The Earth Technology Corporation

June 1989

Geotechnical Report

Metro Rail LPA Phase II • Design Unit B210

Prepared for
METRO RAIL TRANSIT CONSULTANTS
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Los Angeles CA 90013

Prepared by
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June 22, 1989

Metro Rail Transit Consultants
548 South Spring Street, 7th Floor
Los Angeles, California 90013

Attention: Dr. James E. Monsees, Chief Tunnel Engineer

Subject: Draft Geotechnical Report
Design Unit B210
LPA Phase II, Metro Rail Project
Contract No. 1012
Earth Technology Project No. 89-409

Gentlemen:

Enclosed please find five copies of the subject draft report for your review and comments.

Please note that the draft is subject to revision based on your comments and our internal quality assurance reviews. We anticipate being able to submit a final report within two weeks after receiving your comments.

Very truly yours,

THE EARTH TECHNOLOGY CORPORATION (Western)

Bill T. D. Lu, Ph.D., P.E.
Associate

BTL/ebr

Enclosure

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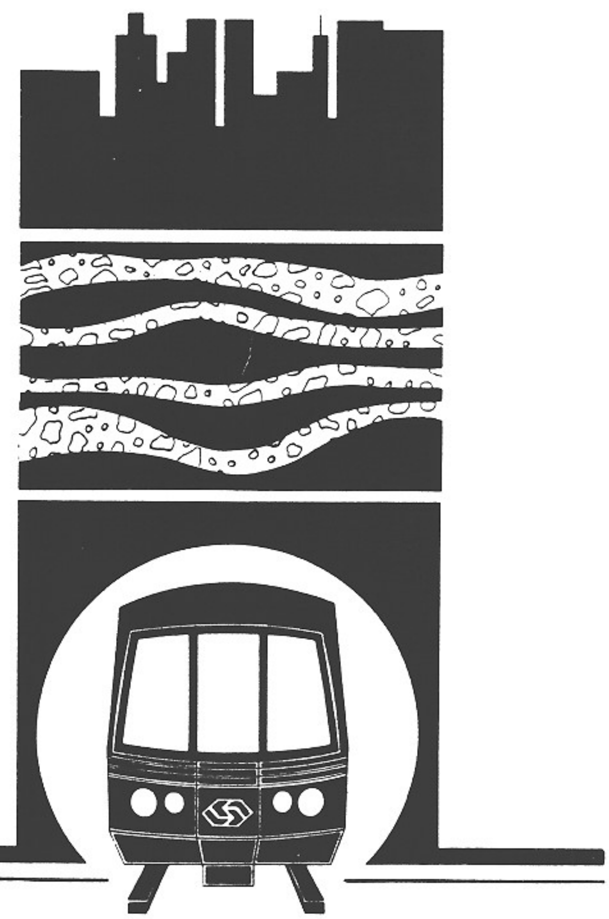

Geotechnical Report

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1.0 Executive Summary

1.0 EXECUTIVE SUMMARY

This report presents the results of a geotechnical investigation for the design of the planned Wilshire/Vermont Station, which is part of the Metro Rail LPA Phase II alignment. The investigation consisted of field exploration and testing, soil mechanics laboratory and chemical laboratory testing, and geotechnical engineering evaluation of subsurface materials and groundwater conditions.

The subsurface conditions at the station, as encountered during this investigation, are relatively uniform and generally consist of 25 to 34 feet of stiff to very stiff fine-grained and dense to very dense granular Old Alluvium overlying Puente Formation bedrock, with shallow perched groundwater within the granular Old Alluvium. Puente Formation bedrock is the major foundation support for the station structure and consists primarily of claystone or clayey siltstone with omnipresent, dipping, thin and weak sandstone beds. The overall engineering properties of Puente Formation bedrock are generally similar to those associated with highly overconsolidated hard and dense soils. However, the thin and weak sandstone beds and bedding planes in the bedrock, if continuous, can potentially become the weakest sliding failure surfaces and preferred groundwater flow pathways.

The observed subsurface conditions can provide excellent foundation support for the planned station structures. The required station excavation can be accomplished relatively rapidly using mechanical excavation techniques and readily available equipment. Geotechnical evaluation for various engineering aspects of station design and construction are summarized below:

1. Dewatering: The presence of shallow perched groundwater in the relatively permeable granular Old Alluvium indicates that dewatering will most likely be needed. Although a detailed hydrological analysis will be needed, we anticipate that drawdown of the groundwater level below the Old Alluvium can be accomplished by well points or deep wells, and the volume of inflow into the excavation during construction can be handled by a drain/pump system. It is also anticipated that dewatering-induced subsidence would be small and should not cause adverse impacts on adjacent buildings.

2. Shoring: Due to the planned station's proximity to existing buildings and limited construction space, shoring will be required

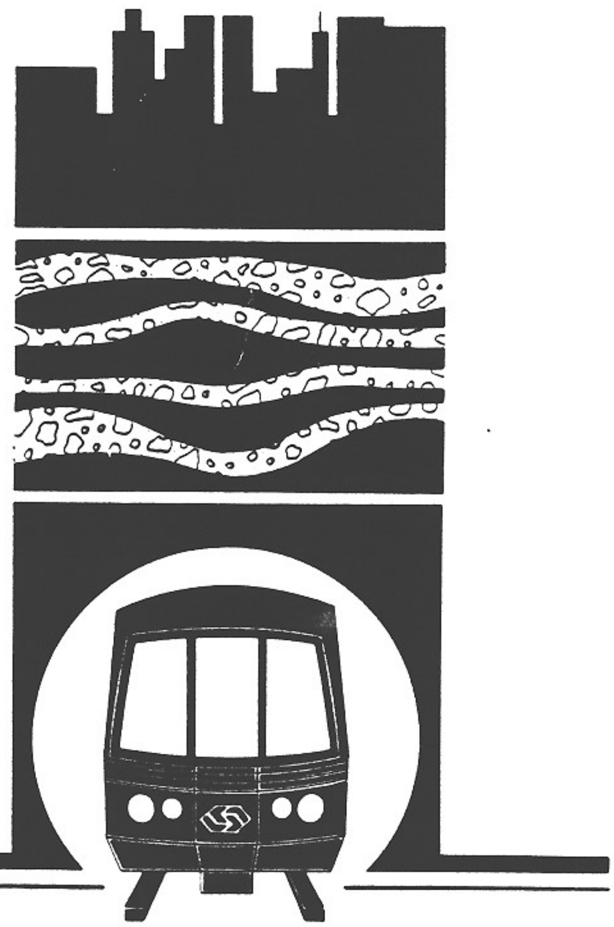
for station excavation and construction. Based on subsurface conditions and cost considerations, the contractor will most likely utilize drilled soldier piles with tiebacks or internal bracing for lateral support. Accordingly, design inputs for these shoring types are presented.

3. Underpinning: Underpinning requirements for most of the adjacent buildings may be minimial if the building surcharges are properly incorporated into the shoring design. One potential exception is the 10-story Borex Building at 3075 Wilshire Boulevard, which requires further assessment for underpinning needs.

4. Foundation Design: The main station structure can be adequately supported on Puente Formation bedrock using a mat foundation. Spread footings can be used as supports for other structural components of the structure. Recommended loads on walls, roof, and slabs of the structure are also presented in this report.

5. Material Handling: It is unlikely that excavated materials will require special hazardous cleanup or handling. Extensive treatment of pumped groundwater prior to disposal is not anticipated; however, this issue may require further chemical testing and coordination with the California Regional Water Quality Control Board.

6. Health and Safety: Although not detected during the field investigation in the station area, the potential for harmful concentrations of methane and hydrogen sulfide in the study area cannot be eliminated. Methane and hydrogen sulfide should be continuously monitored during station excavation and construction. Proper ventilation should be maintained continuously to prevent accumulation of these gases and to minimize the effects of dust generated during construction.



2.0 Introduction

2.0 INTRODUCTION

2.1 GENERAL

This report presents the results of a geotechnical investigation for Design Unit B210, which consists of the planned Wilshire/Vermont Station and its adjacent ancillary facilities. The station is part of the Metro Rail Phase II alignment, which is the second portion of what is now known as the "Locally Preferred Alternative" (LPA). The LPA Phase II consists of 11 stations and 12.9 miles of tunnel. The location of the Wilshire/Vermont station with respect to the Phase II alignment is shown in Figure 2-1. This investigation was performed to evaluate subsurface soils and groundwater conditions at the station. The results will be used for detailed design of the station.

2.2 LOCATION/ALIGNMENT AND PLANNED CONSTRUCTION

Engineering efforts undertaken by MRTC for planning and design of the Wilshire/Vermont Station have been initiated and are ongoing. The location and alignment of the station have been subjected to some revisions as the engineering work progresses. Figure 2-2 shows the current new location and alignment of the station, which were finalized in May 1989. As shown in this figure, the station will consist of two main components: the main structure (with ancilliary facilities), and entrances/mezzanine/platforms leading to the rail facilities. The planned location/alignment of the rail facilities in the station and ancillary facilities starts at Wilshire Boulevard, about 220 feet east of Shatto Place, trends northwest (about N 56° W), traverses Shatto Place, and terminates just south of the Vermont Avenue/Sixth Street intersection. As shown in Figure 2-2, the corridor of mezzanine/platforms with north and south entrances trends east-west, and intersects at about the midpoint of the main station alignment.

The planned station is located in a developed commercial and residential area. The ground surface in the station area is essentially paved, with little, if any, vegetative cover. From the southeast end to a distance of about 600

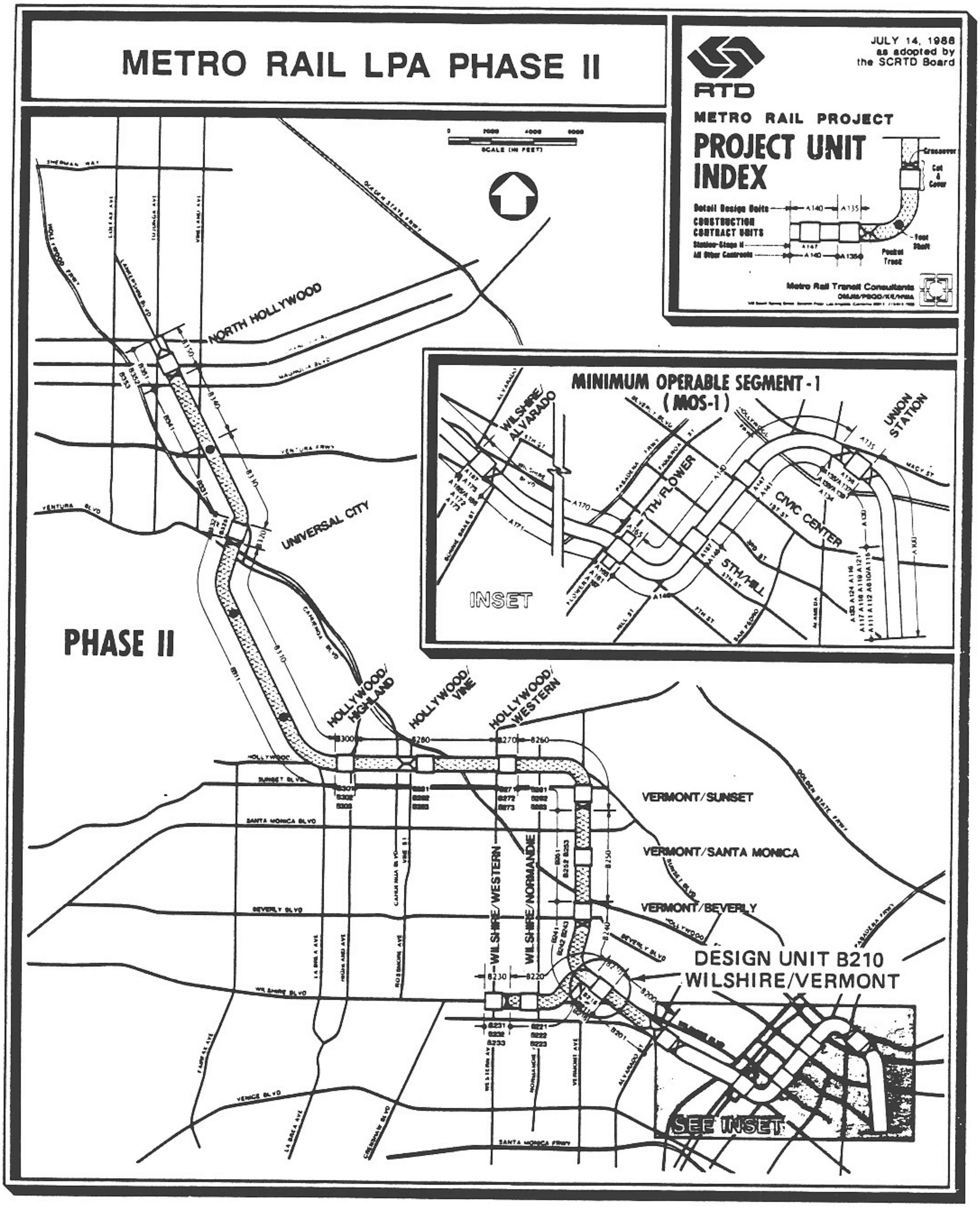


FIGURE 2-1 LOCALLY PREFERRED ALIGNMENT AND LOCATION OF DESIGN UNIT B210

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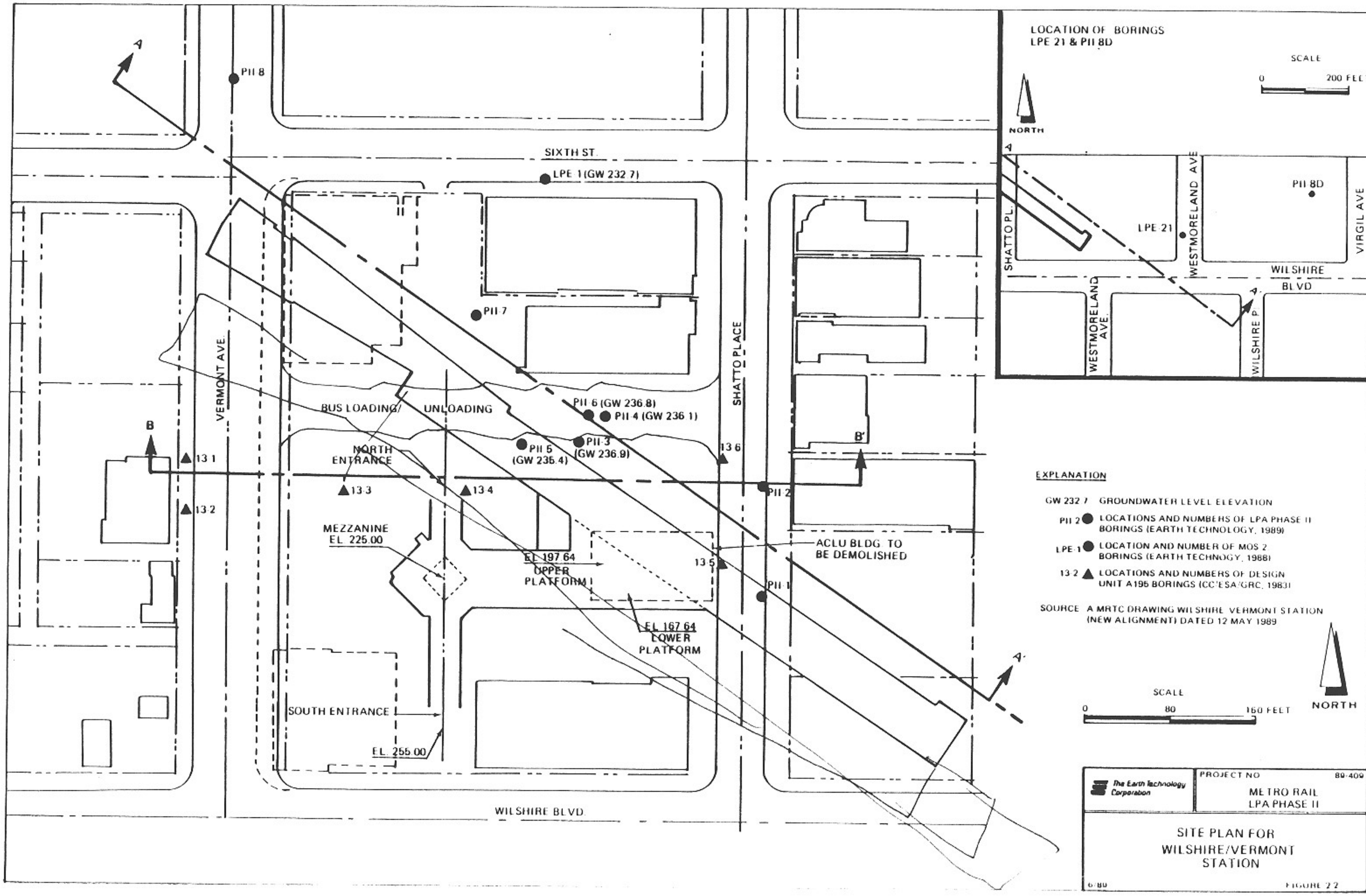
LOCATION OF BORINGS
LPE 21 & PII 8D
SCALE
0
200 FEET
NORTH
A
SHATTO PL.
WESTMORELAND AVE
LPE 21
PII 8D
VIRGIL AVE
WILSHIRE
BLVD
A'
WESTMORELAND AVE.
WILSHIRE P.
A
PII 8
SIXTH ST.
LPE 1 (GW 232 7)
PII 7
VERMONT AVE.
SHATTO PLACE
BUS LOADING/
UNLOADING
PII 6 (GW 236.8)
PII 4 (GW 236 1)
PII 5
(GW 236.4)
PII 3
(GW 236.9)
NORTH
ENTRANCE
B
13 1
13 2
13 3
13 4
13 5
13 6
B'
PII 2
PII 1
MEZZANINE
EL 225.00
EL 197 64
UPPER
PLATFORM
ACLU BLDG. TO
BE DEMOLISHED
EL 167 64
LOWER
PLATFORM
SOUTH ENTRANCE
EL 255 00
WILSHIRE BLVD.
A'
EXPLANATION
GW 232 7 GROUNDWATER LEVEL ELEVATION
PII 2 LOCATIONS AND NUMBERS OF LPA PHASE II BORINGS (EARTH TECHNOLOGY, 1989)
LPE-1 LOCATION AND NUMBER OF MOS 2 BORINGS (EARTH TECHNOGY, 1988)
13 2 LOCATIONS AND NUMBERS OF DESIGN UNIT A195 BORINGS (CC'ESA'GRC, 1983)
SOURCE A MRTC DRAWING WILSHIRE VERMONT STATION (NEW ALIGNMENT) DATED 12 MAY 1989
SCALE
0
80
160 FEET
NORTH
The Earth Technology Corporation
PROJECT NO
89-409
METRO RAIL
LPA PHASE II
SITE PLAN FOR
WILSHIRE/VERMONT
STATION
6-89
FIGURE 2 2

feet along the center line of the current station alignment, the ground surface is generally flat, with a surface elevation of about Elevation 260 ± 2 feet. The ground surface then abruptly drops about 6 feet (retaining wall) and then gently slopes to the west, where the surface at the northwest end of the station is at about Elevation 249 feet.

Several buildings are within 100 feet of the station. Most of these buildings are 1- to 2-story, except for the buildings at 3075 Wilshire Boulevard (10-story), 3079 Wilshire Boulevard (3-story), 611 Shatto Place (4-story), 620 Shatto Place (4-story), and 5160 Sixth Street (3-story).

Cut-and-cover construction is planned for the station. The main structure, including ancillary facilities at both ends, is about 920 feet long, with an inside width of about 48 feet. The overall excavation width will be about 58 feet, assuming a 5-foot space for wall construction at each side. The planned bottom of excavation is at about Elevation 162 feet; this means that the excavation depth for the main structure will range from about 85 to 100 feet.

The surface elevations at the north and south entrances leading to the mezzanine level are at about Elevation 255 feet. The planned mezzanine level is at about Elevation 225 feet. Two platform levels are also planned. The elevations of the upper and lower platforms are at about Elevations 198 and 168 feet, respectively.

2.3 OBJECTIVE AND SCOPE

The primary objective of the geotechnical investigation was to evaluate subsurface soil and groundwater conditions to obtain geotechnical information to be used ~~by design firms~~ in the design of the planned Wilshire/Vermont Station (Detail Design Unit B210).

The scope of this investigation consisted of the following:

1. Review of available literature and reports.
2. Planning and coordination of field work, including:

- o Development of field procedures and manuals
- o Planning of the field investigation program
- o Obtaining permits from government agencies and private property owners
- o Coordination with government agencies and utility companies prior to, during, and after the field work
- o Development and implementation of a project-specific Health and Safety Plan.

3. Performance of a field exploration program, including:

   - o Drilling and sampling of 8 test borings
   - o Obtaining OVA readings on soil samples and background environments
   - o Installing 4 piezometers at selected boring locations
   - o Monitoring groundwater levels and taking water samples for chemical testing
   - o Performing slug tests to determine field permeability
   - o Conducting a wireline logging survey.

4. Performance of a laboratory testing program on selected representative soil and water samples to assess their index and engineering properties and to evaluate general chemical characteristics of the encountered subsurface materials.

5. Preparation of this report documenting the findings, conclusions, and recommendations.

2.4 ADDITIONAL INFORMATION

This geotechnical investigation is a part of an overall geotechnical investigation for a major part of the LPA Phase II alignment, starting at the Wilshire/Vermont Station, turning north along Vermont Avenue, curving west along Hollywood Boulevard, turning northwest at the Hollywood/La Brea intersection, and through the Santa Monica Mountains to the Universal City Station. The subsurface conditions at the Wilshire/Vermont Station are similar to those found at the LPA Phase II alignment portion along most of should mention the Engineering Science Gas Study

Vermont Avenue (i.e., Design Units B240, B250, and B260). Thus, the geotechnical investigation reports for Design Units B240, B250 and B260 that are being prepared for MRTC by Earth Technology also contain geotechnical engineering data relevant to the design and construction of the Wilshire/Vermont Station.

In addition to this report, pertinent project information for the Wilshire/ Vermont Station is also included in the following reports and project data files:

- "Geotechnical Investigation Report, Limited Preliminary Engineering Program, MOS-2 Alignment, Metro Rail Project," prepared for Metro Rail Transit Consultants (MRTC) by the Earth Technology Corporation (1988).
- "Geotechnical Report, Metro Rail Project, Design Unit A195," prepared for Southern California Rapid Transit District (SCRTD) by Converse Consultants, Inc., Earth Science Associates, and Geo/Resource Consultants (CCI/ESA/GRC, 1983).
- "Geotechnical Investigation Report for Metro Rail Project," prepared for SCRTD by CWDD/ESA/GRC (1980).
- Report of Subsurface Gas Investigation - Southern California Rapid Transit District, Metro Rail Project, Wilshire Alignment," prepared by Engineering Science Associates (ESA, 1984).
- "Core Study and Subsurface Condition Report - An Evaluation of Methane Gas Potential along Candidates Alignments of the L.A. Metro Rail Project," prepared for MRTC by ESA (1984).
- "Draft, Subsequent Environmental Impact Report, Los Angeles Rapid Transit Project, Metro Rail," prepared by SCRTD (1987).
- LPA Phase II, Plan and Profile Drawings, prepared by MRTC (May, 1989).

2.5 REMARKS

For the Metro Rail Project, design procedures and criteria for underground structures under earthquake loading conditions are defined in the Southern California Rapid Transit District (SCRTD) report entitled "Supplemental Criteria for Seismic Design of Underground Structures," dated June 1984. Evaluations of the seismological conditions which may impact the project and the probable maximum earthquake which may be anticipated in the Los Angeles area are described in the SCRTD report entitled "Seismological Investigation and Design Criteria," dated May, 1983.

Earthquake-related engineering design is not part of this investigation scope. However, earthquake-induced loading and settlement should be considered in the design of shoring systems and station structures.

Why? It was part of the requirement of Geotechnical Reports by segment A170 - by Converse Consultants.

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3.0 Field Exploration and Laboratory Testing

3.0 FIELD EXPLORATION AND LABORATORY TESTING

This section provides a description of the subsurface exploration and laboratory testing work performed in this program. This field investigation program was a part of a larger geotechnical program performed along the LPA Phase II alignment. Results of the larger geotechnical investigation applicable to the Wilshire/Vermont Station, as well as available reports and project data files (Section 2.4), were also utilized in developing conclusions and recommendations represented in this report.

3.1 FIELD EXPLORATION

Field exploration consisted of drilling and sampling 8 borings (PII-1 through PII-8); installing groundwater monitoring wells in 4 of these borings; performing four in situ permeability tests; monitoring groundwater levels; and water sampling. A plot plan showing boring locations is presented in Figure 2-2. Detailed locations and logs of the borings are presented in Appendix A.

The Field Procedures Manual and the Health and Safety Plan developed for this program and followed during field operations were approved by MRTC.

3.1.1 Borings

Borings were drilled using rotary wash methods with a 4-7/8-inch-diameter bit which produces a nominal 5- to 6-inch-diameter borehole. A tri-cone bit was used in coarse-grained (granular) soils and a drag-bit was used in fine-grained soils. A bentonite drilling fluid was used. Borings were generally drilled to depths of about 20 feet or more below the planned tunnel invert. Penetration depths of the eight borings are shown in Table 3-1. Soil samples were obtained at 5-foot depth intervals by alternately using standard split-spoon samplers and California-type drive samplers lined with 1-inch-high brass rings. Standard split-spoon soil samples were obtained by driving the sampler 18 inches with a 140-pound hammer falling 30 inches. Blow

TABLE 3-1

TOTAL PENETRATION DEPTHS FOR SOIL BORINGS

Boring #	Penetration Depth (Feet)
PII-1	121.5
PII-2	121.5
PII-3	121.0
PII-4	121.0
PII-5	121.5
PII-6	61.0
PII-7	121.5
PII-8	106.0

counts were recorded for each 6-inch driving increment. The total blowcount for the last 12 inches of driving is called the standard penetration resistance.

The driving was terminated when one of the following occurred:

- o A total of 100 blows was reached
- o No obvious sampler advance was observed
- o Sampler was advanced 18 inches.

Soil samples were obtained with the California-type drive samplers by driving the sampler with a 295-pound downhole hammer falling 18 inches. Blowcounts were recorded for each 6-inch driving increment. A Pitcher-barrel sampler was occasionally used when penetration or soil recovery with the drive samplers was difficult due to hard/dense subsurface conditions or when longer samples were desired. At least one Pitcher sample per boring was taken near the station invert depth.

The borings were continuously logged by an experienced geologist or soils engineer. The boring logs were prepared and/or reviewed by a certified engineering geologist (CEG). Drilling operations and borehole log preparation were performed in accordance with the Field Procedures Manual and Health and Safety Plan.

3.1.2 Piezometer Installation

Piezometers were installed in four of the borings (PII-3, -4, -5, and -6). The purpose of the piezometers is to monitor groundwater levels and to obtain water quality samples. Both 2- and 4-inch-diameter PVC casing with 0.01-inch slotted well screen were used for the piezometers. The piezometer well-screened depth interval was estimated based on groundwater levels that were extrapolated from the closest existing available water-level records. Observation of groundwater during drilling and sampling was not possible since the boreholes were filled with drilling fluid.

Piezometers were installed in the borings after the completion of soil sampling. Tap water was used to flush the boring to remove or thin the drilling fluid prior to installation. About 2 feet of backfill sand was placed at the bottom of the boring. The PVC casing assembly was inserted into the boring and backfill sand placed to about 5 feet below the slotted portion of the assembly. Backfill sand consisted of No. 2 and No. 3 Monterey sand for the 0.01-inch and 0.02-inch well screens, respectively. After sand backfilling, bentonite pellets were then poured by gravity to form a bentonite plug about 3 feet thick. Backfill sand was then placed to about 2 feet above the slot portion of the assembly, and bentonite pellets were then poured by gravity to form a plug about 3 feet thick. Cement grout was then pumped into the annulus between the PVC casing and the borehole wall from the top of the bentonite plug to within 12 to 18 inches of the ground surface. At each piezometer location, a circular 12-inch-diameter metal traffic (Pomeco) box was also installed flush with the ground surface. Diagrams of the piezometer installations are presented in Appendix A.

3.1.3 Groundwater Level Monitoring and Sampling

Groundwater levels were monitored in the piezometers using an electronic water-level indicator. Groundwater level readings were taken periodically and are summarized in Table 3-2. Each piezometer was developed by bailing about 10 casing volumes of water. Water quality samples were obtained after bailing.

3.1.4 Slug Tests

Four slug tests were performed to evaluate the horizontal permeability of the Puente Formation bedrock. The slugs test involved the injection of a slug of water into the piezometer well through the well screen and into the formation bedrock, and monitoring water-level recovery at various time intervals until the water level had recovered to its original static level. Results of slug tests and calculated horizontal permeability are summarized in Table 3-3. The permeability of the bedrock as determined by the slug tests range from

TABLE 3-2

SUMMARY OF GROUNDWATER READINGS*

Location (Boring No.)	Ground Surface Elevation (Ft)	Groundwater Level Depth (Ft)	Groundwater Level Elevation (Ft)	Date of Reading
LPE-1	255.0	22.3	232.7	05/31
PII-3	261.0	24.1	236.9	06/08
PII-4	260.5	24.4	236.1	04/02
PII-5	261.0	25.6	235.4	06/08
PII-6	261.0	24.2	236.8	06/08

*Most recent readings

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TABLE 3-3

SLUG TEST RESULTS

Boring No.	Depth of Well (feet)	Groundwater Level Depth (feet)	Depth of Top Seal (feet)	Depth of Bottom Seal (feet)	Screen Interval (feet)	Calculated Permeability (cm/sec)
PII-3	117.5	24.1	58.1 - 59.6	75.5 - 78.0	67.5 - 72.5	5.6×10^{-6}
PII-4	117.5	24.4	38.0 - 40.0	48.0 - 52.0	42.5 - 47.5	4.0×10^{-6}
PII-5	122.0	25.6	50.7 - 52.5	86.4 - 89.6	61.0 - 81.0	1.9×10^{-5}
PII-6	61.0	24.2	33.5 - 36.5	52.3 - 55.5	40.5 - 50.5	2.1×10^{-5}

0.4 x 10-5 cm/sec to 2.1 x 10^{-5} cm/sec, which is about 100 to 500 times more than the vertical permeability of the bedrock as determined by the laboratory tests (Table B-7 in Appendix B). The most logical and plausible explanation for such a significant difference in anisotropic permeability behavior is the omnipresence of predominantly 20 to 350 dipping sandstone beds and bedding planes which serve as preferred hydrological pathways. These hydrological pathways also served as hydrologic connections between Old Alluvium and Puente Formation bedrock. Thus, the Puente Formation bedrock in the site area is not only saturated, but most likely submerged.

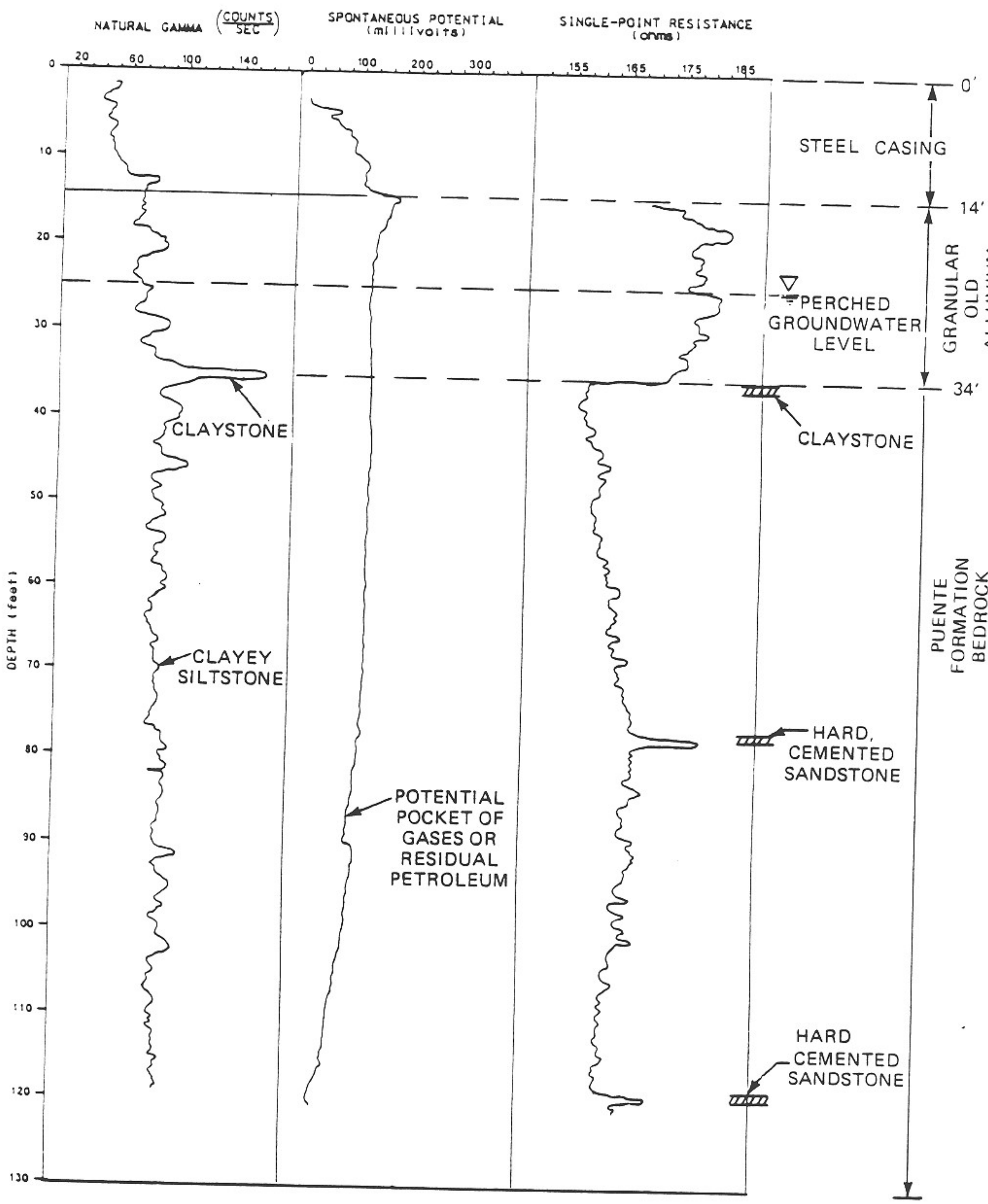
3.1.5 Wireline Logging

Wireline logging for natural gamma radiation (G), spontaneous potential (SP), and single-point resistance (R) logs using a portable borehole logger was performed at Boring PII-3. Each log measures a different physical property (Hallenburg, 1975) described as follows:

- The gamma log measures naturally occurring radioactivity levels of uranium-related elements. Clayey materials generally produce high valued peaks on the gamma log because they absorb radioactive minerals. Therefore, this log can distinguish between clay and sand zones.
- The SP log measures the electric currents produced by chemical reactions between the drilling mud, geologic materials, and groundwater. This log shows chemical changes in clay content and groundwater quantity/quality.
- The resistance log measures the material's inherent resistance to electrical current flow. Generally, a rock matrix has very high resistance. Current flow is confined through the pore spaces within the matrix. Therefore, porosity, permeability and the quantity/quality of pore space fluid greatly affect the material's resistivity. This log can distinguish between clay and sand zones and show changes in groundwater conditions.

Wireline logging results are shown in Figure 3-1. Our interpretation of these results is described below.

The upper 34 feet consists of a granular Old Alluvium composed primarily of silty sand with some gravel. The high resistance and low gamma peaks at



The Earth Technology Corporation

PROJECT NO.: 89-409

LPA-PHASE II METRO RAIL

WIRELINE LOGGING DATA AND INTERPRETATION BORING PII-3

6/89

FIGURE 3-1

17- and 24-foot depths probably represent sand with lower fines content. The low resistance and high gamma peaks at 21- and 30-foot depths probably represent clay zones of moderately plastic fines. The perched groundwater at about a 24-foot depth must be relatively fresh (high resistance) because it did not produce an SP or resistance change. The SP anomaly between 14- and 21-foot depths is probably caused by edge effects from the steel casing.

Puente Formation bedrock was encountered in the boring at 34-foot depth and continues to the boring bottom. This material is predominantly a clayey siltstone interbedded with thin sandstone beds. The alluvium/bedrock interface produced a large amplitude peak on the gamma log and a 60 percent decrease on the resistance log. These abrupt changes are due to a substantial increase in clay content in the bedrock relative to the alluvium. Below 36-foot depth, the logs are relatively uniform and show small fluctuations, probably indicative of relatively uniform bedrock with omnipresent thin sandstone/beds.

Other relevant features as revealed by the wireline logs are described as follows:

- The resistance log increases from 38 to 77 feet, probably because porosity may decrease with depth. The resistance trend probably does not represent a material change because the gamma log is relatively constant. The trend is probably not caused by a change in groundwater quality because the SP log is constant.

- At the 77- to 78-foot depth there is a high resistivity peak which most likely represents the hard cemented sandstone layer described in the boring log. This zone probably has low porosity because the resistivity is very high.

- From 78- to 90-foot depths the gamma and SP logs show relatively low amplitude anomalies. The boring log indicates that sulfur and hydrocarbon odor was observed at about 90-foot depth. The pore space within this zone may be partially filled with residual hydrocarbons or gases instead of being water saturated. The SP anomaly may result from increased chemical reactions caused by the residual petroleum or gases, which may be trapped beneath the cemented sandstone layer at 77- to 78-foot depth.

- From 78- to 118-foot depths the SP and resistance curves decrease with depth. This trend is probably due to the groundwater quality becoming more saline with depth. This trend is probably not caused by a porosity or material change because the gamma log is fairly constant.

- o At the 119- to 120-foot depth there is a high resistance peak similar to the one at the 77 to 78-foot depth. This zone is probably also a hard-cemented sandstone layer.

In summary, the results of wireline logging closely reflect the subsurface conditions encountered in the boring. In addition, the use of wireline logging can provide continuous stratigraphy to supplement the boring information. The wireline logging results also indicate that the logging method is especially useful in locating hard, well-cemented and relatively thick layers of sandstone beds in Puente Formation bedrock.

3.2 LABORATORY TESTING PROGRAM

A laboratory testing program was developed and performed on selected soil, bedrock, and water samples obtained in this investigation. The laboratory tests were intended to provide data for further refinement of subsurface conditions and associated engineering parameters, as well as to assess the extent of possible chemical contamination at the Wilshire/Vermont Station site area. In general, the laboratory test program was developed to:

1. Aid in soil classification and in correlating test data.
2. Obtain an initial assessment of engineering properties of the soils encountered in the investigation.
3. Provide a preliminary chemical characterization of selected soil, water, and gas samples.

The following sections provide a general description of the test program, which was divided into soil mechanics laboratory testing and analytical laboratory (chemical) analysis.

3.2.1 Soil Mechanics Laboratory Testing

A series of soil mechanics laboratory tests was performed on selected representative samples. All tests were performed in accordance with applicable standard test methods specified by the American Society for Testing

Materials (ASTM), or procedures acceptable in geotechnical engineering practice. The test program and procedures are summarized in Table 3-4.

The results of soil mechanics laboratory tests are presented in Appendix B and in the boring logs found in Appendix A. Results of evaluation of the laboratory test data for the engineering properties of encountered subsurface materials are presented in Section 5.

3.2.2 Analytical Laboratory (Chemical) Analysis

In addition to monitoring the background and headspace OVA readings of every soil sample, triple-meter monitoring was performed on samples with high OVA readings for indication of potential presence of hydrogen sulfide (H_2S) concentration, explosivity level, and carbon monoxide concentration during the field work. A limited analytical laboratory (chemical) analysis program was also performed on selected soil and water samples. The analytical laboratory analysis program performed for the investigation is summarized in Table 3-5.

The results of the analytical laboratory analysis program are presented in Appendix C and summarized in Tables 3-6 through 3-13. An evaluation of the results and the potential impacts on design and construction are presented in Sections 4 and 5, respectively.

TABLE 3-4

SUMMARY OF TESTS AND TEST PROCEDURES

Test Type	No. of Tests	Test Procedure
Visual Examination	Every sample	ASTM D 2488-84
Grain Size Distribution	28	ASTM D 422-63 and D 1140-54
Hydrometer Analysis	5	ASTM D 422-63
Unit Weight	55	ASTM D 2937-83
Moisture Content	59	ASTM D 2216-80
Specific Gravity	4	ASTM D 854-83
Atterberg limit	8	ASTM D 4318-84
Direct Shear Tests	57	ASTM D 3080-72
Permeability	5	ASTM D 2434-68 and EPA 9100
Consolidation Test	5	ASTM D 2435-80
Unconfined Compression	24	ASTM D 2166-85
Triaxial Compression	13	*EM 110-2-1906 Appendix 10

*Corps of Engineers

TABLE 3-5

ANALYTICAL LABORATORY ANALYSIS SUMMARY

Test Type	Sample Type	No. of Tests	Test Procedure
Total Recoverable Petroleum Hydrocarbons (TRPH)	Soil Water	12 2	EPA 418.1 EPA 418.1
Aromatic Organic Compounds (BTEX)	Soil Water	12 4 (1)	EPA 8020 EPA 8020
Volatile Organic Compounds	Soil	1	EPA 8240
Semivolatile Organic Compounds	Soil	1	EPA 8270
CAM Metals	Soil	1	California Metals
Sulfide	Soil Water	2 2	EPA 9030 EPA 9030
Sulfate	Soil Water	12 2	EPA 9038 EPA 9038
Total Dissolved Solids (TDS)	Water	1	EPA 160.1
pH	Water	2	EPA 9040

NOTE: (1) including equipment field blank

TABLE 3-6

CHEMICAL TEST RESULTS OF SULFATE CONCENTRATIONS

ON SELECTED SOIL AND WATER SAMPLES

Location/ Sample No.	Sample Type	Sulfate Concentration[1] (ppm)	(DL)	Potential Cement Type for Construction[2]
LPE-1 (Nov 88)	water	680	(50)	II
LPE-1 (May 89)	water	600	(50)	II
PII-5	water	1,520	(50)	V
LPE-1/D-8 (Nov 88)	soil	900	(50)	Regular
PII-1/D-9	soil	160	(10)	Regular
PII-2/D-13	soil	350	(10)	Regular
PII-2/D-1	soil	410	(10)	Regular
PII-2/D-3	soil	260	(10)	Regular
PII-3/D-2	soil	280	(10)	Regular
PII-3/D-6	soil	230	(10)	Regular
PII-4/D-15	soil	220	(10)	Regular
PII-4/D-19	soil	140	(10)	Regular
PII-7/D-15	soil	410	(10)	Regular
PII-8/D-5	soil	31	(10)	Regular
PII-8/D-11	soil	250	(10)	Regular
PII-8/D-17	soil	110	(10)	Regular

NOTES: (1) DL = Detection Limit.
ppm = parts per million.

(2) Cement types are based on recommendations specified in Concrete Manual.

(3) Drinking water regulatory levels:

California Department of Health (DOHS) Action Level: none

Environmental Protection Agency (EPA) Water Quality Standard Maximum Contaminant Level (MCL): 250 ppm

TABLE 3-7

CHEMICAL TEST RESULTS OF SULFIDE CONCENTRATIONS

ON SELECTED SOIL AND WATER SAMPLES

Location/ Sample No.	Sample Type	Sulfide Concentration[1] (ppm)	(DL)
LPE-1 (Nov 88)	water	P	(1)
LPE-1 (May 89)	water	ND	(1)
PII-5A	water	ND	(1)
LPE-1/D-8 (Nov 88)	soil	P	(3)
PII-7/D-15	soil	6.6	(1)

NOTES: (1) DL = Detection Limit.
ND = Not Detected.
P = Present in quantity less than detection limit.

TABLE 3-8

CHEMICAL TEST RESULTS OF TOTAL DISSOLVED SOLIDS (TDS) CONCENTRATIONS

AND pH ON SELECTED WATER SAMPLES

Location	pH	TDS Concentration (ppm)	(DL)
PII-5	7.2	1,600	(100)
LPE-1 (May 1989)	7.0	Not Tested	

NOTES: (1) DL = Detection Limit.
ppm = parts per million.

(2) Drinking water regulatory Levels:

California Department of Health (DOHS) Action Level: none

Environmental Protection Agency (EPA) Water Quality Standard Maximum Contaminant Level (MCL): 250 ppm

TABLE 3-9

CHEMICAL TEST RESULTS OF AROMATIC ORGANIC COMPOUNDS (BTEX) CONCENTRATIONS ON SELECTED WATER AND SOIL SAMPLES

Location/Sample No.			Benzene	Toluene	Ethylbenzene	Xylene
			Concentration (µg/l)			
LPE-1	(water)	(Nov 88)	8	80	12	123
LPE-1	(water)	(May 89)	2.7	9.0	ND	ND
PII-5	(water)		ND	ND	ND	ND
PII-5A	(water)		ND	ND	ND	ND
E.F.B.-1	(water)		ND	ND	ND	ND
			Concentration (µg/kg)			
LPE-1/D-8	(soil)	(Nov 88)	5	44	ND	5
PII-1/D-9	(soil)		<5	24	8.7	62
PII-1/D-13	(soil)		<5	320	<5	13
PII-2/D-1	(soil)		ND	<5	ND	<5
PII-2/D-3	(soil)		ND	ND	ND	ND
PII-3/D-2	(soil)		ND	ND	ND	ND
PII-3/D-6	(soil)		ND	ND	ND	ND
PII-4/D-15	(soil)		21	100	8.3	34
PII-4/D-19	(soil)		5.8	33	<5	29
PII-7/D-15	(soil)		<5	180	<5	14
PII-8/D-5	(soil)		ND	ND	ND	ND
PII-8/D-11	(soil)		7.2	41	ND	5.1
PII-8/D-17	(soil)		ND	31	ND	ND

NOTES:

(1) ND = Not detected: Detection limits for benzene, toluene, ethylbenzene and xylene are 0.5, 1.0, 1.0 and 1.0 µg/l for water samples, respectively. Detection limits for BTEX are 5 µg/kg for soil samples.

(2) According to the Leaking Underground Fuel Tank (LUFT) Field Manual, cleanup action levels for BTEX concentrations are 300 µg/kg, 300 µg/kg, 1,000 µg/kg and 1,000 µg/kg for benzene, toluene, ethylbenzene and xylene, respectively.

(3) According to OSHA and NIOSH regulations, the action levels for Time-Weighted Average (TWA) air concentrations of BTEX that require respirator protection are 5, 100, 100, and 100 ppm for benzene, toluene, ethylbenzene and xylene, respectively.

(4) E.F.B. = Equipment field blank

TABLE 3-10

CHEMICAL TEST RESULTS OF TOTAL RECOVERABLE PETROLEUM HYDROCARBONS (TRPH) CONCENTRATIONS ON SELECTED SOIL AND WATER SAMPLES

Location/ Sample No.	Sample Type	Concentration (mg/l)	(DL)
LPE-1 (Nov 88)	Water	84	(5)
LPE-1 (May 89)	Water	1.2	(1)
PII-5	Water	<1	(1)
Sample Location		(mg/kg)	(DL)
LPE-1/D-8 (Nov 88)	Soil	66	(5)
PII-1/D-9	Soil	ND	(5)
PII-1/D-13	Soil	ND	(5)
PII-2/D-1	Soil	ND	(5)
PII-2/D-3	Soil	ND	(5)
PII-3/D-2	Soil	ND	(5)
PII-3/D-6	Soil	ND	(5)
PII-4/D-15	Soil	ND	(5)
PII-4/D-19	Soil	ND	(5)
PII-7/D-15	Soil	ND	(5)
PII-8/D-5	Soil	ND	(5)
PII-8/D-11	Soil	ND	(5)
PII-8/D-17	Soil	ND	(5)

NOTES: (1) Cleanup action level for TRPH concentration is about 1,000 mg/kg for soil samples according to Leaking Underground Fuel Tank Field Manual.

(2) Action level for air concentration of TRPH that requires respiratory protection is 300 ppm according to Occupational Safety & Health Administration (OSHA) and National Institute for Occupational Safety & Health (NIOSH) regulations.

(3) DL = Detection Limit
ND = Not Detected

TABLE 3-11

CHEMICAL TEST RESULTS OF SEMIVOLATILE ORGANICS CONCENTRATIONS BY

GC/MS (EPA METHOD-8270) ON SOIL SAMPLE NO. D-15, BORING PII-7

Parameter	Concentration (mg/kg)	Parameter	Concentration mg/kg)
Phenol	ND (0.1)	Acenaphthene	ND (0.1)
bis(2-chloroethyl)ether	ND (0.1)	2,4-Dinitrophenol	ND (0.5)
2-Chlorophenol	ND (0.1)	4-Nitrophenol	ND (0.5)
1,3-Dichlorobenzene	ND (0.1)	Dibenzofuran	ND (0.1)
1,4-Dichlorobenzene	ND (0.1)	2,4-Dinitrotoluene	ND (0.1)
Benzyl Alcohol	ND (0.2)	2,6-Dinitrotoluene	ND (0.1)
1,2-Dichlorobenzene	ND (0.1)	Diethylphthalate	ND (0.1)
2-Methylphenol	ND (0.1)	4-Chlorophenyl-phenylether	ND (0.1)
bis(2-chloroisopropyl)ether	ND (0.1)	Fluorene	ND (0.1)
4-Methylphenol	ND (0.1)	4-Nitroaniline	ND (0.5)
N-Nitroso-Di-n-Propylamine	ND (0.1)	4,6-Diknitro-2-Methylphenol	ND (0.5)
Hexachloroethane	ND (0.1)	N-Nitrosodiphenylamine	ND (0.1)
Nitrobenzene	ND (0.1)	4-Bromophenyl-phenylether	ND (0.1)
Isophorone	ND (0.1)	Hexachlorobenzene	ND (0.1)
2-Nitrophenol	ND (0.1)	Pentachlorophenol	ND (0.5)
2,4-Dimethylphenol	ND (0.1)	Phenanthrene	ND (0.1)
Benzoic Acid	ND (0.5)	Anthracene	ND (0.1)
bis-(-Chloroethoxy)methane	ND (0.1)	Di-n-Butylphthalate	ND (0.1)
2,4-Dichlorophenol	ND (0.1)	Fluoranthene	ND (0.1)
1,2,4-Trichlorobenzene	ND (0.1)	Pyrene	ND (0.1)
Naphtalene	ND (0.1)	Butylbenzylphthalate	ND (0.1)
4-Chloroanline	ND (0.2)	3,3'-Dichlorobenzidine	ND (0.2)
Hexachlorobutadiene	ND (0.1)	Benzo(a)Anthracene	ND (0.1)
4-Chloro-3-Methylphenol	ND (0.2)	bis(2-Ethylhexyl)Phthalate	ND (0.1)
2-Methylnaphthalene	ND (0.1)	Chrysene	ND (0.1)
Hexachlorocyclopentadiene	ND (0.1)	Di-n-Octyl Phthalate	ND (0.1)
2,4,6-Trichlorophenol	ND (0.1)	Benzo(b)Fluoranthene	ND (0.1)
2,4,5-Trichlorophenol	ND (0.1)	Benzo(k)Fluoranthene	ND (0.1)
2-Chloronaphthalene	ND (0.1)	Benzo(a)Pyrene	ND (0.1)
2-Nitroaniline	ND (0.5)	Indeno(1,2,3-cd)Pyrene	ND (0.1)
Dimethyl Phthalate	ND (0.1)	Dibenz(a,h)Anthracene	ND (0.1)
Acenaphthylene	ND (0.1)	Benzo(g,h,i)Perylene	ND (0.1)
3-Nitroaniline	ND (0.5)		

% Surrogate Recovery			
2-Fluorophenol	64	2-Fluorobiphenyl	43
Phenol-d_5	72	2,4,6-Tribromophenol	0
Nitrobenzene-d_5	106	Terphenyl-d_{14}	115

NOTES:

ND = Not Detected
( ) = Detection Limit (mg/kg)

TABLE 3-12

RESULTS OF CHEMICAL TESTS OF VOLATILE ORGANICS CONCENTRATIONS BY GC/MS (EPA METHOD - 8240) ON SOIL SAMPLE NO. D-15, BORING PII-7

Parameters (8240)	Concentration (µg/kg)	
	Boring No./Sample No. PII-7/D-15	Detection Limit
Acetone	ND	100
Benzene	ND	10
Bromodichloromethane	ND	10
Bromoform	ND	10
Bromomethane	ND	50
2-Butanone (MEK)	ND	100
Carbon Disulfide	ND	10
Carbon Tetrachloride	ND	10
Chlorobenzene	ND	10
Chlorodibromomethane	ND	10
Chloroethane	ND	50
2-Chloroethyl vinyl ether	ND	10
Chloroform	ND	10
Chloromethane	ND	50
1,1-Dichloroethane	ND	10
1,2-Dichloroethane	ND	10
1,1-Dichloroethene	ND	10
1,2-Dichloroethene (total)	ND	10
1,2-Dichloropropane	ND	10
cis-1,3-Dichloropropene	ND	10
trans-1,3-Dichloropropene	ND	10
Ethylbenzene	ND	10
2-Hexanone	ND	100
Methylene chloride	ND	100
4-Methyl-2-pentanone (MIBK)	ND	50
Styrene	ND	10
1,1,2,2-Tetrachloroethane	ND	10
Tetrachloroethene	ND	10
Toluene	18	10
1,1,1-Trichloroethane	ND	10
1,1,2-Trichloroethane	ND	10
Trichloroethene	ND	10
Trichlorofluoromethane	ND	50
Vinyl Acetate	ND	100
Vinyl Chloride	ND	50
Xylene (total)	ND	10
% Surrogate Recovery		
1,2 dichloroethane d4	77	
Toluene-d8	104	
Bromoflurrobenzene	90	

NOTES: (1) ND = Not Detected
(2) Refer to Table (4) for action levels for toluene concentrations.

TABLE 3-13

CHEMICAL TEST RESULTS OF CAM METALS CONCENTRATIONS ON SOIL

SAMPLE NO. D-15, BORING PII-7

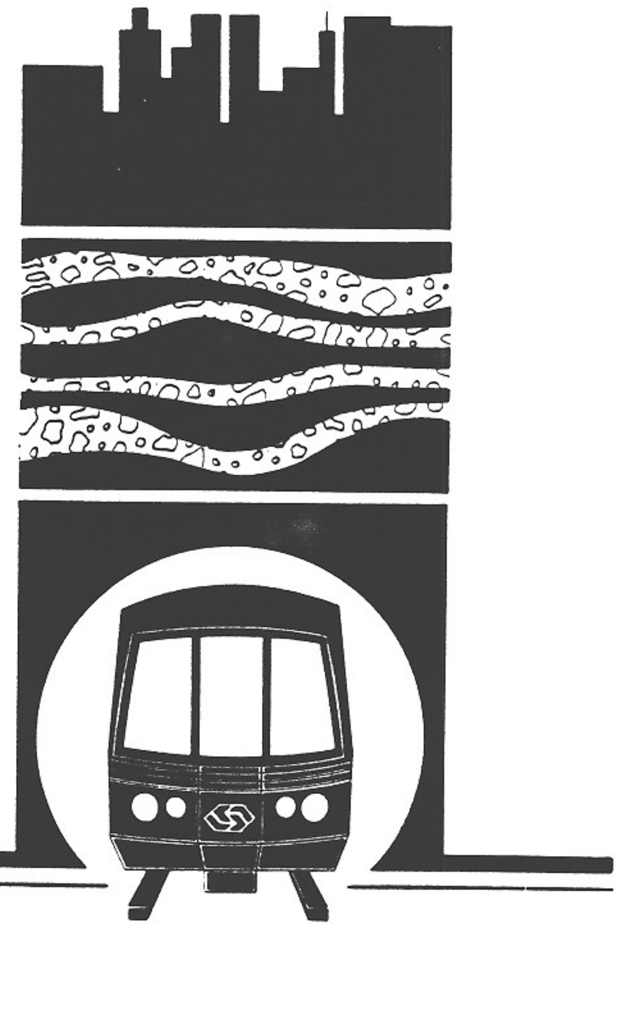
Substances	Concentration (mg/kg) — Concentration: LPE-24/D18	DL	Cleanup Action Level (Note 2)	Air Concentration Limit (mg/m^3) that Requires Respiratory Protection (Note 3)
Antimony	<5.0	5.0	500	0.5
Arsenic	11	1.0	500	0.2
Barium	8.8	5.0	10,000	0.5
Beryllium	< 1.0	1.0	75	0.02
Cadmium	1.1	1.0	100	0.05
Chromium - Total	22	1.0	500	0.5
Cobalt	7.9	1.0	8,000	0.05
Copper	29	1.0	2,500	1
Lead	9.4	1.0	1,000	0.15
Mercury	< 0.05	0.05	20	1
Molybdenum	3.6	1.0	3,500	10
Nickel	31	1.0	2,000	1
Selenium	1.6	1.0	100	0.2
Silver	< 1.0	1.0	500	0.1
Thallium	10	1.0	700	0.1
Vanadium	34	5.0	2,400	0.05
Zinc	69	1.0	5,000	10

NOTES: (1) DL = Detection Limit

(2) California Department of Health Services, Title 22, Section 66699.

(3) OSHA (Occupational Safety & Health Administration) and NIOSH (National Institute For Occupational Safety of Health) regulations.

DRAFT



4.0 Geologic and Subsurface Conditions

4.0 GEOLOGIC AND SUBSURFACE CONDITIONS

4.1 GEOLOGIC SETTING AND CONDITIONS

The LPA Phase II alignment is located within the Los Angeles Basin, as defined by Yerkes, et al. (1965), based on tectonic or structural blocks. As shown in Figure 4-1, the basin so defined can be subdivided into four structural blocks including the Northwestern Block, the Northeastern Block, the Central Block, and the Southwestern Block. The Wilshire/Vermont Station site area is within the Central Block, which is bounded on the north by the Santa Monica-Raymond Hill fault zones, on the northeast and east by the Whittier-Elsinor fault zones, and on the west-southwest by the Newport-Inglewood fault zones (Figure 4-1).

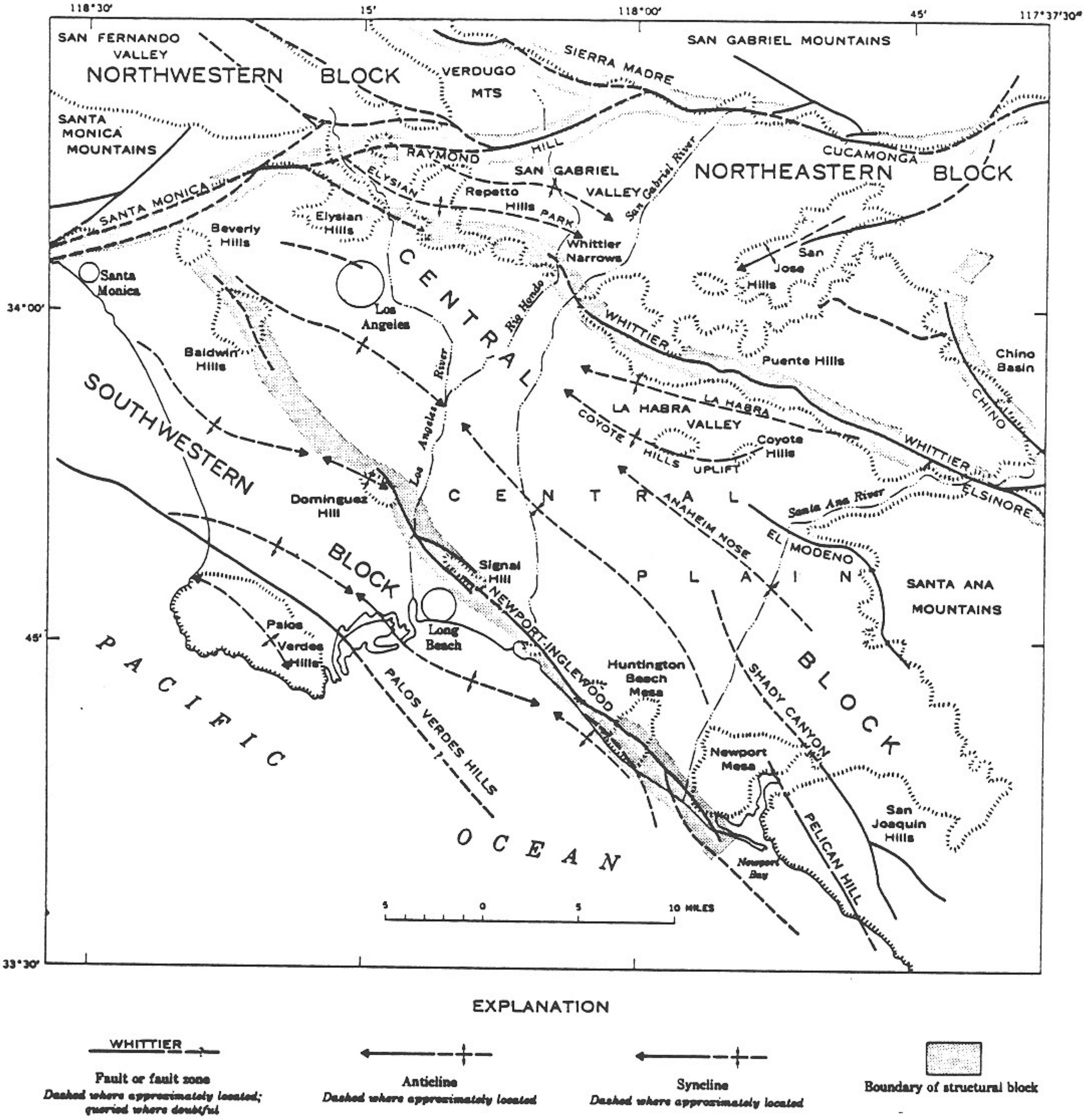
4.2 REGIONAL STRATIGRAPHY AND GEOLOGY

The Central Block of the Los Angeles Basin is underlain by a deep structural depression filled with the following geologic units, in order of deposition:

- Puente Formation (Tp): The Upper Miocene bedrock underlying the area consists predominantly of stratified and weak-interbedded claystone, siltstone, and sandstone. The materials in the Puente Formation are generally low-strength (weak) rocks with local presence of hard sandstone beds, ranging from fractions of an inch to several feet or more.

- Fernando Formation (Tf): This Pliocene sediment consists of massive and very bedded claystone, siltstone, and sandstone, overlying the Puente Formation. The contact is mostly gradational and difficult to locate. This formation was not encountered in the geotechnical investigation performed for the LPA Phase II alignment.

- Old Alluvium (A3 and A4): These Pleistocene sediments consist of granular alluvium (A3) deposited in relatively "swift" water environments, and fine-grained alluvium (A4) deposited in the relatively "quiet" water environments. The granular Old Alluvium consists primarily of medium-dense to very dense clean sand, silty sand, gravelly sand, sandy gravel, and gravel. The fine-grained Old Alluvium consists primarily of medium-stiff to very hard clay, silty clay, sandy clay, clayey silt, and clayey sand.



ADOPTED FROM YERKES, ET AL (1965)

FIGURE 4-1. MAJOR STRUCTURAL FEATURES IN LOS ANGELES BASIN

- o Young Alluvium (A1 and A4): These Holocene sediments consist of granular alluvium (A1) deposited in relatively "swift" water environments and fine-grained alluvium (A2) deposited in relatively "quiet" water environments. The granular Young Alluvium consists predominantly of loose to dense clean sand, silty sand, gravelly sand, and sandy gravel, with potential local presence of cobbles and boulders. The fine-grained Young Alluvium consists of firm to hard clay, clayey silt, and clayey sand, with local presence of traces of gravel.

The margins of the basin and its four blocks are formed by zones of folding and uplifting along basin/block-bounding faults, including the Santa Monica-Raymond Hill, Whittier, and Newport-Inglewood fault zones. In addition, there exist several major geologic features which are mostly inferred and not well delineated. Within the Central Block and adjacent to the LPA Phase II alignment, major geologic features include the Santa Monica fault zone and the Los Angeles anticline. The Santa Monica fault zone forms the northwestern boundary of the Los Angeles Basin's Central Block. The presence of this fault zone is not disputed; however, the actual surface location of this fault zone is not known. The Los Angeles anticline is a gentle upfold in the Puente Formation and trends about N 70° W, which influences the dip of bedrock strata in the area. This anticline acts as trap for oil and gas within the Puente Formation. The Los Angeles City Oil Field is within this anticline.

For the most part, this oil field has been abandoned except near the east end of the oil field, where several producing wells exist. Known boundaries of the oil field traverse Vermont Avenue between 2nd and 4th Streets along the LPA Phase II alignment. Although the known production zones (150 feet or deeper below the ground surface) are much deeper than the invert depths of the LPA Phase II alignment (100 feet or less below the ground surface), the potential presence of trapped oil, tar, or gas in the Puente Formation within the construction depths of the alignment cannot be eliminated.

4.2.2 Site Stratigraphy and Geology

The results of this investigation and available data in the project data file (Section 2.4) indicate the geologic units encountered in the Wilshire/Vermont Station site consist of Old Alluvium (A3 and A4) and bedrock of the Puente Formation (Tp). A more detailed description of these subsurface materials is provided in Section 4.2

The site area is located at the southern flank of the Los Angeles anticline, which influences the dip of the bedrock strata. The closest known oil production field is the Los Angeles City Oil Field with known boundaries about 1,200 feet northeast of the site area. There are no known active or inactive faults crossing or projecting toward the site area.

4.3 SUBSURFACE CONDITIONS

4.3.1 Subsurface Soils and Rocks

The station is located in a relatively well-developed area. Selection of borehole excavations was restricted by the presence of existing buildings and by our ability to obtain the cooperation of private property owners. The eight borings performed for the station were selected to be as close as possible to the center line of the station alignment at the time of the field operation. The depth penetration of borings was selected to be 40 feet below the planned station invert at the time of the field investigation. The field work for the eight borings was completed by March 31, 1989.

Since then, the station alignment was revised in May 1989, and the station invert was revised to be 20 feet deeper than before. As can be seen from Figure 2-2 and Table 3-1, the locations of the completed borings for the station are up to about 100 feet from the center line of the present station alignment area. The boring penetration was only about 20 feet below the presently planned station invert. In addition, no boring was drilled within the station alignment portion east of Shatto Place.

Why say this if it is not necessary

Although the above limitations indicate the need for additional borings to ensure completeness and applicability of the results of this investigation to design and construction of the station, we believe that the subsurface conditions developed in this section on the basis of the results of this investigation and available data in the project files are representative and applicable to the currently planned station alignment and excavation depths. This confidence is based on the following:

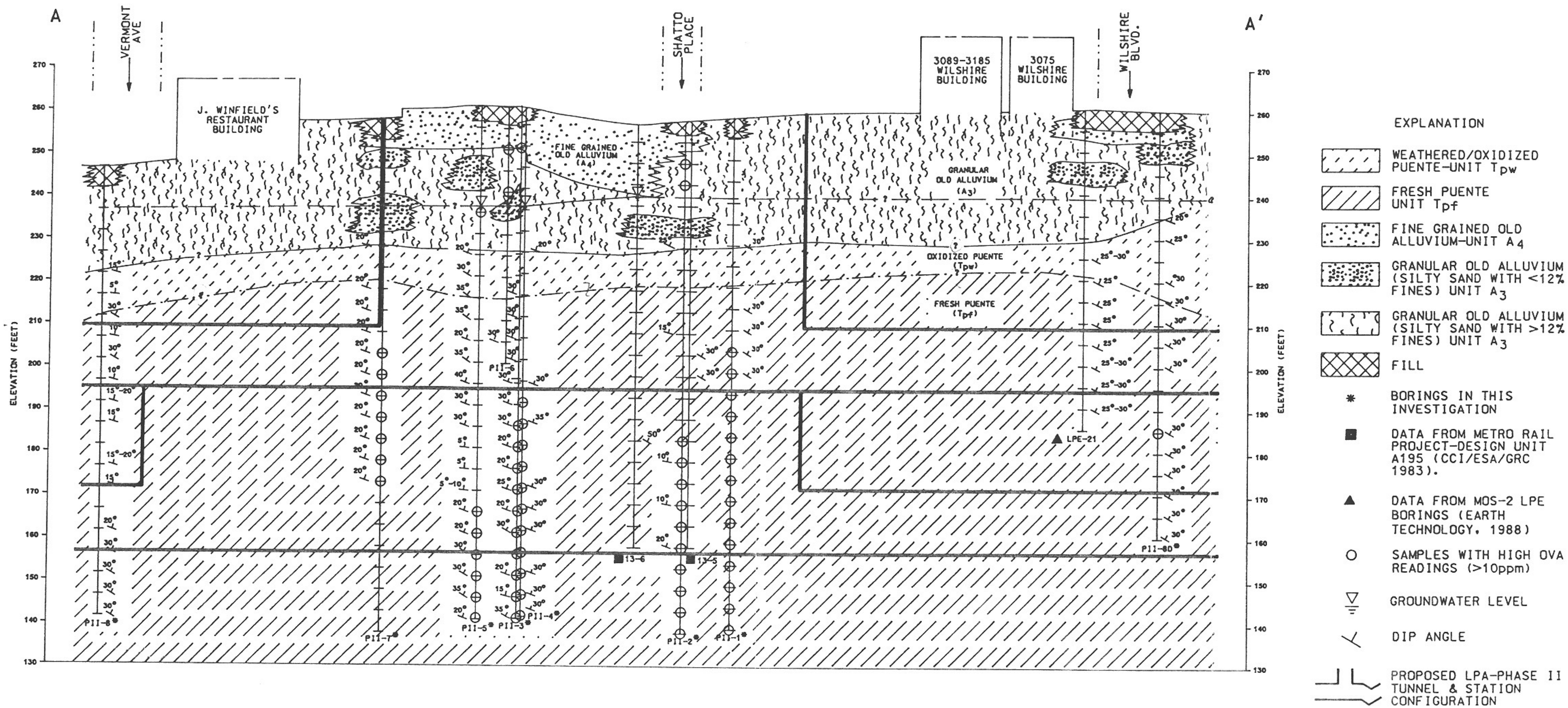
1. This investigation and the previous investigations (Earth Technology, 1988; CCI/ESA/GRC, 1983) encountered similar subsurface soil conditions in the site vicinity, which are relatively uniform and show relatively insignificant lateral and spatial variations.

2. An examination of available subsurface soil and groundwater conditions encountered during geotechnical investigations for the design and construction of two existing buildings at 611 Shatto Place (3-story) and 3075 Wilshire Boulevard (10-story) by LeRoy Crandall and Associates (1956, 1961) again confirms the relatively uniform nature of the subsurface conditions in the site area.

Based on the results of this investigation and available data (Section 2.4), two generalized cross-sectional profiles of the site area are shown in Figures 4-2 and 4-3. In general, the stratigraphy of the site area is relatively uniform and consists of Old Alluvium overlaying Puente Formation bedrock. The Old Alluvium extends to a depth ranging from about 25 to 34 feet below the ground surface, and consists of predominantly granular alluvium (Unit A3) overlain by a 5- to 15-foot-thick zone of upper fine-grained alluvium (Unit A4). The upper fine-grained Old Alluvium consists of primarily firm to very stiff silty clay and clayey sand. This layer is present except at Boring PII-1 (this investigation) and Boring 13-1 (CCI/ESA/GRC, 1983). The granular Old Alluvium overlying the Puente Formation consists predominantly of dense to very dense silty sand with pockets of dense to very dense gravelly sand.

Shallow fill zones up to 5 feet thick were encountered in 6 of the 8 borings. These scattered fill zones overlying the Old Alluvium have insignificant effects on the design and construction of the station.

Puente Formation bedrock (Unit Tp) underlying granular Old Alluvium was encountered in all borings and at elevations ranging from 220 to 230 in the



NOTES:

1. THIS BOREHOLE IS BASED ON INTERPRETATION BETWEEN WIDELY SPACED BORINGS AND LIMITED PIEZOMETRIC DATA AND WAS DEVELOPED AS A VISUAL AID IN DEVELOPING A GENERAL UNDERSTANDING OF SUBSURFACE CONDITIONS AND ENGINEERING CONSIDERATIONS. ACTUAL CONDITIONS ENCOUNTERED DURING SUBSEQUENT INVESTIGATION OR CONSTRUCTION MAY BE DIFFERENT.

2. SUBSURFACE DATA PRESENTED HEREIN ARE SIMPLIFIED INTERPRETATIONS OF BOREHOLE DATA INCLUDED IN APPENDIX A.

3. GROUNDWATER LEVEL DATA ARE BASED ON MONITORING OF LIMITED PIEZOMETERS FOR A SHORT PERIOD OF TIME. SEASONAL VARIATION SHOULD BE EXPECTED.

4. DEPTHS AND LOCATIONS OF TUNNEL AND STATIONS ARE BASED ON AVAILABLE DATA PROVIDED BY MRTC AND ARE SUBJECT TO REFINEMENTS.

5. PLAN AND LOCATION OF ALIGNMENT ARE SHOWN IN FIGURE 2-2.

6. DIMENSIONS AND LOCATIONS OF TUNNEL AND STATIONS ARE BASED ON PLAN AND PROFILE DRAWINGS PROVIDED BY MRTC AND DATED MAY 1989.

0 60 120 FEET

HORIZONTAL SCALE

The Earth Technology Corporation

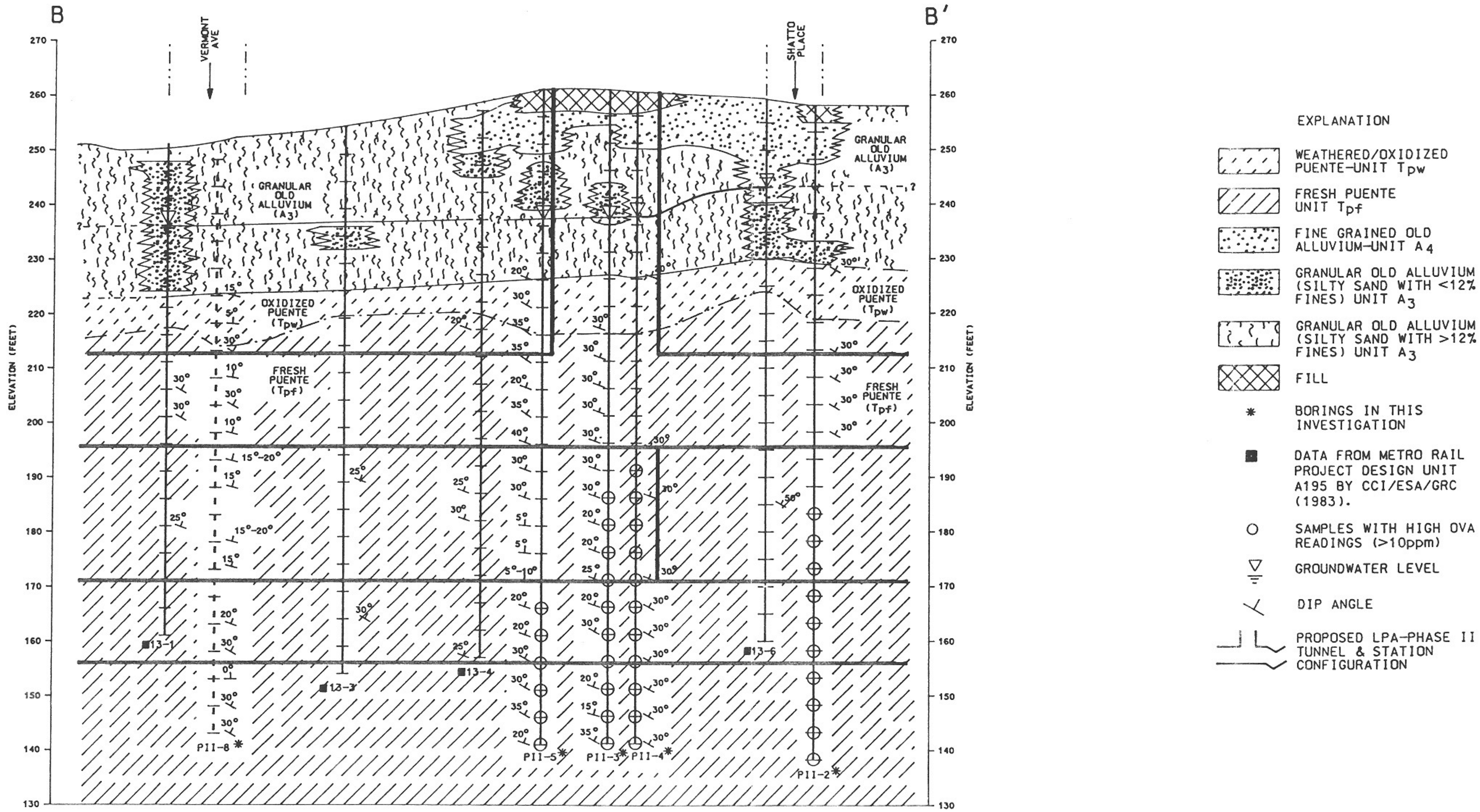
PROJECT NO.: 89-409

METRO RAIL LPA PHASE II

GENERALIZED SUBSURFACE PROFILE ALONG A-A'
WILSHIRE-VERMONT STATION

6/89

FIGURE 4-2



NOTES:

1. THIS CROSS SECTION IS BASED ON INTERPRETATION BETWEEN WIDELY SPACED BORINGS AND LIMITED PIEZOMETRIC DATA AND WAS DEVELOPED AS A VISUAL AID IN DEVELOPING A GENERAL UNDERSTANDING OF SUBSURFACE CONDITIONS AND ENGINEERING CONSIDERATIONS. ACTUAL CONDITIONS ENCOUNTERED DURING SUBSEQUENT INVESTIGATION OR CONSTRUCTION MAY BE DIFFERENT.
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0 50 100 FEET
HORIZONTAL SCALE

The Earth Technology Corporation

PROJECT NO.: 89-409
METRO RAIL
LPA PHASE II

GENERALIZED SUBSURFACE PROFILE
ALONG B-B′
WILSHIRE-VERMONT STATION

6/89

FIGURE 4-3

station area. This bedrock unit primarily consists of clayey siltstone and claystone with omnipresent weak and mostly thinly-bedded sandstone. The sandstone interbeds comprise up to about 50 percent of the bedrock. These sandstone interbeds are mostly weakly cemented with thickness generally on the order of fractions of an inch, except for the infrequent presence of hard sandstone beds, up to 1 foot thick, as evidenced by the chattering of the drill rod observed in the drilling operation (noted in the boring logs presented in Appendix A) and in the wireline logs (Figure 3-1).

The dip angles of the bedrock were observed to range from 20° to 50° and to be predominantly in the range of 20° to 35°. The strike of the bedding was not determined in the field operation. However, the regional trend of the Los Angeles anticline would indicate an approximate N 70° W strike, with a southwesterly dip to be most likely. The strike orientation is approximately parallel to the long axis of the station alignment (about N 56° W). Thus, the bedding planes of the bedrock dip into the northeast side and away from the southwest side of the station excavation. For the northwest and southeast sides of the station excavation, the bedrock dips approximately parallel to the excavated faces. It should be noted that although the bedding planes in the samples were most intact, they were friable and easily separated by hand.

The omnipresent weak and thin sandstone interbeds and the dipping weakly-intact bedding planes in the bedrock are significant to the design and construction of the station and may dictate the following behavioral features:

1. Their presence indicates that engineering properties, in terms of strength and permeability, are anisotropic.

2. Their shear strengths are lower than the remaining bedrock (claystone and clayey siltstone), and they represent the weakest link within the bedrock.

3. They are more permeable and may act as preferred pathways for groundwater flow.

In the site area, the top 7 to 12 feet of the Puente Formation is oxidized and shows varying degrees of weathering (unit Tpw). The bedrock below the oxidized Puente Formation is unweathered and non-oxidized (fresh Puente Formation-Unit Tpf). From an engineering viewpoint, both oxidized and fresh

Puente Formation materials in the site area have similar engineering properties and behavior.

4.3.2 Chemical Contamination in Subsurface Materials

Headspace OVA readings were taken for all recovered samples to evaluate the possible presence and concentration of volatile chemical compounds. All borings in this investigation encountered zones with headspace OVA readings significantly higher than the corresponding background values. The locations of samples with headspace OVA readings 10 ppm or more higher than the corresponding background values are indicated in the cross-sectional profiles (Figures 4-2 and 4-3). As can be seen from these figures, zones of high OVA readings are mostly located in the Puente Formation bedrock. The results of chemical tests performed on selected samples with high OVA readings indicate that the concentration levels of total recoverable petroleum hydrocarbons (TRPH) and four selected volatile (aromatic) organic compounds (BTEX, including benzene, toluene, ethylbenzene, and xylenes) are low, and all are less than cleanup action levels as defined in the leaking underground fuel tank field manual. The low BTEX readings and the proximity to the Los Angeles City Oil Field may indicate that the high headspace OVA readings of soil samples could be due to presence of methane and residual petroleum in the Puente Formation.

The results of limited chemical analyses to detect concentration levels of heavy metals also indicate that the concentration levels of a suite of heavy metals in the subsurface materials are low and below cleanup action levels as specified in Title 22, Section 66699, by the California Department of Health Services.

The low concentration levels of TRPH, BTEX, and CAM metals in the subsurface materials appear to indicate that they are from natural sources and are not due to industrial contamination. what does this mean.

During drilling and sampling activities, sulfur odors were occasionally noticed in the work space and from the samples. Sulfur odors can be generated from various sulfide or sulfate compounds. Among these compounds, hydrogen sulfide (H_2S) is one of the most toxic. During the field investigation, triple-meter readings were taken when high OVA readings of samples were noted. The H_2S concentrations in the background and the work space/headspace surrounding the obtained soil samples were measured to have values ranging from 0 to 4 ppm, which is less than the exposure limit set by the federal Occupational Safety and Health Agency (OSHA) and the National Institute for Occupational Safety and Health (NIOSH, 1985). These results indicate that the potential for H_2S concentration levels exceeding the exposure limit may be minimal during construction; however, H_2S should be monitored and an action plan developed during construction to ensure safety and health of workers.

4.3.3 Groundwater Level and Quality

Groundwater levels were monitored in the piezometers installed in this investigation and in piezometer LPE-1 in the 1988 investigation (Earth Technology, 1988) using an electronic water-level indicator. Groundwater-level readings were taken periodically and are summarized in Table 3-2. The groundwater level at piezometers PII-3 through PII-6, located near the center of the station, was measured at about Elevation 238 feet. The groundwater level at piezometer LPE-1 (Earth Technology, 1988) was measured at about Elevation 232.5 feet. This represents a groundwater gradient of about 0.02 in the site area, which appears to support the reported gradient of about 0.024 in published data (CCI/ESA/GRC, 1983).

The perforated well screens in piezometers PII-3 through PII-6 were installed entirely within the Puente Formation bedrock and not hydrologically connected to the groundwater in the Old Alluvium above the bedrock. The groundwater-level readings from these piezometers are essentially similar to the groundwater-level readings at peizometer LPE-1, which was installed to measure the groundwater level in the Old Alluvium. This appears to indicate that Puente Formation bedrock in the site area is saturated and submerged.

why not?

Under perched water conditions in the Old Alluvium, Puente Formation bedrock can be submerged if hydrologic connections exist between the saturated alluvium and the bedrock. The omnipresence of these sandstone beds and weakly-intact bedding planes are apparently the sources of such hydrologic connections, as evidenced by the results of the slug tests, which indicate the permeability of the bedrock in horizontal directions is on the order of 10^{-5} cm/sec, approximately 100 to 500 times more than the vertical permeability (10^{-7} to 10^{-8} cm/sec) indicated by the results of laboratory permeability tests.

The results of limited chemical testing on water samples obtained from piezometers PII-5, PII-6, and LPE-1 are shown in Tables 3-6 through 3-10 and in Appendix C. The results indicate that the concentration levels of TRPH, BTEX, and sulfide in the water are generally low or not detected, except for the concentration levels of benzene at LPE-1, which varied from 8 ppb measured in November 1988 to 2.7 ppb measured in May 1989. The concentration levels of sulfate in water is relatively high and may require the use of Type II or Type V cements in construction.

The results also indicate the transient nature of chemical compound concentrations in the groundwater as evidenced by different BTEX results on water samples obtained from LPE-1 and tested in November 1988 and May 1989.

4.4 ENGINEERING PROPERTIES OF SUBSURFACE MATERIALS

Is this covered somewhere else?

Based on the results of field and laboratory testing, available data from previous investigations, other published data in the engineering literature, and engineering judgement, relevant engineering properties of the subsurface materials encountered in the site area were developed and used in our engineering evaluation (Section 5). These properties are summarized in Table 4-1. Seismic design was not in the scope of this work. Thus, only relevant static properties are presented. No engineering properties are presented for the localized presence of thin surficial fill, which has little or no effect on the planned design and construction of the station.

The following sections provide a description of the properties for the Old Alluvium and Puente Formation bedrock.

4.4.1 Fine-Grained Old Alluvium (A4)

The upper fine-grained Old Alluvium consists primarily of firm to very stiff clayey silt, silty clay and clayey sand. This layer is about 5 to 15 feet thick and above the observed groundwater levels. The shear strength properties were determined based on limited tests in this investigation, available data from the 1988 investigation (Earth Technology Corporation, 1988) and the 1983 investigation (CCI/ESA/GRC, 1983), and SPT data and index properties correlation with literature data. Elastic properties were primarily based on laboratory test data, available correlations of literature data with SPT data and index properties, and engineering judgement.

4.4.2 Granular Old Alluvium (A3)

The granular Old Alluvium above the Puente Formation bedrock and below the fine-grained Old Alluvium, when present, consists of predominantly dense to very dense silty sand and gravelly silty sand with fines content ranging predominantly from about 10 to 35 percent. This layer is expected to vary significantly. Laboratory tests and correlation of grain size data with literature data indicate that the permeability of this layer can potentially vary from 10^{-3} to 10^{-5} cm/sec or less, with an average value of about 10^{-4} cm/sec.

Strength test data from direct shear tests on selected soil samples in this stratum are consistent with the results obtained from the 1988 and 1983 investigations. The use of a friction angle of 37° and zero cohesion as effective strength parameters for this stratum above and below the perched groundwater is reasonably conservative since the potential apparent cohesion component (normally anticipated for moist sand with some fines content) is neglected.

Elastic modulus and Poisson's ratio for this stratum were also estimated based on literature data, available correlations with SPT data, and engineering judgement. Modulus of granular soils is usually a function of density of the soil, confining stress, and past stress history (overconsolidation effects). For simplicity, without sacrificing accuracy in heave/settlement calculations, the modulus values shown in Table 4-1 for this stratum represent the best estimated average value for use in the engineering evaluation.

4.4.3 Puente Formation Bedrock

The Puente Formation bedrock in the site area consists primarily of clayey siltstone or claystone interbedded with predominantly thin and weak sandstone beds. The engineering behavior of the bedrock is similar to very stiff to hard and highly overconsolidated fine-grained soils with dipping thin sandstone seams. The thin and weak sandstone beds and dipping bedding planes in the site area (except for occasional occurrence of hard sandstone beds up to about 1 foot thick), have lower shear strengths and are more permeable than the adjacent claystone and clayey siltstone. They represent preferred sliding (failure) surfaces and preferred flow pathways if they are dipping into the planned station excavations. Thus, the strength properties and permeability of the Puente Formation bedrock (in directions other than the dips of bedding planes) and the sandstone beds/bedding planes are separately presented for engineering evaluation purpose.

4.4.3.1 Shear Strength of Bedrock. Results of this investigation and previous investigations in the site area were evaluated to develop shear strength parameters. Both drained and undrained shear strength parameters were considered.

As reported in the 1983 investigation, the maximum past pressure on the Puente Formation bedrock may be on the order of 100 ksf. This means that the bedrock within the depth of excavation is overconsolidated with a minimum overconsolidation ratio (the ratio of maximum past pressure the present effective overburden stress) on the order of 15. Undrained shear strength of such an overconsolidated material is expected to be very high. Undrained strength can be estimated either based on the results of unconfined compression (UC) tests or undrained triaxial compression tests (CIU). Because of the presence of weak sandstone beds and bedding planes, all the UC tests performed in this investigation exhibited failure surfaces through either the sandstone beds or bedding planes. Thus, the results of UC tests can not be utilized to estimate the undrained shear strength of the bedrock. Instead, the results of CIU tests were used for such purposes. The recommended undrained shear strength value for the bedrock of 5,000 psf was developed based on the test results and engineering judgement to account for the potential effects of sample disturbance. This value represents a reasonably conservative undrained shear strength of the bedrock for short-term support and stability analysis using the $\phi = 0$ method.

The time required for station excavation and construction will be about one year or more, which is a relatively long time given the overconsolidated nature of the Puente Formation bedrock. Under such conditions, the undrained shear strength of the bedrock generally is not critical to the design, especially with respect to stability, earth pressure, and long-term support of the station structure.

Under confining stresses significantly less than the maximum past pressure, long-term, effective shear strength parameters for highly overconsolidated clayey materials such as the Puente Formation bedrock consist of two components: effective friction angle and effective cohesion. In this investigation, the effective shear strength parameters of the bedrock were evaluated based on the results of the CIU tests as well as engineering judgement. The recommended values shown in Table 4-1 include an effective friction angle (ϕ) of 33° and an effective coefficient (Ce) of 1,200 psf. As can be seen from Figure 4-4, the CIU test results indicated a significant data scatter, possibly due to the variability of the in situ bedrock and the effects of varying degrees of sample disturbance. The recommended effective strength parameters closely corresponds to the near-lower bound values to account for bedrock variability and, thus, are reasonably conservative. Under the anticipated stress ranges in the planned station excavation and construction, these effective strength parameters will exhibit higher shear strength values than those recommended in the 1983 investigation.

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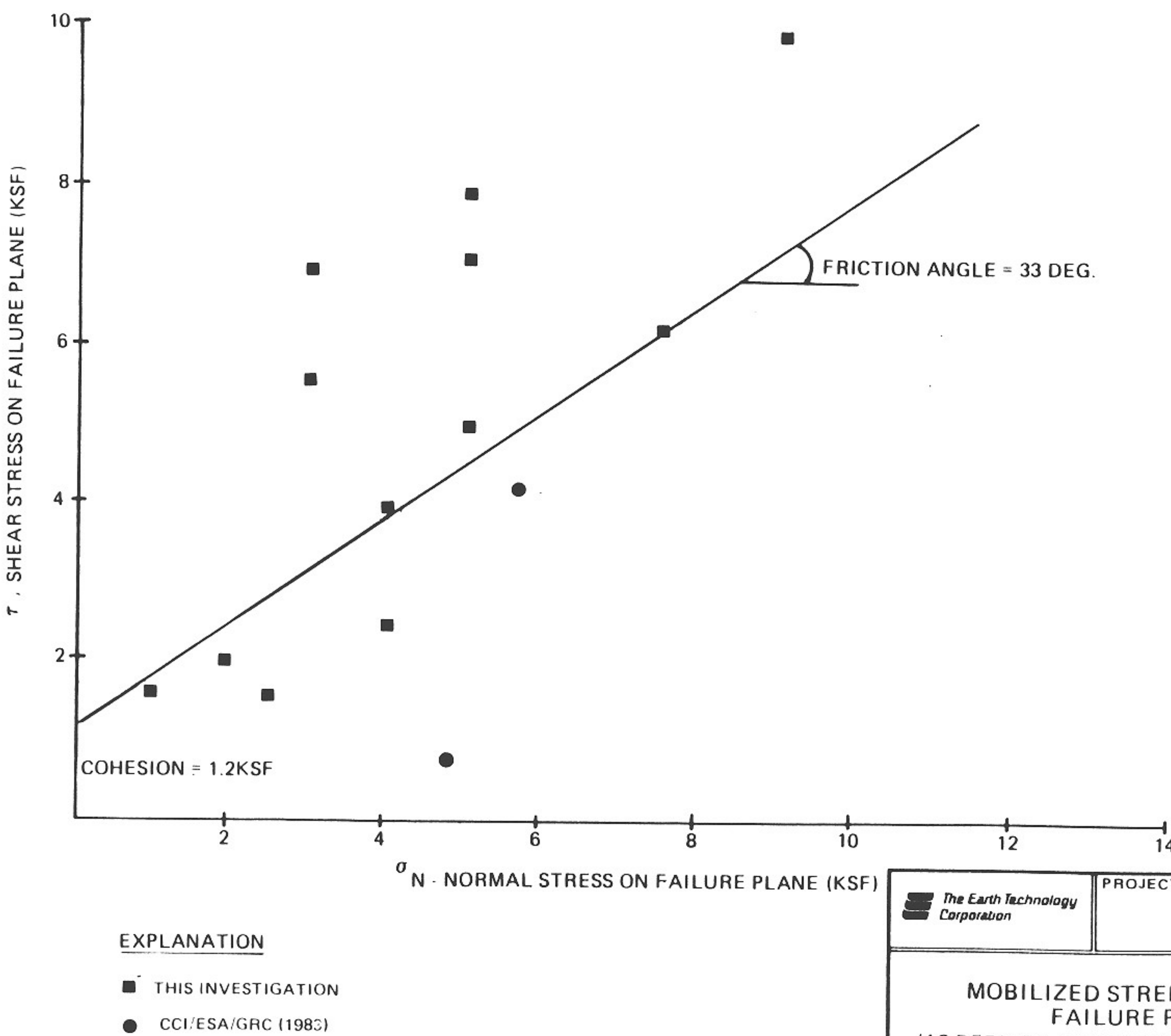

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MOBILIZED STRENGTH ALONG FAILURE PLANE
(AS DERIVED FROM TRIAXIAL TEST RESULTS)

6/89 FIGURE 4-4

4.4.3.2 Shear Strength of Sandstone Beds and Bedding Planes. As mentioned previously, except for the infrequent occurrence of up to 1-foot-thick hard sandstone beds, omnipresent sandstone beds and bedding planes in the site area are generally weaker than the overall strengths of the bedrock as evidenced by the observed shearing patterns (failure along sandstone beds and bedding planes) in the UC tests. An evaluation of the UC test results was performed to interpret the potential shear strength range of the sandstone beds and bedding planes. The results indicate that a friction angle of 24° with zero cohesion can reasonably be used to satisfactorily explain the observed results. The effects of potential sample disturbance would indicate that the obtained shear strength values probably represent lower-bound values for the sandstone beds and bedding planes in the site bedrock. To avoid over-conservatism, we believe that a friction angle of 25° and a cohesion of 200 psf will be reasonably representative of these beds and bedding planes. These values are recommended and used in the engineering analysis (Section 5).

4.4.3.3 **Permeability.** Vertical permeability for the bedrock based on the results of laboratory tests ranges from 10^{-7} to 10^{-8} cm/sec. However, due to the omnipresence of more pervious sandstone beds and bedding planes, the permeability along the dips or near horizontal direction will be significantly higher. The results of slug tests indicate that permeability of about 10^{-5} cm/sec is reasonable along the sandstone beds and bedding planes or near the horizontal direction.

4.4.3.4 **Elastic Properties.** Available laboratory test results and other available data in the project files, together with engineering judgement, were utilized to evaluate the elastic properties of the bedrock. The recommended Young's modulus value for the bedrock, shown in Table 4-1, represents a somewhat conservative near-lower bound value to account for potential variations in the bedrock, as evidence by a large scatter shown in the laboratory test results.

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Evaluation
dations

- Foundation design of station structures
- Construction related safety, health, and spoil disposal issues.

5.2 GROUNDWATER CONTROL AND CONSTRUCTION DEWATERING

5.2.1 Groundwater Control

Perched groundwater levels across the site area were observed to range from about Elevations 232 feet to 240 feet. Since the bottom of the station excavation will be at about Elevation 162 feet, the excavation will extend about 70 to 80 feet below the perched groundwater level, which includes about 10 to 15 feet of granular Old Alluvium (Unit A3) and 60 to 65 feet of the Puente Formation (Unit Tp). Because Unit A3 is relatively pervious, relatively high flow rates into excavation, especially at the initial stage, are likely if groundwater control provisions are not implemented. Hydrological analysis to estimate the potential range of flow rate is not within the scope of this work. However, we believe that groundwater control schemes, either preventing flow from the granular Old Alluvium into excavation or lowering the groundwater table to or below the top of the Puente Formation bedrock by construction dewatering, will be required. Based on our preliminary evaluation, a suitable groundwater control scheme may include, but is not limited to, one or more of the following systems:

- Wells around the excavation perimeter
- Well points around the excavation perimeter
- Well points within the excavation
- Slurry wall around the excavation perimeter.

Further hydrological analysis, design, and cost evaluation will be necessary to establish a most suitable groundwater control scheme. It is understood that the contractor will be responsible for design, installation, and operation of a suitable groundwater control system. As a general guideline, an appropriate groundwater control system should:

- Be installed and in operation for a sufficient time to draw down the groundwater to a desirable level or to adequately prevent significant inflows prior to excavation below the groundwater level
- Reduce the inflow to levels that can be handled by a drain/sump system and allow excavation and construction to proceed without delay
- Not incur ground loss due to piping of the subsurface materials
- Not induce undue and unsafe amounts of settlement to the adjacent existing buildings
- Be operated continuously and equipped with emergency power and backup pumps and accessories
- Incorporate continuous monitoring for evidence of piping and amounts of settlements in the adjacent existing buildings.

5.2.1 Induced Subsidence

Groundwater control pumping during construction will induce some groundwater subsidence. The amount of subsidence depends on the groundwater control scheme utilized, amounts of groundwater-level drawdown, permeability of the subsurface materials, subsurface conditions, and excavation configuration and construction. Groundwater-level drawdown can be caused by construction dewatering and gravity flow of groundwater into the excavation opening, and is also dependent on distances from the dewatering system and excavation openings, excavation configuration, and subsurface material permeability. Thus, groundwater drawdown is time- and distance-dependent.

Settlements caused by groundwater-level drawdowns were calculated assuming the that subsurface conditions within a couple of hundred feet of the station excavation were similar to those encountered in the borings in this investigation and in the 1983 investigation (CCI/ESD/GRC). Judging from the relatively uniform layering nature exhibited by the available subsurface data, this assumption is reasonable. It is estimated that surface settlements for 5 to 15 feet of drawdowns would range about 1/4 to 1/2 inch. It is anticipated the drawdown levels will slowly decrease as the distance away from the excavation opening increases.

What's the basis?

It is anticipated that differential settlements will be significantly less than the total settlement. For 15 feet of drawdown, we estimate the differential settlements would be as follows:

Differential Settlement Over 50 Feet Span	Distance from Excavation Opening (ft)
1/4 inch or less	Within 50 feet
3/32 inch or less	50 feet or 100 feet
1/8 inch or less	Over 100 feet

The above differential settlement estimates are relatively small and should not cause undue impact on the adjacent buildings. However, it is prudent that any existing buildings over 3 stories high and located within 100 feet of excavation be monitored for settlement during dewatering, excavation, and construction to reduce liability.

5.3 STATION EXCAVATION

The current plan (May 1989) of excavation penetration depths for various components of the Wilshire/Vermont Station are as follows:

Component	Approximate Elevation of Bottom of Excavation (ft.)
Entrances	225
Mezzanine	225
Upper Platform	198
Lower Platform	168
Main Station	162

Since perched groundwater levels were observed to be about Elevations 232 to 240 across the site area, which are above the bottoms of excavations for all the structural components of the station, groundwater control will be needed. As an alternative to shored excavations, portions of the required excavation can be accomplished by slope excavation through the portion of the Old Alluvium above the groundwater level if sufficient easements can be obtained. Sloped excavation can also be made for the portion of the Old Alluvium under groundwater level if anticipated groundwater flow from the alluvium into the excavation can be handled through proper groundwater control provisions without delaying construction. Except for the entrance and mezzanine structural components, sloped excavation may not be possible because the costs associated with obtaining sufficient easements for the needed deep sloped excavation and with large amounts of additional excavation and backfilling may be prohibitive.

5.3.1 Sloped Excavation

Compared to shored excavation, sloped excavations will increase the volume of excavated material. Sloped excavations can be used for the station's structural components that require shallower excavations or be used to reduce the height of shoring if sufficient easements can be obtained and proper groundwater control provisions are implemented.

A series of slope stability analyses were performed assuming the perched groundwater at the site is drawn down and maintained at least 5 feet below the granular Old Alluvium at the site and no heavy loads are at or near the top of the slope. The results indicate the following allowable temporary slopes:

1. 1H:1V (one horizontal to one vertical) for the fine-grained Old Alluvium (Unit A4).
2. 1 1/2H:1V for the granular Old Alluvium (Unit A3).
3. 2H:1V for the Puente Formation (Unit Tp) bedrock in the northeast side of the excavation if the omnipresence of thin and weak sandstone beds and bedding plains dipping into the excavation is assumed to be continuous.
4. 1H:1V for the Puente Formation bedrock in the remaining three sides of the excavation, where sandstone beds and bedding plains are either parallel to or dips away from the excavation openings.

It should be noted that construction and proper maintenance of safe, stable slopes are the responsibility of the contractor, based on factors that must be determined in the field from actual construction conditions and the subsurface conditions encountered during construction. Thus, the above allowable slope recommendations can not be construed by the contractor to be guaranteed permissible slopes.

5.3.2 Shored Excavation

The excavation for the cut-and-cover station will extend to a maximum depth of about 100 feet below the ground surface. It is anticipated that about 70 to 80 feet of the excavation will be below the perched groundwater table. Proximity of the excavation to the adjacent existing buildings, limited construction space, and the subsurface conditions in the general area indicate that shoring will be required.

We understand that appropriate shoring system selection, design, installation and maintenance will be the responsibilities of the contractor and subject to review and acceptance by SCRTD. There exist various shoring systems in engineering practice. These include sheet pile, structural slurry, soldier pile walls with tiebacks or internal bracing, and freeze walls. Based on local practice in Los Angeles areas with subsurface conditions similar to those encountered in the site area, soldier pile walls with tiebacks or internal bracing comprise the most likely shoring system. This system was assumed to be used by the contractor for the deep excavation of the station, because:

1. Structural slurry walls are generally significantly more expensive.
2. It is difficult to drive sheet piles into Puente Formation bedrock.
3. Freeze walls are costly to install and maintain in the warm climate of the Los Angeles area. In addition, freezing during construction and subsequent thawing after construction might degrade the weak bedrock and bedding planes, resulting in exerting excessive pressure on the station walls and inducing more settlements to the station structures and adjacent existing buildings.
4. Since the bedrock appears to be submerged continuous slurry, sheet pile or freeze walls may accumulate water and build up significant water pressures behind the shored walls. Design and construction of a deep shored wall to resist significant water pressure differential will be extremely costly compared to soldier pile walls with lagging and tiebacks or internal bracing.

In this investigation the engineering evaluation and discussions provided in this section for the shoring support of the station excavation are related to the soldier pile walls with tiebacks or internal bracing. We will assist

SCRTD and its consultants in evaluating any other shoring systems selected by the contractor.

5.3.2.1 General and Assumptions. Soldier pile wall shoring systems for deep excavations consist of soldier pile walls, lagging, and tiebacks or internal bracing to resist lateral earth and water pressures exerted by the excavation and/or the lateral pressure resulting from the adjacent existing structures if they are not underpinned (Section 5.4). The omnipresence of thin and weak sandstone beds and dipping angels has a significant effect on the excavation and shoring in terms of lateral loading/resistance magnitude.

Both soldier pile walls with tiebacks (cantilevered or anchored shoring) or internal bracing (braced shoring) were considered in the engineering evaluation. The following assumptions were made in the engineering evaluation provided in subsequent sections:

1. The perched groundwater level at the site is drawn down to a few feet below the bottom of the Old Alluvium prior to excavation.
2. No significant accumulation of water and water pressure buildup behind the walls during station excavation and construction.
3. The weak sandstone beds and bedding planes are continuous with a maximum dip angle of about 35°.

The first assumption has been described previously. Although the bedrock is considered to be submerged, the second assumption is appropriate for soldier pile walls and lagging shoring systems since the openings betweeen solidier pile laggings should prevent significant water accumulation and pressure buildup. The presence of weak and dipping sandstone beds and beddings may increase active earth pressure in the northeast side of the station excavation and reduce the passive earth pressure in the southwest side of the station excavation, depending on the continuous nature and the dip angles and shear strengths of the dipping sandstone beds and bedding planes. The results of this investigation indicate that the dip angles in the Puente Formation bedrock range from 0° to 50°, but are predominantly between 20° and 35°. The assumption of a 35° dipping angle is reasonable to avoid overconservatism (i.e., conservative strength over conservatively used steeper and continuous dip angles) so that the active earth pressure values for the northeast side of the excavation are not overconservatively specified.

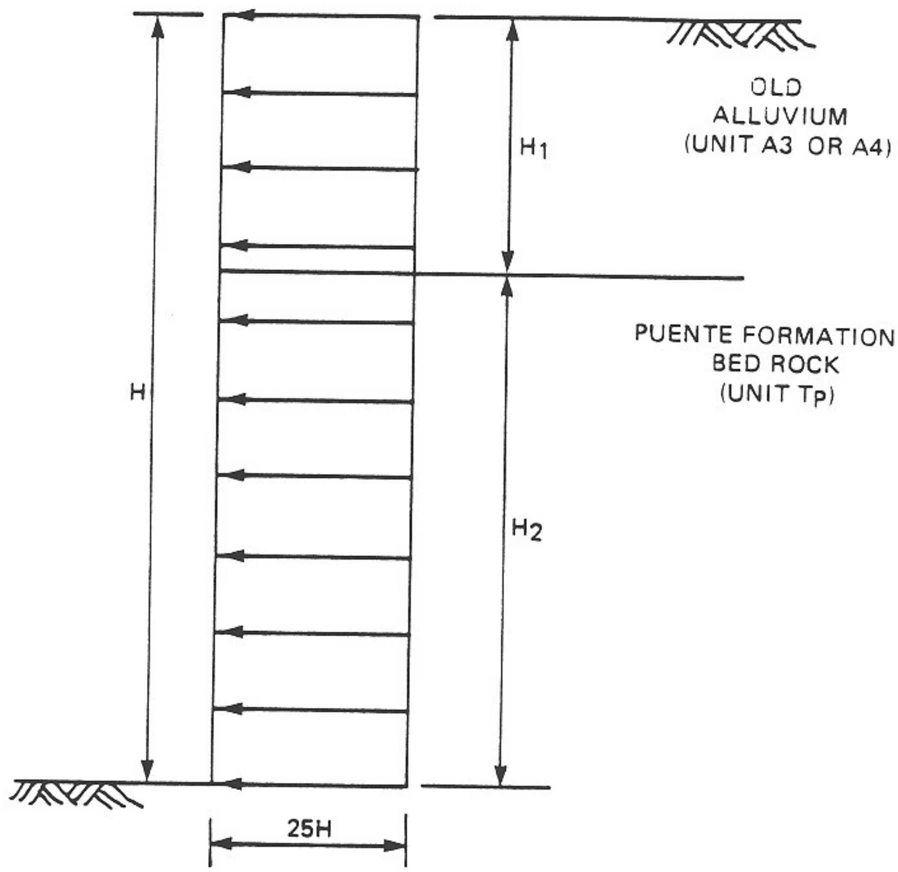
Based on the above assumptions, our engineering evaluation and recommendations with respect to two soldier pile wall shoring systems with internal bracing (braced shoring) or tiebacks (cantilevered shoring) are described in the following sections.

5.3.2.2 Lateral Wall Pressure. Lateral pressure on the shored walls depends on the type of shoring system, construction procedures, and subsurface and groundwater conditions. Based on the available results, anticipated shoring system, and construction procedures, as well as previously stated engineering assumptions, lateral earth pressures on the soldier pile shoring walls for the following cases are shown in Figures 5-1 through 5-4 for use as general guidelines for shoring design:

- o Braced shoring above excavation
- o Cantilevered shoring above excavation
- o Surcharges from sloped excavation, existing building and construction loads
- o Active and passive earth-pressures on soldier piles below the excavation.

The lateral loading diagrams presented in Figures 5-1 to 5-4 are for use in the design of soldier pile details, tiebacks, or an internal bracing system. Various design considerations are described in the following sections.

5.3.2.3 Design Considerations - Soldier Piles and Lagging. The soldier pile walls should be designed to safely resist lateral and vertical loads imposed by the excavation, existing structures, construction loading, environmental loading (such as earthquake loading), and the shoring system itself. The effective pile diameter should be taken as 1.5 times the soldier pile diameter, or half of the pile spacing, whichever is less. Design considerations include pile sizing, embedment depth, and spacing, installation, and lagging provisions.



NOTE: (1) THIS PRESSURE DIAGRAM IS APPLICABLE TO ALL SIDES OF EXCAVATION

(2) EARTH PRESSURE IN PSF

(3) H, H_1 AND H_2 IN FEET

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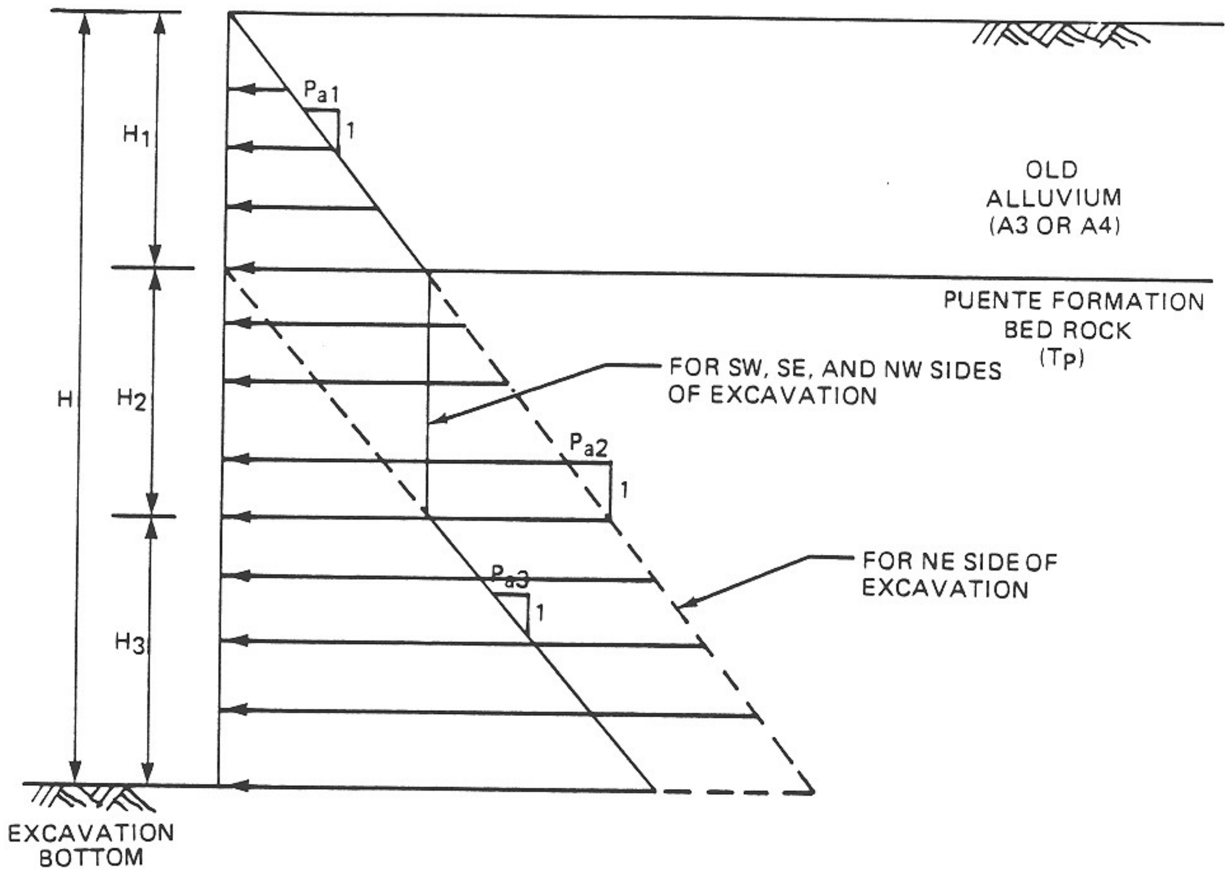
LATERAL EARTH PRESSURE ON BRACED SHORING

6-89

FIGURE 5-1



FOR NE SIDE OF EXCAVATION

P_{a1} = 31 PSF/FT

P_{a2} = 30 PSF/FT

FOR SW, SE, AND NW SIDES OF EXCAVATION

P_{a1} = 31 PSF/FT

P_{a3} = 35 PSF/FT

NOTES: (1) ALL EARTH PRESSURES IN PSF

(2) H, H_1, H_2 AND H_3 IN FEEET

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METRO RAIL
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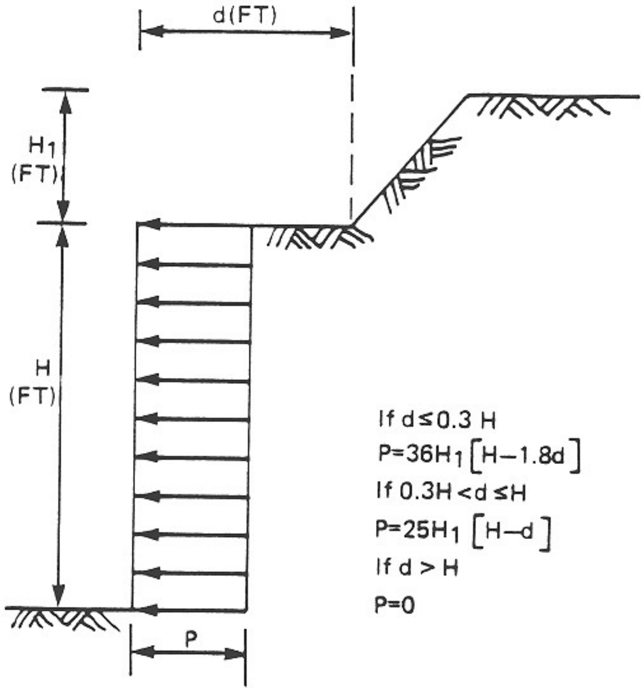
LATERAL EARTH PRESSURE ON CANTILEVERED SHORING

6-89

FIGURE 5-2



If $d \leq 0.3H$

$P = 36H_1 [H - 1.8d]$

If $0.3H < d \leq H$

$P = 25H_1 [H - d]$

If $d > H$

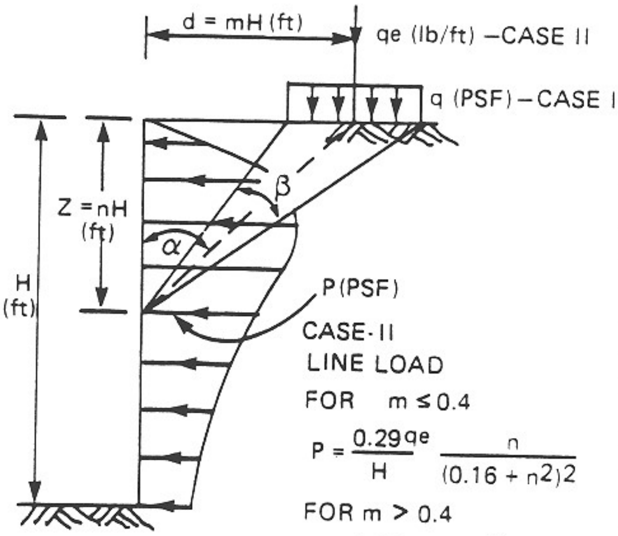
$P = 0$

(a) SLOPED EXCAVATION SURCHARGE

NOTE: CONSTRUCTION SURCHARGE IS ASSUMED TO BE LINE LOAD OR STRIP LOAD

CASE I

STRIP LOAD $P = \frac{2q}{\pi} (\beta - \sin\beta \cos 2\alpha)$



CASE-II

LINE LOAD

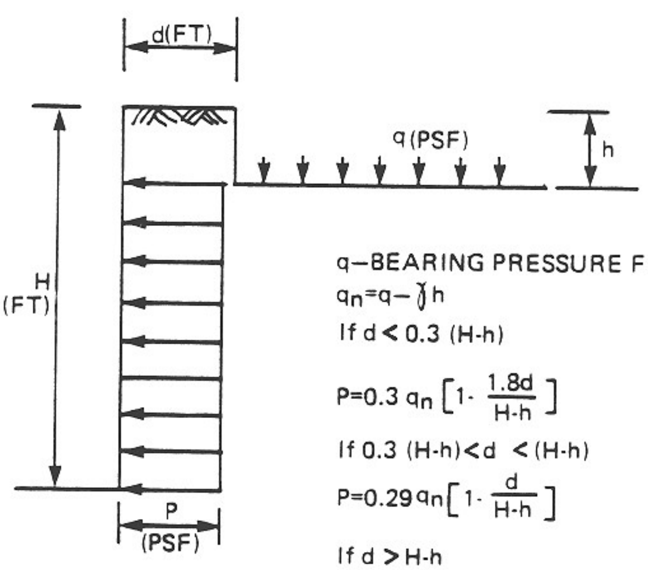
FOR $m \leq 0.4$

$$P = \frac{0.29\,q_e}{H} \cdot \frac{n}{(0.16 + n^2)^2}$$

FOR $m > 0.4$

$$P = \frac{0.28\,q_e}{H} \cdot \frac{m^2 n}{(m^2 + n^2)^2}$$

(b) CONSTRUCTION SURCHARGE



γ – DENSITY (PCF)

q – BEARING PRESSURE FROM EXSISTING BUILDING (PSF)

$q_n = q - \gamma h$

If $d < 0.3\,(H-h)$

$$P = 0.3\,q_n \left[1 - \frac{1.8d}{H-h}\right]$$

If $0.3\,(H-h) < d < (H-h)$

$$P = 0.29\,q_n \left[1 - \frac{d}{H-h}\right]$$

If $d > H-h$

$P = 0$

(c) BUILDING SURCHARGE

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ADDITIONAL LATERAL EARTH PRESSURE ON BRACED OR CANTILEVERED SHORING

6-89 FIGURE 5-3

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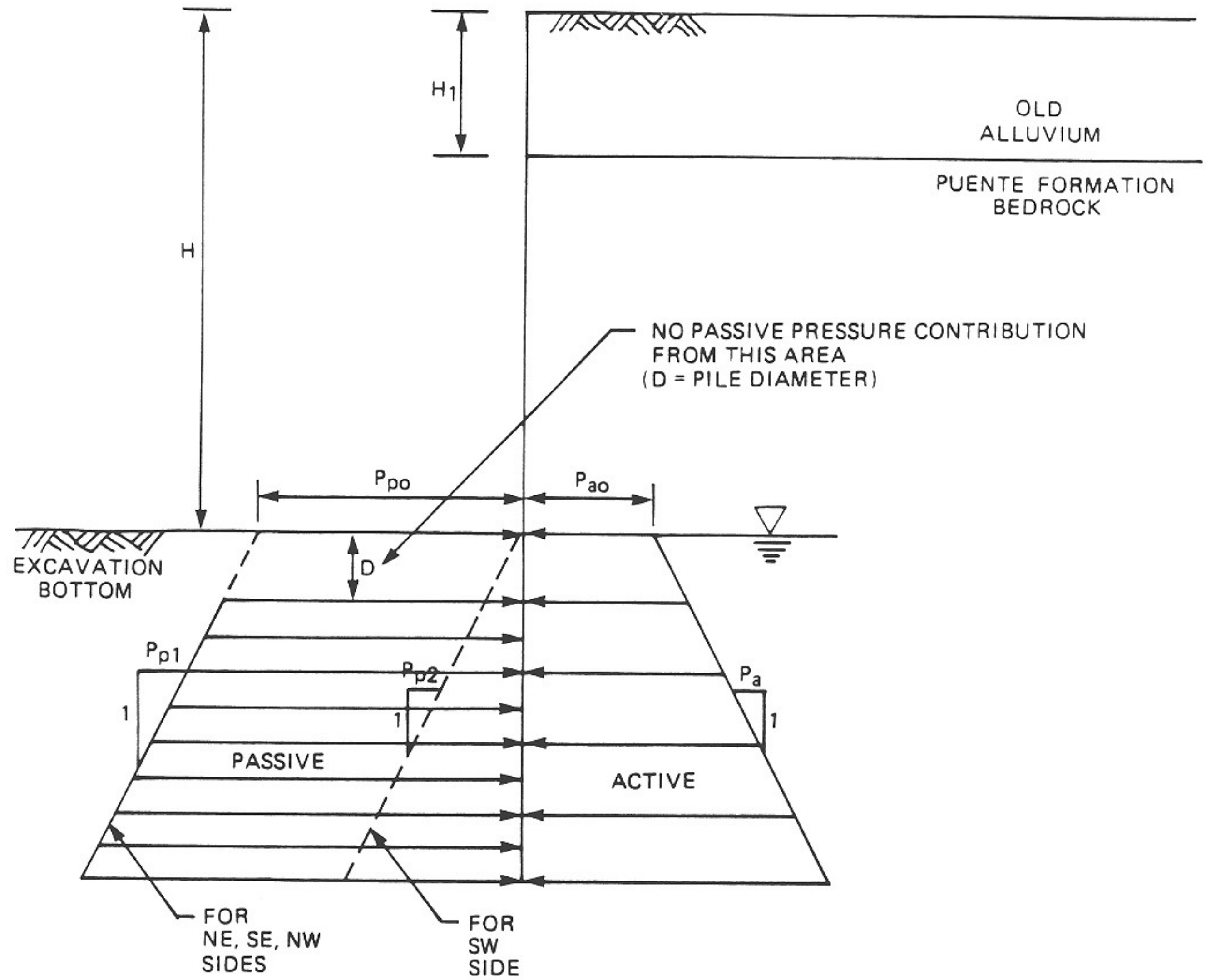

FOR NE SIDE OF EXCAVATION

P_{po} = 2225 PSF, P_{p1} = 99 PSF/FT, Pa = 15 PSF/FT

FOR SW SIDE OF EXCAVATION

P_{po} = 0 PSF, P_{p2} = 71 PSF/FT, Pa = 17 PSF/FT

FOR SE AND NW SIDES OF EXCAVATION

P_{po} = 2225 PSF, P_{p1} = 99 PSF/FT, Pa = 17 PSF/FT

FOR VALUES OF P_{ao} SEE FIGURE 5-2

NOTES: (1) BEDROCK BELOW EXCAVATION BOTTOM IS ASSUMED TO BE SUBMERGED

(2) FACTOR OF SAFTY OF 2.0 IS INCLUDED FOR PASSIVE PRESSURE.

(3) ALL EARTH PRESSURES IN PSF

(4) H, H_1 AND D IN FEET

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LATERAL EARTH PRESSURE ON SOLDIER PILES BELOW EXCAVATION

6-89

FIGURE 5-4

Pile Sizing

Piles sizing includes a proper determination of pile size (diameter or cross section) and type (stiffness) so that stresses in the piles are within allowable limits. All anticipated lateral and vertical loads as well as calculated loads from tiebacks or internal bracing should be applied in calculating the pile stresses. The calculated stresses in the pile can be reduced by 20 percent to account for arching effects due to pile flexibility.

Embedment Depth

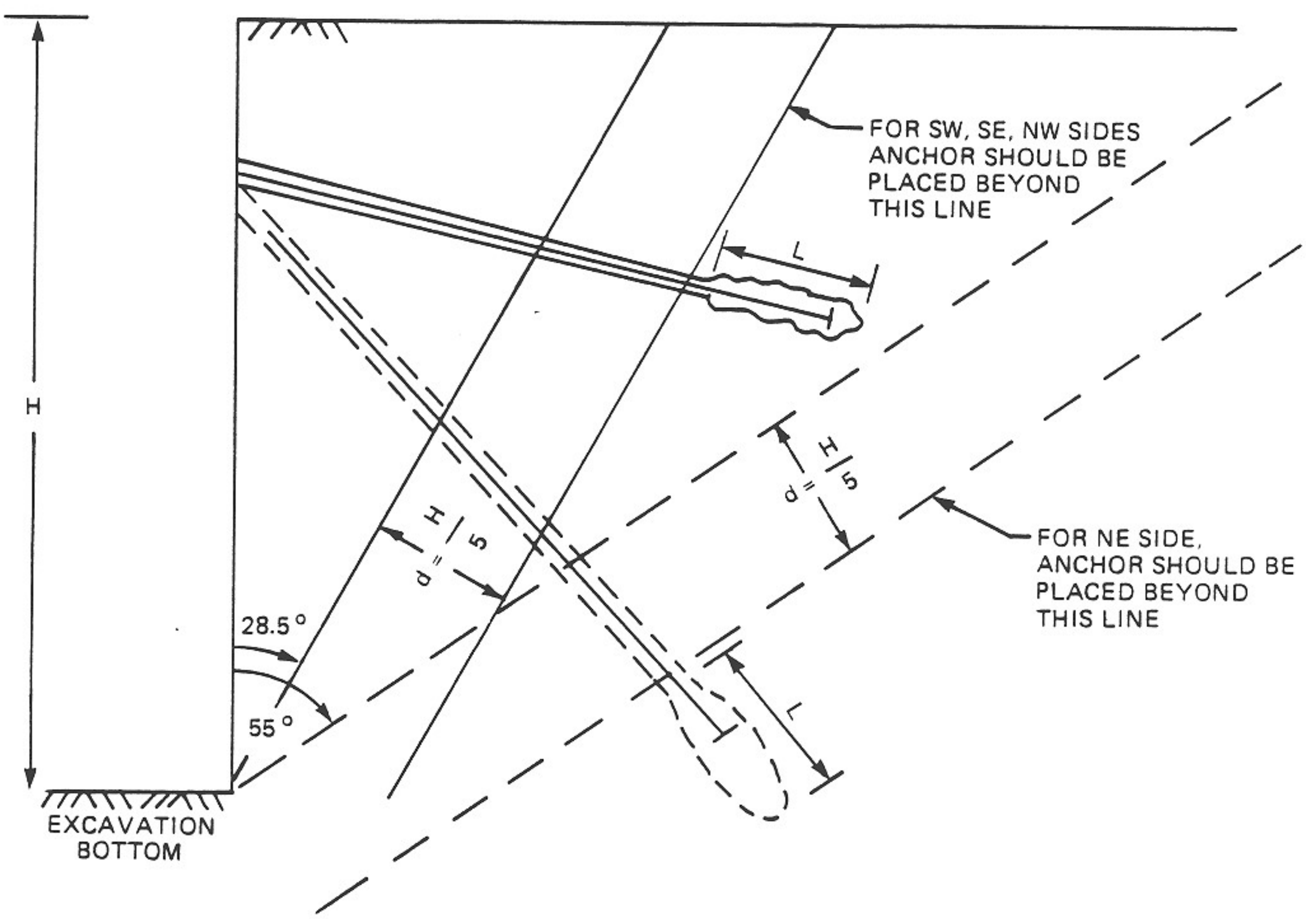
The soldier piles should be sufficiently embedded below the excavation depth to safely resist anticipated lateral and vertical loads. The passive resistance should be much more than the imposed lateral loads (active resistance in Figures 5-1 to 5-4 minus the resistance from tiebacks or internal bracing). For vertical load considerations, the allowable vertical pile capacity shown in Figure 5-5 should be more than the vertical load components from tiebacks. Groundwater-control-induced settlement adjacent to the soldier pile wall, if sufficiently large, may result in negative skin friction on the piles, which would reduce the allowable vertical capacity. After evaluating the negative skin friction potential, it was concluded that the potential for such a condition to develop within the pile embedment depth below the excavation would be minimal; therefore, it was not considered in developing the vertical load capacity shown in Figure 5-5.

Pile Spacing

Optimal pile spacing depends on a number of factors, including subsurface conditions and engineering properties of subsurface materials, pile sizing, and construction procedures and cost. Considering the need for lagging to alleviate soil raveling and minimize ground loss, a pile spacing of 8 feet or less would be reasonable.

Pile Installation

As in similar deep excavations in the Los Angeles area, the soldier piles in the site area should be installed in predrilled holes to the design embedment



L – LENGTH OF ANCHOR BEYOND NO LOAD ZONE
d, H AND L ARE FEET

REFERENCE: FHWA, PERMENENT GROUND ANCHORS, 1984.

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ANCHOR LOCATIONS FOR TIED-BACK WALLS

6-89 FIGURE 5-5

depths. The presence of dense to very dense granular Old Alluvium overlying Puente Formation bedrock in the site area precludes the use of impact driving. Potential caving conditions exist in granular Old Alluvium. Provisions such as use of slurry in the predrilled holes should be implemented to alleviate caving concerns.

Lagging

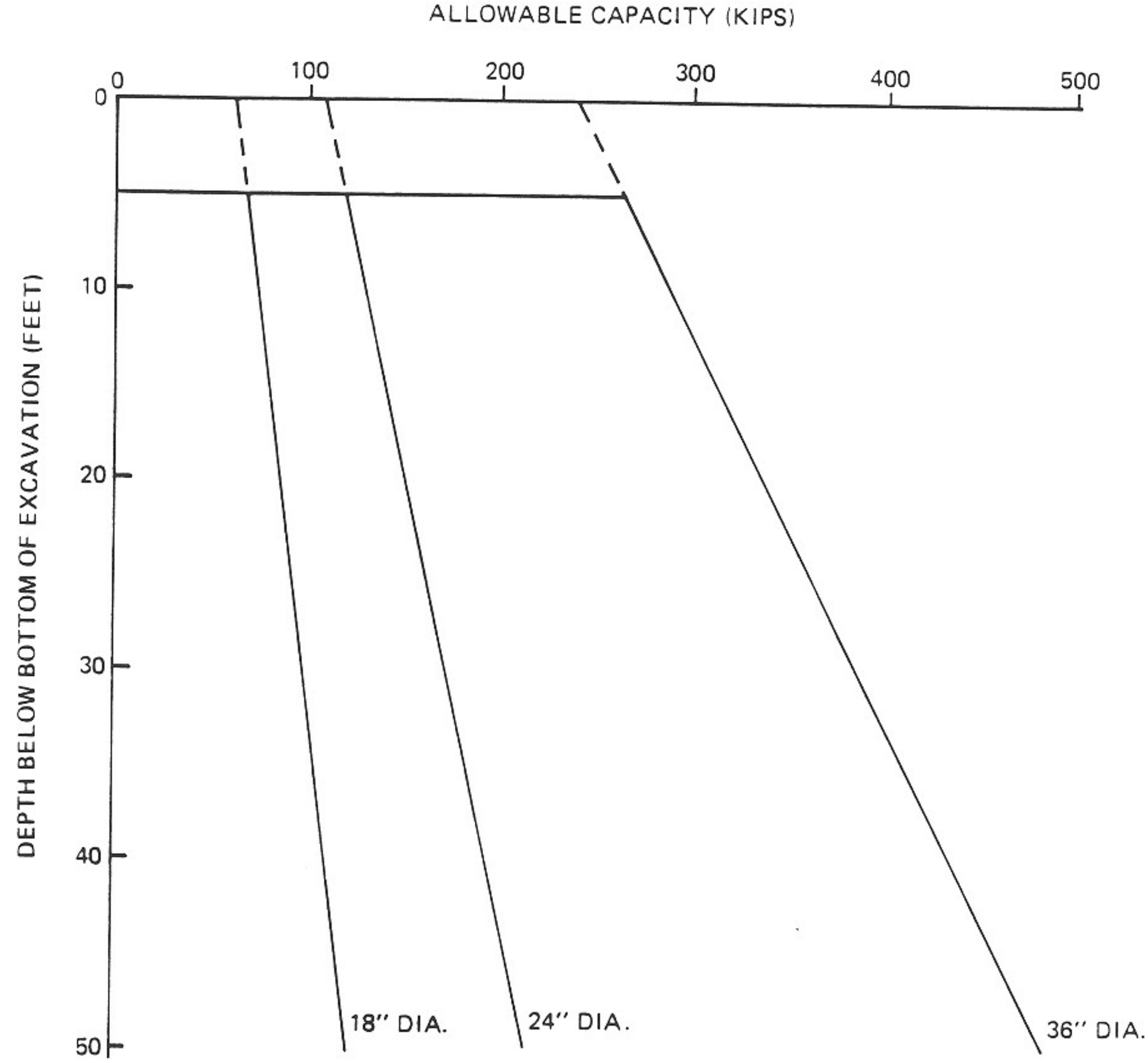
Lagging between soldier piles will be needed to minimize soil raveling or loss of ground, especially in the zones of granular Old Alluvium and in the bedrock in the northeast side of the excavation, where weak sandstone beds and bedding planes dip into the excavation. It is the contractor's responsibility to control the temporary height of exposed soil prior to lagging placement to eliminate raveling and ground loss problems.

Tiebacks

Installing tiebacks in the site area will require permission from the owners of adjacent buildings and avoidance of below-grade obstructions such as a basements or pier foundations in adjacent buildings. There exist many types of tieback anchors, including shaft anchors, belled anchor, anchor blocks, and high-pressure grout anchors. For this project, we assume that straight shaft anchors are going to be used in construction.

In general, allowable capacity of the tieback anchor should be determined in the field based on anchor load tests. For purposes of discussion, the following paragraphs describe our anchor capacity estimates and recommendations.

Effective friction of a tieback anchor can develop only beyond a no-load zone. Our recommendation for the no-load zones considering depth of excavation and potential wedge failure planes in the northeast side and the remaining three sides of the excavation are shown in Figure 5-6. For estimation purposes, the allowable anchor capacity can be determined as follows:



NOTE: FACTOR OF SAFETY OF 3 IS INCLUDED

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VERTICAL CAPACITY FOR STRAIGHT SHAFT SOLDIER PILES

6-89 FIGURE 5-6

$$P = qDL$$

where:

P = allowable anchor load in kips
L = length of anchor beyond the no-load zone in feet
D = anchor diameter in feet
q = soil friction in ksf

q can be determined as follows:

$q = 0.075d < 1.5$ ksf in granular Old Alluvium above perched groundwater
$q = 0.9 + 0.04d < 1.5$ ksf in granular Old Alluvium below groundwater
$q = 0.8$ in Puente Formation bedrock

In addition, the allowble capacity of the anchors completely embedded in granular Old Alluvium should not exceed 150 kips. The anchors may be installed at angles betweem 20° to 50° below the horizontal direction. Potential caving conditions in the granular Old Alluvium are possible, so the contractor should use appropriate methods and measures to prevent caving to minimize ground loss.

Each tieback anchor should be load tested to 150 percent of the design load. At 150 percent of the design load the anchor deflection should not exceed 0.1 inch over a 15-minute time period.

Internal Bracing

If braced shoring systems are employed, the strut loads should be determined using the full load diagrams shown in Figures 5-1 and 5-3. The vertical spacing between struts should be appropriately designed to minimize ground movements. All struts should be preloaded to eliminate slack and minimize ground movement. A preload of about 50 percent of the design load is generally appropriate.

Procedures to compensate for the effects of temperature changes on the strut loads should be developed and implemented so that proper strut preload levels can be monitored and maintained during construction.

5.3.2.4 Ground Movement and Bottom Stability. Shored excavation will incur ground movements in terms of shored wall movement and ground heave. The magnitude of wall movement depends on many factors, including the design and construction of shoring systems, construction schedule, specifications, and subsurface conditions. In general, for a well-designed and constructed shored wall, the maximum horizontal wall deflection will be about 0.1 percent of the excavation depth. For the Wilshire/Vermont Station, the maximum horizontal wall movement may be about 1 to 2 inches. For the shored system with tiebacks, this maximum horizontal deflection will occur near the surface, and the horizontal deflection will decrease with depth. For braced shoring, the maximum horizontal deflection will probably occur near the bottom of the excavation and decrease to about 0.2 to 0.5 inch near the surface.

It is estimated that maximum vertical settlement behind the wall of about 0.5 to 1 inch will probably occur at about 25 to 50 feet from the wall and will decrease as the distance from the maximum settlement location increases.

The maximum excavation depth of the Wilshire/Vermont Station is about 100 feet. This would mean a stress relief of about 7,500 psf at the bottom of excavation, resulting in bottom heave due to elastic and consolidation rebounds. We estimate that the heave at the center of the excavation bottom will be about 2 to 4 inches. A majority of the heave will occur during the excavation. After the excavation is completed, the consolidation heave should be minimal and should pose no concerns. We also concluded that rupture of the excavation bottom due to excessive heave or piping is not likely.

5.4 UNDERPINNING

The need to underpin adjacent existing buildings during station construction depends on many factors, including shoring design/construction, excavation dewatering effects, physical and foundation characteristics of existing buildings, cost, and the cooperation of private property owners. It is difficult to generalize such a need; each existing building has to be evaluated on a case-by-case basis.

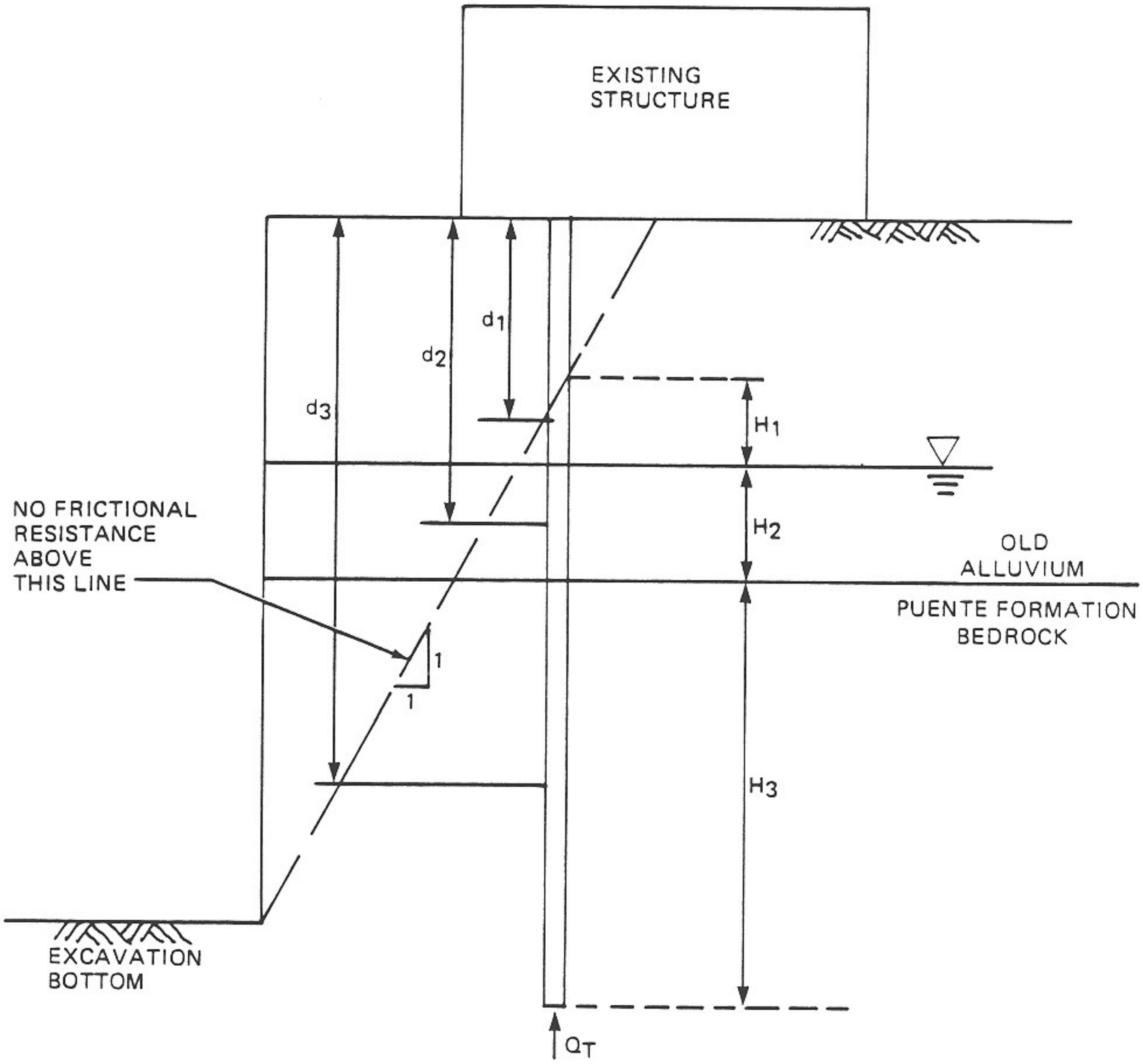
Most of the buildings in the site area, except the Borex Building at 3075 Wilshire Boulevard (10-story), are low-rise, less than 4 stories high. Given a well-designed and constructed shored system with the load imposed by the adjacent building conservatively considered, underpinning is generally not necessary for the low-rise buildings at the site. Although further confirmation is required, the 10-story Borex Building may be supported by drilled piles with tips within the Puente bedrock (LeRoy Crandall, 1961). The need for underpinning this building will depend on whether the pier foundation is adequate and whether the building can satisfactorily resist anticipated settlement in the Puente Formation bedrock due to groundwater-control-induced and shored-wall-related settlement. Thus, further structural and foundation evaluation will be necessary for this building.

Generally, there are several methods for underpinning, if needed. These may include, but are not limited to, jacked piles, drilled piers, and shafts/piers constructed in pre-dug lagged pits to the bearing stratum. To minimize settlement, the logical bearing stratum in the site area would be the Puente Formation bedrock. Our estimated allowable bearing capacity for jacked piles and drilled piers are presented in Figures 5-7 through 5-9 as guidelines.

The settlements of underpinned buildings should be monitored on a regular basis during construction. If the monitored settlements exceed the maximum allowable limits pre-set by the engineers, immediate remedial measures by adding or strengthening underpinning elements or by implementing new under-pinning provisions will be required.

5.5 STATION FOUNDATION SUPPORT AND CONSIDERATIONS

The subsurface materials underlying the station are Old Alluvium (consisting primarily of dense to very dense granular materials overlain by stiff to very stiff fine-grained materials in a limited area) over Puente Formation bedrock. They will provide adequate foundation support for the planned station structures.



ALLOWABLE CAPACITY = $Q_T + (H_1 \times Q_{f1}) + (H_2 \times Qf2) + (H_3 \times Q_{f3})$

Q_T = TIP RESISTANCE AT TIP DEPTH (FIGURE 5-8)

Q_{f1}, Q_{f2}, Q_{f3}= SKIN FRICTION AT DEPTHS d_1, d_2 AND d_3, RESPECTUALY (FIGURE 5-9)

NOTES: (1) Q_{f1}, Q_{f2}, AND Q_{f3}, IN KIPS/FT

(2) Q_T IN KIPS

(3) H_1, H_2, H_3, d_1, d_2, AND d_3 IN FEET

(4) DRAWING IS NOT TO SCALE

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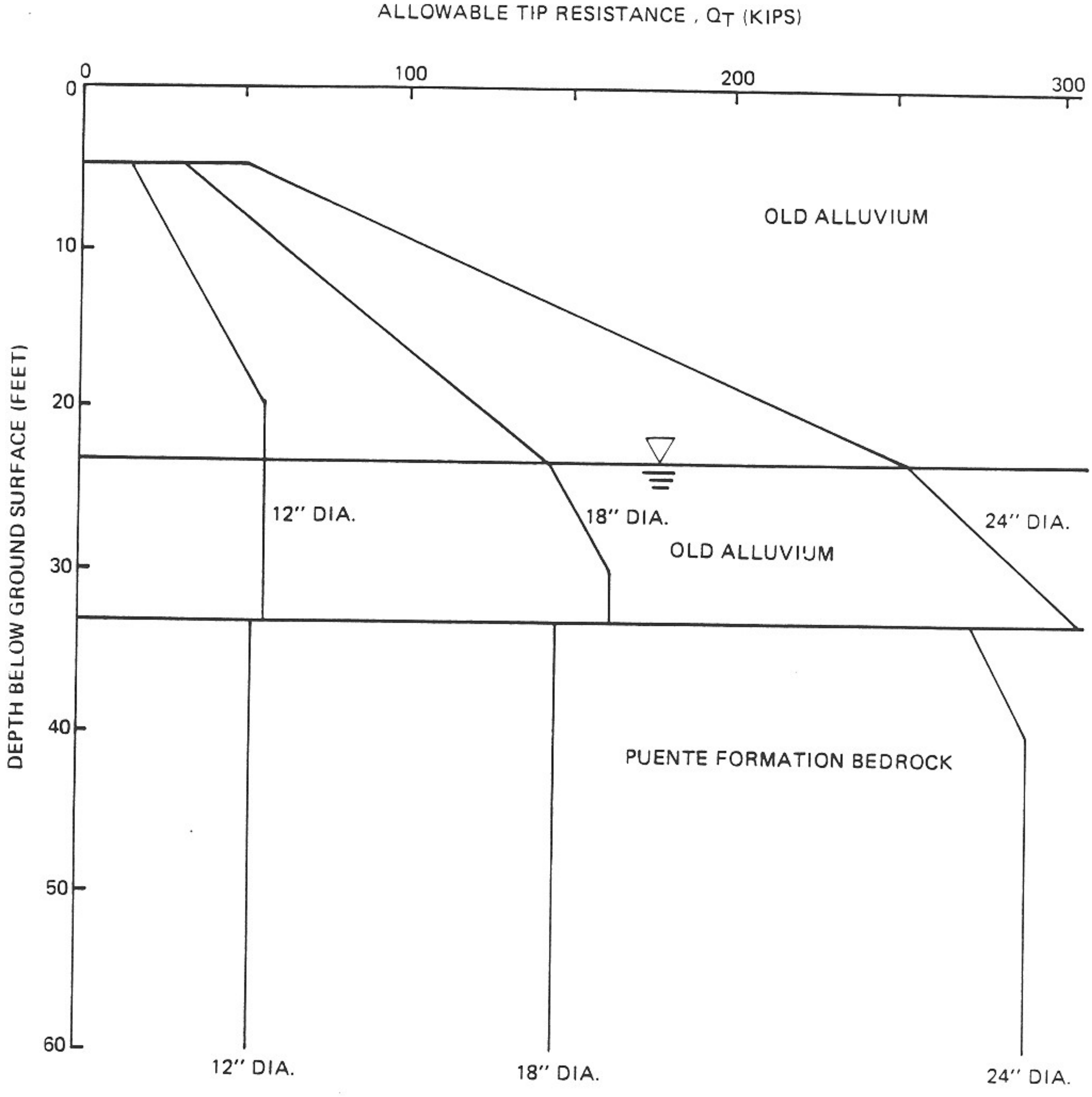
DESIGN CAPACITY OF STRAIGHT SHAFT PILES FOR UNDERPINNING PURPOSES

6-89 FIGURE 5-7



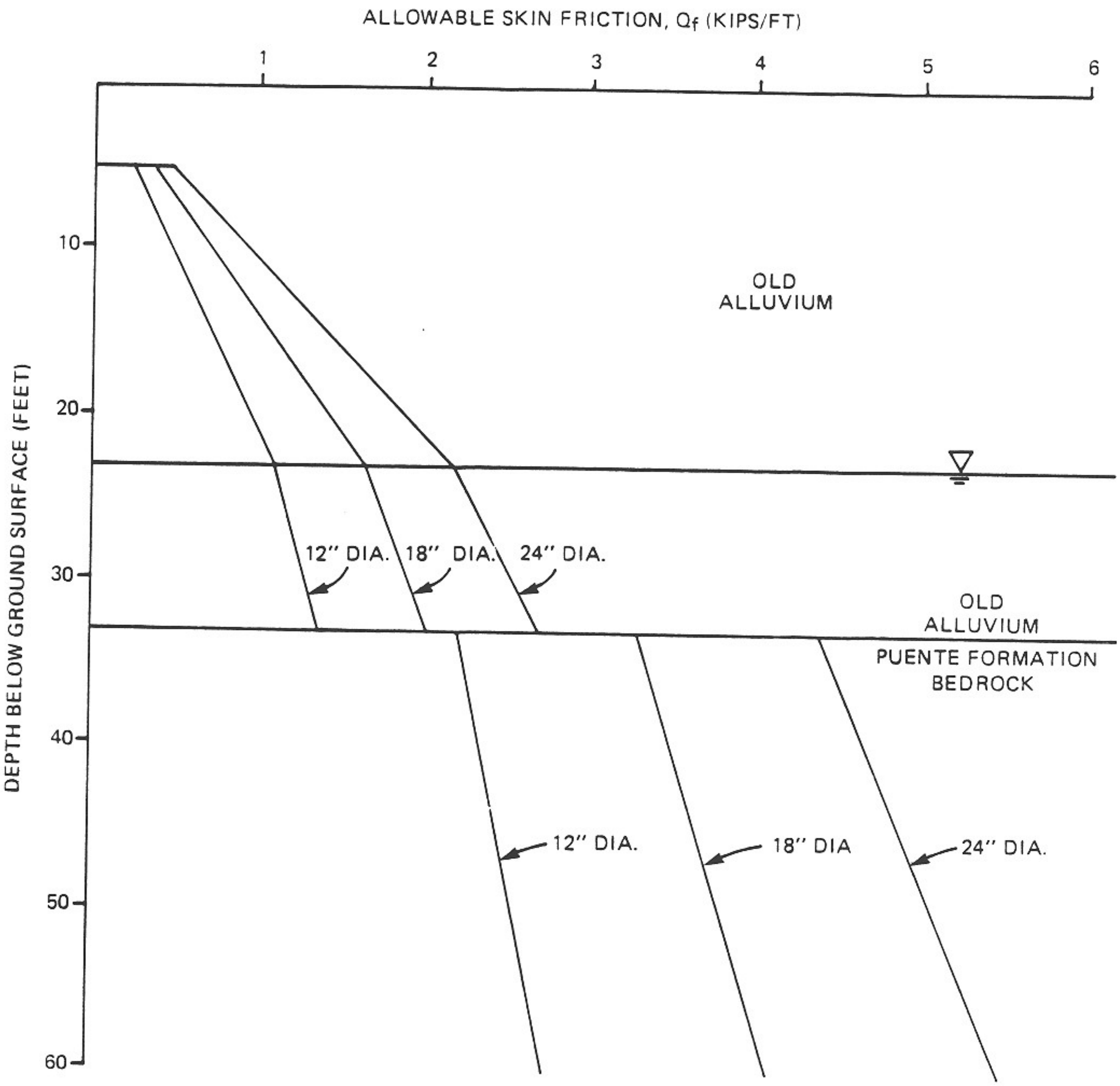
NOTES: (1) FACTOR OF SAFETY OF 3 IS INCLUDED

(2) ASSUMED GROUNDWATER LEVEL IS 23 FEET BELOW GROUND SURFACE

The Earth Technology Corporation	PROJECT NO.: 89-409 METRO RAIL LPA-PHASE II

ALLOWABLE TIP RESISTANCE FOR STRAIGHT SHAFT PILES

6-89 FIGURE 5-8



NOTES: (1) FACTOR OF SAFETY OF 3 IS INCLUDED
(2) ASSUMED GROUNDWATER LEVEL IS 23 FEET BELOW GROUND SURFACES

The Earth Technology Corporation	PROJECT NO.: 89-409 METRO RAIL LPA-PHASE II
ALLOWABLE SKIN FRICTION FOR STRAIGHT SHAFT PILES	
6-89	FIGURE 5-9

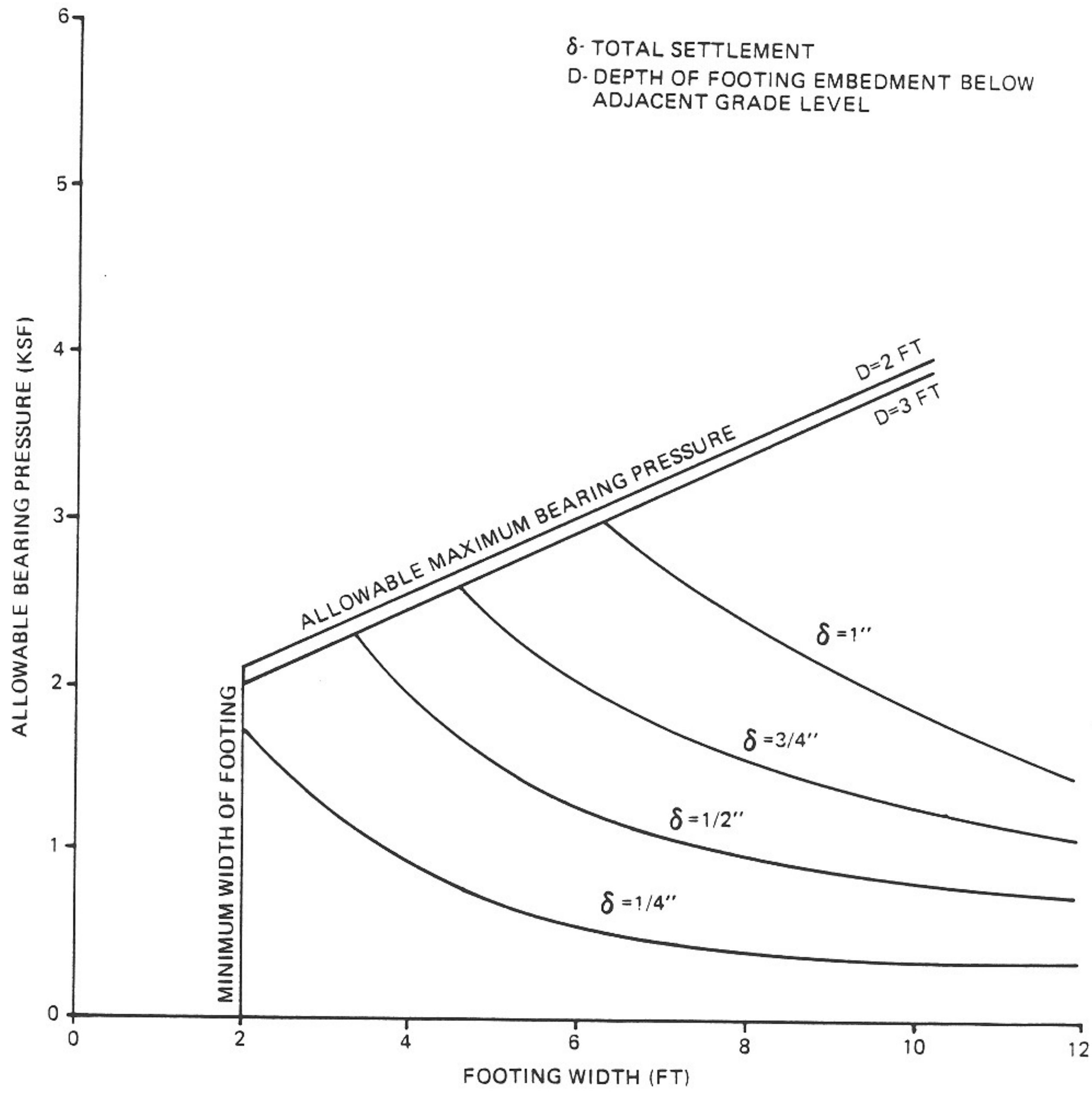
5.5.1 Main Station

We understand that the main station housing the rail facilities will be supported on wide, thick slabs that will function as mat foundations. These foundations will be supported on Puente Formation bedrock. Available information indicates that the average bearing pressure on the mat foundations from the station and backfill will be about 5,000 psf, which is significantly less than the overburden removed by the excavation. This anticipated station load can be safely and adequately supported on the bedrock.

It is estimated that settlement due to the station load of 5,000 psf will be on the order of about 2 to 3 inches. Because of the uniform nature of the station loading and the relative rigidity of the station structure, the differential settlement width is anticipated to be small. We estimate that the differential settlement across the station width will be 1/2 inch or less.

5.5.2 Other Structures

The currently planned foundation level for the mezzanine and upper and lower platforms are within Puente Formation bedrock. Only the entrances and the stairways leading to the mezzanine level will be located above the bedrock. All these structures can be supported by conventional spread footing founded on the bedrock, the Old Alluvium, or properly selected and compacted fill. All spread footings should be a minimum of 2 feet wide and at least 2 feet below the existing grade. All in situ fill materils should be removed and should not be reused as compacted fill for spread footing support. Allowable bearing capacities and estimated total settlement in terms of footing width and bearing pressures for spread footing on bedrock and Old Alluvium are graphically presented in Figures 5-10, 5-11, and 5-12.

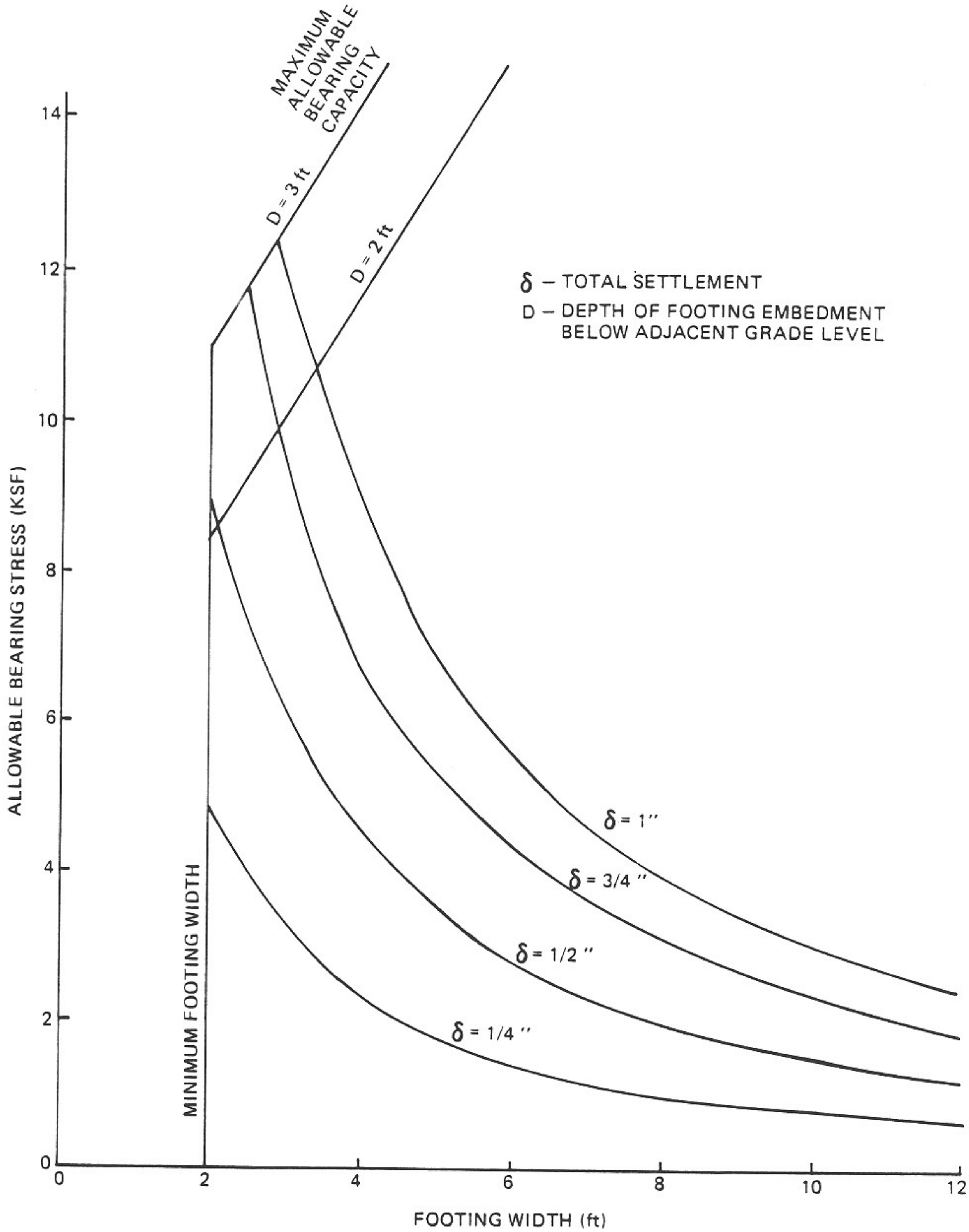


NOTE: FACTOR OF SAFETY OF 3 IS INCLUDED

The Earth Technology Corporation	PROJECT NO.: 89-409 METRO RAIL LPA-PHASE II

BEARING CAPACITY FOR SPREAD FOOTINGS IN FINE-GRAINED OLD ALLUVIUM

6-89 FIGURE 5-10

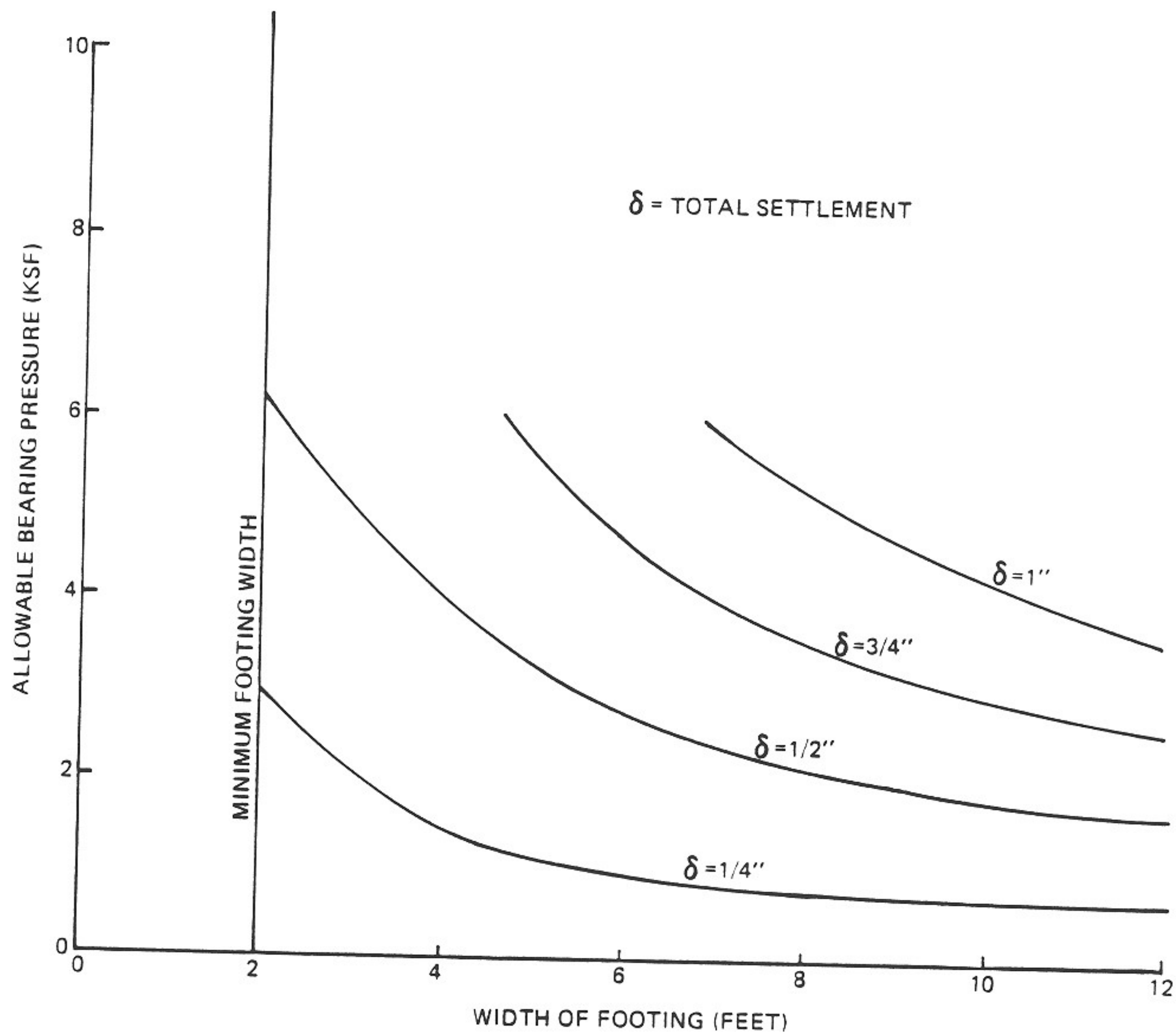


NOTE: FACTOR OF SAFETY OF 3 IS INCLUDED

The Earth Technology Corporation	PROJECT NO.: 89-409 METRO RAIL LPA-PHASE II

BEARING CAPACITY FOR SPREAD FOOTINGS IN GRANULAR ALLUVIUM

6-89 FIGURE 5-11



NOTE: FACTOR OF SAFETY OF 3 INCLUDED
MINIMUM FOOTING EMBEDMENT DEPTH
BELOW ADJACENT GRADE LEVEL = 2 FEET

The Earth Technology Corporation	PROJECT NO.: 89-409 METRO RAIL LPA-PHASE II

BEARING CAPACITY FOR
SPREAD FOOTING IN
PUENTE FORMATION BEDROCK

6-89 FIGURE 5-12

5.5.3 Loads on Overall Station Walls, Slabs, and Roof

The overall station will be constructed as a relatively rigid box. Our recommended permanent earth and water pressure diagrams for the walls, slabs, and roof of the station are shown in Figure 5-13. The following should be noted:

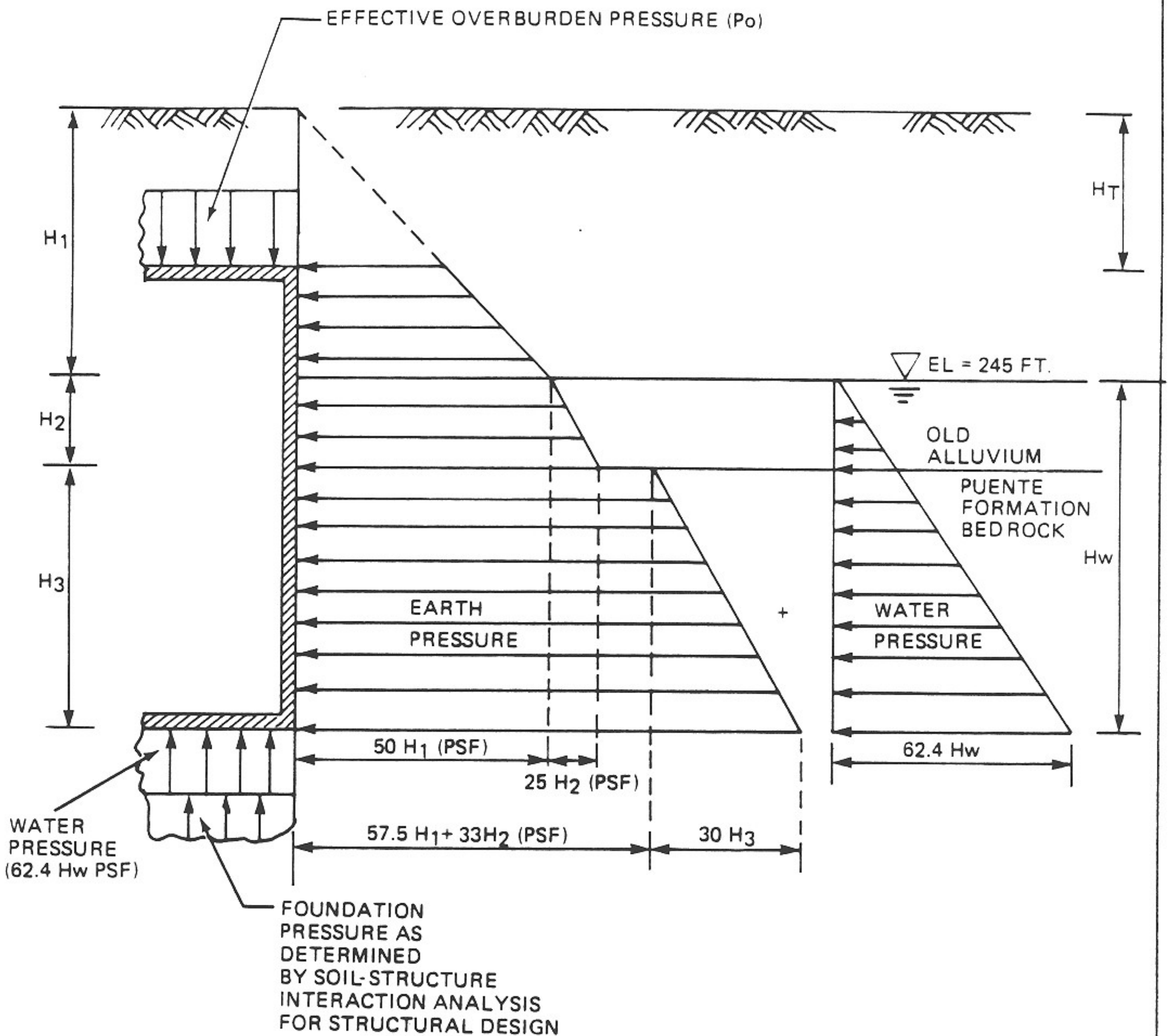
1. To account for potential seasonal variation and potential variations across the station, the groundwater level is set at Elevation 245 feet for design purposes. This is about 3 feet higher than what was observed at Boring 13-6 in 1983 (CCI/ESA/GRC, 1983) and 8 feet higher than what was observed at PII-3, -4, -5 and -6 in this investigation.
2. Potential surcharge effects from adjacent existing buildings which are not underpinned should be considered in the wall pressure diagrams (Figure 5-3). Vertical loads from anticipated traffic and other live loads (car parking, etc.) should be determined and added to the roof loadings.
3. Earthquake loading is not within the scope of this study. However, earth pressure due to design earthquake ground acceleration should be calculated and added to the wall and roof load in the design.

5.5.4 Earthquake-Related Considerations

Seismic design is not a part of this investigation; however, it should be pointed out that liquefaction potential of subsurface materials in the site area is minimal and of no concern since the subsurface materials are either stiff to very dense Old Alluvium or Puente Formation bedrock. The only earthquake-related concern is the potential for seismic-induced settlement, which is anticipated to be minimal but should be determined as part of the station design.

5.5.5 Groundwater Control

Permanent dewatering after completion of the station is expensive and unnecessary. We understand the station is designed to be water-tight. Water-tight provisions should be carried out at least to Elevation 245 feet across the station to account for potential seasonal variation and potential in situ variations that were not detected in this investigation.



OVERBURDEN PRESSURE $P_o = \gamma_{buk} H_T, \; H_T \leq H_1$

$P_o = \gamma_{buk} H_1 + \gamma_{sub} (H_T - H_1), \; H_T > H_1$

WHERE

γ_{bulk} – BULK DENSITY, PCF

γ_{sub} – SUBMERGED DENSITY, PCF

NOTES: (1) ALL PRESSURES IN PSF

(2) H_1, H_2, H_3, Hw AND H_T IN FEET

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EARTH PRESSURE ON BELOW-GRADE PERMANENT STRUCTURES.

6-89 FIGURE 5-13

5.5.6 Earthwork

Based on the subsurface conditions encountered in the investigation, the station excavation can be accomplished relatively rapidly by conventional and readily available excavation equipment. The guidelines and criteria for earthwork with respect to site preparation, foundation preparation, backfill specifications and compaction criteria, and trenching have been adequately addressed in the 1983 investigation (Appendix E in CCI/ESA/GRC, 1988). They can be used in design and bid document preparation.

5.6 CHEMICAL CONTAMINATION AND CONSTRUCTION CONSIDERATIONS

The results of chemical tests on selected soil and water samples are presented in Section 3.2.2 and Appendix C. This section describes various findings of chemical contamination levels in soil and water samples and their potential effects on disposal and workspace environments during construction.

5.6.1 Soil Contamination and Disposal

The available chemical test results indicate that concentration levels of total recoverable petroleum hydrocarbons, aromatic volatile organics, and some heavy metals in soil are low, and well below cleanup action levels specified by various guidelines and regulatory agencies. These low concentraiton levels indicate that these chemical compounds and heavy metals are from natural sources and are not due to industrial contamination. It is anticipated that the excavated materials (spoils) from the station construction can be routinely handled and disposed of without posing any threat to the general public and without the need for special hazardous waste cleanup and disposal.

The available chemical test results also reveal the presence of moderate to severe levels of sulfate compound concentrations in selected soil samples, indicating that Type II cement is likely to be required for station construction.

5.6.2 Water Quality and Disposal

The results of a limited chemical test program on water samples obtained from piezometers PII-5, PII-6, and LPE-1 are shown in Tables 3-6 through 3-10 and in Appendix C. Available chemical test results of selected water samples indicate that the concentration levels of TRPH, BTEX, and sulfide compounds in the water are generally low or not detected, except the concentration levels of benzene at LPE-1, which varied from 8 ppb measured in November 1988 to 2.7 ppb measured in May 1989. The concentration levels of sulfate in water is relatively high and may require the use of Type II or Type V cements in construction.

The results also indicate the transient nature of chemical compound concentrations in the groundwater as evidenced by different BTEX results on water samples obtained from LPE-1 and tested in November 1988 and May 1989.

The California Regional Water Quality Control Board (CRWQCB) requires chemical analyses of a suite of constituents in the groundwater for a National Pollutant Discharge Elimination System (NPDES) permit application to discharge wastewater. These include suspended solids, BOD_5 20°C, oil and grease, settleable solids, turbidity, sulfide, total petroleum hydrocarbons, volatile organic compounds (EPA Method 624), total dissolved solids, chlorides, sulfate and nitrate plus nitrite nitrogen. Apparently, CRWQCB does not have set or unique action limits beyond which wastewater will require treatment before discharge into the groundwater. The CRWQCB's action limits depend on discharge locations and physical characteristics of specific groundwater aquifers and basins and are determined on a case-by-case basis.

It is recommended that the tests required by CRWQCB be performed and discussions with CRWQCB be held to determine whether the spoil water collected during contruction can be discharged into nearby groundwater without treatment.

5.6.3 Health and Safety-Related Construction Considerations

Several health and safety-related construction concerns are addressed in this section.

5.6.3.1 Dust Production. Dust production during excavation could result in unhealthy levels of TRPH, BTEX, and heavy metals in the air and could pose an inhalation hazard for workers if dust is not controlled. The concentration limits of these compounds and metals in air for workers without respiratory protection (Level B or C protection), as specified by various guidelines and regulatory agencies, are summarized in Appendix C. It is unlikely that the air concentrations would reach these limits if the dust is properly controlled.

5.6.3.2 Hydrogen Sulfide. The workspace and breathing-zone hydrogen sulfide (H_2S) readings for the station during this field operation were observed to be minimal, ranging from 0 to 4 ppm, which is less than the action level of 10 ppm specified by OSHA and NIOSH. However, sulfur odors were occasionally noticed during drilling and sampling of borings in this investigation (refer to logs of borings in Appendix A), and the results of limited chemical tests show high concentrations of sulfide compounds in selected soil samples as well as moderate (150 to 1,500 ppm) to severe (more than 1,500 ppm) concentrations of sulfate compounds in water samples. Sulfide and sulfate compounds may be potential sources for generating H_2S under certain chemical environments. In addition, during the development of piezometer PII-13, which is about 2,000 feet north of the station, an abnormally high concentration of H_2S (on the order of 17 ppm) was detected in the headspace (Earth Technology, 1989b). This high concentration level is well above the action level specified by OSHA and NIOSH. Thus, the possibility of breathing-zone H_2S concentrations exceeding the 10 ppm action level during station construction can not be eliminated in the station area. Continuous monitoring of H_2S concentrations during construction will be necessary.

5.6.3.3 **Methane.** Although methane was not monitored in the field program, soil samples obtained from extensive zones within the excavation depth exhibited high headspace OVA readings. In addition, the station is in the general vicinity of the Los Angeles City Oil Field which may be the source of generating and propagating methane in the station vicinity. Thus, the possibility of high methane concentrations in the station area and vicinity cannot be eliminated.

Methane is combustible in air and can explode when the air mixture is about 5 to 15 percent by volume. During station construction, provisions to monitor the methane concentration, explosivity level, and oxygen concentration will be necessary. To ensure the safety of workers and to minimize shutdown, adequate ventilation should be maintained during construction to keep methane concentrations and explosivity levels in the work area within safety levels. The potential presence of high concentrations of methane also require that the station be tightly sealed to prevent accumulation of methane and to avoid combustion and explosion hazards.

5.7 CONSTRUCTION MONITORING SUMMARY

Various construction monitoring recommendations have been previously described and are summarized below:

1. The lateral displacements, vertical settlements, and structural integrity of the adjacent existing buildings due to dewatering, excavation, and construction of the station should be monitored by surveys and instrumentation.

2. The performance of the shored excavation should be monitored. In addition to monitoring the movements of the excavation in and adjacent to the excavation by surveys, inclinometers and other instrumentation, and selected struts, if braced shoring systems are utilized, should be instrumented by strain gages to monitor the strut loads so that timely remedial measures can be implemented if abnormal readings occur.

3. Methane and H_2S should be continuously monitored during excavation and construction to ensure the health and safety of workers.

5.8 SUPPLEMENTARY DATA NEEDS AND GEOTECHNICAL SERVICES

5.8.1 Supplementary Data Needs

The results of this geotechnical investigation have provided a significant database on the subsurface material and groundwater conditions and engineering parameters for design of the Wilshire/Vermont Station. However, additional data are needed to supplement the present geotechnical database and to enhance the confidence level for station design. Additional field investigation, groundwater level monitoring, sampling and testing of groundwater, and a detailed hydrological analysis will be required to obtain the needed supplementary data. These additional tasks are described below:

1. Because the station alignment was revised after the field work for this investigation was completed, at least two additional borings, including one near the southeast end and one near the northwest end of the station, will be needed to verify that the subsurface information developed in this report is valid throughout the station area.

2. Groundwater levels in the piezometers installed in this investigation (PII-3 through -6) and the piezometer installed in the 1988 investigation (LPE-1) should be monitored several times a year to assess the potential seasonal variation of the groundwater levels in the station area to establish realistic maximum design groundwater levels for design purposes.

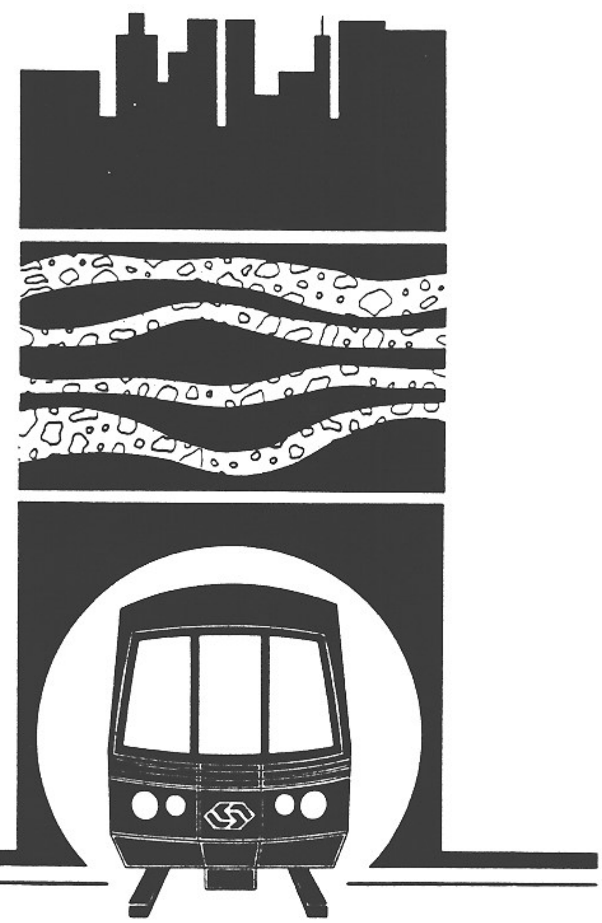
3. As described in Section 5.6.2, a suite of priority pollutant tests on groundwater is needed for an NPDES permit application to discharge pumped water. Groundwater in the existing piezometers in the station area should be sampled and tested for this purpose. Because of the transient nature of groundwater quality in the site area, this groundwater sampling and testing may need to be repeated a number of times so that potential variability in groundwater quality can be established.

4. The amounts of pumped water from dewatering and from groundwater inflows during excavation and construction significantly could affect the design, installation, and operation of dewatering systems and any onsite treatment plant, if needed. Addressing dewatering and disposal needs could constitute a significant part of construction cost. Either under- or over-design to meet such needs could seriously affect construction costs. Thus, a close estimate of anticipated dewatering around and groundwater flows into the excavation through a comprehensive hydrological evaluation is imperative and urgently needed.

5.8.2 Supplementary Geotechnical Services

Geotechnical services and consultation are a integral part of any civil engineering project to ensure safe and economical design and construction. It is recommended that qualified geotechnical services and consultation be obtained to provide geotechnical imput throughout various stages during design and construction of the station, including development and review of plans and specifications/project requirements and bid documents, evaluation of dewatering/shoring/underpinning schemes proposed by the contractor, onsite construction supervision and monitoring, and development and implementation of remedial measures, if needed.

6.0 References



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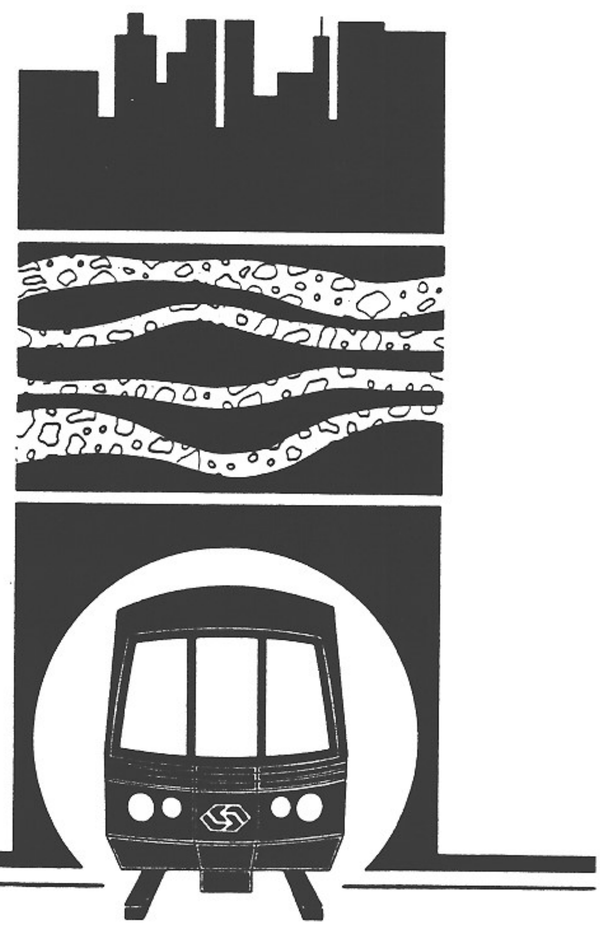
Appendix A

Boring Logs and Piezometer Diagrams



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APPENDIX A

BORING LOGS AND PIEZOMETER DIAGRAMS

Subsurface exploration consisted of drilling and sampling 9 borings and installing 4 piezometers in 4 of these boring locations. This appendix presents the logs and locations of borings, piezometer diagrams and a schematic of the device installed at two piezometer locations for gas sampling and pressure monitoring purposes. This appendix includes the following figures:

	Figure Number		
Boring No.	Log	Location	Piezometer Diagram
PII-1	A-1	A-1A	--
PII-2	A-2	A-A	--
PII-3	A-3	A-3A	A-3B
PII-4	A-4	A-4A	A-4B
PII-5	A-5	A-5A	A-5B
PII-6	A-6	A-6A	A-6B
PII-7	A-7	A-7A	--
PII-8	A-8	A-8A	--
PII-9	A-8D	A-8DA	--

Explanations to the logs of borings are provided in Figures A-I through A-III.

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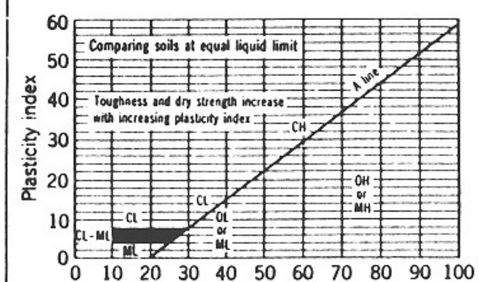
Major divisions			Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weights)	Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria	
Coarse-grained soils: More than half of material is *larger* than No. 200 sieve size[b] (The No. 200 sieve size is about the smallest particle visible to naked eye)	Gravels: More than half of coarse fraction is larger than No. 4 sieve size (For visual classification, the ¼ in. size may be used as equivalent to the No. 4 sieve size)	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses	Use grain size curve in identifying the fractions as given under field identification. Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse grained soils are classified as follows: Less than 5% *GW, GP, SW, SP*; More than 12% *GM, GC, SM, SC*; 5% to 12% *Borderline* cases requiring use of dual symbols	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines			Not meeting all gradation requirements for *GW*
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures			Atterberg limits below "A" line, or *PI* less than 4 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics		Atterberg limits above "A" line, with *PI* greater than 7
	Sands: More than half of coarse fraction is smaller than No. 4 sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines	Example: *Silty sand,* gravelly; about 20% hard, angular gravel particles ½-in. maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)		$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines			Not meeting all gradation requirements for *SW*
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)	*SM*	Silty sands, poorly graded sand-silt mixtures			Atterberg limits below "A" line or *PI* less than 5 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures			Atterberg limits below "A" line with *PI* greater than 7

Identification Procedures on Fraction Smaller than No. 40 Sieve Size

Major divisions		Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	Group Symbols[a]	Typical Names	Information Required for Describing Soils
Fine-grained soils: More than half of material is *smaller* than No. 200 sieve size	Silts and clays liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses
		Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
		Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions
	Silts and clays liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
		High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	Example: *Clayey silt,* brown; slightly plastic; small percentage of fine sand, numerous vertical root holes; firm and dry in place; loess; (*ML*)
		Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	
Highly Organic Soils		Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



Plasticity chart
for laboratory classification of fine grained soils

a *Boundary classifications.* Soils possessing characteristics of two groups are designated by combinations of group symbols. For example *GW-GC*, well graded gravel-sand mixture with clay binder.
b All sieve sizes on this chart are U.S. standard.

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METRO RAIL LPA-PHASE II

UNIFIED SOIL CLASSIFICATION SYSTEM

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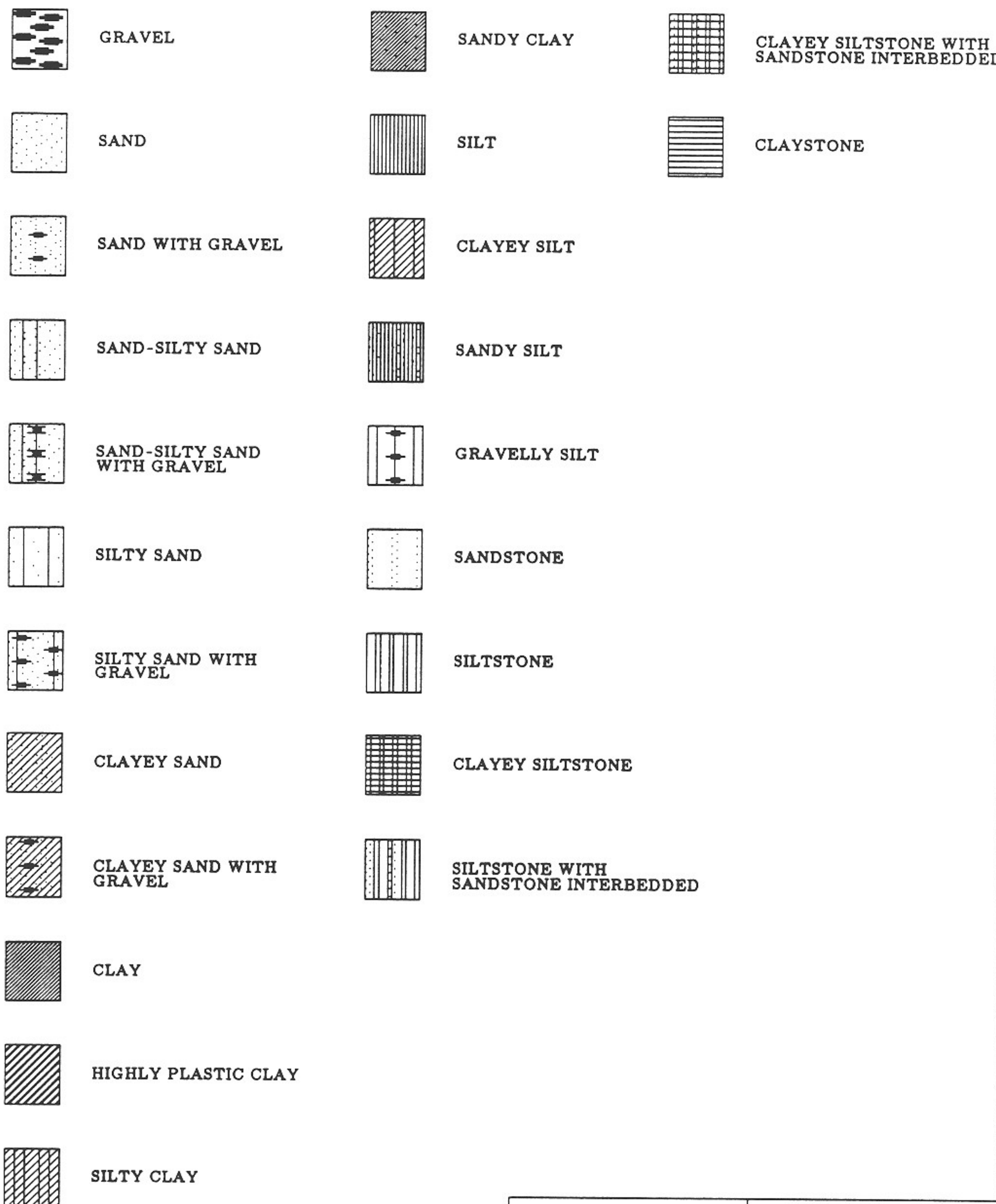
FIGURE A-I



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PROJECT NO.: 89-409
METRO RAIL
LPA-PHASE II

SOIL/ROCK SYMBOLS FOR LOGS OF BORINGS

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FIGURE A-II

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SAMPLE TYPE

- [S] STANDARD SPLIT SPOON SAMPLE
- [D] 2½'' DIA., 12'' DRIVE SAMPLE
- [P] 2 7/8'' DIA. PITCHER SAMPLE
- [NR] NO RECOVERY
- [B] BULK SAMPLE
- [C] CORE SAMPLE

EXPLANATIONS

PENETRATION RESISTANCE (BLOW COUNT)

–BLOW COUNTS FOR 6'' INTERVALS EXCEPT AS NOTED.

MOISTURE CONTENT (%)

–LABORATORY DETERMINED MOISTURE CONTENT

PPM –PARTS PER MILLION

PCF –POUNDS PER CUBIC FOOT

OVA–ORGANIC VAPOR ANALYZER

N/A –NOT APPLICABLE

/ –DENOTES ALTERNATING SOIL TYPES IN A LAYER (EXAMPLE: SP/SW i.e. ALTERNATING POORLY AND WELL GRADED SANDS IN A PREDOMINANTLY SANDY LAYER)

DEFINITION OF TERMS

DESCRIPTIVE TERM	PERCENT BY WEIGHT
TRACE	0-10
LITTLE	10-20
SOME	20-35
AND	35-50

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METRO RAIL
LPA-PHASE II

KEY FOR LOGS OF BORING

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FIGURE A-III

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FIGURE A-1. LOG OF BORING PII-1

Project Name:	METRO RAIL LPA - PHASE II - LOS ANGELES		
Project Number: 89-409	Borehole Number: PII-1	sheet 1 of 4	
Borehole location	Wilshire and Shatto Pl.	Elevation and Datum(feet):	259
Health and Safety:	Upgraded Level D	Date Started: 3/20/89	Date Finished: 3/21/89
Drilling Equipment:	Failing 750	Total Depth(feet): 121.5	Depth to: Bedrock(feet): 29.5 ✓
Drilling Method:	Rotary Wash	Borehole Diameter:	6-inch
Drilling Fluid:	Bentonite Mud	Piezometer Installation: NO	Depth(feet): --
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.		Logged By: Kean Tan	Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: Number	Samples: Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA(ppm)
		3-4 inch ASPHALT CONCRETE.										
		6-inch CLAYEY SAND, Black to light olive brown, fine to medium.	SC	FILL								
		SAND; Light yellowish brown, moist, fine to medium.	SP-SM	A3								
5		SAND-SILTY SAND; Yellowish brown, moist, loose, fine to medium, poorly graded.	SP-SM	A3	1	D	5 8	8"/12"	8			5
10		Same as above, medium dense.	SP-SM	A3	2	S	8 14 19	16"/18"	8			5
15		SILTY SAND WITH GRAVEL; Yellowish brown, moist, very dense, fine to medium sand, gravel up to 1-inch size. (Drill chatter at 17 feet.)	SM	A3	3	D	40 60/5.5"	6"/11.5"	8		20	5
20		SILTY SAND; Pale brown, wet, very dense, nonplastic fines.	SM	A3	4	S	16 25 36	1"/18"	8			5
		(Clayey sand in cuttings at 24 feet.)										
25		SILTY SAND; Yellowish brown, moist, very dense, fine, nonplastic, trace mica.	SM	A3	5	D	32 55	8"/12"	10	91	26	5
30				Tpw	6	S	7	16"/18"	10			5

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FIGURE A-1. LOG OF BORING PII-1

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-1 | Sheet 2 of 4

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		TOP OF PUENTE FORMATION. SILT(STONE); Mottled, pale brown with yellowish brown to reddish yellow, moist, dense, slightly plastic, well bedded, oxidized. Dip approximately 30 deg.		Tpw			14 18					
35		SILT(STONE); Yellowish brown, moist, very dense, oxidized, trace gravel up to 1-inch size, rusty stains, pockets of olive brown, very stiff lean clay.		Tpw	7	D	19 37	12"/12"	7	84	37	5
40		(Cuttings indicate fresh layer starting at 39 feet.) SILTSTONE; Olive brown, damp, very dense, fresh, slightly plastic, micaceous, interbedded with fine sandstone. (Increasing sand content at 41 feet.)		Tpf	8	S	21 33 50/5"	15"/17"	8			5
45		SILTSTONE; Olive brown, moist, very dense, fresh, trace mica, interbedded with fine sandstone. Dark gray, hard, clayey siltstone at tip. Dip approximately 30 deg.		Tpf	9	D	21 47	12"/12"	8	95	28	5
50		CLAYEY SILTSTONE; Dark olive brown to dark gray, moist, hard, fresh, slightly plastic, micaceous, thinly interbedded with fine sandstone. Dip approximately 30 deg. Sulfur odor.		Tpf	10	S	16 32 44	16"/18"	8			5
55		CLAYEY SILTSTONE; Dark olive gray, moist, hard, fresh, slightly plastic, micaceous, thinly interbedded with very fine sandstone.		Tpf	11	D	42 58/4"	8"/10"	40	85	35	5
60		Same as above.		Tpf	12	S	25 50/6"	10/12"	24			5
65		Same as above. Sulfur odor.		Tpf	13	D	60 40/3"	7"/9"	40	86	36	5
70												

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FIGURE A-1. LOG OF BORING PII-1

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-1 | Sheet 3 of 4

Depth (feet)	Lithology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		Same as above. Sulfur odor.		Tpf	14	S	27 50/5"	7"/11"	38			5
		(Slow drilling at 72 feet.)										
75		Same as above. Disturbed sample.		Tpf	15	D	60 40/2.5"	6"/8.5"	20			5
80		CLAYEY SILTSTONE; Dark olive gray, moist, hard, fresh, slightly plastic, micaceous thinly interbedded with sandstone.		Tpf	16	S	36 50/5"	5"/11"	40			5
85		CLAYEY SILTSTONE; Dark olive gray brown, moist, hard, slightly plastic, well cemented, micaceous, thinly interbedded with sandstone. A seam of chalky fragments at the middle of the sample.		Tpf	17	D	75 30/1"	6"/7"	12			4
90		Same as above.		Tpf	18	P	Push 250psi	16"/26"	12			4
95		Same as above. Oil stains in mud tank.		Tpf	19	D	58 42/2.5"	7"/8.5"	400	84	35	4
100		Same as above.		Tpf	20	S	44 50/5"	9"/11"	300			4
105		Same as above.		Tpf	21	D	90 10/0.5"	4"/6.5"	300			4
110												

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FIGURE A-1. LOG OF BORING PII-1

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-1 | Sheet 4 of 4

Depth (feet)	Lithology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		Same as above		Tpf	22	S	42 50/5"	8"/11"	100			4
115		Same as above.		Tpf	23	D	75 25/1.5"	6"/7.5"	100			4
120		Same as above.		Tpf	24	S	75 25/1.5"	7"/7.5"	410			4

BORING TERMINATED AT 121-1/2 FEET.

NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.

Depth scale: 125, 130, 135, 140, 145, 150

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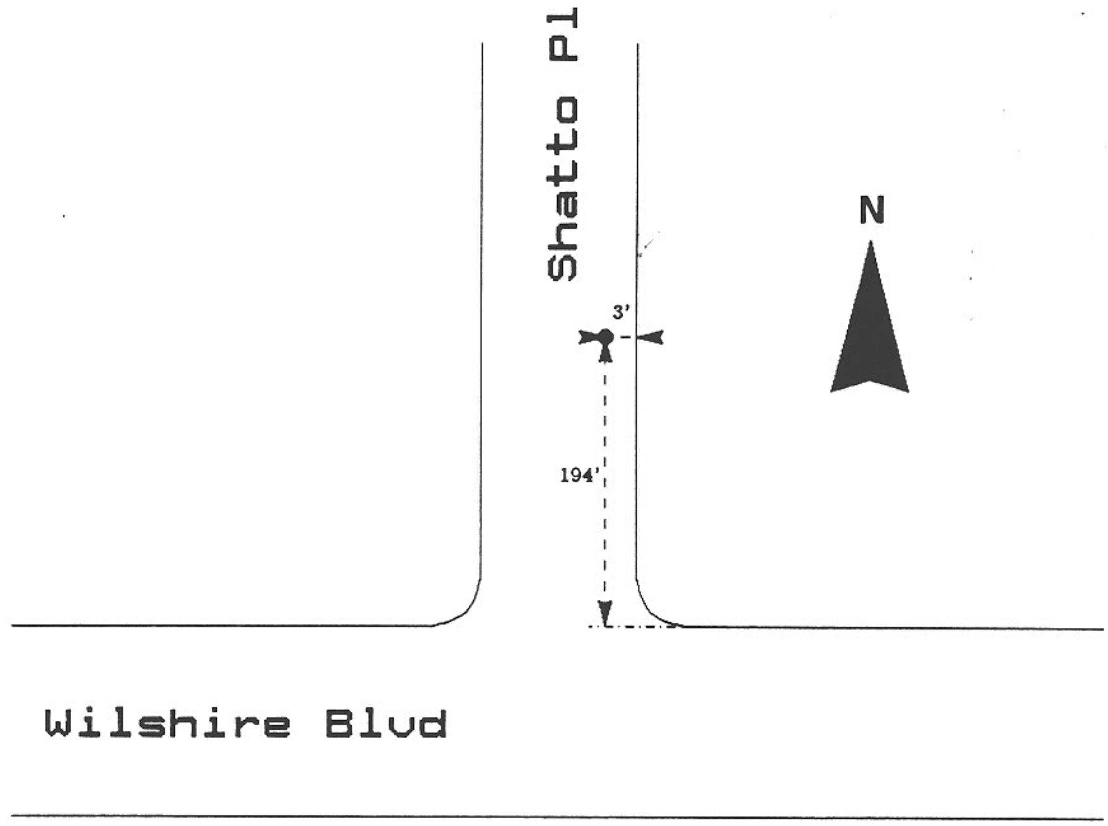

(Not to scale)

The Earth Technology Corporation	PROJECT NO.: 89-409 METRO RAIL LPA-PHASE II

LOCATION OF BOREHOLE PII-1

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FIGURE A-1A

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FIGURE A-2. LOG OF BORING PII-2

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-2		sheet 1 of 4
Borehole location: Wilshire and Shatto Pl.		Elevation and Datum(feet): 259	
Health and Safety: Upgraded Level D		Date Started: 3/17/89	Date Finished: 3/18/89
Drilling Equipment: Failing 750		Total Depth(feet): 121.5	Depth to: Bedrock(feet): 29.5
Drilling Method: Rotary Wash		Borehole Diameter: 6-inch	
Drilling Fluid: Bentonite Mud		Piezometer Installation: NO	Depth(feet): --
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.		Logged By: Kean Tan	Checked By: C. Marshall Payne

Depth (feet)	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
	5-inch ASPHALT CONCRETE.										
	3-1/2 inch CONCRETE.	SM	FILL								
	SILTY SAND; Dark brown, dense.	SC	FILL								
	CLAYEY SAND; Very dark grayish brown, moist, stiff.	ML	A4								
5	CLAYEY SILT; Dark brown, moist, stiff, plastic, slightly sandy.	CL	A4	1	D	10 17	12"/12"	5		18	4
	CLAY; Yellowish brown to brown, moist, very stiff, slightly to moderately plastic, with occasional sand pockets.										
	SAND; medium to coarse at 8 feet.	SP	A4								
	SILTY SAND; Brown, moist, medium dense at 10 feet.	SM	A4								
10	SAND; Olive yellow, moist, very dense, friable, fine to medium sand at 11 feet.	SP	A3	2	S	15 27 21	12"/18"	12			4
15	SILTY SAND; Yellowish brown, moist, very dense, friable, trace clayey sand, a few 1/2 to 1 inch size gravel.	SM	A3	3	D	27 50	6"/12"	11	97	22	4
20	SILTY SAND WITH GRAVEL; Pale olive, moist, very dense, 1-inch size gravel, rounded.	SM	A3	4	S	26 25 28	12"/18"	10			4
25	SAND-SILTY SAND WITH GRAVEL; Yellowish brown, moist, very dense with gravel upto 1 inch in size.	SP-SM	A3	5	D	37 63/5.5"	6"/11.5"	7			4
30											

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FIGURE A-2. LOG OF BORING PII-2

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-2 | Sheet 2 of 4

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		TOP OF PUENTE FORMATION. SILT(STONE); Yellowish brown, moist, dense, thinly bedded, oxidized (moderately weathered), interbedded with sand(stone), trace 1/2-inch size rounded gravel, no joints or fracture. Dip approximately 25-30 deg.		Tpw	6	S	7 14 18	14"/18"	8			4
35		CLAYEY SILT(STONE); Olive brown mottled with olive gray, moist, hard, oxidized, trace mica, well bedded, slightly plastic, color changes to olive gray at bottom.		Tpw	7	D	13 29	12"/12"	7	75	42	4
40		SILT(STONE); Yellowish dark gray, moist, dense, locally oxidized, interbedded with sand(stone). Dip approximately 10-20 deg.		Tpw	8	S	9 17 19	18"/18"	7	77	43	4
		(Slow drilling. Very stiff layer at 43 feet.)										
45		CLAYEY SILTSTONE; Dark olive brown mottled with olive gray, moist, hard, thinly bedded, fresh, micaceous, interbedded with very fine sandstone.		Tpf	9	D	22 67/5.5"	11/11.5"	7	69	47	4
50		CLAYEY SILTSTONE; Dark gray to dark olive gray, moist, hard, moderately bedded, fresh. Dip approximately 10 to 15 deg.		Tpf	10	S	20 42 50	14"/18"	7			7
55		CLAYEY SILTSTONE; Dark olive gray, moist, hard, fresh, clayey, micaceous.		Tpf	11	D	85 15/1.5"	7"/7.5"	7			7
60		CLAYEY SILTSTONE; Very dark gray, moist, hard, fresh, interbedded with sandstone.		Tpf	12	S	29 50/5.5"	11/11.5"	7			7
65		CLAYEY SILTSTONE; Very dark gray, moist, hard, fresh, micaceous, interbedded with sandstone.		Tpf	13	D	88 12/0.25"	6"/6.25"	7	78	39	7
70				Tpf	14	S	30 50/5"	11"/11"	10			7

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FIGURE A-2. LOG OF BORING PII-2

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-2 | Sheet 3 of 4

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SILTSTONE; Very dark gray, moist, hard, fresh, micaceous, interbedded with sandstone.										
75		Same as above.		Tpf	15	D	58 42/2	4"/8"	100	86	33	7
80		CLAYEY SILTSTONE; Very dark gray, moist, hard, fresh, interbedded with sandstone. Dip approximately 10 deg.		Tpf	16	S	32 50 52	16"/18"	180			4
85		CLAYEY SILTSTONE; Very dark gray, moist, hard, fresh, Dip approximately 10 deg.		Tpf	17	D	56 42/2"	6"/8"	800			4
90		Same as above.		Tpf	18	P	Push 350psi	30"/30"	800	88	33	4
95		Same as above.		Tpf	19	D	85 15/0.5"	6"/6.5"	700	80	26	4
100		CLAYEY SILTSTONE; Very dark gray, moist, hard, massive. Dip approximately 20 deg. Sulfur odor.		Tpf	20	S	23 44 50/4"	16"/16"	900			4
105		CLAYEY SILTSTONE; Very dark gray, moist, very stiff, micaceous, trace fine sand, interbedded thin layers of sandstone.		Tpf	21	D	12 22	8"/12"	1000			6
110				Tpf	22	S	20	12"/12"	800			6

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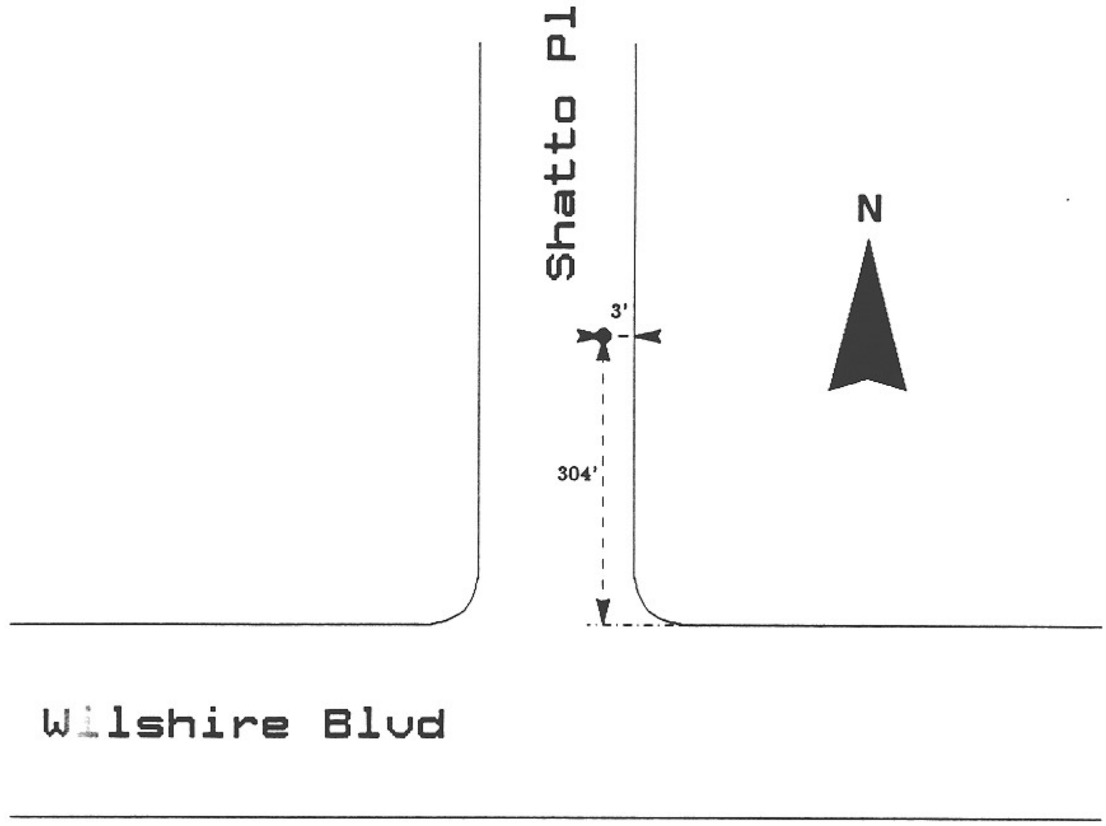
FIGURE A-2. LOG OF BORING PII-2

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-2 | Sheet 4 of 4

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		Same as above.					40/6"					
115		CLAYEY SILTSTONE; Very dark gray, moist, hard, fresh, micaceous, interbedded with thin layers of sandstone, massive, trace fine to medium sand.		Tpf	23	D	80 20/1"	7"/7"	1000			6
120		SILTSTONE; Very dark grayish brown, moist, hard, fresh, trace fine to medium sand.		Tpf	24	S	43 10/1"	7"/7"	1000			6
		BORING TERMINATED AT 121-1/2 FEET.										
125		NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
130												
135												
140												
145												
150												



(Not to scale)

The Earth Technology Corporation	PROJECT NO.: 89-409 METRO RAIL LPA-PHASE II

LOCATION OF BOREHOLE PII-2

6/89

FIGURE A-2A

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FIGURE A-3. LOG OF BORING PII-3

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-3		sheet 1 of 4
Borehole location: United Parking Lot on Shatto Pl.	Elevation and Datum(feet): 261		
Health and Safety: Upgraded Level D	Date Started: 3/20/89		Date Finished: 3/21/89
Drilling Equipment: Failing 750	Total Depth(feet): 121.3		Depth to: Bedrock(feet): 34.5
Drilling Method: Rotary Wash	Borehole Diameter: 6-inch		
Drilling Fluid: Bentonite Mud	Piezometer Installation: YES		Depth(feet): 117.5
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.	Logged By: Pierre Charles		Checked By: C. Marshall Payne

Depth (feet)	Description	USCS Classification	Geologic Unit	Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
	4-inch ASPHALT and 10-inch AGGREGATE BASE.										
	CLAYEY SAND; Dark brown, moist, loose.	SC	A4								
	SILTY SAND/SANDY CLAY.	SM/CL	A4								
5	SILTY CLAY; Dark brown, moist, stiff, medium plastic, trace fine sand. more sand. more clay and silt.	CL	A4	1	S	4 8 8	13"/18"	3			2
10	SILTY SAND; Yellowish brown, moist, very dense, fine to medium sand, slightly plastic fines.	SM	A3	2	D	13 22	6"/12"	25	110	18	2
15	SAND; Yellowish brown, moist, very dense.	SP	A3	3	S	13 28 35	14"/18"	5		11	3
20	(Drill chatter at 19 feet.) SAND-SILTY SAND WITH GRAVEL; Yellowish brown, moist, dense, 3/4-inch size gravel, fine sand, moderately plastic fines. (Drill chatter. Coarse gravel at 21-1/2 feet.)	SP-SM	A3	4	D	27 73/5"	4"/11"	6		26	4
	(Drill chatter at 23 feet. Becoming more sandy.)										
25	(Smooth drilling at 23-1/2 feet.) SILTY SAND; Brownish yellow, moist, very dense, fine to coarse sand, with some gravel and mica.	SM	A3	5	S	18 28 26	11"/18"	6		20	4
30											

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FIGURE A-3. LOG OF BORING PII-3

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-3 | Sheet 2 of 4

Depth (feet)	Description	USCS Classification	Geologic Unit	Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
	SILTY SAND; Yellowish brown, moist, very dense, fine, minor gravel at top of the sample.	SM	A3	6	D	21 31	6"/12"	5	91	28	4
35	TOP OF PUENTE FORMATION. SILTY CLAY(STONE); Dark yellowish brown, moist, hard, highly weathered, highly plastic with very fine sand.		Tpw	7	S	14 28 25	9"/18"	6			3
	Increasing silt content.										
40	CLAYEY SILT(STONE); Yellowish brown to brown, moist, hard, oxidized, thinly interbedded (1/16-inch thick beds) with sandstone and sandy siltstone. Dip approximately 30 deg.		Tpw	8	D	12 23	6"/12"	5	87	30	4
45	CLAYEY SILT(STONE); Yellowish brown, damp, hard, oxidized, interbedded with 1/4-inch thick sandstone spaced at 1-inch. Dip approximately 15 deg.		Tpw	9	S	17 24 26	11"/18"	5			4
50	CLAYEY SILT(STONE); Olive brown to yellowish brown, damp, hard, moderately oxidized, interbedded with 1/4 - 1/2 inch thick siltstone. Dip approximately 30 deg.		Tpw	10	D	21 41	6"/12"	5	79	43	3
55	CLAYEY SILTSTONE; Very dark gray, moist, hard, fresh, interbedded with 1/2 - 1 -inch thick brownish gray sandstone, micaceous. Dip approximately 10 deg.		Tpf	11	S	20 38 50/3"	15"/15"	5			4
60	CLAYEY SILTSTONE; Very dark gray, damp to dry, hard, very distinctly bedded, fresh, trace sandstone. Dip approximately 40 deg.		Tpf	12	D	35 65/5"	6"/11"	7	86	34	5
65	CLAYEY SILTSTONE; Very dark gray, damp, hard, some well cemented 1/16 inch thick sandstone interbeds, highly micaceous, fresh. Dip approximately 25-30 deg.		Tpf	13	S	31 69/4"	10"/10"	7			4
70											

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FIGURE A-3. LOG OF BORING PII-3

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-3 | Sheet 3 of 4

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SILTSTONE; Very dark gray, damp, hard, fresh, well defined 1/16-inch thick beds at 1/4-inch spacing, trace very fine grained light gray sandstone, sulfur odor. Dip approximately 30 deg.		Tpf	14	D	30 65	6"/12"	7	83	37	4
75		CLAYEY SILTSTONE; Very dark gray to dark grayish brown, damp to dry, hard, fresh. Dip approximately 30 deg.		Tpf	15	S	31 69/6"	12"/12"	200			4
		(Drill chatter. Cemented sandstone fragments in mud.)										
80		CLAYEY SILTSTONE; Very dark gray, damp, hard, fresh, micaceous, slightly cemented. Dip approximately 25 deg.		Tpf	16	D	31 45	6"/12"	900			5
85		CLAYEY SILTSTONE; Very dark gray, damp, hard, fresh, well defined bedding, slightly cemented. Dip approximately 20 deg.		Tpf	17	S	26 74/6"	11"/12"	950			5
90		Same as above. Sulfur and slight hydrocarbon odor.		Tpf	18	D	32 68/6"	6"/12"	800	80	32	5
95		Same as above.		Tpf	19	P	Push 280psi	24"/30"	700			5
100		CLAYEY SILTSTONE; Very dark gray, damp, hard, fresh, slightly cemented, interbedded with light gray sandstone. Dip approximately 30 deg.		Tpf	20	D	31 69/5"	6"/11"	900	86	32	5
105		CLAYEY SILTSTONE; Very dark gray, damp, hard, interbedded with sandstone. Dip approximately 25 deg.		Tpf	21	S	35 65/6"	12"/12"	200			5
110												

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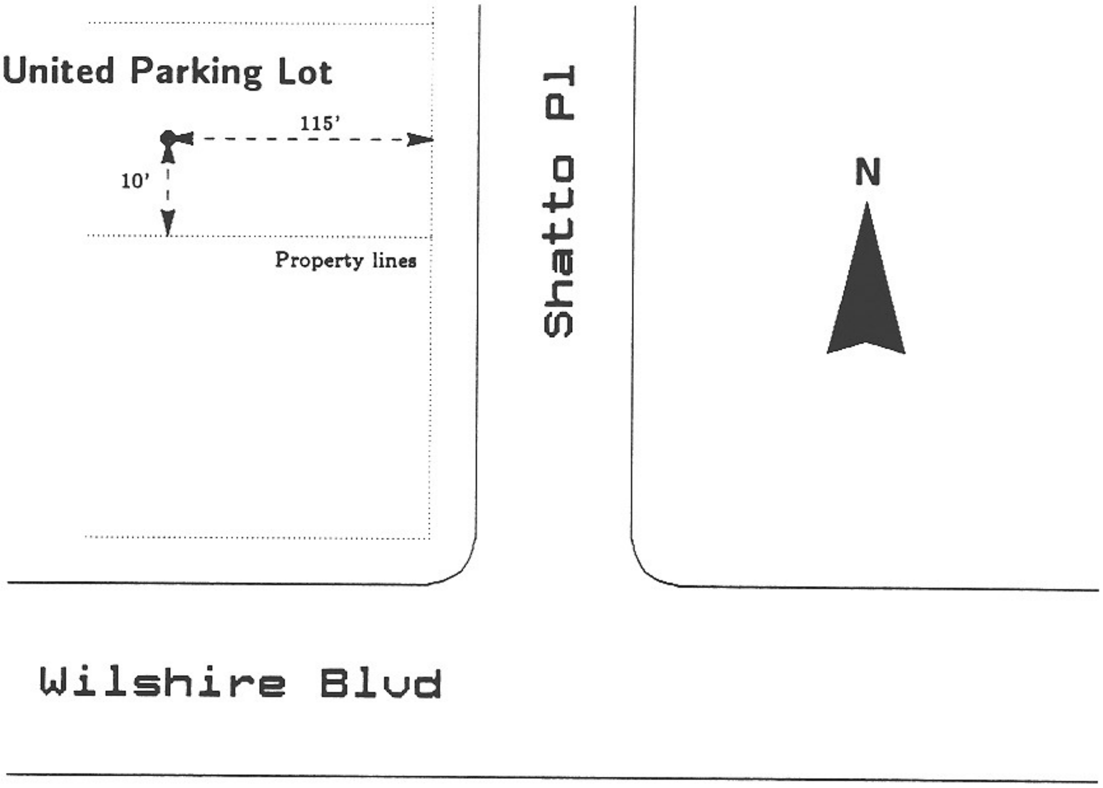
FIGURE A-3. LOG OF BORING PII-3

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-3 | Sheet 4 of 4

Depth (feet)	Description	USCS Classification	Geologic Unit	Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
	CLAYEY SILTSTONE; Very dark gray, damp, hard, with minor sandstone. Dip approximately 20 deg.		Tpf	22	D	33 67/5"	6"/11"	600			5
115	SILTSTONE; Very dark gray, damp, very dense, a few sandstone interbeds, light gray, Dip approximately 15 deg.		Tpf	23	S	33 42 25/3"	15"/15"	1000			5
120	SILTSTONE; Very dark gray, damp to dry, very dense, some sandstone interbeds, slightly cemented, Dip approximately 35 deg.		Tpf	24	D	44 56/5"	6"/11"	1000			5
	BORING TERMINATED AT 121 FEET. INSTALLED A PIEZOMETER.										
125											
130											
135											
140											
145											
150											

NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other loccations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.



(Not to scale)

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PROJECT NO.: 89-409

METRO RAIL
LPA-PHASE II

LOCATION OF BOREHOLE PII-3

6/89

FIGURE A-3A

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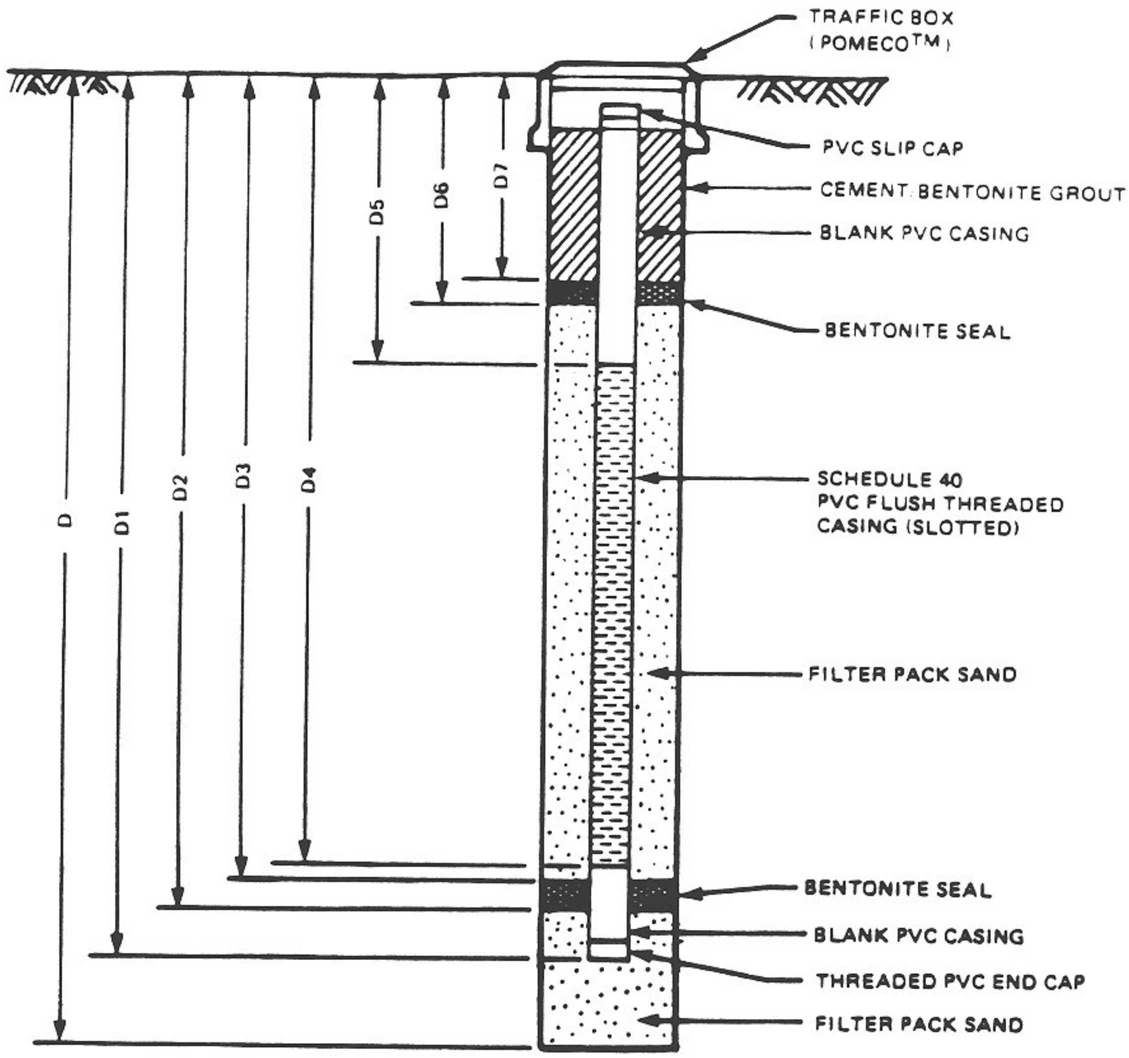

TOTAL DEPTH (D)	=	121.3	FEET
TOTAL DEPTH OF CASING (D1)	=	117.5	FEET
DEPTH TO BOTTOM OF BOTTOM SEAL (D2)	=	78.0	FEET
DEPTH TO TOP OF BOTTOM SEAL (D3)	=	75.5	FEET
DEPTH TO BOTTOM OF WELL SCREEN (D4)	=	72.5	FEET
DEPTH TO TOP OF WELL SCREEN (D5)	=	67.5	FEET
DEPTH TO BOTTOM OF TOP SEAL (D6)	=	59.6	FEET
DEPTH TO TOP OF TOP SEAL (D7)	=	58.1	FEET
WELL CASING DIAMETER	=	2	INCH
WELL SCREEN SLOT SIZE	=	0.02	INCH
FILTERPACK SAND TYPE	=	NO. 2	MONTEREY
BENTONITE SEAL TYPE	=		1/8" PELLETS

The Earth Technology Corporation	PROJECT NO.: 89-409 METRO RAIL LPA-PHASE II

DIAGRAM OF PIEZOMETER PII-3

6/89

FIGURE A-3B

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FIGURE A-4. LOG OF BORING PII-4

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-4		sheet 1 of 4
Borehole location: United Parking Lot on Shatto Pl.	Elevation and Datum(feet): 261		
Health and Safety: Upgraded Level D	Date Started: 3/23/89		Date Finished: 3/23/89
Drilling Equipment: Failing 750	Total Depth(feet): 121.5		Depth to: Bedrock(feet): 34.5
Drilling Method: Rotary Wash	Borehole Diameter: 6-inch		
Drilling Fluid: Bentonite Mud	Piezometer Installation: YES		Depth(feet): 117.5
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.	Logged By: Pierre Charles		Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		2-inch ASPHALT CONCRETE.										
		10-inch AGGREGATE BASE.										
		SANDY CLAY; Dark brown, fill material.	SC	FILL								
		SILTY SAND / SANDY SILT.	SM/ML	A4								
5		SILTY CLAY; Brown motled with yellowish brown to light olive brown, damp, medium stiff to stiff, moderately plastic, trace mica. Increasing sand content at tip.	CL	A4	1	D	3 7	6"/12"	6	105	20	5
10		CLAYEY SAND; Yellowish brown, moist, very dense, fine to medium sand.	SC	A4	2	S	12 17 27	8"/18"	6			5
15		SILTY SAND; Olive yellow, damp, dense, fine to medium sand.	SM	A3	3	D	12 16	6"/12"	6	102	21	5
20		(Drill chatter at 19-1/2 feet) SILTY SAND; Light yellowish brown, moist, very dense, fine to medium sand, nonplastic fines, up to 1-inch size well rounded gravel at top of sample.	SM	A3	4	S	16 35 30	15"/18"	6			5
25		SILTY SAND WITH GRAVEL; Light yellowish brown, moist, very dense, fine to medium sand. Some 1/2-inch size gravel and rusty stains at top of sample. Some mica, fine sand and increasing silt content at tip.	SM	A3	5	D	28 32	6"/12"	6	99	24	5
30												

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FIGURE A-4. LOG OF BORING PII-4

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-4 | Sheet 2 of 4

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		SANDY SILT; Pale brown, moist, very dense, fine sand, non-plastic fines, micaceous.	ML	A4	6	S	17 29 31	10"/18"	6			5
35		(More silty cuttings at 34-1/2 feet.)										
		TOP OF PUENTE FORMATION. CLAYEY SILT(STONE); Olive brown mottled with reddish yellow, damp, very stiff, oxidized, micaceous, interbedded with very fine sandstone. Dip approximately 20 deg.		Tpw	7	D	11 14	6"/12"	8	84	36	5
40		CLAYEY SILT(STONE); Olive brown, moist, hard, moderately oxidized, less apparent bedding.		Tpw	8	S	12 19 25	14"/18"	6			5
45		CLAYEY SILTSTONE; Very dark gray, moist, hard, appears fresh, slight cementation, interbedded with fine sandstone. Dip approximately 30 deg. (Slower drilling at 48-1/2 feet)		Tpf	9	D	26 15	6"/12"	6	76	42	5
50		CLAYEY SILTSTONE; Very dark olive gray, moist, hard, fresh, micaceous.		Tpf	10	S	27 50/3" Ref.		6			5
55		CLAYEY SILTSTONE; Very dark gray, moist, hard, fresh, micaceous, slightly cemented, thinly bedded.		Tpf	11	D	26 60	6"/12"	6	85	35	5
60		CLAYEY SILTSTONE; Very dark gray, moist, hard, fresh, micaceous.		Tpf	12	S	27 60/6"	12"/12"	8			5
65		CLAYEY SILTSTONE; Very dark gray, damp, hard, fresh, thinly bedded, slightly micaceous. Dip approximately 30 deg.		Tpf	13	D	37 60/5"	6"/11"	8	86	33	5
70												

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FIGURE A-4. LOG OF BORING PII-4

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-4 | Sheet 3 of 4

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SILTSTONE; Dark olive brown to olive gray, moist, hard, fresh, less apparent bedding.		Tpf	14	S	36 64/3"	9"/9"	40			5
75		CLAYEY SILTSTONE; Very dark gray, moist, hard, fresh, well cemented, thinly bedded. Dip approximately 35 deg.		Tpf	15	D	40 60/3"	6"/9"	200	90	30	5
		(Cemented fragments in cuttings at 79 feet.)										
80		CLAYEY SILTSTONE; Very dark gray, moist, hard, fresh, thinly bedded. Slight sulfur odor.		Tpf	16	S	33 41 26/2"	11"/14"	400			5
85		Same as above.		Tpf	17	D	40 60	6"/10"	400	88	28	5
90		Same as above. Dip approximately 30 deg.		Tpf	18	P	Push 270psi	26"/30"	300			5
95		Same as above with lens of siltstone, trace sandstone.		Tpf	19	D	40 60	6"/12"	250			5
100		Same as above.		Tpf	20	S	50/4" Ref.	4"/4"	400			5
105		Same as above.		Tpf	21	D	35 60	6"/12"	400			5
110												

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FIGURE A-4. LOG OF BORING PII-4

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-4 | Sheet 4 of 4

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		Same as above.		Tpf	22	S	29 50/6" Ref.	9"/12"	350			5
115		Same as above.		Tpf	23	D	50 50/4"	6"/10"	500			5
120		Same as above.		Tpf	24	S	40 60	12"/12"	150			6
		BORING TERMINATED AT 121 FEET. PIEZOMETER INSTALLED.										
		NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change with passage of time at this location. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
125												
130												
135												
140												
145												
150												

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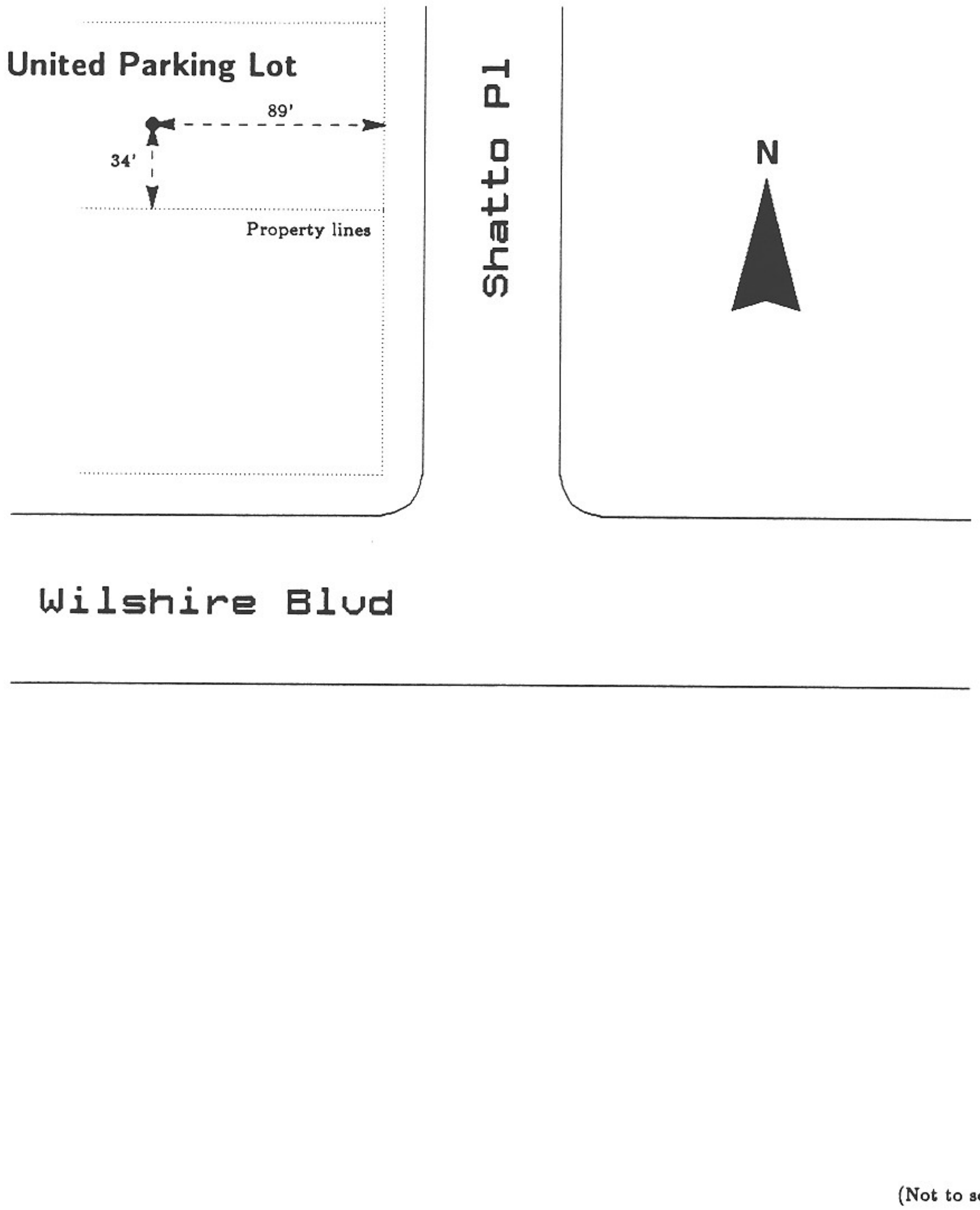

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LOCATION OF BOREHOLE PII-4

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FIGURE A-4A

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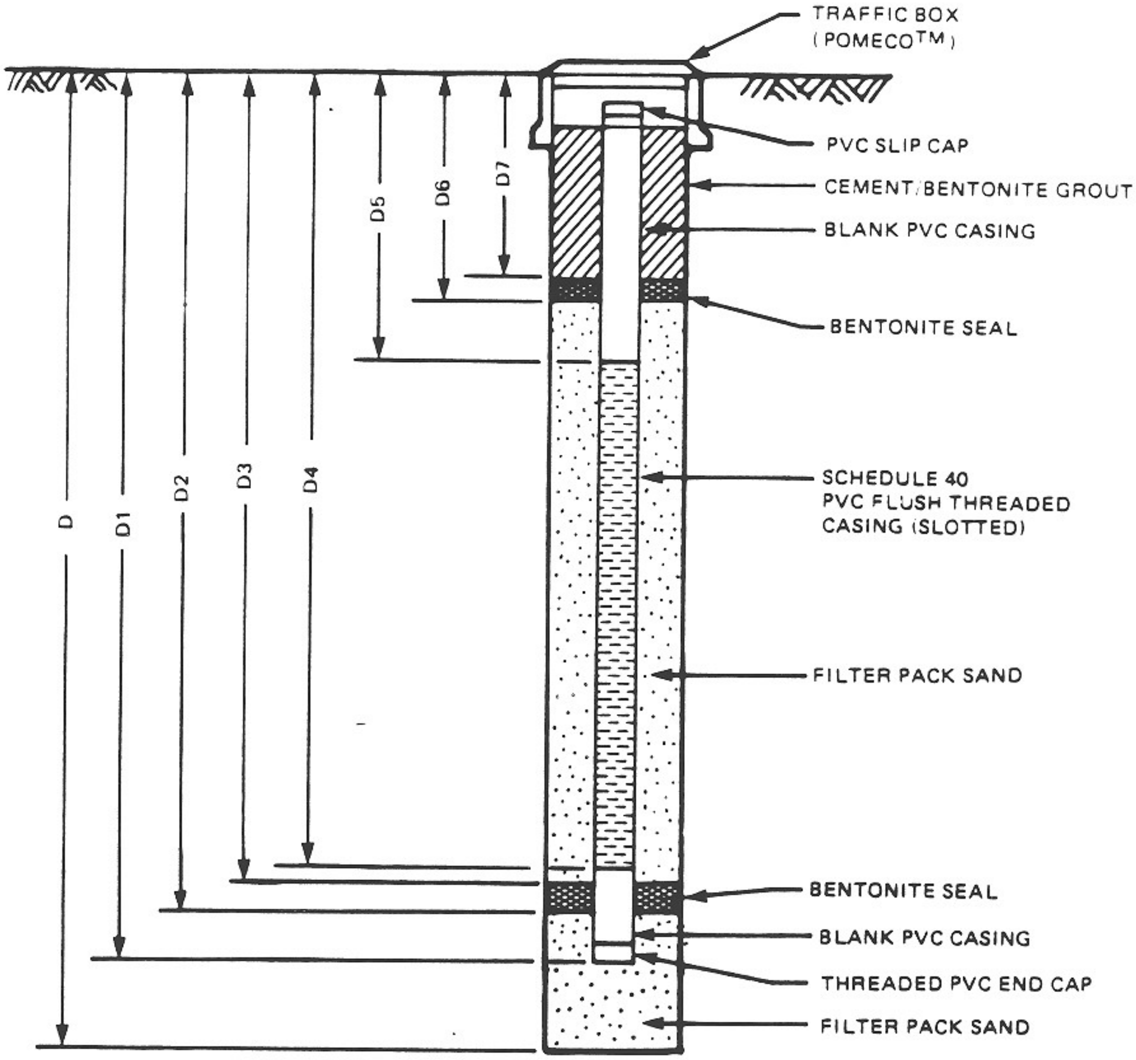

TOTAL DEPTH (D)	=	121.5	FEET
TOTAL DEPTH OF CASING (D1)	=	117.5	FEET
DEPTH TO BOTTOM OF BOTTOM SEAL (D2)	=	52.0	FEET
DEPTH TO TOP OF BOTTOM SEAL (D3)	=	48.0	FEET
DEPTH TO BOTTOM OF WELL SCREEN (D4)	=	47.5	FEET
DEPTH TO TOP OF WELL SCREEN (D5)	=	42.5	FEET
DEPTH TO BOTTOM OF TOP SEAL (D6)	=	40.0	FEET
DEPTH TO TOP OF TOP SEAL (D7)	=	38.0	FEET
WELL CASING DIAMETER	=	2	INCH
WELL SCREEN SLOT SIZE	=	0.02	INCH
FILTERPACK SAND TYPE	=	NO. 2	MONTEREY
BENTONITE SEAL TYPE	=		HOLE PLUG

The Earth Technology Corporation	PROJECT NO.: 89-409 METRO RAIL LPA-PHASE II

DIAGRAM OF PIEZOMETER PII-4

6/89

FIGURE A-4B

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FIGURE A-5. LOG OF BORING PII-5

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-5		sheet 1 of 4
Borehole location United Parking Lot on Shatto Pl.		Elevation and Datum(feet): 260	
Health and Safety: Upgraded Level D		Date Started: 3/16/89	Date Finished: 3/17/89
Drilling Equipment: Failing 750		Total Depth(feet): 121.2	Depth to: Bedrock(feet): 34.5
Drilling Method: Rotary Wash		Borehole Diameter: 8-inch	
Drilling Fluid: Bentonite Mud		Piezometer Installation: YES	Depth(feet): 120.6
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.		Logged By: Pierre Charles	Checked By: C. Marshall Payne

Depth (feet)	Description	USCS Classification	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
	3-1/2-inch of ASPHALT CONCRETE										
	CLAYEY SAND; Dark brown, moist, loose.	SC	FILL								
	SANDY SILT/SILTY SAND; Yellowish brown, wet, dense. SANDY SILT; Dark brown, wet, dense.	ML/SM	A4								
5	SILTY CLAY/CLAYEY SILT; Strong brown, moist, medium stiff, massive, slightly porous, slightly sandy, with some black fragments (charcoal), mild gasoline odor.	CL/ML	A4	1	D	2 4	6"/12"	10	104	20	5
10	CLAYEY SAND; Dark yellowish brown, moist, very stiff, very fine to fine sand, plastic fines.	SC	A4	2	S	5 9 11	18"/18"	5			5
15	(Increasing sand content.) SAND; Olive yellow, wet, dense, very fine to medium sand, clean.	SP	A3	3	D	7 13	6"/12"	5	100	20	5
	(Gravelly sand to gravel in cuttings from 17 to 18-1/2 feet)	SP	A3								
20	(Sandy clay in cuttings at 18-1/2 feet) SAND-SILTY SAND; Olive yellow, wet, very dense, fine to coarse with some mica, pea gravel at top of sample.	SP-SM	A3	4	S	23 39 40	11"/18"	9			5
25	(1/4 to 1-inch size gravel in cuttings from 24 to 25 feet) SILTY SAND; Light yellowish brown, wet, very dense, fine to medium sand, no apparent bedding.	SM	A3	5	D	18 28		12	94	26	5
30											

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FIGURE A-5. LOG OF BORING PII-5

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-5 | Sheet 2 of 4

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		SILTY SAND; Olive yellow, moist, very dense, very fine to fine, some iron-stained thin layers.	SM	A3	6	S	17 32 40	11"/18"				5
35		TOP OF PUENTE FORMATION. SILT(STONE); Mottled, yellow/green/gray, damp, dense, iron stained, moderate to very weathered, moderate to well indurated, thinly bedded. Dip approximately 20 deg. (Slow drilling from 38 to 39-1/2 feet)		Tpw	7	D	10 20	5"/12"				5
40		(Fast drilling, clay in cuttings at 39-1/2 feet) CLAYEY SILT(STONE); Mottled, gray/yellow/red, damp, hard, weathered, lightly indurated, oxidized, seams of rusty brown non-plastic silt(stone). Dip approximately 30 to 45 deg.		Tpw	8	S	10 14 25	18"/18"	9			5
45		CLAYEY SILTSTONE; Grayish olive, damp, hard, unoxidized, well bedded, micaceous with some very fine sandstone beds. Dip approximately 35 deg.		Tpf	9	D	19 35	6"/12"	6	80	40	5
50		CLAYEY SILTSTONE; Gray olive, damp, hard, trace very fine sandstone, unoxidized, well bedded, micaceous. Dip approximately 35 deg.		Tpf	10	S	21 44 35/3"	15"/15"	6			5
55		CLAYEY SILTSTONE; Dark gray, damp, hard, interbedded sandstone, thinly bedded, unoxidized, micaceous. Dip approximately 20 deg.		Tpf	11	D	22 50	6"/12"	8			5
60		CLAYEY SILTSTONE; Dark gray, damp, hard, interbedded thin layers of sandstone, unoxidized. Dip approximately 35 deg.		Tpf	12	S	24 52 24/2"	14"/14"	5			5
65		CLAYEY SILTSTONE; Dark gray, damp, hard, interbedded 1/8 to 1/4 thick layers of very light gray fine sandstone, unoxidized. Dip approximately 40 deg.		Tpf	13	D	25 50	6"/12"	7	74	48	5
70												

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FIGURE A-5. LOG OF BORING PII-5

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-5 | Sheet 3 of 4

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SILTSTONE; Dark gray, damp, hard, interbedded with 1-1/4 thick layers of dark brown sandstone, more sandstone at the tip. Dip approximately 30 deg.		Tpf	14	S	25 55 20/1"	13"/13"	5			5
75		CLAYEY SILTSTONE; Very dark gray, damp, hard, interbedded sandstone and some mica, unoxidized. Dip approximately 30 deg.		Tpf	15	D	35 55	6"/12"	5			5
80		CLAYEY SILTSTONE; Dark olive gray, damp, hard, little clay, unoxidized to slightly oxidized. Dip approximately 5 deg.		Tpf	16	S	17 37 46	18"/18"	5			5
85		SILTSTONE; Dark gray, damp, very dense, interbedded sandstone,unoxidized. Dip approximately 5 deg.		Tpf	17	D	26 74/5.5"	6"/11.5"	6	89	32	5
90		CLAYEY SILTSTONE; Dark gray to black, damp, hard, interbedded with few layers of sandstone, unoxidized. Dip approximately 5 to 10 deg.		Tpf	18	S	25 75/5.5"	11/11.5"	7			5
95		CLAYEY SILTSTONE; Dark gray, damp, hard, interbedded sandstone, very fine. Dip approximately 20 deg. (Drill chatter at 96 feet. 3/10-foot thick hard cemented layer)		Tpf	19	D	26 50	6"/12"	200			5
100		CLAYEY SILTSTONE; Dark gray, damp, hard, trace of sandstone.		Tpf	20	P	Push 280psi	24"/30"	800			5
105		CLAYEY SILTSTONE; Dark gray, damp, hard, interbedded 1/4-inch thick brown fine sandstone. Dip approximately 30 deg.		Tpf	21	D	32 68/5"	6"/11"	300			5
110												

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FIGURE A-5. LOG OF BORING PII-5

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-5 | Sheet 4 of 4

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SILTSTONE; Very dark gray, damp, hard, interbedded with light gray sandstone. Dip approximately 30 deg.		Tpf	22	S	100/6"	2"/6"	320			4
115		CLAYEY SILTSTONE; Very dark gray, damp, hard, interbedded with light gray to brown sandstone. Dip approximately 35 deg.		Tpf	23	D	32 68	6"/12"	550			6
120		CLAYEY SILTSTONE; Dark gray, damp, stiff, some clay, interbedded with gray very fine sandstone. Dip approximately 30 deg.		Tpf	24	S	25 45 30/2"	12"/14"	800			6
		BORING TERMINATED AT 121-1/2 FEET. PIEZOMETER INSTALLED.										
125												
130												
135												
140												
145												
150												

NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary of subsurface material types and the transition may be gradual.

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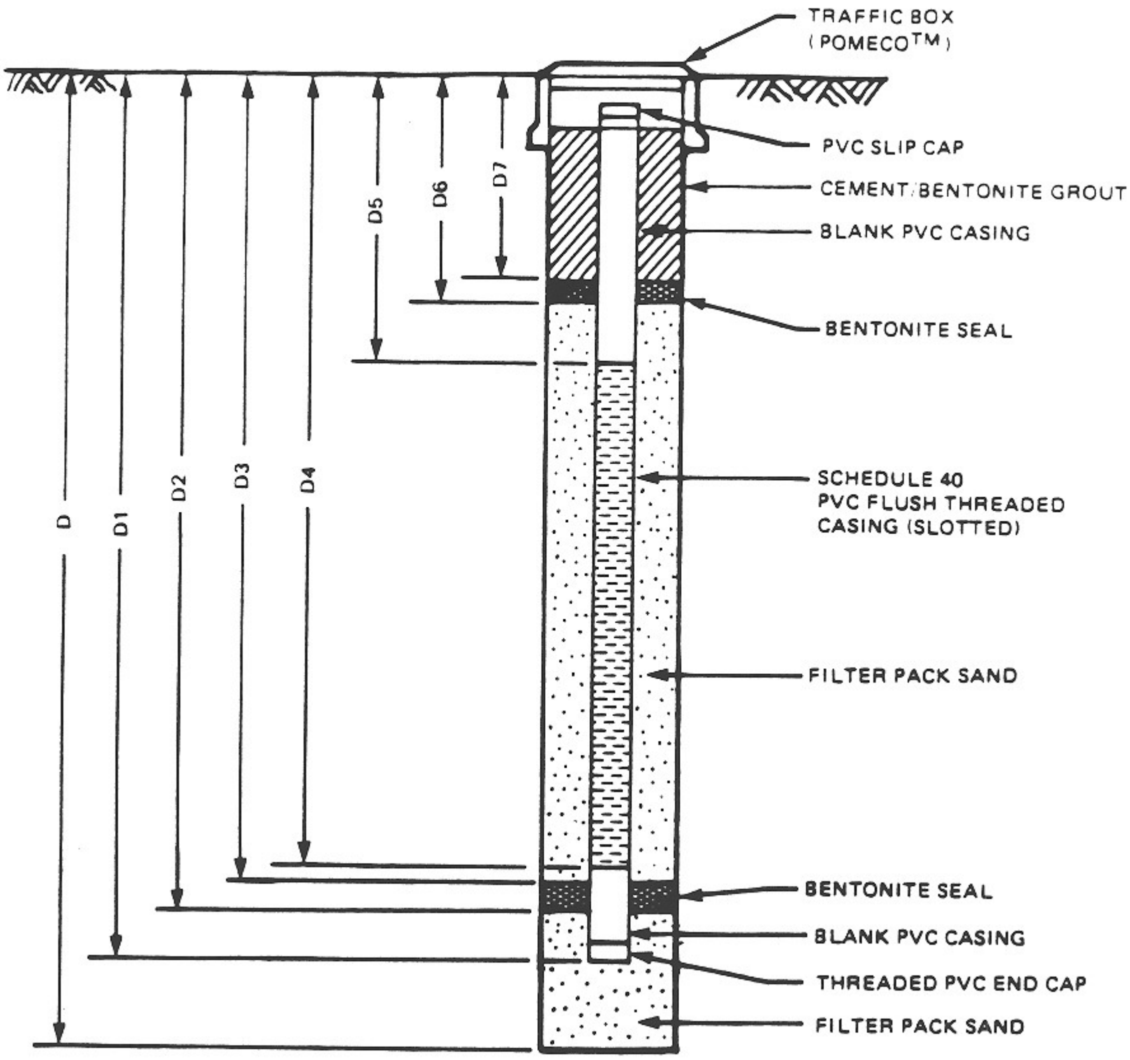

TOTAL DEPTH (D)	=	121.2	FEET
TOTAL DEPTH OF CASING (D1)	=	120.6	FEET
DEPTH TO BOTTOM OF BOTTOM SEAL (D2)	=	89.6	FEET
DEPTH TO TOP OF BOTTOM SEAL (D3)	=	86.4	FEET
DEPTH TO BOTTOM OF WELL SCREEN (D4)	=	81.0	FEET
DEPTH TO TOP OF WELL SCREEN (D5)	=	61.0	FEET
DEPTH TO BOTTOM OF TOP SEAL (D6)	=	52.5	FEET
DEPTH TO TOP OF TOP SEAL (D7)	=	50.7	FEET
WELL CASING DIAMETER	=	4	INCH
WELL SCREEN SLOT SIZE	=	0.02	INCH
FILTERPACK SAND TYPE	=	NO. 2	MONTEREY
BENTONITE SEAL TYPE	=		HOLE PLUG

The Earth Technology Corporation

PROJECT NO.: 89-409

METRO RAIL
LPA-PHASE II

DIAGRAM OF PIEZOMETER PII-5

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FIGURE A-5B

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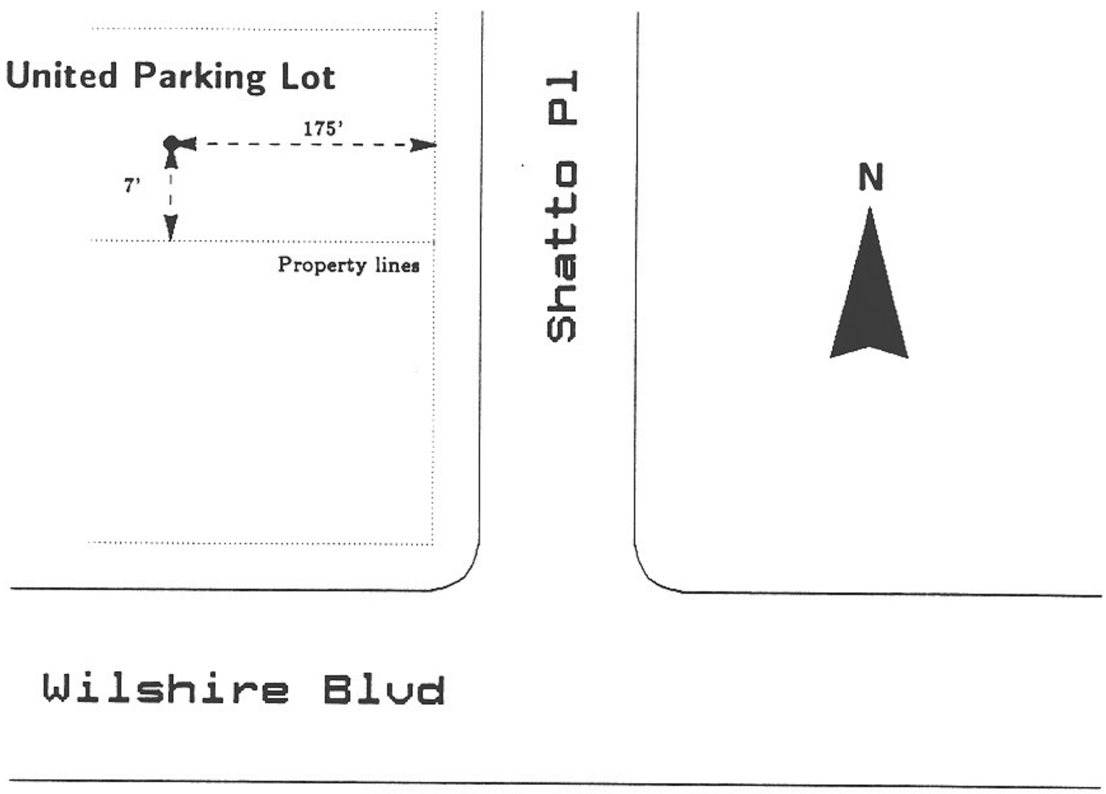

(Not to scale)

The Earth Technology Corporation	PROJECT NO.: 89-409 METRO RAIL LPA-PHASE II

LOCATION OF BOREHOLE PII-5

6/89

FIGURE A-5A

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FIGURE A-6. LOG OF BORING PII-6

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-6		sheet 1 of 2
Borehole location United Parking Lot on Shatto Pl.		Elevation and Datum(feet): 260	
Health and Safety: Upgraded Level D		Date Started: 3/22/89	Date Finished: 3/22/89
Drilling Equipment: Failing 750		Total Depth(feet): 61.0	Depth to: Bedrock(feet): 34.5
Drilling Method: Rotary Wash		Borehole Diameter: 8-inch	
Drilling Fluid: Bentonite Mud		Piezometer Installation: YES	Depth(feet): 61.0
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.		Logged By: Pierre Charles	Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA(ppm)
		2-inch ASPHALT.										
		10-inch AGGREGATE										
		SILTY SAND; Dark brown with some black organoic material.	SM	FILL								
		SANDY SILT;	ML	A4								
5		SANDY CLAY; Very dark grayish brown, damp, dense, moderately plastic, fine sand.	CL	A4	1	S	5 19 22	9"/18"	5			5
10		SAND-SILTY SAND; Very pale yellow, moist, dense, fine to medium.	SP-SM	A3	2	D	11 14	6"/12"	150			5
15		SILTY SAND; Very pale brown, moist, verty dense, fine to medium sand.	SM	A3	3	S	12 18 30	8"/18"	10			5
20		(Gravel in cuttings at 19-1/2 feet) SILTY SAND; Very pale brown, moist, very dense, fine sand, slightly plastic fines, micaceous, trace gravel at top.	SM	A3	4	D	22 32	6"/12"	15	102	17	5
25		SAND-SILTY SAND; Very pale brown, moist, very dense, fine to medium sand, occasional coarse sand and trace fine gravel upto 1/2-inch size, micaceous.	SP-SM	A3	5	S	15 30 40	8"/18"	6			5
		(Gravel in cuttings at 29 feet.)										
30												

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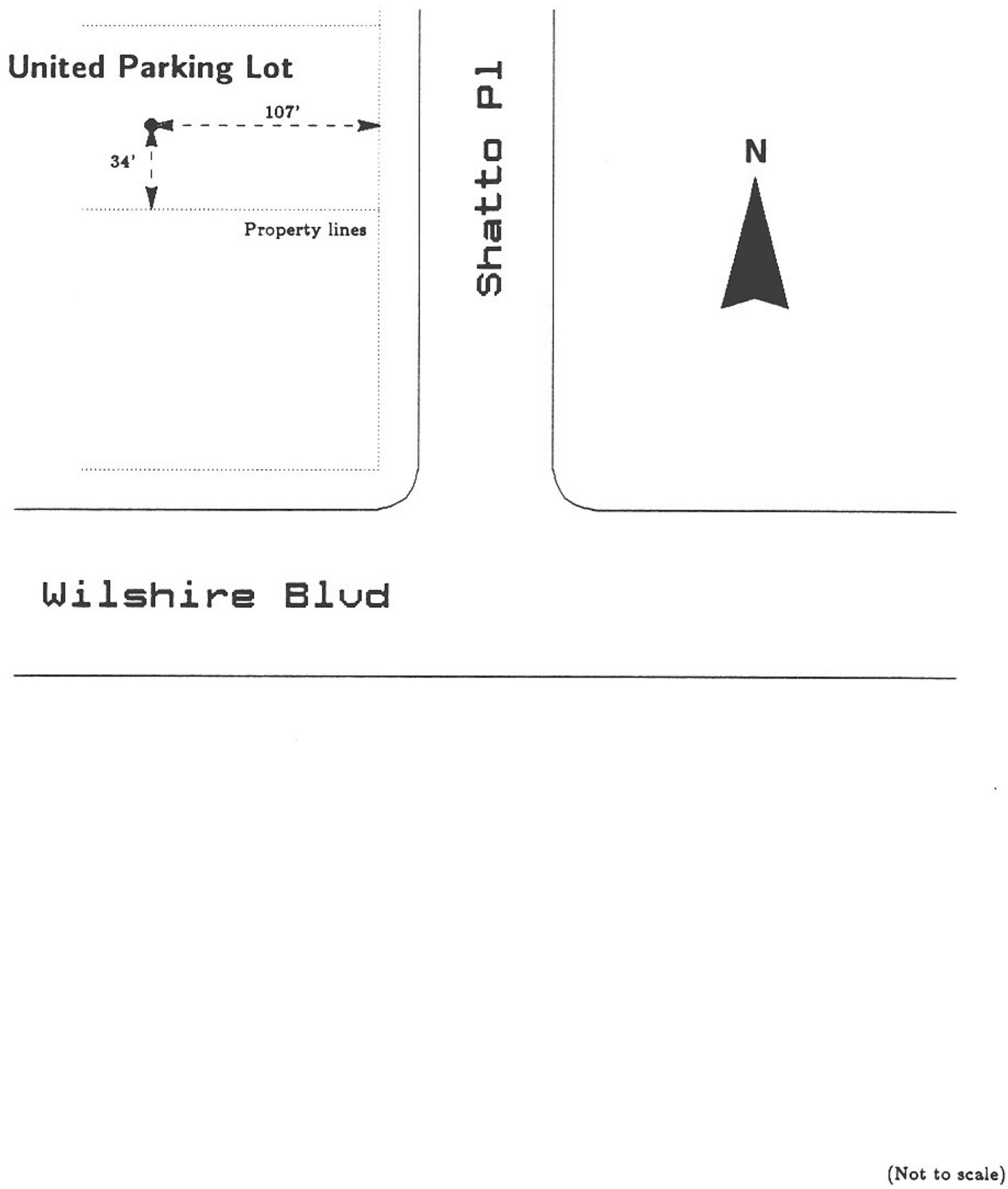
FIGURE A-6. LOG OF BORING PII-6

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-6 | Sheet 2 of 2

Depth (feet)	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA(ppm)
	SILTY SAND; Very pale brown, moist, medium dense, very fine sand , occasional coarse sand, trace gravel to 3/4-inch size at top, micaceous.	SM	A3	6	D	15 26	6"/12"	5	105	11	5
35	(Silt in cuttings at 34-1/2 feet) TOP OF PUENTE FORMATION. SILT(STONE); Mottled, brown/reddish brown/dark gray, damp, dense, oxidized, interbedded with 1/8 to 1/2-inch thick very fine sandstone.		Tpw	7	S	9 15 21	16"/18"	6			3
40	SILT(STONE); Mottled, damp, medium dense, oxidized, interbedded with light gray sandstone, more clayey at tip of the sample. Dip approximately 30 deg.		Tpw	8	D	11 14	6"/12"	8	80	41	5
	(Dark fragments in cuttings at 42-1/2 feet, cuttings appear to be unoxidized.)										
45	CLAYEY SILTSTONE; Mottled, damp, hard, carbonated, cemented,interbedded with light gray, very fine sandstone.		Tpf	9	S	11 23 42	13"/18"	8			5
50	CLAYEY SILTSTONE; Very dark gray, damp, hard, fresh, few sandstone interbeds, no cementation.		Tpf	10	D	34 72	6"/12"	5			5
55	(No recovery)		Tpf		P	Push 200psi	NR				
	(Cemented fragments in cuttings at 57-1/2 feet) Same as above. Dip approximately 20-30 deg.		Tpf	11	P	Push 300psi	24"/30"	6			5
60	Same as above.		Tpf	12	D	33 67/6"	6"/12"	6			5
65	BORING TERMINATED AT 61 FEET. PIEZOMETER INSTALLED. NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
70											



The Earth Technology Corporation	PROJECT NO.: 89-409 METRO RAIL LPA-PHASE II

LOCATION OF BOREHOLE PII-6

6/89 FIGURE A-6A

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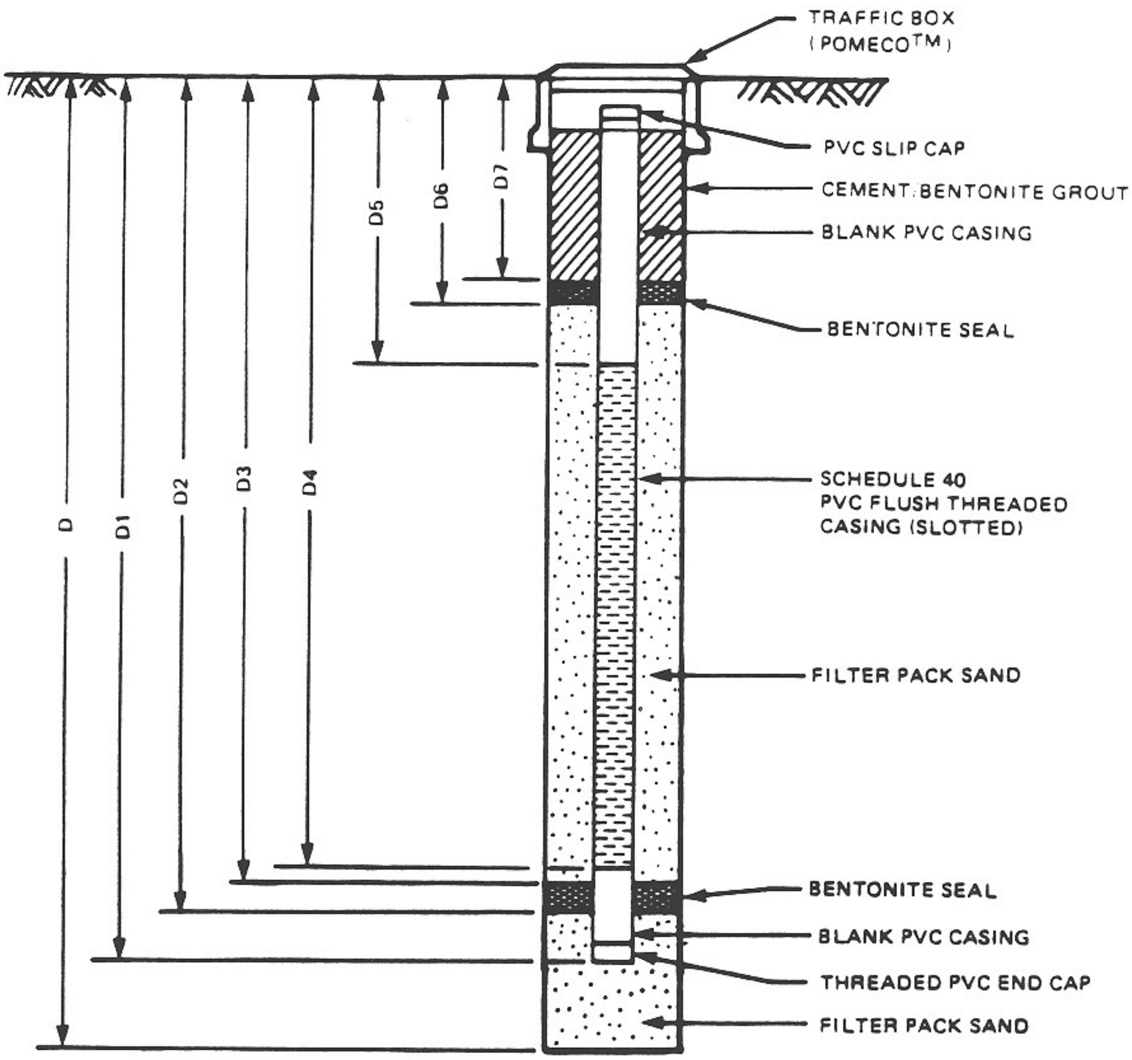

TOTAL DEPTH (D)	=	61.0	FEET
TOTAL DEPTH OF CASING (D1)	=	61.0	FEET
DEPTH TO BOTTOM OF BOTTOM SEAL (D2)	=	55.5	FEET
DEPTH TO TOP OF BOTTOM SEAL (D3)	=	52.3	FEET
DEPTH TO BOTTOM OF WELL SCREEN (D4)	=	50.5	FEET
DEPTH TO TOP OF WELL SCREEN (D5)	=	40.5	FEET
DEPTH TO BOTTOM OF TOP SEAL (D6)	=	36.5	FEET
DEPTH TO TOP OF TOP SEAL (D7)	=	33.5	FEET
WELL CASING DIAMETER	=	4	INCH
WELL SCREEN SLOT SIZE	=	0.02	INCH
FILTERPACK SAND TYPE	=	NO. 2	MONTEREY
BENTONITE SEAL TYPE	=		1/8" PELLETS

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PROJECT NO.: 89-409

METRO RAIL
LPA-PHASE II

DIAGRAM OF PIEZOMETER PII-6

6/89

FIGURE A-6B

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FIGURE A-7. LOG OF BORING PII-7

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-7		sheet 1 of 4
Borehole location J. Winfield's Restaurant Parking Lot		Elevation and Datum(feet): 257	
Health and Safety: Upgraded Level D		Date Started: 3/21/89	Date Finished: 3/22/89
Drilling Equipment: Failing 750		Total Depth(feet): 121.5	Depth to: Bedrock(feet): 29.0
Drilling Method: Rotary Wash		Borehole Diameter: 6-inch	
Drilling Fluid: Bentonite Mud		Piezometer Installation: NO	Depth(feet): --
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.		Logged By: Kean Tan	Checked By: C. Marshall Payne

Depth (feet)	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
	3 to 4-inch ASPHALT										
	SAND; Light olive brown, fine to medium sand. Same as above except more gravelly. Same as above except clayey.	SP	FILL								
5	SANDY CLAY; Dark yellowish brown, damp, hard, some fine sand.	CL / SC	A4 / A4	1	D	13 23	7"/12"	7	111	17	7
	CLAYEY SAND; Dark yellowish brown, damp, dense. SAND; Pale yellow, damp, medium dense, medium sand, appears oxidized.	SP	A3								
10	SAND-SILTY SAND; Pale yellow, damp, very dense, medium sand, appears oxidized.	SP-SM	A3	2	S	9 17 24	8"/18"	7			7
15	SILTY SAND; Pale yellow, moist to wet, very dense, medium sand, 1/2 to 1-inch size gravel, oxidized. (Drill chatter at 17 feet. Coarse sand to gravel in cuttings.)	SM	A3	3	D	29 50/3"	6"/9"	8	113	16	7
20	GRAVELLY SAND; Pale yellow, moist, medium sand. SILTY SAND; Pale yellow, moist, very dense, fine to medium sand, trace 1/2-inch size gravel.	SP	A3	4	S	31 31 34	12"/18"	4			4
25	(No recovery with catcher. Hole caving.)	SP	A3	5	D	37 63/3"	NR				4
	(Heavy drill chatter. Gravel in cuttings.) SILTY SAND;	SP	A3								
30	TOP OF PUENTE FORMATION										

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FIGURE A-7. LOG OF BORING PII-7

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-7 | Sheet 2 of 4

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		SILT(STONE); Mottled, yellow/brown/gray, damp, dense, oxidized, trace clay, interbedded with gravelly sandstone, cemented, well bedded. Dip approximately 20 deg.		Tpw	6	S	19 16 16	14"/18"	4			4
35		Same as above.		Tpw	7	D	20 44	12"/12"	4	82	41	4
		CLAYEY SILTSTONE; Dark olive gray, damp, hard, trace sandstone.		Tpf								
40		CLAYEY SILTSTONE; Dark olive gray, damp, hard, very dark grayish brown sandstone interbeds. Dip approximately 20 deg.		Tpf	8	S	17 32 50/5"	12"/17"	5			4
45		Same as above. Hard.		Tpf	9	D	75 25/1"	2"/7"	7			4
50		CLAYEY SILTSTONE; Dark olive gray, damp, hard, interbedded with very dark grayish brown, fine to medium sandstone, Dip approximately 20 deg.		Tpf	10	S	27 50/3.5"	8"/9.5"	9			4
55		Same as above.		Tpf	11	D	80 20/1"	6"/7"	15			7
60		Same as above.		Tpf	12	S	44 50/3.5"	8"/9.5"	15			7
65		Same as above.		Tpf	13	D	85 15/0.5"	5"/6.5"	34	78	32	7
70												

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FIGURE A-7. LOG OF BORING PII-7

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-7 | Sheet 3 of 4

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		Same as above.		Tpf	14	S	40 50/2.5"	6"/8.5"	40			7
75		Same as above.		Tpf	15	D	78 22/1"	6"/7"	38			7
80		Same as above.		Tpf	16	S	37 50/5"	5"/11"	34			7
85		CLAYEY SILTSTONE; Dark olive gray, damp, hard, highly plastic, well bedded, micaceous.		Tpf	17	D	80 20/0.5"	6"/6.5"	34	80	39	7
90		Same as above with sandstone interbeds.		Tpf	18	P	Push 300psi		5			4
95		Same as above.		Tpf	19	D	70 30/1.5"	5"/7.5"	5	74	43	4
100		Same as above.		Tpf	20	S	37 50/3.5"	8"/9.5"	5			4
105		CLAYEY SILTSTONE; Dark olive gray, damp, hard, cemented, micaceous.		Tpf	21	D	44 56/4"	6"/10"	5			4
110												

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FIGURE A-7. LOG OF BORING PII-7

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-7 | Sheet 4 of 4

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		Same as above.		Tpf	22	S	31 50/4.5	8"/10.5"	8			4
115		CLAYEY SILTSTONE; Dark olive gray, damp, hard, cemented, micaceous, interbedded, soft to stiff, plastic, claystone.		Tpf	23	D	30 50/4.5"	8"/10.5"	5			4
120		SILTSTONE; Dark gray, damp, very dense, alternating claystone, olive gray.		Tpf	24	S	26 37 50/4"	12"/16"	5			4
		BORING TERMINATED AT 121-1/2 FEET.										
		NOTE: This borehole log is based on field classification, and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
125												
130												
135												
140												
145												
150												

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The Earth Technology Corporation	PROJECT NO.: 89-409 METRO RAIL LPA-PHASE II

LOCATION OF BOREHOLE PII-7

6/89

FIGURE A-7A

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FIGURE A-8. LOG OF BORING PII-8

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-8		sheet 1 of 4
Borehole location: Vermont Ave., north of 6th street		Elevation and Datum(feet): 245	
Health and Safety: Upgraded Level D		Date Started: 4/29/89	Date Finished: 4/29/89
Drilling Equipment: Failing 750		Total Depth(feet): 106.1	Depth to: Bedrock(feet): 24.2
Drilling Method: Rotary Wash		Borehole Diameter: 6-inch	
Drilling Fluid: Bentonite Mud		Piezometer Installation: NO	Depth(feet): --
Hammer Information: SPT Hammer: 140-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.		Logged By: Pierre Charles	Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		12-inch ASPHALT and CONCRETE										
		6-inch WOOD -- rail tie										
		6-inch AGGREGATE BASE	SP	FILL								
		SAND; Medium, probably base material.										OVA levels not recorded
5		SAND; Moist, dense, some fines with medium plasticity.										
		SILT/CLAYEY SILT; Mottled, damp, very stiff to hard, low to medium plasticity, very fine sand at the top.	ML	A4	1	D	12 19	6"/12"	1	90	25	
		SILTY SAND; mottled, damp, dense to very dense, fine to medium sand, at the tip.	SM	A3								
10		SILTY SAND; Brown, moist, very dense, fine to medium sand, trace mica.	SM	A3	2	S	9 14 20	6"/18"	21			
15		SILTY SAND; Yellowish brown, moist, very dense, fine to medium sand, low plastic fines, trace mica.	SM	A3	3	D	16 24	6"/12"	6	101	14	
		(Easier drilling at 17 feet.)										
20		SILTY SAND; Pale brown, moist, very dense, medium sand, some black fragments.	SM	A3	4	S	16 22 32	6"/18"	38			
		(Silty Gravel in cuttings at 23-1/2 feet.)										
25		TOP OF PUENTE FORMATION. CLAYEY SILT(STONE); Mottled, pale brown/light gray, moist, very stiff, very oxidized, interbedded with very fine sandstone, micaceous, rusty stains, moderately defined bedding. Dip approximately 15 to 20 deg.		Tpw	5	D	13 14	10"/12"	150			
30												

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FIGURE A-8. LOG OF BORING PII-8

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-8 | Sheet 2 of 4

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		SILT(STONE); Mottled, mainly olive gray, moist, dense to very dense, interbedded with fine sandstone, moderately well bedded, low plastic fines. Dip 0 to 5 deg.		Tpw	6	S	13 17 22	16"/18"	15			
35		(Color changes at 34 feet.) CLAYEY SILTSTONE; Mottled, dark brown/dark olive gray, damp, hard, fresh, micaceous, very plastic fines, well and thinly bedded, laminated, fresh. Dip approximately 30 deg.		Tpf	7	D	13 36	12"/12"	7	90	32	
40		CLAYEY SILTSTONE; Dark olive gray to olive brown, damp, hard, fresh, thinly laminated, very cemented, slight effervesce with HCl, trace mica. Dip approximately 0 to 10 deg.		Tpf	8	S	22 50 28/3"	15"/15"	82			
45		CLAYEY SILTSTONE; Dark gray, damp, hard, fresh, highly plastic, thinly laminated, interbedded with sandstone, moderate efferverse with HCl in siltstone portion, no apparent cementation. Dip approximately 30 deg.		Tpf	9	D	20 46	10"/12"	14	89	33	
50		CLAYEY SILTSTONE; Dark olive gray, damp, hard, fresh, less defined bedding, interbedded with sandstone, increasing sand fraction. Dip 0 to 10 deg.		Tpf	10	S	18 38 44/2.5"	16"/18"	48			
55		CLAYEY SILTSTONE; Very dark gray, damp, hard, fresh, low to medium plasticity, interbedded with sandstone, micaceous, not cemented. Dip 15 to 20 deg. (Black oil stain in mud tank.)		Tpf	11	D	25 50	12"/12"	17			
60		CLAYEY SILTSTONE; Dark gray, damp, hard, fresh, not cemented, micaceous. Dip approximately 15 deg.		Tpf	12	P	Push 270psi	17"/30"	8	86	34	
65		(Hard drilling from 64.8 to 65.2 feet.) (No recovery.)		Tpf	13	D	50/1" Refusal	NR				
70												

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FIGURE A-8. LOG OF BORING PII-8

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-8 | Sheet 3 of 4

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		CLAYEY SILTSTONE; Dark gray/Dark brown, damp, hard, fresh, very fine sand, micaceous, locally very poorly cemented, interbedded with 1-inch thick sandstone beds, well defined. Dip approximately 15 to 20 deg.		Tpf	14	S	18 32 50/6"	10"/18"	50			
75		Same as above. Dip 15 deg.		Tpf	15	D	30 55	12"/12"	50	100	30	
80		(Very hard drilling at 79 feet.) CLAYEY SILTSTONE; Very dark gray, damp, hard, thinly laminated, very cemented, moderate reaction to HCl. (hard layer ends at 80.4 feet.)		Tpf	16	P	Push 300psi	4"/6"				
85		CLAYEY SILTSTONE; Dark gray to dark olive brown, damp, hard, low plasticity fines, interbedded with sandstone, trace mica. Dip approximately 20 deg.		Tpf	17	D	30 70/5"	9"/11"	1000	89	30	
90		CLAYEY SILTSTONE; Very dark gray, damp, hard, low plastic, interbedded sandstone, micaceous, thinly laminated. Dip 30 deg.		Tpf	18	S	14 52 34/4"	15"/16"	1000			
95		CLAYEY SILTSTONE; Very dark gray, damp, hard, low plastic, micaceous, poorly defined bedding, thinly laminated. No dip.		Tpf	19	D	44 56/4"	10"/10"	1000	87	31	
100		CLAYEY SILTSTONE; Very dark gray, damp, hard, well bedded, thinly laminated, interbedded with sandstone, not cemented. Dip approximately 30 deg.		Tpf	20	P	Push 250psi	30"/30"	1000			
105		Same as above.		Tpf	21	D	33 67	12"/12"	1000			
110		BORING TERMINATED AT 106 FEET. NOTE: This borehole log is based on field classificattion and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface										

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FIGURE A-8. LOG OF BORING PII-8

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-8 | Sheet 4 of 4

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA(ppm)
		conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.										
115												
120												
125												
130												
135												
140												
145												
150												

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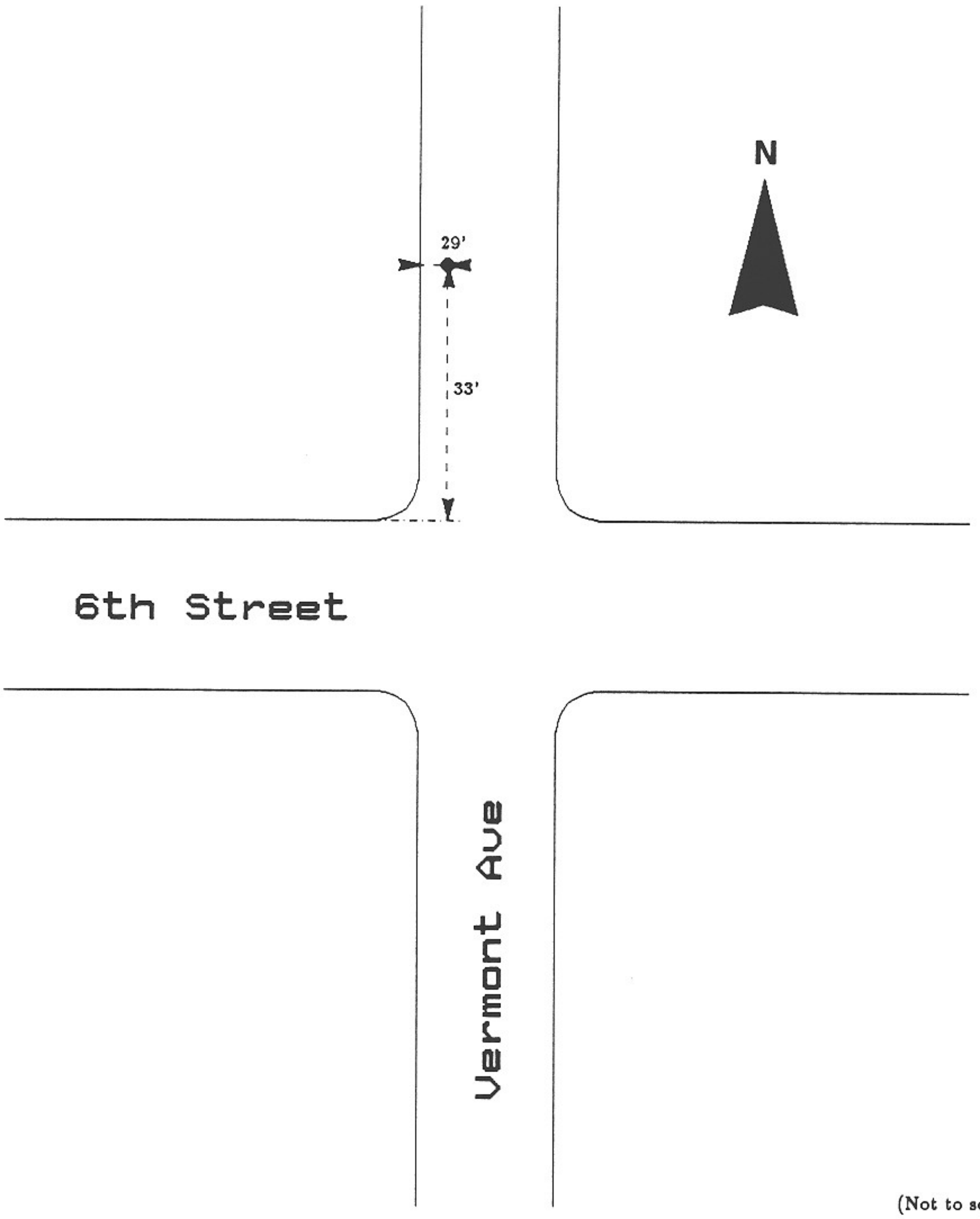

(Not to scale)

The Earth Technology Corporation	PROJECT NO.: 89-409 METRO RAIL LPA-PHASE II

LOCATION OF BOREHOLE PII-8

6/89

FIGURE A-8A

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FIGURE A-8D. LOG OF BORING PII-8D

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES			
Project Number: 89-409	Borehole Number: PII-8D		sheet 1 of 3
Borehole location Unocal 76 Parking Lot on Virgil Ave.	Elevation and Datum(feet):		
Health and Safety: Upgraded Level D	Date Started: 3/23/89		Date Finished: 3/24/89
Drilling Equipment: Failing 750	Total Depth(feet): 101.8		Depth to: Bedrock(feet): 25.1
Drilling Method: Rotary Wash	Borehole Diameter: 6-inch		
Drilling Fluid: Bentonite Mud	Piezometer Installation: NO		Depth(feet): --
Hammer Information: SPT Hammer: 139-lb and 30-inch drop. DOWNHOLE Hammer: 295-lb and 18-inch drop.	Logged By: Kean Tan		Checked By: C. Marshall Payne

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA(ppm)
		3-inch ASPHALT										
		6-inch BASE COURSE.										
		CLAYEY SAND; Fine to medium sand.	SC	FILL								
5		SANDY CLAY; Olive brown, damp, hard, trace fine sand. Color changed to mottled light olive brown and reddish yellow at the tip.	CL	A4	1	D	15 34	4"/12"	5			
10		SAND-SILTY SAND; Yellow, moist, very dense, fine to medium sand, poorly graded.	SP-SM	A3	2	S	9 12 21	10"/18"	5			
		(Gravel at 14 feet.)										
15		SILTY SAND; Yellow, moist, very dense, fine to medium sand with 1/2 to 1-1/2 -inch size gravel.	SM	A3	3	D	19 34	6"/12"	5			
20		Same as above. Micaceous.	SM	A3	4	S	14 21 21	14"/18"	5			
		(At 23 feet, drill rig chatters, gravel in cuttings; Black color, tar-like substance in strainer.)										
25		TOP OF PUENTE FORMATION. CLAYEY SILT(STONE); Mottled, yellow/gray/brown, damp, hard, oxidized, slightly plastic, trace fine sand(stone), appears impregnated with tar (dried-up old oily material). Dip approximately 20 deg.		Tpw	5	D	13 28	12"/12"	6	55	58	
30												

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FIGURE A-8D. LOG OF BORING PII-8D

Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-8D | Sheet 2 of 3

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples: Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
		SILT(STONE); Mottled, yellow/brown/gray, damp, dense, oxidized, thinly bedded, trace clay. Dip approximately 25 deg.		Tpw	6	S	6 9 16	18"/18"	5			
35		Same as above.		Tpw	7	D	17 35	12"/12"	5	76	44	
40		CLAYEY SILT(STONE); Mottled, yellow/gray/brown, damp, hard, oxidized, thinly bedded. Dip approximately 20 deg.		Tpw	8	S	13 20 26	17"/18"	4			
45		CLAYEY SILTSTONE; Dark olive gray, damp, hard, appears fresh, well bedded, micaceous. Dip approximately 30 deg.		Tpf	9	D	57 43/2.5"	7"/8.5"	4			
50		Same as above.		Tpf	10	P	Push 240psi	24"/28"	4	78	41	
55		Same as above. Sulfur odor.		Tpf	11	D	56 44/2"	4"/8"	7			
60		CLAYEY SILTSTONE; Dark olive gray, damp, hard, cemented, interbedded with dark grayish brown sandstone. Dip approximately 30 deg.		Tpf	12	S	29 50/5"	10"/11"	6			
65		Same as above.		Tpf	13	~~D~~	85 15/0.5"	3"/6.5"	8			
70		Drill rig chatters. Cuttings indicate cemented, very hard, siliceous siltstone fragments (shale-like).										

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FIGURE A-8D. LOG OF BORING PII-8D

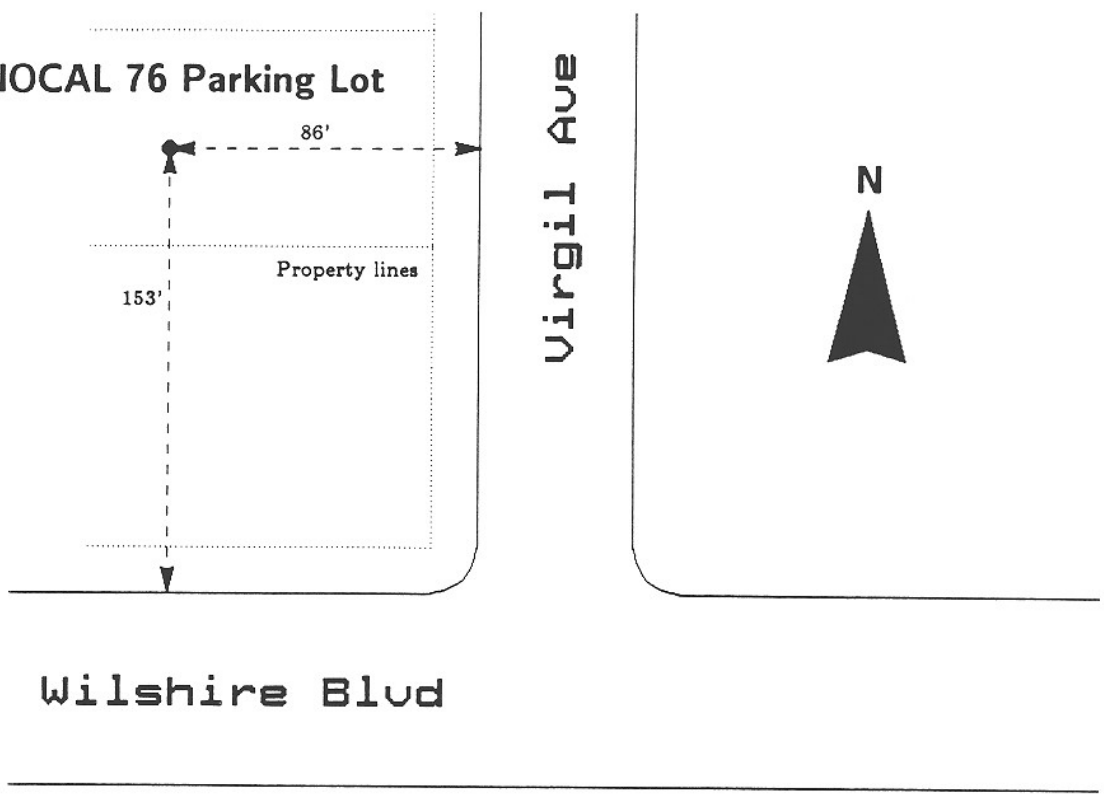
Project Name: METRO RAIL LPA - PHASE II - LOS ANGELES

Project Number: 89-409 | Borehole Number: PII-8D | Sheet 3 of 3

Depth (feet)	Lith-ology	Description	USCS Classification	Geologic Unit	Samples Number	Type	Blow Count	Recovery	OVA (ppm)	Dry Density (pcf)	Moisture Content (%)	Background OVA (ppm)
75		CLAYEY SILTSTONE; Dark olive gray, hard, cemented, interbedded with very fine dark grayish brown sandstone. Sulfur odor. Dip approximately 30 deg.		Tpf	15	D	78 22/1.5"	4"/7.5"	12			3
80		Same as above.		Tpf	16	P	Push 300psi	24"/28"	4	87	32	3
		Heavy drill chatter at 83 feet. Hard layer										
85		End of hard layer. Same as above at 75 feet.		Tpf	17	D	55 45/2.5"	6"/8.5"	7			3
90		Same as above.		Tpf	18	S	29 50	8"/12"	4			3
95		Same as above.		Tpf	19	D	82 18/0.5"	3"/6.5"	5			3
100		Same as above.		Tpf	20	S	37 50/2.5"	7"/8.5"	5			3
105		BORING TERMINATED AT 121-2/3 FEET.										
110												

BORING TERMINATED AT 121-2/3 FEET.

NOTE: This borehole log is based on field classification and visual soil description, and is further modified to include results of laboratory classification tests, where available. This summary applies only at the location of this boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with passage of time. The data presented is simplification of actual conditions encountered. The stratification lines represent the approximate boundary between subsurface material types and the transition may be gradual.



The Earth Technology Corporation	PROJECT NO.: 89-409 METRO RAIL LPA-PHASE II

LOCATION OF BOREHOLE PII-8D

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FIGURE A-8DA

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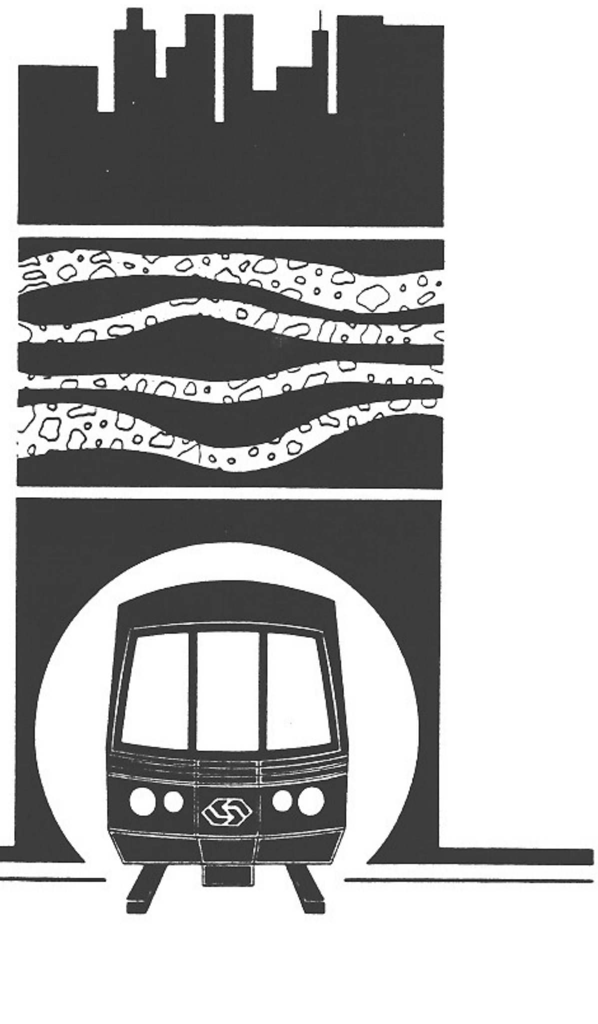
Appendix B

Results of Soil Mechanics Laboratory Test Program



APPENDIX B

RESULTS OF SOIL MECHANICS LABORATORY TEST PROGRAM

This appendix presents the results of soil mechanics laboratory tests performed on selected representative soil samples. A description of the soil mechanics laboratory test program and test procedures has been provided in Section 3.2. In this appendix, test results are presented in tables and figures as follows:

Table or Figure	Test Results
Table B-1	Dry Density, Moisture Content and Calculated Void Ratio
Table B-2	Grain Size Analysis
Table B-3	Atterberg Limits
Table B-4	Specific Gravity
Table B-5	Unconfined Compression Tests
Table B-6	Direct Shear Tests
Table B-7	Permeability Determination
Table B-8	Engineering Properties of all geologic units - Summary of Laboratory test results
Figures B-1 through B-26	Grain Size Distribution Curves
Figures B-27 through B-32	Triaxial Test Results
Figures B-33 through B-51	Direct Shear Test Results
Figures B-52 through B-75	Unconfined Compression Test Results
Figure B-76 through B-80	Consolidation Test Results

TABLE B-1.

SUMMARY OF DRY DENSITY, MOISTURE CONTENT AND CALCULATED VOID RATIO

(Page 1 of 2)

Boring No.	Sample* No.	Depth (Feet)	USCS Classi- fication	Geologic Unit	Dry Density (PCF)	Moisture Content (%)	Calculated Void Ratio
PII-1	D-3	15-16	SM	A_3	-	20.4	-
PII-1	D-5	25-26	SM	A_3	90.7	25.9	0.84
PII-1	D-7	35-36	-	Tpw	83.7	36.7	0.98
PII-1	D-9	45-46	-	Tpf	94.5	28.0	0.75
PII-1	D-11	55-56	-	Tpf	85.3	35.0	0.94
PII-1	D-13	65-66	-	Tpf	85.5	35.7	0.93
PII-1	D-19	95-96	-	Tpf	83.5	35.1	0.98
PII-2	D-1	5-6	SM	A_3	-	17.5	-
PII-2	D-3	15-16	SM	A_3	97.1	22.1	0.72
PII-2	D-7	35-36	-	A_3	74.9	42.1	1.21
PII-2	D-9	45-46	-	Tpf	76.5	42.8	1.17
PII-2	D-13	65-66	-	Tpf	77.7	38.9	1.13
PII-2	D-15	75-76	-	Tpf	85.6	32.8	0.93
PII-2	P-18	90-92.5	-	Tpf	87.9	32.7	0.88
PII-2	D-19	95-96	-	Tpf	80.2	35.1	1.06
PII-3	D-2	10-11	SM	A_3	109.5	18.2	0.53
PII-3	D-4	20-21	SP-SM	A_3	-	25.8	-
PII-3	D-6	30-31	SM	A_3	90.9	27.8	0.84
PII-3	D-8	40-41	-	Tpw	86.5	30.3	0.91
PII-3	D-10	50-51	-	Tpf	78.6	42.9	1.10
PII-3	D-12	60-61	-	Tpf	86.4	33.8	1.00
PII-3	D-14	70-71	-	Tpf	82.5	37.3	0.91
PII-3	D-18	90-91	-	Tpf	80.1	32.4	1.06
PII-3	D-20	100-101	-	Tpf	85.7	31.9	0.93
PII-4	D-1	5-6	CL	A_4	104.5	20.0	0.60
PII-4	D-3	15-16	SM	A_3	102.1	20.8	0.64
PII-4	D-5	25-26	SM	A_3	99.0	24.1	0.69
PII-4	D-7	35-36	-	Tpw	83.9	36.0	0.97
PII-4	D-9	45-46	-	Tpf	76.1	42.2	1.17
PII-4	D-11	55-56	-	Tpf	85.4	35.0	0.94
PII-4	D-13	65-66	-	Tpf	86.1	33.3	0.92
PII-4	D-15	75-76	-	Tpf	89.9	29.6	0.84
PII-4	D-17	85-86	-	Tpf	88.1	28.2	0.88
PII-5	D-1	5-6	CL-ML	A_4	104.1	20.1	0.61
PII-5	D-3	15-16	SP	A_3	100.1	20.3	0.67
PII-5	D-5	25-26	SM	A_3	94.3	26.0	0.77
PII-5	D-9	45-46	-	Tpf	80.3	40.3	1.06
PII-5	D-13	65-66	-	Tpf	73.6	47.5	1.25
PII-5	D-17	85-86	-	Tpf	88.0	32.1	0.86
PII-6	D-4	20-21	SM	A_3	102.1	16.5	0.64
PII-6	D-6	30-31	SM	A_3	104.5	11.0	0.60
PII-6	D-8	40-41	-	Tpf	79.7	40.8	1.08
PII-7	D-1	5-6	SC	A_4	110.5	17.1	0.51
PII-7	D-3	15-16	SM	A_3	112.5	15.7	0.49
PII-7	D-7	35-36	-	Tpw	81.5	40.9	1.03
PII-7	D-13	65-66	-	Tpf	78.1	31.8	1.12
PII-7	D-17	85-86	-	Tpf	79.8	38.7	1.07

*D-Drive Samples
P-Thin Wall Tube (Pitcher) Samples

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TABLE B-1.

SUMMARY OF DRY DENSITY, MOISTURE CONTENT AND CALCULATED VOID RATIO

Boring No.	Sample* No.	Depth (Feet)	USCS Classi- fication	Geologic Unit	Dry Density (PCF)	Moisture Content (%)	Calculated Void Ratio
PII-7	D-19	95-96	-	Tpf	74.3	42.5	1.23
PII-8	D-1	5-6	ML	A_4	89.7	25.0	0.86
PII-8	D-3	15-16	SM	A_3	100.8	13.6	0.66
PII-8	D-7	35-36	-	Tpf	89.7	32.3	0.84
PII-8	D-9	45-46	-	Tpf	88.8	33.0	0.86
PII-8	P-12	60-62.5	-	Tpf	86.1	33.7	0.92
PII-8	D-15	76-76	-	Tpf	-	30.0	-
PII-8	D-17	85-86	-	Tpf	89.4	29.6	0.85
PII-8	D-19	95-96	-	Tpf	87.1	31.1	0.90
PII-8D	D-7	35-36	-	Tpw	75.6	43.7	1.19
PII-8D	P-10	50-52.5	-	Tpf	77.7	40.7	1.13
PII-8D	P-16	80-82.5	-	Tpf	87.2	32.3	0.90

*D-Drive Samples
P-Thin Wall Tube (Pitcher) Samples

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TABLE B-2

SIEVE ANALYSIS RESULTS

BORING NO.	SAMPLE NO.*	DEPTH (Feet)	USCS CLASSIFICATION	GEOLOGIC UNIT	PERCENT** GR	SA	FINES
PII-1	D-1	5-6	SP-SM	A_3	0	90	10
PII-1	D-3	15-16	SM	A_3	22	59	19
PII-1	D-5	25-26	SM	A_3	1	71	28
PII-1	S-6	30-31.5		T_{pw}	0	9	91
PII-2	D-3	15-16	SM	A_3	0	83	17
PII-2	S-4	20-21.5	SM	A_3	18	60	22
PII-2	D-5	25-26	SP-SM	A_3	29	60	11
PII-3	D-2	10-11	SM	A_3	2	66	33
PII-3	S-3	15-16.5	SM	A_3	0	75	25
PII-3	D-4	20-21	SP-SM	A_3	27	61	12
PII-3	S-5	25-26.5	SM	A_3	1	70	29
PII-3	D-6	30-31	SM	A_3	0	80	20
PII-3	S-7	35-36.5		T_{pw}	0	6	94
PII-4	D-3	15-16	SM	A_3	0	87	13
PII-4	S-4	20-21.5	SM	A_3	4	80	16
PII-4	D-5	25-26	SM	A_3	25	57	18
PII-4	D-7	35-36		T_{pw}	0	6	94
PII-5	D-1	5-6	CL-ML	A_4	0	47	53
PII-5	D-5	25-26	SM	A_3	2	81	17
PII-5	D-13	65-66		T_{pf}	0	17	83
PII-7	D-3	15-16	SM	A_3	0	83	17
PII-7	D-7	35-36		T_{pw}	0	18	82
PII-8	D-3	15-16	SM	A_3	1	86	13
PII-8	D-7	35-36		T_{pf}	0	39	61
PII-8D	D-3	15-16	SM	A_3	3	82	15
PII-8D	D-5	25-26		T_{pw}	0	62	38

* D - DRIVE SAMPLES
S - SPT SAMPLES

**GR - GRAVEL
SA - SAND
FINES - SILT AND CLAY

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TABLE B-3.

ATTERBERG LIMIT TEST RESULTS

Boring No.	Sample* No.	Depth (Feet)	USCS Class.	Geologic Unit	Liquid Limit	Plastic Limit	Plasticity Index
PII-1	D-17	85-86	-	Tpf	53	33	20
PII-2	D-1	5-6	CL	A_4	40	15	25
PII-2	D-13	65-66	-	Tpf	54	36	18
PII-3	S-7	35-36.5	CH	A4	56	25	31
PII-3	D-14	70-71	-	Tpf	49	31	18
PII-4	D-1	5-6	CL	A_4	46	16	30
PII-7	D-11	55-56	-	Tpf	55	31	24
PII-7	D-17	85-86	-	Tpf	50	29	21

*D-Drive Samples
S-SPT Samples

TABLE B-4.

SPECIFIC GRAVITY TEST RESULTS

Boring No.	Sample* No.	Depth (Feet)	USCS Classification	Geologic Unit	Specific Gravity
PII-2	D-5	25-26	SM	A_3	2.71
PII-2	D-17	85-86	--	Tpf	2.60
PII-5	D-3	15-16	SM	A_3	2.65
PII-7	D-11	35-36	--	Tpf	2.7

*D-Drive Samples

TABLE B-5.

UNCONFINED COMPRESSION TEST RESULTS

Boring No.	Sample* No.	Depth (Feet)	Geologic Unit	Unconfined Compressive Strength (KSF) Peak	Residual
PII-1	D-11	55-56	Tpf	1.9	0.9
PII-1	D-19	95-96	Tpf	8.0	1.9
PII-2	D-9	45-46	Tpf	0.6	0.5
PII-2	P-18	90-91	Tpf	19.7	0.6
PII-2	D-19	95-96	Tpf	0.5	0.3
PII-3	D-12	60-61	Tpf	8.5	0.1
PII-3	D-18	90-91	Tpf	7.8	0.2
PII-3	P-19	95-97.5	Tpf	9.5	2.1
PII-3	D-20	100-101	Tpf	7.0	0.2
PII-4	D-9	45-46	Tpf	9.0	1.7
PII-4	D-11	55-56	Tpf	7.9	1.9
PII-4	D-13	65-66	Tpf	12.0	0.2
PII-4	D-15	45-76	Tpf	8.7	1.3
PII-4	P-18	90-91	Tpf	9.5	0.1
PII-5	D-17	85-86	Tpf	4.3	2.4
PII-6	D-8	40-41	Tpw	2.3	1.1
PII-7	D-13	65-66	Tpf	10.1	0.5
PII-8	D-7	35-36	Tpf	2.8	1.9
PII-8	P-12	60-62.5	Tpf	5.3	0.9
PII-8	D-15	75-76	Tpf	5.3	1.1
PII-8	D-19	95-96	Tpf	4.0	0.4
PII-8D	D-7	35-36	Tpw	1.7	0.3
PII-8D	P-10	50-52.5	Tpf	14.6	2.4
PII-8D	P-16	80-82.5	Tpf	15.0	6.5

*D-Drive Samples
P-Thin Wall Tube (Pitcher) Samples

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TABLE B-6.

DIRECT SHEAR TEST RESULTS

Boring No.	Sample* No.	Depth (Feet)	USCS Class.	Geologic Unit	Applied Normal Stress (PSF)	Shear Stress (PSF) Peak	Shear Stress (PSF) Residual	Estimated Strength Parameters Cohesion (PSF)	Estimated Strength Parameters Friction Angle (Deg)
PII-1	D-7	35-36		T_{pw}	2,100 4,200 8,400	1,968 3,156 5,030	1,843 3,093 5,030	1,031	26
PII-1	D-13	65-66		Tpf	4,000 8,000 16,000	3,593 6,936 11,748	3,437 6,593 11,529	1,093	34
PII-2	D-3	15-16	SM	A_3	1,000 2,000 4,000	1,218 2,000 3,499	1,156 1,937 3,437	469	37
PII-2	D-13	65-66		Tpf	4,000 8,000 16,000	4,449 10,373 13,123	4,343 10,342 12,873	3,093	34
PII-2	D-15	75-76		Tpf	4,000 8,000 12,000	3,036 6,047 7,020	3,036 5,582 6,977	1,384	26
PII-3	D-2	10-11	SM	A_3	750 1,500 3,000	1,187 1,625 2,968	970 1,533 2,847	516	39
PII-3	D-6	30-31	SM	A_3	2,000 4,000 6,000	1,718 3,374 7,092	1,689 3,285 6,883	0	41
PII-3	D-10	50-51		Tpf	3,000 6,000 12,000	4,421 6,055 8,819	3,361 4,818 7,574	3,039	26
PII-3	D-14	70-71		Tpf	4,000 8,000 16,000	4,155 8,342 10,717	3,968 8,061 10,686	2,968	27
PII-4	D-3	15-16	SM	A_3	1,000 2,000 4,000	1,031 1,593 2,937	1,001 1,533 2,878	359	33

*D-Drive Samples

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TABLE B-6.

DIRECT SHEAR TEST RESULTS

Boring No.	Sample* No.	Depth (Feet)	USCS Class.	Geologic Unit	Applied Normal Stress (PSF)	Shear Stress (PSF) Peak	Shear Stress (PSF) Residual	Estimated Strength Parameters Cohesion (PSF)	Estimated Strength Parameters Friction Angle (Deg)
PII-4	D-5	25-26	SM	A_3	1,500	2,130	743	231	51
					3,000	3,810	3,216		
					6,000	8,213	6,772		
PII-5	D-1	5-6	CL-ML	A_4	300	319	298	165	25
					600	420	420		
					1,200	728	728		
PII-5	D-9	45-46	--	Tpf	2,750	3,485	2,262	1,423	33
					5,500	4,624	4,442		
					11,000	8,748	8,447		
PII-7	D-3	15-16	SM	A_3	900	420	415	0	36.0
					1,800	1,224	968		
					3,600	2,612	1,857		
PII-7	D-7	35-36	--	Tpw	2,000	2,620	1,772	1,686	22
					4,000	3,172	2,618		
					8,000	5,040	4,497		
PII-7	D-17	85-86	--	Tpf	5,000	6,653	6,240	4,277	30
					10,000	11,162	9,696		
					16,000	13,197	10,875		
PII-8	D-7	35-36	--	Tpf	2,000	2,716	1,746	1,063	35
					4,000	3,455	2,421		
					8,000	6,761	4,736		
PII-8	D-17	85-86	--	Tpf	4,000	4,637	3,378	2,225	35
					8,000	8,403	6,485		
					12,000	10,138	8,214		
PII-8D	D-5	25-26	--	Tpw	1,500	1,362	995	511	32
					3,000	2,559	2,139		
					6,000	4,261	3,639		

*D-Drive Samples

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TABLE B-7. PERMEABILITY TEST RESULTS

Boring No.	Sample* No.	Depth (feet)	USCS Classification	Geologic Unit	Permeability (cm/sec)
PII-1	D-5	25 - 26	SM	A_3	8.1×10^{-6}
PII-4	D-7	35 - 36	--	T_{pw}	3.2×10^{-8}
PII-5	D-5	25 - 26	SM	A_3	6.8×10^{-6}
PII-5	D-13	65 - 66	--	T_{pf}	2.0×10^{-7}
PII-8	D-3	15 - 16	SM	A_3	1.3×10^{-4}

* D = Drive Samples

TABLE B-8. ENGINEERING PROPERTIES OF ALL GEOLOGIC UNITS - SUMMARY OF LABORATORY TEST RESULTS

GEOLOGIC MATERIAL	GEOLOGIC UNIT	USCS SOIL CLASSIFICATION	SHEAR STRENGTH PARAMETERS: FRICTION ANGLE (degrees)			SHEAR STRENGTH PARAMETERS: COHESION (ksf)			UNCONFINED COMPRESSIVE STRENGTH (ksf)			DRY DENSITY (pcf)			MOISTURE CONTENT %			PERMEABILITY (cm/s)			CALCULATED VOID RATIO			YOUNG'S MODULUS (ksf)		
			RANGE	MEAN	S.D*	RANGE	MEAN	S.D*	RANGE	MEAN	S.D*	RANGE	MEAN	S.D*	RANGE	MEAN	S.D*	RANGE	MEAN	S.D.*	RANGE	MEAN	S.D.*	RANGE	MEAN	S.D.*
OLD ALLUVIUM (Granular)	A3	SM, SP-SM, SM/ML	32.3-50.7	38.3	6.7	0.2-0.5	0.4	0.1	-	-	-	90.7-112.5	101.1	6.7	11.0-27.8	19.8	2.6	$6.8x10^{-6}$ $1.3x10^{-4}$	$5x10^{-6}$	$3.5x10^{-6}$	0.49-0.84	0.66	0.11	1371	1371	--
OLD ALLUVIUM (Fine grained)	A4	CL, ML, SC, CL-ML, CH	24.8	24.8	-	0.17	0.17	-	-	-	-	89.7-104.5	99.4	6.9	17.5-25.0	20.7	2.6	-	-	-	0.6-0.86	0.69	0.12	--	--	--
PUENTE FORMATION	T_{pw}, T_{pf}	--	22.4-34.8	29.8	4.3	1.0-4.3	2.1	1.0	0.5-19.7	7.3	4.7	73.6-94.5	83.1	5.1	28.0-47.5	35.7	2.2	$3.2x10^{-8}$ $2.0x10^{-7}$	$1.2x10^{-7}$		0.75-1.25	1.0	0.12	1120-5600	3117	2041

*S.D. - Standard Deviation

**Young's Modulus obtained from triaxial test results.

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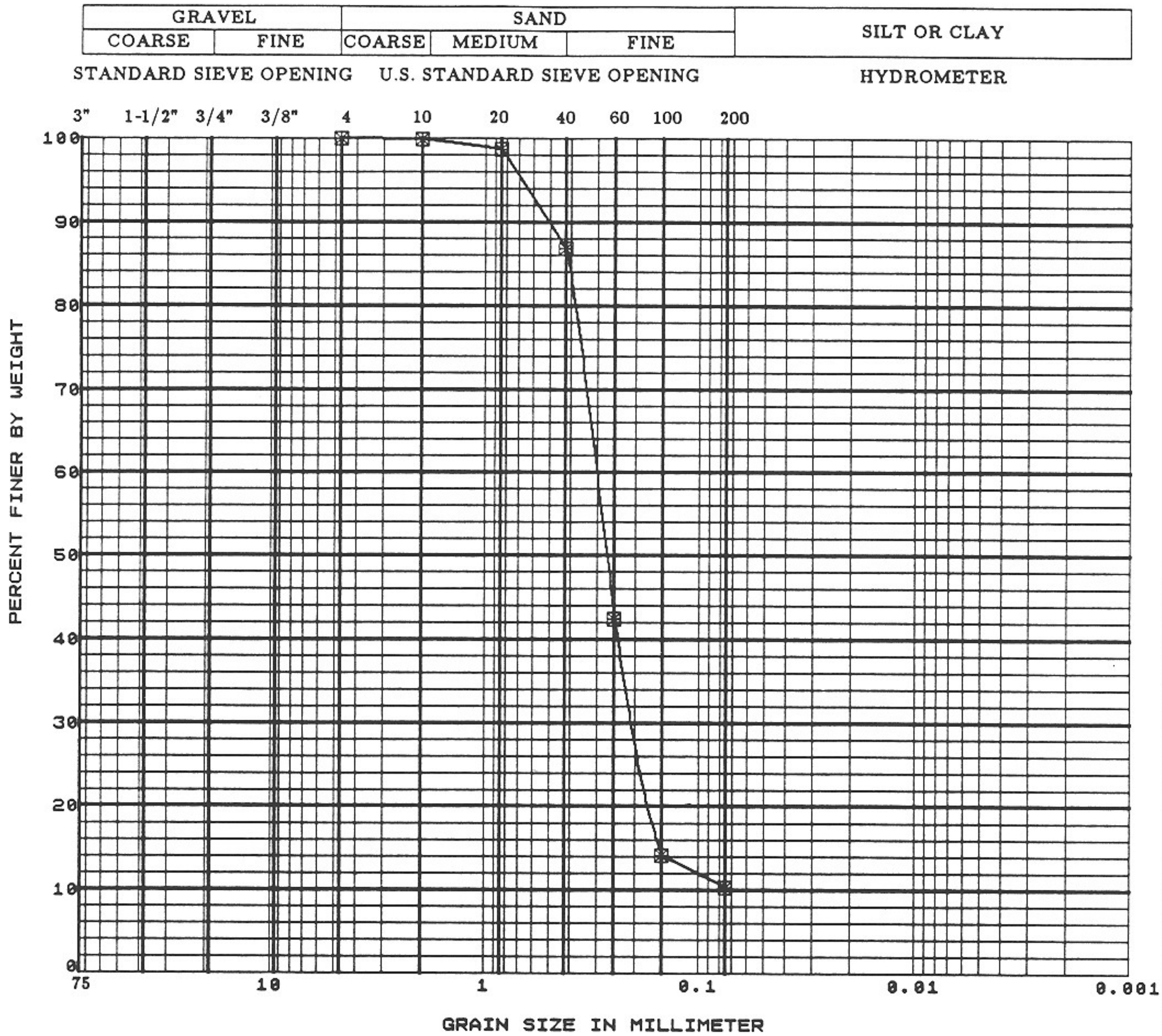

SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-1	D-1	5.1	DRIVE	SP-SM			

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GRAIN SIZE DISTRIBUTION CURVE

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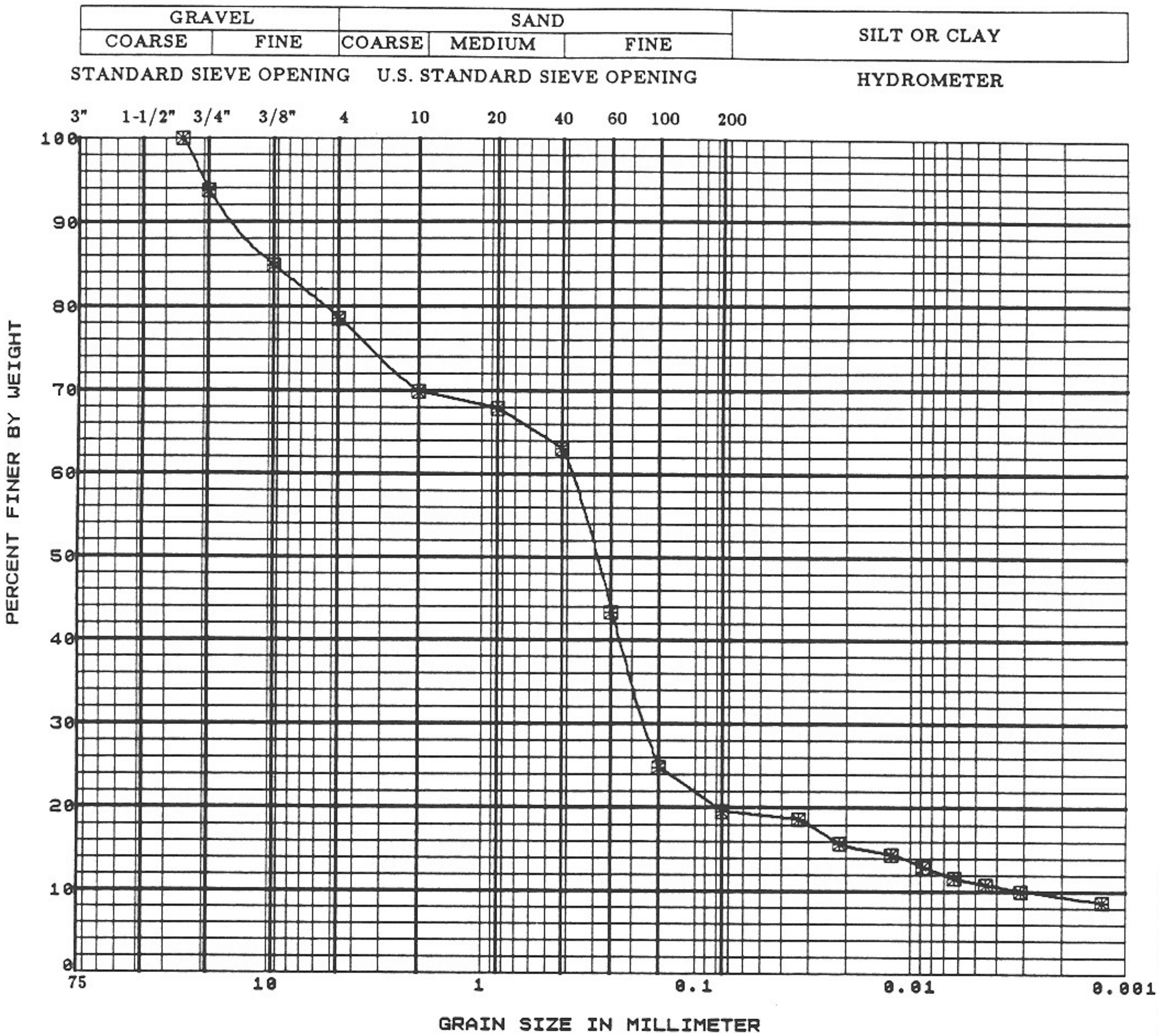
FIGURE B-1



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-1	D-3	14.8	DRIVE	SM			

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FIGURE B-2

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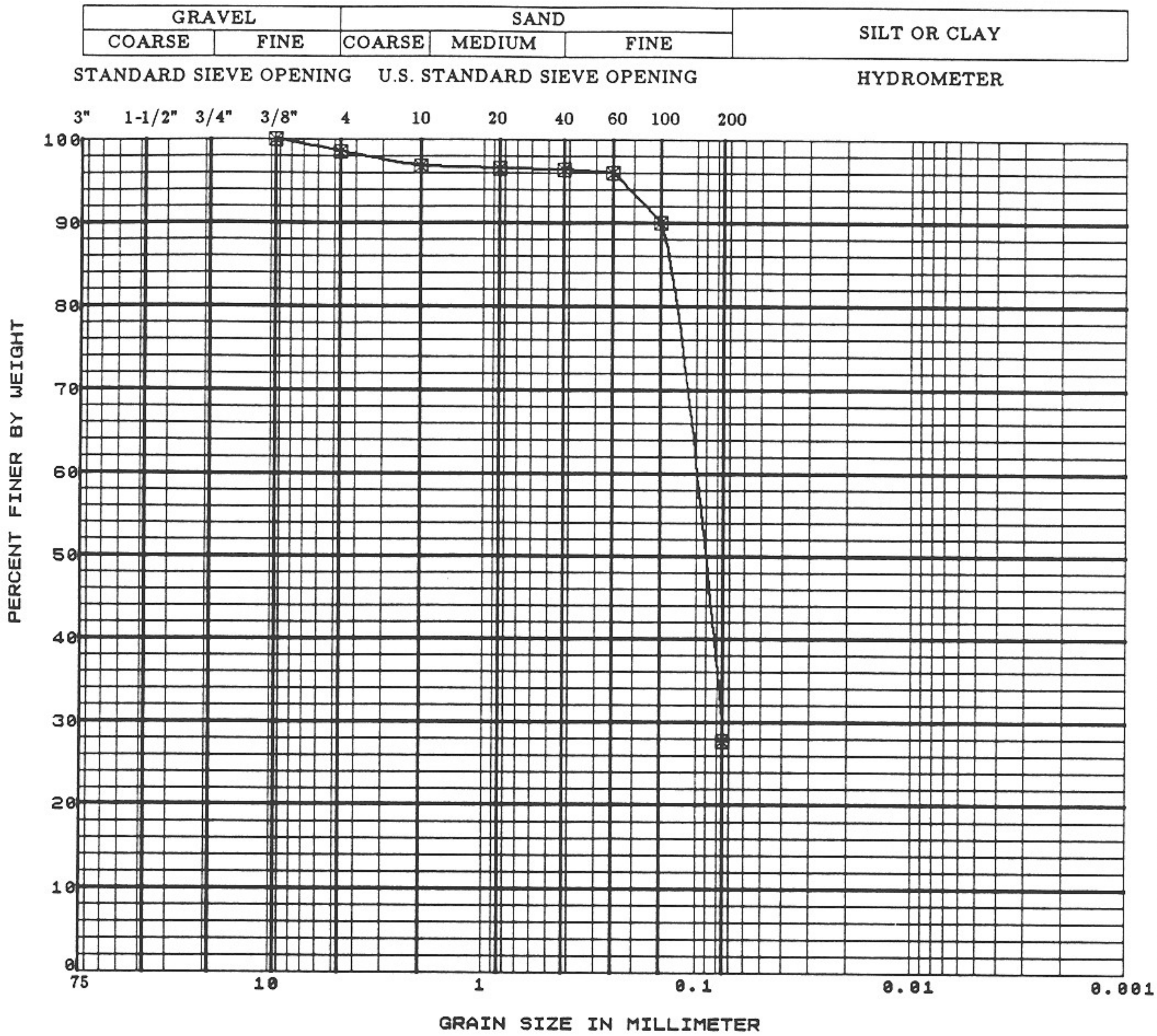

SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-1	D-5	24.7	DRIVE	SM			

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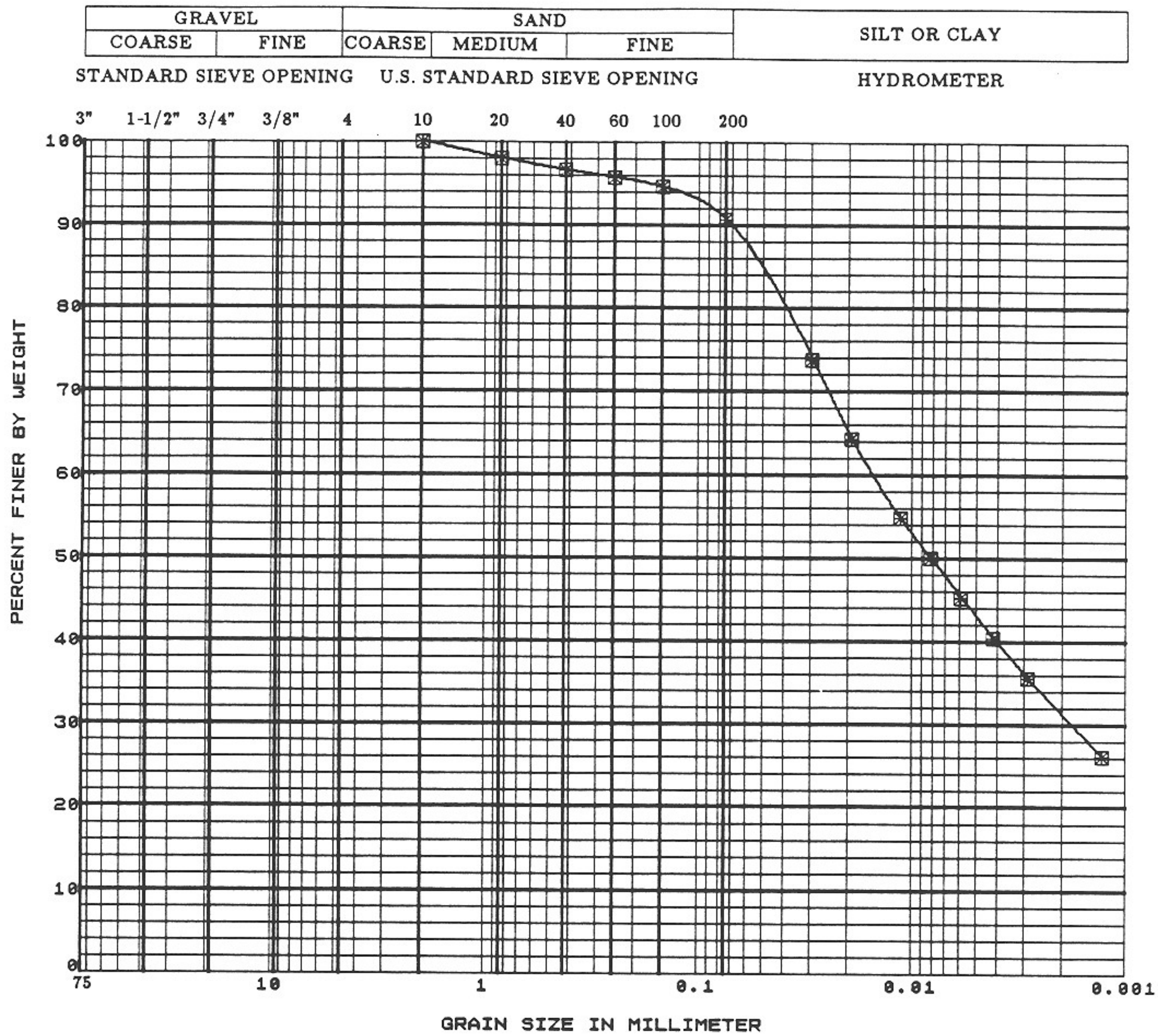
FIGURE B-3

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-1	S - 6	29.5	SPT				

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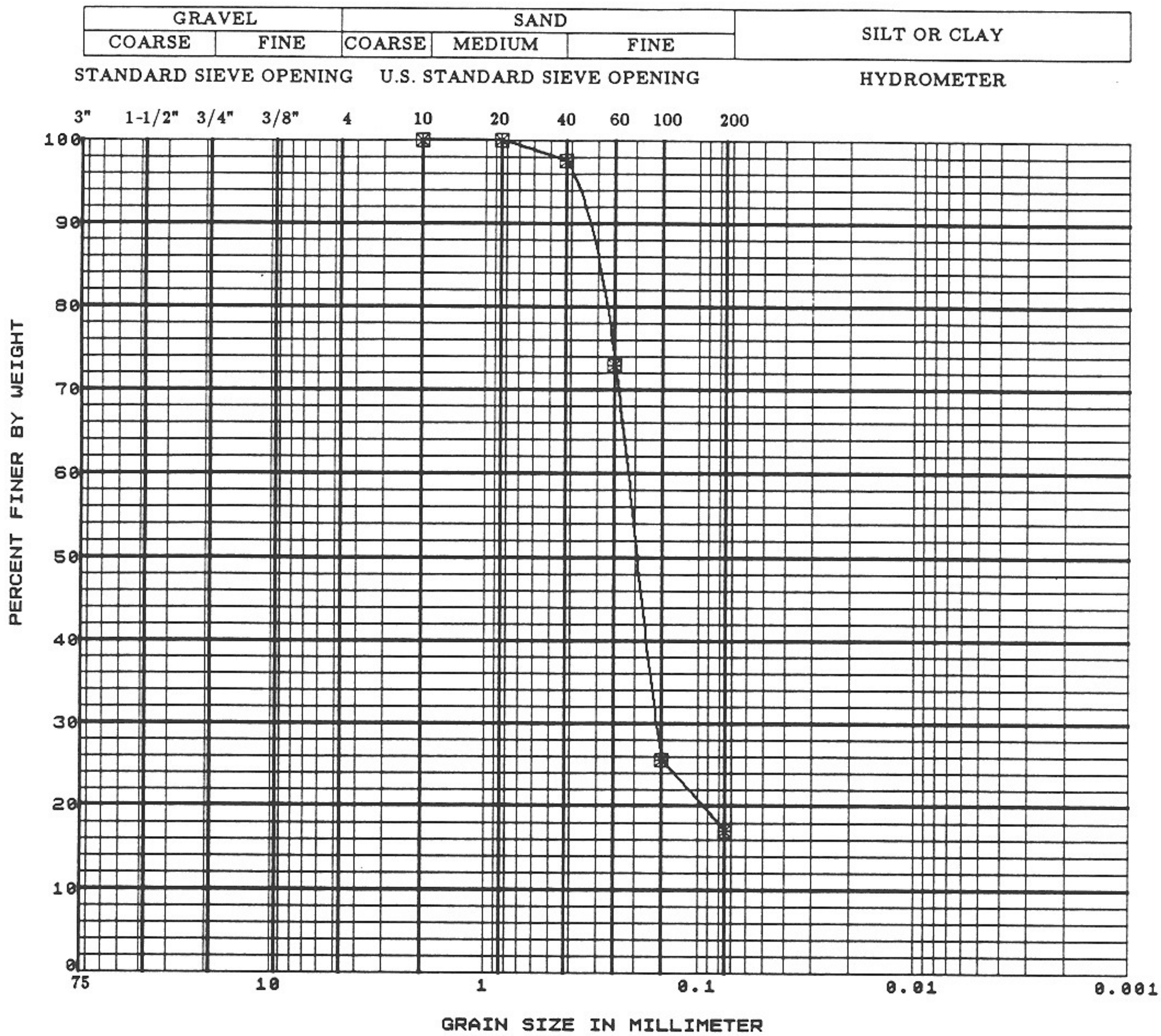
FIGURE B-4



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-2	D-3	14.9	DRIVE	SM			

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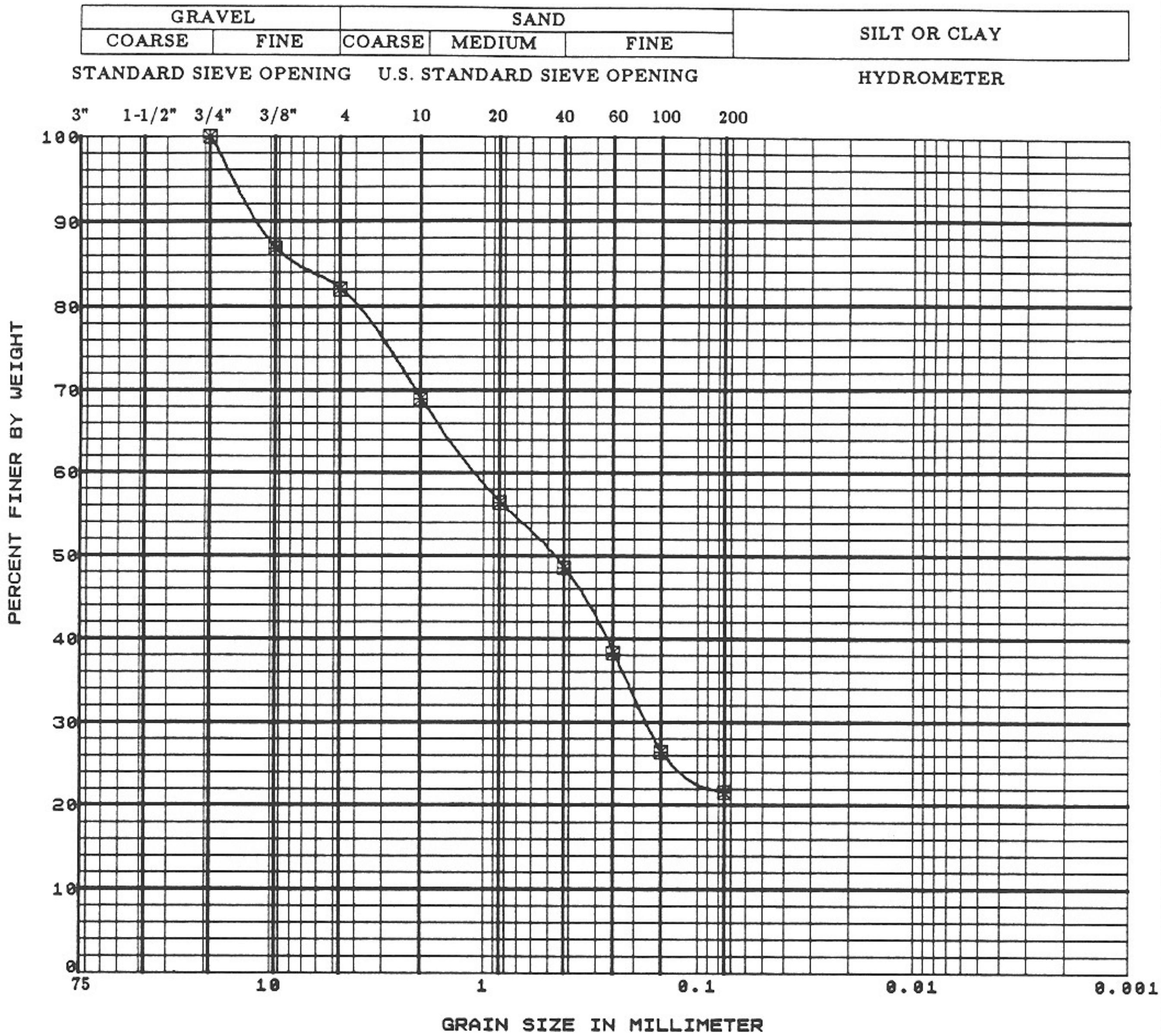
FIGURE B-5

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-2	S - 4	19.9	SPT	SM			

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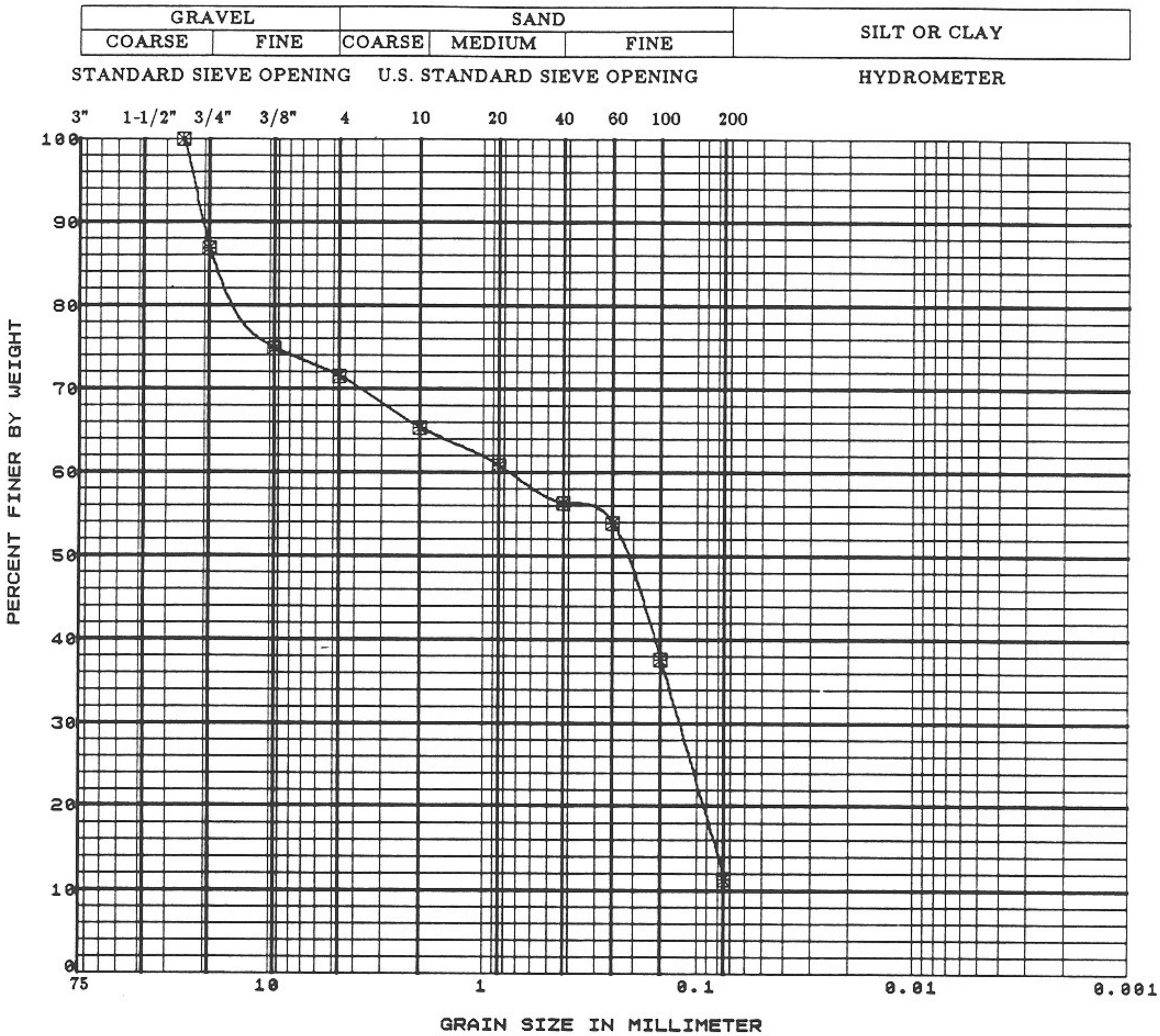
FIGURE B-6

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-2	D-5	24.6	DRIVE	SP-SM			

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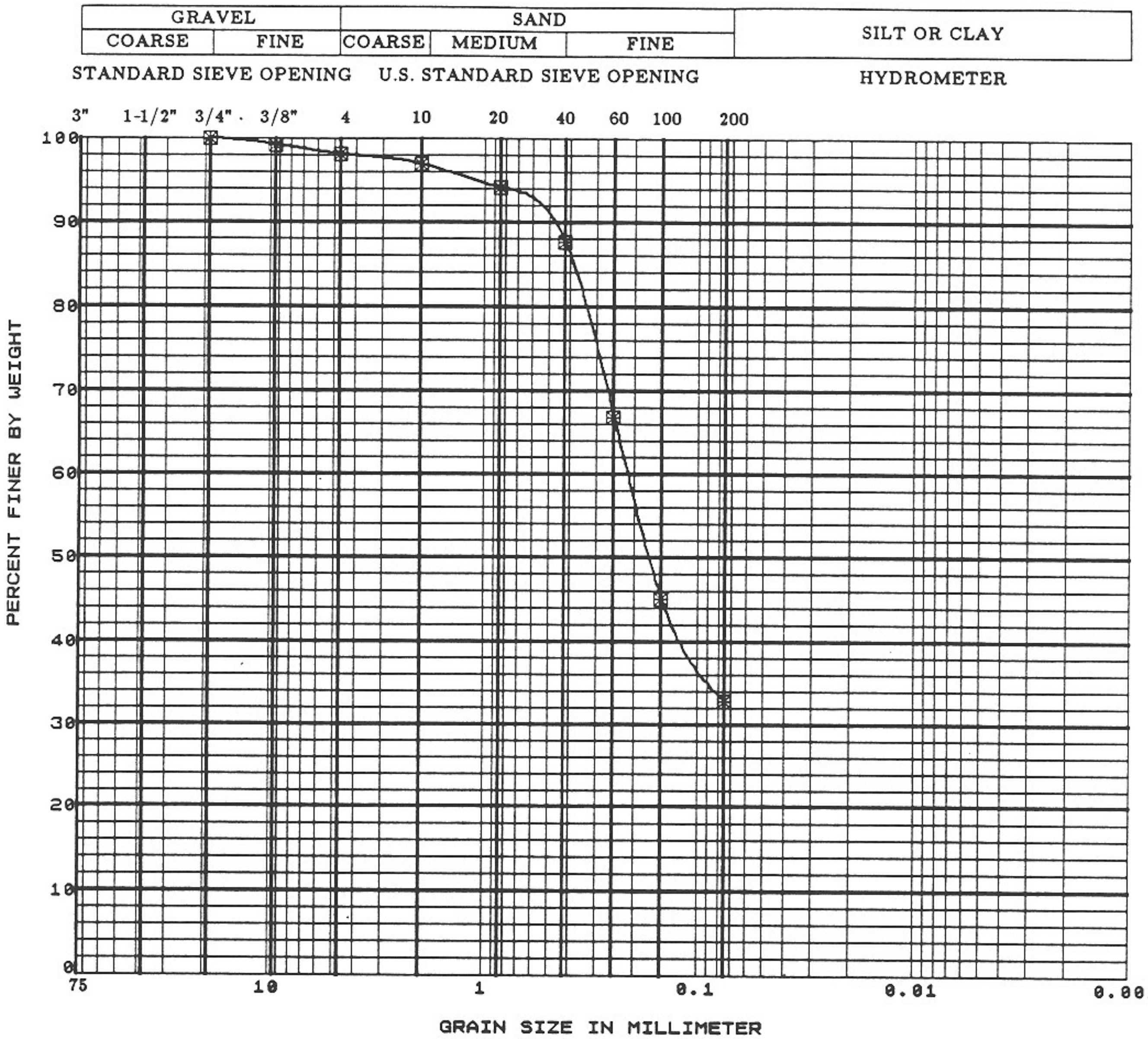
FIGURE B-7



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-3	D-2	9.9	DRIVE	SM			

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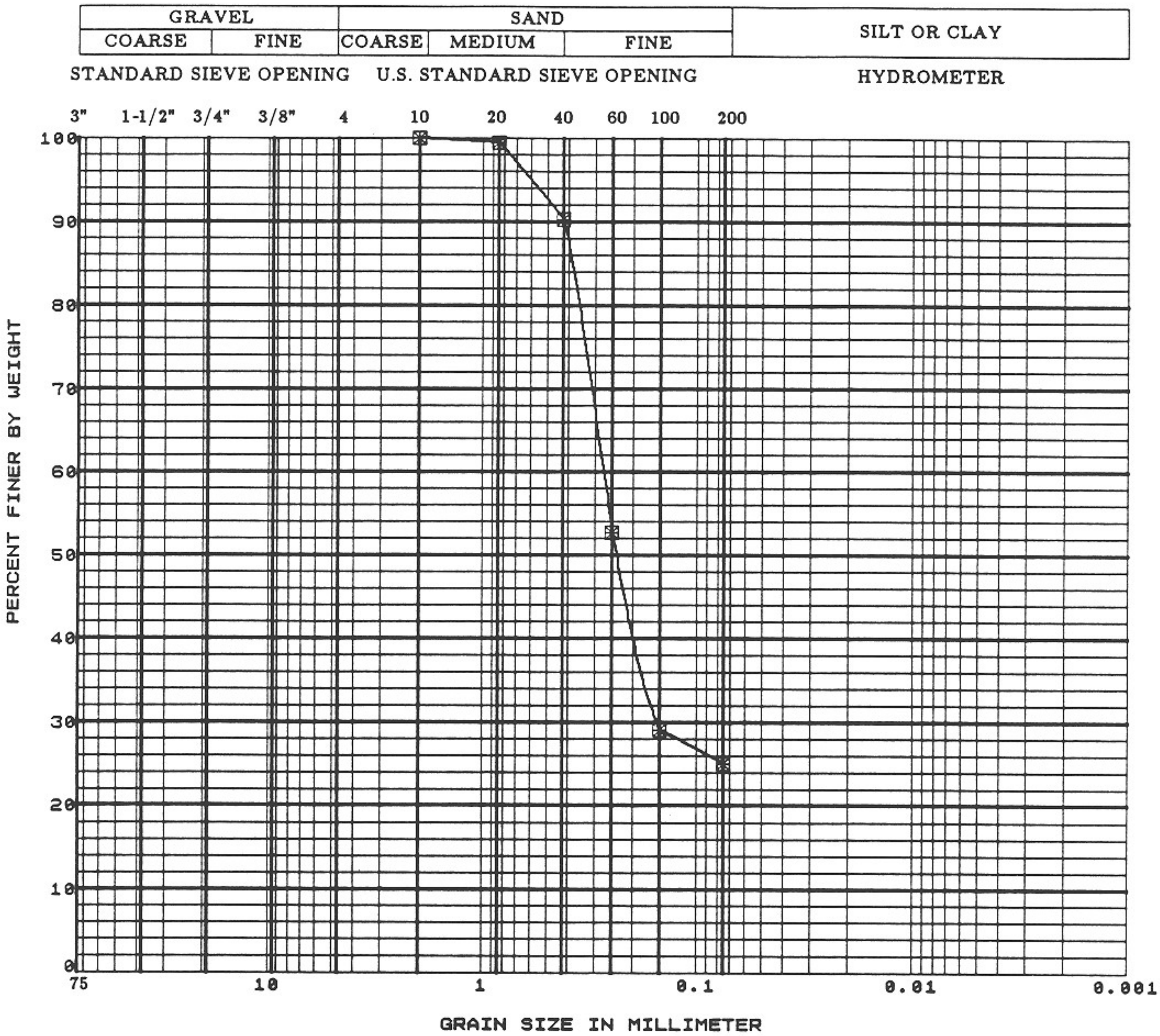
FIGURE B-8

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-3	S - 3	15.1	SPT	SP			

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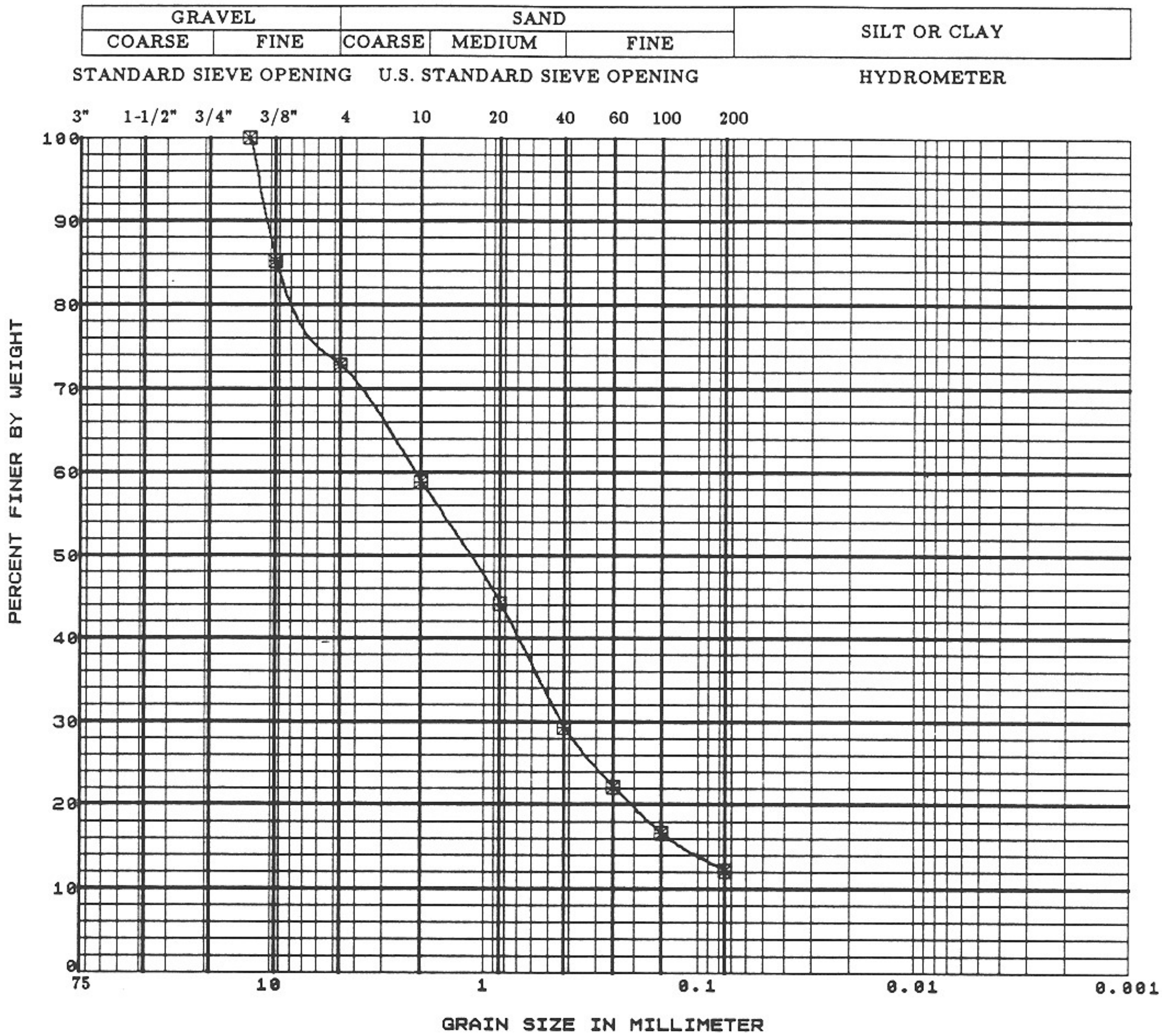
FIGURE B-9

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-3	D-4	20.0	DRIVE	SP-SM			

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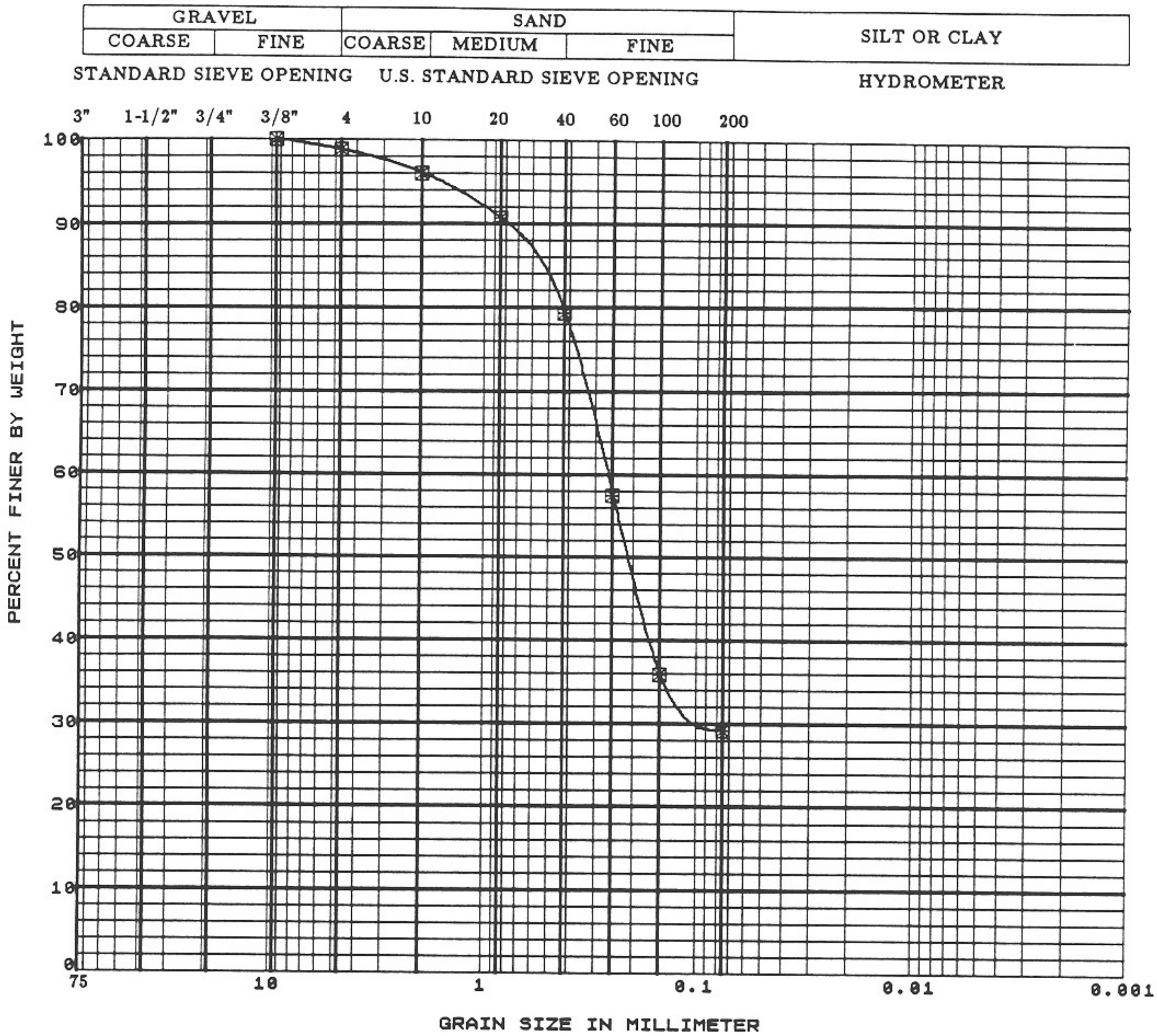
FIGURE B-10

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-3	S - 5	24.8	SPT	SM			

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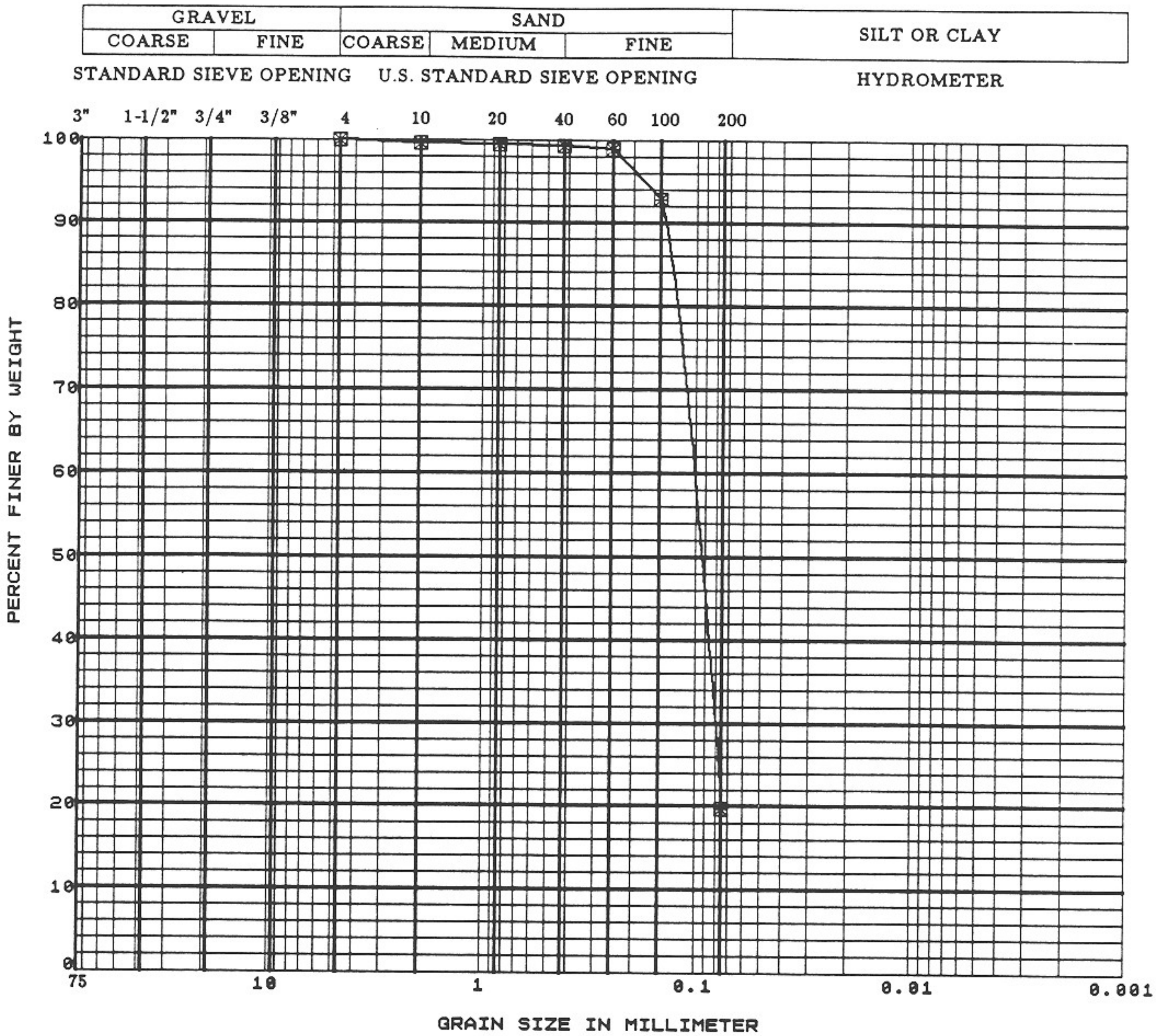
FIGURE B-11

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-3	D-6	29.8	DRIVE	SM			

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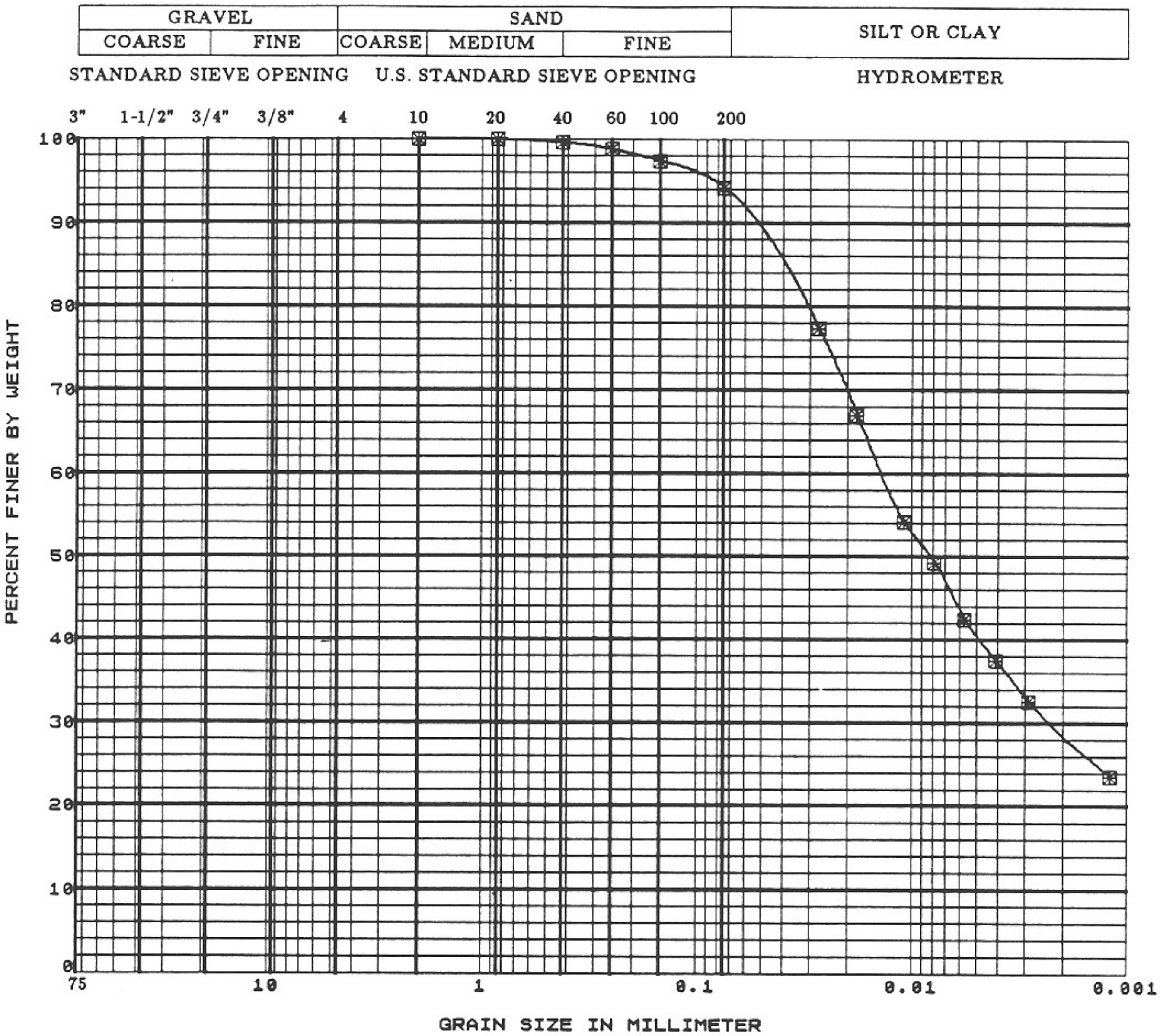
FIGURE B-12

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-3	S - 7	35.2	SPT		56	25	31

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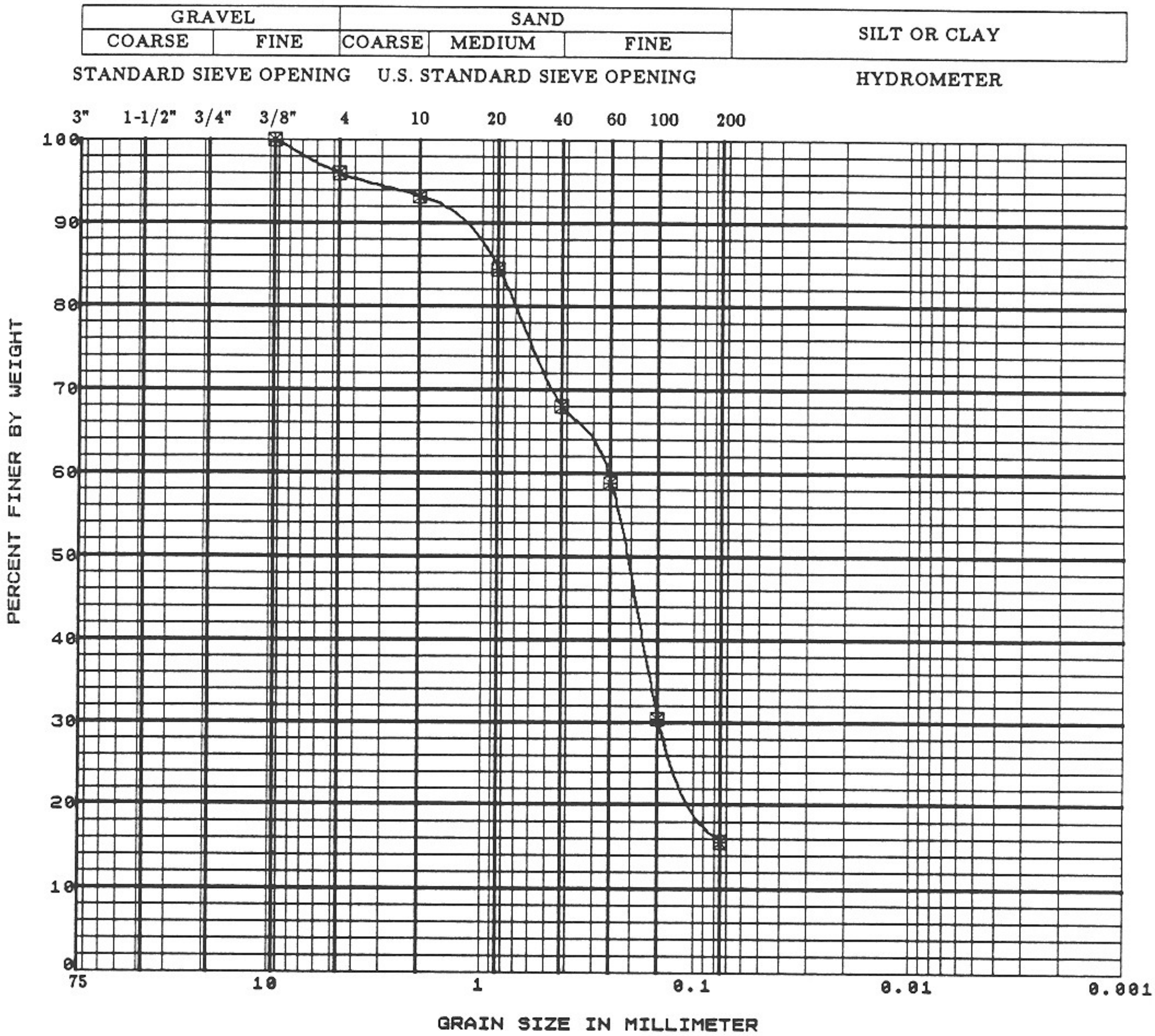
FIGURE B-13



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-4	S - 4	20.0	SPT	SM			

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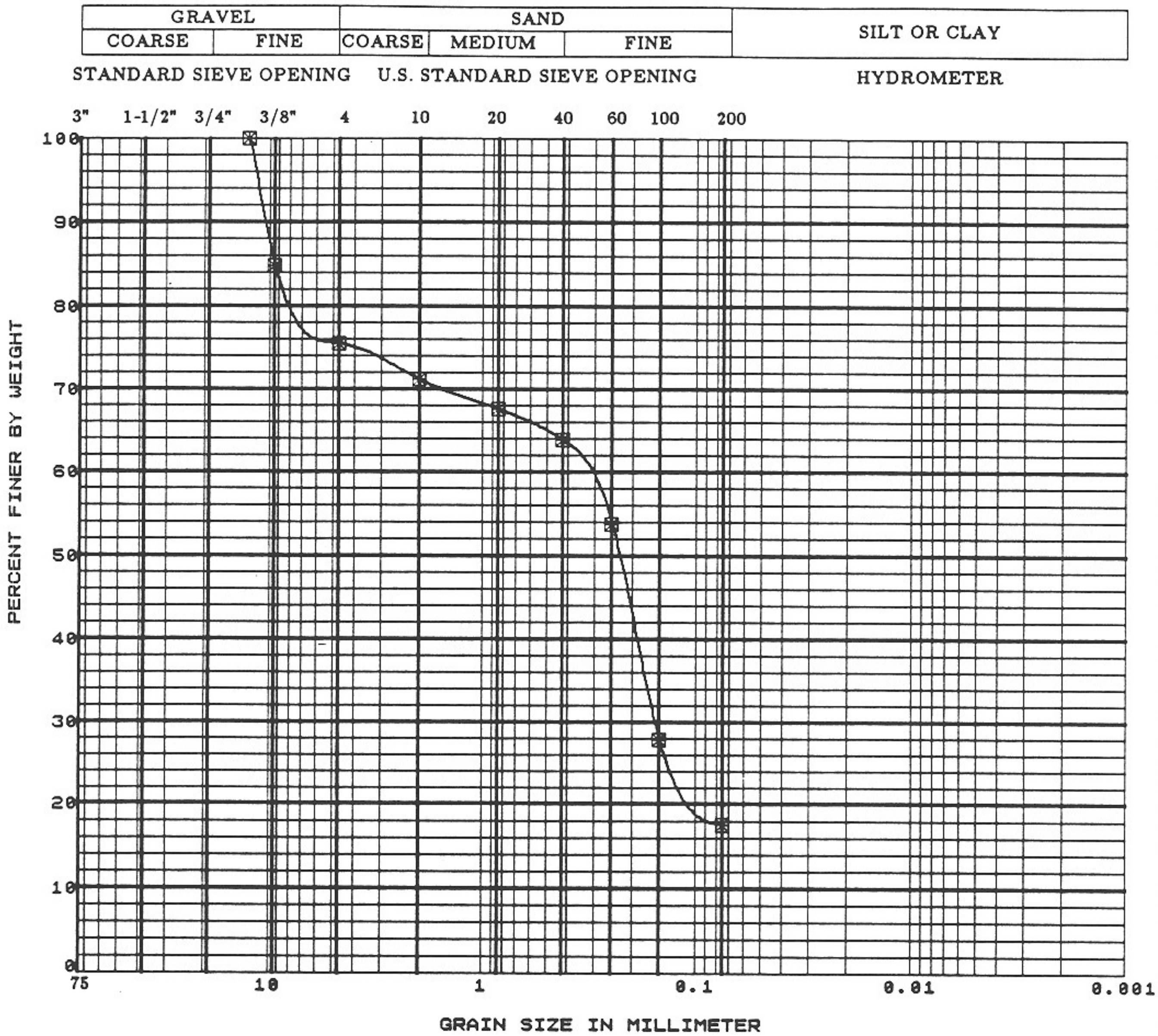
FIGURE B-15



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-4	D-5	24.8	DRIVE	SM			

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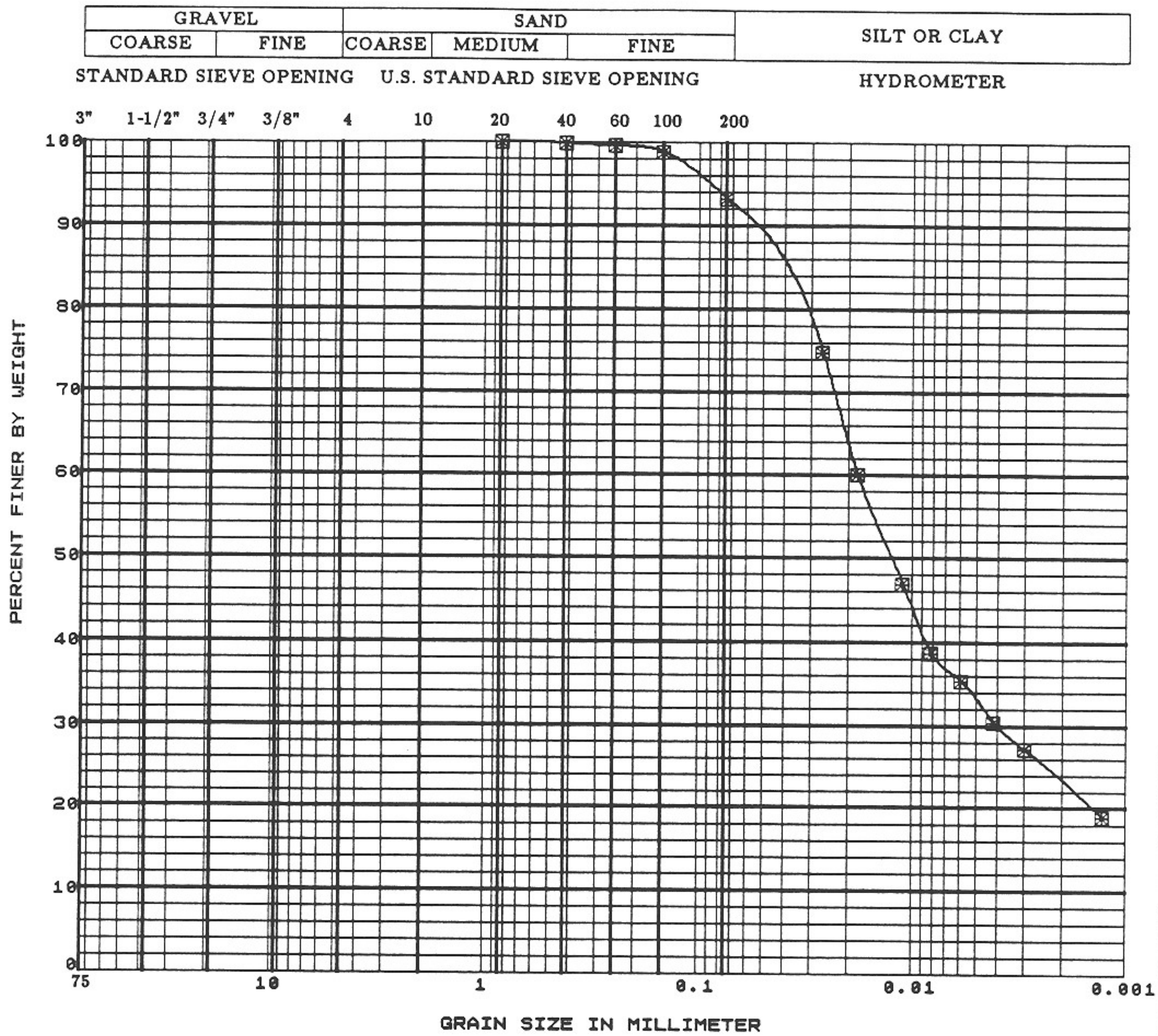
FIGURE B-16



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-4	D-7	34.9	DRIVE				

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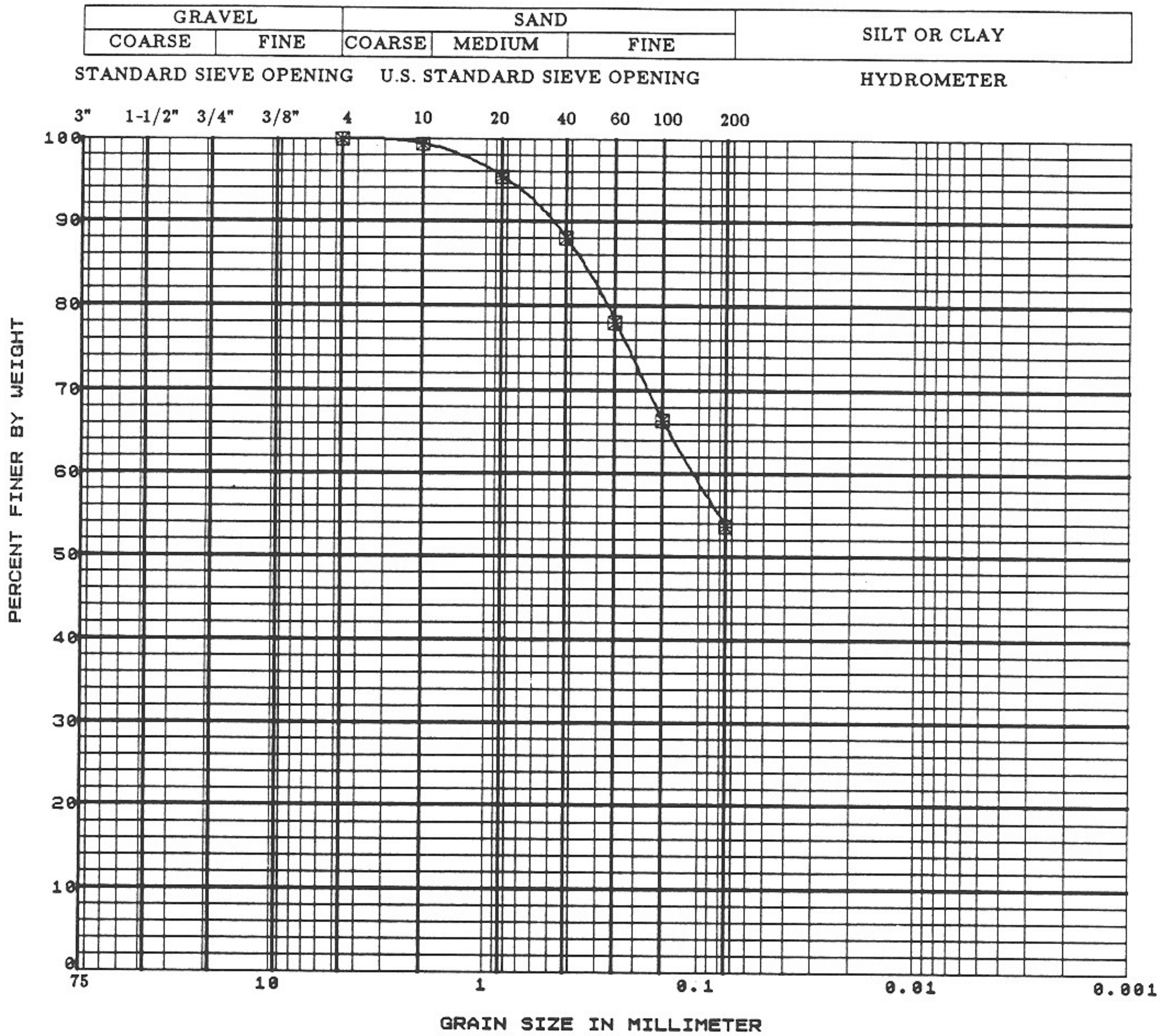
FIGURE B-17

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-5	D-1	4.8	DRIVE	CL/ML			

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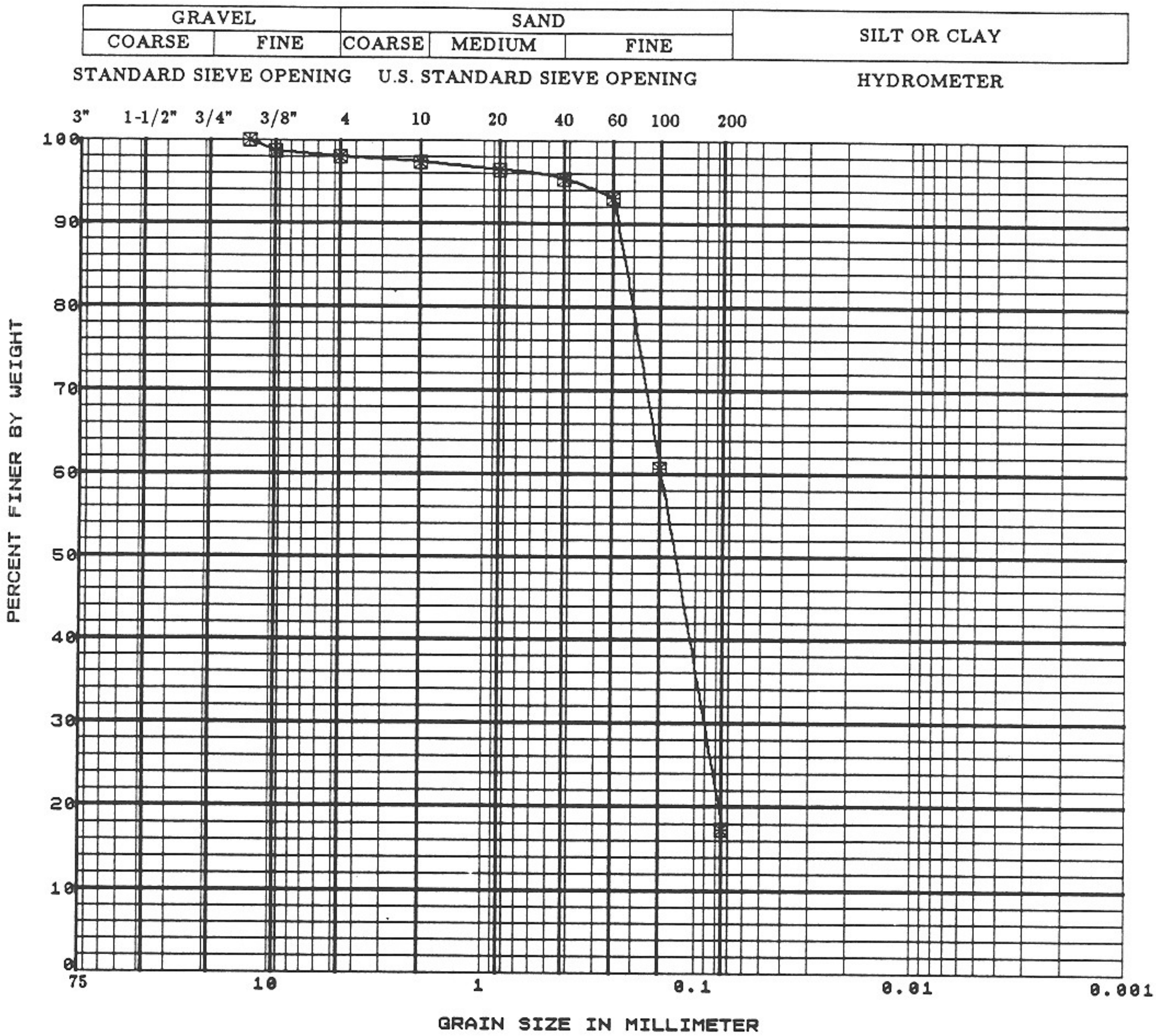
FIGURE B-18

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-5	D-5	24.7	DRIVE	SM			

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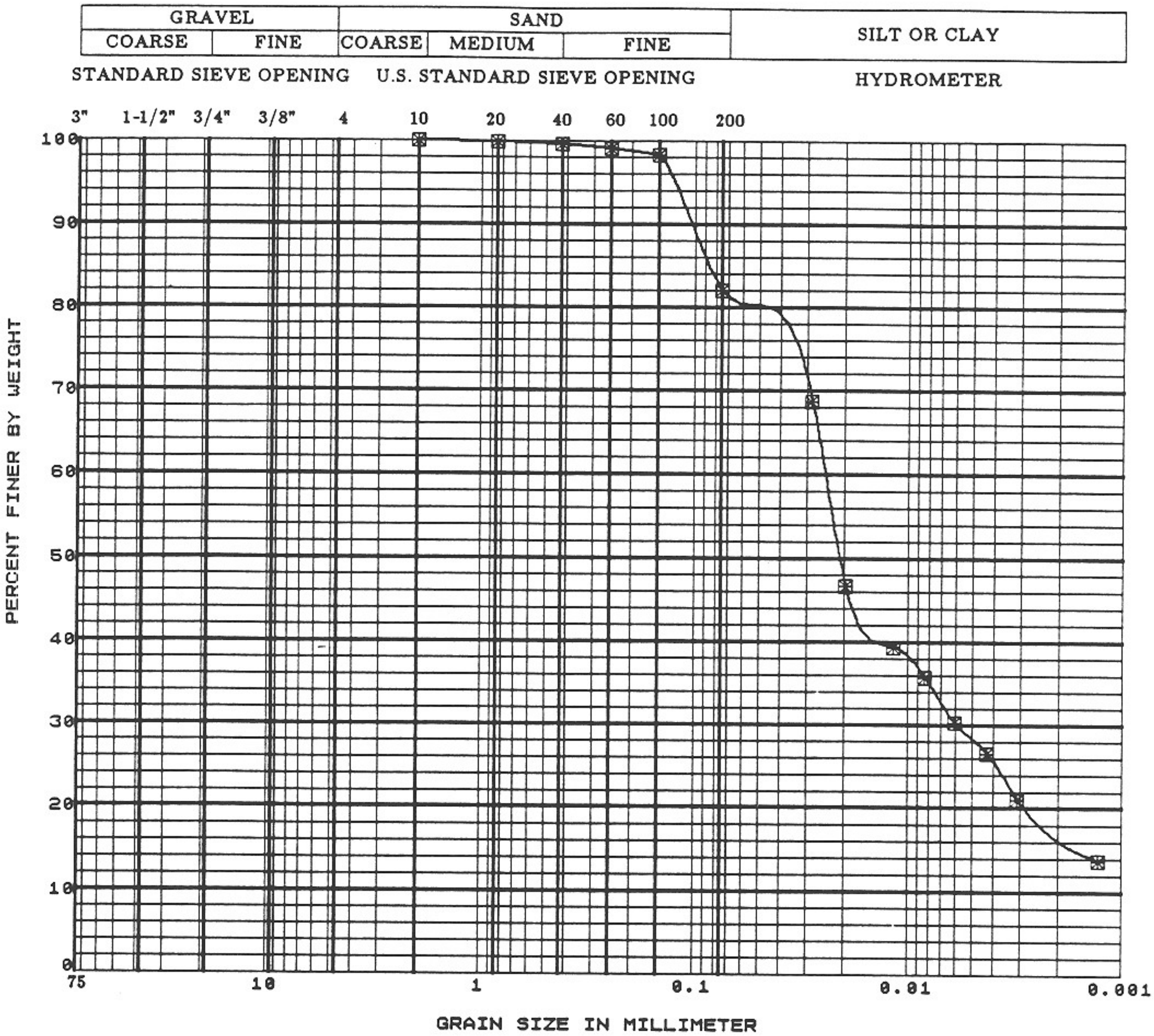
FIGURE B-19

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-5	D-13	64.8	DRIVE				

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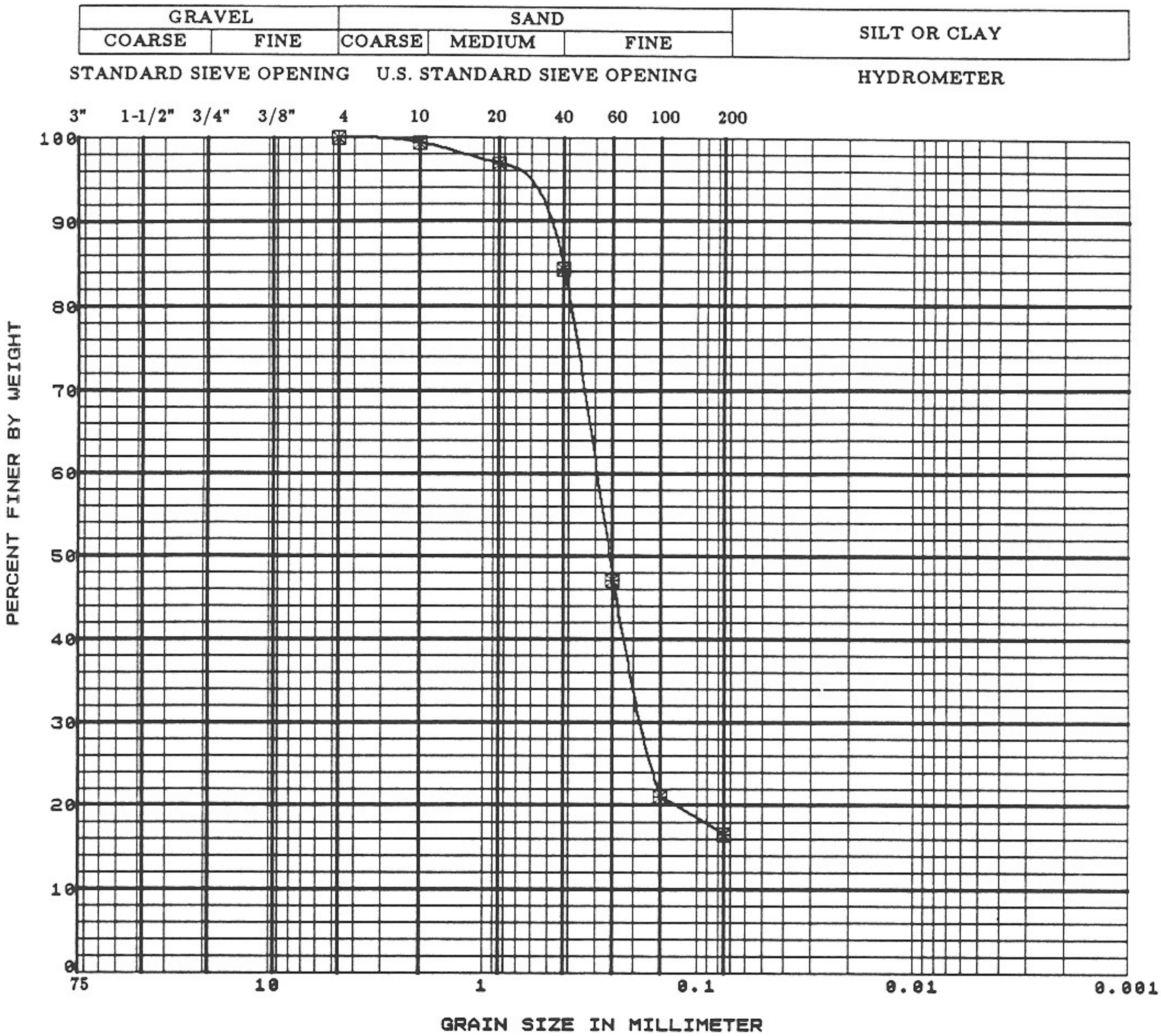
FIGURE B-20

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-7	D-3	14.9	DRIVE	SM			

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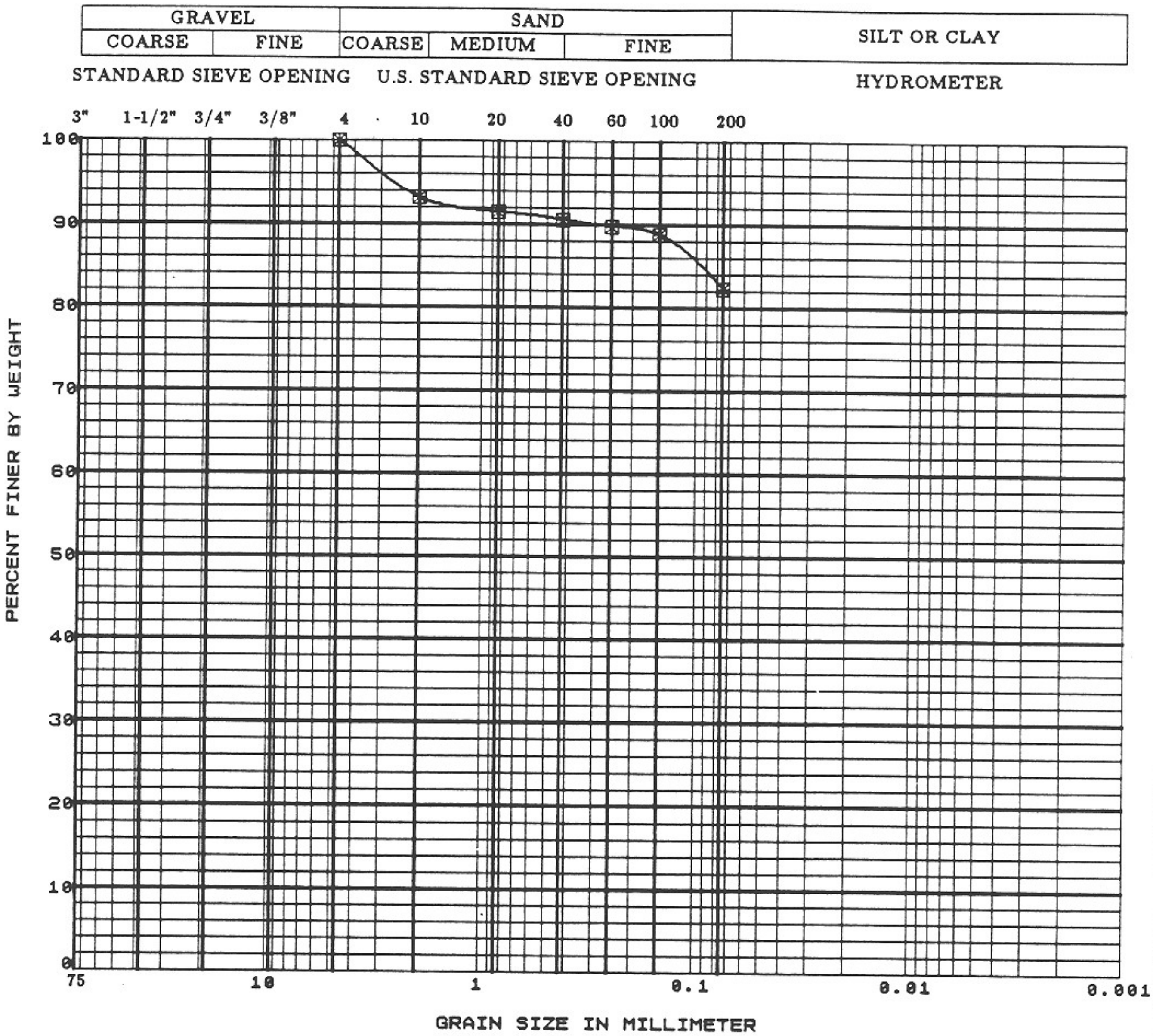
FIGURE B-21

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-7	D-7	34.5	DRIVE				

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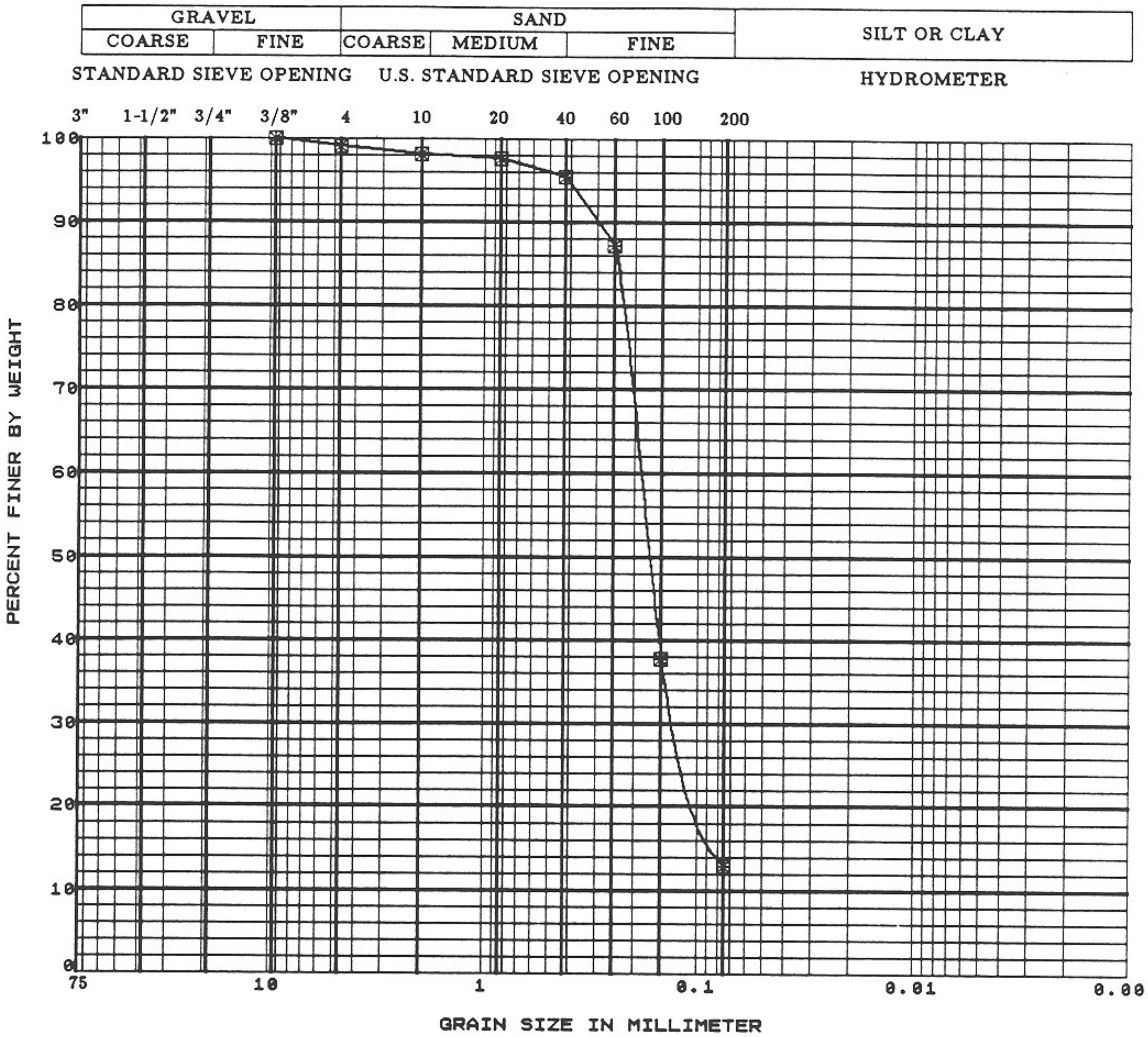
FIGURE B-22

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-8	D-3	15.0	DRIVE	SM			

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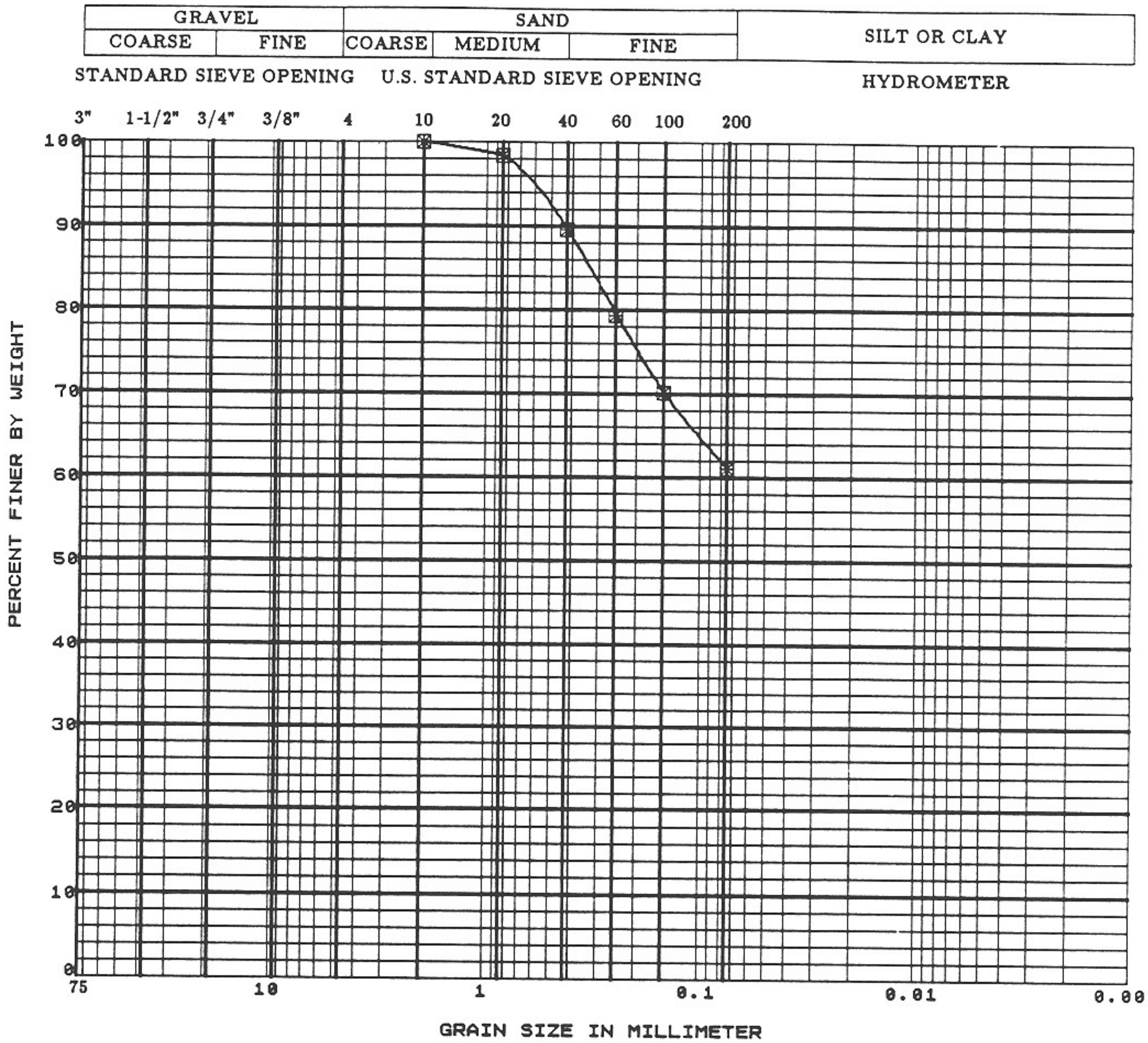
FIGURE B-23



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-8	D-7	35.0	DRIVE				

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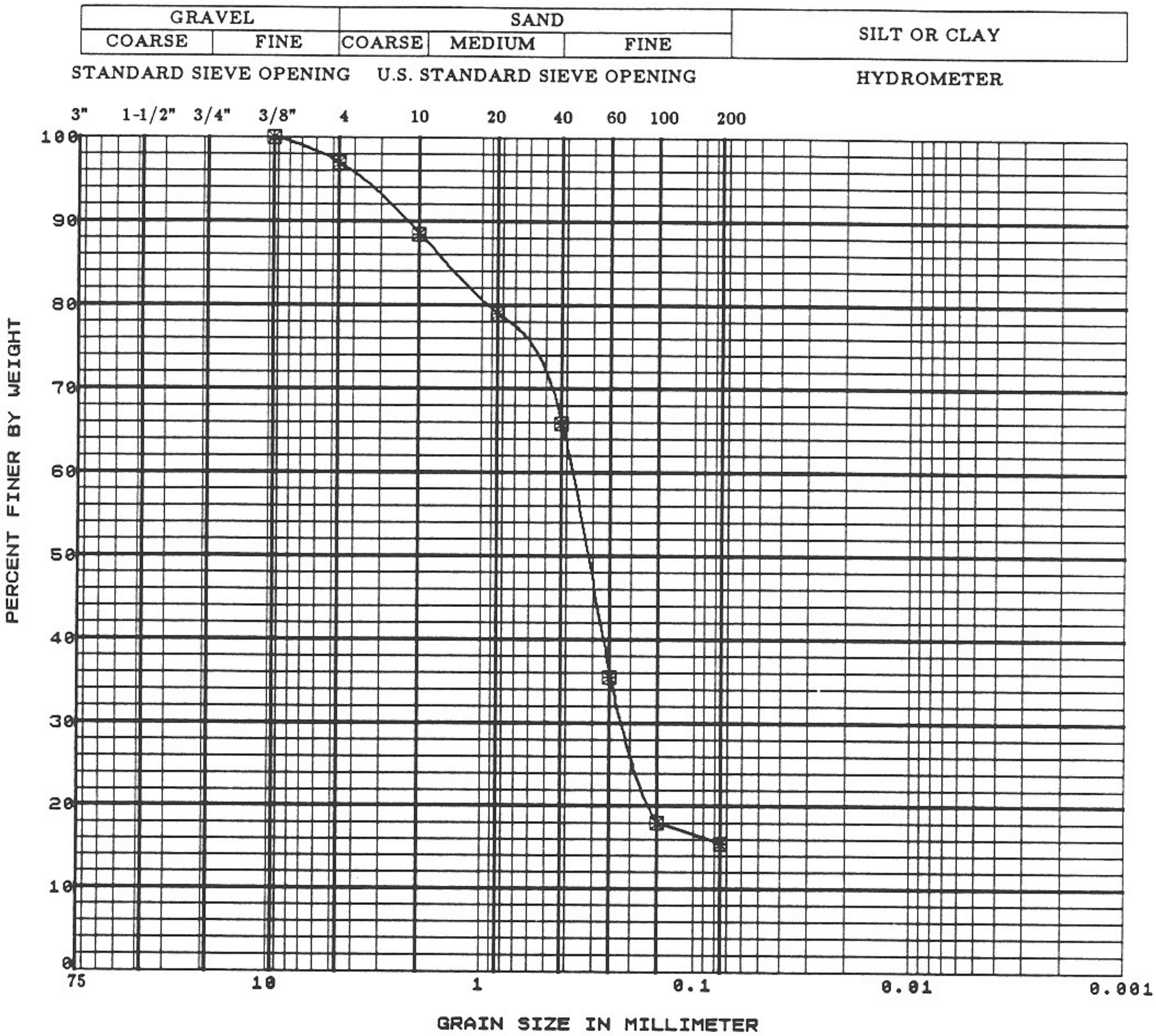
FIGURE B-24



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-8D	D-3	14.8	DRIVE	SM			

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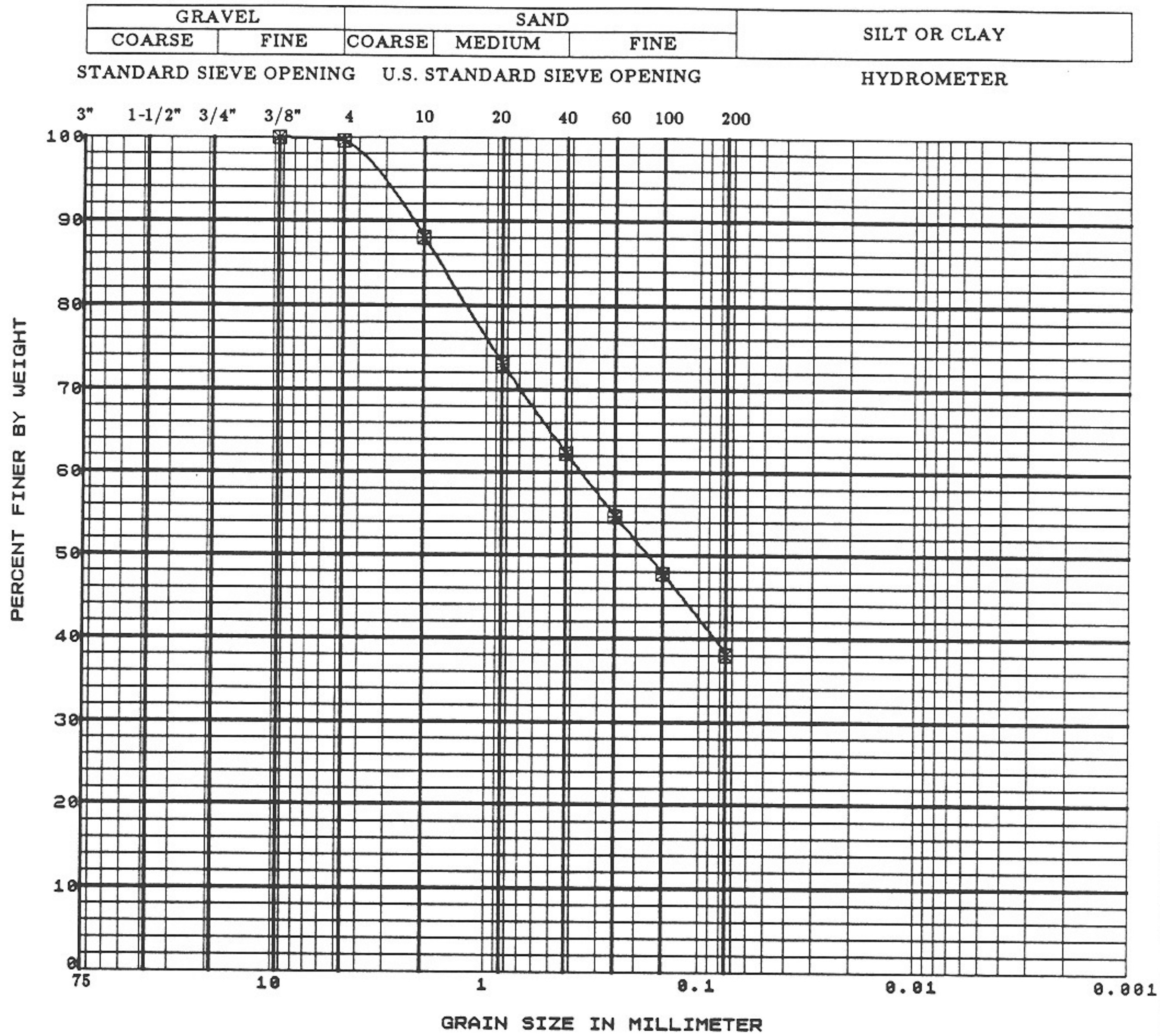
FIGURE B-25

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
⊠	PII-8D	D-5	25.1	DRIVE				

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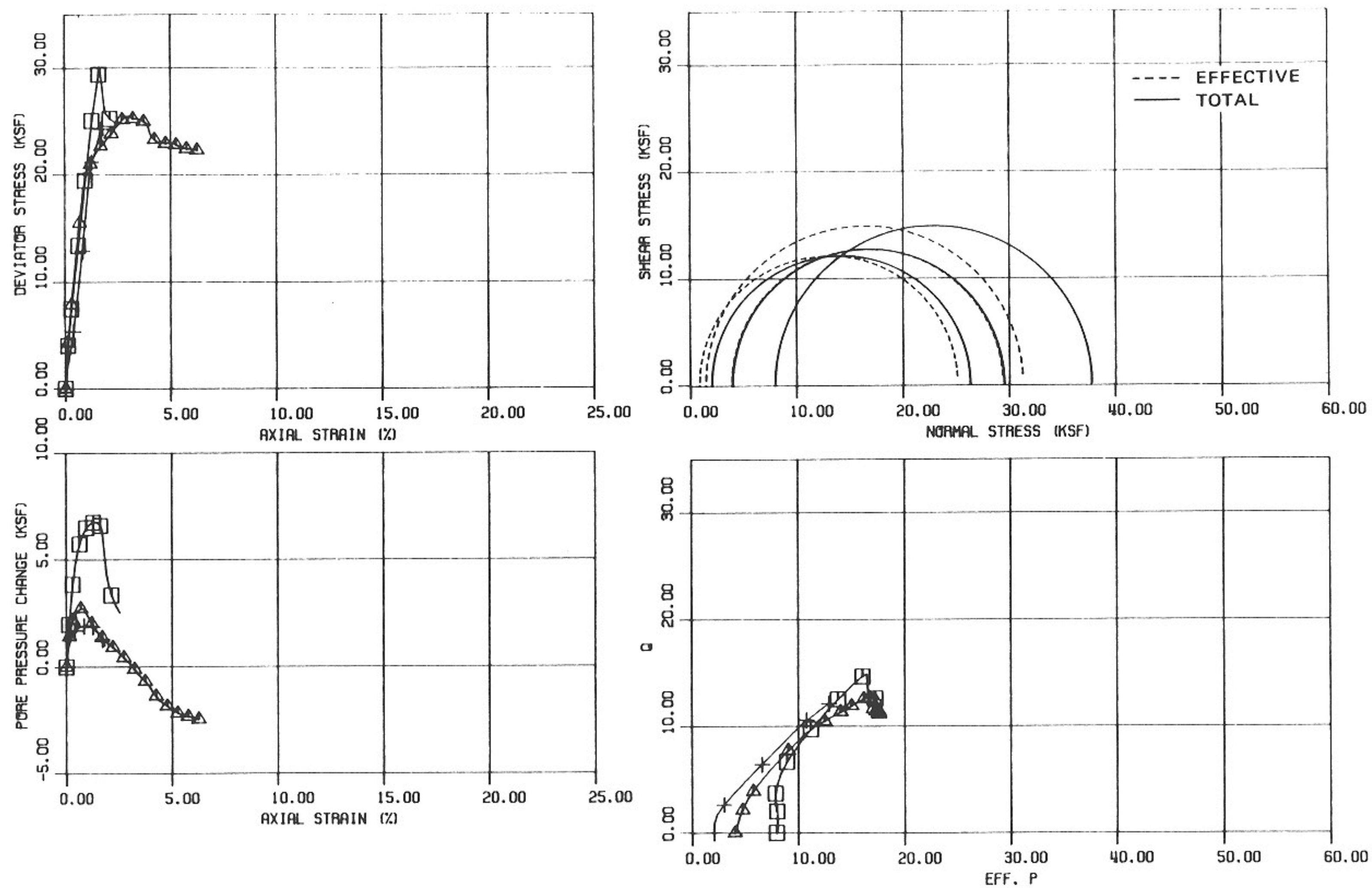
FIGURE B-26

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	TEST TYPE	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	EFF. CONF. PRESSURE (KSF)	MAX DEV. STRESS (KSF)	STRAIN RATE (%/HR)	BACK PRESSURE (KSF)
□	PII-1	P-18	90-92.5	PITCHER		CU	80.6	41.9	7.9	29.8	6.000	7.5
▲	PII-1	P-18	90-92.5	PITCHER		CU	80.6	41.9	4.0	25.5	6.000	10.1
+	PII-1	P-18	90-92.5	PITCHER		CU	80.6	41.9	2.0	24.3	6.000	10.1

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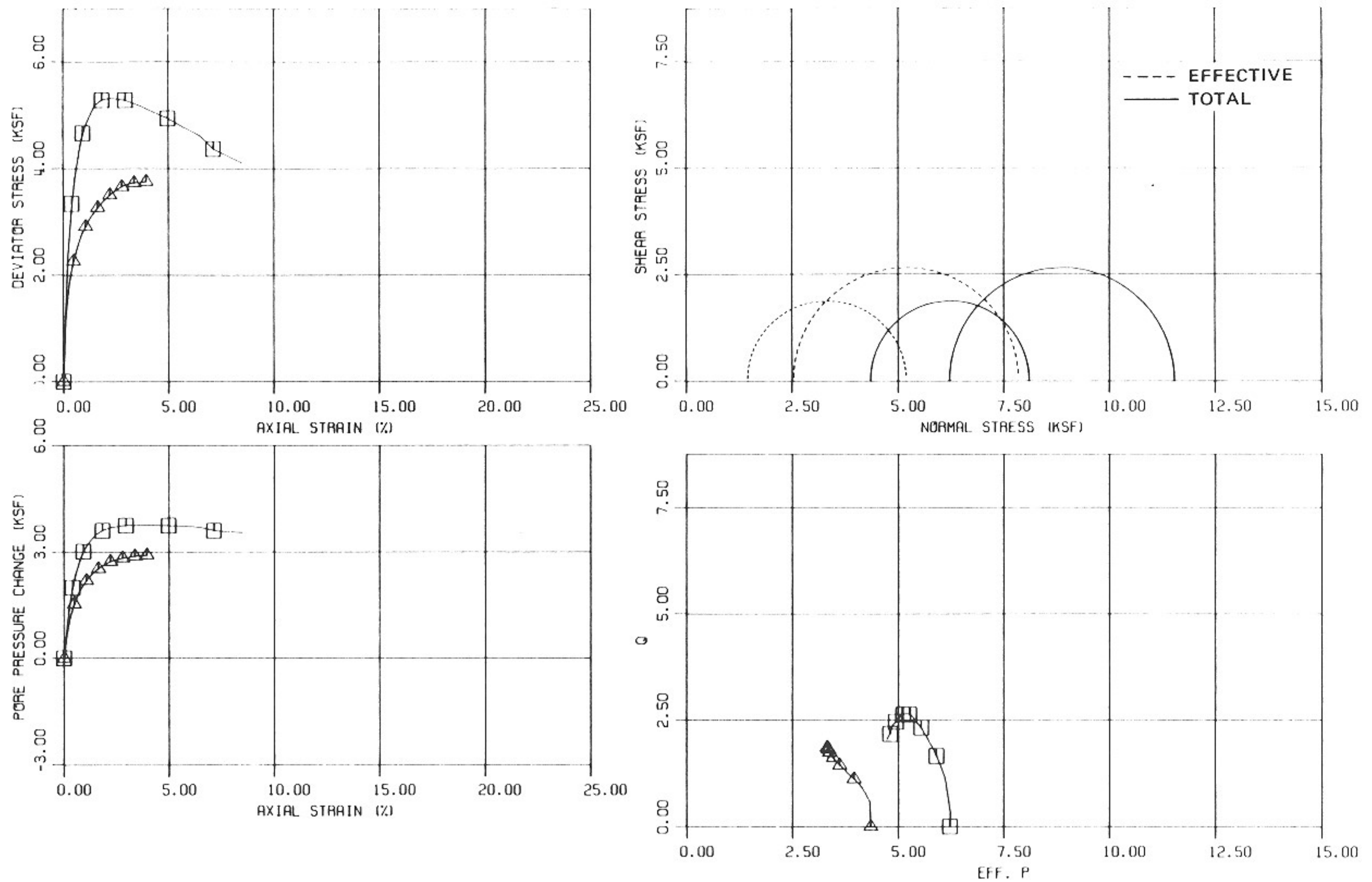
TEST TYPE: $\overline{\text{CIU}}$

FIGURE B-27

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	TEST TYPE	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	EFF. CONF. PRESSURE (KSF)	MAX DEV. STRESS (KSF)	STRAIN RATE (%/HR)	BACK PRESSURE (KSF)
⊡	PII-2	D-7	35-36	DRIVE		CU	74.8	42.1	6.2	5.3	6.000	7.2
△	PII-2	D-7	35-36	DRIVE		CU	74.8	42.1	4.3	3.8	6.000	7.0

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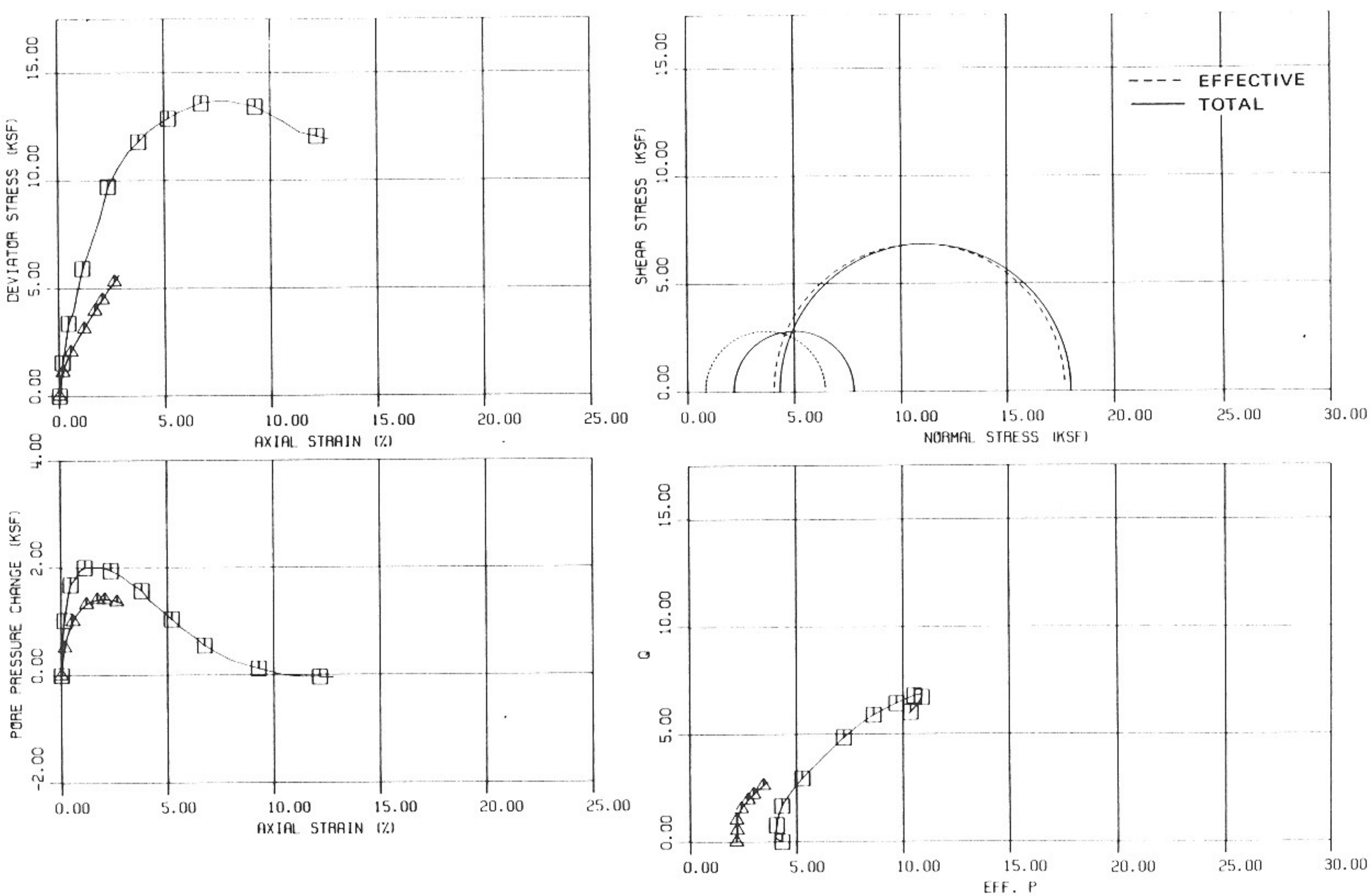
TEST TYPE: CIU

FIGURE B-28

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	TEST TYPE	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	EFF. CONF. PRESSURE (KSF)	MAX DEV. STRESS (KSF)	STRAIN RATE (%/HR)	BACK PRESSURE (KSF)
□	PII-4	D-17	85-86	DRIVE		CU	88.1	28.2	4.3	13.7	6.000	10.1
△	PII-4	D-17	85-86	DRIVE		CU	88.1	28.2	2.2	5.6	6.000	10.1

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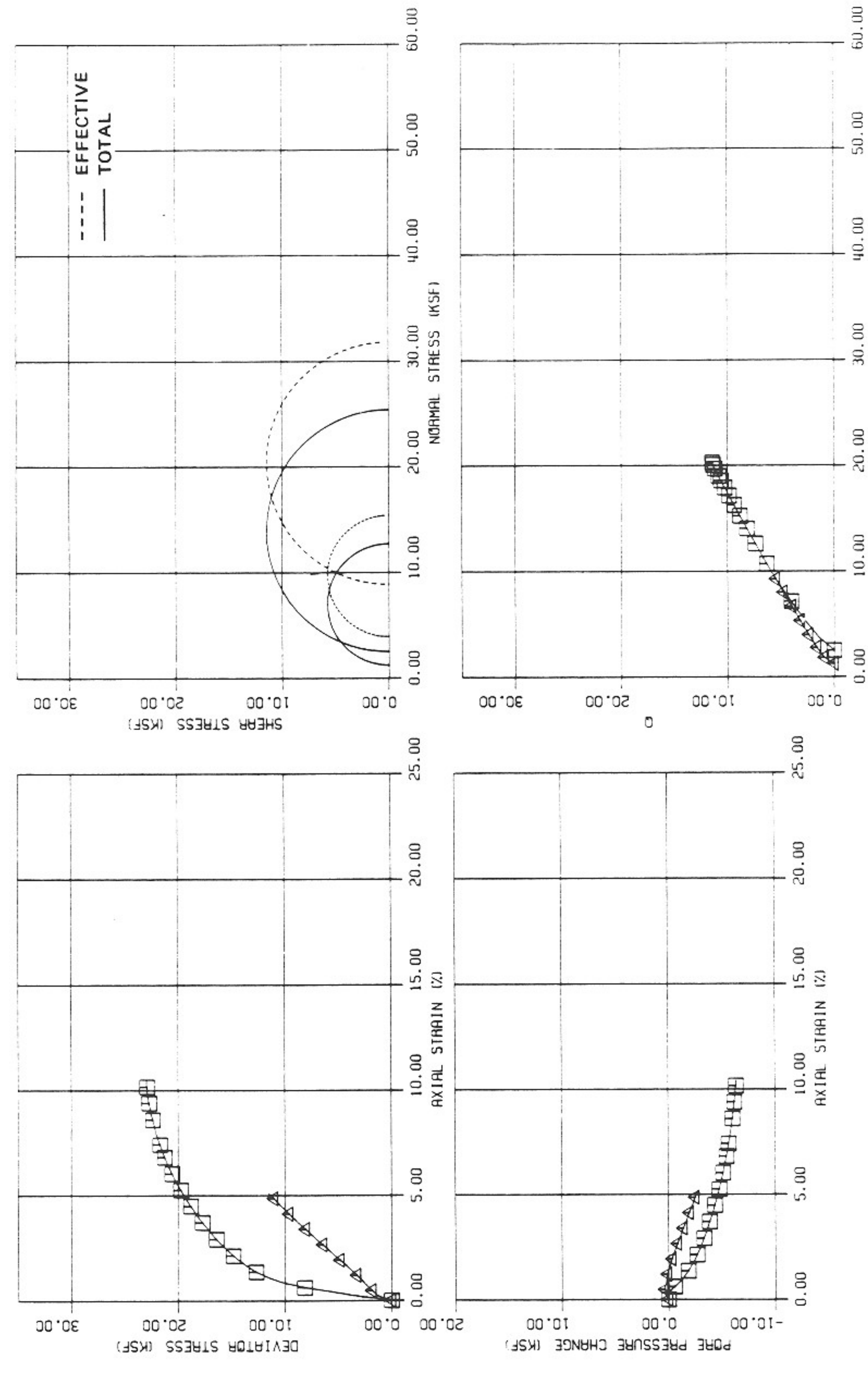
TEST TYPE: CIU

FIGURE B-29

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	TEST TYPE	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	EFF. CONF. PRESSURE (KSF)	MAX DEV. STRESS (KSF)	STRAIN RATE (%/HR)	BACK PRESSURE (KSF)
□	PII-5	D-3	15-16	DRIVE	SP	CU	100.1	20.3	2.5	22.9	6.000	10.1
△	PII-5	D-3	15-16	DRIVE	SP	CU	100.1	20.3	1.2	11.5	6.000	10.1

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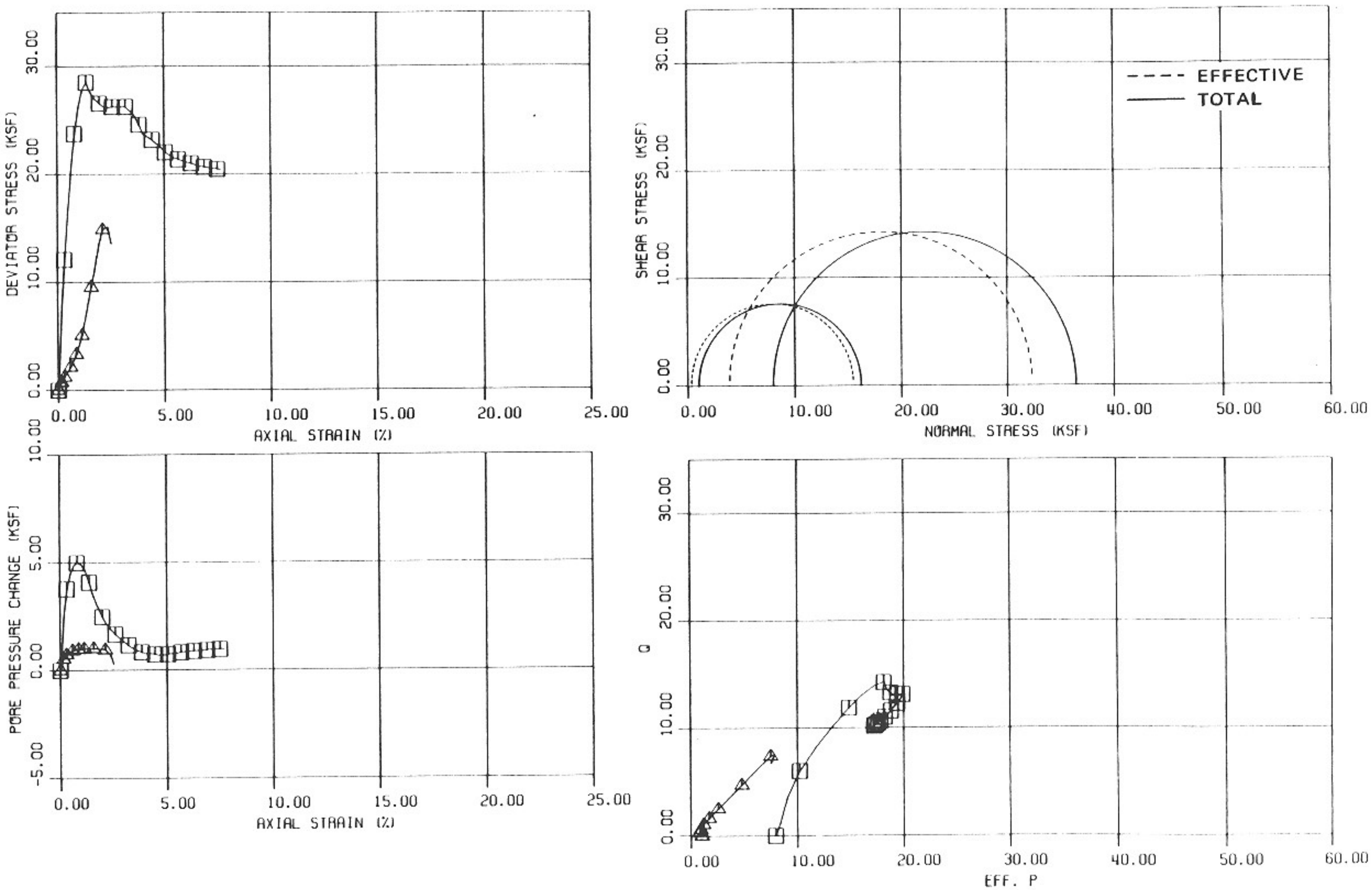
TEST TYPE: CIU

FIGURE B-30

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	TEST TYPE	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	EFF. CONF. PRESSURE (KSF)	MAX DEV. STRESS (KSF)	STRAIN RATE (%/HR)	BACK PRESSURE (KSF)
⊡	PII-6	P-11	55-57.5	PITCHER		CU	88.4	31.1	7.9	28.5	6.000	13.0
▲	PII-6	P-11	55-57.5	PITCHER		CU	88.4	31.1	1.0	15.2	6.000	13.0

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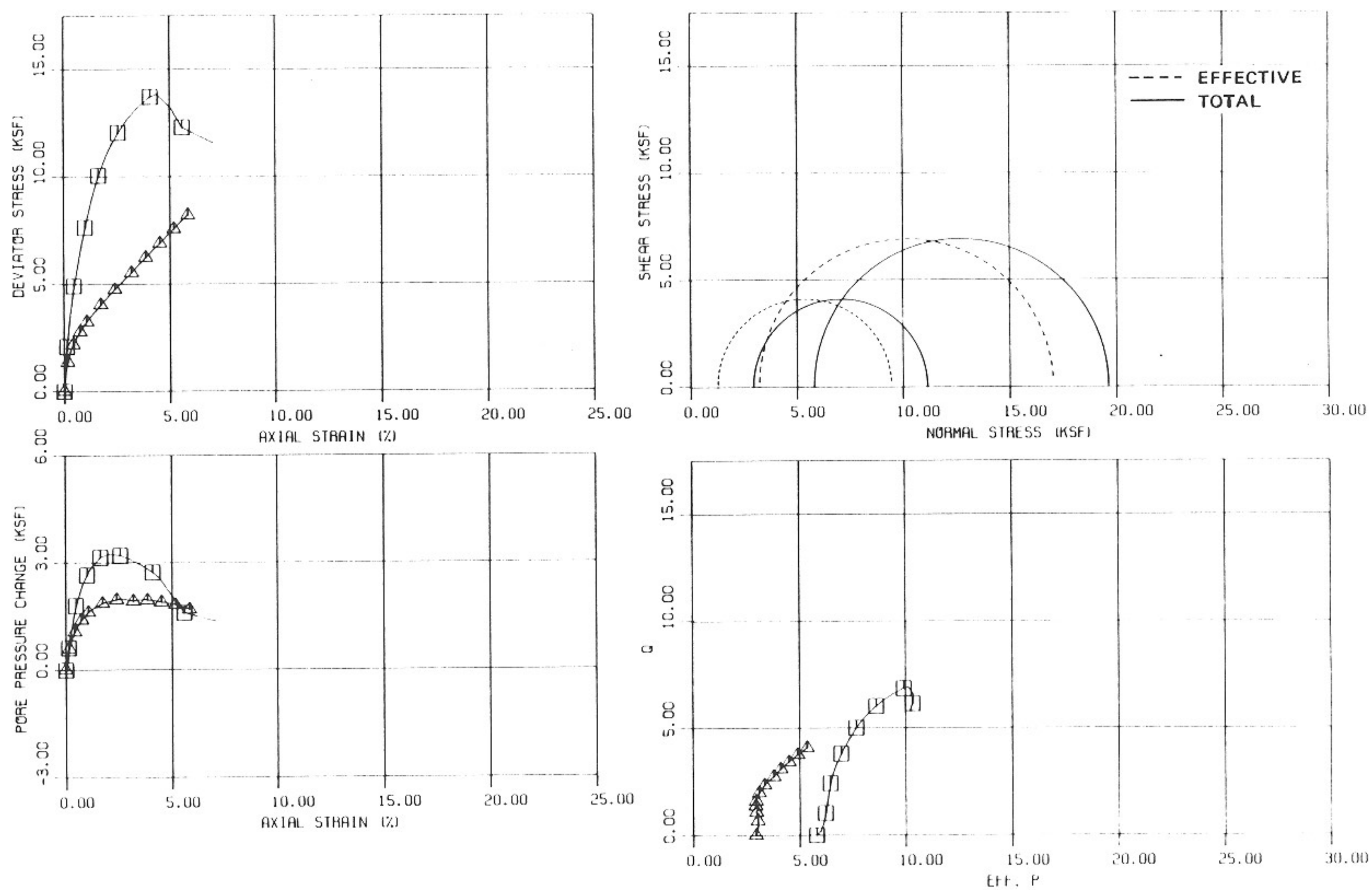
TEST TYPE: CIU

FIGURE B-31

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	TEST TYPE	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	EFF. CONF. PRESSURE (KSF)	MAX DEV. STRESS (KSF)	STRAIN RATE (%/HR)	BACK PRESSURE (KSF)
□	PII-8	D-9	45-46	DRIVE		CU	74.8	42.1	5.8	13.8	6.000	13.1
△	PII-8	D-9	45-46	DRIVE		CU	74.8	42.1	2.9	8.2	6.000	13.1

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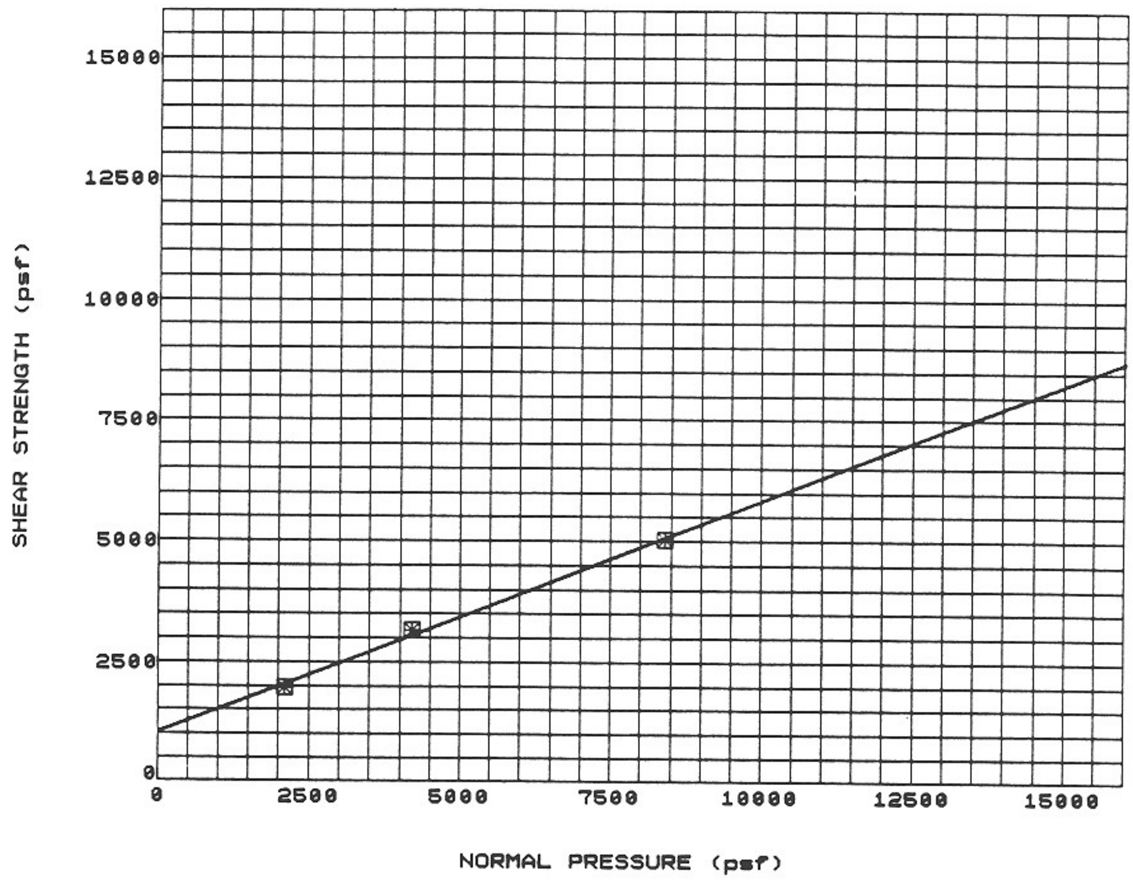
FIGURE B-32



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	PII-1	D-7	34.7	DRIVE		1031	26	

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DIRECT SHEAR TEST RESULTS

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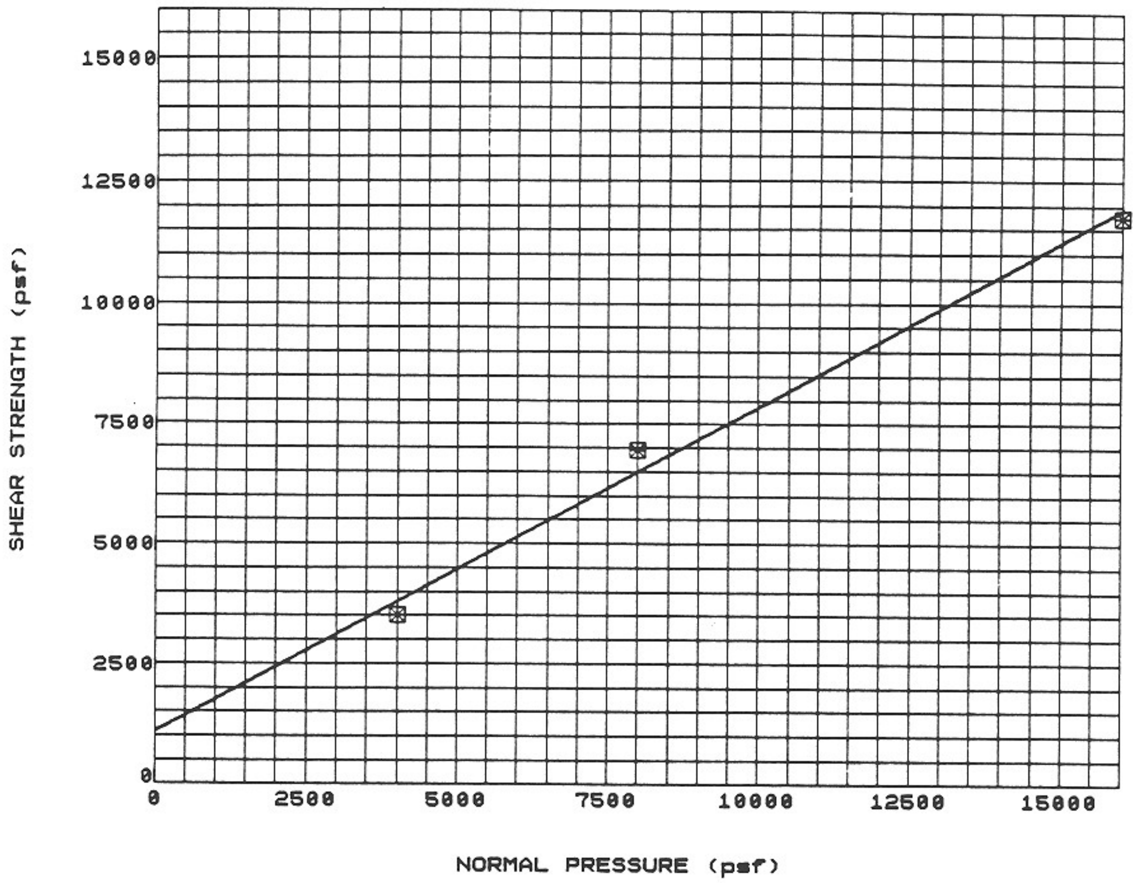
FIGURE B-33

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	PII-1	D-13	64.9	DRIVE		1093	34	

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METRO RAIL LPA-PHASE II

DIRECT SHEAR TEST RESULTS

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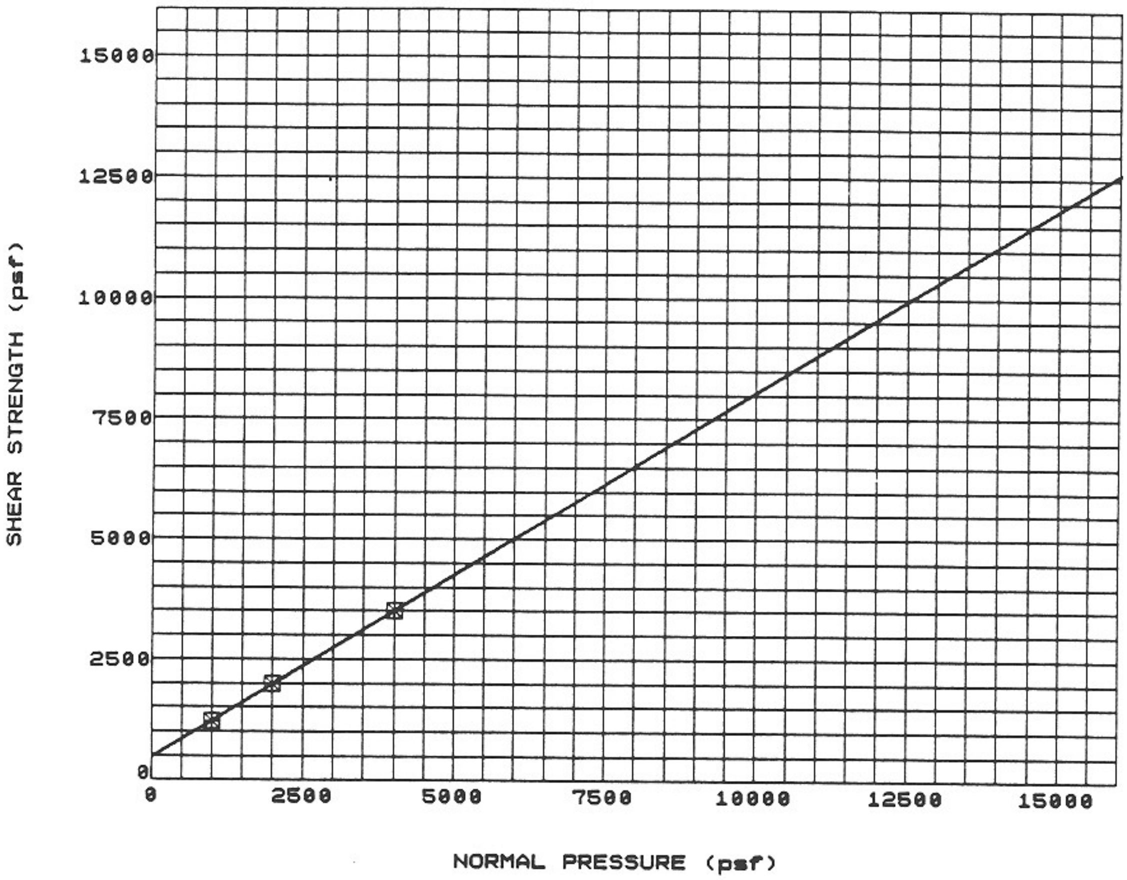
FIGURE B-34



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	PII-2	D-3	14.9	DRIVE	SM	469	37	

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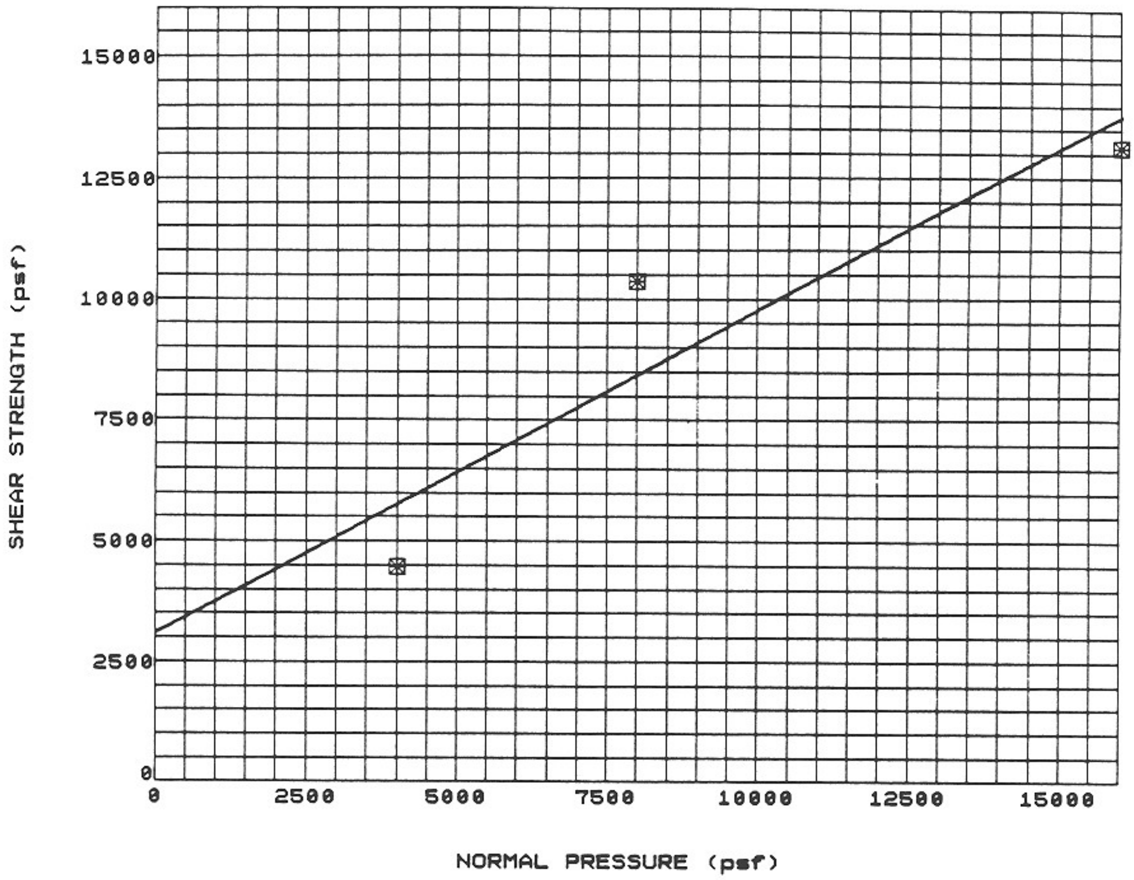
FIGURE B-35



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	PII-2	D-13	64.8	DRIVE		3093	34	

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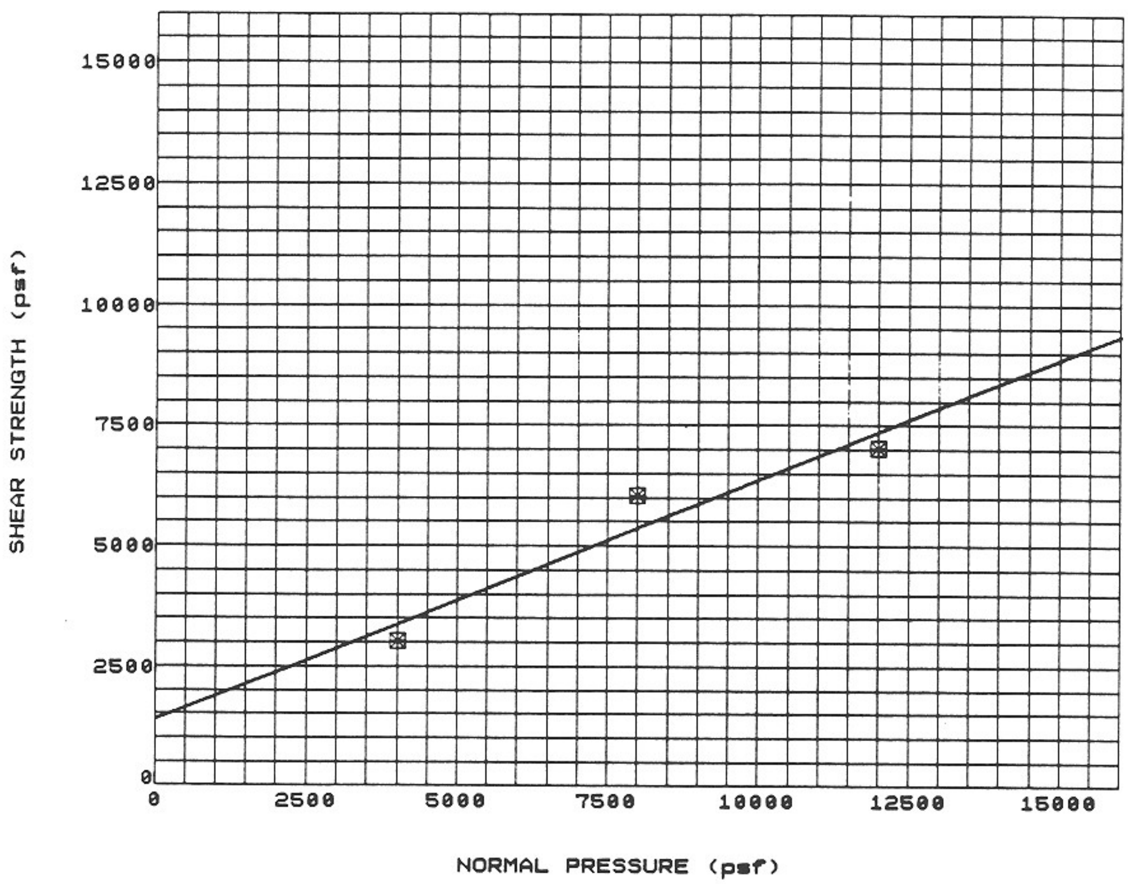
FIGURE B-36



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	PII-2	D- 15	74.5	DRIVE		1384	26	

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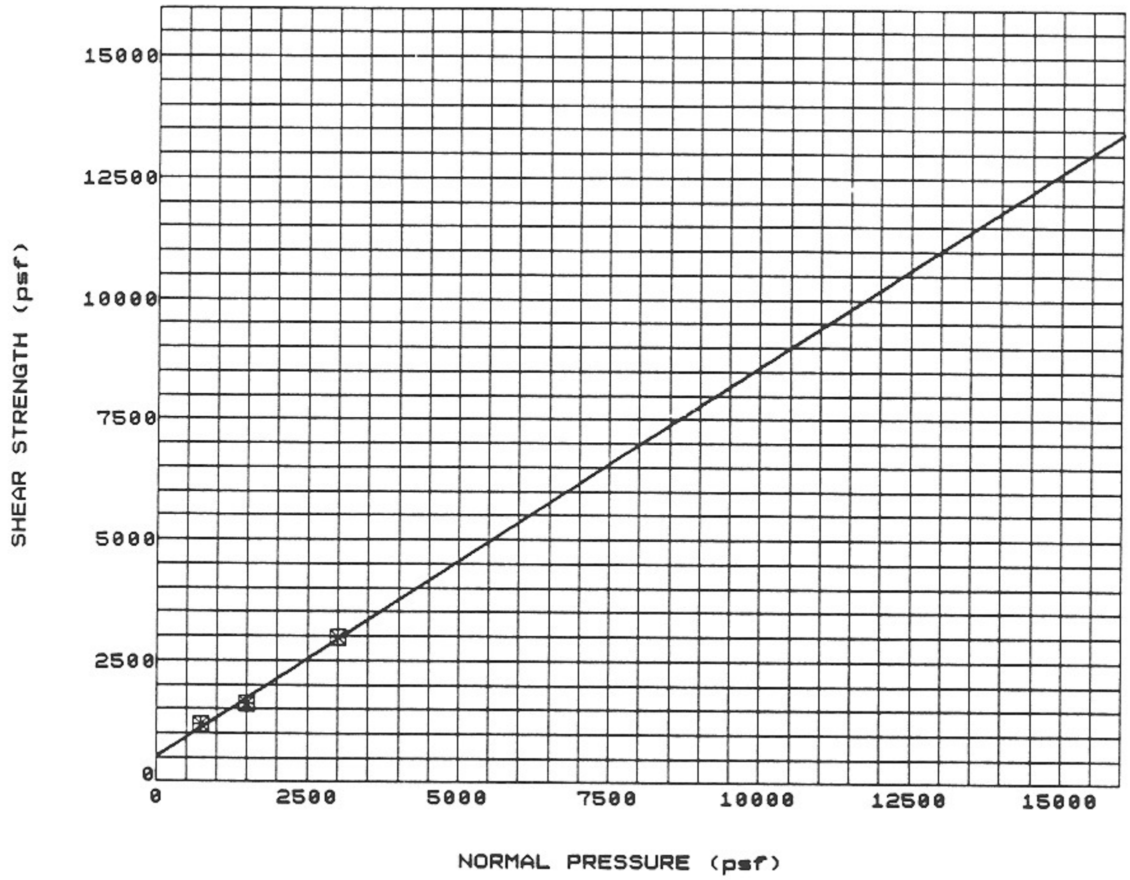
FIGURE B-37

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
☒	PII-3	D-2	9.9	DRIVE	SM	516	39	

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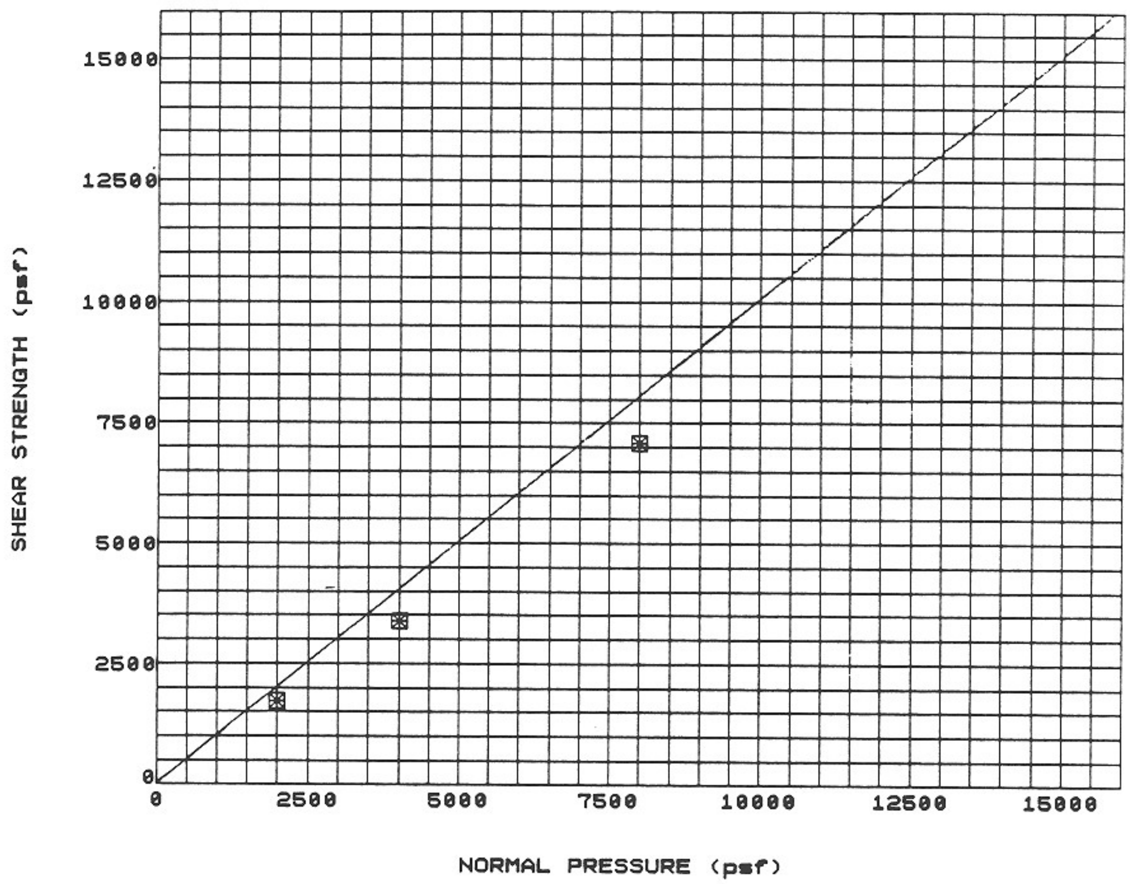
FIGURE B-38



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	PII-3	D-6	29.80	DRIVE	SM	0	41	

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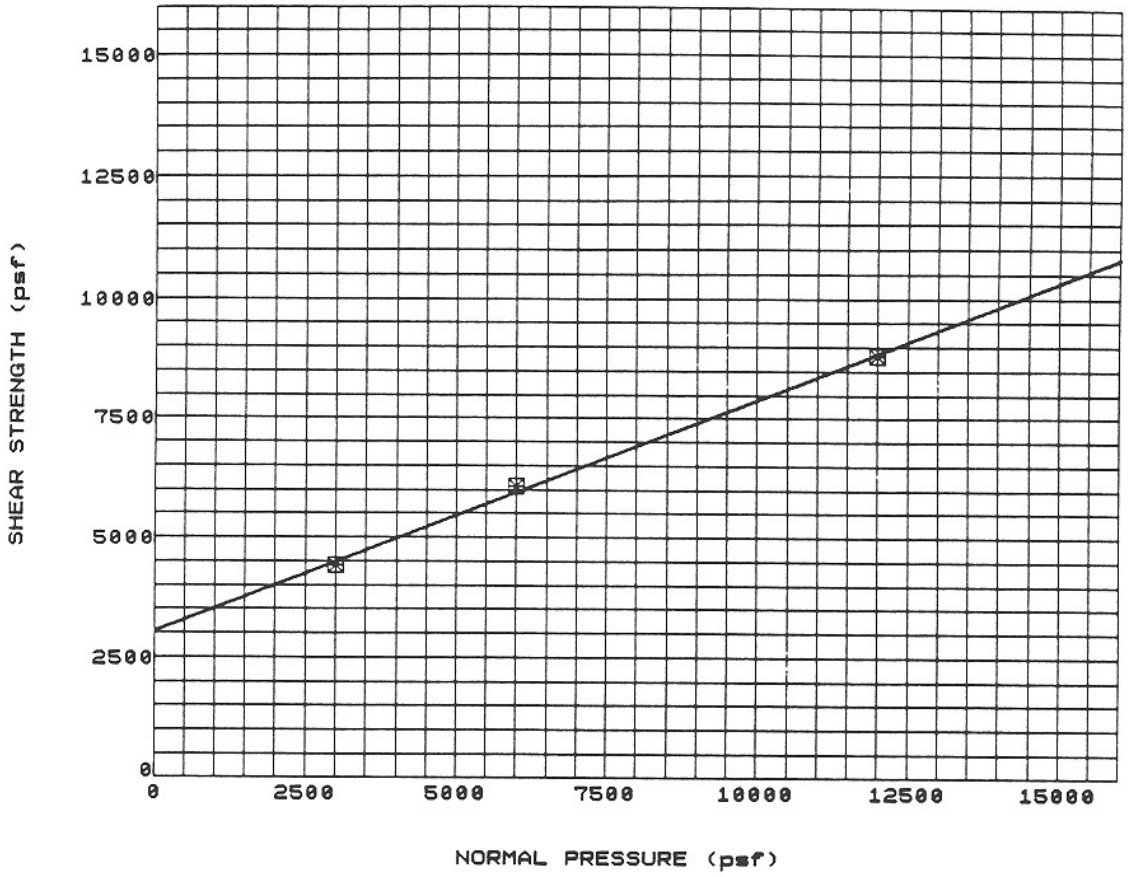

SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	PII-3	D-10	49.8	DRIVE		3039	26	

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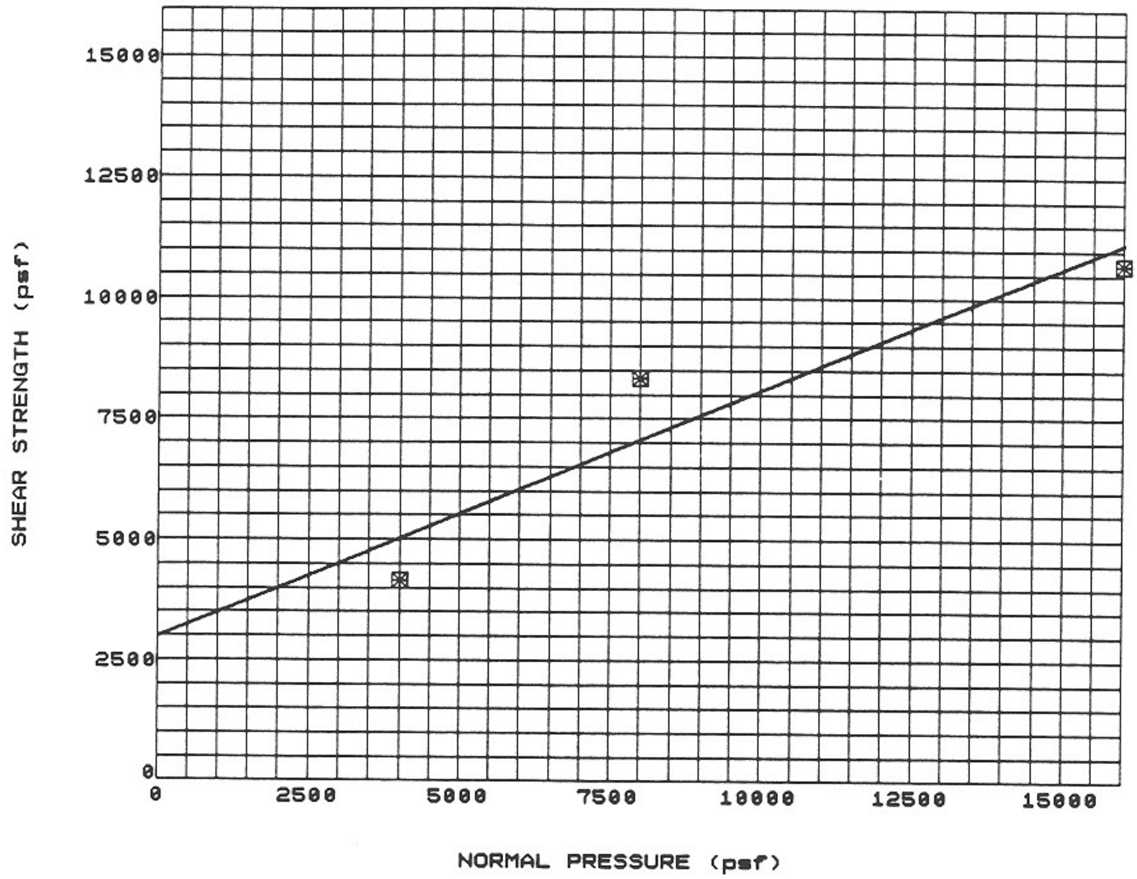
FIGURE B-40

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	PII-3	D-14	70.1	DRIVE		2968	27	

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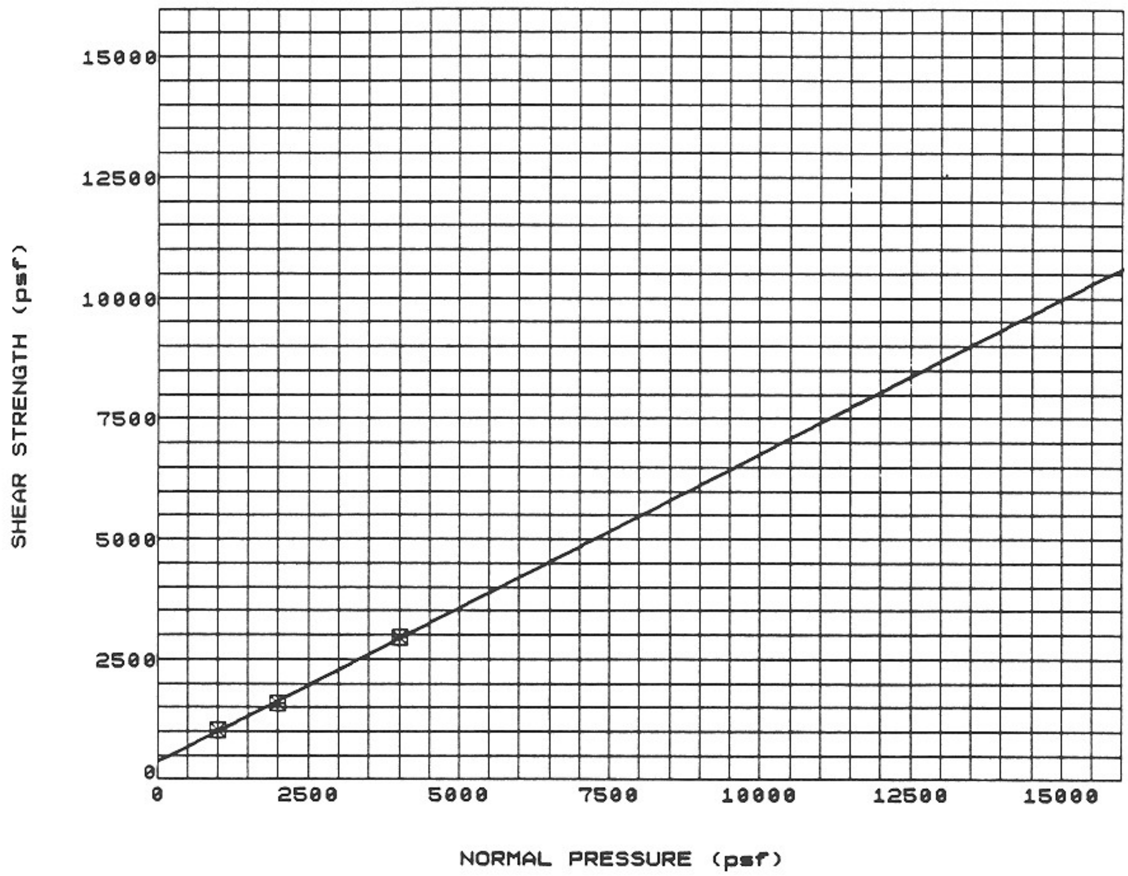
FIGURE B-41

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	PII-4	D-3	15.0	DRIVE	SM	359	33	

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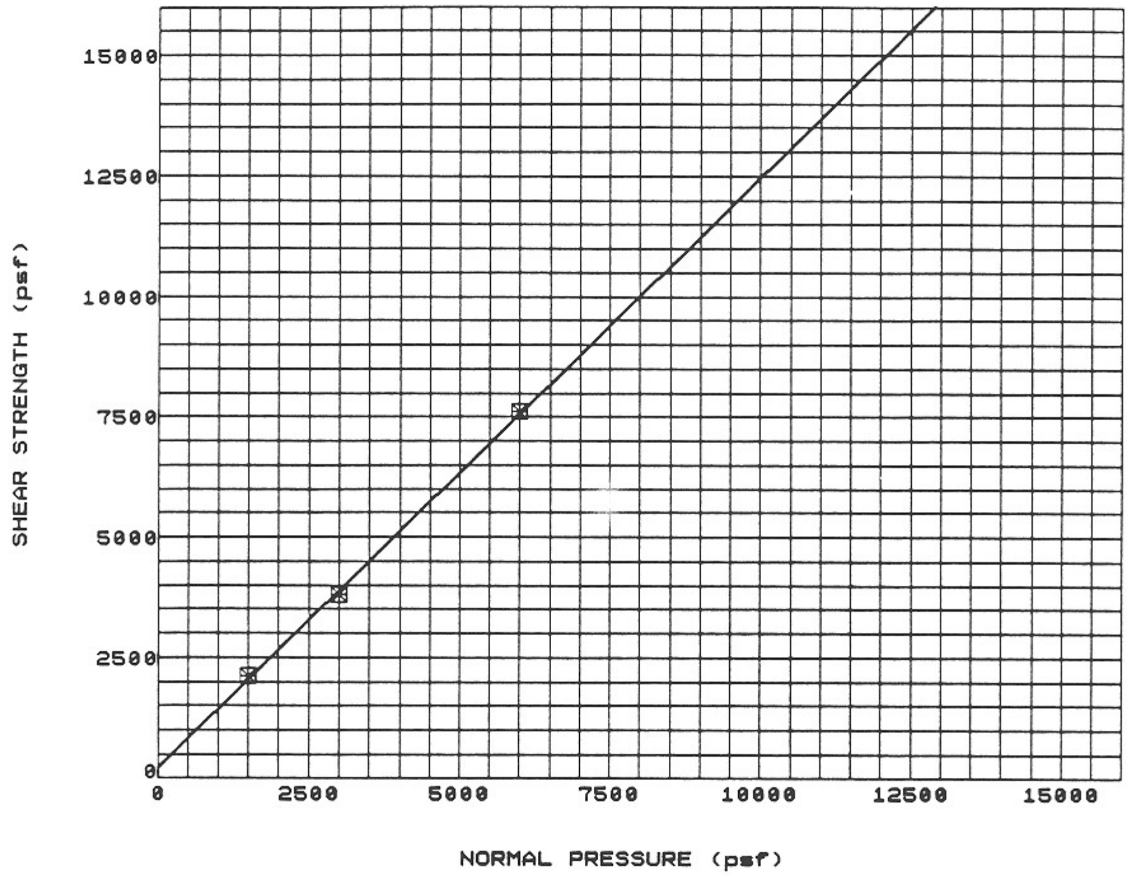
FIGURE B-42

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	PII-4	D-5	24.8	DRIVE	SM	231	51	

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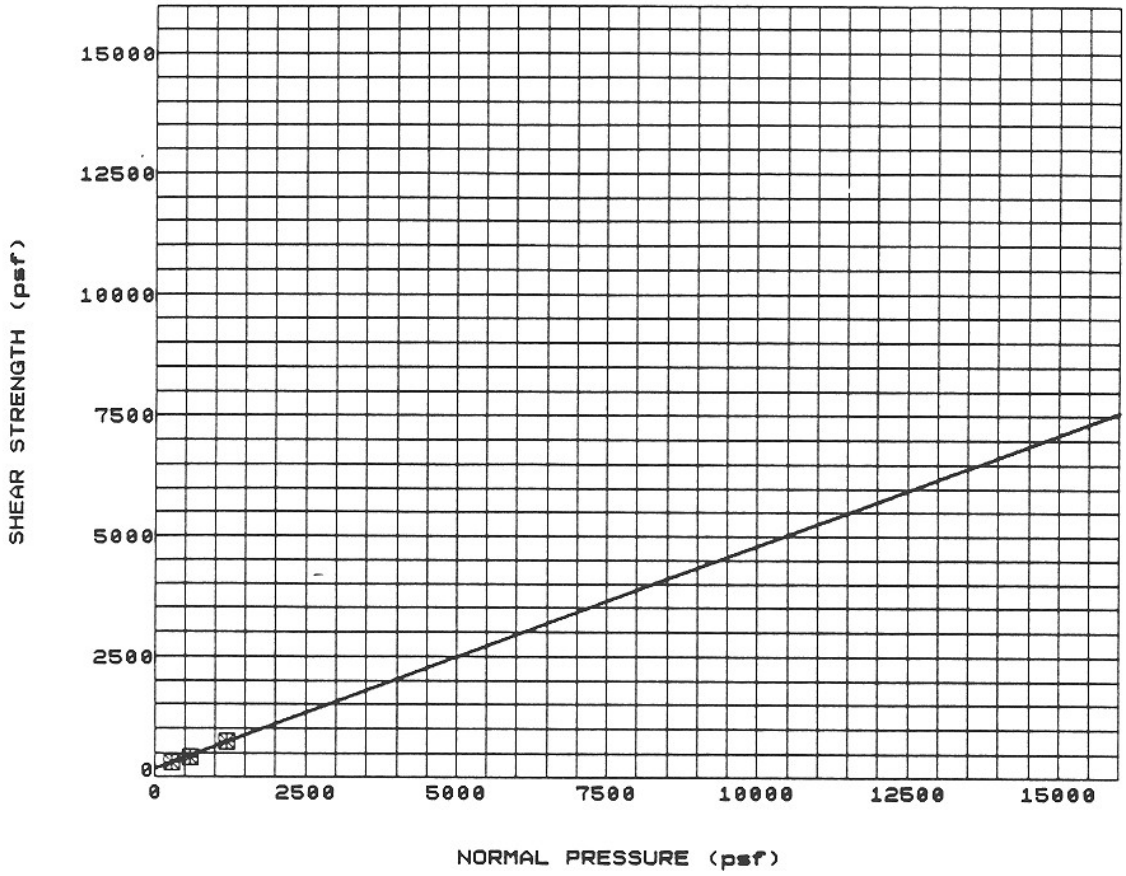
FIGURE B-43



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	PII-5	D-1	4.8	DRIVE	CL/ML	165	25	

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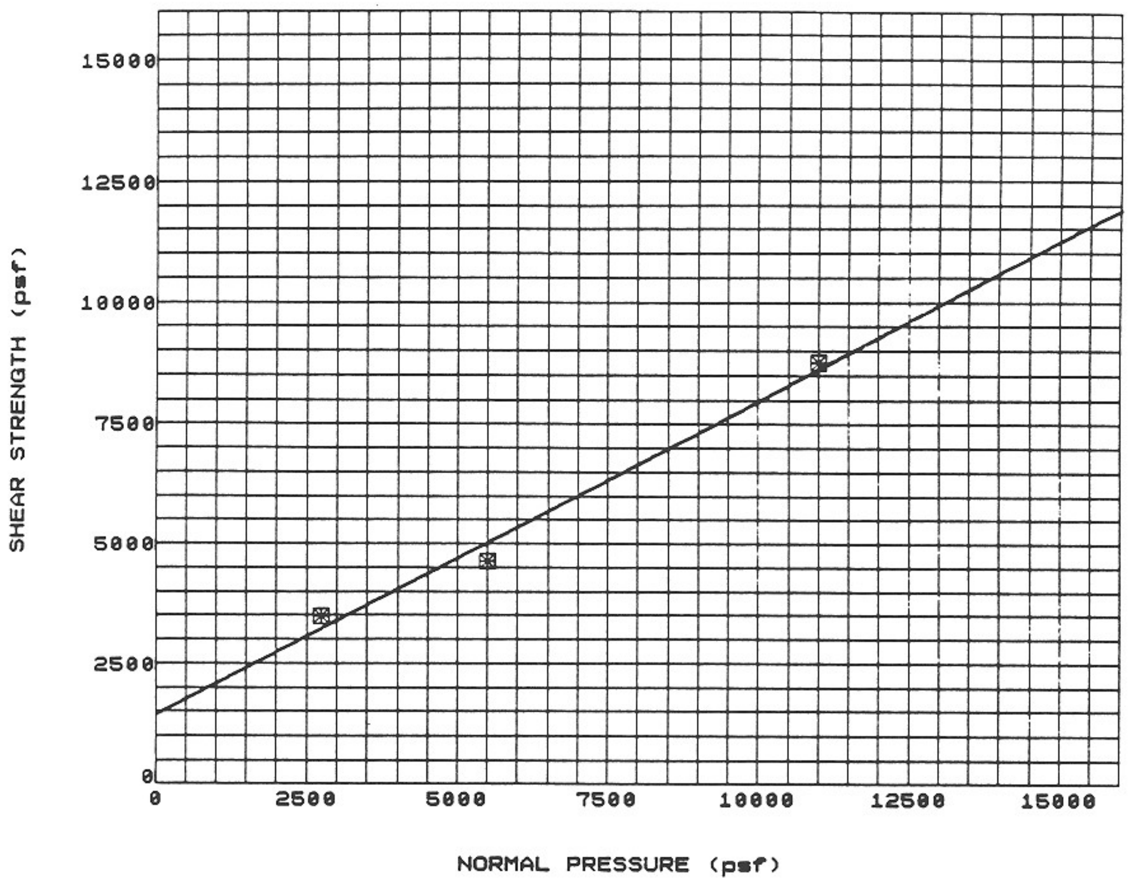
FIGURE B-44



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	PII-5	D-9	44.9	DRIVE		1423	33	

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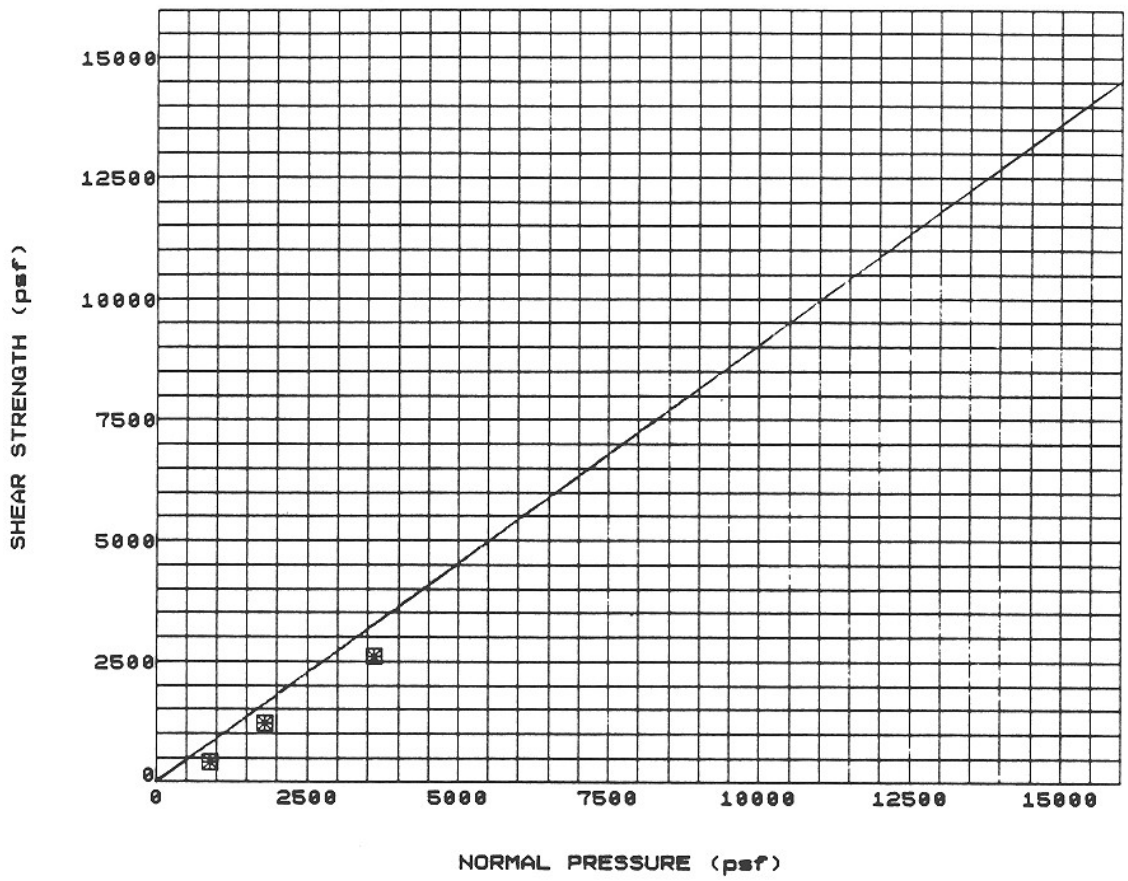
FIGURE B-45

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	PII-7	D-3	14.90	DRIVE	SM	0	36	

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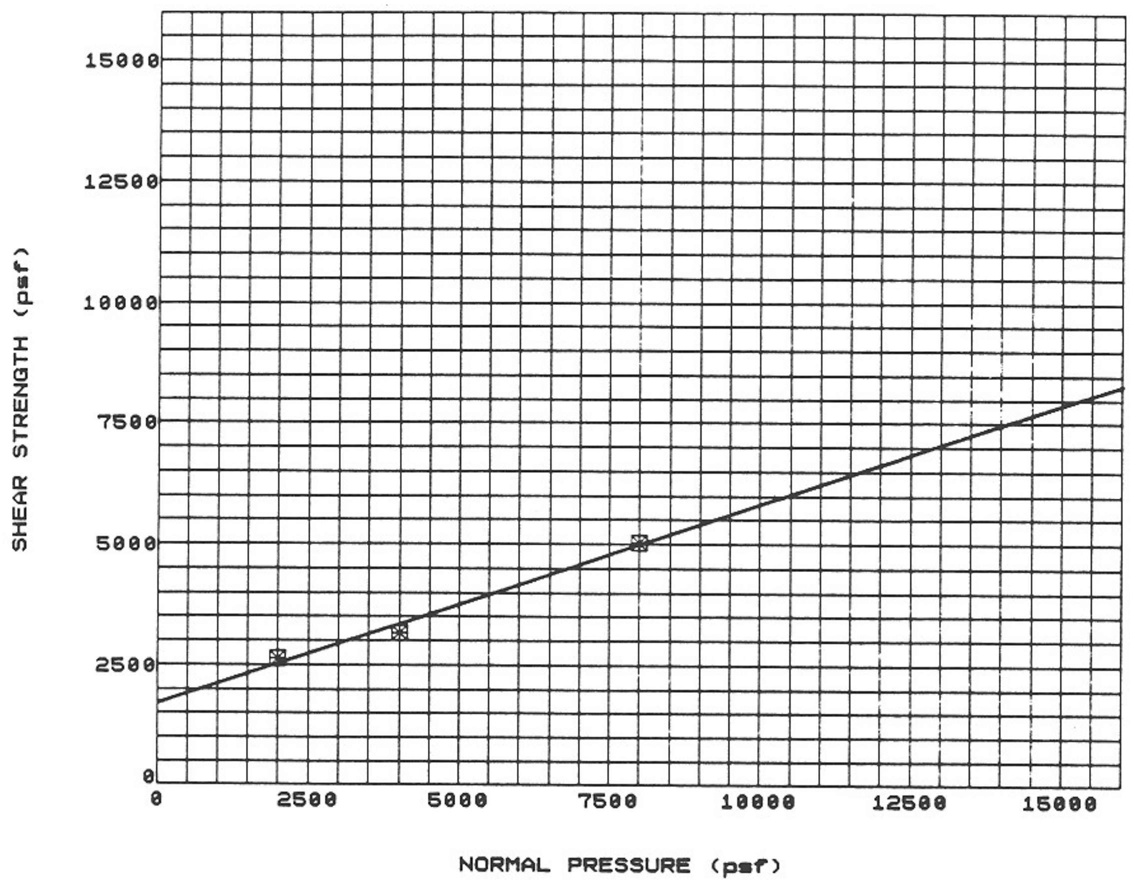
FIGURE B-46

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	PII-7	D-7	34.5	DRIVE		1686	22	

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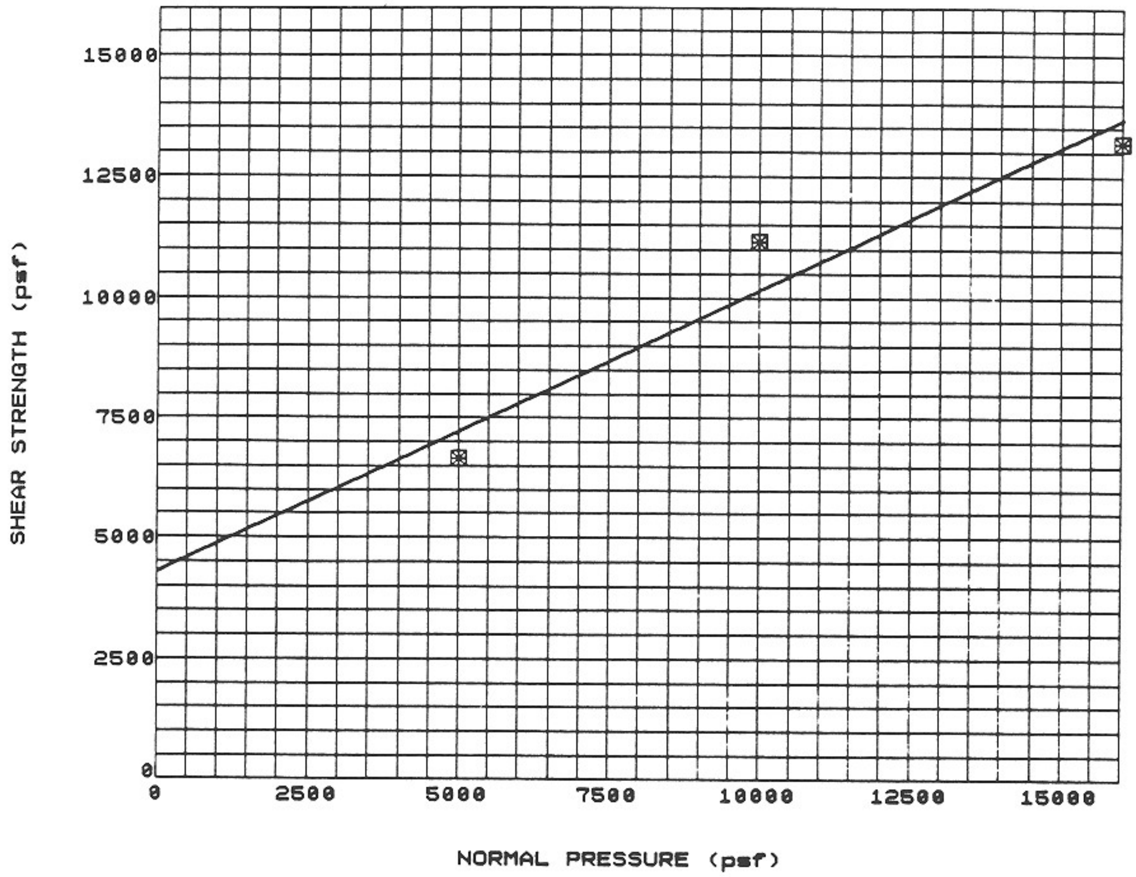
FIGURE B-47



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	PII-7	D-17	85.1	DRIVE		4277	30	

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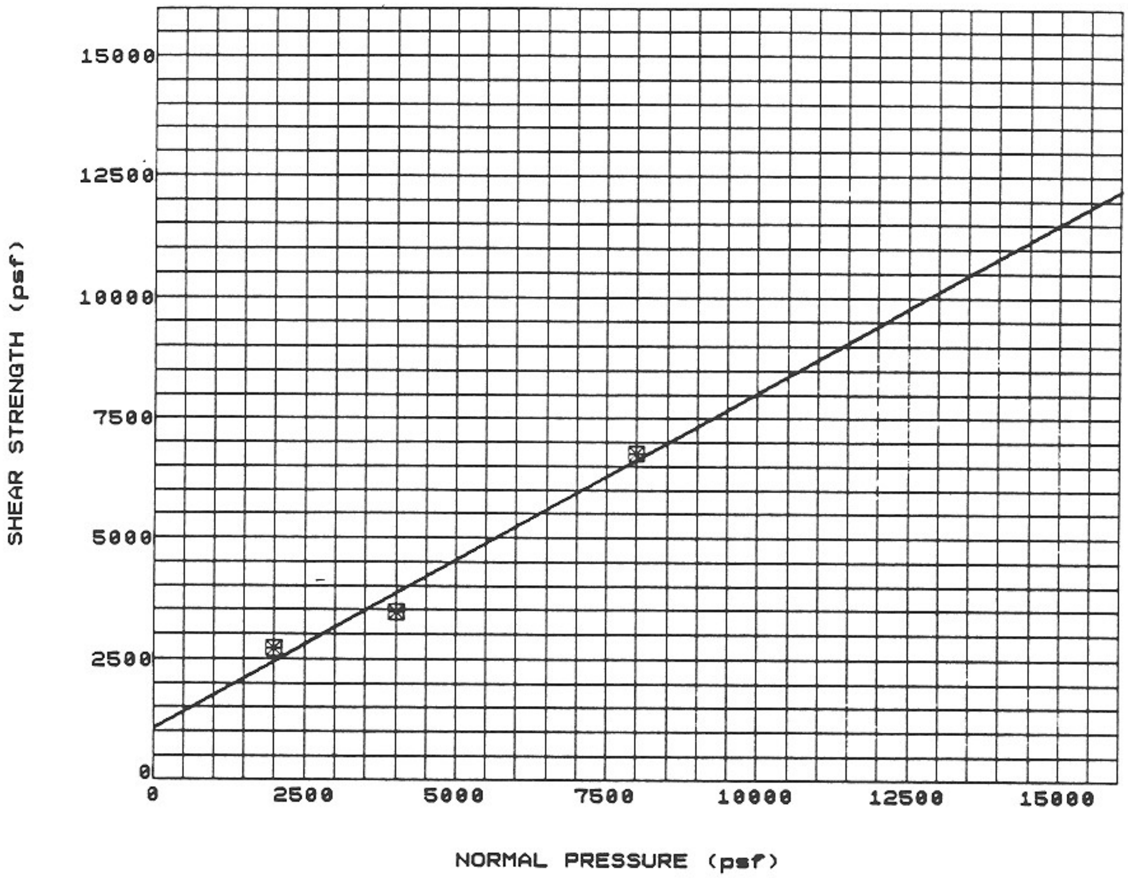
FIGURE B-48



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	PII-8	D-7	35.0	DRIVE		1063	35	

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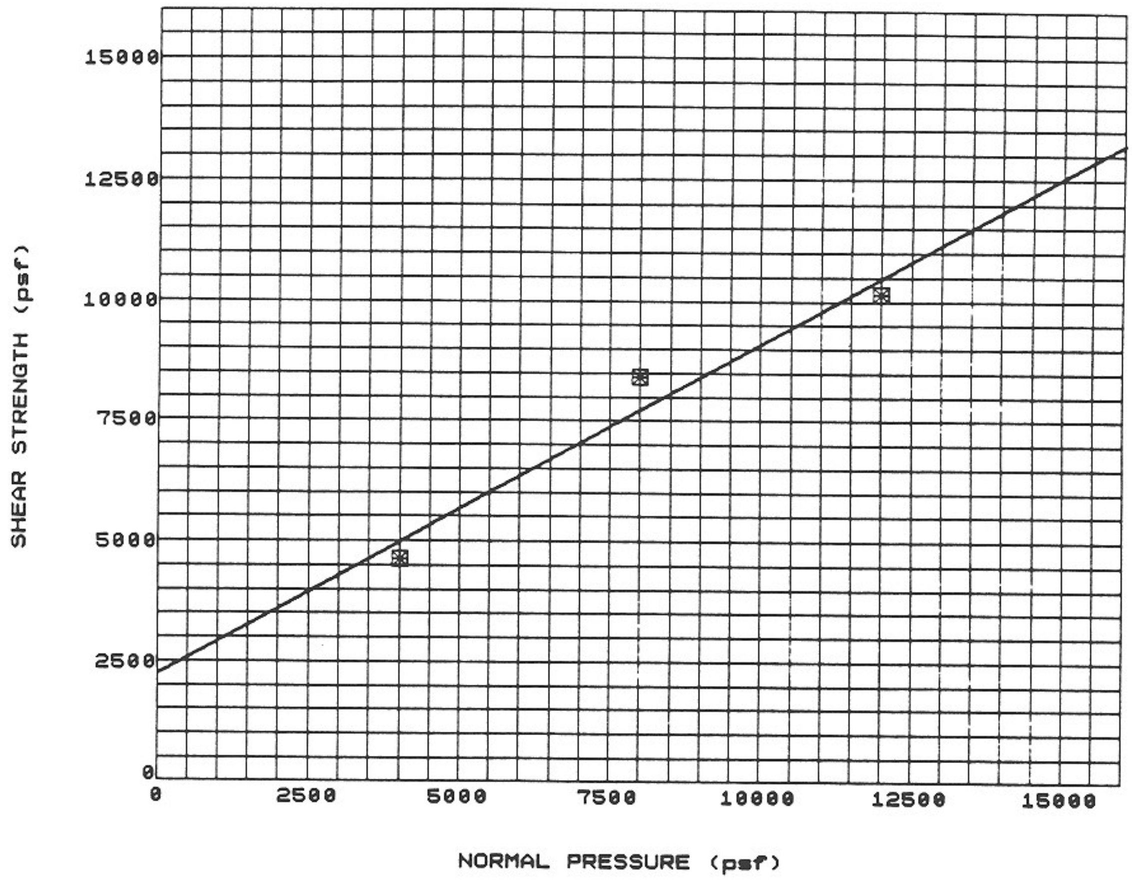
FIGURE B-49

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	PII-8	D- 17	85.1	DRIVE		2225	35	

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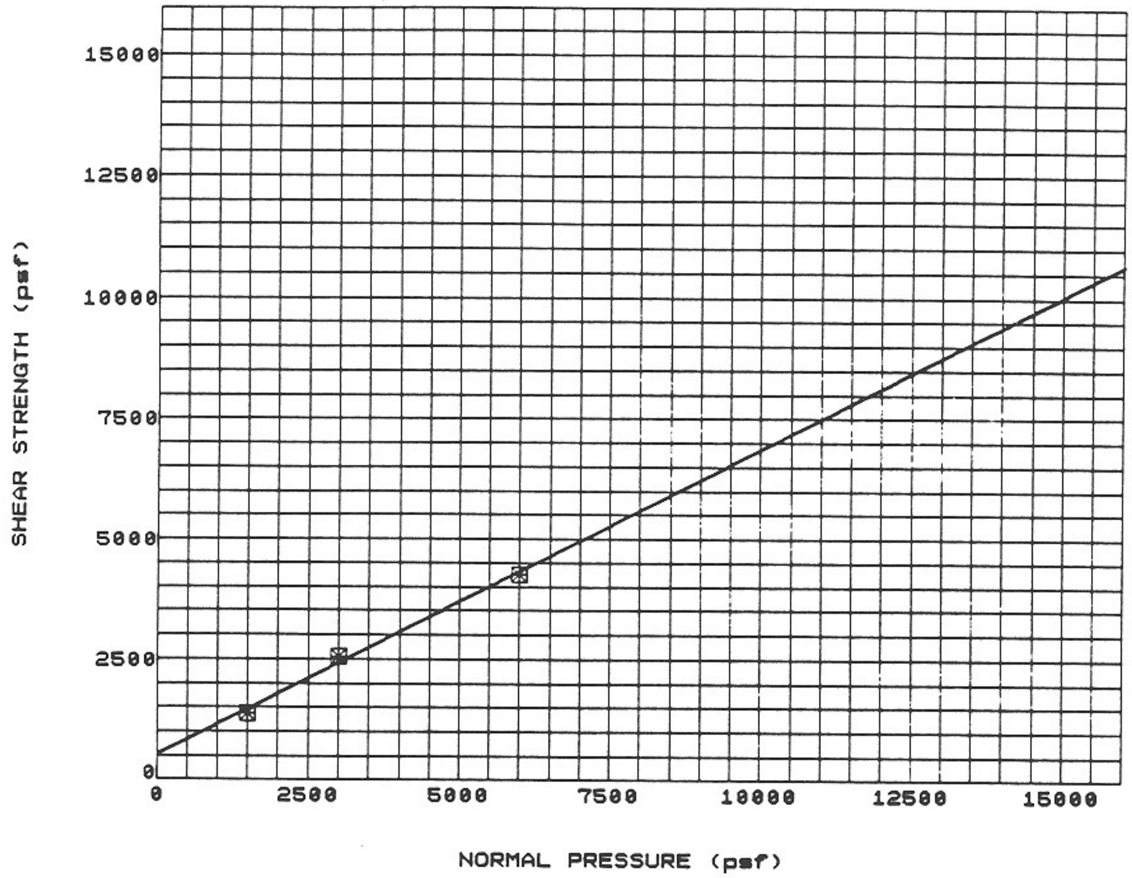
FIGURE B-50

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COHESION C (psf)	FRICTION ANGLE (degree)	REMARKS
⊠	PII-8D	D-5	25.1	DRIVE		511	32	

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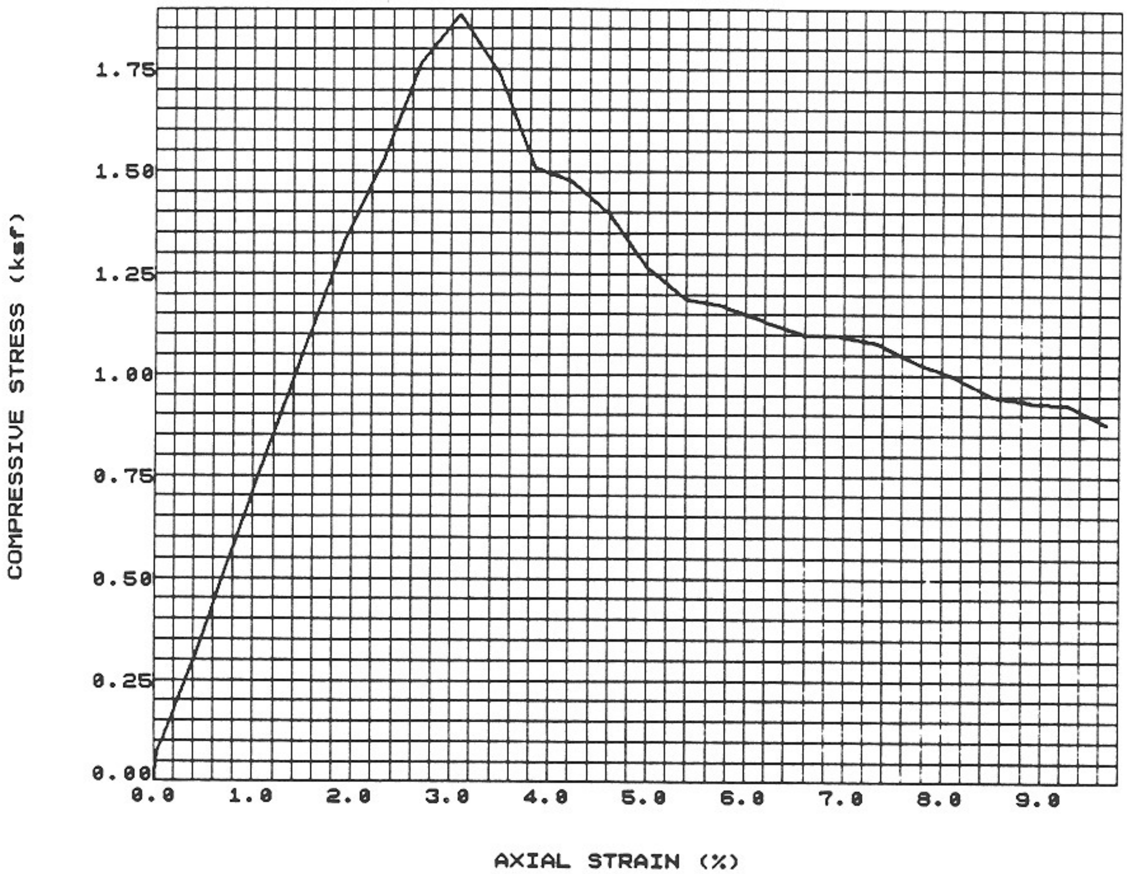
FIGURE B-51

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-1	D-11	55-56	DRIVE		1.88	0.88

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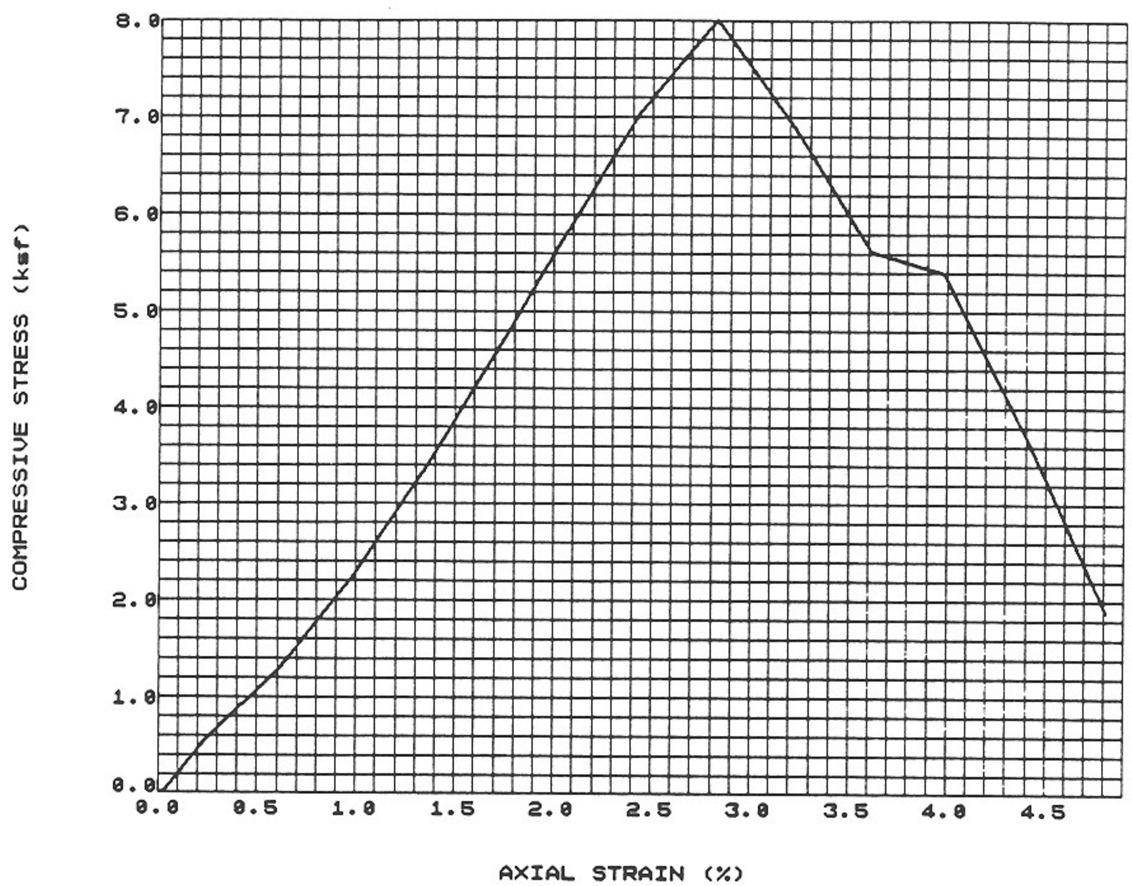
FIGURE B-52

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-1	D-19	95-96	DRIVE		8.00	1.88

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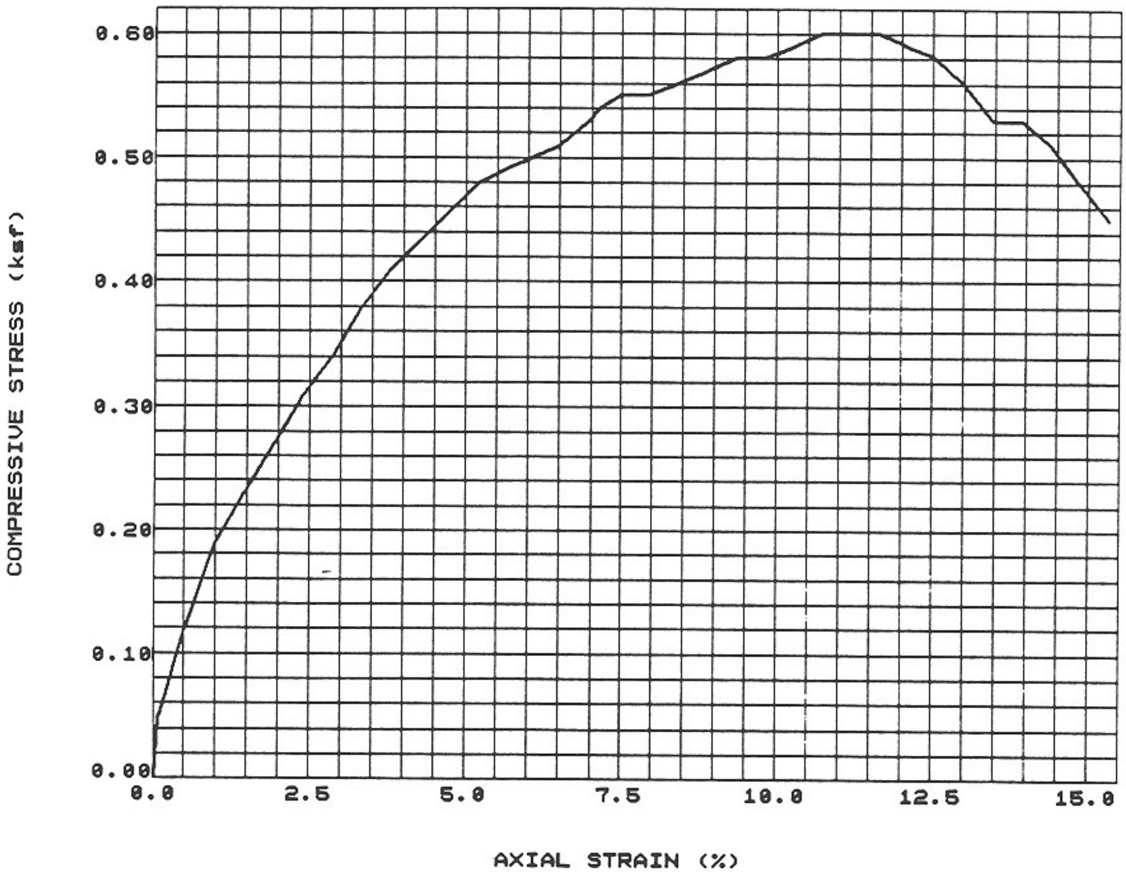
FIGURE B-53

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-2	D-9	45-46	DRIVE		0.60	0.45

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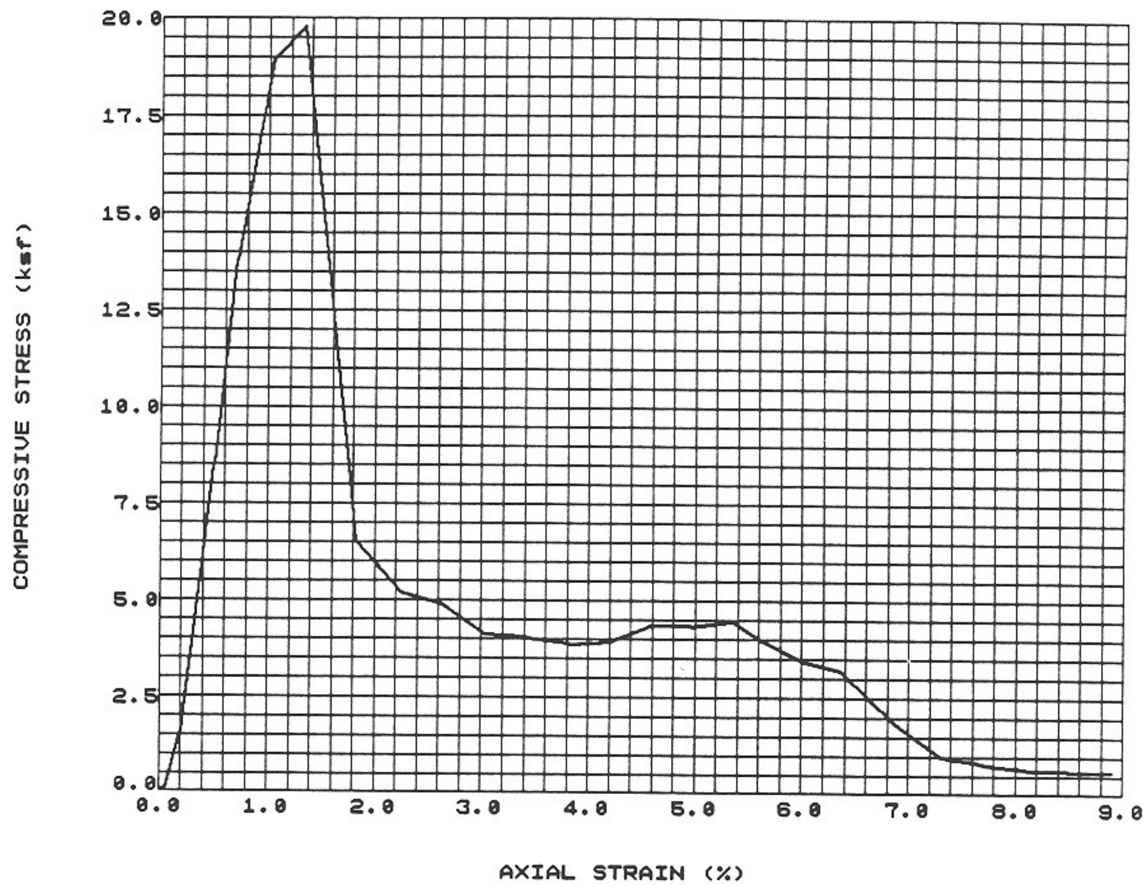
FIGURE B-54



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-2	P-18	90-91	PITCHER		19.7	0.60

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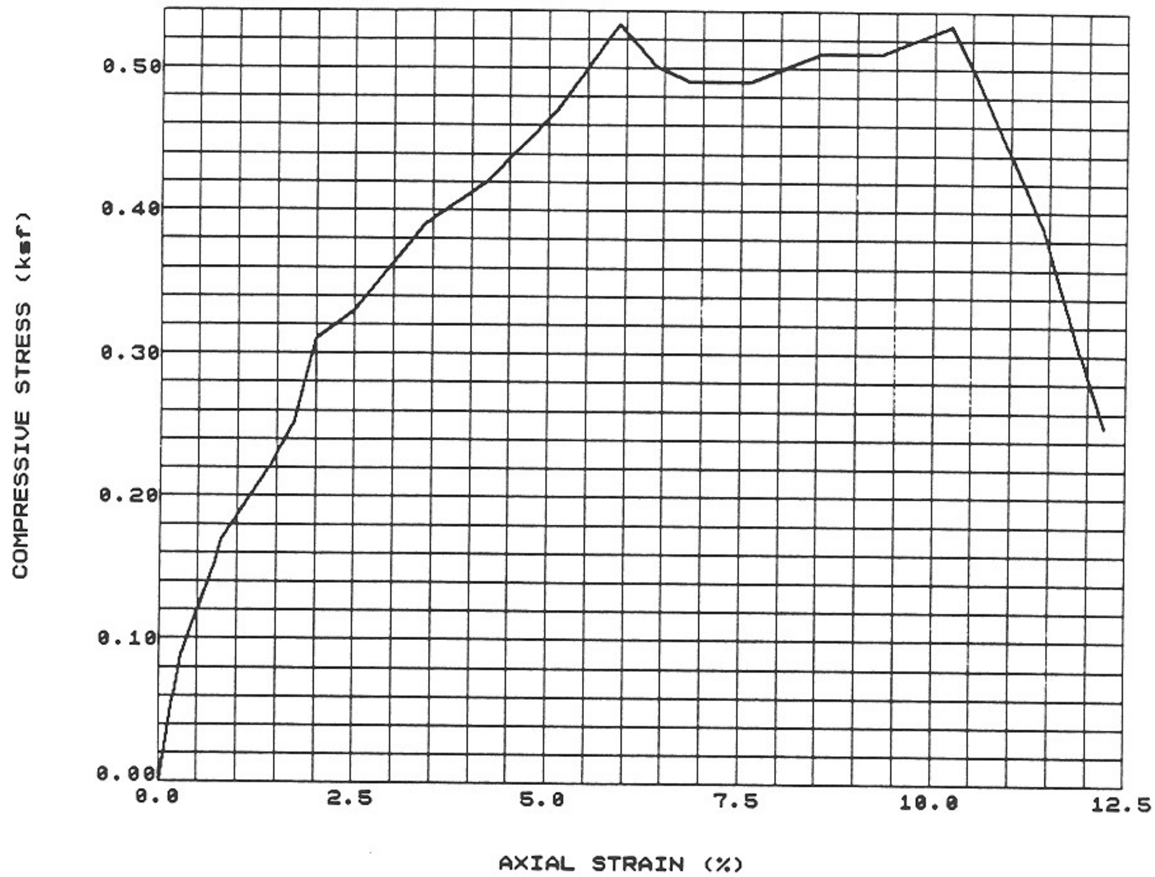
FIGURE B-55



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-2	D-19	95-96	DRIVE		0.53	0.25

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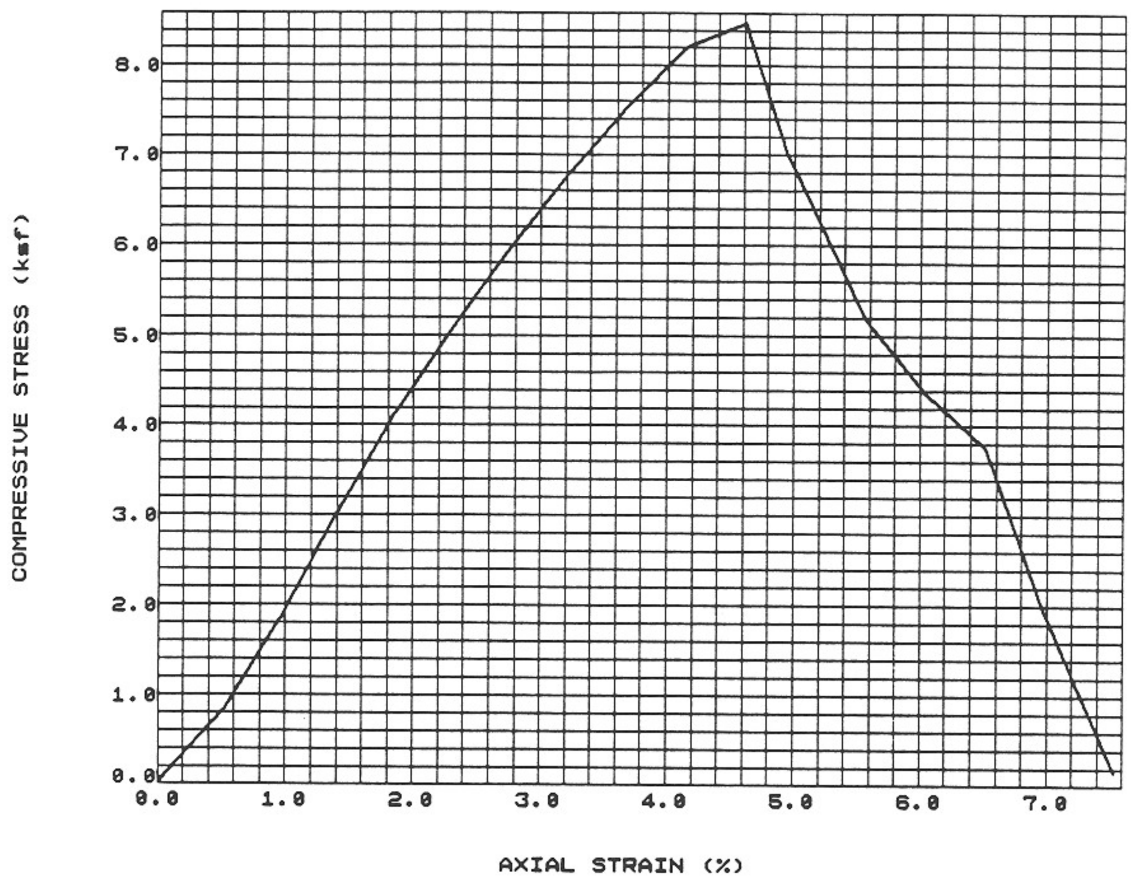
FIGURE B-56



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-3	D-12	60-61	DRIVE		8.47	0.14

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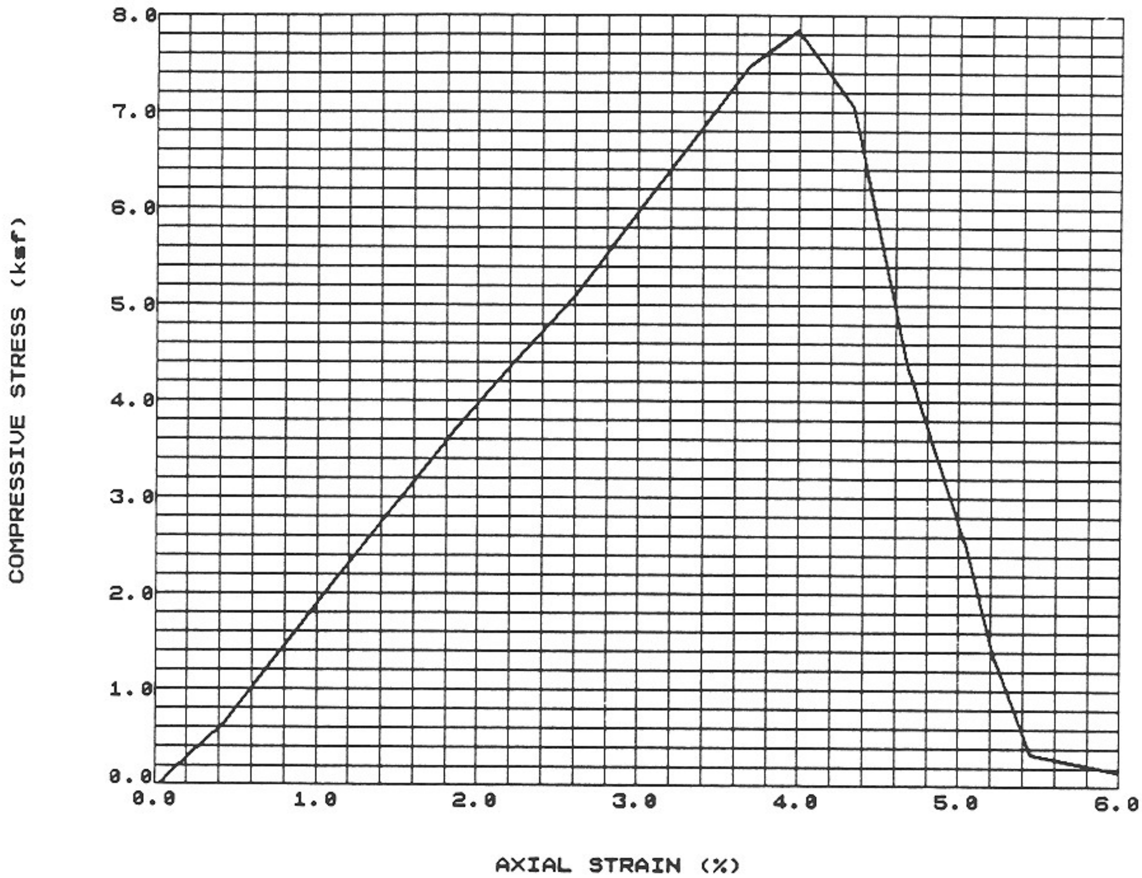
FIGURE B-57

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-3	D-18	90-91	DRIVE		7.83	0.15

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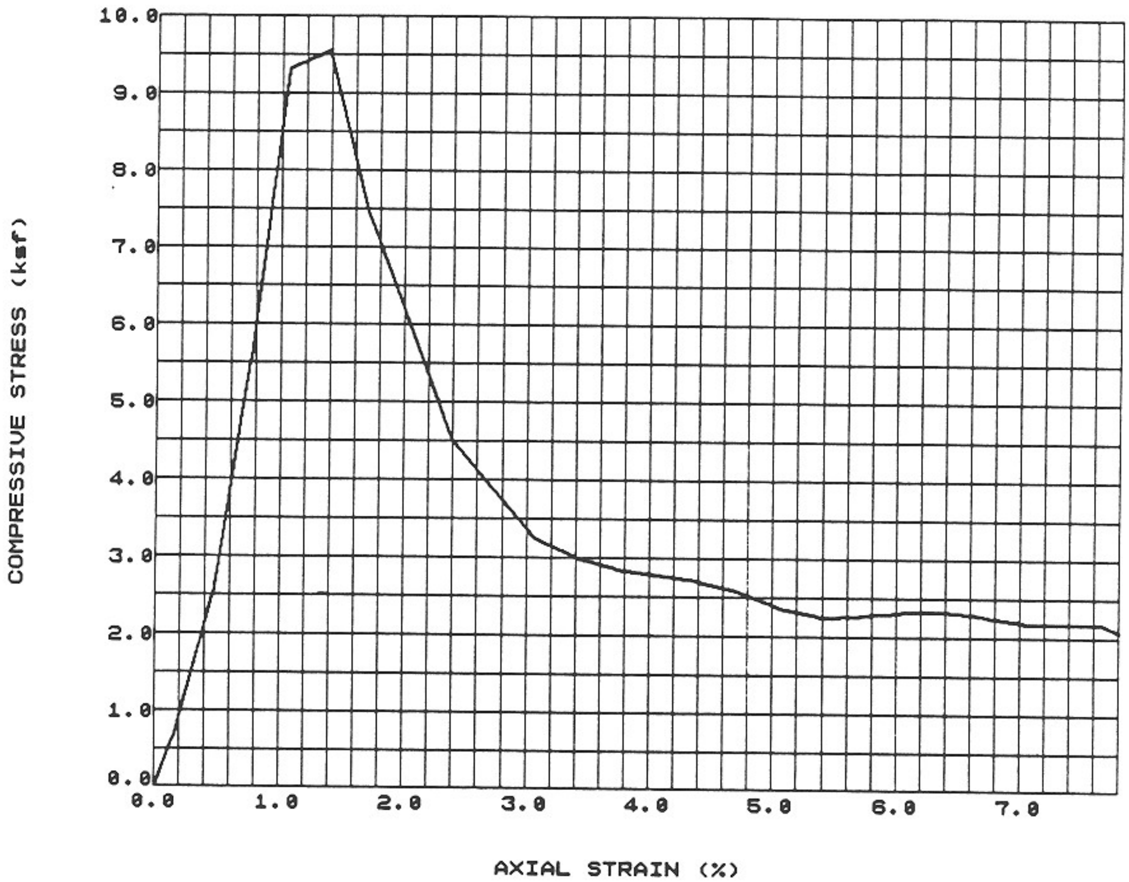
FIGURE B-58

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-3	P-19	95-97.5	PITCHER		9.54	2.07

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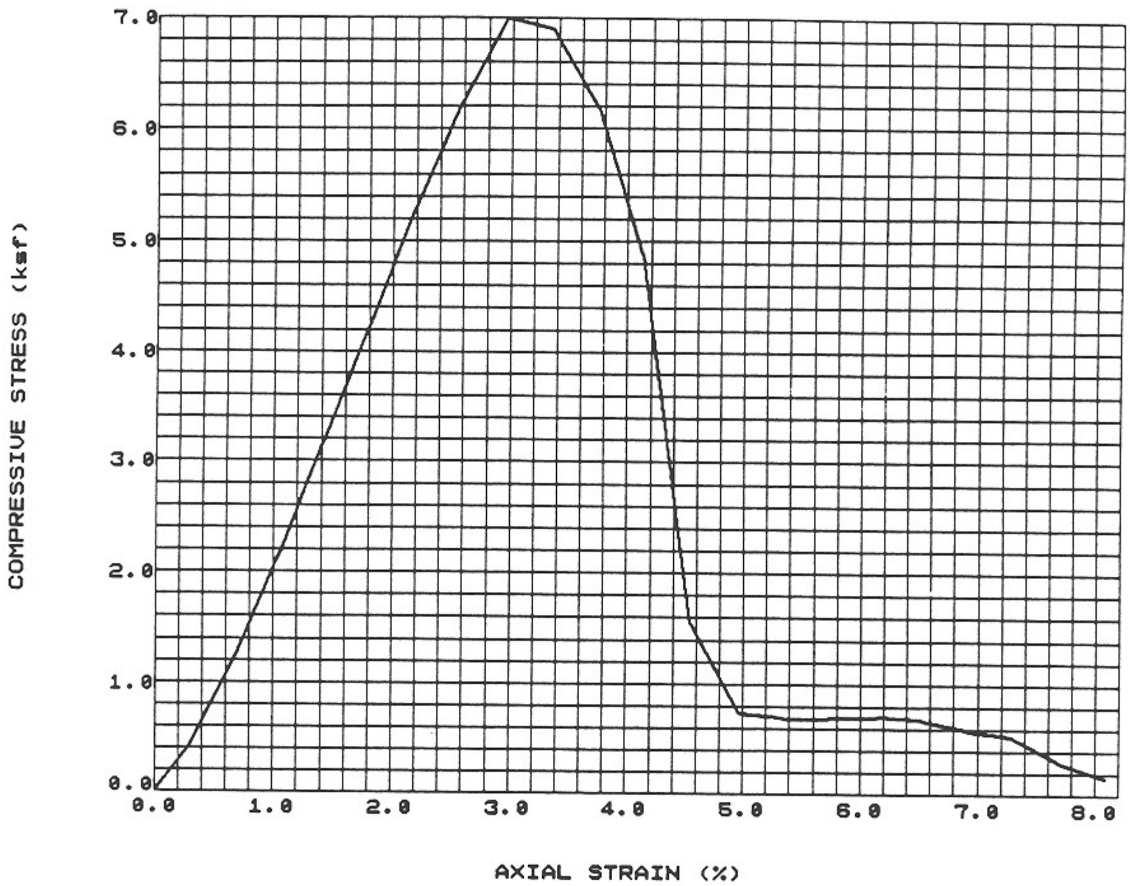
FIGURE B-59



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-3	D-20	100-101	DRIVE		6.98	0.16

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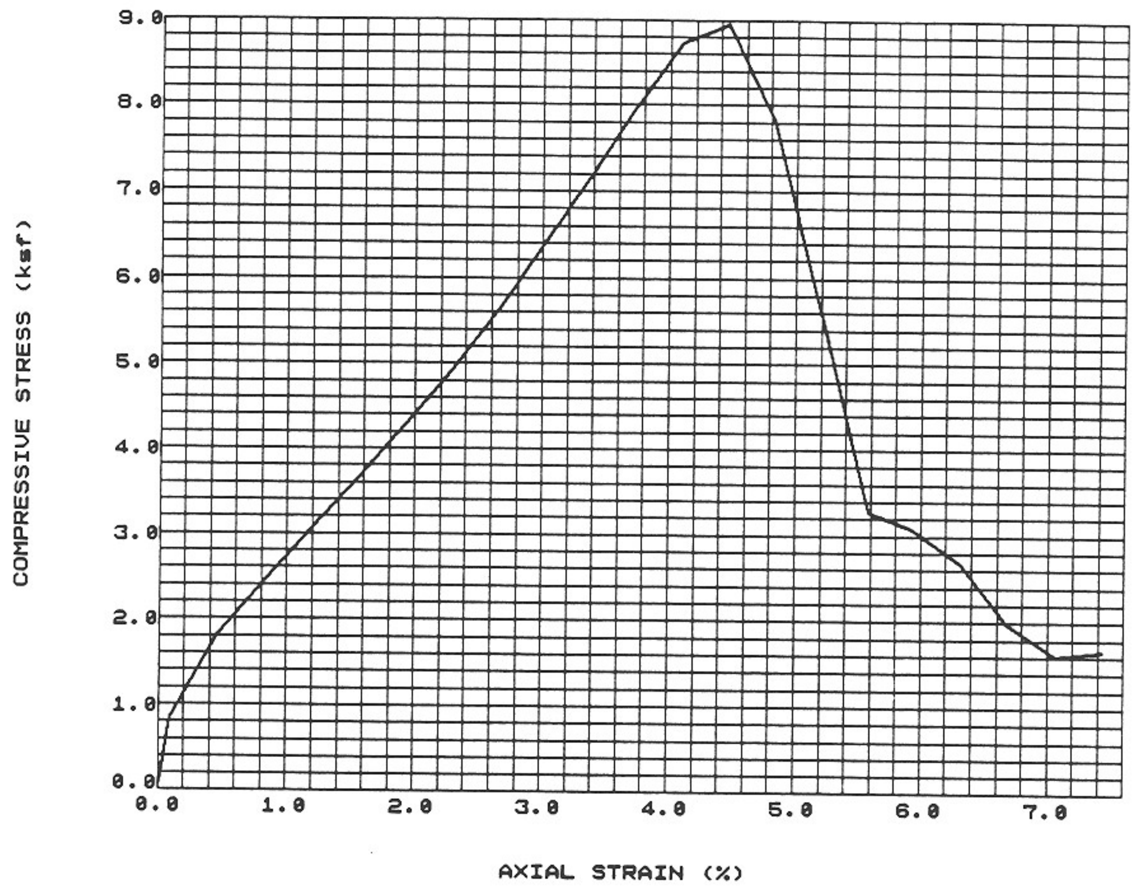
DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-4	D-9	45-46	DRIVE		8.95	1.66

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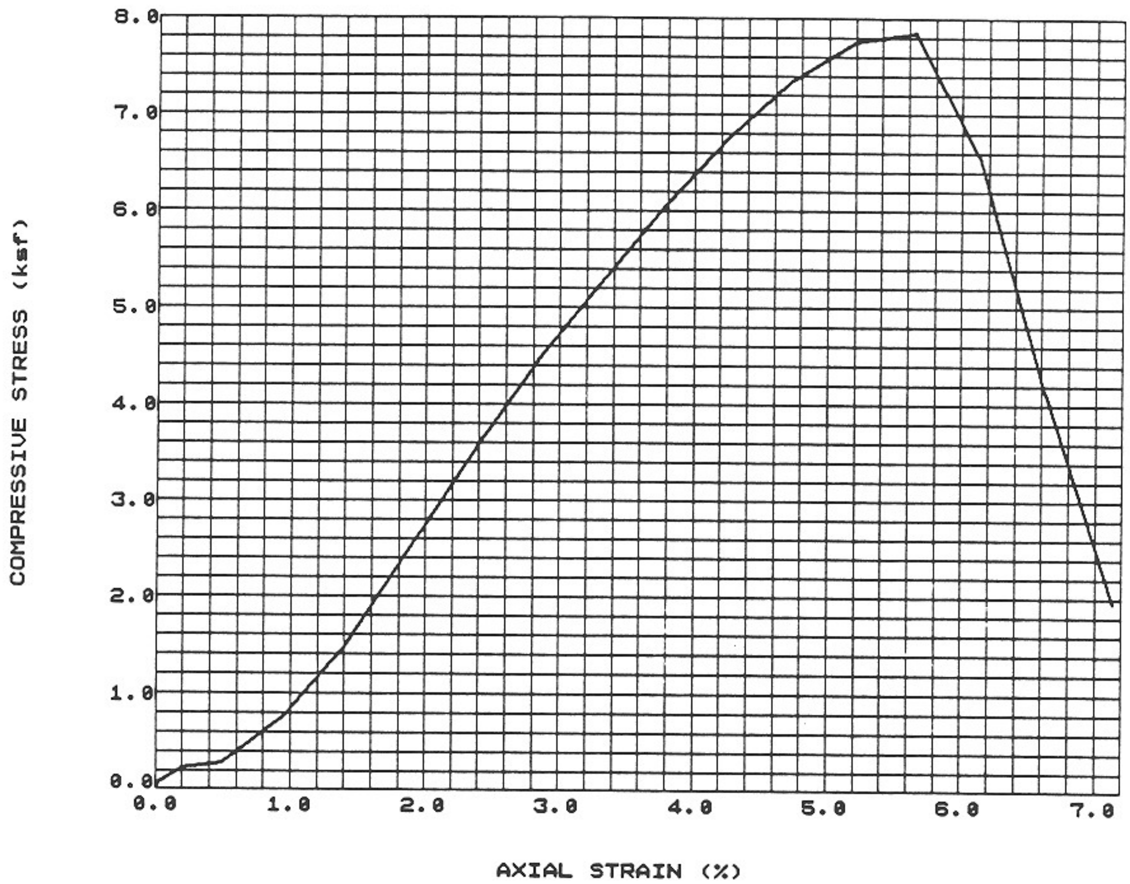
FIGURE B-61

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-4	D-11	55-56	DRIVE		7.85	1.94

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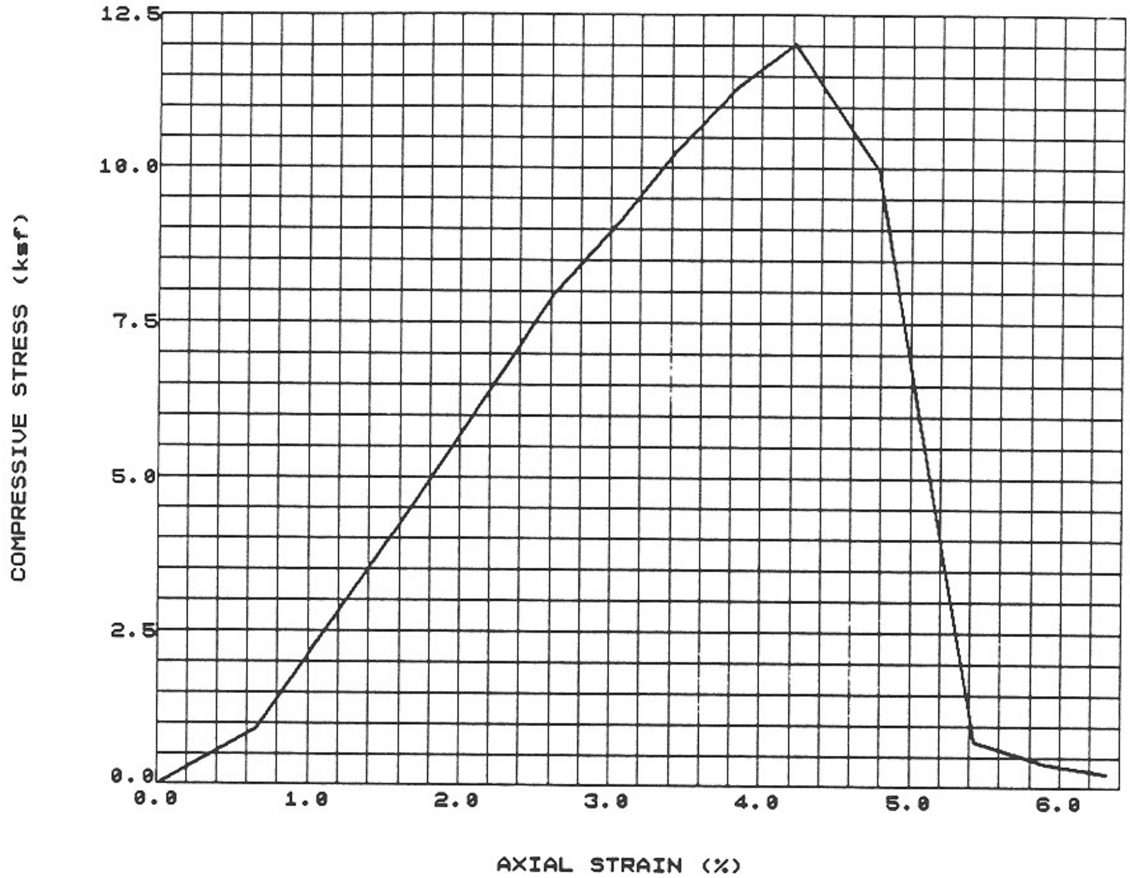
FIGURE B-62

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-4	D-13	65-66	DRIVE		12.01	0.21

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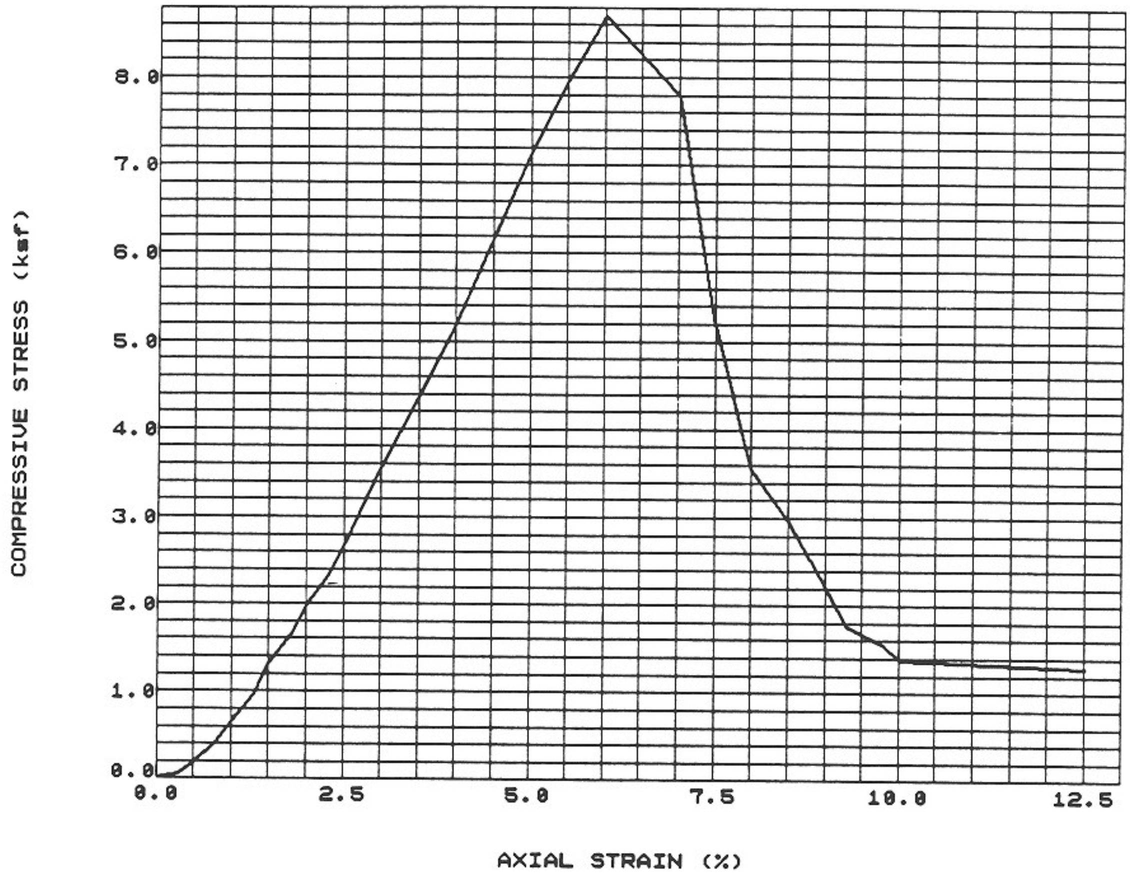
FIGURE B-63

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-4	D-15	75-76	DRIVE		8.69	1.28

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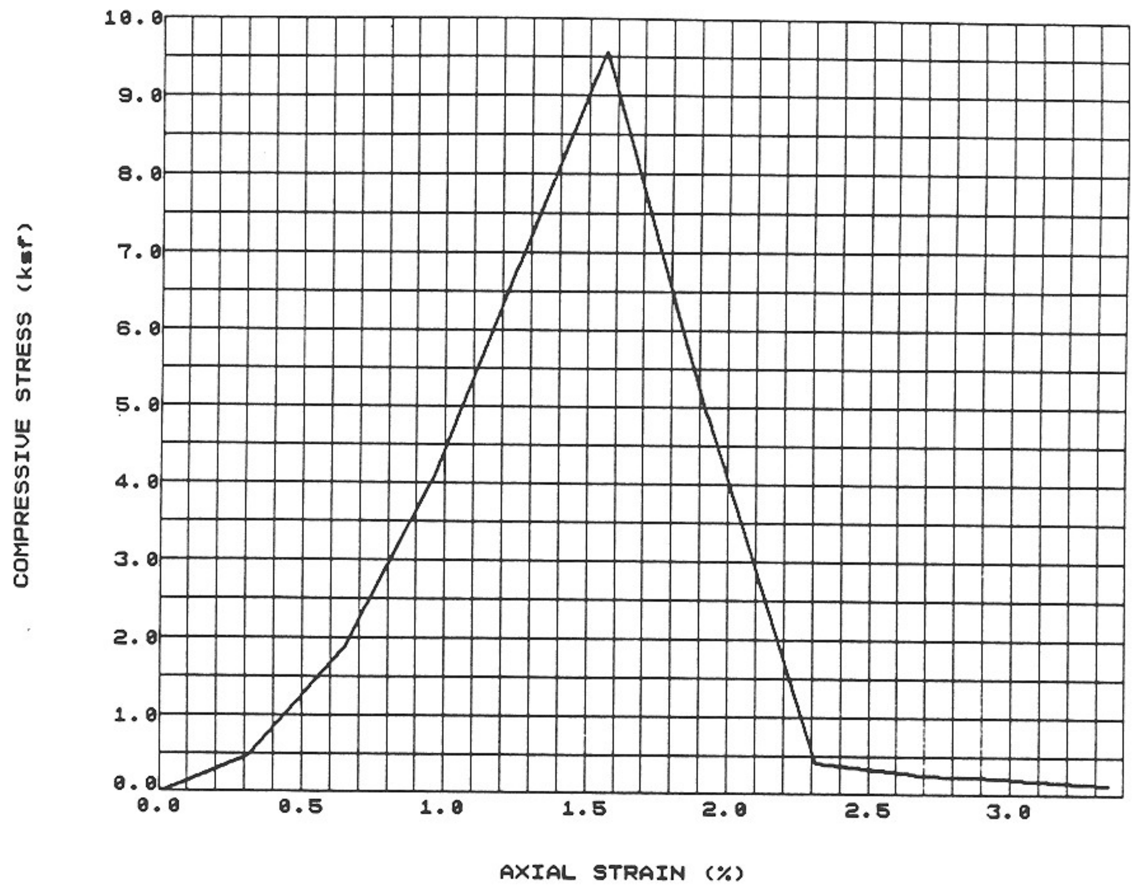
FIGURE B-64

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-4	P-18	90-91	PITCHER		9.54	0.13

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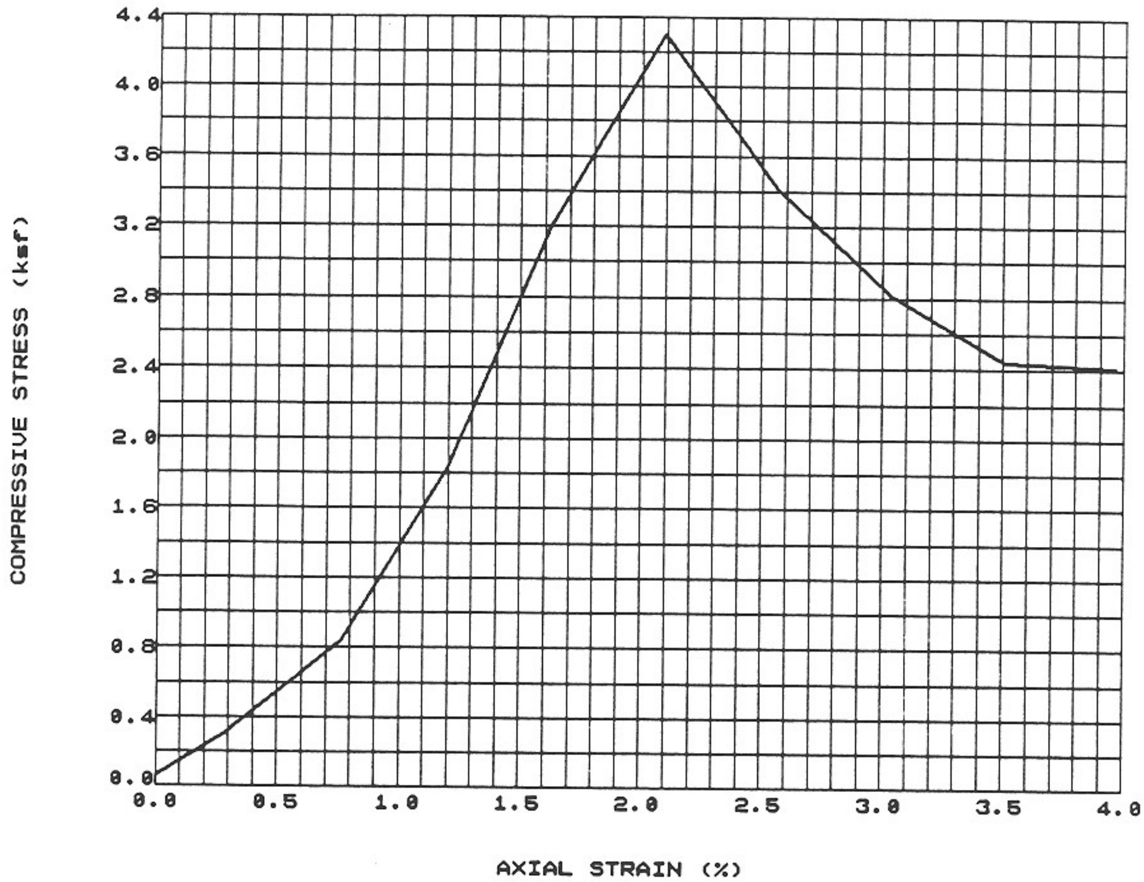
FIGURE B-65

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-5	D-17	85-86	DRIVE3		4.30	2.41

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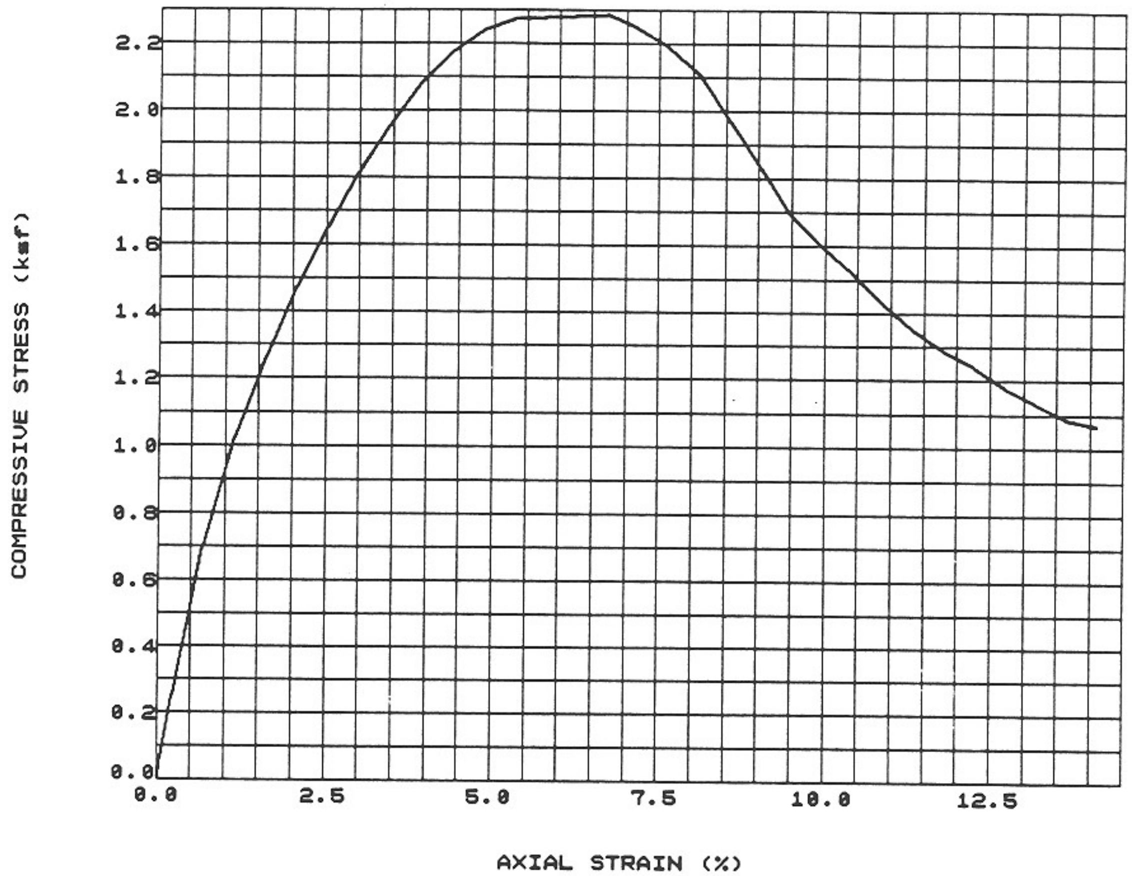
FIGURE B-66

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-6	D-8	40-41	DRIVE		2.28	1.06

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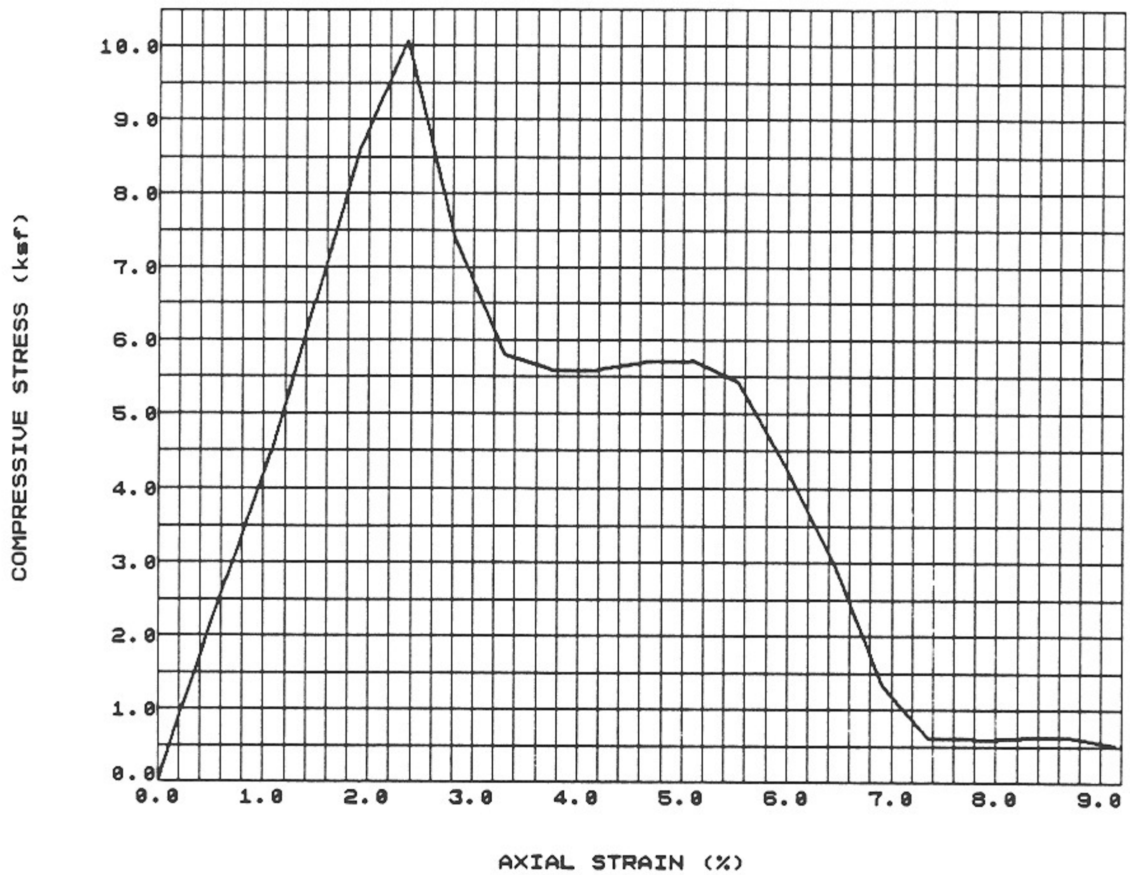
FIGURE B-67

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-7	D-13	65-66	DRIVE		10.06	0.51

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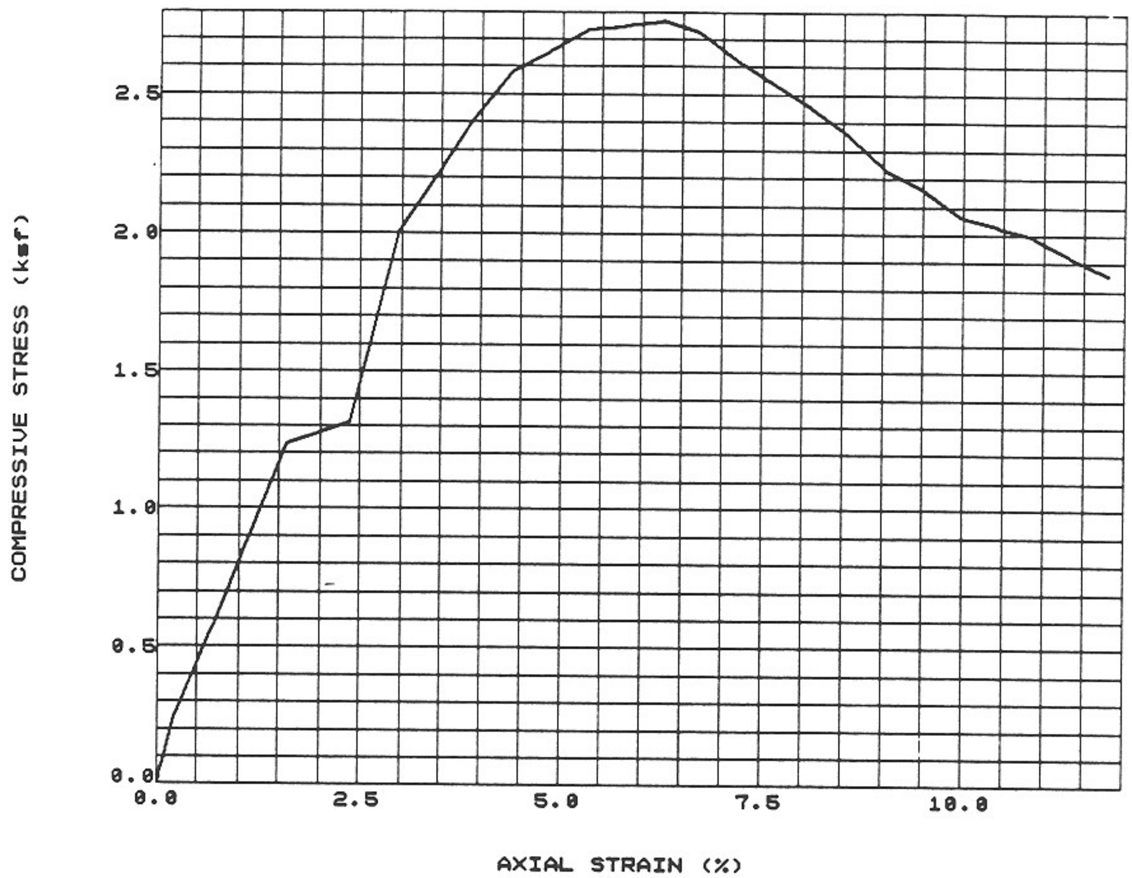
FIGURE B-68

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-8	D-7	35-36	DRIVE		2.76	1.85

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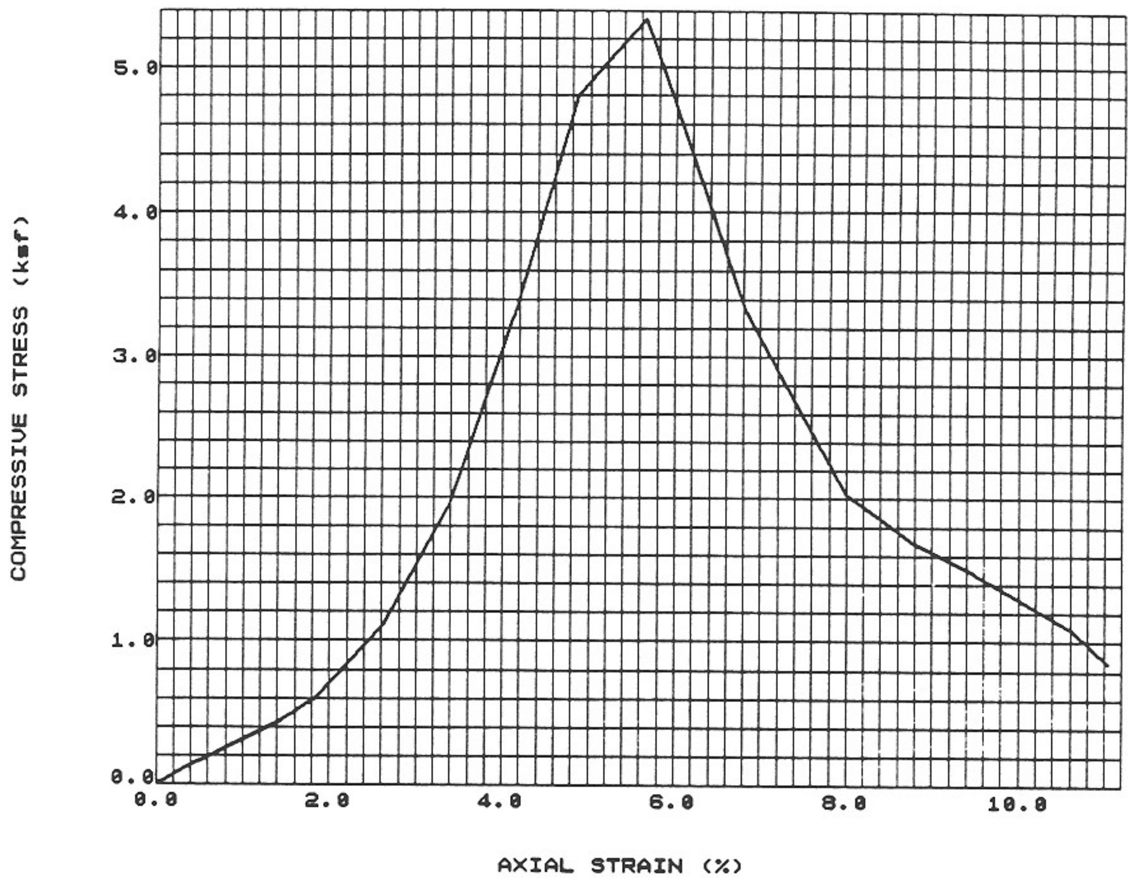
FIGURE B-69

DRAFT



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-8	P-12	60-62.5	PITCHER		5.34	0.85

The Earth Technology Corporation

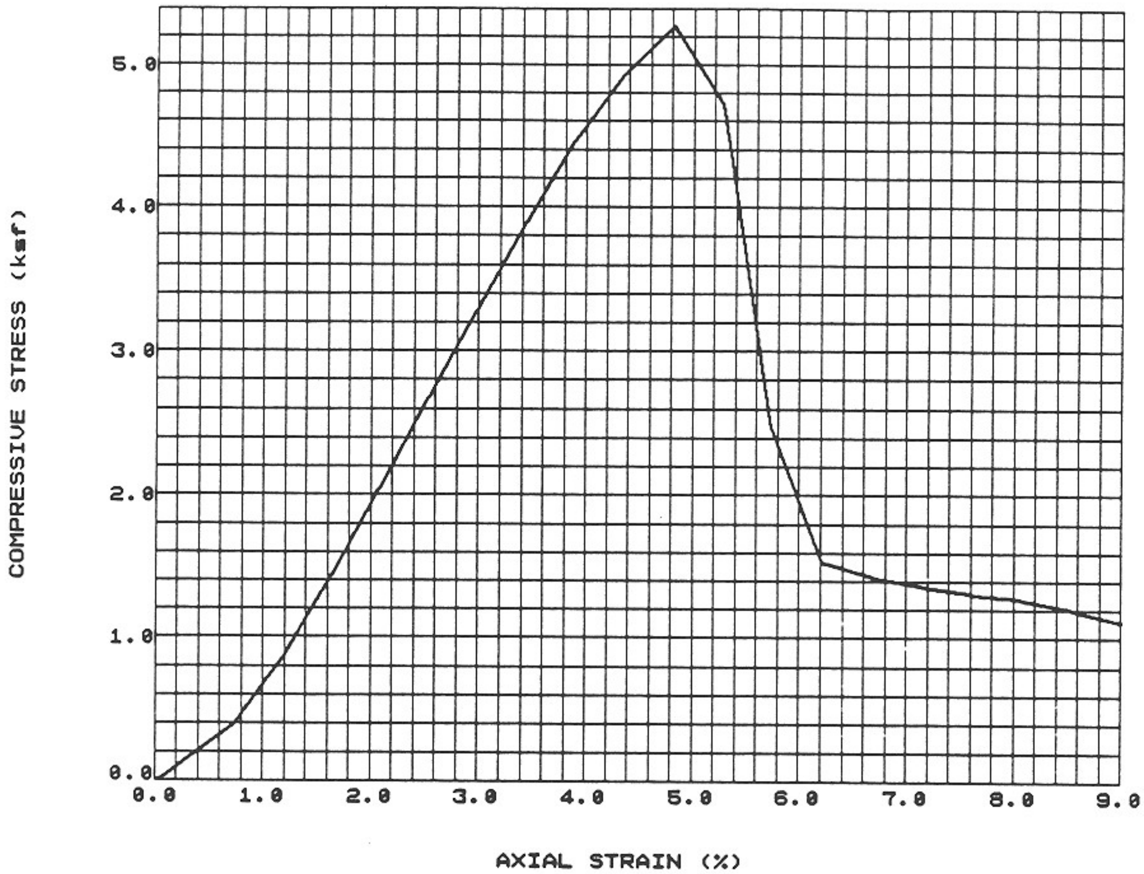
PROJECT NO.: 89-409

METRO RAIL
LPA-PHASE II

UNCONFINED COMPRESSION TEST RESULTS

06/89

FIGURE B-70



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-8	D-15	75-76	DRIVE		5.27	1.11

The Earth Technology Corporation

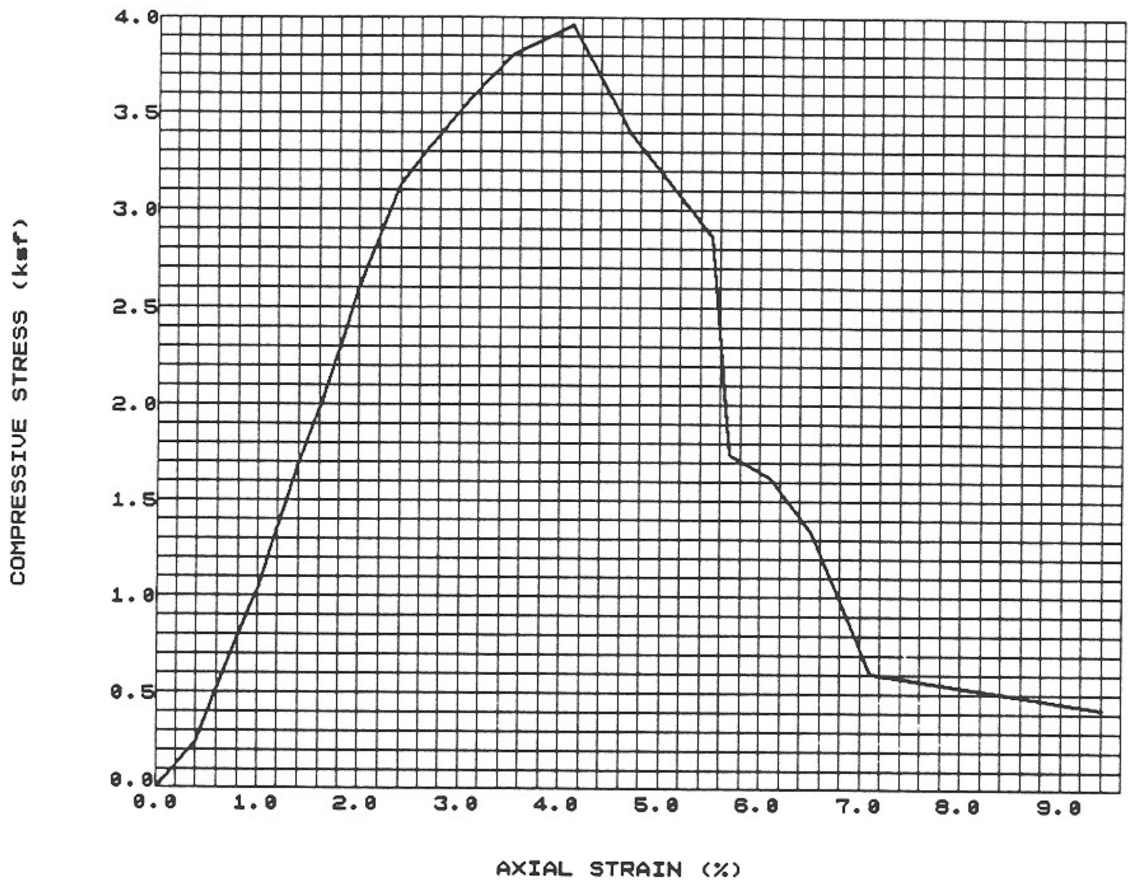
PROJECT NO.: 89-409

METRO RAIL
LPA-PHASE II

UNCONFINED COMPRESSION TEST RESULTS

06/89

FIGURE B-71



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-8	D-19	95-96	DRIVE		3.96	0.42

The Earth Technology Corporation

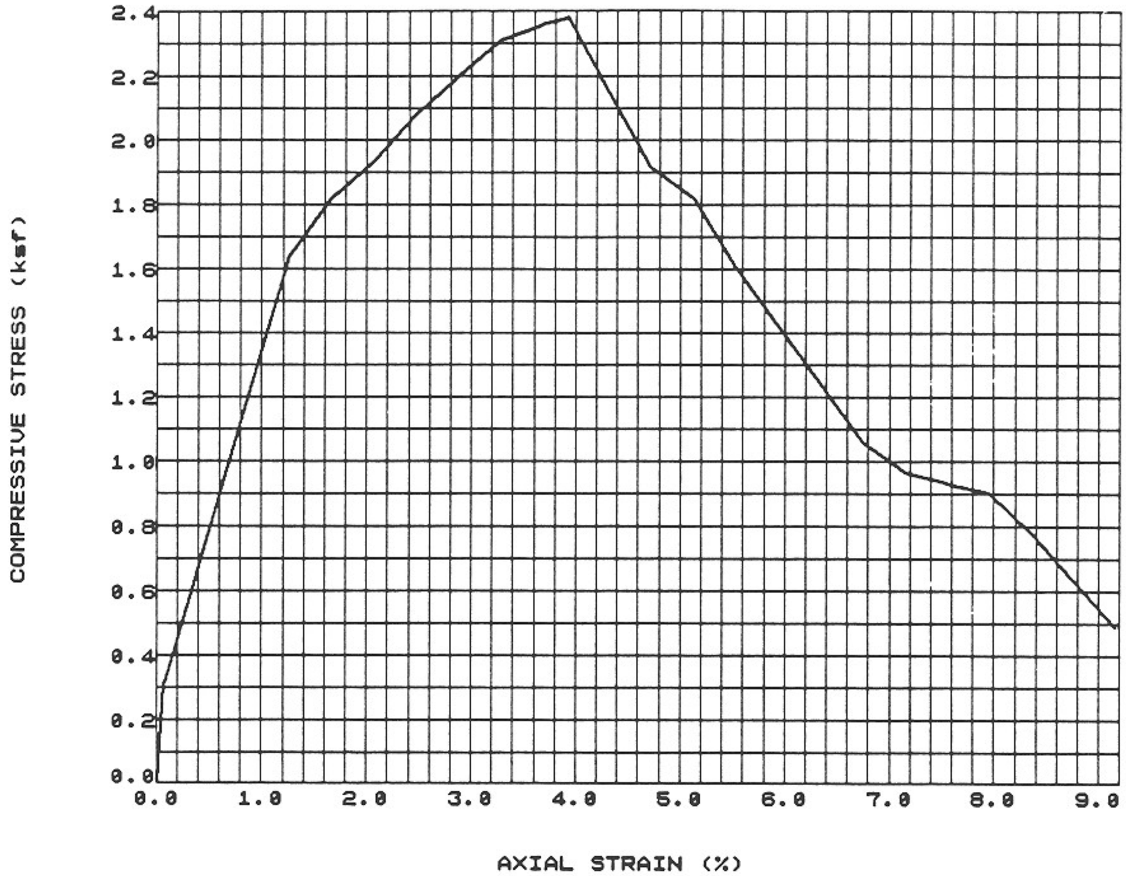
PROJECT NO.: 89-409

METRO RAIL
LPA-PHASE II

UNCONFINED COMPRESSION TEST RESULTS

06/89

FIGURE B-72



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-6D	D-7	35-36	DRIVE		2.38	0.48

The Earth Technology Corporation

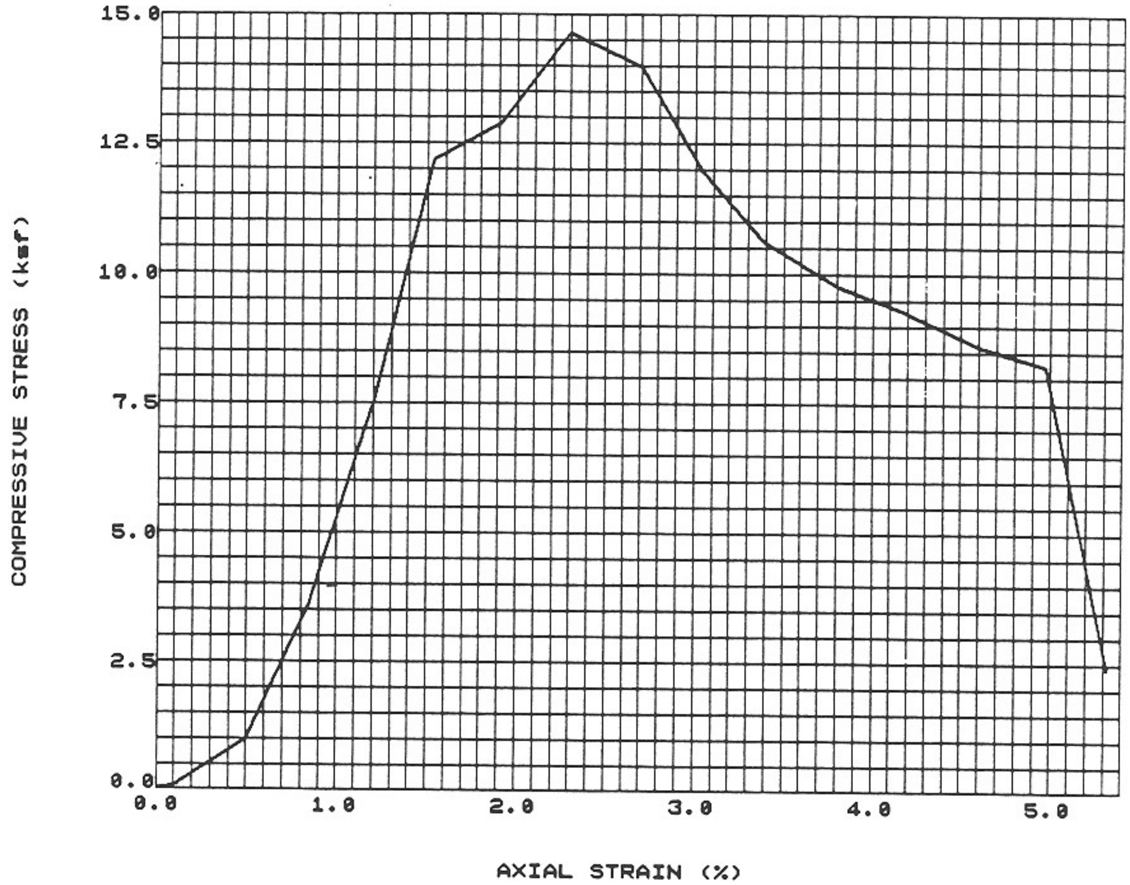
PROJECT NO.: 89-409

METRO RAIL
LPA-PHASE II

UNCONFINED COMPRESSION TEST RESULTS

06/89

FIGURE B-73



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-8D	P-10	50-52.5	PITCHER		14.6	2.39

The Earth Technology Corporation

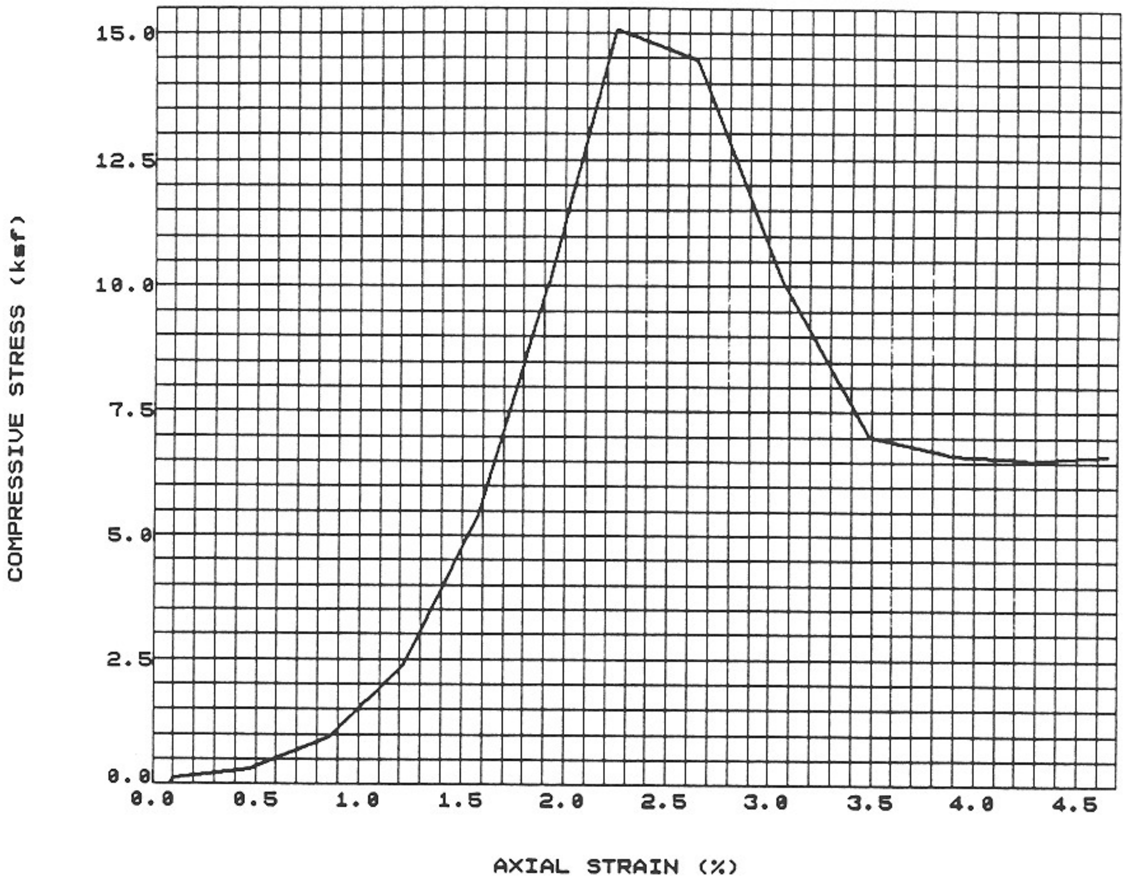
PROJECT NO.: 89-409

METRO RAIL LPA-PHASE II

UNCONFINED COMPRESSION TEST RESULTS

06/89

FIGURE B-74



SYMBOL	BORING NO.	SAMPLE NO.	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	COMPRESSIVE STRENGTH (ksf)	RESIDUAL STRENGTH (ksf)
	PII-8D	P-16	80-82.5	PITCHER		15.0	6.62

The Earth Technology Corporation

PROJECT NO.: 89-409

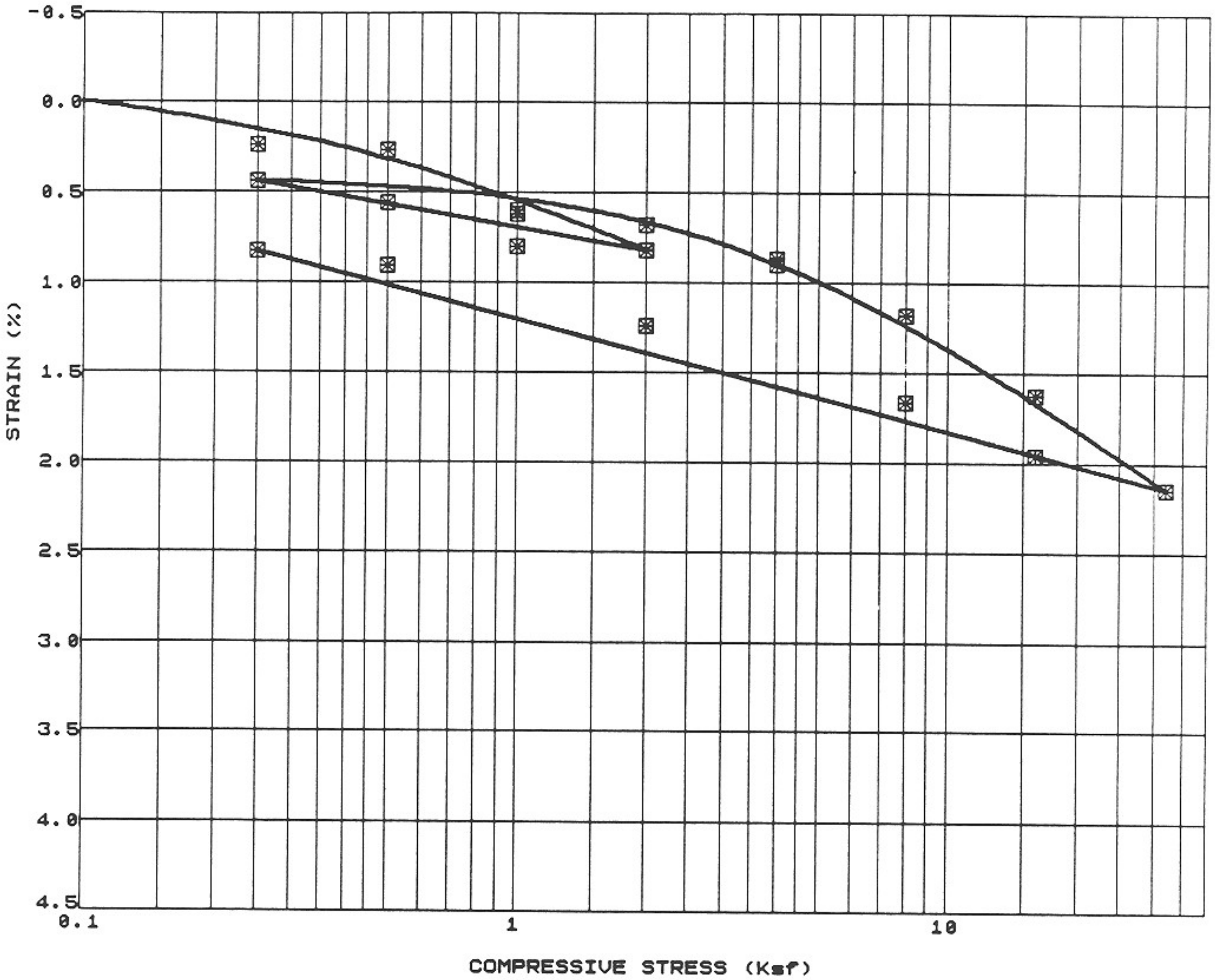
METRO RAIL
LPA-PHASE II

UNCONFINED COMPRESSION TEST RESULTS

06/89

FIGURE B-75

DRAFT



SYMBOL	BORING NO.	SAMPLE NO	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	Cc *	Cr *	REMARKS *
⊠	PII-1	P - 18	90.10	PITCHER		1.7	0.6	Coefficients Strain Related

The Earth Technology Corporation

PROJECT NO.: 89-409

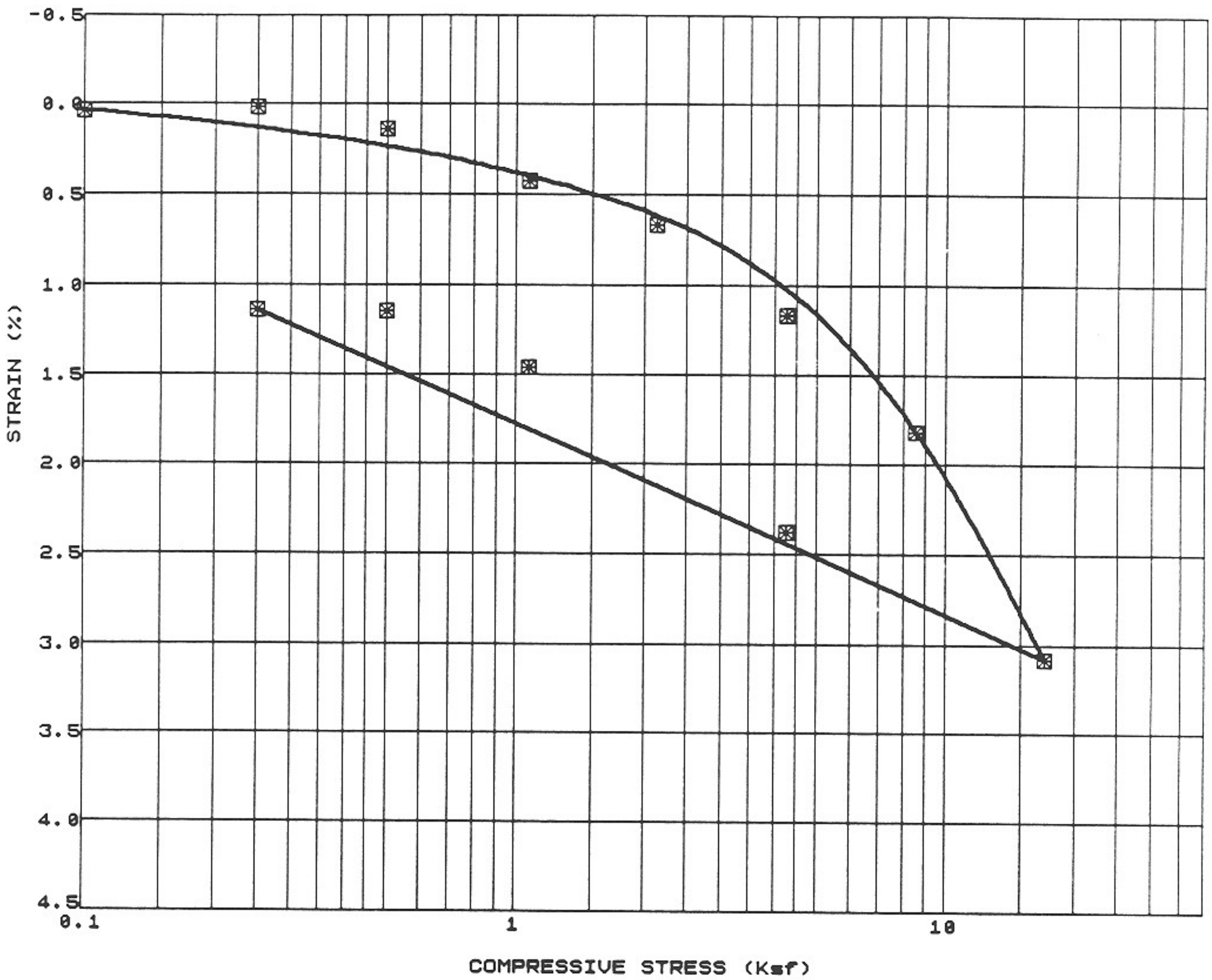
METRO RAIL
LPA-PHASE II

CONSOLIDATION TEST RESULTS

6/89

FIGURE B-76

DRAFT



SYMBOL	BORING NO.	SAMPLE NO	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	Cc *	Cr *	REMARKS *
⊠	PII-4	D-11	55.00	DRIVE		4.3	1.1	Coefficients Strain Related

The Earth Technology Corporation

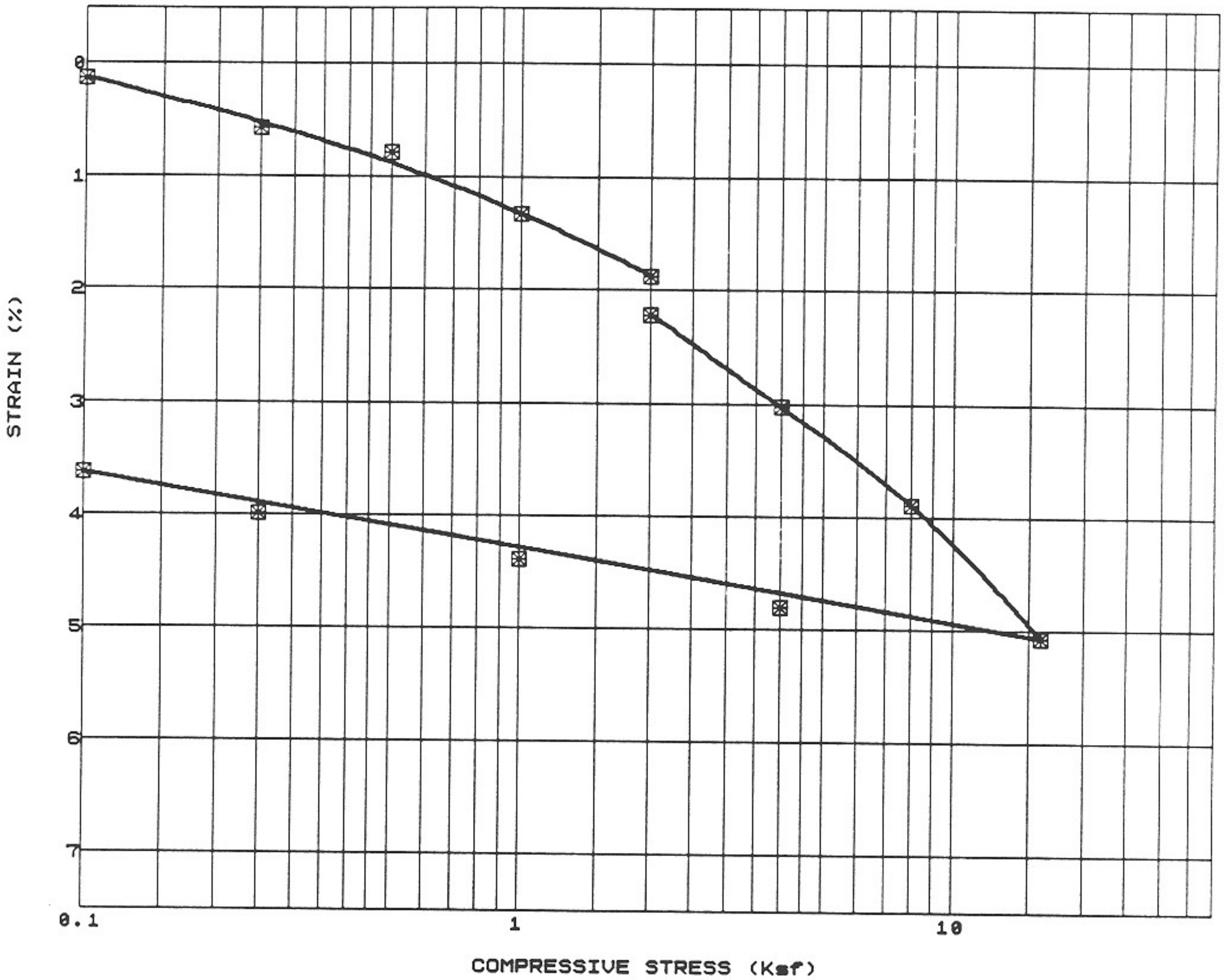
PROJECT NO.: 89-409

METRO RAIL
LPA-PHASE II

CONSOLIDATION TEST RESULTS

6/89

FIGURE B-77



SYMBOL	BORING NO.	SAMPLE NO	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	Cc *	Cr *	REMARKS *
⊠	PII-6	D-4	19.80	DRIVE	SM	3.9	0.7	Coefficients Strain Related

The Earth Technology Corporation

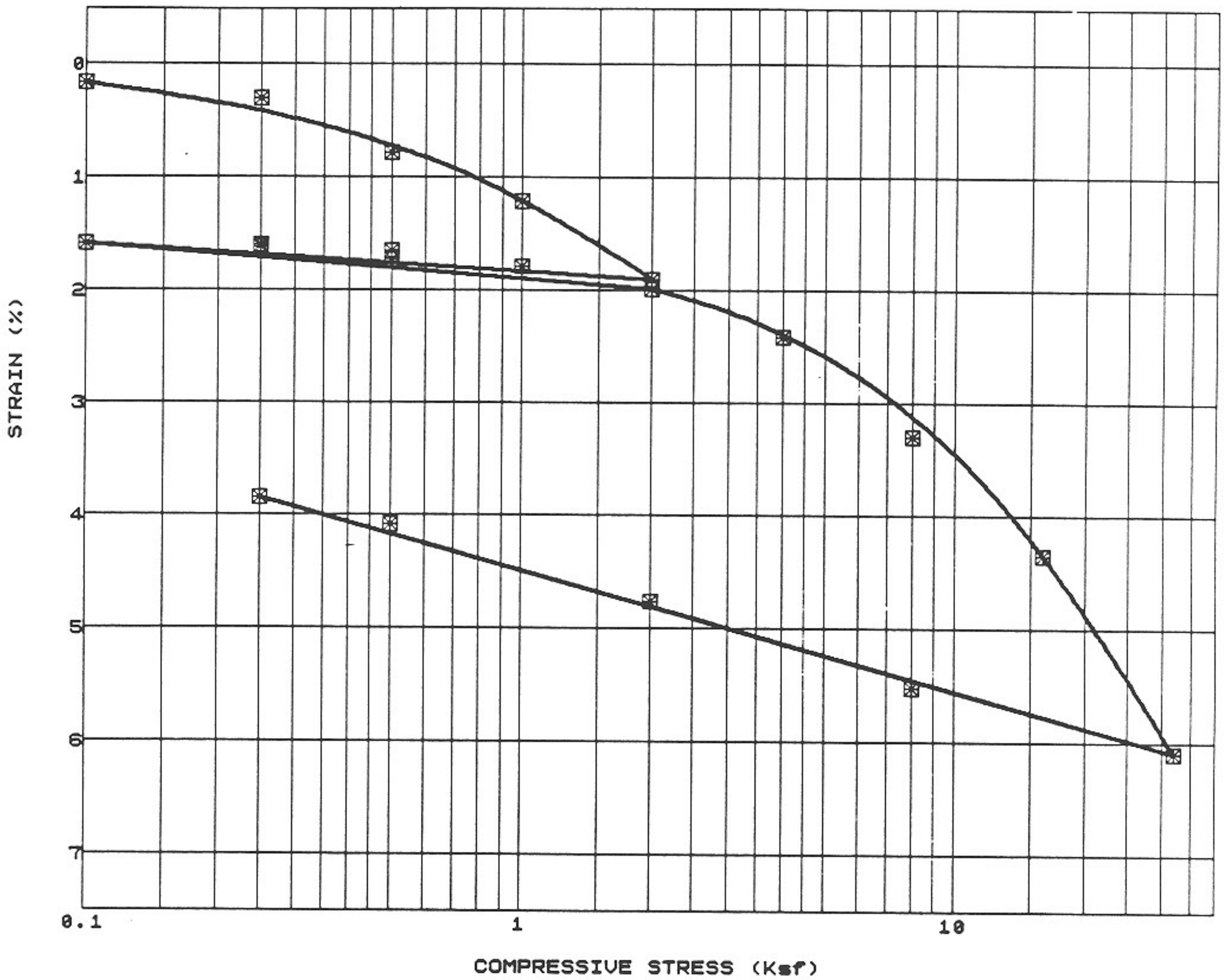
PROJECT NO.: 89-409

METRO RAIL LPA-PHASE II

CONSOLIDATION TEST RESULTS

6/89

FIGURE B-78



SYMBOL	BORING NO.	SAMPLE NO	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	Cc *	Cr *	REMARKS *
⊠	PII-6	P - 11	57.50	PITCHER		5.8	1.1	Coefficients Strain Related

The Earth Technology Corporation

PROJECT NO.: 89-409

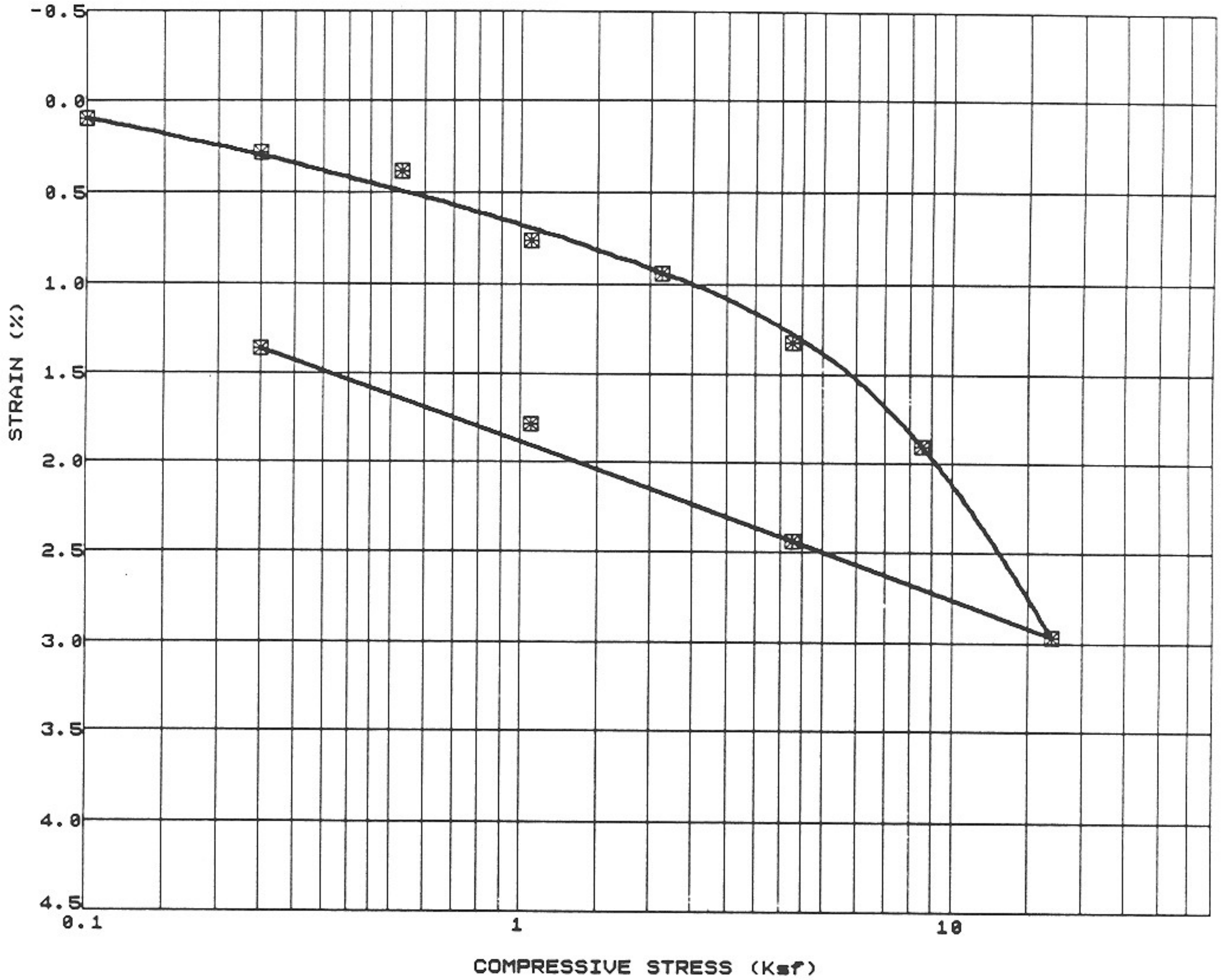
METRO RAIL
LPA-PHASE II

CONSOLIDATION TEST RESULTS

6/89

FIGURE B-79

DRAFT



SYMBOL	BORING NO.	SAMPLE NO	DEPTH (ft)	SAMPLE TYPE	SOIL TYPE	Cc *	Cr *	REMARKS *
⊠	PII-7	D-19	95.10	DRIVE		3.7	0.9	Coefficients Strain Related

The Earth Technology Corporation

PROJECT NO.: 89-409

METRO RAIL
LPA-PHASE II

CONSOLIDATION TEST RESULTS

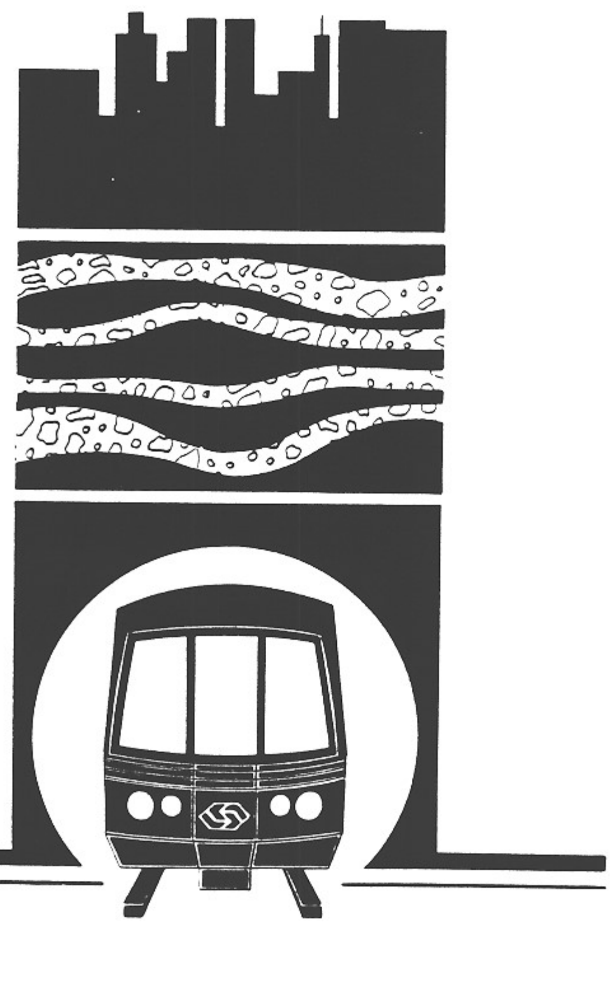
6/89

FIGURE B-80

DRAFT

Appendix C

Chemical Laboratory Test Results



APPENDIX C

CHEMICAL LABORATORY TEST RESULTS

A total of 13 soil and 7 water samples were selected and transported to CKY Environmental Services, Inc. of Torrance, California, for a limited characterization of potential chemical contamination. The results presented in their reports are included in this Appendix. A summary of the test results and potential effects on the LPA alignment construction are described in Section 3.2 (Tables 3-6 through 3-13) and Section 5.6, respectively.

DRAFT

C K Y incorporated
Environmental Services

Date: 04/21/89
890421

Earth Technology Corporation
3777 Long Beach Blvd.
Long Beach, CA 90807-3309

Attn: Mr. Bill Lu

Subject: Laboratory Report
Project: Metro Rail

Enclosed is the laboratory report for samples received on 04/18/89. The samples were received in coolers with ice and intact; the chain-of-custody forms were properly filled out. The data reported includes:

Method	No. of Analysis
EPA 602 (BTEX)	3 Water

The results are summarized on one page.

Please feel free to call if you have any questions concerning these results.

Sincerely,

Dr. Kam Pang
Laboratory Director

DRAFT

GY

EPA METHOD - 602
BTEX

CLIENT:	Earth Technology Corp.	DATE REC'D:	04/18/89
PROJECT:	Metro Rail/89-409-04	DATE ANALYZED:	04/18/89
CONTROL NO:	890421	MATRIX TYPE:	Water

		RESULTS (ug/L)			
SAMPLE ID:	CONTROL NO:	Benz	Toluene	Et Benz	Xyls
PII-5	890421-1	ND	ND	ND	ND
PII-5A	890421-2	ND	ND	ND	ND
EFB-1	890421-3	ND	ND	ND	ND
DETECTION LIMIT		0.5	1	1	1

DRAFT

CKY incorporated
Environmental Services

Date: 05/08/89
890421

Earth Technology Corporation
3777 Long Beach Blvd.
Long Beach, CA 90807-3309

Attn: Mr. Bill Lu

Subject: Laboratory Report
Project: Metro Rail

Enclosed is the laboratory report for samples received on 04/18/89. The samples were received in coolers with ice and intact; the chain-of-custody forms were properly filled out. The data reported includes:

Method	No. of Analysis
EPA 160.1 (TDS)	1 Water
EPA 376.1 (Sulfide)	1 Water

The results are summarized on two pages.

Please feel free to call if you have any questions concerning these results.

Sincerely,

Dr. Kam Pang
Laboratory Director

DRAFT

EPA METHOD 160.1
TOTAL DISSOLVED SOLIDS

CLIENT:	Earth Technology	**DATE REC'D:**	04/18/89
PROJECT:	Metro Rail/89-409-04	**DATE ANALYZED:**	05/06/89
CONTROL NO:	890421	**MATRIX TYPE:**	Water

SAMPLE ID:	**CONTROL NO:**	**RESULTS (mg/L)**	**DETECTION LIMIT (mg/L)**
PII-5	890421-1	1600	100

DRAFT

EPA METHOD 376.1
SULFIDE

CLIENT:	Earth Technology	**DATE REC'D:**	04/18/89
PROJECT:	Metro Rail/89-409-04	**DATE ANALYZED:**	05/06/89
CONTROL NO:	890421	**MATRIX TYPE:**	Water

SAMPLE ID:	**CONTROL NO:**	**RESULTS (mg/L)**	**DETECTION LIMIT (mg/L)**
PII-5A	890421-1	ND	1

DRAFT

C K Y incorporated
Environmental Services

Date: 05/23/89
890523

Earth Technology Corporation
3777 Long Beach Blvd.
Long Beach, CA 90807-3309

Attn: Mr. Bill Lu

Subject: Laboratory Report
Project: Metro Rail II/89-212-0105

Enclosed is the laboratory report for samples received on 05/08/89. The samples were received in coolers with ice and intact; the chain-of-custody forms were properly filled out. The data reported includes:

Method	No. of Analysis
EPA 418.1 (TRPH)	9 Soils
EPA 8020 (BTEX)	9 Soils
Method 9038	9 Soils

The results are summarized on four pages.

Please feel free to call if you have any questions concerning these results.

Sincerely,

Dr. Kam Pang
Laboratory Director

3551 Voyager St., Suite 102, Torrance, ...

DRAFT

GKY

EPA METHOD 418.1
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS

CLIENT:	The Earth Technology	**DATE REC'D:**	05/08/89
PROJECT:	Metro Rail II	**DATE EXTRACTED:**	05/09/89
CONTROL NO:	890523	**DATE ANALYZED:**	05/10/89
MATRIX TYPE:	Soil		

SAMPLE ID:	CONTROL NO:	RESULTS (mg/kg)	DETECTION LIMIT (mg/kg)
PII-1 D-9	890523-1	ND	5
PII-1 D-13	890523-2	ND	5
PII-2 D-1	890523-3	ND	5
PII-2 D-3	890523-4	ND	5
PII-3 D-2	890523-5	ND	5
PII-3 D-6	890523-6	ND	5
PII-4 D-15	890523-7	ND	5
PII-4 D-19	890523-8	ND	5
PII-7 D-15	890523-9	ND	5

DRAFT

GKY

QUALITY CONTROL DATA

CLIENT: The Earth Technology Corp.
PROJECT: Metro Rail II
CKY I.D.: 890523

METHOD 418.1
MATRIX: Soil

SAMPLE ID: 890523-06

COMPOUND	SAMPLE RESULTS (mg/kg)	AMOUNT SPIKED (mg/kg)	% REC.	DUP. % REC.	RPD
IR Ref Oil	ND	100	120	130	8

METHOD 8020
MATRIX: Soil

SAMPLE ID: 890523-01

COMPOUND	SAMPLE RESULTS (ppb)	AMOUNT SPIKED (ppb)	% REC.	DUP. % REC.	RPD
Benzene	1.1	20	90	100	11
Toluene	24	20	90	80	12
Et. Benzene	8.7	20	72	82	13
Xylenes	62	40	95	118	17

METHOD 9038
MATRIX: Soil

SAMPLE ID: 890523-04

COMPOUND	SAMPLE RESULTS (mg/L)	AMOUNT SPIKED (mg/L)	% REC.	DUP. % REC.	RPD
Sulfate	260	200	90	80	5

DRAFT

GKY

EPA METHOD - 8020
BTEX

CLIENT:	The Earth Technology	**DATE REC'D:**	05/08/89
PROJECT:	Metro Rail II	**DATE EXTRACTED:**	05/09/89
CONTROL NO:	890523	**DATE ANALYZED:**	05/12/89
MATRIX TYPE:	Soil		

SAMPLE ID:	CONTROL NO:	Benz	Toluene	Et Benz	Xyls
		RESULTS (ug/kg)			
PII-1 D-9	890523-1	<5	24	8.7	62
PII-1 D-13	890523-2	<5	320	<5	13
PII-2 D-1	890523-3	ND	<5	ND	<5
PII-2 D-3	890523-4	ND	ND	ND	ND
PII-3 D-2	890523-5	ND	ND	ND	ND
PII-3 D-6	890523-6	ND	ND	ND	ND
PII-4 D-15	890523-7	21	100	8.3	34
PII-4 D-19	890523-8	5.8	33	<5	29
PII-7 D-15	890523-9	<5	180	<5	14
DETECTION LIMIT		5	5	5	5

DRAFT

GKY

EPA METHOD 9038
SULFATES

CLIENT:	The Earth Technology	**DATE REC'D:**	05/08/89
PROJECT:	Metro Rail II	**DATE EXTRACTED:**	N/A
CONTROL NO:	890523	**DATE ANALYZED:**	05/15/89
MATRIX TYPE:	Soil		

SAMPLE ID:	CONTROL NO:	RESULTS (mg/L SO_4)	DETECTION LIMIT (mg/L)
PII-1 D-19	890523-1	160	10
PII-1 D-13	890523-2	350	10
PII-2 D-1	890523-3	410	10
PII-2 D-3	890523-4	260	10
PII-3 D-2	890523-5	280	10
PII-3 D-6	890523-6	230	10
PII-4 D-15	890523-7	220	10
PII-4 D-19	890523-8	140	10
PII-7 D-15	890523-9	410	10

DRAFT

CKY incorporated
Environmental Services

Date: 05/30/89
890533

Earth Technology Corporation
3777 Long Beach Blvd.
Long Beach, CA 90807-3309

Attn: Mr. Bill Lu

Subject: Laboratory Report
Project: Metro Rail II/89-212-0105

Enclosed is the laboratory report for samples received on 05/15/89. The samples were received in coolers with ice and intact; the chain-of-custody forms were properly filled out. The data reported includes:

Method	No. of Analysis
EPA 418.1 (TRPH)	28 Soils
EPA 8020 (BTEX)	28 Soils
Method 9038 (Sulfates)	28 Soils

The results are summarized on six pages.

Please feel free to call if you have any questions concerning these results.

Sincerely,

Dr. Kam Pang
Laboratory Director

5551 Voyager St., Suite 102, Torrance, Ca. [illegible]

DRAFT

EPA METHOD 418.1
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS

CLIENT:	The Earth Technology	**DATE REC'D:**	05/15/89
PROJECT:	Metro Rail II	**DATE EXTRACTED:**	05/17/89
CONTROL NO:	890533	**DATE ANALYZED:**	05/18/89
MATRIX TYPE:	Soil		

SAMPLE ID:	**CONTROL NO:**	**RESULTS (mg/kg)**	**DETECTION LIMIT (mg/kg)**
PII-8 D-5	890533-1	ND	5
PII-8 D-11	890533-2	ND	5
PII-8 D-17	890533-3	ND	5
PII-9 D-6	890533-4	ND	5
PII-9 D-16	890533-5	45	5
PII-10 D-12	890533-6	190	5
PII-11 D-5	890533-7	ND	5
PII-11 D-13	890533-8	ND	5
PII-12 D-9	890533-9	210	5
PII-12 D-15	890533-10	190	5
PII-13 D-11	890533-11	14,000	5
PII-15 D-5	890533-12	25	5
PII-15 D-11	890533-13	68,000	5
PII-16 D-7	890533-14	36	5
P11-16 D-9	890533-15	25,000	5
P11-17 D-6	890533-16	8,800	5
PII-17 D-10	890533-17	100	5
PII-18 D-5	890533-18	ND	5
PII-18 D-9	890533-19	930	5
PII-20 D-2	890533-20	ND	5
PII-20 D-8	890533-21	34	5
PII-21B D-5	890533-22	5.4	5
PII-21B D-11	890533-23	180	5
PII-22 D-3	890533-24	ND	5
PII-22 D-9	890533-25	81	5
PII-23 D-4	890533-26	ND	5
PII-24 D-2	890533-27	ND	5
PII-24 D-14	890533-28	72	5

DRAFT

GKY

EPA METHOD - 8020
BTEX

CLIENT:	The Earth Technology	**DATE REC'D:**	05/15/89
PROJECT:	Metro Rail II	**DATE EXTRACTED:**	05/20/89
CONTROL NO:	890533	**DATE ANALYZED:**	05/20/89
MATRIX TYPE:	Soil		

		RESULTS (ug/kg)			
SAMPLE ID:	CONTROL NO:	Benz	Toluene	Et Benz	Xyls
PII-8 D-5	890533-1	ND	ND	ND	ND
PII-8 D-11	890533-2	7.2	41	ND	5.1
PII-8 D-17	890533-3	ND	31	ND	ND
PII-9 D-6	890533-4	<5	5.9	ND	ND
PII-9 D-16	890533-5	ND	25	ND	<5
PII-10 D-12	890533-6	<5	22	ND	<5
PII-11 D-5	890533-7	ND	ND	ND	ND
PII-11 D-13	890533-8	9.3	70	ND	8.7
PII-12 D-9	890533-9	<5	170	ND	<5
PII-12 D-15	890533-10	ND	26	ND	ND
PII-13 D-11	890533-11	ND	ND	ND	ND
PII-15 D-5	890533-12	ND	ND	ND	ND
PII-15 D-11	890533-13	<5	32	ND	17
PII-16 D-7	890533-14	ND	<5	ND	ND
P11-16 D-9	890533-15	ND	5.3	ND	ND
P11-17 D-6	890533-16	ND	10	ND	ND
PII-17 D-10	890533-17	ND	9.5	ND	ND
PII-18 D-5	890533-18	ND	<5	ND	ND
PII-18 D-9	890533-19	ND	24	ND	9.2
PII-20 D-2	890533-20	ND	ND	ND	ND
PII-20 D-8	890533-21	ND	18	ND	ND
PII-21B D-5	890533-22	ND	13	ND	5.4
PII-21B D-11	890533-23	<5	47	<5	6.4
PII-22 D-3	890533-24	ND	ND	ND	ND
PII-22 D-9	890533-25	ND	11	ND	ND
PII-23 D-4	890533-26	ND	12	ND	ND
PII-24 D-2	890533-27	27	25	ND	11
PII-24 D-14	890533-28	ND	54	ND	ND
DETECTION LIMIT		5	5	5	5

DRAFT

EPA METHOD 9038
SULFATES

CLIENT:	The Earth Technology	**DATE REC'D:**	05/15/89
PROJECT:	Metro Rail II	**DATE EXTRACTED:**	05/25/89
CONTROL NO:	890533	**DATE ANALYZED:**	05/25/89
MATRIX TYPE:	Soil		

SAMPLE ID:	CONTROL NO:	RESULTS (mg/L SO_4)	DETECTION LIMIT (mg/L)
PII-8 D-5	890533-1	31	10
PII-8 D-11	890533-2	250	10
PII-8 D-17	890533-3	110	10
PII-9 D-6	890533-4	140	10
PII-9 D-16	890533-5	240	10
PII-10 D-12	890533-6	750	10
PII-11 D-5	890533-7	880	10
PII-11 D-13	890533-8	360	10
PII-12 D-9	890533-9	220	10
PII-12 D-15	890533-10	490	10
PII-13 D-11	890533-11	200	10
PII-15 D-5	890533-12	105	10
PII-15 D-11	890533-13	315	10
PII-16 D-7	890533-14	30	10
P11-16 D-9	890533-15	900	10
P11-17 D-6	890533-16	680	10
PII-17 D-10	890533-17	1180	10
PII-18 D-5	890533-18	80	10
PII-18 D-9	890533-19	340	10
PII-20 D-2	890533-20	70	10
PII-20 D-8	890533-21	390	10
PII-21B D-5	890533-22	110	10
PII-21B D-11	890533-23	770	10
PII-22 D-3	890533-24	50	10
PII-22 D-9	890533-25	580	10
PII-23 D-4	890533-26	1040	10
PII-24 D-2	890533-27	66	10
PII-24 D-14	890533-28	460	10

DRAFT

CKY

QUALITY CONTROL DATA

CLIENT: The Earth Technology Corp.
PROJECT: Metro Rail II
CKY I.D.: 890533

==

METHOD 418.1
MATRIX: Soil

SAMPLE ID: 890533-08

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
IR Ref Oil	ND	112	107	98	9

METHOD 418.1
MATRIX: Soil

SAMPLE ID: 890533-18

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
IR Ref Oil	ND	112	120	116	4

METHOD 418.1
MATRIX: Soil

SAMPLE ID: 890533-20

COMPOUND	SAMPLE RESULTS (ppm)	AMOUNT SPIKED (ppm)	% REC.	DUP. % REC.	RPD
IR Ref Oil	ND	112	98	103	4

DRAFT

CKY

QUALITY CONTROL DATA

CLIENT: The Earth Technology Corp.
PROJECT: Metro Rail II
CKY I.D.: 890533

METHOD 8020
MATRIX: Soil

SAMPLE ID: 890533-01

COMPOUND	SAMPLE RESULTS (ppb)	AMOUNT SPIKED (ppb)	% REC.	DUP. % REC.	RPD
Benzene	ND	20	80	95	17
Toluene	ND	20	90	110	20
Et. Benzene	ND	20	70	80	11
Xylenes	ND	40	95	105	10

METHOD 8020
MATRIX: Soil

SAMPLE ID: 890533-11

COMPOUND	SAMPLE RESULTS (ppb)	AMOUNT SPIKED (ppb)	% REC.	DUP. % REC.	RPD
Benzene	ND	20	80	90	12
Toluene	ND	20	95	100	5
Et. Benzene	ND	20	75	85	13
Xylenes	ND	40	100	115	14

DRAFT

CKY

QUALITY CONTROL DATA

CLIENT: The Earth Technology Corp.
PROJECT: Metro Rail II
CKY I.D.: 890533

METHOD 8020
MATRIX: Soil

SAMPLE ID: 890533-21

COMPOUND	SAMPLE RESULTS (ppb)	AMOUNT SPIKED (ppb)	% REC.	DUP. % REC.	RPD
Benzene	ND	20	95	85	11
Toluene	18	20	85	60	34
Et. Benzene	ND	20	80	75	6
Xylenes	ND	20	105	105	0

DRAFT

C K Y Incor...
Environmental ...

Date: 06/06/89
890601

The Earth Technology Corporation
3777 Long Beach Blvd.,
Long Beach, CA 90807-3309

Attn: Mr. Bill Lu

Subject: Laboratory Report
Project: Metro Rail/89-409-06

Enclosed is the laboratory report for samples received on 06/01/89. The samples were received in coolers with ice and intact; the chain-of-custody forms were properly filled out. The data reported includes:

Method	No. of Analysis
EPA 418.1 (TRPH)	2 Water
EPA 602 (BTEX)	1 Water
Sulfate 9038	2 Water
Sulfide 9030	1 Water
PH 9040	2 Water

The results are summarized on six pages.

Please feel free to call if you have any questions concerning these results.

Sincerely,

Dr. Kam Pang
Laboratory Director

DRAFT

GKY

EPA METHOD 418.1
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	06/01/89
PROJECT:	Metro Rail/89-409-06	**DATE EXTRACTED:**	06/03/89
CONTROL NO:	890601	**DATE ANALYZED:**	06/03/89
MATRIX TYPE:	Water		

SAMPLE ID:	CONTROL NO:	RESULTS (ppm)	DETECTION LIMIT (ppm)
PII-5	890601-1	<1	1
LPE 1	890601-2	1.2	1

DRAFT

GKY

EPA METHOD - 602
BTEX

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	06/01/89
PROJECT:	Metro Rail/89-409-06	**DATE EXTRACTED:**	06/02/89
CONTROL NO:	890601	**DATE ANALYZED:**	06/02/89
MATRIX TYPE:	Water		

			RESULTS (ug/L)		
SAMPLE ID:	CONTROL NO:	Benz	Toluene	Et Benz	Xyls
LPE 1	890601-2	2.7	9.0	ND	ND
DETECTION LIMIT		0.5	1	1	1

DRAFT

GKY

EPA METHOD 9038
SULFATE

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	06/01/89
PROJECT:	Metro Rail/89-409-06	**DATE EXTRACTED:**	06/03/89
CONTROL NO:	890601	**DATE ANALYZED:**	06/03/89
MATRIX TYPE:	Water		

SAMPLE ID:	**CONTROL NO:**	**RESULTS (mg/L SO_4)**	**DETECTION LIMIT (mg/L SO_4)**
PII-5	890601-1	1500	10
LPE 1	890601-2	600	10

DRAFT

GY

EPA METHOD 9030
SULFIDE

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	06/01/89
PROJECT:	Metro Rail/89-409-06	**DATE EXTRACTED:**	06/03/89
CONTROL NO:	890601	**DATE ANALYZED:**	06/03/89
MATRIX TYPE:	Water		

SAMPLE ID:	**CONTROL NO:**	**RESULTS (mg/L)**	**DETECTION LIMIT (mg/L)**
LPE 1	890601-2	ND	1

DRAFT

GKY

EPA METHOD - 9040 - pH

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	06/01/89
PROJECT:	Metro Rail/89-409-06	**DATE EXTRACTED:**	06/03/89
CONTROL NO:	890601	**DATE ANALYZED:**	06/03/89
MATRIX TYPE:	Water		

SAMPLE I.D.	CONTROL NO.	pH
PII-5	890601-1	7.2
LPE 1	890601-2	7.0

DRAFT

CKY

QUALITY CONTROL DATA

CLIENT: The Earth Technology Corporation
PROJECT: Metro Rail II/89-409-06
CKY I.D.: 890601

==

METHOD EPA 9038
MATRIX: Water

SAMPLE ID: 890601-01

COMPOUND	SAMPLE RESULTS (mg/L)	AMOUNT SPIKED (mg/L)	% REC.	DUP. % REC.	RPD
Sulfate	1500	100	130	120	0.6

DRAFT

C K Y incorp...
Environmental S...

Date: 06/12/89
890601

The Earth Technology Corporation
3777 Long Beach Blvd.,
Long Beach, CA 90807-3309

Attn: Mr. Bill Lu

Subject: Laboratory Report
Project: Metro Rail/89-409-09

Enclosed is the laboratory report for samples received on 05/31/89. The samples were received in coolers with ice and intact; the chain-of-custody forms were properly filled out. The data reported includes:

Method	No. of Analysis
EPA 8240 (VOC by GC/MS)	1 Soil
EPA 8270	1 Soil
CAM Metals	1 Soil
Sulfides	1 Soil

The results are summarized on five pages.

Please feel free to call if you have any questions concerning these results.

Sincerely,

Dr. Kam Pang
Laboratory Director

DRAFT

GKY

EPA METHOD - 8240
VOLATILE ORGANICS BY GC/MS

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	05/31/89
PROJECT:	Metro Rail/89-409-09	**DATE EXTRACTED:**	06/01/89
SAMPLE ID:	PII-7 D-15	**DATE ANALYZED:**	06/01/89
CONTROL NO:	890564-1	**MATRIX TYPE:**	Soil

PARAMETERS (8240)	**RESULTS (ug/kg)**	**DETECTION LIMIT (ug/kg)**
Acetone	ND	100
Benzene	ND	10
Bromodichloromethane	ND	10
Bromoform	ND	10
Bromomethane	ND	50
2-Butanone (MEK)	ND	100
Carbon Disulfide	ND	10
Carbon Tetrachloride	ND	10
Chlorobenzene	ND	10
Chlorodibromomethane	ND	10
Chloroethane	ND	50
2-Chloroethyl vinyl ether	ND	10
Chloroform	ND	10
Chloromethane	ND	50
1,1-Dichloroethane	ND	10
1,2-Dichloroethane	ND	10
1,1-Dichloroethene	ND	10
1,2-Dichloroethene (total)	ND	10
1,2-Dichloropropane	ND	10
cis-1,3-Dichloropropene	ND	10
trans-1,3-Dichloropropene	ND	10
Ethylbenzene	ND	10
2-Hexanone	ND	100
Methylene chloride	ND	100
4-Methyl-2-pentanone (MIBK)	ND	50
Styrene	ND	10
1,1,2,2-Tetrachloroethane	ND	10
Tetrachloroethene	ND	10
Toluene	18	10
1,1,1-Trichloroethane	ND	10
1,1,2-Trichloroethane	ND	10
Trichloroethene	ND	10
Trichlorofluoromethane	ND	50
Vinyl Acetate	ND	100
Vinyl Chloride	ND	50
Xylene (total)	ND	10

% Surrogate Recovery	
1,2 dichloroethane d4	77
Toluene-d8	104
Bromoflurrobenzene	90

ND = Not Detected

DRAFT

EPA METHOD - 8270
SEMIVOLATILE ORGANICS BY GC/MS

CLIENT:	Earth Technology Corp.	DATE REC'D:	05/31/89
PROJECT:	Metro Rail/89-409-09	DATE EXTRACTED:	06/01/89
SAMPLE ID:	PII-7 D-15	DATE ANALYZED:	06/06/89
CONTROL NO:	890564-1	MATRIX TYPE:	Soil

PARAMETER	RESULTS (mg/kg)	PARAMETER	RESULTS (mg/kg)
Phenol	ND (0.1)	Acenaphthene	ND (0.1)
bis(2-chloroethyl)ether	ND (0.1)	2,4-Dinitrophenol	ND (0.5)
2-Chlorophenol	ND (0.1)	4-Nitrophenol	ND (0.5)
1,3-Dichlorobenzene	ND (0.1)	Dibenzofuran	ND (0.1)
1,4-Dichlorobenzene	ND (0.1)	2,4-Dinitrotoluene	ND (0.1)
Benzyl Alcohol	ND (0.2)	2,6-Dinitrotoluene	ND (0.1)
1,2-Dichlorobenzene	ND (0.1)	Diethylphthalate	ND (0.1)
2-Methylphenol	ND (0.1)	4-Chlorophenyl-phenylether	ND (0.1)
bis(2-chloroisopropyl)ether	ND (0.1)	Fluorene	ND (0.1)
4-Methylphenol	ND (0.1)	4-Nitroaniline	ND (0.5)
N-Nitroso-Di-n-Propylamine	ND (0.1)	4,6-Dinitro-2-Methylphenol	ND (0.5)
Hexachloroethane	ND (0.1)	N-Nitrosodiphenylamine	ND (0.1)
Nitrobenzene	ND (0.1)	4-Bromophenyl-phenylether	ND (0.1)
Isophorone	ND (0.1)	Hexachlorobenzene	ND (0.1)
2-Nitrophenol	ND (0.1)	Pentachlorophenol	ND (0.5)
2,4-Dimethylphenol	ND (0.1)	Phenanthrene	ND (0.1)
Benzoic Acid	ND (0.5)	Anthracene	ND (0.1)
bis-(2-Chloroethoxy)methane	ND (0.1)	Di-n-Butylphthalate	ND (0.1)
2,4-Dichlorophenol	ND (0.1)	Fluoranthene	ND (0.1)
1,2,4-Trichlorobenzene	ND (0.1)	Pyrene	ND (0.1)
Naphthalene	ND (0.1)	Butylbenzylphthalate	ND (0.1)
4-Chloroanline	ND (0.2)	3,3'-Dichlorobenzidine	ND (0.2)
Hexachlorobutadiene	ND (0.1)	Benzo(a)Anthracene	ND (0.1)
4-Chloro-3-Methylphenol	ND (0.2)	bis(2-Ethylhexyl)Phthalate	ND (0.1)
2-Methylnaphthalene	ND (0.1)	Chrysene	ND (0.1)
Hexachlorocyclopentadiene	ND (0.1)	Di-n-Octyl Phthalate	ND (0.1)
2,4,6-Trichlorophenol	ND (0.1)	Benzo(b)Fluoranthene	ND (0.1)
2,4,5-Trichlorophenol	ND (0.1)	Benzo(k)Fluoranthene	ND (0.1)
2-Chloronaphthalene	ND (0.1)	Benzo(a)Pyrene	ND (0.1)
2-Nitroaniline	ND (0.5)	Indeno(1,2,3-cd)Pyrene	ND (0.1)
Dimethyl Phthalate	ND (0.1)	Dibenz(a,h)Anthracene	ND (0.1)
Acenaphthylene	ND (0.1)	Benzo(g,h,i)Perylene	ND (0.1)
3-Nitroaniline	ND (0.5)		

% Surrogate Recovery	
2-Fluorophenol	64
Phenol-d_5	72
Nitrobenzene-d_5	106
2-Fluorobiphenyl	43
2,4,6-Tribromophenol	0
Terphenyl-d_{14}	115

ND = Not Detected
( ) = Detection Limit (mg/kg)

DRAFT

CAM METALS

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	05/31/89
PROJECT:	Metro Rail/89-409-09	**DATE EXTRACTED:**	06/02/89
SAMPLE ID:	PII-7 D-15	**DATE ANALYZED:**	06/05/89
CONTROL NO:	890564-1	**MATRIX TYPE:**	Soil

PARAMETERS	RESULTS (mg/kg)	DETECTION LIMIT (mg/kg)
Antimony	3.9	5.0
Arsenic	11	1.0
Barium	8.8	5.0
Beryllium	<1.0	1.0
Cadmium	1.1	1.0
Chromium	22	1.0
Cobalt	7.9	1.0
Copper	29	1.0
Lead	9.4	1.0
Mercury	<0.05	0.05
Molybdenum	3.6	1.0
Nickel	31	1.0
Selenium	1.6	1.0
Silver	<1.0	1.0
Thallium	10	1.0
Vanadium	34	5.0
Zinc	69	1.0

DRAFT

GKY

METHOD 9030
SULFIDE

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	05/31/89
PROJECT:	Metro Rail/89-409-09	**DATE ANALYZED:**	06/03/89
CONTROL NO:	890564	**MATRIX TYPE:**	Soil

SAMPLE ID:	**CONTROL NO:**	**RESULTS (mg/Kg)**	**DETECTION LIMIT (mg/Kg)**
PII-7D-15	890564-1	6.6	1

DRAFT

CKY

QUALITY CONTROL DATA

CLIENT: Earth Technology Corporation
PROJECT: Metro Rail/89-409-09
CKY I.D.: 890564

METHOD EPA 6010
MATRIX: Soil

SAMPLE ID: 890564-01

COMPOUND	SAMPLE RESULTS (mg/Kg)	AMOUNT SPIKED (mg/Kg)	% REC.	DUP. % REC.	RPD
Cobalt	7.9	20	76	61	14
Lead	9.4	50	75	61	16
Beryllium	0.50	10	92	75	19
Silver	0.21	10	80	69	14
Thallium	10	50	82	68	15
Vanadium	34	100	76	65	11

METHOD EPA 7470
MATRIX: Soil

SAMPLE ID: 890378-02

COMPOUND	SAMPLE RESULTS (mg/Kg)	AMOUNT SPIKED (mg/Kg)	% REC.	DUP. % REC.	RPD
Mercury	0.74	2.5	90	86	3

DRAFT

C K Y incorporated
Environmental Services

Date: 06/06/89
890543

Earth Technology Corporation
3777 Long Beach Blvd.
Long Beach, CA 90807-3309

Attn: Mr. Bill Lu

Subject: Laboratory Report
Project: Metro II/89-409-03

Enclosed is the laboratory report for samples received on 05/18/89. The samples were received in coolers with ice and intact; the chain-of-custody forms were properly filled out. The data reported includes:

Method	No. of Analysis
EPA 418.1 (TRPH)	10 Water
EPA 8020 (BTEX)	10 Water
Method 9038 (Sulfates)	10 Water
Sulfide 9030	10 Water
PH	10 Water

The results are summarized on six pages.

Please feel free to call if you have any questions concerning these results.

Sincerely,

Dr. Kam Pang
Laboratory Director

DRAFT

EPA METHOD - 8020
BTEX

CLIENT:	The Earth Technology	**DATE REC'D:**	05/18/89
PROJECT:	Metro II/89-409-03	**DATE EXTRACTED:**	05/23/89
CONTROL NO:	890543	**DATE ANALYZED:**	05/23/89
MATRIX TYPE:	Water		

		RESULTS (ppb)			
SAMPLE ID:	CONTROL NO:	Benz	Toluene	Et Benz	Xyls
PII-13-Bore Hole	890543-1	ND	ND	6.9	11
P11-20-Bore Hole	890543-2	350	78	50	2300
PII-29A-Bore Hole	890543-3	ND	ND	ND	2.5
PII-35-Bore Hole	890543-4	ND	ND	21	4.5
PII-43-Bore Hole	890543-5	ND	ND	11	16
PII-46B-Bore Hole	890543-6	ND	ND	ND	ND
PII-66-Bore Hole	890543-7	ND	ND	ND	ND
PII-86-Bore Hole	890543-8	ND	ND	1.7	3.1
PII-95A-Bore Hole	890543-9	ND	ND	ND	ND
PII-105-Bore Hole	890543-10	ND	ND	4.3	21
Trip Blank	890543-11	ND	ND	ND	ND
DETECTION LIMIT		0.5	1	1	1

DRAFT

C K Y Incorporated
Environmental Services

Date: 06/06/89
890601

The Earth Technology Corporation
3777 Long Beach Blvd.,
Long Beach, CA 90807-3309

Attn: Mr. Bill Lu

Subject: Laboratory Report
Project: Metro Rail/89-409-06

Enclosed is the laboratory report for samples received on 06/01/89. The samples were received in coolers with ice and intact; the chain-of-custody forms were properly filled out. The data reported includes:

Method	No. of Analysis
EPA 418.1 (TRPH)	2 Water
EPA 8020 (BTEX)	1 Water
Sulfate 9038	2 Water
Sulfide 9030	1 Water
PH 9040	2 Water

The results are summarized on six pages.

Please feel free to call if you have any questions concerning these results.

Sincerely,

Dr. Kam Pang
Laboratory Director

DRAFT

EPA METHOD - 8020
BTEX

CLIENT:	Earth Technology Corp.	**DATE REC'D:**	06/01/89
PROJECT:	Metro Rail/89-409-06	**DATE EXTRACTED:**	06/02/89
CONTROL NO:	890601	**DATE ANALYZED:**	06/02/89
MATRIX TYPE:	Water		

		RESULTS (ug/L)			
SAMPLE ID:	CONTROL NO:	Benz	Toluene	Et Benz	Xyls
LPE 1	890601-2	2.7	9.0	ND	ND
DETECTION LIMIT		0.5	1	1	1

DRAFT

EPA METHOD 9038
SULFATES

CLIENT:	The Earth Technology	**DATE REC'D:**	05/15/89
PROJECT:	Metro Rail II	**DATE EXTRACTED:**	05/25/89
CONTROL NO:	890533	**DATE ANALYZED:**	05/25/89
MATRIX TYPE:	Soil		

SAMPLE ID:	CONTROL NO:	RESULTS* (mg/kg SO_4)	DETECTION LIMIT* (mg/kg)
PII-8 D-5	890533-1	31	10
PII-8 D-11	890533-2	250	10
PII-8 D-17	890533-3	110	10
PII-9 D-6	890533-4	140	10
PII-9 D-16	890533-5	240	10
PII-10 D-12	890533-6	750	10
PII-11 D-5	890533-7	880	10
PII-11 D-13	890533-8	360	10
PII-12 D-9	890533-9	220	10
PII-12 D-15	890533-10	490	10
PII-13 D-11	890533-11	200	10
PII-15 D-5	890533-12	105	10
PII-15 D-11	890533-13	315	10
PII-16 D-7	890533-14	30	10
P11-16 D-9	890533-15	900	10
P11-17 D-6	890533-16	680	10
PII-17 D-10	890533-17	1180	10
PII-18 D-5	890533-18	80	10
PII-18 D-9	890533-19	340	10
PII-20 D-2	890533-20	70	10
PII-20 D-8	890533-21	390	10
PII-21B D-5	890533-22	110	10
PII-21B D-11	890533-23	770	10
PII-22 D-3	890533-24	50	10
PII-22 D-9	890533-25	580	10
PII-23 D-4	890533-26	1040	10
PII-24 D-2	890533-27	66	10
PII-24 D-14	890533-28	460	10

* As ammended