report, please feel free to call or write. Thank you.

SINCERELY,

Ray G. Orquiola

RAY G. ORQUIOLA, CHEMIST

WATER TESTING
AND
CONSULTING LABORATORY
3825 SANTA CLAUS LANE
CARPINTERIA, CA 93013
Telephone (805) 684-3301

REFERENCE METHODS OF ANALYSIS USED BY THE WATER TESTING & CONSULTING LABORATORY (BASED FROM EPA 1983 METHODS FOR CHEMICAL ANALYSIS OF WATER & WASTES, AND 1985 STANDARD METHODS FOR THE EXAMINATION OF WATER & WASTEWATER, 16th EDITION).

PARAMETER & UNIT	METHODS	REFERENCE
A. PHYSICAL PROPERTIES		
☐ Color, Unit	Colorimetric, Platinum-Cobalt	EPA Method 110.2
☑ Conductance, Micromhos/Cm 25°C	Specific Conductance, Wheatstone Bridge	EPA Method 120.1
☐ Hardness, Total(mg/l as $CaCO_3$	Titrimetric, EDTA	EPA Method 130.1
☐ Odor, Theshold Odor	Comparison with odor-free water at 60°C	" " 140.1
☐ pH, Unit	Electrometric Measurement	" " 150.1
☐ RESIDUE: mg/l		
☐ Total Dissolved (Filterable)	Gravimetric dried at 180°C	" " 160.1
☐ Total Suspended(Non-fiterable)	Gravimetric dried at 103°C-105°C	" " 160.2
☐ Total Solids	Gravimetric dried at 103°-105°C	" " 160.3
☐ Volatile	Gravimetric, Ignited at 550°C	" " 160.4
☐ Settleable Matter	Volumetric, IMHOFF Cone	" " 160.5
☐ Temperature, °C	Thermometric	" " 170.1
☐ Turbidity,NTU	Nephelometric	" " 180.1
B. METALS: All Units in mg/l		
☐ Aluminum, Al	AA Furnace	" " 202.2
☐ Arsenic, as As	AA Furnace	" " 206.2
☐ Barium, as Ba	AA Furnace	" " 208.2
☐ Beryllium, as Be	AA Furnace	" " 210.2
☐ Boron, as B	Colorimetric, Curcumin	" " 212.3
☐ Cadmium, as Cd	AA Furnace	" " 213.2
☐ Calcium, as Ca	Titrimetric, EDTA	" " 215.2
☐ Calcium, as Ca	AA, Direct Aspiration	" " 215.1
☐ Chromium, as Cr	AA Furnace	" " 218.2
☐ Hexavalent Chromium(Cr+ 6)	Chelation Extraction	" " 218.4
☐ Chromium(Dissolved)	AA Furnace	" " 218.3
☐ Cobalt, as Co	AA Furnace	" " 219.2
☐ Gold, as Au	AA Furnace	" " 231.2
☐ Iridium, as Ir	AA Furnace	" " 235.2
☐ Iron, as Fe	AA Direct Aspiration	" " 236.1
☐ Lead, as Pb	AA Furnace	" " 239.2
☐ Magnesium, as Mg	AA Direct Aspiration	" " 242.1
☐ Manganese, as Mn	AA Direct Aspiration	" " 243.1
☐ Mercury, as Hg	Cold Vapor, Manual	" " 245.1
☐ Mercury, as Hg (in sediments)	Cold Vapor, Sediments	" " 245.5
☐ Molybdenum, as Mo	AA Furnace	" " 246.2
☐ Nickel, as Ni	AA Furnace	" " 249.1
☐ Osmium as Os	AA Furnace	" " 252.2
☐ Palladium, as Pd	AA Furnace	" " 253.2
☐ Platinum, as Pt	AA Furnace	" " 255.2
☐ Rhodium, as Rh	AA Furnace	" " 265.2
☐ Selenium, as Se	AA Furnace	" " 270.2
☐ Silver, as Ag	AA Furnace	" " 272.2
☐ Sodium, as Na	AA Direct Aspiration	" " 273.1
☐ Thallium, as Tl	AA Furnace	" " 279.2
☐ Tin, as Sn	AA Furnace	" " 282.2
☐ Copper as Cu	AA Direct Aspiration	" " 220.1

CALIFORNIA STATE HEALTH APPROVED LABORATORY

Cont. on back page

PARAMETERS & UNIT	METHODS	REFERENCE
METALS ☐ Potassium	AA Direct Aspiration	EPA Method 258.1
☐ Titanium, as Ti	AA Furance	EPA Method 283.2
☐ Zinc, as Zn	AA Direct Aspiration	" " 289.1
C. INORGANIC, NON-METALLICS (All Units in mg/1)		
☐ Acidity as $CaCO_3$	Titrimetric	" " 305.1
☑ Alkalinity as $CaCO_3$ BICARBONATE	Titrimetric, pH 4.5	" " 310.1
☐ Bromide as Br	Titrimetric	" " 320.1
☐ Chloride as Cl	Titrimetric, Mercuric Nitrate	" " 325.3
☑ Chloride as Cl	Argentometric Method	1985 Std. Method 407 A
☐ Chlorine as Cl_2	DPD-Spectrophotometric	EPA Method 330.5
☐ Cyanide as CN (Total)	Colorimetric, Spectrophotometric	" " 335.2
☐ Fluoride as F	Colorimetric, SPDNS with Distillation	" " 340.1
☐ Iodide as I	Titrimetric	" " 345.1
☐ Nitrogen- Ammonia	Colorimetric; Titrimetric Distillation	" " 350.1
☐ Nitrogen-Kjeldahl(Total)	Colorimetric; Titrimetric(Distillation)	" " 351.3
☐ Nitrate-N	Colorimetric, Brucine	" " 352.1
☐ Nitrate-N	Colorimetric-Chromotropic Acid	1985 Std. Method 418 D
☐ Nitrate-N	Cadmium Reduction	1985 Std. Method 418 C
☐ Nitrate-Nitrite	Colorimetric, Cadmium REduction	EPA Method 353.3
☐ Nitrite	Spectrophotometric	" " 354.1
☐ Oxygen, Dissolved	Modified Winkler(Full Bottle Technique)	" " 360.2
☐ Phosphorous(All Forms)	Colorimetric, Ascorbic Acid(Single Reagent)	" " 365.3
☐ Silica as SiO_2(Dissolved)	Colorimetric	" " 370.1
☐ Sulfate as SO_4	Turbidimetric	" " 375.4
☐ Sulfide as $S^=$ (high H_2S)	Titrimetric, Iodine	" " 376.1
☐ Sulfide as $S^=$(Low H_2S)	Colorimetric, Methylene Blue	" " 376.2
☐ Sulfite as SO_3	Titrimetric	" " 377.1
D. ORGANICS(All units in mg/1)		
☐ BOD 5 day, 20°C)	Winkler Azide	" " 405.1
☐ Chemical Oxygen Demand(COD)	Titrimetric, Mid-Level	" " 410.1
☐ Chemical Oxygen Demand(COD)	Titrimetric, Low Level	" " 410.2
☐ Chemical Oxygen Demand(COD)	Titrimetric, High Level for Saline Waters	" " 410.3
☐ Oil and Grease(Total Recoverable)	Gravimetric, Separatory Funnel Extraction	" " 413.1
☐ Organic Carbon(Total) - TOC	Combustion-Infrared	" " 414.1
☐ Petroleum Hydrocarbons, Total	Freon Extraction- Silica Gel	1985 Std. Methods 503 E
☐ Phenolics, Total Recoverable	Spectrophometric, Manual 4-AAP-Distillation	EPA Method 420.1
☐ Methylene Blue Active Substances(MBAS)	Colorimetric, Methylene Blue	" " 425.1
☐ Pesticides	Gas Chromatographic	1985 Std. Method p.538
☐ Herbicides	" "	" " " p.550
E. RADIOLOGICAL:		
☐ Gross Alpha, pCi/1	Proportional Counter	" " " p. 640
☐ Gross Beta, pCi/1	" "	" " " p. 640
F. TOXICITY BIOASSAY		
☐ Lethal Concentration LC50	96-Hr. Static Bioassay	" " " p. 690

OTHERS:

Staal, Gardner & Dunne, Inc.
Consulting Engineers and Geologists
121 North Fir Street, Suite E,
Ventura, California 93001 (805) 653-5556

CHAIN OF CUSTODY RECORD

Date 3/13/89 Page 1 of 2

CLIENT MPWMD

ADDRESS

PROJECT NAME Lower Carmel River Hydrogeologic Assessment

PROJECT MANAGER Martin Feeney

PHONE NUMBER 653-5556

SAMPLERS: (Signature) Michael S Enke

	SAMPLE NUMBER	LOCATION DESCRIPTION	DATE	TIME	SAMPLE TYPE WATER Comp.	SAMPLE TYPE WATER Grab.	AIR	SOLID	NO. OF CNTNRS	TESTS REQUIRED
#89291	MW-1D	Carmel River State Beach	3/7/89	—		✓			1	EC, Chloride & Bicarbonate Ion Conc.
#89292	MW-1M	"	"	—		✓			1	"
#89293	MW-1S	"	"	—		✓			1	"
#89294	MW-2D	Mission Ranch	3/9/89	—		✓			1	"
#89295	MW-2M	"	"	—		✓			1	"
#89296	MW-2S	"	"	—		✓			1	"
#89297	MW-3D	Odello Field	3/[illegible]/89			✓			1	"

Relinquished by: (Signature) Michael S Enke
Received by: (Signature) Scott B
Date/Time 3/13/89 0913

Relinquished by: (Signature) Scott B
Received by: (Signature) Ray D. O
Date/Time

Relinquished by: (Signature)
Received by Mobile Laboratory for field analysis: (Signature)
Date/Time

Dispatched by: (Signature)
Date/Time
Received for Laboratory by: Ray D. O
Date/Time 3/13/89 9:58 AM

Method of Shipment:

Special Instructions: ~~Report Field EC~~

SOURCE: Adapted from U.S. EPA, 1985

Staal, Gardner & Dunne, Inc.
Consulting Engineers and Geologists
121 North Fir Street, Suite F,
Ventura, California 93001 (805) 653-5556

CHAIN OF CUSTODY RECORD

Date 3/13/89 Page 2 of 2

CLIENT MPWMD

ADDRESS

PROJECT MANAGER Martin Feeney

PHONE NUMBER

PROJECT NAME Lower Carmel River Hydrogeologic Assessment

SAMPLERS: (Signature)

	SAMPLE NUMBER	LOCATION DESCRIPTION	DATE	TIME	SAMPLE TYPE WATER Comp.	SAMPLE TYPE WATER Grab.	AIR	SOLID	NO. OF CNTNRS	TESTS REQUIRED
#89298	MW 3M	Odello Field	3/11/89	—		✓			1	EC, Chloride & Bicarbonate Ion
#89299	MW 3S	"	3/11/89			✓			1	"

Relinquished by: (Signature)	Received by: (Signature)	Date/Time 3/13/89 0913
Relinquished by: (Signature)	Received by: (Signature)	Date/Time
Relinquished by: (Signature)	Received by Mobile Laboratory for field analysis: (Signature)	Date/Time
Dispatched by: (Signature) Date/Time	Received for Laboratory by:	Date/Time 3/13/89 9:58

Method of Shipment:

Special Instructions:

SOU Adap om U PA, 1

APPENDIX D

STORAGE CALCULATIONS

FILE: LCAVOL
DATE: 4/15/89

CARMEL RIVER AQUIFER-COASTAL UNIT: STORAGE CALCULATIONS

SLICE (elevation)	AREA OF SLICE (acres)	SLICE THICKNESS (feet)	SPECIFIC YIELD %	STORAGE acre-feet
<(-200)	3.89	20.0	0.21	16.3
(-200)-(-180)	13.56	20.0	0.21	57.0
(-180)-(-160)	39.01	20.0	0.21	163.8
(-160)-(-140)	66.86	20.0	0.21	280.8
(-140)-(-120)	119.7	20.0	0.21	502.7
(-120)-(-100)	171.94	20.0	0.21	722.1
(-100)-(-80)	220.23	20.0	0.21	925.0
(-80)-(-60)	272.11	20.0	0.21	1142.9
(-60)-(-40)	296.43	20.0	0.21	1245.0
(-40)-(-20)	318.32	20.0	0.21	1336.9
(-20)-(0)	341.12	20.0	0.21	1432.7
				7825.3
0-(+3.5)	357.41	3.5	0.21	262.7

STORAGE BELOW SEA LEVEL (acre-feet)	7825.3
STORAGE ABOVE SEA LEVEL (acre-feet)	262.7
TOTAL STORAGE (acre-feet)	8088

88152
MBF

SGD

GROUND WATER IN STORAGE ABOVE SEA LEVEL —

— ACRES —

WATER LEVEL (Feet)	E	W	TOTAL
> 5.0	—	—	42.8
5.0 - 4.75	22.1	26.1	48.2
4.75 - 4.50	23.5	26.9	50.4
4.5 - 4.25	15.6	38.7	54.3
4.25 - 4.0	17.0	38.8	55.8
4.0 - 3.75	11.2	62.9	74.1
.75 - 3.5	-	32.8	32.8
3.5 - 3.0	-	7.1	7.1
			365.5

350	≥ 3.0'	= 1050
+ 7.1 @	+ 0.5	3.55
32.8 @	+ 0.75	24.6
74.1 @	+ 1.0	74.1
55.8	+ 1.25	69.75
54.3 @	+ 1.5	81.45
50.4 @	+ 1.75	88.2
48.2 @	+ 2.0	96.4
42.8 @	2.25	96.3
		1584.35 ACRE/FEET

1584.35 x 0.21 = **332.7 AF**

≅ 4.76 FEET W/ATER LEVEL.

APPENDIX E

ALTERNATIVE ANALYSIS

```
                       LCA-COASTAL UNIT: PROD WELL SIMULATION

                              GENERAL AQUIFER ANALYSIS


                      WELL DATA
                      LOCATION                   DISCHARGE            TIME PUMPING
                    X(FT)      Y(FT)               (GPM)                 (DAYS)
   NEW WELL          +0.0        +0.0              +620.00                 +0.0
   N.IMAGE        +4000.0        +0.0              +620.00                 +0.0
   S.IMAGE        -3000.0        +0.0              +620.00                 +0.0


                      OBSERVATION POINT DATA
                      LOCATION
                    XO(FT)       YO(FT)
                 -2000.0        +0.0
   2             -4000.0        +0.0
   3             -6000.0        +0.0
   4             -8000.0        +0.0


              AQUIFER CHARACTERISTICS
     HYDRAULIC CONDUCTIVITY (GPD/SQ FT) =  2000
     SPECIFIC YIELD =  .2
     AQUIFER THICKNESS (FT) =  200


 TIME=  120  DAYS
 OBSERVATION POINT  1  XO= -2000  FT, YO=  0  FT
 DRAWDOWN DUE TO WELL  1   NEW WELL =  .5190173  FT
 DRAWDOWN DUE TO WELL  2   N.IMAGE =  .1697951  FT
 DRAWDOWN DUE TO WELL  3   S.IMAGE =  .761135  FT
 TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.449947  FT
 TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.455246  FT

 OBSERVATION POINT  2  XO= -4000  FT, YO=  0  FT
 DRAWDOWN DUE TO WELL  1   NEW WELL =  .2887667  FT
 DRAWDOWN DUE TO WELL  2   N.IMAGE =  9.971382E-02  FT
 DRAWDOWN DUE TO WELL  3   S.IMAGE =  .761135  FT
 TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.149616  FT
 TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.152939  FT

 OBSERVATION POINT  3  XO= -6000  FT, YO=  0  FT
 DRAWDOWN DUE TO WELL  1   NEW WELL =  .1697951  FT
 DRAWDOWN DUE TO WELL  2   N.IMAGE =  5.729648E-02  FT
 DRAWDOWN DUE TO WELL  3   S.IMAGE =  .3817299  FT
 TOTAL DRAWDOWN IN CONFINED AQUIFER =  .6088215  FT
 TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  .6097565  FT

 OBSERVATION POINT  4  XO= -8000  FT, YO=  0  FT
 DRAWDOWN DUE TO WELL  1   NEW WELL =  9.971382E-02  FT
 DRAWDOWN DUE TO WELL  2   N.IMAGE =  3.187688E-02  FT
 DRAWDOWN DUE TO WELL  3   S.IMAGE =  .221011  FT
 TOTAL DRAWDOWN IN CONFINED AQUIFER =  .3526017  FT
 TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  .3529053  FT
```

```
TIME=  240  DAYS
OBSERVATION POINT  1  XO= -2000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .6393962  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .2704388  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .8835597  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.793395  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.801514   FT

OBSERVATION POINT  2  XO= -4000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .401311  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .1858521  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .8835597  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.470723  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.476166   FT

OBSERVATION POINT  3  XO= -6000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .2704388  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .1279133  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .4987778  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  .8971298  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  .8991547   FT

OBSERVATION POINT  4  XO= -8000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .1858521  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  8.738858E-02  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .3280285  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  .6012693  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  .6021729   FT


TIME=  360  DAYS
OBSERVATION POINT  1  XO= -2000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .710497  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .3346193  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .955347  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  2.000463  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  2.010574   FT

OBSERVATION POINT  2  XO= -4000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .4697323  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .244539  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .955347  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.669618  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.676651   FT

OBSERVATION POINT  3  XO= -6000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .3346193  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .1802306  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .5687493  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.083599  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.086548   FT

OBSERVATION POINT  4  XO= -8000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .244539  FT
```

```
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .1328631  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .3945073  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  .7719094  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  .773407  FT


TIME=  480  DAYS
OBSERVATION POINT  1  XO= -2000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .761135  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .3817299  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  1.006329  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  2.149194  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  2.160874  FT

OBSERVATION POINT  2  XO= -4000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .5190173  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .2887667  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  1.006329  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.814113  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.822418  FT

OBSERVATION POINT  3  XO= -6000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .3817299  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .221011  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .6188191  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.22156  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.225311  FT

OBSERVATION POINT  4  XO= -8000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .2887667  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .1697951  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .4428017  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  .9013635  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  .9034119  FT


TIME=  500  DAYS
OBSERVATION POINT  1  XO= -2000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .8004933  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .4189499  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  1.045894  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  2.265337  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  2.278305  FT

OBSERVATION POINT  2  XO= -4000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .5575596  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .3242115  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  1.045894  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.927665  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.937042  FT

OBSERVATION POINT  3  XO= -6000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .4189499  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .2542977  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .6578353  FT
```

```
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.331083   FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.335541   FT

OBSERVATION POINT  4  X0= -8000  FT, Y0=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .3242115  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .2006227  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .4807432  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.005577   FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.008118   FT


TIME=  720  DAYS
OBSERVATION POINT  1  X0= -2000  FT, Y0=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .8326928  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .4497146  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  1.078231  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  2.360639   FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  2.374741   FT

OBSERVATION POINT  2  X0= -4000  FT, Y0=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .5892133  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .3537734  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  1.078231  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  2.021216   FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  2.03154   FT

OBSERVATION POINT  3  X0= -6000  FT, Y0=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .4497146  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .2823823  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .6898062  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.421903   FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.427002   FT

OBSERVATION POINT  4  X0= -8000  FT, Y0=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .3537734  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .2270017  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .5119937  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.092769   FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.095779   FT
```

```
                 LCA-COASTAL UNIT: PROD WELL SIMULATION

                          GENERAL AQUIFER ANALYSIS


                 WELL DATA
                 LOCATION                       DISCHARGE               TIME PUMPING
              X(FT)      Y(FT)                    (GPM)                   (DAYS)
  NEW WELL       +0.0       +0.0                 +620.00                   +0.0
  N.IMAGE     +4000.0       +0.0                 +620.00                   +0.0
  S.IMAGE     -3000.0       +0.0                 +620.00                   +0.0


                 OBSERVATION POINT DATA
                 LOCATION
              XO(FT)       YO(FT)
 1           -2000.0        +0.0
 2           -4000.0        +0.0
 3           -6000.0        +0.0
 4           -8000.0        +0.0


        AQUIFER CHARACTERISTICS
  HYDRAULIC CONDUCTIVITY (GPD/SQ FT) =  2000
  SPECIFIC YIELD =  .2
  AQUIFER THICKNESS (FT) =  200


TIME=  120  DAYS
OBSERVATION POINT  1  XO= -2000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .5190173  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .1697951  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .761135  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.449947  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.455246  FT

OBSERVATION POINT  2  XO= -4000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .2887667  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  9.971332E-02  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .761135  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.149616  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.152939  FT

OBSERVATION POINT  3  XO= -6000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .1697951  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  5.729648E-02  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .3817299  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  .6088215  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  .6097565  FT

OBSERVATION POINT  4  XO= -8000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  9.971362E-02  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  3.167688E-02  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .221011  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  .3526017  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  .3529053  FT
```

```
TIME=  240  DAYS
OBSERVATION POINT  1  XO= -2000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .6393962  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =   .2704388  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .8835597  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.793395  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.801514  FT

OBSERVATION POINT  2  XO= -4000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .401311  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .1858521  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .8835597  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.470723  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.476166  FT

OBSERVATION POINT  3  XO= -6000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .2704388  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .1279133  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .2987778  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  .6971298  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  .6991547  FT

OBSERVATION POINT  4  XO= -8000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .1858521  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  8.738858E-02  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .3280285  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  .6012693  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  .6021729  FT


TIME=  360  DAYS
OBSERVATION POINT  1  XO= -2000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .710497  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .3346173  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .955347  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  2.000461  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  2.010574  FT

OBSERVATION POINT  2  XO= -4000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .4697323  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .244539  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .955347  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.669618  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.676631  FT

OBSERVATION POINT  3  XO= -6000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .3346173  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .1802306  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .5687493  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.083599  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.086548  FT

OBSERVATION POINT  4  XO= -8000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .244539  FT
```

```
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .1328631  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .3945073  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  .7719094  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  .773407  FT


TIME=  460  DAYS
OBSERVATION POINT  1  X0= -2000  FT, Y0=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .761135  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .3817299  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  1.006329  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  2.149194  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  2.160874  FT

OBSERVATION POINT  2  X0= -4000  FT, Y0=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .5190173  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .2887667  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  1.006329  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.814113  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.822416  FT

OBSERVATION POINT  3  X0= -6000  FT, Y0=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .3817299  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .221011  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .6188191  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.22156  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.225311  FT

OBSERVATION POINT  4  X0= -8000  FT, Y0=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .2587667  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .1697751  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .4428017  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  .9015635  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  .9034117  FT


TIME=  500  DAYS
OBSERVATION POINT  1  X0= -2000  FT, Y0=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .8004933  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .4189499  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  1.045894  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  2.265337  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  2.278305  FT

OBSERVATION POINT  2  X0= -4000  FT, Y0=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .5570096  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .3242113  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  1.045894  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.927445  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.937042  FT

OBSERVATION POINT  3  X0= -6000  FT, Y0=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .4189499  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .2542977  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .6578353  FT
```

```
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.331083  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.335541  FT

OBSERVATION POINT  4  XO= -8000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .3242115  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .2006227  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .4807432  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.005577  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.008118  FT


TIME=  720  DAYS
OBSERVATION POINT  1  XO= -2000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .8326928  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .4497146  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  1.078231  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  2.360639  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  2.374741  FT

OBSERVATION POINT  2  XO= -4000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .5892133  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .3537734  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  1.078231  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  2.021218  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  2.03154  FT

OBSERVATION POINT  3  XO= -6000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .4497146  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .2823823  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .6898062  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.421903  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.427002  FT

OBSERVATION POINT  4  XO= -8000  FT, YO=  0  FT
DRAWDOWN DUE TO WELL  1   NEW WELL =  .3537734  FT
DRAWDOWN DUE TO WELL  2   N.IMAGE =  .2270019  FT
DRAWDOWN DUE TO WELL  3   S.IMAGE =  .5119937  FT
TOTAL DRAWDOWN IN CONFINED AQUIFER =  1.092769  FT
TOTAL DRAWDOWN CORRECTED FOR WATER TABLE =  1.095779  FT
```

88152/MBF

MW-1 WATERLEVEL ELEV. = + 1.0

GRADIENT $1/420$ $= 0.0023$

$K = ,0031$

$q = (0031)(,0023)(70) = 0,00052$

$$z = \left(\frac{(40)(.0005)}{(,0031)}\right) \left(\frac{2(40)(,00052)(x)}{(0,0031)}\right)^{1/2}$$

$$(6.7) + (13.4\ (x))^{1/2}$$

x				z
0	6.7	+	0	6.7
25	6.7	+	18,3	25,0
50	6.7	+	25,8	32.5
100	6.7	+	36.6	43.3
200	6.7	+	51,7	58.4
300	6.7	+	63.4	70.1
400	6.7	+	73,2	79.9
450	6.7	+	77.6	84.3

88152/MBR

GRADIENT 0.008 WATER LEVEL @ MW-1 3.3

$K =$ 0.0031

$q = (.0031)(.008)(70\text{ FT}) = 0.0017$

$$z = \frac{40(.0017)}{(.0031)} + \left(\frac{2(40)(.0017)(x)}{(0.0031)}\right)^{1/2}$$

$$= 21.9 + (43.9)$$

x				z
0	21.9	+	—	21.9
25	"		33.12	55.02
50	"		46.8	68.7
100	"		66.18	88.08
200	"		93.3	115.2
300	"		114.7	136.6
400	"		132.5	154.4
430	"		140.5	162.4

88152/MBF

WATER LEVEL @ MW-1 = 2.0

GRADIENT CHANGE TO $\quad 2/420 = .0047$

$K = .0031$

$q = (.0031)(.0047)(70) = 0.001$

$\therefore$

@ 420

$$\left(\frac{(40)(.001)}{0.0031}\right) + \left(\frac{2(40)(.001)(420)}{(.0031)}\right)$$

$$(12.9) \qquad \left(25.8\,(x)\right)^{1/2}$$

x			z
0	12.9		12.9
25	"	25.4	38.3
50	"	35.9	48.8
100	"	50.8	63.7
200	"	71.8	84.7
300	"	87.9	100.8
400	"	101.6	114.5
450	"	107.7	120.6

68152

Return to MF

60

MB

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT
187 Eldorado • Suite E • P.O. Box 85 • Monterey, CA 93940 • (408) 649-4866

TRANSMITTAL

TO: Martin Feeney
Staal, Gardner & Dunne Inc
121 N. Fir Street, Suite F
Ventura, CA 93001

DATE: 3/22/89

RE: Copy of Clark (1989) summary report on Cypress Point Fault

WE ARE SENDING YOU:

✓ DOCUMENTS

___ DOCUMENTS YOU REQUESTED

___ COPY OF LETTER

___ AGREEMENT OR CONTRACT

___ OTHER

THE ABOVE ITEMS ARE SUBMITTED:

☐ At your request

☐ For your information and files

☐ For your approval

☐ Please review and comment

☐ For your action

☐ Please sign and return

☐ Please telephone me

REMARKS: Please review & comment

COPIES TO:

Thanks,

BY: Joe Oliver

Geoscience Department
Indiana University of Pennsylvania
114 Walsh Hall
Indiana, Pennsylvania 15705-1087

(412) 357-2379

IUP

March 9, 1989

Monterey Peninsula Water
  Management District
187 El Dorado Street, Suite E
Monterey, California 93940

RECEIVED
MAR 1 3 1989
M.P.W.M.D.

Attention: Mr. Joe Oliver
District Geohydrologist

Subject: Geologic analysis of the Cypress Point fault in the vicinity of the lower Carmel River Valley.

As a result of our telephone conversation of February 7, 1989, I agreed to evaluate the Cypress Point fault as it might effect the bedrock geometry in connection with your ongoing investigation of possible salt water intrusion of the lower Carmel River Valley aquifer.

Procedure. This present study consisted of the following five parts:

(1) review of all published geologic work on this and related faults and of my 1973 field work,

(2) two field days mapping the possible southeastward continuation of this fault across the Palo Corona Ranch and along San Jose Creek canyon to the south,

(3) two one-half days examining the fault exposures east of Cypress Point and at Carmel Point,

(4) study of aerial photography coverage (4/12/85 - 4/13/85) of the area, and

(5) local revision of the geologic map of Clark and others (1974).

Mapping. Lawson (1893) first described the exposure of this fault at Pescadero Point, where he interpreted the Carmelo "Series" (Paleocene) as having been downdropped to the east against the granite. Bowen (1969) mapped this fault from Pescadero Point 1.7 miles northwestward to Cypress Point and showed the northeastern side as relatively downthrown. Bowen (1969) also mapped an unnamed fault that separates granodiorite and basalt at Carmel Point, which he extended southeastward and eastward as a concealed fault beneath the Carmel River Valley

Based on offshore work, Clark and others (1974) reported:

> Seismic profiles offshore indicate that the fault extends continuously northwestward as a single fault from Cypress Point for about 2 miles and then discontinuously as a zone of en echelon faults for another 2 miles to the southern wall of Monterey Canyon. The fault is identified in the seismic reflection profiles principally from juxtaposition of sediments of Quaternary or Tertiary age against granodiorite and from linear topographic features on the sea floor.

Clark and others (1974) extended the Cypress Point fault southeastward across Carmel Bay to join the fault at Carmel Point, where vesicular basalt flows and basaltic flow-breccias (dated at 27.0 m.y. by Clark and others, 1984) are faulted against Cretaceous granodiorite to the southwest. They showed this fault continuing to the southeast, where it was concealed beneath Quaternary sediments, and postulated that it separated basalt mapped by Lawson (1893), but no longer exposed, from presumably granitic basement to the southwest.

Recent mapping by William Dupré (written communication, 1989) delineates three en echelon faults east of Cypress Point with possible right-lateral strike-slip displacement. My recent mapping east of Carmel Point suggests an en echelon fault about 400 feet east of the earlier mapped fault that separates Oligocene basalts to the west from probable Paleocene Carmelo Formation to the east (see attached map).

As presently mapped, the Cypress Point fault trends northwest-southeast for as much as 7.5 miles. Its extension to the southeast of Carmel Point is still in doubt, although Logan (1983) has stated that "The inferred extension to the southeast is supported by the borehole records...."

My recent field work on the Palo Corona Ranch and along San Jose Creek canyon to the southeast has failed to reveal any significant structural or stratigraphic discordances that would permit the extension of this fault southeastward to San Jose Creek canyon and its possible continuation to the Blue Rock -- Miller Creek fault zone, as delineated by Ross (1976).

Displacement. The main strand of the Cypress Point fault juxtaposes the Carmelo Formation with granodiorite at Pescadero Point and basalt with granodiorite at Carmel Point, suggesting that the northeast side is relatively downthrown. The actual amount of dip-slip separation may be small as the Carmelo locally rests depositionally on the granodiorite, and the basalt also appears to rest on the granodiorite north of San Jose Creek (see attached map). At Carmel Point the dip-slip separation may be less than 65 feet, as Bowen (1965) has estimated the basalt to be 50 to 60 feet thick, and Clark and others (1984) have estimated these volcanics to be 65 feet thick.

Several lines of evidence suggest right-lateral displacement on the Cypress Point fault. Dupré (written communication, 1989) has postulated right-lateral strike-slip displacement east of Cypress Point. The relatively straight trend, its en echelon character, and the parallelism of this fault to faults of the Monterey Bay fault zone, on which first-motion studies indicate right-slip, support this latter interpretation.

Time of Movement. Clark and others (1974) suggested that movement along the Cypress Point fault occurred before the Quaternary. East of Carmel Point, however, the terrace platform surface appears to be more than three feet higher above the basalt northeast of the fault than on the granodiorite to the southwest. This apparent elevation difference could have resulted from late Quaternary movement, as McKittrick (1988) has suggested an age of about 100,000 years b.p. for this lowest terrace. Alternatively, this elevation difference across the fault could result from deposition on an irregular platform surface.

Effect on Barrier. If dip-slip displacement along the Cypress Point fault did produce a relatively upthrown granitic barrier near the mouth of the Carmel River, Pleistocene erosion most probably trenched this barrier. During the last glacial maximum 16,000 to 18,000 years b.p., most coastal streams incised their channels to below present-day levels. Dupré (oral communication, 1989) estimates that the Pajaro River incised its channel to more than 205 feet below present sea level, whereas Schwartz and others (1986) estimate that Elkhorn Valley incised a stream channel more than 125 feet below present-day sea level. Likewise, the Carmel River would have incised its valley at that time with the probable amount of incision being somewhere between that of Elkhorn Valley and the Pajaro River. Submarine contours on the map of Clark and others (1974) delineate a tributary of the Carmel submarine canyon trending toward the mouth of the Carmel River, which also supports that interpretation that this river incised a channel into the granitic basement.

Thus, the granitic headland south of the mouth of the Carmel River most probably does not produce a barrier to salt water intrusion. The present scarp between this granitic headland and Quaternary alluvium to the northeast may well be the result of differential Pleistocene erosion facilitated by les resistant sheared bedrock along the southeastward projection of the Cypress Point fault.

Recommendations. (1) Geophysical exploration is warranted at the mouth of Carmel River to determine the depth of incision of the postulated granitic barrier. (2) Careful inspection by an experienced geologist of bedrock samples obtained by exploratory drilling beneath Quaternary alluvium near the mouth of Carmel River, including the differentiation of basalt from granodiorite, will be necessary to delineate the earlier postulated southeastward extension of the Cypress Point fault.

Joseph C. Clark
Geologist

References and map attached.

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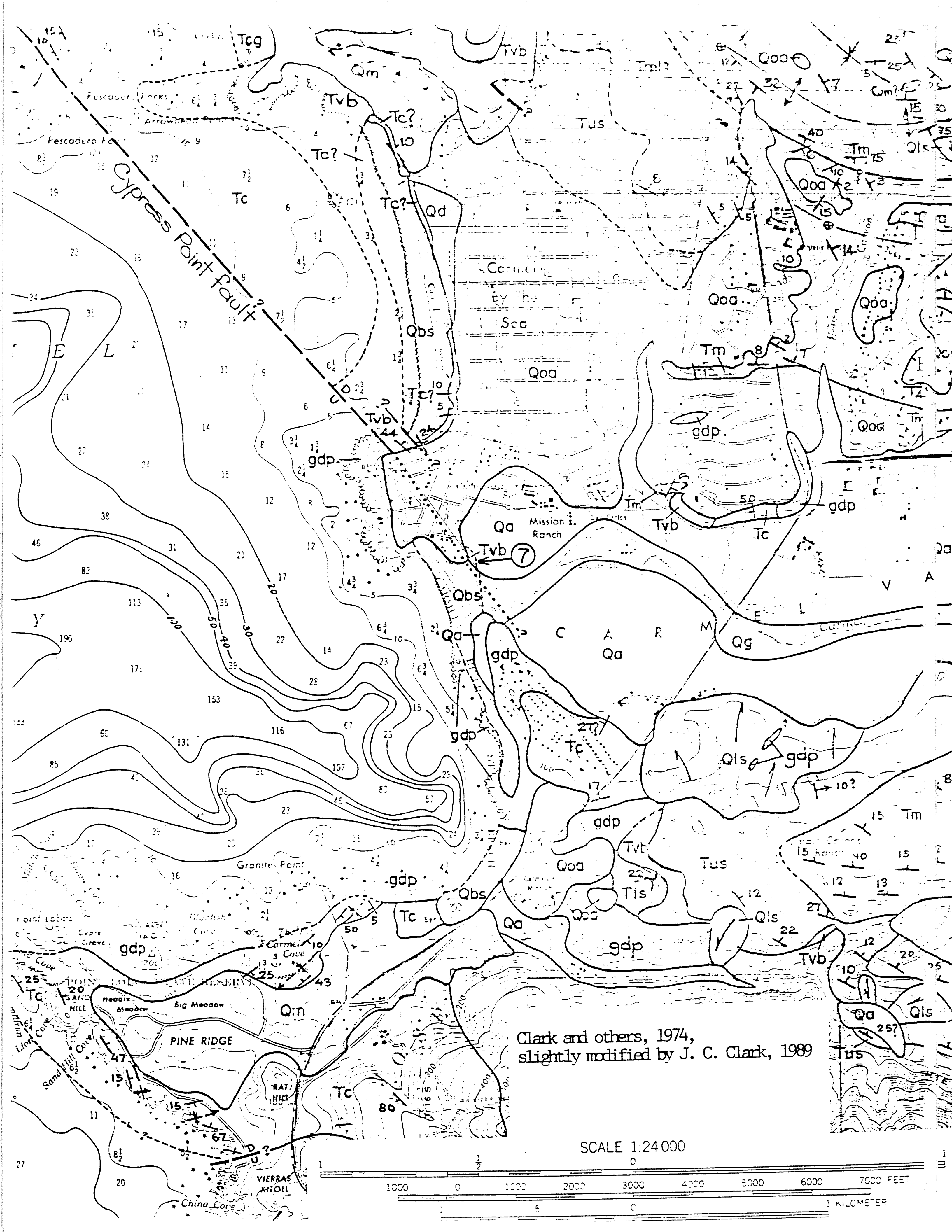


Clark and others, 1974,
slightly modified by J. C. Clark, 1989

DESCRIPTION OF MAP UNITS

	SURFICIAL SEDIMENTS
Qbs	Beach sand; near Carmel Beach includes (near-shore) sands just offshore
Qg	River sand and gravel
Qd	Dune sand
Qa	Alluvium
Qls	LANDSLIDE DEBRIS Some or parts of some may be very young and possibly actively moving. Half arrows show direction of downslope movement
	OLDER SURFICIAL SEDIMENTS (DISSECTED)
Qod	Older dune sand
Qoa	Older alluvium and terrace gravel and sand; at Monterey contains Pholas-bored pebbles at base and into underlying Monterey Shale
Qm	Marine terrace sand and gravel
Qar	AROMAS SAND (Pleistocene) Aromas Red Sands of Allen (1946) and Bowen (1965). Nonmarine; yellowish-brown to grayish-orange fine sand
QTp	PASO ROBLES FORMATION (Pliocene(?) and Pleistocene) Old alluvium deposited in a valley. Light-gray gravel, sand, and clay
QTs	*SEDIMENTARY DEPOSITS Seismic characteristics suggest poorly bedded sands and gravels; stratigraphic position unknown
Ts	*SEDIMENTARY ROCKS Mudstone and coarse-grained, arkosic sandstone; marine; middle or late Tertiary
Tsm	SANTA MARGARITA(?) SANDSTONE (Miocene) Marine and brackish-marine, white, friable, fine- to coarse-grained, arkosic sandstone; upper Miocene, possibly lower Pliocene
	MONTEREY SHALE (Miocene) Siliceous marine deposits
Tmd	Diatomite (Canyon del Rey Diatomite Member of Bowen, 1965), white, soft, punky, commonly silty; Delmontian Stage[1/] (type) of Kleinpell (1938), upper Miocene
Tm	Siliceous shale (Aquajito Shale Member of Bowen, 1965), light-brown to white, hard, brittle, platy; Mohnian Stage, upper Miocene
Tml	Semi-siliceous shale, thin-bedded, yellowish-brown, foraminiferal; includes interbedded yellowish-brown siltstone; Luisian Stage, middle Miocene
Tss	MARINE SANDSTONE Buff to light-gray, friable arkosic sandstone; locally pebbly; in San Jose Canyon area contains interbedded conglomerate; middle Miocene; possibly in part upper and lower Miocene
Tus	Sandstone as above, upper part (mapped as Los Laureles Sandstone Member of Monterey Formation by Bowen, 1965)
Tvb	Volcanic rocks. Flows and flow-breccias of basalt and basaltic andesite (carmeloite of Lawson, 1893)
Tls	Sandstone as above, lower part (mapped as Los Tularcitos Member of Chamisal Formation by Bowen, 1965)
Trc	RED BEDS OF ROBINSON CANYON Robinson Canyon Member of Chamisal Formation of Bowen (1965). Terrestrial; red to gray arkosic sandstone, siltstone, and conglomerate; middle and possibly lower Miocene
Tc	CARMELO FORMATION OF BOWEN (1965) (Paleocene) Carmelo Series of Lawson (1893); marine; interbedded sandstone, siltstone, mudstone, and cobble-pebble conglomerate
Tcg	Cobble and boulder conglomerate, mostly of granitic detritus
	GRANITIC ROCKS Light-gray crystalline rocks composed of about 2/3 feldspars, 1/3 quartz, and small amounts of biotite and hornblende; age, Cretaceous(?)
gdp	granodiorite, porphyritic
gd	Granodiorite
*qd	Quartz diorite
ms	METAMORPHIC ROCKS Biotite schist-gneiss and mixtures of granitic rocks

APPENDIX F

ADDENDUM TO HYDROGEOLOGIC INVESTIFATION "COASTAL CARMEL RIVER AQUIFER", DATED MAY 1989; DRILLING OF TEST HOLE NO. 6, CARMELO ROAD, CARMEL, CALIFORNIA

Staal, Gardner & Dunne, Inc.

SGD Consulting Engineers and Geologists

Monterey Peninsula Water Management District
Post Office Box 85
Monterey, California 93940

May 3, 1989

Reference: 88152

Attention: Mr. Joe Oliver
District Geohydrologist

Subject: Addendum to Hydrogeologic Investigation "Coastal Carmel River Aquifer", dated May 1989; Drilling of Test Hole No. 6, Carmelo Road, Carmel, California.

Dear Mr. Oliver:

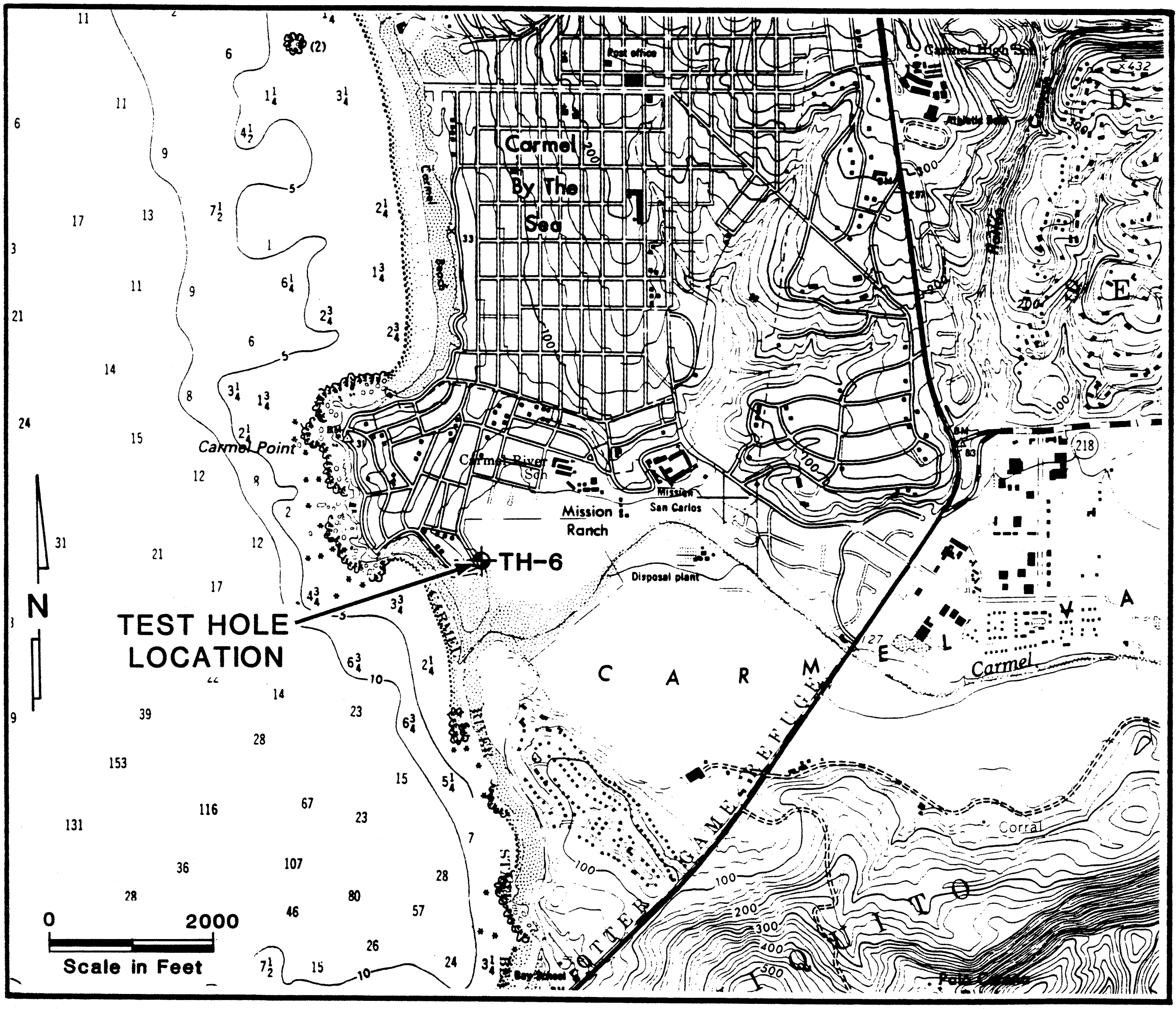
Presented in this brief letter-report are the findings and conclusions arising from the drilling of a exploratory drill hole along Carmelo Road, near the Carmel River Beach State Park parking lot. The location of the drill hole is shown on Figure 1 - Site Location Map. As you are aware, the drill hole was the sixth and final drill hole included in our scope of work for the coastal Carmel River Aquifer assessment and was drilled to further define the geology and structure of the basin and specifically, to refine the location of the Cypress Point fault.

The drill hole was drilled on April 24, 1989 utilizing a truck-mounted and rotary drill rig owned and operated by Salinas Pump Company of Salinas, California. The drill hole was logged by a SGD field geologist and bulk samples collected at regular intervals. The lithologic log compiled is attached. Upon completion, the drill hole was backfilled with cuttings.

Review of the lithologic log reveals that the drill hole encountered beach sand to a depth of 15 feet at which depth basalt was encountered. The basalt, as encountered, was slightly weathered displaying an iron oxide varnish where exposed. Fresh surfaces revealed a grey matrix with phenocrysts of olivine. Below a depth of 17 feet penetration was extremely slow and drilling was therefore terminated upon reaching a depth of 19 feet. No ground water was detected in the drill hole during drilling operations, although at a depth of 18 feet there was some evidence of increasing moisture. This is consistent with the water level contours presented in the May 1989 report suggesting water levels in this area of the basin of approximately +3.0 to 4.0 feet in elevation. The elevation of TH-6 is estimated at 17 feet, therefore the elevation of the bottom of the drill hole is approximately -2.0 feet, or approximately 5 feet below the projected water table. The absence of significant amounts of water is likely

FIGURE 1

SITE LOCATION MAP



the result of the low permeability of the basalt and the tendency for the air rotary method "dry-out" the first evidence of water.

The presence of volcanic rock at this location confirms the work of Lawson (1893) who mapped basalt at this location, based on an outcrop which was subsequently obscured by dense vegetation. The presence of volcanics at this location also supplements the geomorphic data for the extension of the Cypress Point fault to the south. Clark (1989) suggests that volcanics exist only to the east of the fault based on exposures to the north at Carmel Point. Volcanic basalt of similar lithologic character was also encountered in Test Hole #3, located along the western fence line of Mission Ranch. The presence of volcanics in that location suggests that in the northwest portion of the basin the Santa Lucia granite may be overlain with a veneer of volcanics. This interpretation is further supported by the outcrop of basalt mapped by Clark just north of Mission Ranch on Rio Road.

We believe that although the findings arising from the drilling of TH-6 add significantly to the geologic data available for interpretation of the regional geology of the area, the findings have little, if any, bearing on the hydrogeology of the study area. Therefore it is our belief that the conclusions and recommendations of the subject report are still valid.

We appreciate the opportunity to be of service. Please do not hesitate to call, if you have any questions.

Sincerely,

STAAL, GARDNER & DUNNE, INC.

Martin B. Feeney
Certified Engineering Geologist 1454

MBF:av/27

Enclosure: Lithologic Log

LOG OF DRILL HOLE

JOB NO. : 88152A
PROJECT : MPWMD, Lower Carmel River
LOCATION: Carmelo Road
DRILLING METHOD: Rotary Air - 6"

LOGGED BY : M. S. Burke
DRILLED BY: Salinas Pump
TIME START: 1000 4/24/89
TIME STOP : 1130 4/24/89

DRILL HOLE NO.: TP-6
DRILLING DATE : 4/24/89
DATUM: MSL
REFERENCE EL. : 17.0 feet (approx.)

ELEVATION (FEET) DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNT (BLOWS PER FOOT)	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	Atterberg Limits		TORVANE (TSF)	POCKET PENETROMETER (TSF)	ADDITIONAL TESTS
								LIQUID LIMIT (%)	PLASTIC LIMIT (%)			
					BEACH SAND (Qs) SAND (SW), brown, loose, dry, fine- to coarse-grained, subangular to subrounded, predominantly quartz, with minor fine to coarse subangular gravel and common organic material fragments (twigs, leaves, etc.)							
5												
10												
10												
					moist							
15												
0					**UNNAMED VOLCANICS (Tvb)** BASALT (Rx), moderately weathered, gray to olive gray, moderately hard, common reddish brown, phenocrysts, biotite, dry very hard, moist							
					Bottom of drill hole at a depth of 19 feet. No ground water encountered. Drill hole backfilled.							

SHEET 1 OF 1

LEGEND TO LOGS ON PLATE A-2

PLATE A-1.1