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Converse Consultants
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GEOTECHNICAL REPORT

METRO RAIL PROJECT

DESIGN UNIT A310

BY

CONVERSE CONSULTANTS, INC.
EARTH SCIENCES ASSOCIATES
GEO/RESOURCE CONSULTANTS

APRIL 1984

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April 16, 1984

Metro Rail Transit Consultants
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Attention: Mr. B.I. Maduke, Senior Geotechnical Engineer

Gentlemen:

This letter transmits our final geotechnical investigation report for Design Unit A310 prepared in accordance with our Contract No. 503 agreement dated September 30, 1983 between Converse Consultants, Inc. and Metro Rail Transit Consultants (MRTC). This report provides geotechnical information and recommendations to be used by design firms in preparing designs for Design Unit A310.

Our study team appreciate the assistance provided by the MRTC staff, especially Mr. B.I. Maduke. We also want to acknowledge the efforts of each member of the Converse team, in particular Julio Valera and Jim Doolittle.

Respectfully submitted,

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This report has been prepared by CCI/ESA/GRC under the professional supervision of the principal soils engineer and engineering geologist whose seals and signatures appear hereon.

The findings, recommendations, specifications or professional opinions are presented, within the limits prescribed by the client, after being prepared in accordance with generally accepted professional engineering and geologic principles and practice. There is no other warranty, either express or implied.

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Section 1.0

Executive Summary

1.0 EXECUTIVE SUMMARY

This report presents the results of our geotechnical investigations and engineering analyses for the A310 Design Unit of the Southern California Rapid Transit District's Metro Rail Project in Los Angeles. The A310 Design Unit consists of the Fairfax/Santa Monica and La Brea/Sunset Stations and about three miles of tunnel line. The Stations will be constructed by cut-and-cover methods and require excavations as deep as 82 feet below the existing ground surface. The line between the Stations will be constructed by tunneling methods and will have a variable depth of cover ranging between 24 and 100 feet above the crowns of the twin single-track tunnels. Construction will occur in alluvial soils having variable gas and groundwater conditions. The report defines the subsurface conditions and provides recommendations for design and construction purposes. Although this report may be used for construction purposes, it is not intended to provide all of the information that may be required.

1.1 STATIONS

The subsurface conditions at the station structures consist of fine-grained and coarse-grained Alluvium which are primarily clays, sandy clays, clayey sands, sands, and silty sands. Groundwater was encountered within the Alluvium at depths of 53 to 55 feet below the existing ground surface at the La Brea/Sunset Station, and at depths of 59 to 75 feet below the existing ground surface at the Fairfax/Santa Monica Station.

Station construction will consist of excavations approximately 560 feet long, 60 feet wide, and up to 82 feet deep. The permanent structures at both Stations will be a concrete box bearing on the Alluvium and retaining alluvial deposits. Since a portion of the excavations will extend through and below the groundwater table, some dewatering will be required. No major dewatering problems are expected to be encountered at either of the Station sites. The contractor will be responsible for designing a construction dewatering system, installing, and operating it subject to review and acceptance by the Metro Rail Construction Manager.

Temporary support of the Station excavations will be provided by either a conventional or a conservative type shoring system with internal bracing or external tieback systems. Successful installation of tiebacks will require certain precautions to maintain the stability of such borings, especially below the groundwater. Lateral pressures and other guidelines for design of temporary support systems are provided in this report.

The undisturbed natural Alluvium will adequately support the permanent reinforced concrete Station structures. Design lateral pressures for permanent structures for various loading conditions are outlined in the text of the report.

1.2 TUNNELS

Subsurface conditions along the A310 tunnel alignment are suitable for the use of soft ground tunneling techniques utilizing a shield with hand and/or mechanical excavating equipment. The entire tunnel alignment will pass through horizons of variable Alluvium. Groundwater levels lie above the invert of the tunnel for about 51 percent of its total length. Groundwater levels are above the crown of the tunnel over an estimated 25 percent of its length. Therefore, some flowing ground conditions could be encountered at the face, and the potential for blow-outs at the invert should be anticipated. It is, therefore, anticipated that shield tunneling construction methods will require means for the utilization of fore polling and/or breast boarding techniques to maintain stability of the face. In addition, surface and/or local subsurface dewatering measures will be required to control seepage inflows and to provide for the stability of the soils at the face and invert of the tunnels along certain portions of the tunnel alignment.

The southern end of the tunnel alignment in Design Unit A310 is considered potentially gassy to gassy per the classification contained in Tunnel Safety Orders issued by the California Division of Industrial Safety and adopted from California Administrative Code, Title 8, page 684-18.

1.3 UNDERPINNING

Guidelines for assessing the need for underpinning of buildings adjacent to the Station construction and along the tunnel alignment are discussed in the report. Detailed analyses to identify and recommend which buildings and/or facilities shall be underpinned will be carried out by the section designer for this Design Unit.

Between Stations 574+50± and 576+77±, the crowns of the twin tunnel line are anticipated to pass approximately 10 to 13 feet below the footings of a building located on the northeast corner of the intersection of Fairfax Avenue and Beverly Boulevard. The evaluation of the underpinning requirements and the behavior of the tunnel and footings under static and earthquake loading conditions to assure the long-term integrity and stability of the structures will be carried out by others.

1.4 SEISMIC CONSIDERATIONS

Analysis of the field Standard Penetration Test blow count data, field geophysical data, and the gradational characteristics of the coarse-grained alluvial soils indicate that liquefaction of such soils during a maximum design earthquake has a low probability at the Fairfax/Santa Monica and La Brea/Sunset Station sites.

Design procedures and criteria for underground structures under earthquake loading conditions are defined in the SCRTD report entitled "Guidelines for Seismic Design of Underground Structures" dated March 1984. Seismological conditions which may impact the project and the operating and maximum design earthquakes which may be anticipated in the Los Angeles area are described in the SCRTD report entitled "Seismological Investigations and Design Criteria" dated May 1983. The 1984 report complements and supplements the 1983 report. Site specific static and dynamic properties for materials in Design Unit A220 are given in the report.

Section 2.0

Introduction

2.0 INTRODUCTION

This report presents the results of a geotechnical investigation for Design Unit A310. The unit includes the Fairfax/Santa Monica and La Brea/Sunset Stations and about three miles of subsurface track line proceeding south to north and west to east from the north end of the Fairfax/Beverly Station to the south end of the Hollywood/Cahuenga Station. This design unit will be part of the proposed 18.6-mile long Metro Rail Project (see Drawing 1, Vicinity Map). The purpose of the investigation is to provide geotechnical information to be used by the design firms in preparing designs for the project. Although this report may be used for construction purposes, it is not intended to provide all the geotechnical information that may be required. The work performed for this study included field reconnaissance, drilling and logging of exploratory borings, geologic interpretation, field and laboratory testing, engineering analyses, and development of recommendations for design and construction of the two Stations and the tunnels.

Additional geotechnical information on the Metro Rail Project is included in the following reports, some of which may pertain to Design Unit A310:

- "Geotechnical Investigation Report, Metro Rail Project," Volume I - Report, and Volume II - Appendices, prepared by Converse Ward Davis Dixon, Earth Sciences Associates, and Geo/Resource Consultants, submitted to SCRTD in November 1981: This report presents general geologic and geotechnical data for the entire project. The report also comments on tunneling and shoring experiences and practices in the Los Angeles area.
- "Seismological Investigation & Design Criteria, Metro Rail Project," prepared by Converse Consultants, Lindvall, Richter & Associates, Earth Sciences Associates, and Geo/Resource Consultants, submitted to SCRTD in May 1983: This report presents the results of a seismological investigation.
- "Geologic Aspects of Tunneling in the Los Angeles Area" (USGS Map No. MF866, 1977), prepared by the U.S. Geological Survey in cooperation with the U.S. Department of Transportation. This publication includes a compilation of boring data in the general vicinity of the proposed Metro Rail Project.
- "Rapid Transit System Backbone Route," Volume IV, Book 1, 2 and 3, prepared by Kaiser Engineers, June, 1962 for the Los Angeles Metropolitan Transit Authority. This report presents the results of a Test Boring Program for the Wilshire Corridor and logs of borings.

Pertinent data from these previous reports have been incorporated in this report.

The design concepts discussed in this geotechnical report are based on the "General Plans, CBD to North Hollywood Line Plans, Sheets 12 to 60, dated July 1983; and "Final Report for the Development of Milestone 10: Fixed Facilities, Sheets 48 to 62, dated September 1983.

Section 3.0

Site and Project Description

3.0 SITE AND PROJECT DESCRIPTION

3.1 GENERAL

The proposed Design Unit A310 consists of approximately 3.3 miles of tunnel extending from the northern end of the Fairfax/Beverly Station (tunnel Station 573+24) to the southern end of the Hollywood/Cahuenga Station (tunnel Station 749+30). The existing ground surface elevations along the alignment vary between approximately 191 feet at the south end to 382 feet at the north end. Included in this design unit are the Fairfax/Santa Monica Station which extends from Stations 623+92 to 629+52, and the La Brea/Sunset Station which extends from Stations 694+90 to 700+50.

Construction of the tunnel and Stations within this design unit will be entirely in alluvial soil deposits. The depth of cover above the tunnel invert ranges from a minimum of about 46 feet to a maximum of about 117 feet. Groundwater is encountered at depths ranging from approximately 11 feet to over 130 feet throughout the alignment route.

After leaving the Fairfax/Beverly Station, the alignment passes through a set of short reverse curves and returns to the Fairfax Avenue right-of-way north of Oakwood Avenue and then proceeds north under Fairfax to the Fairfax/Santa Monica Station that straddles Santa Monica Boulevard. The Metro Rail alignment through this segment remains under Fairfax Avenue extending north to a point north of Fountain Avenue where it curves eastward under the Sunset Boulevard right-of-way at Stanley Avenue. The alignment continues east to the La Brea/Sunset Station just west of La Brea Avenue.

After leaving the La Brea/Sunset Station, the alignment continues easterly under the Sunset Boulevard right-of-way to Hudson Avenue where it curves northerly to an off-street alignment west of Cahuenga Boulevard to the Hollywood/Cahuenga Station that straddles Hollywood Boulevard. Just north of the Station, a pocket track for storage of a six-car train is to be constructed.

3.2 FAIRFAX/SANTA MONICA STATION SITE

The Fairfax/Santa Monica Station site will be located beneath Fairfax Avenue between Romaine and Norton Streets. Land use along the major streets in this Station area is primarily low-rise (generally less than 3 stories), storefront retail, and small neighborhood shopping centers. There are many vacant lots and parking lots interspersed with a generally low level of development. Land use off the major streets is primarily residential with a variety of housing types.

The single entry to this Station will be located on the southwest corner of the intersection of Fairfax and Santa Monica. Bus turnout lanes are proposed for the north and south sides of Santa Monica adjacent to the Station entry. Locating the entry on this corner will require the demolition of an existing commercial building.

A single mezzanine will provide sufficient space to meet the projected patronage demand but still permit the later construction of additional station entries if future development or patronage warrants the addition. The station is planned with a center platform and with ancillary space provided at each end of the Station. A traction power substation will be located at the north end of the Station structure.

The proposed main Station area will consist of a reinforced concrete structure about 560 feet long and 60 feet wide (outside wall dimensions). The ground surface varies from Elevation 277 feet at the south end of the Station to Elevation 294 feet at the north end. The top of rail varies between Elevation 220.0 to 221.5 feet. The depths of excavation for the Station structure will range from 66 feet below the existing ground surface at the south end to a depth of 82 feet at the north end. After the Station is constructed, between 10 and 30 feet of fill will be placed above the Station box structure.

3.3 LA BREA/SUNSET STATION

The La Brea/Sunset Station will be located beneath Sunset Boulevard between Formosa and Orange Drive. The Station area is characterized by mixed-use development. The major streets, Sunset and La Brea, have low-rise (generally less than 3 stories) commercial facilities. The areas behind the major streets are primarily single-family residential. Hollywood High School is located nearby. A Safeway Supermarket is located on the southeast corner of La Brea and Sunset, service stations are on the northeast and southwest corners, and a Tiny Naylor's Restaurant is on the northwest corner.

The Station is planned with a single entry to be located on the southwest corner of the intersection of Sunset and La Brea. The construction of the entry will require the removal of an existing service station. The Station is planned with a single mezzanine. The station will have a center platform with ancillary space provided at each end of the Station. The required traction power substation will be located at grade immediately to the south of the Station entrance.

The proposed main Station area will consist of a reinforced concrete structure about 560 feet long and 60 feet wide (outside wall dimensions). The ground surface at the Station site varies from Elevation 350 feet at the west end to Elevation 348 feet at the east end. The top of rail elevation varies from 303.0 feet (west end) to 301.6 feet (east end). The depth of excavation will be approximately 54 feet at both ends of the Station. After the Station is constructed, about 10 feet of fill will be placed above the Station box structure.

3.4 TUNNEL ALIGNMENT

As shown on Drawings 2 through 7, the twin tunnel line in Design Unit A310 is approximately 3.3 miles long, starting at tunnel station 573+24 and ending at tunnel station 749+30. The tunnel continues in a north-south direction from the north end of the Fairfax/Beverly Station along Fairfax

Avenue. It continues north past the Fairfax/Santa Monica Station until it reaches Sunset Boulevard, where it makes a 90-degree right turn and heads east along Sunset Boulevard. It continues east past the La Brea/Sunset Station until it reaches Cahuenga Boulevard, where it makes a 90-degree left turn and heads north along Cahuenga Boulevard until it reaches the south end of the Hollywood/Cahuenga Station.

A total of 20 cross passages are planned along this tunnel alignment. Shafts and/or vent structures are not shown on recent (January 1984) SCRTD plans for Design Unit A310.

Section 4.0

Field Exploration and Laboratory Testing

4.0 FIELD EXPLORATION AND LABORATORY TESTING

4.1 GENERAL

The information presented in this report is based primarily upon field and laboratory investigations carried out in 1981 and 1983. This information was derived from field reconnaissance, borings, geologic reports and maps, groundwater measurements, field gas measurements, field geophysical surveys, groundwater quality tests, and laboratory tests on soil and rock samples.

4.2 BORINGS

A total of 41 exploratory boreholes have been drilled along, or in relative close proximity to, the proposed tunnel alignment and two Station structures included in Design Unit A310. Of the 41 borings, 34 are rotary wash type borings and 7 are large-diameter or "man-size" auger holes. Five of the rotary wash borings were drilled as part of the 1981 geotechnical investigation, 21 borings were drilled for this investigation during October and November of 1983, and 6 supplementary borings were drilled in March 1984. The large-diameter boreholes were drilled in 1983.

Locations of all the borings used in the interpretation of the subsurface conditions present along the proposed tunnel alignment are shown in Drawings 2 through 7 and in Drawings 8 and 10 for the Fairfax/Santa Monica and La Brea/Sunset Station sites, respectively.

Most borings were drilled at four Station sites. The Station sites include the Fairfax/Beverly, Fairfax/Santa Monica, La Brea/Sunset, and Hollywood/Cahuenga Station sites. The Fairfax/Santa Monica and La Brea/Sunset Stations are part of Design Unit A310, whereas the Fairfax/Beverly and Hollywood/Cahuenga Stations are Design Units A275 and A350, respectively. While the borings that were drilled at the Fairfax/Beverly and Hollywood/Cahuenga Stations are not located within the bounds of Design Unit A310, the information provided in the borehole logs was used in the interpretation of the subsurface conditions at the extreme southern and northern segments of the tunnel alignment in the design unit. A detailed description of the field procedures employed in logging the boreholes as well as the field logs of all the borings are included in Appendix A.

Groundwater observation wells (piezometers) were installed in 15 of the borings drilled along the proposed tunnel alignment and/or Station sites. Free water levels were also observed in several of the large-diameter boreholes. A summary of the groundwater levels measured in the piezometers installed at the site, in addition to those observed in the large-diameter boreholes, is presented in Section 5.5.

4.3 GEOPHYSICAL MEASUREMENTS

Downhole and crosshole compression and shear wave velocity surveys were made in several boreholes situated along the tunnel alignment and several Station structure locations during the 1981 geotechnical investigation.

In particular, downhole surveys were performed in Borings CEG-23, CEG-23A, CEG-24, and CEG-28 down to depths of about 200 feet. Crosshole surveys were performed in borehole arrays drilled at the Fairfax/Santa Monica and Hollywood/Cahuenga Station sites. The results of the downhole and crosshole surveys are summarized in Appendix B in addition to a discussion of the procedures employed in the field to perform these surveys.

4.4 OIL AND GAS ANALYSES

Oil, gas or strong odors, and/or gasoline were noted during the drilling and logging of 10 of the 41 boreholes drilled along or near the tunnel alignment of Design Unit A310. These holes were, in general, located at the extreme southern and northern boundaries of this design unit. During the 1981 investigation, gas chromatograph analyses were performed on gas samples obtained from Borings CEG-23 and CEG-23A. Results of these analyses and a description of the testing methodology are presented in Appendix C.

A "gas detector" was also used to evaluate the lack of oxygen and/or the presence of combustible gases prior to the logging of the large-diameter boreholes drilled in 1983. Strong hydrogen sulfide (H_2S) odors were noted in Boring 23B and gasoline encountered in Boring 28C (refer to Appendices A and C and Section 5.6 and 7.5).

4.5 WATER QUALITY ANALYSES

Chemical analyses have been performed on water samples obtained from six borings drilled during the 1981 investigation and two water samples obtained from the large-diameter Borings 23B and 27A, which were drilled in early 1983. The chemical analyses and the results of these tests are summarized in Appendix D. The results of these tests indicate that the groundwater found within Design Unit A310 is of poor quality (refer to Section 5.5).

4.6 GEOTECHNICAL LABORATORY TESTING

A laboratory testing program was performed on representative soil and rock samples. These consisted of classification tests, consolidation tests, triaxial compression tests, dynamic and cyclic triaxial tests, resonant column tests, unconfined compression tests, direct shear tests, and permeability tests.

Appendix E summarizes the testing procedures and presents the detailed results from the testing program performed as part of this investigation. Appendix E also presents, in summary form, the results of the 1981 laboratory testing program.

Section 5.0

Subsurface Conditions

5.0 SUBSURFACE CONDITIONS

5.1 GENERAL

The tunnel line and Stations will be entirely in alluvial soil deposits. The geologic map of the project area presented in the 1981 geotechnical investigation (Drawing No. 1) shows the tunnel line traversing both Young Alluvium (Qal) and Alluvial Fan (Qf) deposits. The young near-surface alluvial soils, which range from 30 to 80 feet in thickness within this design unit, are underlain by Old Alluvium (Qalo). During the field programs conducted for this and the 1981 investigations, the contact between the Old and Young Alluvium was difficult to identify since the soils in these two deposits are generally very similar.

For the purposes of this report, Young and Old Alluvium have not be differentiated and are simply referred to as Alluvium. The Alluvium along the tunnel alignment has been subdivided into fine-grained and coarse-grained Alluvium. These soils are generally randomly layered, lenticular, and discontinuous over relatively short distances.

Generalized geologic interpretations of the subsurface conditions along the proposed route are presented on Drawings 2 through 7.

General descriptions of the soils that have been encountered along the proposed alignment for Design Unit A310 include:

- Coarse-Grained Alluvium: These soils are predominantly silty and poorly graded sands; however, silty and sandy gravels have also been encountered in the boreholes. The materials range from medium dense to very dense and have relatively low compressibility.

- Fine-Grained Alluvium: These fine-grained soils consist of sandy and silty clays, clayey and sandy silts, and clayey sands. The fines have generally slight to medium plasticity. These soils are generally very stiff to hard and medium dense to very dense at depth. However, at relatively shallow depths (that is, generally less than 20 to 25 feet deep), these soils may be soft to firm and loose to medium dense.

A significant number of boulders were not encountered in the boreholes drilled within this design unit. A few boulders were encountered between the depths of 49 and 70 feet in the large-diameter borehole (25A) which was drilled on Sunset Boulevard near Fairfax. Boulders were also reported in the log of Borehole 26D at a depth of about 72 feet. In addition, cobbles have also been noted in a few of the boreholes drilled along the alignment. It is likely that some soils containing boulders will be encountered along portions of this tunnel alignment.

5.2 FAIRFAX/SANTA MONICA STATION

Drawing 4 shows a generalized subsurface cross section through the proposed Fairfax/Santa Monica Station site and Drawing 9 shows a more detailed subsurface profile through the site. The subsurface profile consists of a pavement section which overlies alternating layers/lenses of fine-grained and coarse-grained Alluvium which extend to depths greater than 200 feet. Bedrock was not encountered in any of the exploratory boreholes drilled at the site, one of which extended to a depth of about 200 feet.

The upper 20 to 25 feet of the subsurface profile through the Station site consists primarily of moist to wet fine-grained soils which include silty and sandy clays, clayey and sandy silts, and clayey sands. Results of Standard Penetration Test blow counts taken in these soils range from 5 to 30 blows/foot but average around 10 to 15 blows/foot. These measurements indicate that the soils are firm to very stiff and loose to medium dense but are predominantly stiff and medium dense.

Below the depth of about 25 feet, both fine-grained and coarse-grained Alluvium was encountered. Standard Penetration Test blow counts range from about 16 to well over 50 blows/foot but average around 40 blows/foot. These results, as well as results obtained from laboratory tests, indicate that these soils are very stiff to hard and medium dense to very dense.

A large diameter borehole (Boring 24A) was drilled at this Station site to a depth of about 75 feet. The hole did not experience any belling, caving, or sloughing during drilling and logging. A slow oozing of soil occurred between the depths of 65 and 66 feet. Water flowed into the hole at an estimated rate of 0.5 gpm from gravel layers between the depths of 70 and 72 feet. No unusual strong odors were detected during the drilling and logging of this hole nor in any other boring drilled at the site.

5.3 LA BREA/SUNSET STATION

Drawing 6 shows a generalized subsurface cross-section, and Drawing 11 shows a more detailed profile through the La Brea/Sunset Station site. The subsurface profile consists of a pavement section underlain by alternating layers/lenses of fine-grained and coarse-grained alluvial soil deposits which extend to depths estimated to about 200 feet. Bedrock was not encountered in any of the boreholes drilled at the site, one of which extended to a depth of 102 feet. About 1 to 3 feet of a clayey and silty sand fill were encountered in five of the seven exploratory boreholes drilled at the site.

The upper 20 feet of the subsurface profile through the Station site consists primarily of sandy clays, silty sand, and sandy silts. A 4-foot thick layer of silty gravel was encountered in Borehole 26-5 at a depth of about 14 feet. Standard Penetration Test blow counts for these near-surface materials range from 5 to 22 blows/foot and average around 10 blows/foot. These results as well as results from laboratory tests indicate that these soils are firm to very stiff and loose to medium dense, but are generally stiff and medium dense.

Below a depth about 20 feet, fine-grained and coarse-grained Alluvium was encountered. Standard Penetration Test blow counts measured in these deeper soils range from 15 to over 100 blows/foot, and average between 40 and 60 blows/foot. These measurements and laboratory tests indicate that these soils are stiff to hard and medium dense to very dense, but are generally hard and dense to very dense.

The large-diameter borehole (26B) drilled at the site was drilled to a depth of 61 feet. Caving, belling, and/or sloughing was not a problem in this hole up to a depth of 54 feet. Some sloughing occurred between the depths of 54 and 58 feet, which corresponds to the limits of a water-bearing gravelly sand layer. Water, as noted in the log, collected in this hole up to a depth of 54 feet during the drilling and logging operations.

No unusual odors were noted in any of the exploratory boreholes drilled at this site.

5.4 TUNNEL ALIGNMENT

The tunnel line in Design Unit A310 is about 3.1 miles long (excluding the track within the two Station structures) and extends from station 573+24 (the north end of the Fairfax/Beverly Station) to Station 749+30 (the south end of the Hollywood/Cahuenga Station). Included in this unit are the Fairfax/Santa Monica and the La Brea/Sunset Stations.

The tunnel will pass beneath a building which is located just north of the Fairfax/Beverly Station, roughly between Stations 574+50± and 576+77±. The crown of the tunnel between these Stations varies between Elevation 156 and 159. The foundation of the building is at Elevation 169; therefore, there may be only 10 to 13 feet of cover above the crown of the tunnel at this location.

Groundwater quality, the occurrence of oil and/or gas, and faults that occur along the tunnel alignment are discussed in subsequent sections of this chapter.

5.5 GROUNDWATER

Groundwater has been measured within the Alluvium at several locations along the proposed tunnel alignment. Table 5-1 presents groundwater levels and fluctuations measured in the piezometers which have been installed along the tunnel line and at the Fairfax/Santa Monica and La Brea/Sunset Station sites. Water levels that were observed during the drilling and logging of rotary wash and large-diameter boreholes, within which piezometers were not installed, are also compiled in this table. Pneumatic devices were installed in Boring 23C at two different depths to measure groundwater levels. The devices were placed at depths of 39.5 feet and 64.8 feet and were separated by an 8-foot thick cement slurry plug. Readings obtained from the devices during early March 1984 have yielded groundwater elevations which differ by less than two feet. The groundwater elevations listed in Table 5-1 for Boring 23C are the average of the readings obtained from the two pneumatic devices where were installed.

Table 5-1

Groundwater Observation Well Data

		Groundwater Elevation[a] (feet)					
Boring	Initial[b] (Date)	1/81-3/81	4/82	2/83-3/83	10/83-11/83	12/83-1/84	3/84
CEG-23	180 (12/31/80)	182	179	181	--	--	--
23-1[c]	182 (11/7/83)	--	--	--	182[b]	--	--
23-2[c]	179 (11/7/83)	--	--	--	179[b]	--	--
23-3[c]	177 (11/7/83)	--	--	--	177	--	--
23-4[c]	175 (11/7/83)	--	--	--	175	--	--
23B[c]	180 (2/3/83)	--	--	180[b]	--	--	--
23C[d]	190 (3/3/84)	--	--	--	--	--	189 (3/13/84)
CEG-23A	194 (2/15/81)	193	--	--	193	--	--
23D	--	--	--	--	--	--	211
24-1	--	--	--	--	218	219	219
24-4	--	--	--	--	217	216	218
24A[c]	210 (10/13/83)	--	--	--	210[b]	--	--
24B	--	--	--	--	--	--	226
25A[c]	280--Dry (1/26/83)	--	--	--	--	--	--
25B[c]	277--Dry (10/12/83)	--	--	--	--	--	--
25C	--	--	--	--	--	--	268
26A	295 (3/2/83)	--	--	295[b]	--	--	295
26B[c]	297 (10/11/83)	--	--	--	297[b]	--	--
26-1	--	--	--	--	--	285	283
26-5	--	--	--	--	--	295	295
26C[e]	- - - - - - - -	DESTROYED	- - -	- - -	- - -	- - -	- - -
26D	--	--	--	--	--	--	300
27A[c]	298 (2/10/83)	--	--	298[b]	--	--	--
CEG-28[c]	310 (1/12/81)	310	--	--	--	--	--
CEG-28A	386 (2/26/81)	357	365	--	--	--	--
28B	329 (2/18/83)	--	--	336	--	352	351
28C[a]	354 (10/10/83)	--	--	--	354[b]	--	--
28-5	312 (12/20/83)	--	--	--	--	312[b]	310

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[a] Elevations rounded to the nearest foot.

[b] Initial reading recorded at time of drilling or within a few days after drilling.

[c] No piezometers installed in borehole. Groundwater elevation listed was observed during drilling and logging.

[d] Two pneumatic devices installed in this hole to meaure groundwater levels. Groundwater elevation listed is interpreted value

[e] Piezometer was paved over by asphalt shortly after installation.

An interpretation of the available groundwater data is shown in Drawings 2 through 7 for the tunnel alignment included in Design Unit A310 and in Drawings 9 and 11 for the Fairfax/Santa Monica and La Brea/Sunset Station sites, respectively.

Out of a total of seven large-diameter boreholes drilled along this reach of tunnel, only two boreholes, 25A and 25B, experienced no inflows of groundwater. The depth of these two holes were 100 feet and 81 feet, respectively. These borings did not experience any significant sloughing, belling, or caving. In the five remaining large-diameter boreholes, groundwater was observed in the borings. In all except Boring 24A, groundwater caused caving and/or sloughing.

Additional discussions on the groundwater conditions along the tunnel alignment are given in Chapter 7.0 of this report. Drawings 2 through 7 indicate that roughly 1.6 miles or about 51 percent of the tunnel line has water levels which are above the proposed elevation of the tunnel invert. However, only about three-quarters of a mile of this tunnel segment appears to have groundwater levels which are above the crown of the tunnel. The highest water levels above the invert of the tunnel occurs at the southern end of the tunnel alignment between Stations 573+24 to 613+00± just north of the Fairfax/Beverly Station site.

The groundwater levels recorded at the Fairfax/Santa Monica Station site show a slight gradient from the north to the south side of the Station. The groundwater elevations at the north and south sides of the Station are 219 feet and 213 feet, respectively. The water levels at both the north and south ends are about 7 feet above the bottom of the Station excavation (refer to Drawing 9).

The groundwater levels measured at the La Brea/Sunset Station are nearly constant at Elevation 295 within the limits of the Station structure. From the west end of the Station platform toward Formosa Avenue and Boring 26-1, the groundwater level appears to drop to between Elevations 283 and 285 (refer to Drawing 11).

During the 1981 geotechnical investigation, six water samples taken from six boreholes drilled along (or in close proximity to) the present tunnel alignment were subjected to chemical analyses. During the drilling and logging of two large-diameter boreholes in early 1983 along this tunnel reach, two additional water samples were obtained and tested. Seven of the eight water samples that were tested were taken from depths less than 60 feet. The one remaining sample was obtained from a depth of 109 feet. Results of the chemical analyses performed during the 1981 and 1983 investigations are summarized in Appendix D.

Based on the results of the chemical analyses, the groundwater quality along the proposed tunnel alignment is generally poor. Total Dissolved Solids (TDS) of the eight tested water samples range from 494 to 863 PPM. For comparison, the U.S. Environmental Protection Agency TDS standard for potable domestic drinking water is 500 PPM. Sulfate contents of the samples range from 6 to 272 PPM, and four of the eight samples have sulfate contents greater than 150 PPM. A sulfate content above 150 PPM is generally regarded to be deleterious to concrete lining.

5.6 OIL AND GAS

Tar, petroleum, gas, and/or strong odors were not detected in any of the borings drilled at the Fairfax/Santa Monica Station site or the La Brea/Sunset Station site. Boring CEG-24, which was drilled during the 1981 geotechnical investigation, was drilled to a depth of about 203 feet and no unusual strong odors were noted by the geologist. Thus, within the major portion of the tunnel alignment for Design Unit A310, gassy or potentially gassy tunneling conditions would not appear to present a major problem.

Petroleum, gas, and/or strong odors have, however, been encountered in the exploratory boreholes drilled at the Fairfax/Beverly Station site which is at the extreme southern end of the Design Unit A310 tunnel line and is within the boundary of the Salt Lake oil field. Strong hydrogen sulfide odors were detected at a depth of 27 feet in the large-diameter borehole (Boring 23B) drilled at this Station site. From there to the bottom of the hole, there were considerable sulfurous odors and a gas detector recorded the presence of combustible gases. Results of chromatographic analyses of gas samples obtained during the 1981 geotechnical investigation are presented in Appendix C. Oil was found in the formation from 40 to 75 feet and gas bubbled through the sidewalk cold joints during the drilling operations. In addition, petroleum was noted in the logs of all the rotary-wash boreholes drilled at the site. Depths at which petroleum was first encountered range from about 50 to 68 feet. However, the amount of bitumen found at depths less than 60 feet was too small to influence the engineering characteristics of the materials. Some sulfurous/organic odors were also noted in the logs of Boreholes 23C and CEG-23A, which are located some 900 and 1600 feet from the Fairfax/Beverly Station site, respectively (i.e., at Stations 582± and 589±).

The only other borehole drilled near the tunnel alignment in which strong petroleum odors and/or gas was detected is the large-diameter boring (Boring 28C) which was drilled just north of the Hollywood/Cahuenga Station site near Station 760±. Petroleum odors were detected in this borehole when it had reached a depth of 49 feet. In addition, about 1 inch of gasoline was noted floating at the surface of the groundwater that collected at the bottom of this hole. A possible source of this gasoline is believed to be an abandoned service station which is located about 150 feet north of the boring. This boring is not within the limits of Design Unit A310; however, the occurrence of this gasoline and potentially hazardous condition so close to the proposed tunnel line are drawn to the attention of the reader.

5.7 FAULTS

The tunnel line of Design Unit A310 crosses the Santa Monica Fault Zone near the south end of the alignment. This fault is judged to be potentially active. The near-surface location of this fault zone is not well defined, but interpretations of available subsurface data suggest the surface trace of the zone could lie between tunnel Stations 580± to 610±, a distance of approximately 3000 feet. This location has not been conclusively confirmed. Subsurface data near Boring CEG-27 appear to indicate the presence of the Santa Monica fault in the Hollywood area (CEG-27 is approximately 1500 feet south of the proposed alignment). These data suggest about 150 feet of vertical offset along a 50° north-dipping reverse fault (north side up) with bedrock thrust over Alluvium.

The projected ground surface traces of other concealed faults that cross the proposed tunnel are the San Vicente and the Hollywood faults. These faults are located at the extreme southern and northern ends of the tunnel, respectively.

The projected ground surface trace of the San Vicente fault crosses the tunnel alignment at about a 45° angle near Station 572± and is in the Fernando Formation bedrock. This fault is not known to displace the overlying San Pedro Sand; therefore, it may not intersect tunnel grade. This fault is not known to be active or potentially active, and neither the physical condition nor the width of the fault zone is known. The fault is likely a trap for gas and oil since it crosses the Salt Lake oil field.

The projected ground surface trace of the Hollywood fault zone is located between Stations 757± to 763± (approximately 600 feet wide) at the base of the Santa Monica Mountains near the Hollywood/Cahuenga Station site. This fault is judged to be active based on interpretations of data obtained during the 1981 geotechnical investigation. The fault zone crosses the proposed cut-and-cover reach (north of the Hollywood/Cahuenga Station) between Stations 758± and 764± at the proposed track grade.

More detailed descriptions and information on the faults within Design Unit A310 are contained in the November 1981 Geotechnical Investigation Report, Volume 1, Section 4.4.2 and Volume 2, Appendix D.

5.8 ENGINEERING PROPERTIES OF SUBSURFACE MATERIALS

5.8.1 General

Based on our review and interpretation of boring logs, inspection of soil samples, and interpretation and evaluation of results of field and laboratory test data, we have grouped the subsurface materials encountered at the Fairfax/Santa Monica and La Brea/Sunset Station sites into two general subsurface units. These units include coarse-grained Alluvium and fine-grained Alluvium. This section provides descriptions of these units and presents engineering parameters used in our analyses (see Table 5-2). These parameters are based on the laboratory test results, field test results, data from previous investigations, published data of observed and recorded field behavior from construction projects, and engineering judgment.

5.8.2 Coarse-Grained Alluvium

This alluvial unit consists primarily of silty and poorly graded sands which are generally medium dense to dense. Silty and sandy gravels have also been encountered in this unit. Strength tests performed on these materials include both direct shear and triaxial compression. Drained (effective) strength parameters are considered appropriate for static design. Young's Modulus or initial tangent modulus values for these

Table 5-2

Material Properties Selected for Static Design

Material Property	Fine-Grained Alluvium	Coarse-Grained Alluvium
Moist Density Above Groundwater (pcf)	125	125
Saturated Density (pcf)	130	130
Effective Stress Strength		
ϕ' (degrees)	34	36
c' (psf)	0	0
Total Stress Strength[a]		
ϕ (degrees)	20	--
c (psf)	0	--
Unconfined Compressive Strength (psf)[b]	3000	--
Permeability (cm/sec)	10^{-5} to 10^{-7}	10^{-3} to 10^{-5} (d) 10^{-2} to 10^{-3} (e)
Initial Tangent Modulus (psf)	300 σ'_v[c]	300 σ'_v[c]
Poisson's Ratio	0.40	0.35

---

[a] The total stress parameters should be used to determine the increase in undrained strength with depth for use in undrained strength analyses where $\phi = 0$ degrees.

[b] Applies to depth greater than about 20 feet.

[c] σ'_v is the effective overburden pressure (psf) equal to effective density times overburden depth. Moist density should be used to determine σ'_v above the water table and submerged density (saturated density minus water density) should be used for the effective density of soils below the water table.

[d] Range of permeabilities for poorly graded and silty fine sands.

[e] Range of permeabilities for sandy and/or silty gravels and coarse sands.

materials were developed using results of triaxial compression tests performed as part of this investigation and checked for consistency with tests performed on similar material types from other design units. Modulus values were found to be a function of the mean confining pressure at the end of the consolidation process.

Permeability tests performed on a limited number of triaxial test specimens during this and the 1981 investigation yield permeabilities varying between 10^{-3} and 10^{-6} cm/sec (see Appendix E). However, realizing the fact that permeabilities that were measured during testing are more appropriate for vertical seepage versus horizontal seepage, and since the soils that were encountered at the site are rather lenticular, permeability values which are somewhat higher than those reported in the laboratory test results are recommended for design calculations. It should be noted that sandy and/or silty gravels and coarse sands may be encountered at the Station sites. The permeability of these types of materials typically range between 10^{-2} and 10^{-3} cm/sec. These properties and other physical properties that are recommended for design are presented in Table 5-2.

5.8.3 Fine-Grained Alluvium

This alluvial unit consists of interbedded silty and sandy clays, clayey and sandy silts, and clayey sands which are generally stiff to hard and medium dense to very dense. However, at relatively shallow depths (i.e., generally less than 20 to 25 feet deep), these soils may be soft to firm and loose to medium dense.

Since these soils are generally silty and clayey in nature, both drained (effective) and undrained (total) strength parameters have been developed primarily from the results of triaxial compression tests. The recommended strength parameters given in Table 5-2 have been developed from the results of tests performed on samples obtained from the Station sites, although a limited number of strength test results obtained from other boreholes located within this design unit were used in the development of both sets of strength parameters.

As in the case of the coarse-grained alluvium, the Young's Modulus or initial tangent modulus values were found to be a function of the mean confining pressure at the end of consolidation.

Permeability tests performed on triaxial test samples of fine-grained alluvium obtained from the two Station sites and other design units indicate that these soils have permeability ranging from about 10^{-5} to 10^{-8} cm/sec. However, since the soils were found to be interbedded and lenticular, slightly higher permeabilities are recommended for design calculations.

Section 6.0

Geotechnical Evaluations and Design Criteria for Stations

6.0 GEOTECHNICAL EVALUATIONS AND DESIGN CRITERIA FOR STATIONS

6.1 GENERAL

Geotechnical design criteria for design and construction of the Fairfax/Santa Monica and La Brea/Sunset Stations are provided in this section of the report. To the extent practical, the criteria have been generalized to consider various potential design and construction concepts. As the design is finalized and specific details are formulated, these geotechnical criteria may be subject to some revision.

The excavation for both Stations will be through alluvial deposits which consist predominantly of clayey sands and sandy clays containing layers and lenses of silts, clays, sands, and silty sands. As shown in Table 6-1, the depth of the excavation at the Fairfax/Santa Monica Station will range from 66 feet (Elevation 211) at the south end of the Station to 82 feet (Elevation 212) at the north end. The bottom of the excavation at the La Brea/Sunset Station will be at Elevation 296 at the west end of the Station and Elevation 294 at the east end, corresponding to a 54-foot excavation (see Table 6-2). At the Fairfax/Santa Monica Station, the measured groundwater table is 7 feet above the bottom of the excavation. At the La Brea/Sunset Station site, the groundwater table is within 1 foot of the bottom of the excavation (see Tables 6-1 and 6-2). For both Stations, the permanent structure will in essence be a concrete box bearing on Alluvium and retaining Alluvium deposits.

The primary geotechnical considerations at the Station sites include:

- Selection, design, and construction of the temporary shoring system and the permanent wall system.
- Development of underpinning guidelines.
- Establishing magnitude and distribution of soil and water pressures acting on the permanent structures, and designing for these loads.

6.2 EXCAVATION DEWATERING

6.2.1 General

Based on an excavation bottom ranging from Elevation 211 to 212 feet at the Fairfax/Santa Monica Station site, and from Elevation 294 to 296 at the La Brea/Sunset Station site, the proposed excavations will only extend from 1 to 7 feet below the measured groundwater levels at the two sites. This thickness of saturated alluvium will require minor construction dewatering to complete the excavations. At the Fairfax/Santa Monica site, about 7 feet of saturated alluvium will have to be dewatered, whereas only about 1 foot of saturated alluvium will have to be dewatered at the La Brea/Sunset Station site. Based on the estimated permeabilities of these materials, this dewatering can probably be accomplished by use of sump pumps within the excavation combined with supplementary ditch drains. No major dewatering problems are expected to be encountered at either of the Station

Table 6-1

SUMMARY OF EXCAVATION AND GROUNDWATER DEPTHS AND ELEVATIONS DESIGN UNIT A310--FAIRFAX/SANTA MONICA STATION

	Elevation (feet)				Depth (feet)	
	Ground Surface	Top of Rail	Bottom of Excavation	Measured Water Level	Depth to Groundwater	Depth of Excavation
South End of Station	277	220	211	218	59	66
North End of Station	294	221.5	212	219	75	82

Table 6-2

SUMMARY OF EXCAVATION AND GROUNDWATER DEPTHS AND ELEVATIONS DESIGN UNIT A310--LA BREA/SUNSET STATION

	Elevation (feet)				Depth (feet)	
	Ground Surface	Top of Rail	Bottom of Excavation	Measured Water Level	Depth to Groundwater	Depth of Excavation
West End of Station	350	303	296	295	55	54
East End of Station	348	301.6	294	295	53	54

Note: Groundwater information based on data presented in Table 5-1.

sites. Nevertheless, the contractor will be responsible for designing, installing, and operating a suitable construction dewatering system subject to review and acceptance by the Metro Rail Construction Manager.

6.3 UNDERPINNING

6.3.1 Underpinning/Support Methods

The need to underpin and the appropriate type of underpinning for specific structures located adjacent to the proposed excavations depend on many factors. Some of the most important factors are soil and groundwater conditions, depth of excavation, type of structure and proximity to the excavation, type of shoring, and consequences of potential ground movements. Thus, each structure needs to be evaluated separately. The specific requirements for underpinning will be the responsibility of the section designers. However, to aid the designers in evaluating underpinning requirements, general geotechnical underpinning guidelines are presented in this section of the report.

There are several commonly used methods for underpinning. These include jacked piles, slant drilled piles, and hand-dug pit or pier underpinning. Another technique which has been used is the "column pick-up" method which provides a means of jacking up selected columns in the event that settlements do occur. These various techniques are discussed below.

- o Jacked Piles: These piles generally consist of open end pipe piles 6 to 18 inches in diameter. These sections are generally preferred due to their relatively low volume displacement which facilitates placement. Open end pipe sections have the additional advantage of permitting clean-out to reduce point and shaft resistance during installation. If point resistance is to be relied on, the pipe should be filled with concrete prior to reaching its desired elevation.

- o Slant Drilled Piles: This method consists of placing a steel pile in a shaft (generally 12- to 24-inch diameter) drilled from the side of the foundation. The shaft is drilled at a small angle of slant under the foundation and then back-reamed to provide a vertical slot below the foundation. A steel pipe is placed under the foundation, and the shaft is filled with concrete. In weak soils or in ground subject to sloughing, this method can result in settlement if there is loss of ground into the drilled hole.

- o Hand-Dug Pits: This method consists of excavating an approach pit beneath the footing and advancing square or rectangular shafts, normally 3 to 5 feet wide, down to the bearing stratum. The shaft excavations are lagged for the entire depth with the lagging normally left in place permanently. Reinforcement is placed, and concrete is tremied into the shaft(s).

- o Column Pick-Up: This technique provides a method of releveling specific structural elements without underpinning in the event that excessive settlements occur. However, it is a very expensive and time consuming method. The technique involves providing a structural break between the column (or wall) and its foundation. Special connections are made to transmit loads around the structural break and jacking, or other means, is used to relevel the column or wall. After completion of the excavation, a permanent connection between the building and foundation is re-established. Since this method does not transfer foundation loads to a lower stratum, both shoring and permanent walls must be designed for surcharge loads imposed by the existing structure.

6.3.2 Underpinning Considerations

From an engineering standpoint, the need to underpin is evaluated on the basis of expected ground movements and potential for structural damage. Figure 6-1 presents guidelines for evaluating if a structure may be within the influence zones of the excavation; however, further evaluation of expected ground movements should be made based upon the type of shoring proposed. Section 6.4.6 discusses the anticipated ground movements in the vicinity of the excavation due to shoring. A conservatively designed shoring system (higher design lateral pressures) could be constructed to reduce ground movements due to shoring and thereby reduce the need to underpin.

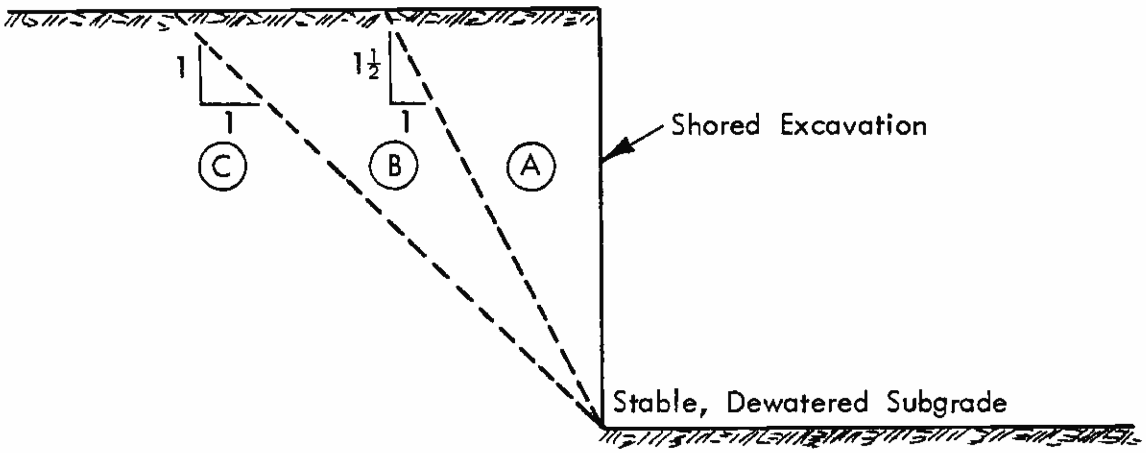
Review of Drawings 2 through 7 indicate that several significant structures are located in close proximity to the proposed Fairfax/Santa Monica Station. Thus, underpinning of these structures may be required. Underpinning at this site should not present any major problems. The upper 20 to 25 feet of the profile consist mainly of fine-grained materials which are stiff and/or medium dense. Below these depths, both firm to very stiff fine-grained and medium dense to very dense coarse-grained alluvium were encountered. These should provide adequate support for the underpinning piles. Some minor caving could occur within localized zones of the coarse-grained alluvium, but this should be rather limited in extent since the groundwater table is quite deep.

There appears to be no need for underpinning at the La Brea/Sunset Station site.

6.3.3 Design Criteria

Figures 6-2 through 6-4 present geotechnical criteria for jacked circular pipe piles and slant drilled piles. Figure 6-2 illustrates the procedures for determining the geometry of the support zones required to use Figures 6-3 and 6-4. No support should be allowed within any existing fill soils encountered or within the "no support" zone shown on Figure 6-2.

If jetting or other methods which remove soil ahead of the pile are used, no shaft frictional resistance should be allowed. To ensure proper end bearing, jetting must not be used for the final 5 feet of penetration. Group action of piles or piers should be considered and an appropriate reduction factor applied to determine the effective group capacity. An appropriate reduction factor is presented in the Los Angeles City Building Code Section 91.2808b.



NOTES: 1) These guidelines are applicable only for stiff or dense stable ground conditions. Other soil and/or foundation conditions may require further analyses.

2) For structure foundations bearing in zones A, B, or C, the following guidelines are presented:

ZONE Ⓐ Special Provisions Required for Important Structures:

Underpinning or construction of conservative shoring system (designed to support lateral loads from building foundations with acceptably small ground movements) must be considered.

ZONE Ⓑ Generally No Special Provisions Required:

Properly designed shoring system generally adequate without underpinning unless underlain by poor soils or adjacent to especially sensitive structures.

ZONE Ⓒ No Special Provisions

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UNDERPINNING GUIDELINES

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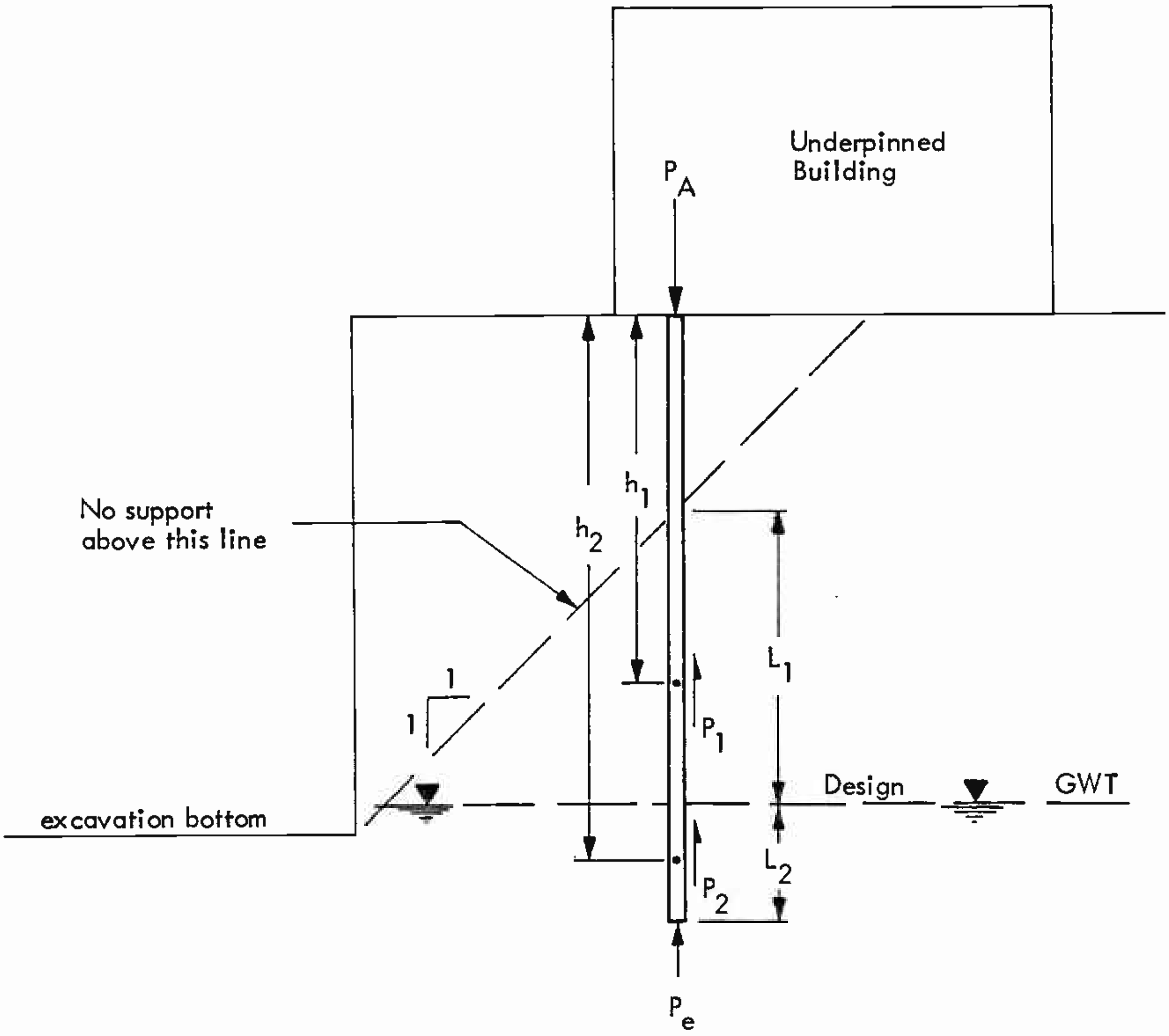
Figure No.
6-1



$$P_A = p_1 \cdot L_1 + p_2 \cdot L_2 + P_e$$

WHERE: $^*p_1$ = average frictional resistance at h_1

$^*p_2$ = average frictional resistance at h_2

$^{**}P_e$ = end bearing support

* See Figure 6-3 for values of p_1 and p_2

** See Figure 6-4 for values of P_e

UNDERPINNING - DESIGN CAPACITY CRITERIA

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Figure No.
6-2

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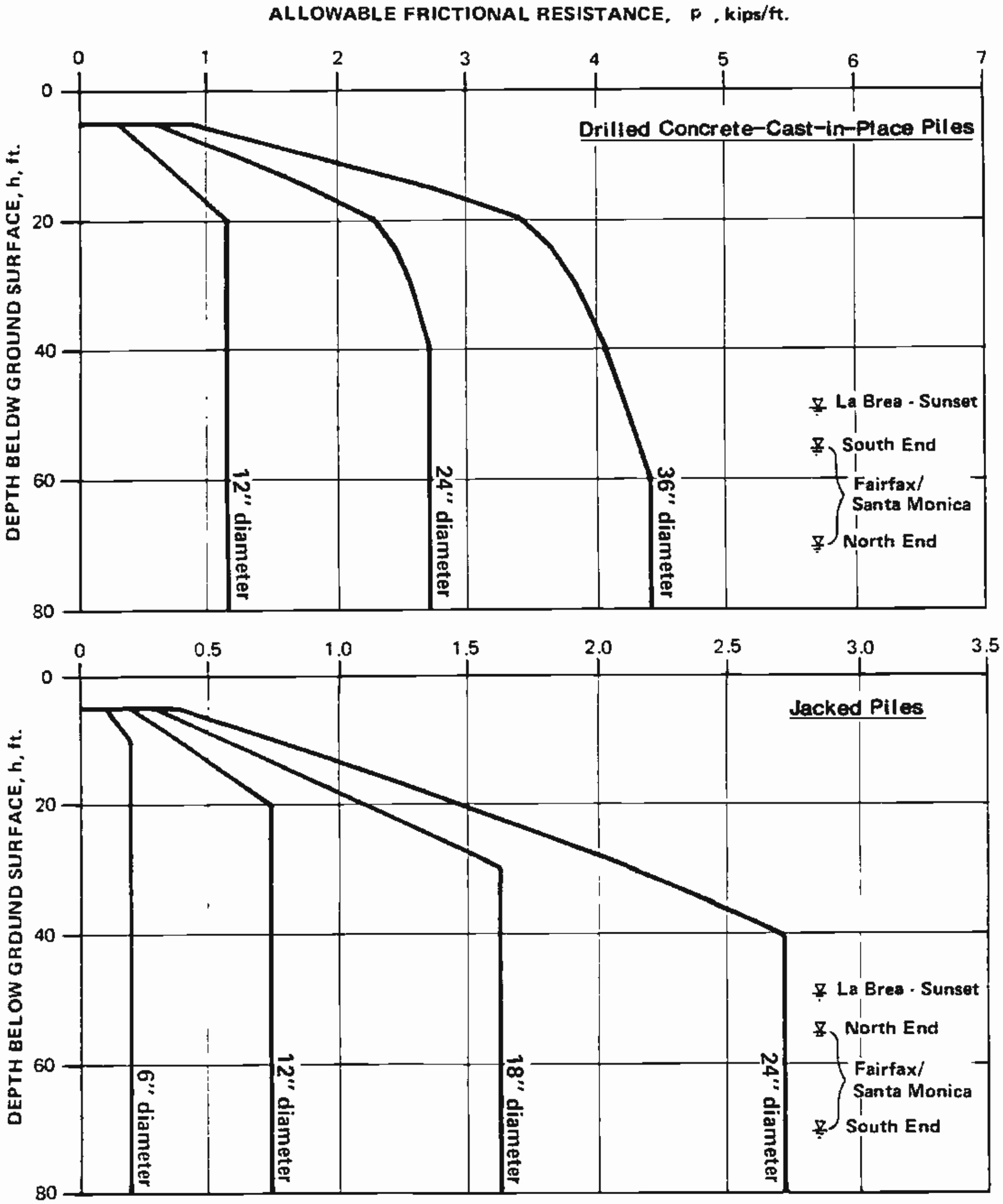

NOTES: 1) See Figure 6-2 for evaluation of total vertical pile capacity. Figure 6-4 should be used to evaluate capacity due to end-bearing support.

2) Maximum pile frictional resistance taken as value corresponding to a depth equal to 20 times diameter of the pile.

3) Water levels indicated correspond to those recommended for design of the stations.

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UNDERPINNING - VERTICAL PILE FRICTIONAL RESISTANCE IN ALLUVIUM

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Figure No.
6-3

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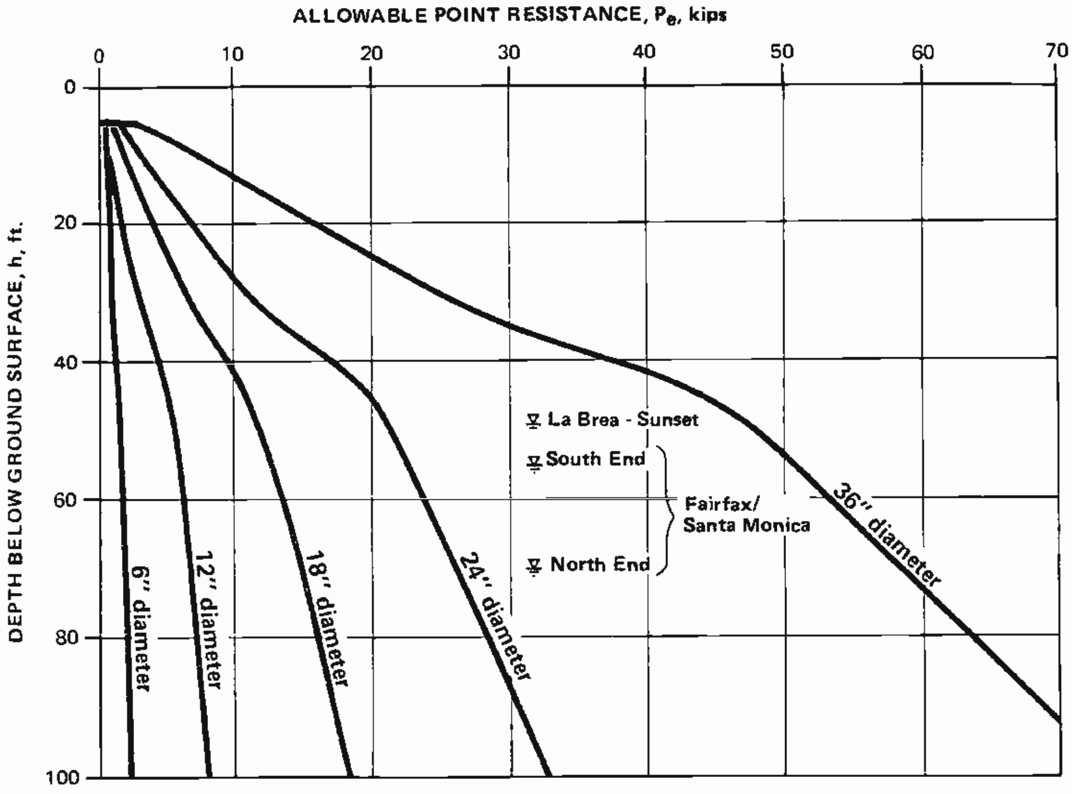

NOTES: 1) See Figure 6-2 for evaluation of total vertical pile capacity. Figure 6-3 should be used to evaluate capacity due to frictional resistance along length of pile.

2) Water levels indicated correspond to those recommended for design of the stations.

3) Jacked piles assumed to consist of circular pipe pile filled with concrete.

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UNDERPINNING – VERTICAL PILE END-BEARING RESISTANCE IN ALLUVIUM FOR CAST-IN-PLACE OR JACKED PILES

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Figure No.
6-4

Total capacity of hand-dug, lagged piers should be limited to end bearing only and must extend below the "no support" line shown on Figure 6-2. All piers are assumed to be 36-inch square or larger in section. For design, an allowable bearing capacity of 1 ksf may be used for piers which bear on the undisturbed soft to firm alluvium and penetrate at least 10 feet below the ground surface. This value applies only if the bearing surface is properly cleaned and approved by a qualified engineer.

The expected lateral ground movements due to the excavation are discussed in Section 6.4.6. The capability of the existing structure and underpinning system to sustain these lateral movements should be evaluated. If it becomes necessary to reduce the magnitude of the expected movements, additional lateral restraint should be provided by tieback anchors or other methods.

6.3.4 Underpinning Performance

Underpinning is not a guarantee that the structure will be totally free from either settlements or lateral movement. Some settlement may occur during the underpinning process. Additional vertical and/or lateral movement may occur during the construction of the main excavation, depending on the performance of both the shoring and underpinning elements.

6.3.5 Underpinning Instrumentation

Elevation reference points should be established on each foundation element to be underpinned. The points should be monitored on a regular basis consistent with the construction progress (readings may be required daily). Maximum allowable movements should be established for each element by the engineer prior to underpinning. If it appears that these limits may be exceeded, immediate measures should be taken such as restressing underpinning elements, adding more supports or changing installation procedures.

Where a group of three or more jacked piles is used to underpin a foundation element, load relaxation of previously installed piles can occur.

6.4 TEMPORARY SLOPED EXCAVATIONS AND SHORING SUPPORT SYSTEMS

6.4.1 General

The required excavation depths below the existing ground surface are tabulated in Tables 6-1 and 6-2 for both Station sites. There are several ways to construct the excavation including a conventional shoring system with underpinning of adjacent structures as required, or a conservatively designed shoring system which would eliminate or reduce the need to underpin. Driven sheet piles are not considered feasible due to the presence of dense layers of cohesionless soils. We understand that the shoring system will be chosen and designed by the contractor in accordance with specified criteria and subject to the review and acceptance by the Metro Rail Construction Manager.

The contractor may propose one of the following shoring systems with either tiebacks or internal bracing for lateral support:

- o Conventional Shoring System: Significant buildings at the Fairfax/Santa Monica Station site located within the underpinning zone (see Figure 6-1) may require underpinning.
- o Conservative Shoring System: This could consist of a conservatively designed wall which may limit ground movements sufficiently to eliminate or reduce the need for underpinning.

The discussions and design criteria presented in this section pertain to these general shoring methods. Other shoring support systems may also be appropriate and may be considered by the contractor.

6.4.2 Sloped Excavations

Portions of the required excavation could be made with a sloped excavation, particularly the shallower cuts around the entry structures. Sloped excavations would significantly reduce the height of the temporary shoring. The use of sloped excavations at the site would depend on whether easements can be obtained to extend the limits of the excavation. Construction of a wide bench at the toe of the cut slope would probably be required to provide access to the shored excavation but would increase the volume of excavated soil.

The major factors which detemine the safe, stable slope include soil conditions, groundwater conditions, the weather (i.e., dry or heavy rain), construction procedures and scheduling, and others. Applicable governmental safety codes must also be complied with.

For evaluation of excavation alternatives, temporary slopes of 1.5H:1V may be assumed for the upper alluvial deposits. These recommendations assume suitable site dewatering where necessary, no heavy loads at the top of the slope, slope protection, and some slope maintenance. In addition, these recommendations should not be construed by the contractor to be a guaranteed permissible slope since the actual safe slope will be a function of actual construction and field conditions.

6.4.3 Soldier Pile Shoring System

A soldier pile and lagging shoring system consisting of soldier piles installed in pre-drilled holes is a common method of shoring deep excavations in the Los Angeles area. Both conventional and conservative shoring systems may be used at the Station sites. The conservative wall should be designed for higher soil loads since this will reduce ground movements behind the wall. Appendix D.1 summarizes several case studies in the Los Angeles area involving soldier pile excavations to depths exceeding 100 feet.

To our knowledge there are no data on field measurements of actual lateral soil pressures for shored excavations in the Los Angeles area, and therefore the design pressures of Appendix D.1 have not been strictly verified by measurements during construction. However, the performance of shoring systems designed based on local practice has generally been good. Therefore, the local practice was considered in the development of our recommended design criteria.

Soldier piles have been installed in the Los Angeles area in soils similar to those encountered at the proposed Station sites. Within the Alluvium, particularly below the groundwater table, caving can be a problem. The contractor should recognize that caving conditions may be encountered in construction of soldier piles or other drilled shaft elements such as tiebacks.

The coarse-grained soils will require support between soldier piles to eliminate loss of ground. Typically, wooden lagging is used although precast concrete or steel panels could also be used.

6.4.4 Shoring Design Criteria

This section provides design criteria for both conventional and conservative shoring systems consisting of soldier piles and wooden lagging supported by tiebacks or internal bracing. The soldier piles are assumed to consist of steel W or H-sections installed in predrilled circular shafts. It is assumed that the drilled shaft will be filled with structural concrete below the bottom of the excavation and lean mix above the subgrade. Thus, for computing the allowable vertical and lateral capacities, the piles are assumed to have circular concrete sections.

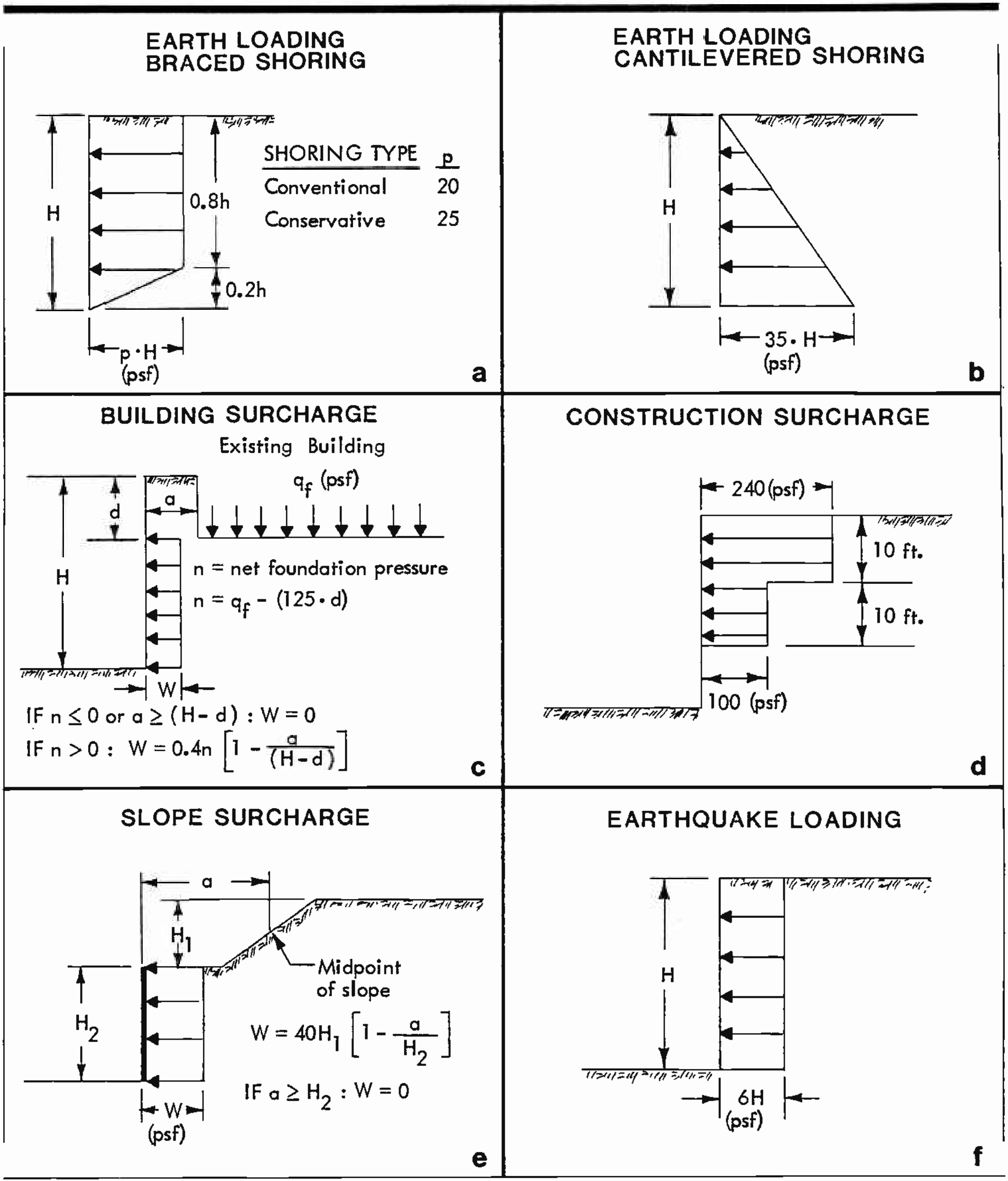
Specific shoring design criteria include:

- Design Wall Pressure: Figures 6-5a and 6-5b present the recommended lateral earth pressure on the temporary shoring walls. Design lateral pressures for both conventional and conservative shoring systems are presented in Figure 6-5a. Figure 6-5e also includes the case of partial sloped cuts. The full loading diagram should be used to determine the design loads on tieback anchors and the required depth of embedment of the soldier piles. For computing design stresses in the soldier piles, the computed values can be multiplied by 0.8. For sizing lagging, the earth pressures can be reduced by a factor of 0.5.

- Depth of Pile Embedment: The embedment depth of the soldier pile below the lowest anticipated excavation depth must be sufficient to satisfy both the lateral and vertical capacities under static and dynamic loading conditions.

  The required depth of embedment to satisfy vertical loads should be computed based on allowable vertical loads shown on Figure 6-6.

  The imposed lateral load on the pile should be computed based on the earth pressure diagrams of Figure 6-5 minus the support from tiebacks or internal bracing. The required depth of embedment to satisfy lateral loads should be computed based on the net allowable passive resistance (total passive resistance of the soldier pile minus the active earth pressure below the



LATERAL LOADS ON TEMPORARY SHORING (WITH DEWATERING)

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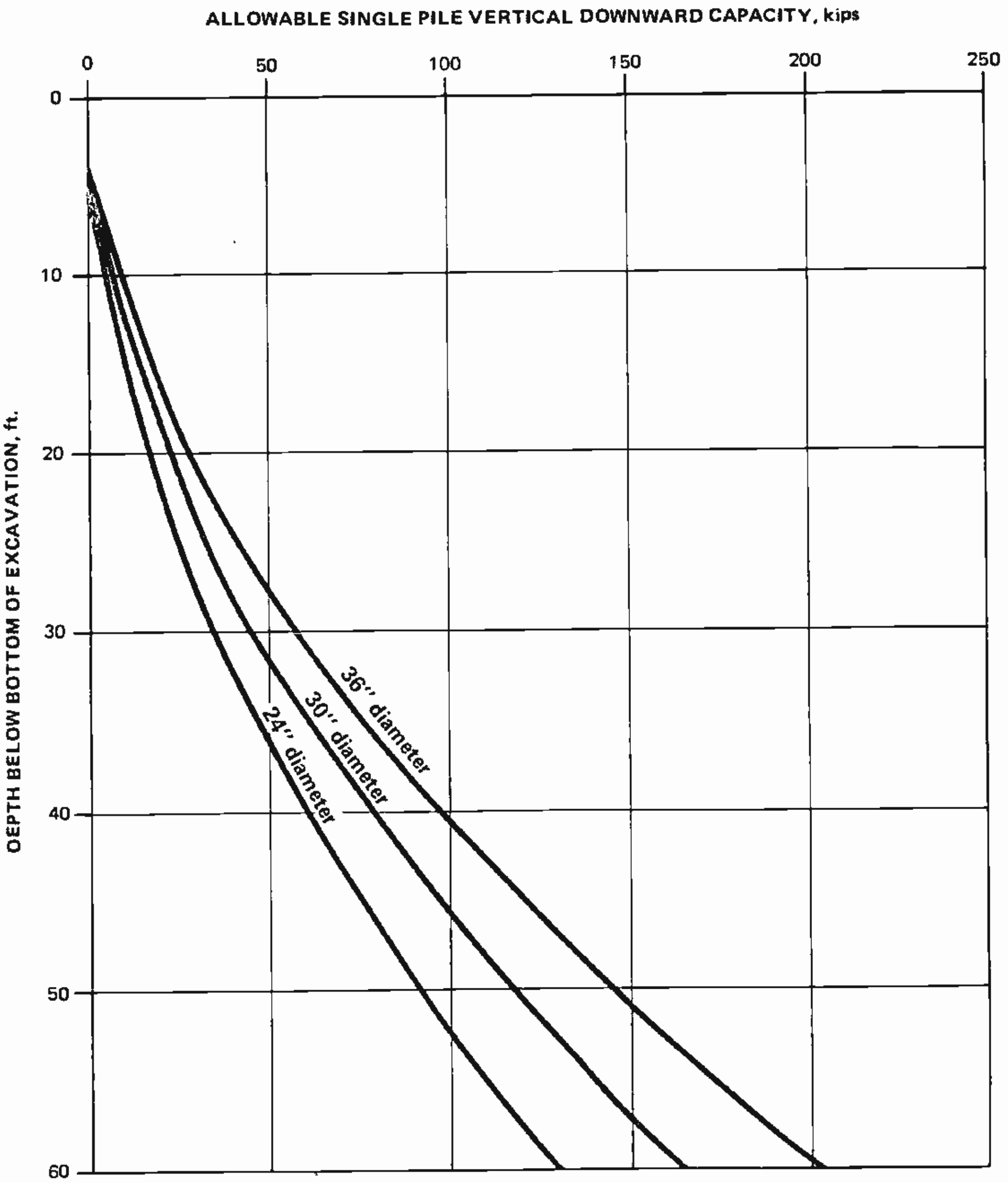
Figure No.
6-5



NOTES:
1) Total capacity includes contributions from both shaft frictional resistance and end-bearing support.
2) For seismic design, capacities may be increased by one-third.
3) Groundwater level at bottom of excavation.
4) Applicable only for drilled shaft piles.

ALLOWABLE VERTICAL PILE CAPACITY IN ALLUVIUM
FOR SHORING AND DECKING

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Figure No.
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excavation). Due to arching effects, it is recommended that the effective pile diameter be assumed equal to 1.5 pile diameters or half of the pile spacing, whichever is less. Figure 6-7 indicates the recommended method to compute net passive resistance.

- <u>Pile Spacing and Lagging</u>: The optimum pile spacing depends on many factors including soil loads, member sizes, and costs. At the Station sites the upper soils consist of sandy and clayey soils which may be subject to ravelling and sloughing. Thus, it is recommended that the pile spacing be limited to about 8 feet, and that continuous lagging be placed to minimize ravelling of soils and loss of ground between soldier piles. The contractor should limit the temporary exposed soil height to less than 3 feet to control ravelling problems, especially in the dewatered zone.

- <u>Excavation Stability</u>: Stability calculations should be performed to insure that the shoring/tieback system has an adequate factor of safety against deep-seated failure.

6.4.5 Internal Bracing and Tiebacks

6.4.5.1 General: Tiebacks and/or internal bracing may both be suitable to support the temporary shoring wall for the proposed excavation. Tiebacks have the advantage of producing an open excavation which can significantly simplify the excavation procedure and construction of the permanent structure. Obtaining permission to install tiebacks under adjacent properties and encountering obstructions from adjacent below grade structures (such as basements) can also affect the economics and feasibility of tiebacks.

Based on available field data, there does not appear to be a significant difference between the maximum ground movements of properly designed and carefully constructed tieback walls or internally braced walls. However, there is a difference in the distribution of the ground movements. Prestressing of both tiebacks and struts is essential to confirm design capacities and minimize ground movements.

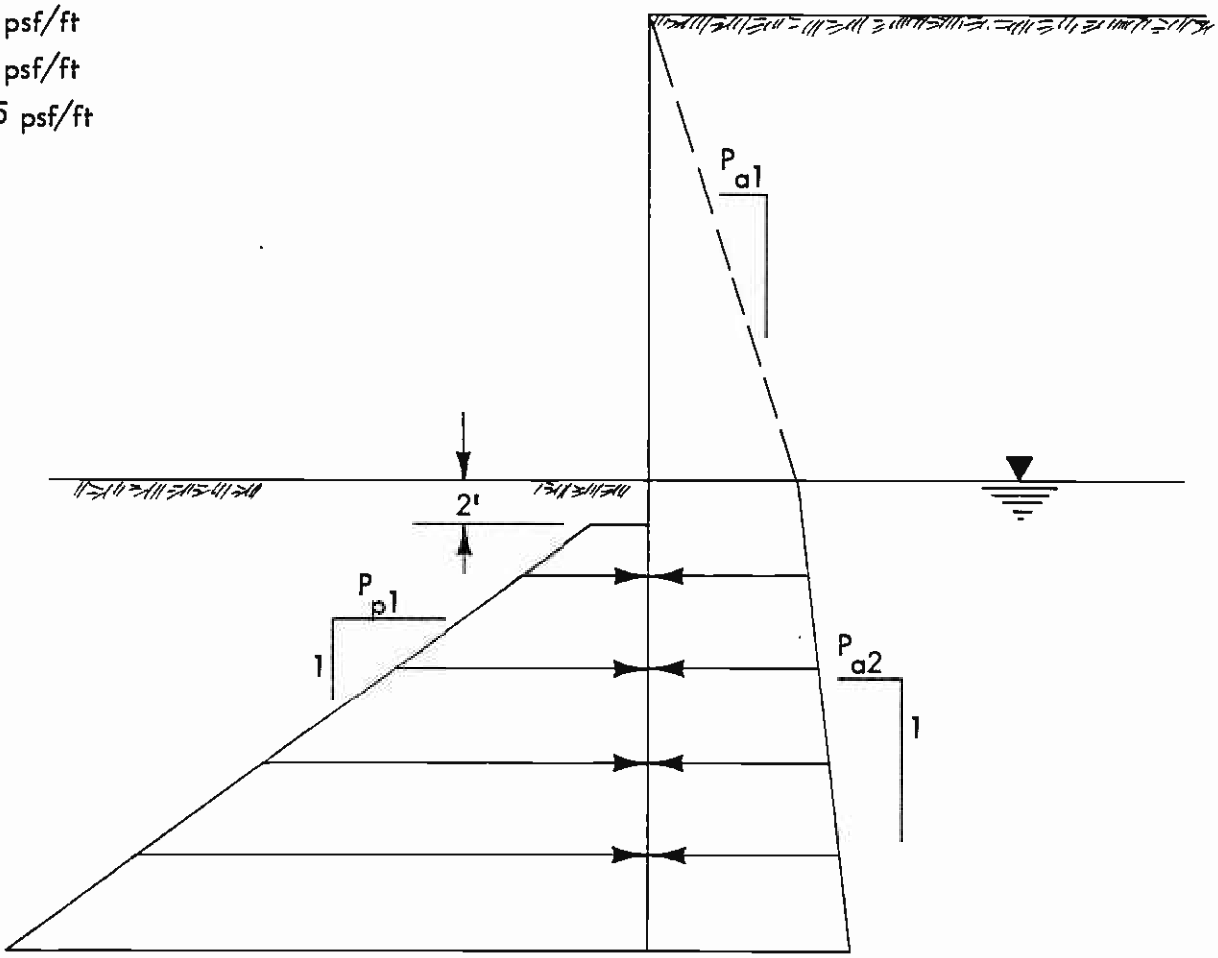
6.4.5.2 Internal Bracing: The contractor should not be allowed to extend the excavation an excessive distance below the lowest strut level prior to installing the next strut level. The maximum vertical distance depends on several specific details such as the design of the wall and the allowable ground movement. These details cannot be generalized. However, as a guideline, we recommend consideration of the following maximum allowable vertical distances between struts:

- Conventional Shoring System: 12 feet.

- Conservative Shoring System: 8 feet.

Recommended Unit Pressures

P_{a1} = 35 psf/ft
P_{a2} = 18 psf/ft
P_{p1} = 165 psf/ft



Where: P_p = Allowable unit passive pressure
P_a = Unit active pressure

NOTE:
1.) The site is assumed to be dewatered
2.) Available passive pressure = Total Passive - Active
3.) Available passive pressure can be assumed to act on 1.5 pile diameters or ½ the pile spacing whichever is less.
4.) Active pressure shown is for evaluation of available passive pressure. Lateral shoring pressures are presented on Fig. 6-2

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SOLDIER PILE PASSIVE RESISTANCE

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Figure No.
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In addition, the contractor should not be allowed to extend the excavation more than 3 feet below the designated support level before placing the next level of struts. The contractor may be allowed to excavate a trench within the excavation to facilitate construction operations provided the trench is not less than 15 feet horizontally from the shoring and does not extend more than 6 feet below the designated support level.

To remove slack and limit ground movement, the struts should be preloaded. A preload equal to 50% of the design load is normally desirable. Stresses due to temperature variations shall be taken into account in the design of the struts.

6.4.5.3 Tieback Anchors: There are numerous types of tieback anchors available, including large diameter straight shaft friction anchors, belled anchors, high pressure grouted anchors, high pressure regroutable anchors, and others. Generally, in the Los Angeles area, high capacity straight shaft or belled anchors have been used in association with stable soil conditions.

Tieback anchor capacity can be determined only in the field based on anchor load tests. For estimating purposes, we recommend that the capacity of drilled straight shaft friction anchors in the Alluvium be computed based on the following equation:

$$P = \pi DLq \quad \text{(anchor capacity)}$$

where

P = allowable anchor design load in pounds
D = anchor diameter in feet
L = anchor length beyond no load zone in feet
q = allowable soil adhesion in Alluvium in psf.

The design adhesion value (q) can be taken equal to:

$$q = 20d < 750 \text{ psf} \quad ,$$

where:

d = average depth of the anchor in feet beyond the no-load zone; measured vertically from the ground surface.

Allowable anchor capacity/length relationships for tieback types other than straight shaft friction anchors such as high pressure grouted anchors and high pressure regroutable anchors must be based on experience in the field and on the results of test anchors.

For design purposes, it should be assumed that the potential wedge of failure behind the shored excavation is determined by a plane drawn at 35 degrees with the vertical through the bottom of the excavation. Only the frictional resistance developed beyond the no-load line should be assumed effective in resisting lateral loads. Based on specific site conditions, the extent of the no-load zone may be locally decreased to avoid underground obstructions.

The anchors may be installed at angles between 20 and 50 degrees below the horizontal. Based on specific site conditions, these limits could be expanded to avoid underground obstructions. Structural concrete should be placed in the lower portion of the anchor up to the limit of the no-load zone. Placement of the anchor grout should be done by pumping the concrete through a tremie or pipe extending to the bottom of the shaft. The anchor shaft between the no-load zone and the face of the shoring must be backfilled with a sand slurry or equivalent after concrete placement. Alternatively, special bond breakers can be applied to the strands or bars in the no-load zone and the entire shaft filled with concrete.

For tieback anchor installations, the contractor should be required to use a method which will minimize loss of ground due to caving. Potential caving in the alluvium could be a problem particularly for anchors installed below the groundwater table. Uncontrolled caving not only causes installation problems but could result in surface subsidence and settlement of overlying buildings. To minimize caving, casing could be installed as the hole is advanced but must be pulled as the concrete is poured. Alternatively, the hole could be maintained full of slurry or a hollow stem auger could be used.

It is recommended that each tieback anchor be test loaded to 150% of the design load and then locked off at the design load. At 150% of the design load, the anchor deflection should not exceed 0.1 inches over a 15-minute period. In addition, 5% to 10% of the anchors should be test-loaded to 200% of the design load and then locked off at the design load. At 200% of design load the anchor deflections should not exceed 0.15 inches over a 15-minute period. The rate of deflection should consistently decrease during the test period. If the rate of deflection does not decrease the test should not be considered satisfactory.

6.4.6 Anticipated Ground Movements

The ground movements associated with a shored excavation depend on many factors including the contractors procedures and schedule, and, therefore, the distribution and magnitude of ground movements are difficult to predict. Based on shoring performance data for documented excavation cases in similar ground conditions, combined with our engineering judgment, we estimate that the ground movements associated with properly designed and carefully constructed shoring systems will be as follows:

- Conventional Wall With Tieback Anchors: The maximum horizontal wall deflection will equal about 0.1% to 0.2% of the excavation depth. The maximum horizontal movement should occur near the top of the wall and decrease with depth. The maximum vertical settlement behind the wall should be equal to about 50% to 100% of the maximum horizontal deflection and will probably occur at a distance behind the wall equal to about 25% to 50% of the excavation depth.

- Conventional Wall With Internal Bracing: The maximum ground movement will be similar to those anticipated with tiebacks. However, the maximum horizontal movement will probably occur near the bottom of the excavation decreasing to about 25% of the maximum at the surface.
- Conservative Wall With Tiebacks: We believe that the wall systems designed by utilizing the higher earth pressures presented for conservative walls will reduce ground movements and limit the maximum horizontal and vertical movements to about 0.1% of the excavation depth.
- Conservative Wall With Internal Bracing: Similar to those described above for the conservative tieback supported wall.

6.5 SUPPORT OF TEMPORARY DECKING

Where temporary street decking requires center support, the piles would have to extend below the maximum proposed excavation level for support. At these depths, the piles would be founded within the deeper alluvial deposits. These materials are suitable for supporting pile loads.

Since the shoring contractor will probably install soldier piles to support the excavation, we believe that he may use similar piles to support the center decking. Accordingly, the allowable loads on these types of piles have been evaluated for several typical diameters. The recommended allowable design loads are shown on Figure 6-6. These values include both end bearing and shaft friction.

6.6 INSTRUMENTATION OF THE EXCAVATION

In our opinion the proposed excavation at the two Station sites should be instrumented to reduce liability (by having documentation of performance), to validate design and construction requirements, to identify problems before they become critical, and to obtain data valuable for future designs.

We recommend the following instrumentation program:

- Preconstruction Survey: A qualified civil engineer should complete a visual and photographic log of all streets and structures adjacent to each site prior to construction. This will minimize the risk associated with claims against the owner/contractor. If substantial cracks are noted in the existing structures, they should be measured and periodically remeasured during the construction period.

- Surface Survey Control: It is recommended that several locations around the excavation and on any nearby structures be surveyed prior to any construction activity and then periodically to monitor potential vertical and horizontal movement to the nearest 0.01 feet. In addition, survey makers should be placed at the top of piles spaced no more than every fourth pile or 25 feet, whichever is less.

- Tiltmeters: Tiltmeters are used to monitor the verticality of buildings adjacent to the excavation and can provide a forewarning of distress. Normally, ceramic plates are glued to the building walls and read using a portable tiltmeter containing the same type of tilt sensor used in inclinometers. It is recommended that a few tiltmeters be placed on the exterior walls of buildings which are located within the underpinning zone defined on Figure 6-1. Baseline reading should be made prior to all construction activity, and subsequent readings should be made at several excavation/construction stages through the end of construction.

- Inclinometers: It is recommended that a limited number of inclinometers be installed prior to excavation and monitored around the Stations' excavations. Inclinometers should be located on each side of the excavation. The casing could be installed within the soldier pile holes or in separate holes immediately adjacent to the shoring wall. Baseline readings of the inclinometers should be made a short time after installation. Subsequent readings should be made at regular intervals of excavation progress.

- Heave Monitoring: The magnitude of the total ground heave should be measured. This information will be valuable in determining the ground response to load change and as an indirect check on the magnitude of the predicted settlement of the Stations' structures.

  We recommend that heave gages be installed along the longitudinal centerline of each excavation on about 200-foot centers. The devices could consist of conical steel points, installed in a borehole, and monitored with a probing rod that mates with the top of the conical point. The borehole should be filled with a thick colored slurry to maintain an open hole and allow for easy hole location. The top of the points should be at least 2 feet below the bottom of the final excavation to protect it from equipment, yet allow for easy access should the hole collapse.

  The points should be installed and surveyed prior to starting excavation. Once the excavation begins, readings should be taken at about two-week intervals until the excavation is completed and all heave has stopped.

- Convergence Measurements: We recommend the use of tape extensometers to measure the convergence between the points at opposite faces of the excavation during various stages of excavation. These measurements provide inexpensive data to supplement the inclinometer and survey information.

- Additional Measurements of Strut Loads: If internal bracing is used, we recommend that the loads on at least four struts at each support level be monitored periodically during the construction period. These measurements provide data on support loads and a forewarning of load reductions which would result in excessive ground movements.
- Frequency of Readings: An appropriate frequency of instrumentation readings depends on many factors including the construction progress, the results of the instrumentation readings (i.e., if any unusual readings are obtained), costs, and other factors which cannot be generalized. The devices should be installed and initial readings should be taken as early as possible. Readings should then be taken as frequently as necessary to determine the behavior being monitored. For ground movements this should be no greater than one- to two-week intervals during the major excavation phases of the work. Strut load measurements should be more frequent, possibly even daily, when significant construction activity is occurring near the strut (such as excavation, placement of another level of struts, etc.).

  The frequency of the readings should be increased if unusual behavior is observed.

In our opinion, it is important that the installation and measurement of the instrumentation devices be under the direction and control of the Engineer. Experience has shown when the instrumentation program has been included in the bid package as a furnish and install item, the quality of the work has often been inadequate such that the data are questionable. The contractor can provide support to the Engineer in installing the instrumentation by defining Support Work (Contractor) and Specialist Work (Engineer) in the bid documents.

6.7 EXCAVATION HEAVE AND SETTLEMENT OF STRUCTURES

The proposed excavations will substantially change the ground stresses below and adjacent to the excavations. The proposed 66- to 82-foot excavation at the Fairfax/Santa Monica Station will decrease the vertical ground stresses by about 8000 to 10,000 psf. At the La Brea/Sunset Station site, the 54-foot excavation will produce a stress decrease of about 6500 psf. These stress reductions will cause the soils below the bottom of the excavations to rebound or heave. This response is not due to the occurrence of any swelling type of soils, but simply the response to stress unloading. In addition, even with a suitable shoring system, shear stresses will develop, tending to cause the soils adjacent to the walls to heave upward. Since the excavations will be open for an extended period, the heave is expected to be completed prior to construction of the Stations. The Stations' structures and subsequent backfilling will reload the soils. We estimate that the Station and backfill loads will be in the range of 5000 to 6000 psf at the Fairfax/Santa Monica Station, and from

4000 to 5000 psf at the La Brea/Sunset Station. These loads will cause the ground to reconsolidate or settle.

The maximum heave at the center of the excavations will be on the order of 2 to 4 inches. The majority of this heave will occur during the excavation phase of construction. This estimate is based on computations of elastic shear deformation (elastic rebound) and unit volume changes (elastic heave) within the soils underlying the proposed excavations.

Settlements on the order of 2 to 3 inches were computed due to the imposed loads from the structures and backfill. This will occur even though the weight of the excavated materials exceed that of the completed structures and backfill. Due to the long, narrow shape of the imposed load, the theoretical differential settlement is relatively small, on the order of 1/2 inch over half the structure width. These calculations are based on the assumption of a uniform foundation bearing pressure and a perfectly flexible structure. The actual differential settlements will be less than the theoretical flexible foundation case because of the rigid type Station structures..

We understand that MRTC is contemplating modification of the Design Criteria and Standards for underground structures to permit use of a simplifying and conservative assumption resulting in a uniform net foundation bearing pressure for the design of the invert slabs of box structures. The use of the elastic soil-structure analysis or the simplifying uniform pressure approach is left to the discretion of MRTC and the Section Designer.

6.8 PERMANENT FOUNDATION SYSTEMS

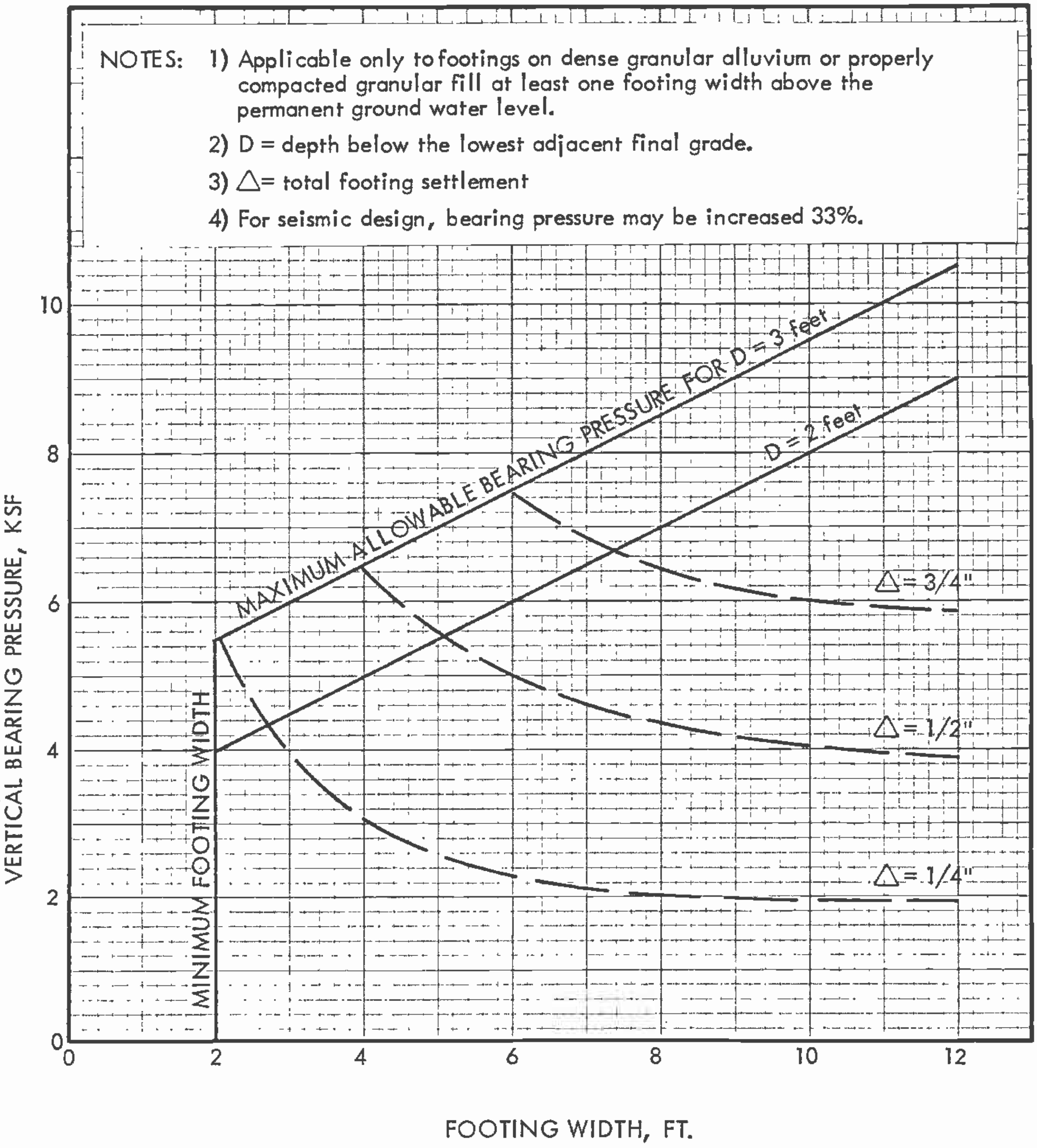
6.8.1 Main Stations

The base of the proposed Stations' structures will function as a massive mat foundation. At the proposed foundation levels, the mat will be bearing on the clayey sands and sandy clays of the Alluvium. We estimate that the net mat foundation bearing pressures for the two Station sites will range from about 4000 to 6000 psf. In our opinion the Stations can be adequately supported on mat foundations bearing on the underlying Alluvium as indicated in the previous Section.

6.8.2 Support of Surface Structures

Surface structures can be generally supported on conventional spread footings founded on properly compacted fill or on undisturbed firm Alluvium. Allowable bearing pressures and estimated total settlements of spread footings can be estimated based on Figures 6-8 and 6-9. These figures are generally conservative due to lack of detailed information on structural loadings and site conditions at the surface structure location. Detailed site specific studies should be performed to provide final design recommendations for specific structures.

All spread footing foundations should be founded at least 2 feet below the lowest adjacent final grade and should be at least 2 feet wide. The bearing values shown on Figures 6-8 and 6-9 are for full dead load and



NOTES:
1) Applicable only to footings on dense granular alluvium or properly compacted granular fill at least one footing width above the permanent ground water level.
2) D = depth below the lowest adjacent final grade.
3) △= total footing settlement
4) For seismic design, bearing pressure may be increased 33%.

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ALLOWABLE BEARING & SETTLEMENT FOR SPREAD FOOTING ON GRANULAR SOILS

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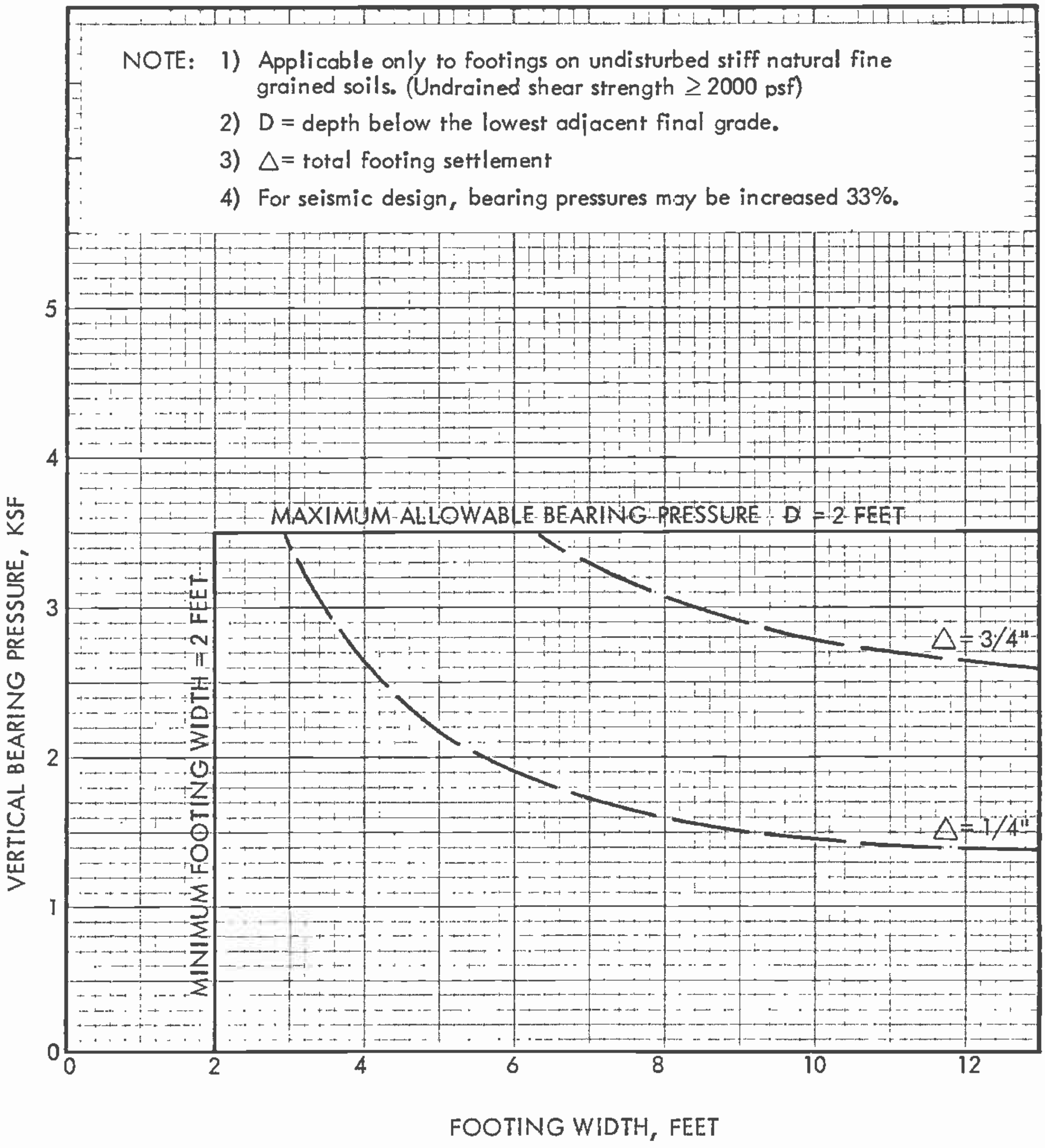
Figure No.
6-8



NOTE:
1) Applicable only to footings on undisturbed stiff natural fine grained soils. (Undrained shear strength ≥ 2000 psf)
2) D = depth below the lowest adjacent final grade.
3) △ = total footing settlement
4) For seismic design, bearing pressures may be increased 33%.

ALLOWABLE BEARING & SETTLEMENT FOR SPREAD FOOTING ON FINE-GRAINED SOILS

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Figure No.
6-9

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frequently applied live load. For transient loads, including seismic and wind loads, the bearing values can be increased by one-third. Differential settlements between adjacent footings should be estimated as 1/2 of the average total settlements or the difference in the estimated total settlements shown on Figures 6-8 and 6-9, whichever is larger.

For design, resistance to lateral loads on surface structures can be assumed to be provided by passive earth pressure and friction acting on the foundations. An allowable passive pressure of 350 psf/ft may be used for the sides of footings poured neat against dense or stiff Alluvium or properly compacted fill. Frictional resistance at the base of foundations should be determined using a frictional coefficient of 0.4 with dead load forces.

6.9 PERMANENT GROUNDWATER PROVISIONS

We understand that all of the Stations will be designed to be water-tight and to resist the full permanent hydrostatic pressures.

We recommend that full waterproofing be carried at least 5 feet above the anticipated maximum groundwater levels given in Section 6.10 for the two Stations.

6.10 STATIC LOADS ON PERMANENT SLABS AND WALLS

6.10.1 Hydrostatic Pressures

As tabulated in Tables 6-1 and 6-2, the maximum groundwater levels as measured within the borings drilled at the Station sites in 1983 and 1984 ranged from Elevation 218 to Elevation 219 at the Fairfax/Santa Monica Station site, and at about Elevation 295 at the La Brea/Sunset Station site. It is recommended that for design the maximum groundwater levels be assumed to be approximately five feet higher than the maximum measured levels.

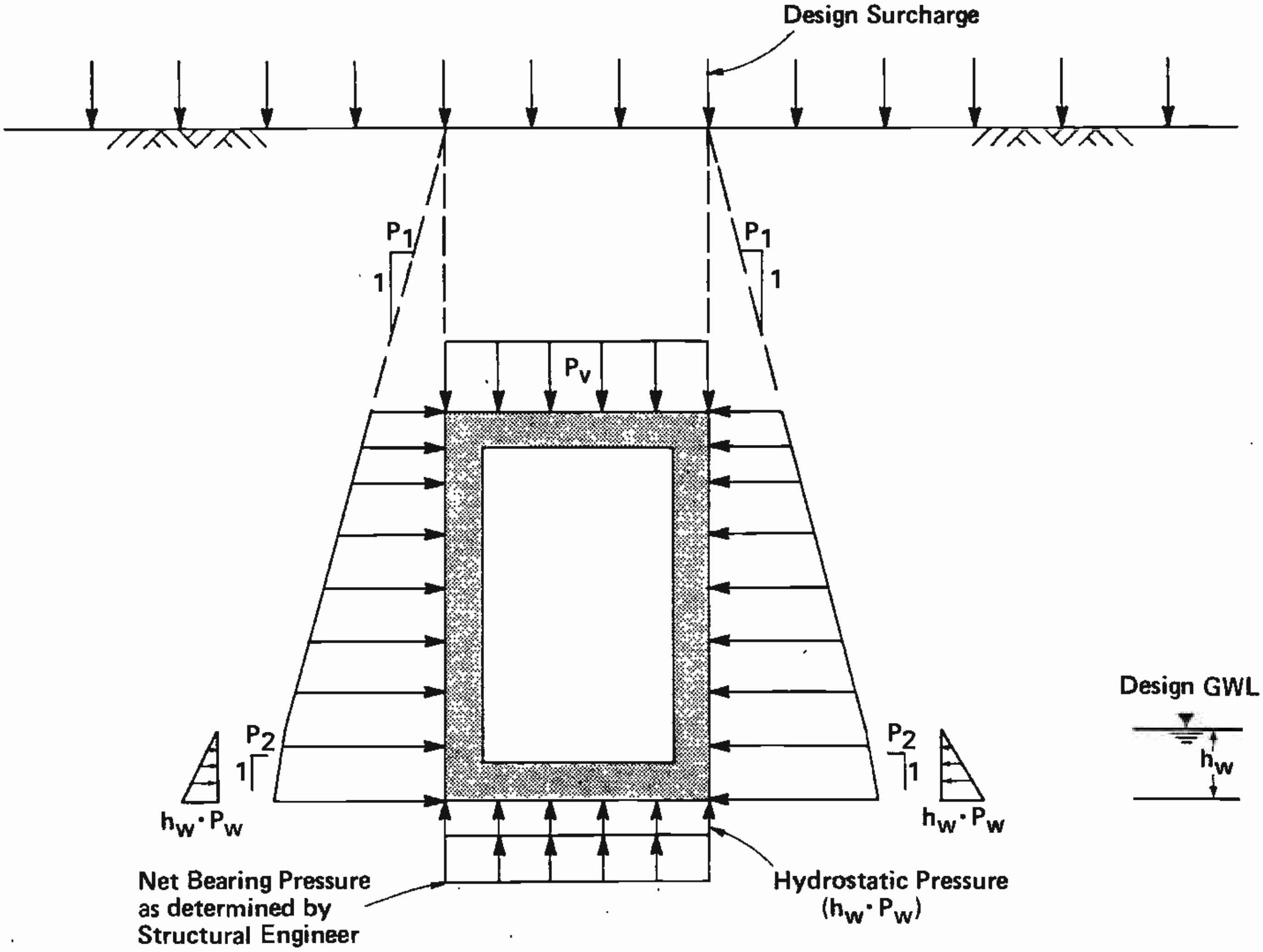
6.10.2 Permanent Static Earth Pressures

The permanent static lateral and vertical earth pressures recommended for design are tabulated in Figure 6-10.

Vertical earth pressures on the roof of the Stations should be taken equal to the full weight of the overburden soil plus surcharge.

6.10.3 Surcharge Loads

Lateral surcharge loads from existing buildings not underpinned above an elevation equal to the invert of the Stations must be added to the lateral design earth pressure loads. The lateral surcharge loads are identical to those recommended for temporary walls. Procedures for computing these are presented on Figure 6-5. Vertical surcharge loads due to surface traffic, etc., should also be included in roof design. In addition, consideration



LOADING CONDITION	DESIGN LOAD PARAMETERS, psf				Design GWL, Elev.	
	P_1	P_2	P_w	P_v*	Fairfax/ Santa Monica	La Brea/ Sunset
End of Construction	35	18	62.4	—	* *	* *
Long Term	55	30	62.4	—	225	300
Side Sway * * *	35/55	18/30	62.4	—	* *	* *

* P_v = Full overburden pressure (depth x total density of soil) + surcharge

* * Designer should use a GWL (between the base of slab and design water levels tabulated above) which will be most critical for the loading condition.

* * * Side sway conditions assume "End Construction" loading on one side of the structure and "Long Term" loading on the other.

LOADS ON PERMANENT WALLS

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should be given to loads imposed by earthmoving equipment during backfill operations.

6.11 PARAMETERS FOR SEISMIC DESIGN

6.11.1 General

Design procedures and criteria for underground structures under earthquake loading conditions are defined in the Southern California Rapid Transit District (SCRTD) report entitled "Guidelines for Seismic Design of Underground Structures," dated March 1984. The evaluation of the seismological conditions which may impact the project and the earthquake intensities which may be anticipated in the Los Angeles area are described in the SCRTD report entitled "Seismological Investigation and Design Criteria," dated May 1983. The 1984 report complements and supplements the 1983 report.

6.11.2 Dynamic Material Properties

Values of apparent wave propagation velocities for use in travelling wave analyses have been presented in Table B-2 of Part II, Appendix B of the May 1983 report. Other dynamic soil parameters will also be required for input into the various types of analyses recommended in the seismic design criteria report. These include values of dynamic Young's modulus, dynamic constrained modulus, and dynamic shear modulus at low strain levels. In addition, certain types of equivalent linear analyses require that the variation of dynamic shear modulus and soil hysteretic damping with the level of shear strain be known.

Average values of compression and shear wave velocities based on interpretation of limited crosshole geophysical surveys performed in Borings CEG-24 and CEG-28, and other borings in similar materials during the 1981 investigation are presented in Table 6-3. These velocities have been used together with the tabulated values of density and Poisson's ratio to establish appropriate modulus values at low strain levels. Computed modulus values for the Alluvium corresponding to various depths are tabulated in Table 6-3.

The variation of dynamic shear modulus, expressed as the ratio of G/G_{max}, with the level of shear strain is presented in Figure 6-11 for the various geologic units. Similar relationships for soil hysteretic damping are presented in Figure 6-12. These relationships were developed from the results of field geophysical surveys, resonant column tests, and cyclic triaxial tests performed in the field and in the laboratory on representative samples of the various geologic units, together with published data for similar materials.

6.11.3 Liquefaction Potential

The generalized subsurface cross sections have been described in Section 5.0 are shown in Drawings 9 and 11. The groundwater levels at both Station sites are quite deep and close to the bottom of the excavations. Therefore, only the saturated soils below these depths must be evaluated for

Table 6-3

RECOMMENDED DYNAMIC MATERIAL PROPERTIES FOR ALLUVIUM FOR USE IN DESIGN

Property	Depth (feet)		
	20	20 to 60	60 to 100
Average Compression Wave Velocity, V_p, ft/sec	2,300	2,300	2,300 (moist) 5,000 (saturated)
Average Shear Wave Velocity, V_s, ft/sec	1,000	1,100	1,300
Poisson's Ratio	0.40	0.40	0.40 (moist) 0.45 (saturated)
Young's Modulus, E, psi	67,000	67,000	67,000 (moist) 182,000 (saturated)
Constrained Modulus, E_c, psi	142,500	142,500	142,500 (moist) 700,000 (saturated)
Shear Modulus, G_{max}, psi	27,000	32,000	47,000

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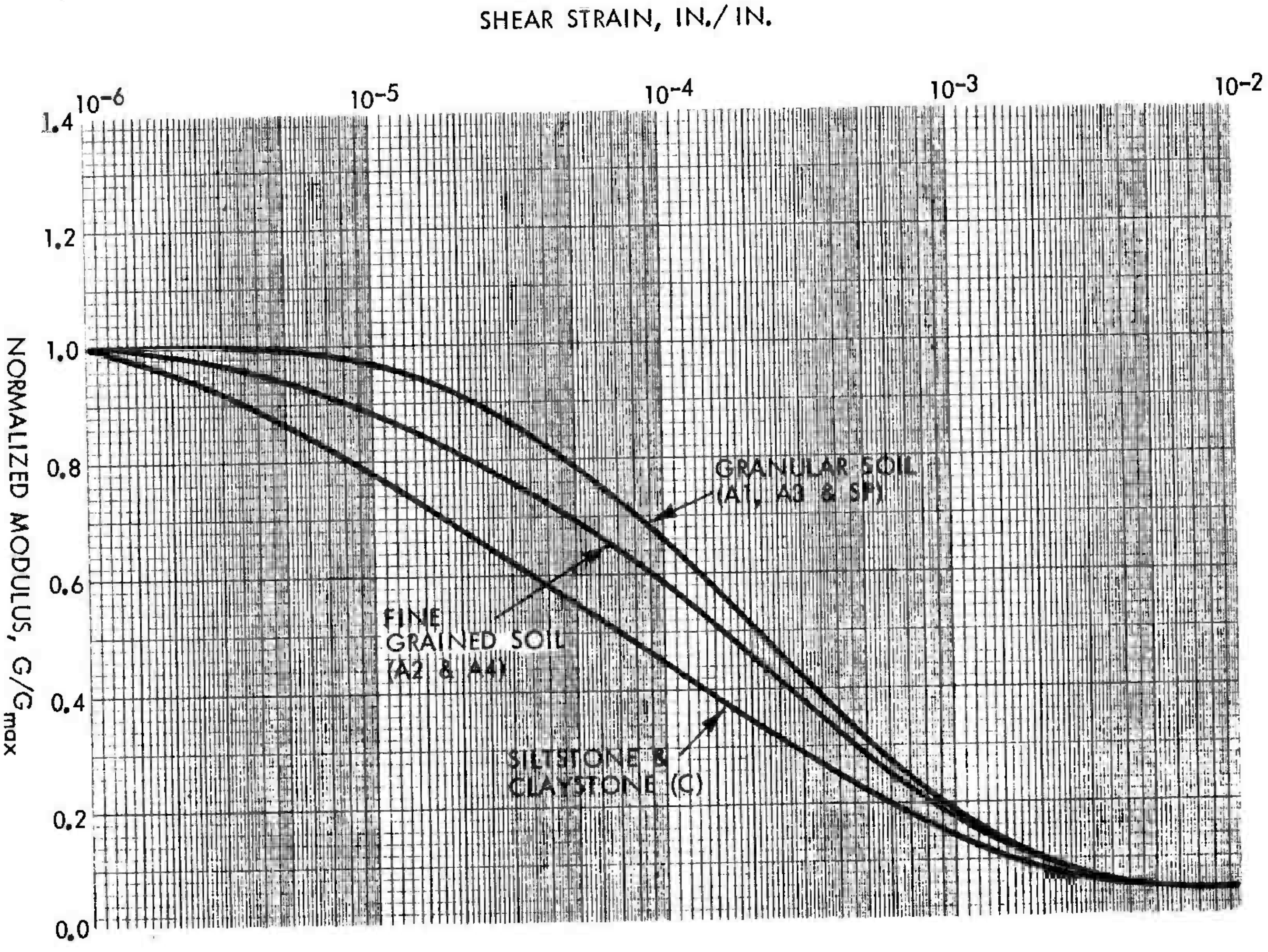

RECOMMENDED DYNAMIC SHEAR MODULUS RELATIONSHIPS

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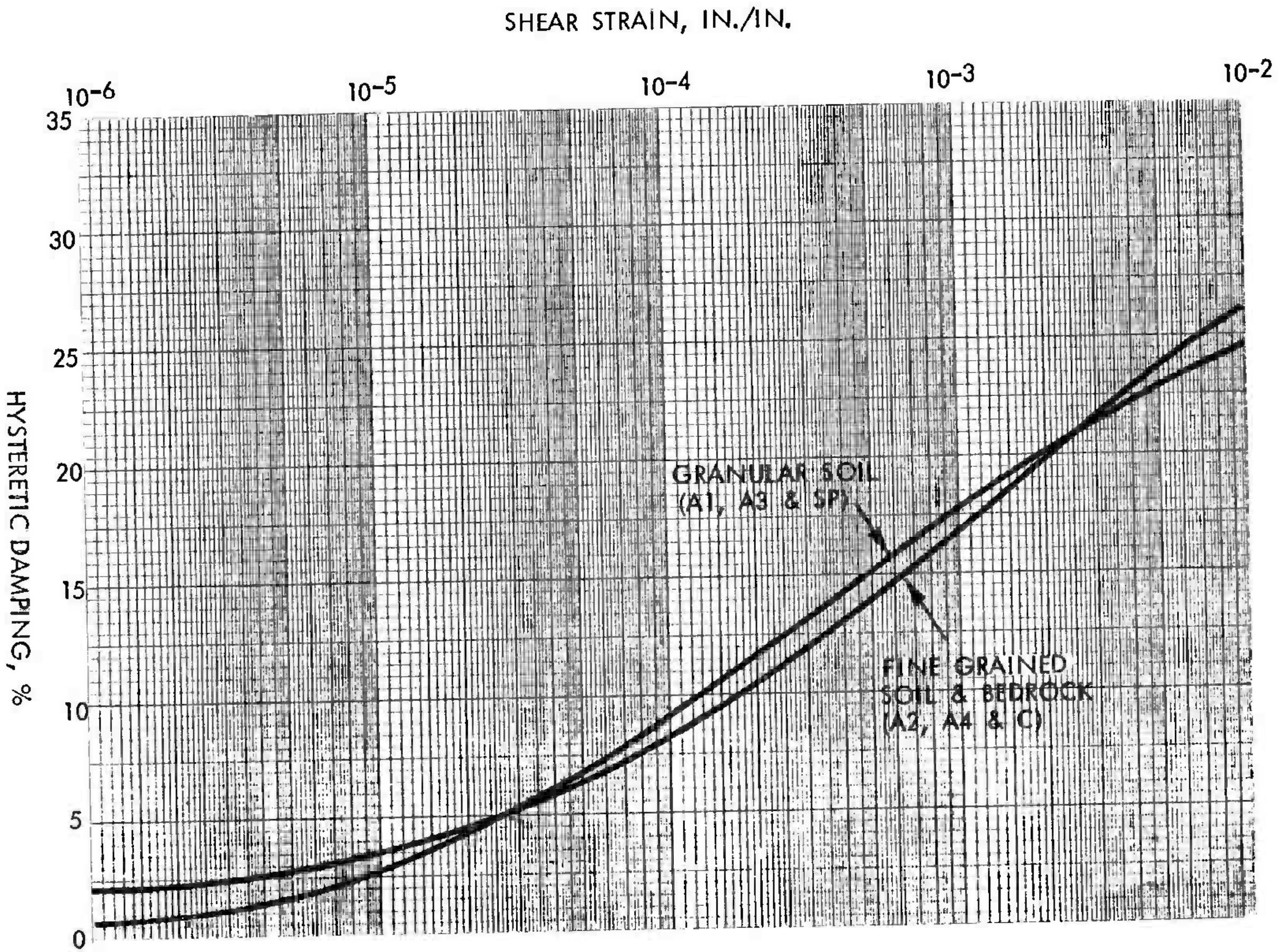

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RECOMMENDED DYNAMIC DAMPING RELATIONSHIPS

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Figure No.
6-12

liquefaction potential. These include the dense clayey sands and silty sands lenses within the Alluvium.

The liquefaction evaluation procedures used are based mainly on correlations of field Standard Penetration Tests (SPT) and performance of soils during previous earthquakes. The field Standard Penetration Tests made at the two Station sites during this and the previous geotechnical investigation (1981 Geotechnical Investigation Report) were used for our evaluation of the liquefaction potential of the saturated alluvial soils. Available field geophysical data were also used in our evaluation as a general indicator of liquefaction potential.

In addition to the field SPT and geophysical data, laboratory gradations of the site soils obtained from the field were compared with gradations of materials which have liquefied during past earthquakes and those which are considered most susceptible to liquefaction based on laboratory tests.

Based on our review of the available data, the saturated sandy soils within the Alluvium deposits would have a low potential for liquefaction during the postulated design earthquake. This conclusion is based, in part, on procedures which are commonly employed to estimate the liquefaction potential of saturated cohesionless soil deposits (Seed et al., 1983) as well as other considerations and engineering judgment.

6.12 EARTHWORK CRITERIA

Site development at the two Station sites is expected to consist primarily of excavation for the subterranean structures but will also include general site preparation, foundation preparation for near surface structures, slab subgrade preparation, and backfill for subterranean walls and footings and utility trenches. Recommendations for major temporary excavations and dewatering are presented in Sections 6.2 and 6.4. Suggested guidelines for site preparation, minor construction excavations, structural fill, foundation preparation, subgrade preparation, site drainage, and utility trench backfill are presented in Appendix E. Recommended specifications for compaction of fill are also presented in Appendix E. Construction specifications should clearly establish the responsibilities of the contractor for construction safety in accordance with CALOSHA requirements.

Excavated granular alluvium (sand, silty sand, gravelly sand, sandy gravel) are considered suitable for re-use as compacted fill, provided it is at a suitable moisture content and can be placed and compacted to the required density. The excavated fine-grained materials are not considered suitable because these materials will make compaction difficult and could lead to fill settlement problems after construction. If granular alluvium materials cannot be stockpiled, imported granular soils could be used for fill, subject to approval by the soils engineer.

It should be understood that some settlement of the backfill will occur even if the fill soils are properly placed and compacted. Cracking and/or settlement of pavement on and around the backfilled excavations should be expected to occur for at least the first year following construction. Placement of the final pavement section should be delayed at least one year.

Section 7.0

Tunnel Alignment – Geotechnical Evaluation and Tunneling Conditions

7.0 TUNNEL ALIGNMENT--GEOTECHNICAL EVALUATION AND TUNNELING CONDITIONS

7.1 GENERAL

The general geologic stratigraphy along the Design Unit A310 tunnel alignment is shown in Drawings 2 through 7. The length of track within this design unit is about 3.3 miles long and extends between Station 573+24 and Station 749+30. Excluding the length of track within the Fairfax/Santa Monica and La Brea/Sunset Stations, the length of tunnel line is about 3.1 miles.

The depth of ground cover above the crown of the tunnel varies along the alignment from a minimum of about 24 feet near Station 746± (except where the tunnel passes beneath the footings of buildings located between Stations 574+50± and 576+77±) to a maximum of about 100 feet near Station 653± (refer to Table 7-1 for additional information). An interpretation of the groundwater data available along, or in close proximity to, the tunnel alignment suggests that about 1.6 miles or about 51 percent of the tunnel line has water levels which are above the elevation of the tunnel invert. However, only about three-quarters of a mile or about 24 percent of the tunnel line has water levels above the elevation of the tunnel crown.

It should be noted that the subsurface conditions and groundwater elevations discussed in the following text are based on an interpretation of the available subsurface and groundwater data. The groundwater level data used in the interpretation were obtained from observation wells installed in boreholes widely spaced along the tunnel alignment. Therefore, the interpretation of the groundwater conditions depicted in Drawings 2 through 7 should be considered as approximate. Since many of the boreholes drilled along the tunnel alignment were drilled only about one month prior to the writing of this report, the period of record for the groundwater level data is short and consists of only one or two water level readings. Consequently, seasonal fluctuations in the groundwater which might occur along the tunnel alignment during the year cannot be established at this time. It is for these reasons that the groundwater observation wells should be read several times a year until project construction and more frequently during construction, if possible. These data will aid in confirming the groundwater conditions depicted in Drawings 2 through 7 and will also provide valuable data to the contractor in determining his construction schedule and procedures.

7.2 STRATIGRAPHY, GROUNDWATER, AND TUNNELING CONDITIONS

The twin tunnel line proposed in Design Unit A310 will pass entirely through fine-grained and coarse-grained Alluvium. The materials which are included in these two soil classifications are described in Section 5.1 through 5.4 of this report. The following descriptions define groundwater conditions and soft ground tunneling conditions between the cut-and-cover Stations.

7.2.1 Station 573+24 to Station 623+92 (5068 feet - Drawings 2, 3, and 4)

This tunnel segment lies between the Fairfax/Beverly and Fairfax/Santa Monica Station sites. The water levels for about 4000 feet of this tunnel, from Station 573+24 to Station 613±, are above the crown of the tunnel. From Station 613± to the Fairfax/Santa Monica Station site at Station 623±92, interpreted levels either fall within the cross section of the tunnel or follow the elevation of the tunnel invert. Consequently, all of the tunnel line in this segment will probably encounter some saturated alluvial soils.

The groundwater level near the Fairfax/Beverly Station site, at Station 573+24 (refer to Table 7-1), is about 43 feet above the elevation of the tunnel invert or 25 feet above the tunnel crown assuming an 18-foot diameter tunnel. The head of groundwater above the tunnel crown decreases until it intersects the crown near Station 613±. Between Stations 613± and 620±, the water levels fall within the tunnel cross section. From Station 620± to the Fairfax/Santa Monica Station site, the water levels are at or just below the invert of the tunnel. Since the alluvium along the tunnel alignment of Design Unit A310 consists of interbedded or interlayered horizons of fine- and coarse-grained soils, it is conceivable that some flowing ground conditions may be encountered during the construction of this tunnel segment, as suggested by the variable stratigraphic conditions at the tunnel grades shown in Figure 7-1 for Borings 23C and 23D. This conclusion is also based on the behavior of the soils observed in the large-diameter borehole, Boring 23B, which was drilled at the Fairfax/Beverly Station site (refer to Table 7-2). Groundwater flowed into this hole at an estimated rate of 18± gpm. This inflow was generally confined to a coarse clayey sand layer between the depths of about 52 and 63 feet and caused caving of the sidewalls between the depths of 52 and 61 feet.

At the intersection of Fairfax and Beverly and starting at about Station 574+50, the twin tunnels pass beneath a structure with footings situated at about Elevation 169. The crowns of the tunnels at this location are at about Elevation 156, or about 13 feet below the elevation of the footings. At about Station 576+77, the crowns of the tunnels are at about Elevation 159 and are only about 10 feet below the footing of the building. The exact elevation of the bottom of the wall footings of the building will have to be established prior to the start of construction.

The heterogeneous nature of the soil conditions notwithstanding, the tunnel reach between the Fairfax/Beverly and Fairfax/Santa Monica Stations is suitable for use of soft ground tunneling techniques utilizing a shield with hand and/or mechanical excavating equipment. We do not believe that tunneling without a shield would be feasible in the soil and groundwater conditions along this tunnel reach. Construction shield tunneling methods will require means for the utilization of forepoling and/or breast boarding techniques to maintain stability of the face, prevent loss of ground, and avoid surface settlement along the alignment. The contractor should be prepared to search for, and relieve excessive hydrostatic uplift pressures below tunnel invert to prevent local blow-outs at the tunnel invert and flowing ground of the tunnel face. The heterogeneous and non-continuous nature of the alluvial soils suggest that a general dewatering system in the Alluvium may be difficult.

If a dewatering system is utilized to lower the groundwater levels along this reach of the tunnel, total and differential settlements are likely to occur at the ground surface and their consequences should be adequately evaluated by the section designers.

7.2.2 Station 629+52 to Station 694+90 (6538 feet - Drawings 4, 5, and 6)

This tunnel segment lies between the Fairfax/Santa Monica and La Brea/Sunset Station sites. The depth of cover above the crown of the tunnel varies from a minimum of 32 feet in the vicinity of the west side of the La Brea/Sunset Station to a maximum of about 100 feet near Station 653± (refer to Table 7-1 for additional information).

The reported groundwater along this reach of the tunnel is at or below the elevation of the tunnel invert. Water levels are the highest at the north end of the Fairfax/Santa Monica Station site (Station 629+52), at about Elevation 219. For comparison, the completed tunnel invert is at about Elevation 218. From this location, groundwater levels are as much as 20± feet below the elevation of the tunnel invert. Examples of stratigraphic and groundwater variations along this tunnel segment are illustrated in Figure 7-1, Borings 24B and 25C.

Table 7-2 summarizes the observations made in four large-diameter auger borings drilled along, or in relative close proximity to, this tunnel segment. Logs of Borings 24A, 25A, 25B, and 26B are also provided in Appendix A. Caving and/or sloughing generally occurred in these boreholes only when water bearing coarse-grained soils were encountered. Two of the holes, Borings 25A and 25B, were drilled to depths of 100 and 81 feet, respectively. These holes did not encounter any groundwater and the sidewalls stood well and did not experience any caving. It should be noted, however, that Boring 25A is located about 600 feet from the tunnel alignment and was not drilled to a depth corresponding to tunnel grade, even though its total depth was 100 feet (refer to Table 7-2).

A number of boulders were encountered between the depths of 49 feet and 70 feet (Elevations 341± and 320±, respectively, and 60± feet above the crown elevation) in the large-diameter Borehole, 25A, which was drilled on Sunset Boulevard near Fairfax. Soils containing gravels and cobbles were also noted in the logs of the rotary-wash borings drilled along this tunnel reach.

Based on the behavior of the soils encountered in the large-diameter boreholes and the types of soils penetrated by the rotary-wash borings drilled along the alignment, we believe that the tunnel segment between the Fairfax/Santa Monica and La Brea/Sunset Station sites can be constructed using soft ground tunneling techniques utilizing a shield with hand and/or mechanical excavated equipment. Methods of tunnel construction not employing a shield will not be successful in this segment of the tunnel. Shield tunneling construction may not require full support of the tunnel face. However, because coarse-grained materials may be encountered at tunnel grade, the means for utilization of breast boarding techniques to maintain the stability of the tunnel face and prevent loss of ground caused by running soils should be provided.

7.2.3 Station 700+56 to 749+30 (4880 feet - Drawings 6 and 7)

This section of tunnel lies between the La Brea/Sunset and Hollywood/Cahuenga Station sites. The soil cover above the crown of this tunnel varies from a minimum of about 31 feet at Stations 700±50 and 749±30 to a maximum of about 40 feet near Station 714± (refer to Table 7-1 for additional information).

Groundwater levels along the tunnel segment, from about Station 700+50 to Station 736±, are reported to be either at or near the tunnel invert or within the cross section of the tunnel. The available groundwater data does not suggest water levels above the crown of the tunnel along this reach. From Station 736± to the Hollywood/Cahuenga Station site, the tunnel grade follows the ground surface topography as it rises in elevation upon entering the Hollywood/Cahuenga Station. Consequently, the groundwater level near the Hollywood/Cahuenga Station site is about 24 feet below the completed tunnel invert.

Observations made in the two large-diameter boreholes, 27A and 28C, which were drilled along or close to this tunnel segment are summarized in Table 7-2. Boring 27A was drilled about 700 feet southeast of Station 740±, whereas Boring 28C was drilled north of the Hollywood/Cahuenga Station at tunnel station 760±. Logs of these two boreholes are also provided in Appendix A along with the logs of other borings drilled along this reach.

Water was first encountered in the large-diameter boring, 27A, at a depth of about 55 feet, or at about Elevation 295. This is about 14 feet below that of the invert of the tunnel located about 700 feet from this borehole. Nevertheless, the caving and groundwater inflows that took place in this hole are representative of those that might take place at other locations along the tunnel alignment where water is encountered in this general area. Water was apparently originating from a sand layer between the depths of 55.5 and 57.5 feet (Elevations 295± and 293±, respectively). The total depth of this hole was 95 feet (Elevation 255±) and, upon completion, the hole caved back to about 72 feet (Elevation 278±). The water level in the hole was at 55 feet below the ground surface after 2 hours, 53 feet after 8 hours, and 52.4 feet after 21 hours.

The large-diameter Boring 28C is not located within the bounds of the tunnel alignment of Design Unit A310. However, the observations made in this hole as summarized in Table 7-2 are worth noting, since this hole passed through similar geologic materials.

Boulders were reported in the log of Borehole 26D, which was drilled along this reach of the tunnel alignment. Heavy drill rig chatter was noted at a depth of about 72 feet and continued to a depth of 76 feet, where the hole was terminated. Gravel and cobbles were also reported in the log of this hole starting at a depth of about 62 feet. These types of materials were also noted in Borehole 26C starting at a depth of about 47 feet. Based on the information provided in the logs of these boreholes, it is likely that zones containing some large cobbles and/or boulders will be encountered along this tunnel segment.

The ground conditions between the La Brea/Sunset and Hollywood/Cahuenga Station sites are suitable for the use of soft ground tunneling techniques utilizing a shield with hand and/or mechanical excavating equipment. We do not believe that methods of tunnel construction not employing a shield will be successful. Construction shield tunneling may not require full support of the tunnel face at all times. This is likely the case only along the segment of this tunnel situated completely above the level of the groundwater. Along the tunnel reach where groundwater is likely to be encountered, the contractor should be prepared to search for, and relieve excessive hydrostatic pressure below the tunnel invert in order to prevent local blow-outs and/or flowing ground conditions. The heterogeneous and noncontinuous nature of the alluvial soils suggest that a general dewatering system in the alluvium may be difficult.

Between Stations 710± and 720± (see Drawing 6), the available groundwater data suggests that the groundwater level will have to be lowered by as much as 20 feet in order to place it below the tunnel invert.

7.3 GROUNDWATER--INFLOWS AND MINERAL ANALYSES

Groundwater inflows from saturated alluvial soils, in our judgment, are likely to be significant and will cause caving problems. This conclusion is primarily based on the observed behavior of the soils encountered in the large-diameter or man-sized auger borings 23B, 24A, 26B, 27A, and 28C. Groundwater inflows and experienced caving problems are summarized in Table 7-1 and have also been discussed in previous sections of this report. Logs of the boreholes listed in Table 7-2 are also included in Appendix A.

The entire zone of alluvium below the groundwater level is considered saturated. Although there are many fine-grained, tight, clay and silt beds, there are several relatively pervious sand horizons that could contribute a considerable amount of water into the face of the tunnel excavation. A good example of this is reported in the log of Boring 23B, which recorded an inflow of 18± gpm for the interval between 52 and 60 feet. Inflow rates of about 1± gpm are reported in the logs of other large-diameter holes, all of which caused caving and/or belling of the sidewalls.

A total of eight groundwater samples taken from boreholes drilled along, or in close proximity to, the proposed tunnel alignment have been subjected to chemical analyses. Seven of the water samples were taken from depths less than 60 feet and one was obtained from a depth of 109 feet. Results of the chemical analyses performed are summarized in Appendix D.

Based on the results of the chemical analyses, the groundwater quality along the proposed tunnel alignment is generally poor. Total Dissolved Solids (TDS) of the eight tested water samples range from 494 to 863 PPM. For comparison, the U.S. Environmental Protection Agency TDS standard for potable domestic drinking water is 500 PPM. Sulfate contents of the samples range from 6 to 272 PPM, and four of the eight samples have sulfate contents greater than 150 PPM. A sulfate content above 150 PPM is generally regarded to be deleterious to concrete. For details on corrosion, refer to studies performed for SCRTD by Waters Consultants (Professional Services Group, Inc.), San Diego, California.

7.4 ENGINEERING PROPERTIES OF TUNNELING MATERIALS

The engineering properties of the fine- and coarse-grained Alluvium, as applied to tunneling, are similar to those described in Section 5.8 and in Table 5-2, "Material Properties Selected for Static Design."

In general, the alluvial material should not squeeze, although there could be a slight tendency for squeezing of local, saturated, clayey interlayers. Such behavior should not impede shield tunneling operations.

7.5 GAS, OIL, AND FAULTING

For the majority of the tunnel line segment in Design Unit A310, gassy or potentially gassy tunneling conditions do not appear to be a major problem. The segment of tunnel just north of the Fairfax/Beverly Station site should be classified as gassy. These classifications are from the California Administrative Code, Title 8, page 684.18. Appropriate tunneling equipment should conform with CALOSHA requirements and California Tunnel Safety Orders. Some sulfurous/organic odors were noted in the logs of Boreholes 23C and CEG-23A, which are located some 900 and 1600 feet away from the Fairfax/Beverly Station site, respectively. Strong petroleum odors and gasoline were noted in the log of Boring 28C which was drilled just north of the Hollywood/Cahuenga Station site.

Minor amounts of petroleum were encountered at relatively shallow depth (i.e., about 40 to 70 feet) in the exploratory boreholes drilled at the Fairfax/Beverly Station site. This station and the segment of tunnel to Station 584± are within the bounds of the Salt Lake Oil Field. The amount of bitumen encountered in the area at depths less than about 60 feet was too small to influence the engineering characteristics of the materials.

For additional details on gas, refer to Section 5.6 and Appendices A and C of this report and additional studies performed for SCRTD by Engineering Science, Arcadia, California.

The tunnel line included in Design Unit A310 crosses the projected ground surface traces of the San Vicente Fault (see Drawing 2) and the Santa Monica Fault (see Drawing 3). The alignment also crosses the Hollywood fault zone which is located north of the Hollywood/Cahuenga Station site (see Drawing 7). This fault is situated outside but close to the limits of Design Unit A310. Additional information on these faults is provided in Section 5.7 of this report. The presence of the San Vicente and Santa Monica faults along the reach of tunnel included in Design Unit A310 should not cause any particular problems during the tunneling operations at the proposed tunnel grade.

7.6 CROSS PASSAGES

Southern California Rapid Transit District Drawings CSK-10 (Sheet 4 of 7) and CSK-11 (Sheet 5 of 7) dated January 12, 1984, indicate 20 cross passages are planned at tunnel line Stations listed below (see Drawings 3 through 7):

580+48
587+72
594+96
602+20
609+44
616+68
636+75
644+02
651+29
658+55
665+82
673+09
680+35
687+62
707+45
714+42
721+40
728+37
735+34
742+31

According to SCRTD tunnel standard Drawings SD-053 and SD-054, the cross passage dimensions are about 20 feet long, 10 feet wide, and 12 feet high. The plans also indicate the finished opening will be supported by a 2-foot thick concrete liner.

All cross passages will be excavated in interbedded and heterogeneous fine-grained and coarse-grained Alluvium. The two cross passages at Stations 580+48 and 587+72 will be in ground that should be considered as potentially gassy to gassy. All cross passages should encounter similar stratigraphic, groundwater, and tunneling conditions as described in Section 7.0.

7.7 SHAFTS

Available information shown on the SCRTD plans for Design Unit A310 do not indicate that shafts and/or vent structures are present within this design unit.

7.8 SPECIAL TUNNELING PROBLEM AREAS

Due to a high groundwater table, relatively shallow cover over the tunnel crown and unknown conditions, research should be performed to establish underground conditions prior to start of construction at the following stations:

- Stations 574+50 to 576+77(±) - The exact elevation of the bottom of the wall footing of the building situated on the northeast corner of the intersection of Fairfax and Beverly should be established prior to the start of construction.

7.9 DESIGN FOR EARTHQUAKES

Design procedures and criteria for underground stuctures under earthquake loading conditions are defined in the Southern California Rapid Transit District (SCRTD) report entitled "Guidelines for Design of Underground Structures," dated March 1984. Evaluations of the seismological conditions which may impact the project and the probable and maximum credible earthquakes, which may be anticipated in the Los Angeles area, are described in Converse's report to SCRTD entitled "Seismological Investigation & Design Criteria," dated May 1983. The 1984 report complements and supplements the 1983 report.

TABLE 7-1
SUMMARY OF GROUND SURFACE AND GROUNDWATER ELEVATIONS ALONG TUNNEL ALIGNMENT

	ELEVATION — feet (1)				DEPTH — feet (1)	
Tunnel Station (feet)	Ground Surface	Ground-water (2)	Tunnel Crown	Tunnel Invert	Ground Surface to Tunnel Crown	Groundwater Level to Tunnel Invert
573 +24	191	180	155	137	36	43
580	200	187	163	145	37	42
590	215	195	178	160	37	35
600	228	204	192	174	36	30
610	246	212	206	188	40	24
620	266	216	233	215	33	1
630	296	219	237	219	59	0
640	334	223	248	230	86	–7
650	362	228	263	245	99	–17
660	372	242	278	260	94	–18
670	354	255	293	275	61	–20
680	345	270	308	290	37	–20
690	349	283	320	302	29	–20
700 (3)	348	295	——	302(TOR)	46(TOR)	-7
710	344	297	308	290	36	7
720	345	300	310	292	35	8
730	349	300	316	298	33	2
740	360	303	331	313	29	–10
749 +30	382	310	352	334	30	–24

Notes: (1) All elevations and depths given in this table are approximate. Elevations taken from General Plans, Contract No. A310, Fairfax/Beverly to Hollywood/Cahuenga. Crown and invert elevations refer to the outside of the tunnel liner at the top & bottom of an assumed 18 foot diameter lined tunnel.

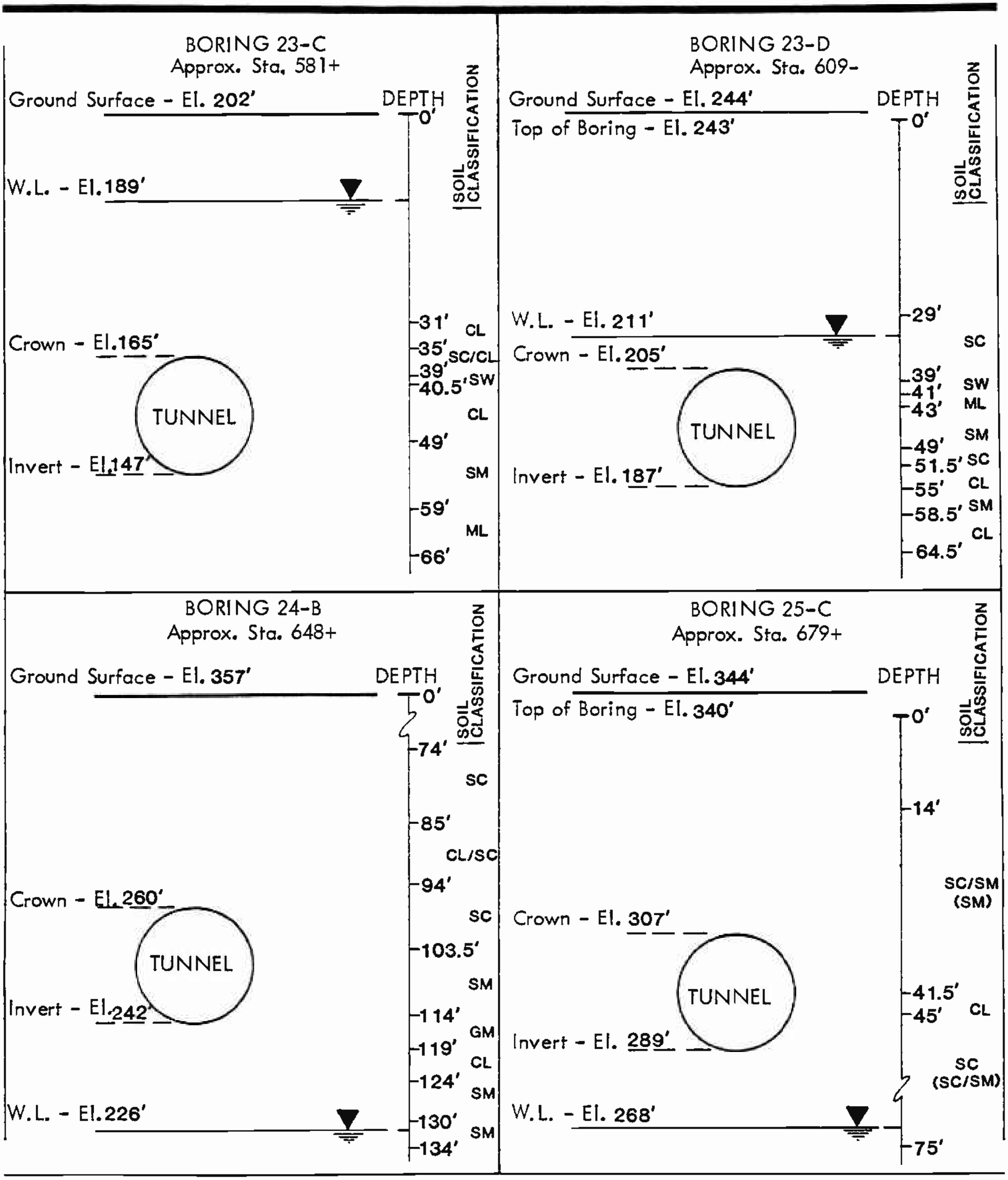
(2) Groundwater elevations listed for the tunnel stations based on an interpretation of available groundwater data. The groundwater data were obtained from observation wells installed in boreholes which are widely space along (or in close proximity to) the proposed tunnel alignment.

(3) This station is within the La Brea/Sunset Station Site. Invert of tunnel corresponds to top of rail at this location.

TABLE 7-2
GROUNDWATER INFLOWS AND CAVING CONDITIONS OBSERVED IN LARGE-DIAMETER BOREHOLES

Boring No.	Approximate Tunnel Station	ELEVATION – feet(1)					Water Chemistry (TDS/PH) (PPM/–)	Gas/Oil	Remarks
		Ground Surface at Station/ Boring	Crown/Invert of Tunnel	Bottom of Hole	Ground-Water(2)	Caving/Sloughing Interval(s)			
238	573(3)	191/189	155/137	114	180	129 to 137	853/7.9	Yes	Caving in medium coarse clayey sand in response to seepage (rate ≃ 18gpm). Strong H_2S odor noted from El. 162 (Depth = 27 feet). Oil from El. 144 to 149 (Depth 40 to 75 feet).
24A	625(3)	280/280	235/217	206	210	None	N/A	None	Slight oozing of soil from boring wall between El. 214 to 215 (Depth = 65 to 66 feet). ±0.5 gpm from El. 208 to 210 (Depth = 70 to 72 feet)
25A	648(4)	357/390	260/242	290	None	None	N/A	None	No caving. No ground water encountered.
25B	670	354/358	293/275	277	None	None	N/A	None	No caving. No groundwater encountered.
26B	696(3)	349/351	318/300	290	297	293 to 297	N/A	None	Sloughing/caving occured in 4 foot thick gravelley sand layer in response to water seepage.
27A	740(4)	360/350	331/313	255	298	292 to 295	714/8.3	None	Less than 1 gpm inflow from sandy lens between El. 292 and 296. Hole drilled to 95 feet caved back to 72 feet upon completion. Water level at El. 295 (Depth ~ 65 feet) 2 hours after drilling.
28C	760(5)	407/406	358/340	349	354	349 to 354	N/A	Yes	Hole belled to about 6 to 8 feet at El 354. ±1 inch of gasoline floating on groundwater in hole. Possible source thought to be abandoned service station located 150 feet from hole.

Notes:
(1) All elevations and depths given in this table are approximate. Elevations taken from General Plans, Contract No. A310, Fairfax/Beverly to Hollywood/Cahuenga. Tunnel crown and invert elevations refer to the inside of the tunnel liner at the top & bottom of the lined tunnel.
(2) Elevation of groundwater encountered in hole at time of drilling and logging. Groundwater elevation may not be the same as shown in Drawing 2 through 7, 9, and 11.
(3) Boring located within bounds of station structure. Elevations for crown and invert are for tunnel located in vicinity of borehole.
(4) Boring located more than 500 feet away from tunnel alignment.
(5) Boring not located within bounds of tunnel alignment included in Design Unit A310.



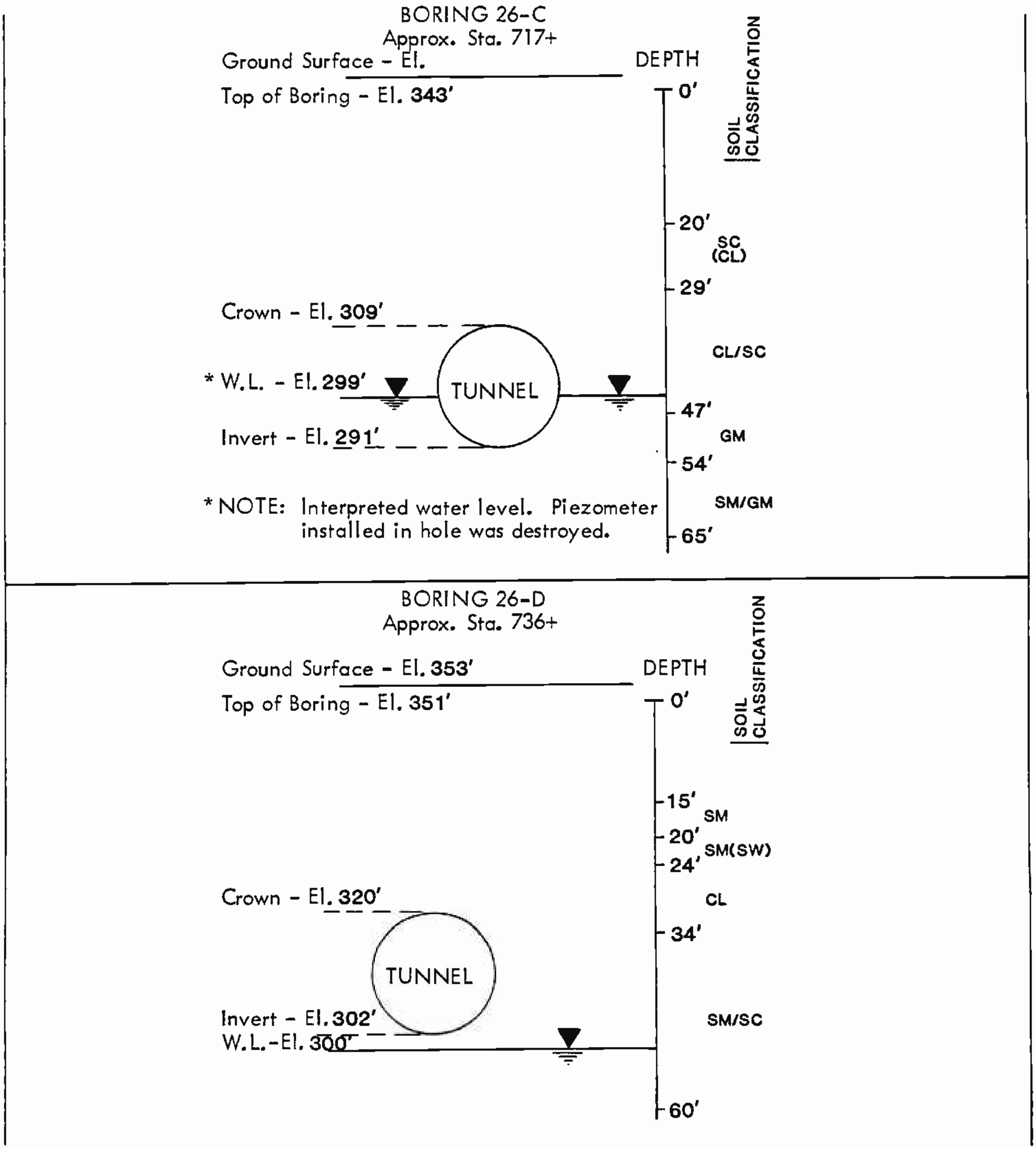
EXAMPLES OF STRATIGRAPHIC VARIATIONS - TUNNEL ALIGNMENT

DESIGN UNIT A310
Southern California Rapid Transit District
METRO RAIL PROJECT

Project No.
83-1140

Converse Consultants Geotechnical Engineering and Applied Sciences

Figure No.
7-1



* NOTE: Interpreted water level. Piezometer installed in hole was destroyed.

EXAMPLES OF STRATIGRAPHIC VARIATIONS - TUNNEL ALIGNMENT

DESIGN UNIT A310
Southern California Rapid Transit District
METRO RAIL PROJECT

Project No.
83-1140

Figure No.
7-2

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Section 8.0

Supplementary Geotechnical Services

8.0 SUPPLEMENTARY GEOTECHNICAL SERVICES

Based on the available data and the current design concepts, the following supplementary geotechnical services may be warranted:

- Supplemental Investigations: Consideration should be given to performing supplemental geotechnical investigations at the sites of proposed peripheral at-grade structures near the Stations. The purpose of these studies would be to determine site specific subsurface conditions and provide site specific final design recommendations for these peripheral structures.

- Observation Well Monitoring: The groundwater observation wells should be read several times a year until project construction and more frequently during construction if possible. These data will aid in confirming the recommended maximum design groundwater levels. They will also provide valuable data to the contractor in determining his construction schedule and procedures.

- Review Final Design Plans and Specifications: A qualified geotechnical engineer should be consulted during the development of the final design concepts and should complete a review of the geotechnical aspects of the plans and specifications.

- Shoring Design Review: Assuming that the shoring systems are designed by the contractor, a qualified geotechnical engineer should review the proposed systems in detail including review of engineering computations. This review would not be a certification of the contractor's plans but rather an independent review made with respect to the owner's interests.

- Construction Observations: A qualified geotechnical engineer should be on site full time during installation of the shoring system, preparation of foundation bearing surfaces, and placement of structural backfills. The geotechnical engineer should also be available for consultation to review the shoring monitoring data and respond to any specific geotechnical problems that occur.

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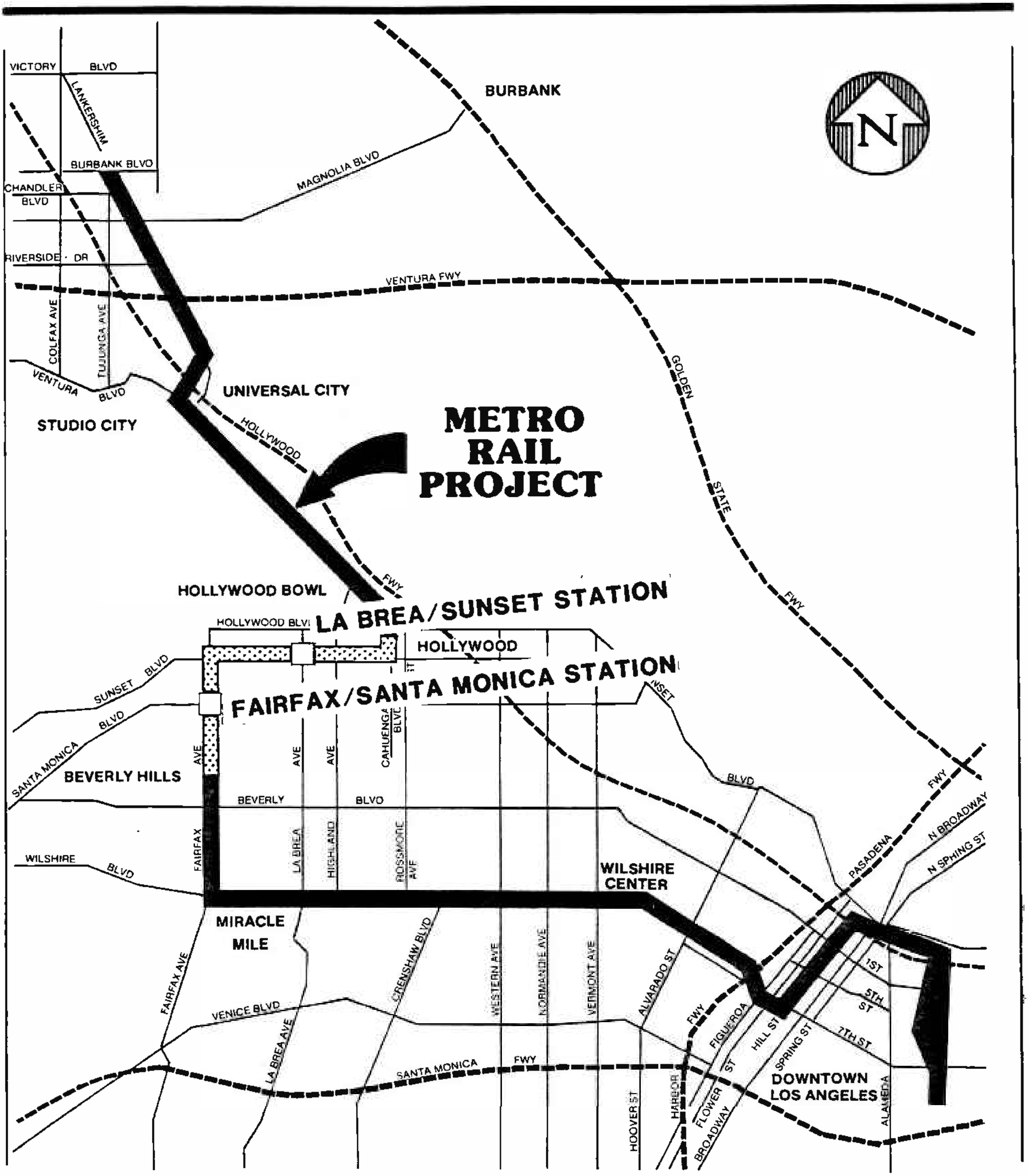
Drawings



VICINITY MAP

DESIGN UNIT A310

Southern California Rapid Transit District

METRO RAIL PROJECT

Project No

83-1140

Drawing No

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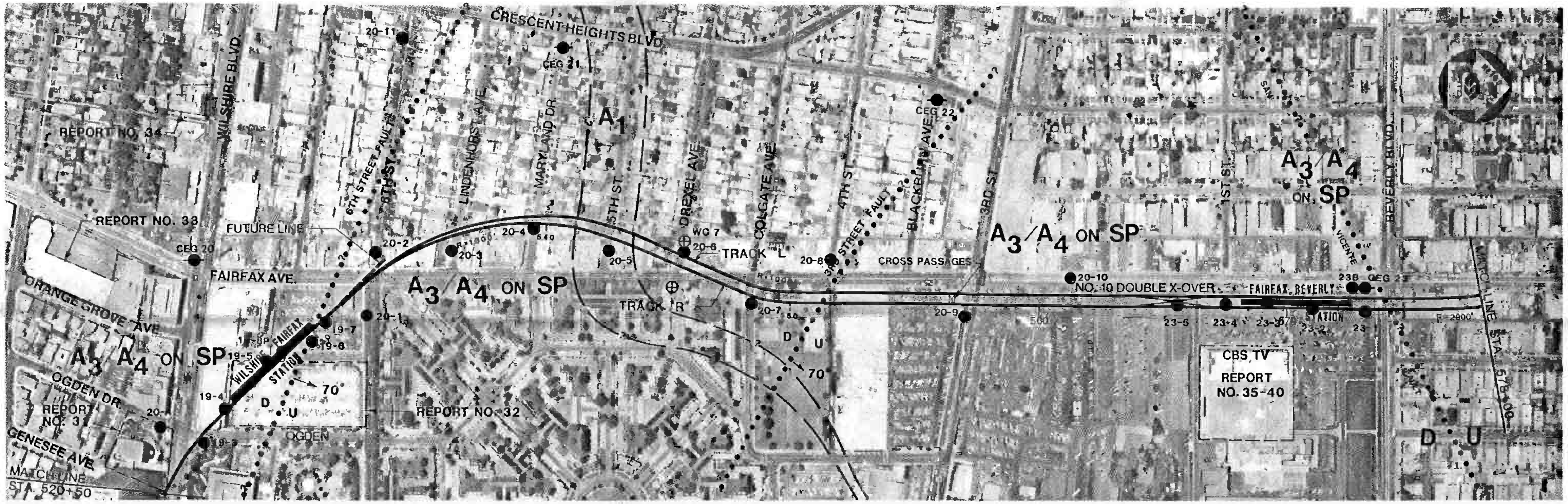
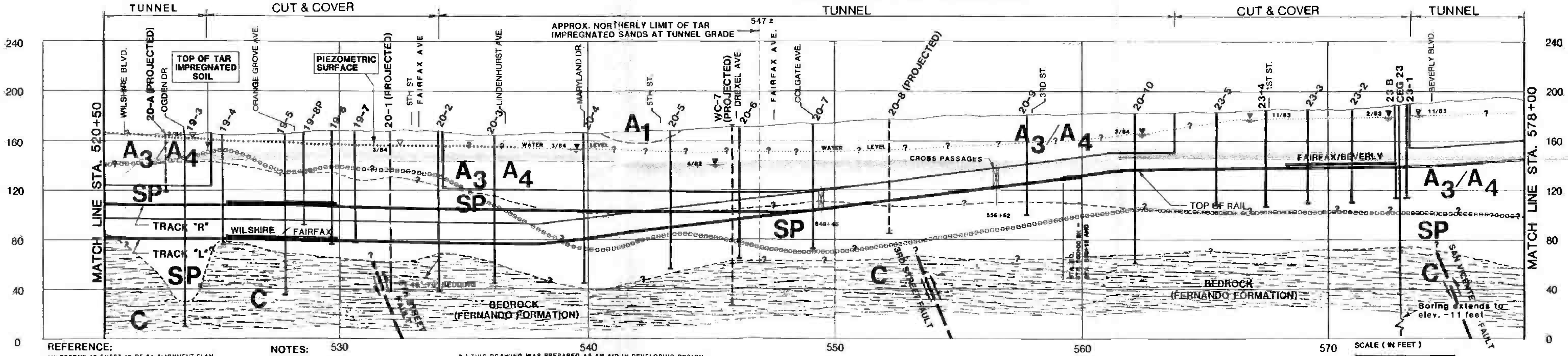


LOCATION OF BORINGS



REFERENCE:

MILESTONE 10 SHEET 10 OF 21 ALIGNMENT PLAN AND PROFILE STATION 520+50 TO STATION 578+00 DATED MARCH 1983

NOTES:

1.) LOCATION AND GRADE OF TUNNEL AND STATION SUBJECT TO CHANGE.
2.) FOR EXPLANATION OF GEOLOGIC SYMBOLS SEE DRAWING NO.12.
3.) THIS DRAWING WAS PREPARED AS AN AID IN DEVELOPING DESIGN RECOMMENDATIONS. SUBSURFACE INFORMATION PRESENTED ON DRAWING IS BASED ON INTERPOLATION AND EXTRAPOLATION OF SUBSURFACE DATA BETWEEN AND BEYOND BORING LOCATIONS. ACTUAL CONDITIONS ENCOUNTERED DURING CONSTRUCTION MAY BE DIFFERENT.

GEOLOGIC SECTION

REV.	DATE	BY	SUB.	APP.	DESCRIPTION

THE PREPARATION OF THIS DRAWING HAS BEEN FINANCED IN PART THROUGH A GRANT FROM THE U. S. DEPARTMENT OF TRANSPORTATION, URBAN MASS TRANSPORTATION ADMINISTRATION, UNDER THE URBAN MASS TRANSPORTATION ACT OF 1964, AS AMENDED, AND IN PART BY THE TAXES OF THE CITIZENS OF LOS ANGELES COUNTY AND OF THE STATE OF CALIFORNIA

REV.	DATE	BY	SUB.	APP.	DESCRIPTION

DESIGNED BY
DRAWN BY
CHECKED BY
IN CHARGE
DATE

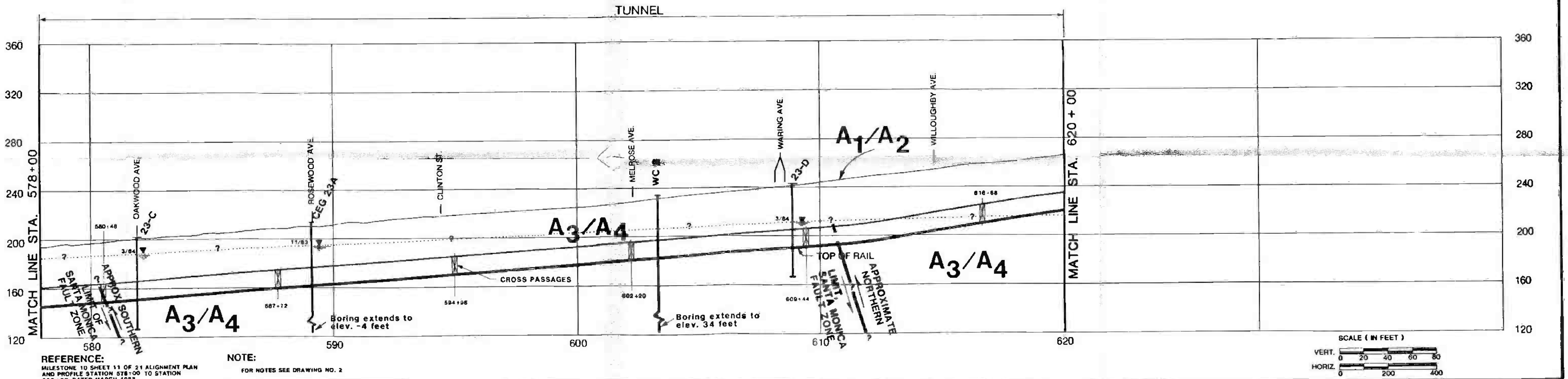
SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT
RTD

CCI/ESA/GRC
General Geotechnical Consultants
Submitted R.M. Pride Date 4-13-84

DMJM/PBQD/KE/HWA
A JOINT VENTURE
GENERAL CONSULTANTS
APPROVED

DESIGN UNIT A310
LOCATION OF BORINGS AND GEOLOGIC SECTION

PROJECT NO. 83-1140
DRAWING NO. 2
REV.
SCALE AS SHOWN
SHEET NO.



REFERENCE:

MILESTONE 10 SHEET 11 OF 21 ALIGNMENT PLAN AND PROFILE STATION 578+00 TO STATION 620+00 DATED MARCH 1983

NOTE:

FOR NOTES SEE DRAWING NO. 2

REV.	DATE	BY	SUB	APP.	DESCRIPTION

THE PREPARATION OF THIS DRAWING HAS BEEN FINANCED IN PART THROUGH A GRANT FROM THE U. S. DEPARTMENT OF TRANSPORTATION, URBAN MASS TRANSPORTATION ADMINISTRATION, UNDER THE URBAN MASS TRANSPORTATION ACT OF 1964, AS AMENDED, AND IN PART BY THE TAXES OF THE CITIZENS OF LOS ANGELES COUNTY AND OF THE STATE OF CALIFORNIA

REV.	DATE	BY	SUB.	APP.	DESCRIPTION

DESIGNED BY
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IN CHARGE
DATE

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
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CCI/ESA/GRC
General Geotechnical Consultants
Submitted R.M. Pride Date 4-13-84

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GENERAL CONSULTANTS
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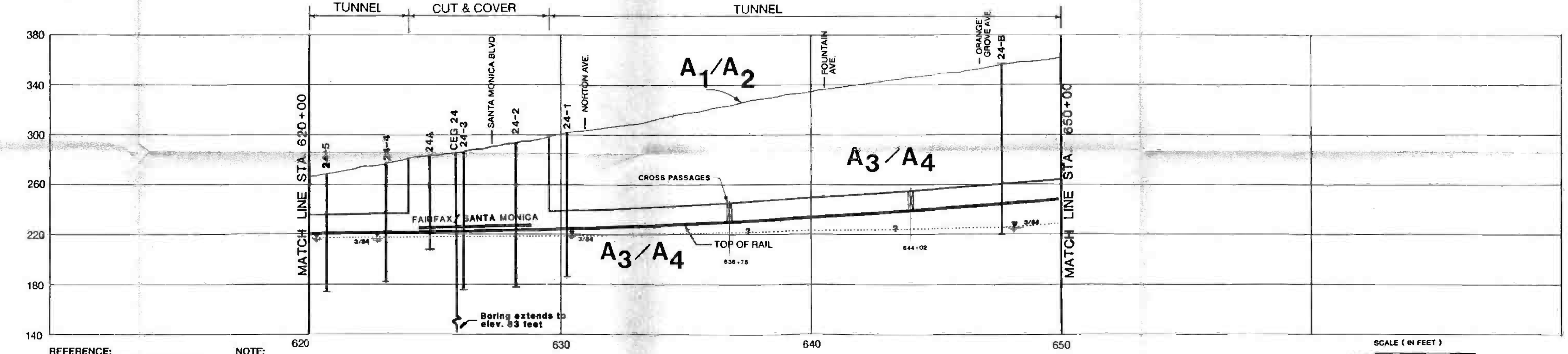
DESIGN UNIT A310
LOCATION OF BORINGS AND GEOLOGIC SECTION

PROJECT NO. 83-1140
DRAWING NO. 3
REV.
SCALE AS SHOWN
SHEET NO.



REFERENCE:
MILESTONE 10 SHEET 12 OF 21 ALIGNMENT PLAN AND PROFILE STATION 620+00 TO STATION 650+00 DATED MARCH 1983

NOTE:
FOR NOTES SEE DRAWING NO. 2

SCALE (IN FEET)
VERT. 0 20 40 60 80
HORIZ. 0 200 400

REV.	DATE	BY	SUB.	APP.	DESCRIPTION

THE PREPARATION OF THIS DRAWING HAS BEEN FINANCED IN PART THROUGH A GRANT FROM THE U. S. DEPARTMENT OF TRANSPORTATION, URBAN MASS TRANSPORTATION ADMINISTRATION, UNDER THE URBAN MASS TRANSPORTATION ACT OF 1964, AS AMENDED, AND IN PART BY THE TAXES OF THE CITIZENS OF LOS ANGELES COUNTY AND OF THE STATE OF CALIFORNIA

REV.	DATE	BY	SUB.	APP.	DESCRIPTION

DESIGNED BY
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SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
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CCI/ESA/GRC
General Geotechnical Consultants
Submitted K.M. Pride Date 4-13-84

DMJM/PBQD/KE/HWA
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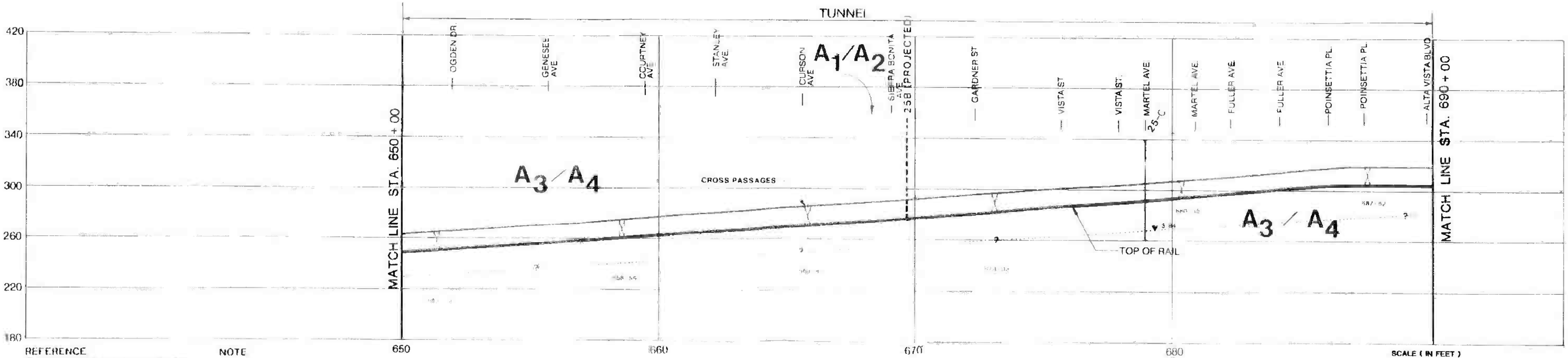
DESIGN UNIT A310
LOCATION OF BORINGS AND GEOLOGIC SECTION

PROJECT NO. 83-1140
DRAWING NO. 4
REV.
SCALE AS SHOWN
SHEET NO.



REFERENCE
MILESTONE 10 SHEET 13 OF 21 ALIGNMENT PLAN AND PROFILE STATION 650+00 TO STATION 690+00 DATED MARCH 1983

NOTE
FOR NOTES SEE DRAWING NO. 2

SCALE (IN FEET)
VERT. 0 20 40 60 80
HORIZ. 0 200 400

REV.	DATE	BY	SUB	APP	DESCRIPTION

THE PREPARATION OF THIS DRAWING HAS BEEN FINANCED IN PART THROUGH A GRANT FROM THE U. S. DEPARTMENT OF TRANSPORTATION, URBAN MASS TRANSPORTATION ADMINISTRATION, UNDER THE URBAN MASS TRANSPORTATION ACT OF 1964, AS AMENDED, AND IN PART BY THE TAXES OF THE CITIZENS OF LOS ANGELES COUNTY AND OF THE STATE OF CALIFORNIA

REV.	DATE	BY	SUB.	APP.	DESCRIPTION

DESIGNED BY
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SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT
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General Geotechnical Consultants
Submitted E.M. Lude Date 4-13-84

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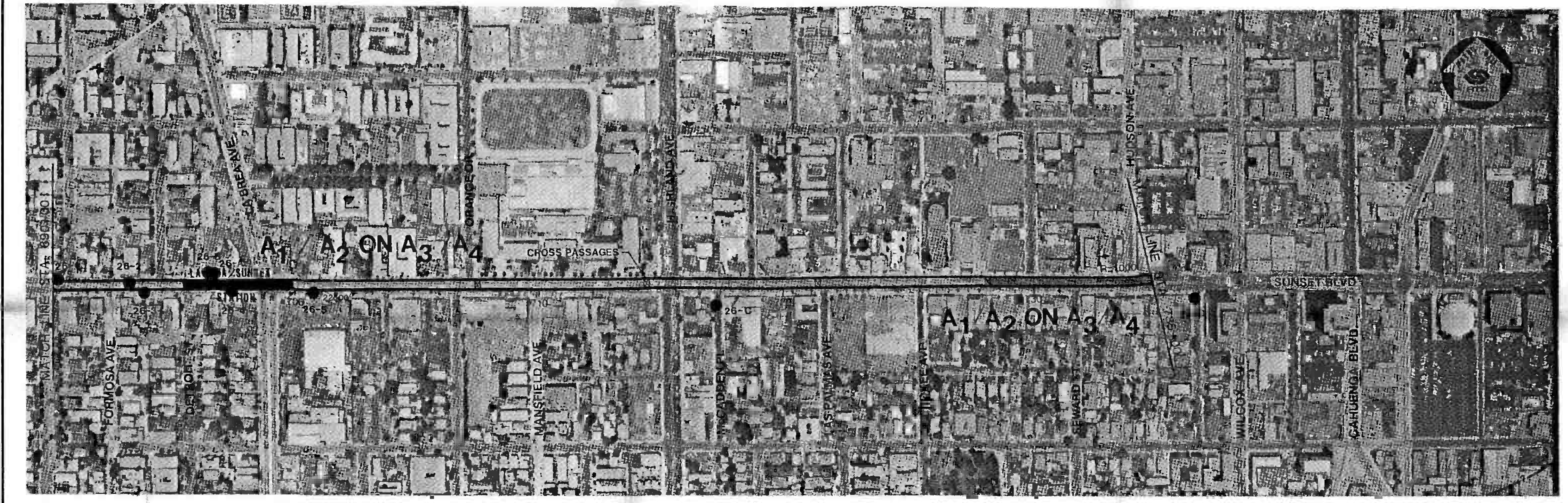
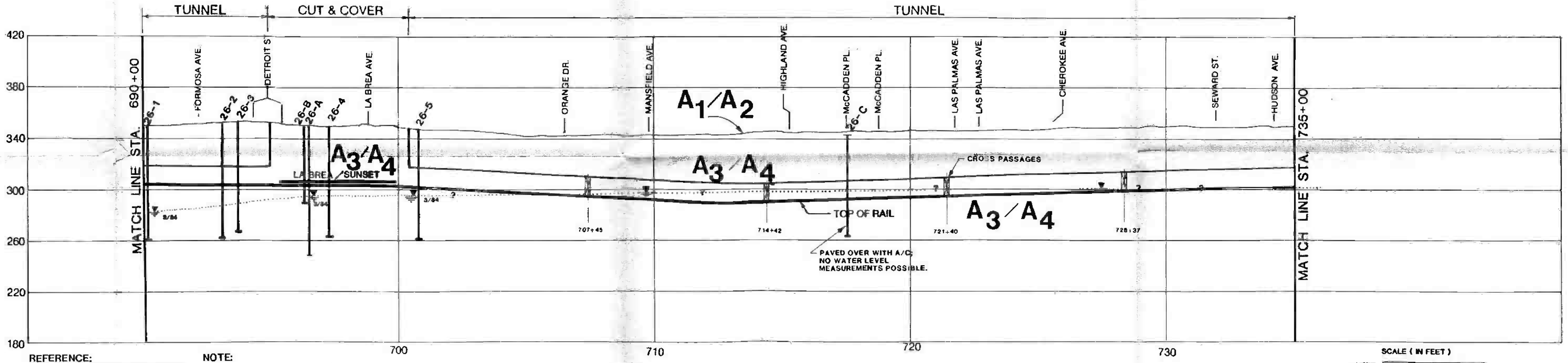
DESIGN UNIT A310
LOCATION OF BORINGS AND GEOLOGIC SECTION

PROJECT NO. 83-1140
DRAWING NO. 5
REV.
SCALE AS SHOWN
SHEET NO.





REFERENCE:
MILESTONE 10 SHEET 14 OF 21 ALIGNMENT PLAN AND PROFILE STATION 690+00 TO STATION 735+00 DATED MARCH 1983

NOTE:
FOR NOTES SEE DRAWING NO. 2

SCALE (IN FEET)
VERT. 0 20 40 60 80
HORIZ. 0 200 400

REV.	DATE	BY	SUB.	APP.	DESCRIPTION

THE PREPARATION OF THIS DRAWING HAS BEEN FINANCED IN PART THROUGH A GRANT FROM THE U. S. DEPARTMENT OF TRANSPORTATION, URBAN MASS TRANSPORTATION ADMINISTRATION, UNDER THE URBAN MASS TRANSPORTATION ACT OF 1964, AS AMENDED, AND IN PART BY THE TAXES OF THE CITIZENS OF LOS ANGELES COUNTY AND OF THE STATE OF CALIFORNIA

REV.	DATE	BY	SUB.	APP.	DESCRIPTION

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SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
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General Geotechnical Consultants
Submitted RM Price Date 4-13-84

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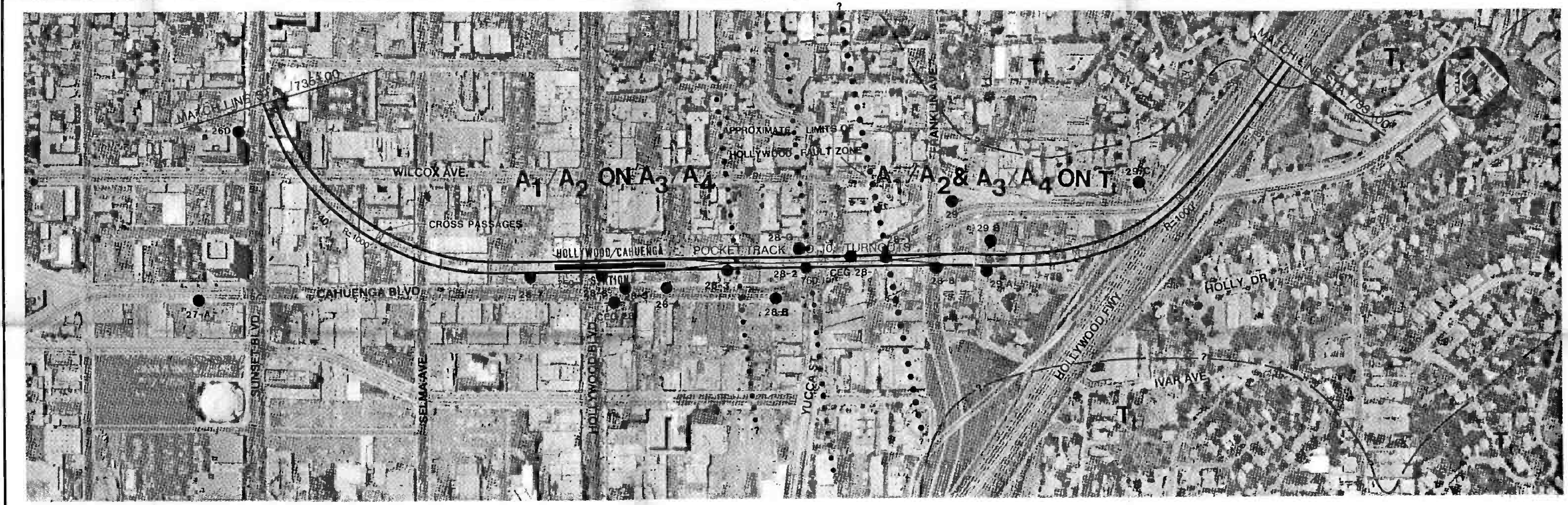
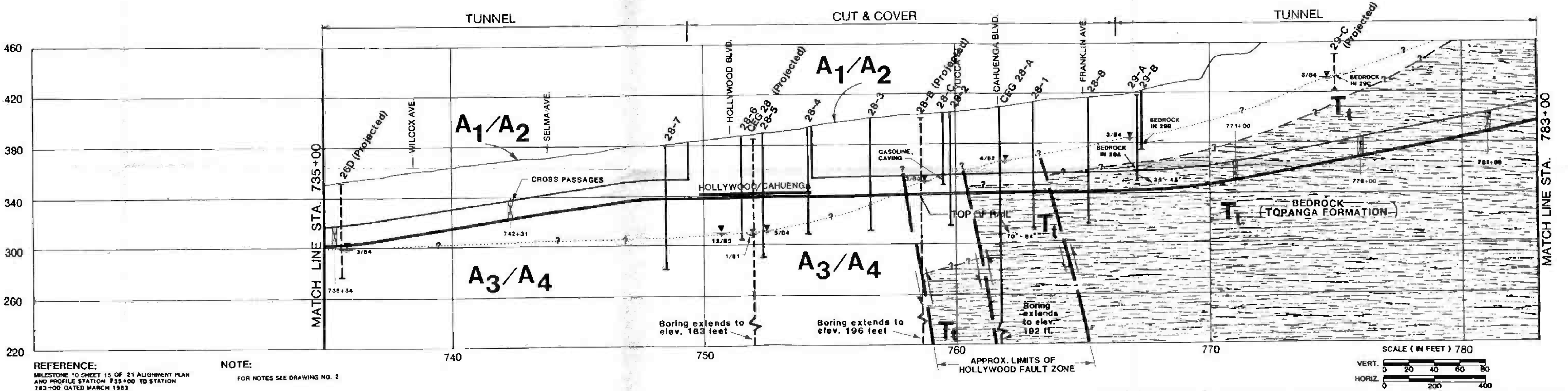
DESIGN UNIT A310 LOCATION OF BORINGS AND GEOLOGIC SECTION

PROJECT NO. 83-1140
DRAWING NO. 6
REV.
SCALE AS SHOWN
SHEET NO.





REFERENCE:
MILESTONE 10 SHEET 15 OF 21 ALIGNMENT PLAN AND PROFILE STATION 735+00 TO STATION 783+00 DATED MARCH 1983

NOTE:
FOR NOTES SEE DRAWING NO. 2

REV.	DATE	BY	SUB.	APP.	DESCRIPTION

THE PREPARATION OF THIS DRAWING HAS BEEN FINANCED IN PART THROUGH A GRANT FROM THE U. S. DEPARTMENT OF TRANSPORTATION, URBAN MASS TRANSPORTATION ADMINISTRATION, UNDER THE URBAN MASS TRANSPORTATION ACT OF 1964, AS AMENDED, AND IN PART BY THE TAXES OF THE CITIZENS OF LOS ANGELES COUNTY AND OF THE STATE OF CALIFORNIA

REV.	DATE	BY	SUB.	APP.	DESCRIPTION

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DATE

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT
RTD

CCI/ESA/GRC
General Geotechnical Consultants
Submitted RM Pride Date 4-13-84

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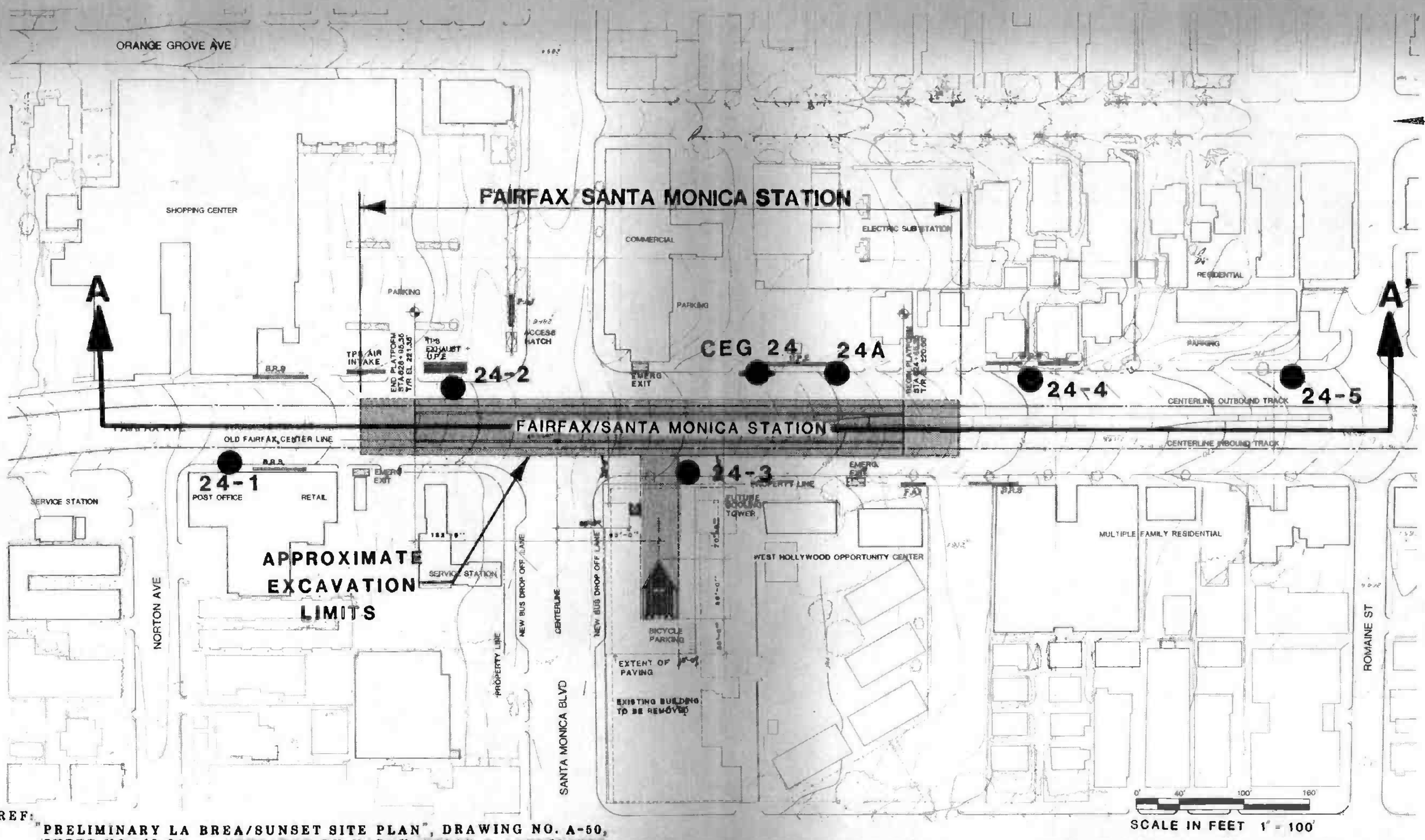
DESIGN UNIT A310
LOCATION OF BORINGS AND GEOLOGIC SECTION

PROJECT NO. 83-1140
DRAWING NO. 7
REV.
SCALE AS SHOWN
SHEET NO.



REF: "PRELIMINARY LA BREA/SUNSET SITE PLAN", DRAWING NO. A-50, SHEET NO. 48 OF PREPARED BY HARRY WEESE & ASSOCIATES, ORIGINAL SCALE 1" = 40', REDUCED TO 1" = 100', DATED 3-10-83.

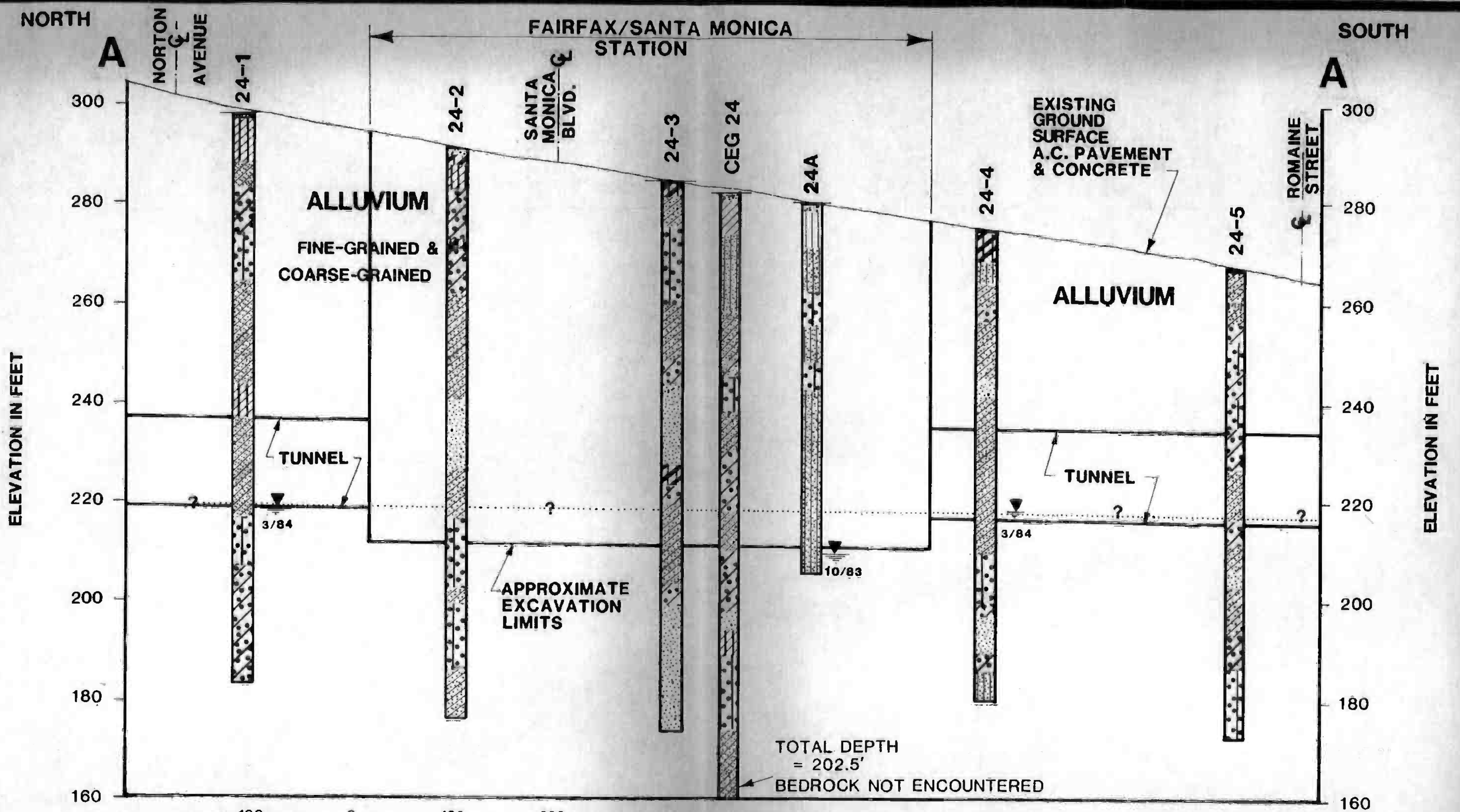
NOTES: FOR SUBSURFACE SECTION A-A' SEE DRAWING NO. 9
FOR EXPLANATION OF SYMBOLS SEE DRAWING NO. 12

LOCATION OF BORINGS - FAIRFAX/SANTA MONICA STATION

DESIGN UNIT A310
Southern California Rapid Transit District
METRO RAIL PROJECT

Converse Consultants
Geotechnical Engineering and Applied Sciences

Scale As Shown
Date APR., '84
Prepared by KLF
Checked by RG
Approved By JAD
Project No 83-1140
Drawing No 8



SCALE: HOR. 100 0 100 200
VER. 20 0 20 40

NOTES: 1.) FOR LOCATION OF SUBSURFACE SECTION A-A' SEE DRAWING NO.8

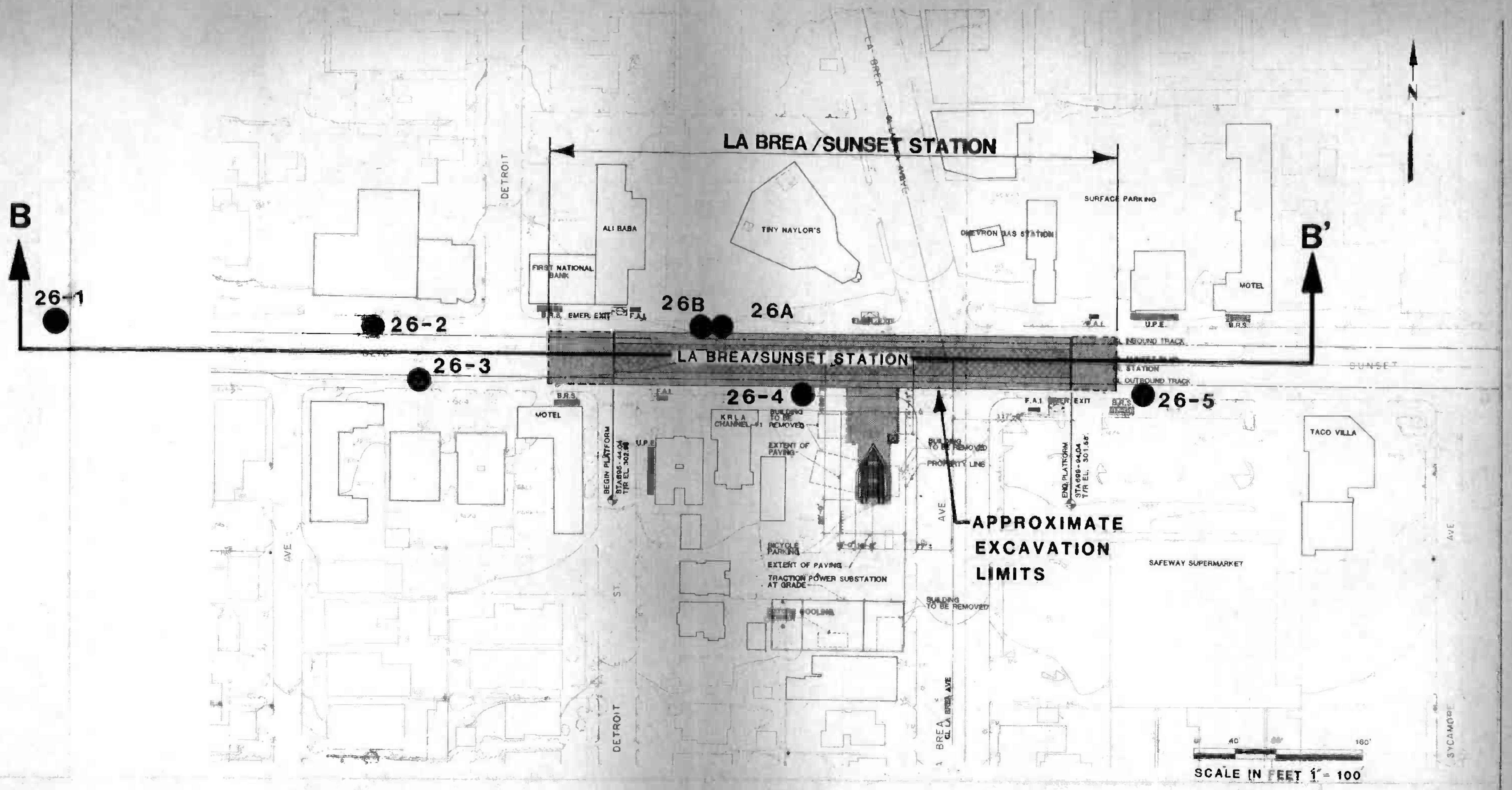
2.) FOR EXPLANATION OF SYMBOLS SEE DRAWING NO.12

SUBSURFACE SECTION A-A' - FAIRFAX/SANTA MONICA STATION

DESIGN UNIT A310
Southern California Rapid Transit District
METRO RAIL PROJECT

Converse Consultants Geotechnical Engineering and Applied Sciences

Scale As shown
Date APR.,'84
Prepared by APT
Checked by RG
Approved by JAD
Project No 83-1140
Drawing No 9



REF:
"PRELIMINARY FAIRFAX/SANTA MONICA STATION SITE PLAN", DRAWING NO. A-53, SHEET NO. 58 OF 67, PREPARED BY HARRY WEESE & ASSOCIATES, ORIGINAL SCALE 1"=40', REDUCED TO 1"= 100', DATED 6-6-83.

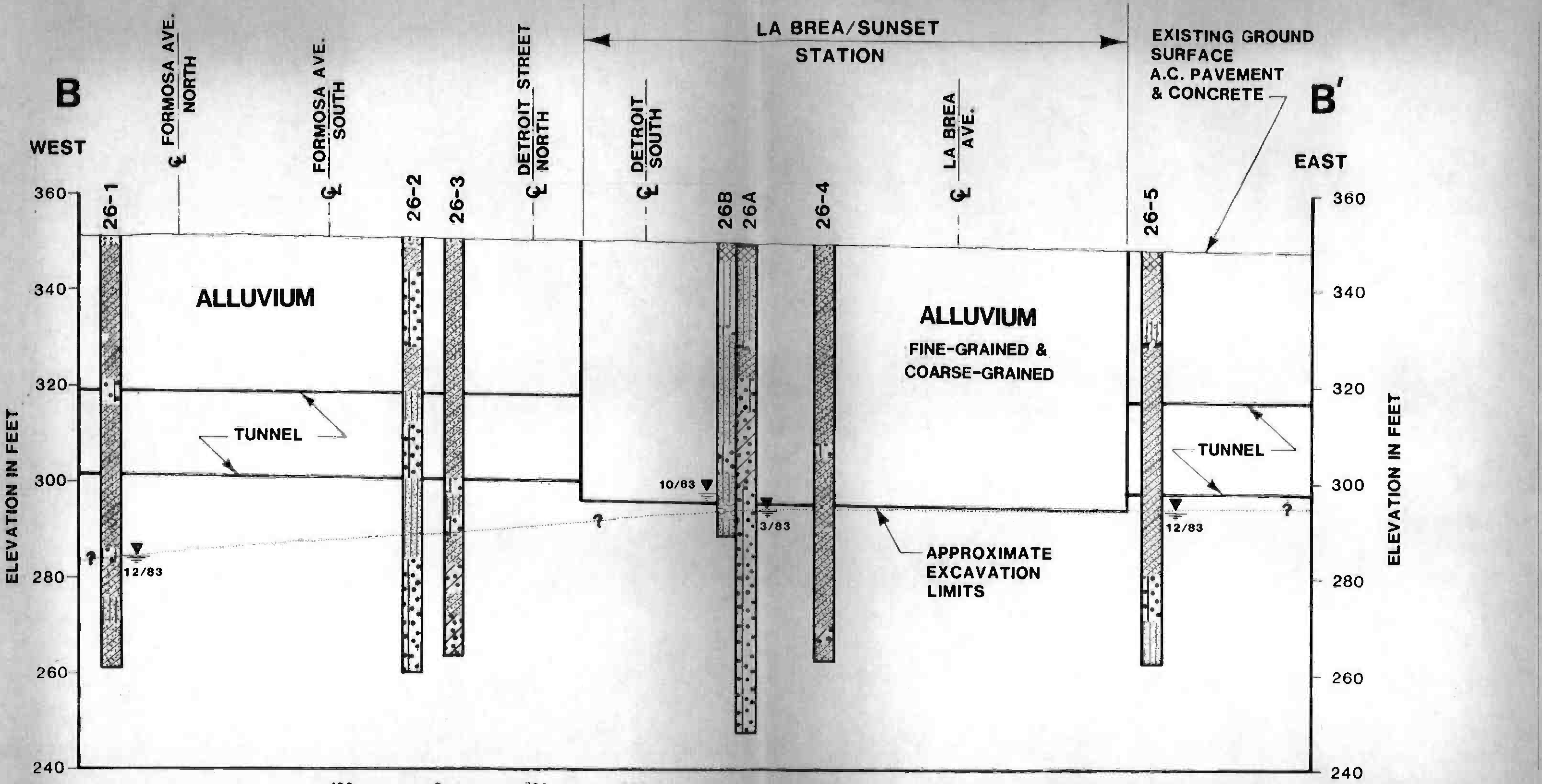
NOTES: FOR SUBSURFACE SECTION B-B' SEE DRAWING NO. 11
FOR EXPLANATION OF SYMBOLS SEE DRAWING NO. 12

LOCATION OF BORINGS - LA BREA/SUNSET STATION

DESIGN UNIT A310
Southern California Rapid Transit District
METRO RAIL PROJECT

Converse Consultants
Geotechnical Engineering and Applied Sciences

Scale	As Shown	Project No	
Date	APR., 84	83-1140	
Prepared by	KLF	Drawing No	
Checked by	RG	10	
Approved By	JAD		



SCALE: HOR. 100 0 100 200
VER. 20 0 20 40

NOTES: 1.) FOR LOCATION OF SUBSURFACE SECTION B-B' SEE DRAWING NO. 10
2.) FOR EXPLANATION OF SYMBOLS SEE DRAWING NO. 12

SUBSURFACE SECTION B-B' - LA BREA/SUNSET STATION

DESIGN UNIT A310
Southern California Rapid Transit District
METRO RAIL PROJECT

Converse Consultants
Geotechnical Engineering and Applied Sciences

Scale	As Shown
Date	APR., '84
Prepared by	APT
Checked by	RG
Approved by	JAD
Project No.	83-1140
Drawing No	11

GEOLOGIC UNITS

SOFT GROUND TUNNELLING

QUATERNARY	HOLOCENE	A_1	YOUNG ALLUVIUM (Granular): Includes clean sands, silty sands, gravelly sands, sandy gravels, and locally contains cobbles and boulders. Primarily dense, but ranges from loose to very dense.
		A_2	YOUNG ALLUVIUM (Fine-grained): Includes clays, clayey silts, sandy silts, sandy clays, clayey sands. Primarily stiff, but ranges from firm to hard.
	PLEISTOCENE	A_3	OLD ALLUVIUM (Granular): Includes clean sands, silty sands, gravelly sands, and sandy gravels. Primarily dense, but ranges from medium dense to very dense.
		A_4	OLD ALLUVIUM (Fine-grained): Includes clays, clayey silts, sandy silts, sandy clays, and clayey sands. Primarily stiff, but ranges from firm to hard.
		SP	SAN PEDRO FORMATION: Predominantly clean, cohesionless, fine to medium-grained sands, but includes layers of silts, silty sands, and fine gravels. Primarily dense, but ranges from medium dense to very dense. Locally impregnated with oil or tar.
TERTIARY	PLIOCENE	C	FERNANDO AND PUENTE FORMATIONS: Claystone, siltstone, and sandstone; thinly to thickly bedded. Primarily low hardness, weak to moderately strong. Locally contains very hard, thin cemented beds and cemented nodules.

ROCK TUNNELLING

(Terzaghi Rock Condition Numbers apply)*

3 —Terzaghi Rock Condition Number

—Approximate boundary between Terzaghi numbers

TERTIARY	MIOCENE	2-5	TOPANGA FORMATION: Conglomerate, sandstone, and siltstone; thickly bedded; primarily hard and strong (Geologic symbol Tt).
		1-5	TOPANGA FORMATION: Basalt; intrusive, primarily hard and strong (Geologic symbol Tb).

TERZACHI ROCK CONDITION NUMBERS*

1 Hard and intact

2 Hard and stratified or schistose

3 Massive, moderately jointed

4 Moderately blocky and seamy

5 Very blocky and seamy (closely jointed)

6 Crushed but chemically intact rock or unconsolidated sand; may be running or flowing ground

7 Squeezing rock, moderate depth

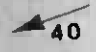
8 Squeezing rock, great depth

9 Swelling rock

---

*In practice, there are not sharp boundaries between these categories, and a range of several Terzaghi Numbers may best describe some rock.

SYMBOLS

- - - - - -?	Geologic contact: approximately located; queried where inferred
U ●●●●●? D	Fault (view in plan): dotted where concealed; queried where inferred; (U) upthrown side, (D) downthrown side
	Fault (view in geologic section): approximately located: queried where inferred; arrows indicate probable movement; attitude in profile is an apparent dip and is not corrected for scale distortion
	Dip of bedding: from unoriented core samples: bedding attitudes may not be correctly oriented to the plane of the profile, but represent dips to illustrate regional geologic trends; number gives true dip in degrees, as encountered in boring
	Ground water level: approximately located; queried where inferred
●	Boring — CEG (1981)
●	Boring — CCI/ESA/GRC (1983)
○	Boring — Nuclear Regulatory Commission (1980)
⊕	Boring — Woodward-Clyde (1977)
⦶	Boring — Kaiser Engineers (1962)
⊖	Boring — Other (USGS 1977 and various foundation studies)

▥	SILT
▨	CLAY
▥	SANDY SILT
▨	SANDY CLAY
▥	CLAYEY SILT
▨	SILTY CLAY
▨	SILTY SAND
▨	CLAYEY SAND
▨	SAND
▨	GRAVELLY SAND
▨	SANDY GRAVEL
▨	GRAVEL
▨	GRAVELLY CLAY
▨	TAR SILT & CLAY
▤	TAR SAND
▩	FILL
▤	SILTSTONE
▤	CLAYSTONE
▤	INTERBEDDED SANDSTONE WITH SILTSTONE OR CLAYSTONE
▨	SANDSTONE
▨	SANDSTONE, CONGLOMERATE
▨	CEMENTED ZONE
▩	META—SANDSTONE
▨	BASALT
▨	BRECCIA
▨	SHEAR ZONE

NOTES:

1) The geologic sections are based on interpolation between borings and were prepared as an aid in developing design recommendations. Actual conditions encountered during construction may be different.

2) Borings projected more than 100' to the profile line were considered in some of the interpretation of subsurface conditions. However, final interpretation is based on numerous factors and may not reflect the boring logs as presented in Appendix A.

3) Displacements shown along faults are graphic representations. Actual vertical offsets are unknown.

GEOLOGIC EXPLANATION

DESIGN UNIT A310
Southern California Rapid Transit District
METRO RAIL PROJECT

Converse Consultants
Geotechnical Engineering
and Applied Sciences

Scale	N/A
Date	APR., 1984
Prepared by	RG
Checked by	JAD
Approved By	HAS
Project No	83-1140
Drawing No	12

BRU 40 107

Appendix A

Field Exploration

APPENDIX A FIELD EXPLORATION

A.1 GENERAL

Field exploration data presented in this report for Design Unit A310 include information obtained from borings drilled for this and previous geotechnical investigations. Table A-1 summarizes pertinent information on 41 exploratory boreholes that have been drilled along, or in relative close proximity to, the proposed tunnel alignment and Station structures of Design Unit A310. Information is also provided for three rotary wash borings drilled during the 1981 geotechnical investigation which are no longer along the proposed tunnel alignment or located near a Station structure. Borings CEG-25, CEG-26, and CEG-27 are located about 1200 to 1300 feet from the present tunnel alignment on Fountain Avenue. The logs of these holes are included at the end of this appendix because the information provided in the logs of these boreholes has been judged to be generally representative of the subsurface conditions that exist along the present tunnel alignment.

Of the 41 borings that have been drilled within or reasonably close to the limits of Design Unit A310, 34 are rotary wash type borings and 7 are large-diameter or "man-size" auger holes. Five of the rotary wash borings were drilled as part of the 1981 geotechnical investigation, two were drilled in February 1983, 21 borings were drilled for this investigation during October and November of 1983 and 6 supplementary borings were drilled in February and March 1984. Locations of all borings listed in Table A-1 (except Borings CEG-25, CEG-26, and CEG-27) are shown in Drawings 2 through 7. Locations are also shown in Drawings 8 and 10 for the Fairfax/Santa Monica and La Brea/Sunset Station sites, respectively.

The borings drilled as part of this investigation were located at four Station sites and along the proposed tunnel alignment. The station sites are the Fairfax/Beverly, Fairfax/Santa Monica, La Brea/Sunset, and Hollywood/Cahuenga Station sites. The Fairfax/Santa Monica and La Brea/Sunset Stations are part of Design Unit A310, whereas the Fairfax/Beverly and Hollywood/Cahuenga Stations are Design Units A275 and A350, respectively. While the borings that were drilled at the Fairfax/Beverly and Hollywood/Cahuenga Stations are not located within the bounds of Design Unit A310, the information provided in the borehole logs was used in the interpretation of the subsurface conditions at the extreme southern and northern segments of the tunnel alignment in this design unit. Edited field logs for 41 of the 44 borings listed in Table A-1 are included at the end of this appendix. Logs from 6 boreholes drilled near the Hollywood/Cahuenga Station site are not included as indicated in Table A-1. The logs are, however, included in the geotechnical report for Design Unit A350.

Groundwater observation wells (piezometers) were installed in 15 of the borings drilled along the proposed tunnel alignment and/or Station sites (see Table A-1). Two pneumatic transducers were installed in Boring 23-C at two different depths in order to measure groundwater levels. Groundwater samples were obtained from a few selected borings and subjected to chemical analyses. Oil, strong odors, and/or gasoline were noted in 10 of

TABLE A-1
BORING LOG SUMMARY
DESIGN UNIT A310

BORING NUMBER	DATE DRILLED (Mo/Yr)	TYPE (1)	GROUND (2) SURFACE ELEVATION (ft.)	TOTAL DEPTH (ft.)	PIEZOMETER		WATER SAMPLE TESTED	OIL AND/OR STRONG ODOR	COMMENTS
						INSTALLED DEPTH (ft.)			
CEG-23	12/80-1/81	RW	189	200.7	yes	5.0-200.0	yes	yes	Downhole
CEG-23A	2/81	RW	214	217.5	yes	3.0-217.5	yes	yes	Downhole
23B	2/83	LD	189	75.0	no	–	yes	yes	Some Caving
23-1	11/83	RW	191	76.5	no	–	–	yes	
23-2	11/83	RW	187	75.9	no	–	–	yes	
23-3	11/83	RW	185	75.8	no	–	–	yes	
23-4	11/83	RW	183	76.3	no	–	–	yes	
23-5	11/83	RW	184	74.9	no	–	–	yes	
CEG-24	2/81	RW	282	202.5	no	–	–	no	Down & X-holes
24A	10/83	LD	280	74.5	no	–	–	no	No Caving
24-1	10/83	RW	298	115.0	yes	0.0-115.0	–	no	
24-2	10/83	RW	291	115.0	no	–	–	no	
24-3	10/83	RW	284	110.9	no	–	–	no	
24-4	10/83	RW	274	95.0	yes	0.0-9.5	–	no	
24-5	10/83	RW	267	95.0	no	–	–	no	
25A	1/83	LD	390	100.0	no	–	–	no	No Caving
25B	10/83	LD	358	81.0	no	–	–	no	No Caving
26A	2/83	RW	351	102.0	yes	0.0-100.0	–	no	
26B	10/83	LD	351	61.0	no	–	–	no	Some Sloughing
26-1	11/83	RW	350	90.0	yes	10.0-90.0	–	no	
26-2	11/83	RW	351	90.0	no	–	–	no	
26-3	11/83	RW	350	86.0	no	–	–	no	
26-4	11/83	RW	348	86.5	no	–	–	no	
26-5	11/83	RW	347	86.5	yes	20.0-85.5	–	no	
27A	2/83	LD	350	95.0	no	–	yes	no	
CEG-28	1/81	RW	385	202.0	no	–	–	no	Down & X-hole
CEG-28A (6)	2/81	RW	410	217.5	yes	(5)	yes	no	
28B (6)	2/83	RW	401	206.0	yes	0.0-205.0	–	no	
28C	10/83	LD	406	57.0	no	–	–	yes (3)	Some Belling
28-2 (6)	11/83	RW	406	90.5	no	–	–	no	
28-3 (6)	11/83	RW	398	90.0	no	–	–	no	
28-4 (6)	11/83	RW	392	85.0	no	–	–	no	
28-5 (6)	11/83	RW	388	100.0	yes	0.0-100.0	–	no	
28-6	11/83	RW	386	82.5	no	–	–	no	
28-7	11/83	RW	383	99.0	no	–	–	no	
CEG-25 (4)	12/80	RW	323	202.5	yes	0.0-200.0	yes	no	Not Near Present Alignment but Subsurface Condition Generally Representative
CEG-26 (4)	12/80	RW	316	209.5	yes	0.0-86.0	yes	no	
CEG-27 (4)	12/80	RW	322	201.0	yes	0.0-200.0	yes	no	
SUPPLEMENTARY BORINGS									
23-C	3/84	RW	202	76.0	–	–	–	yes	Installed 2 pneumatic transducers
23-D	3/84	RW	243	76.0	yes	1.0-76.0	–	–	
24-B	3/84	RW	357	137.0	yes	0.0-137.0	–	–	
25-C	2/84	RW	340	75.0	yes	0.0-75.0	–	–	
26-C	2/84	RW	343	80.0	yes	0.0-80.0	–	–	
26-D	2/84	RW	351	76.0	yes	1.0-76.0	–	–	

NOTES:

(1) Types — RW: Rotary wash boring (small diameter)
LD: Large diameter auger boring (32 to 36 diameter)

(2) Ground surface elevations approximate and rounded to nearest foot.

(3) Source of gasoline floating on top of water in this hole may be an abandoned service station located about 150 feet north of boring.

(4) Borings drilled about 1200 to 1300 feet from proposed tunnel alignment.

(5) Two stage piezometer: upper stage, 0.0-40.0 feet; lower stage, 54.0-217.5 feet.

(6) Logs for these boreholes not included in this Appendix. See Report for Design Unit A350.

the borings listed in Table A-1. These borings are located near the extreme southern and northern ends of Design Unit A310.

Most rotary wash borings were sampled at regular intervals using the Converse ring sampler, Pitcher barrel sampler, and the Standard Split Spoon (SPT) sampler. Sample and core recovery was generally good in the soils encountered in the boreholes. The large-diameter or "man-sized" auger holes were logged by a downhole observer(s) when safety and groundwater conditions permitted.

The following subsections describe the field exploration procedures and provide explanations of symbols and notations used in preparing the field boring logs. Copies of the field boring logs are presented following the text of this appendix.

A.2 ROTARY WASH BORINGS

A.2.1 Technical Staff

Members of three firms (CWDD/ESA/GRC) participated in the drilling exploration program. The field geologist continuously supervised each rotary wash boring during the drilling and sampling operation. The geologist was also responsible for preparing a detailed lithologic log of the rotary wash cuttings and for sample/core identification, labeling and storage of all samples, and installation of piezometer pipe, gravel pack, and bentonite seals.

A.2.2 Drilling Contractor and Equipment

Drilling was performed by Pitcher Drilling Company of East Palo Alto, California, with Failing 1500 rotary wash rigs, each operated by a two-man crew.

A.2.3 Sampling and Logging Procedures

Logging and sampling were performed in the field by the geologist. The following describes sampling equipment, procedures, and notations used on the lithologic logs to indicate drilling and sampling modes.

As indicated in Table A-1, 8 borings were drilled during the 1981 geotechnical investigation. Three of these borings (i.e., CEG-23, CEG-24, and CEG-28) were drilled near the station structure sites which were proposed at the time of the 1981 investigation. The remaining borings were drilled along the tunnel alignment proposed at that time.

The soils encountered in the borings drilled along the proposed tunnel alignment during the 1981 investigation were sampled every 10 feet using a Standard Split Spoon (SPT) sampler driven with a standard 30-inch stroke, 140-pound hammer. At each 20-foot interval and prior to the SPT sampler, an undisturbed Converse ring sample was obtained using a downhole slip-jar hammer.

In the rotary wash borings drilled near the Station structures during the 1981 geotechnical investigation, a more intensive sampling program was followed. The interval between SPT samples was decreased to every 5 feet and performed throughout the entire depth of the boring or until continuous bedrock sampling began. Similar to the borings drilled along the tunnel alignment, undisturbed Converse ring samples were taken at 20-foot interval followed by the SPT sampler.

When bedrock was encountered, the borings were either sampled with a Pitcher Barrel or cored continuously to the total depth of the boring. The choice of using the Pitcher Barrel or NX core barrel was made during drilling depending on the ground conditions encountered.

Two rotary wash borings (Borings 26A and 28B) were drilled within (or close to) the bounds of Design Unit A310 during February 1983. The purpose of these borings was to provide supplemental geotechnical information along the tunnel alignment. In Boring 26A, soils were sampled about every 10 feet with the SPT sampler. The Converse ring sampler was also used and proceeded the Split Spoon sampler at intervals of about every 20 feet. Boring 28A was drilled to provide additional information needed to locate the Hollywood fault. Therefore, regular sampling intervals were not followed during the drilling of this hole.

Five rotary wash borings were drilled at each of the two Station sites included in Design Unit A310 during the months of October and November of 1983. Borings drilled at the Fairfax/Santa Monica Station site (Borings 24-1 through 24-5) were drilled to depths ranging from 95 to 115 feet. The borings drilled at the La Brea/Sunset Station site (Borings 26-1 through 26-5) had depths ranging from about 86 to 90 feet. With the exception of Boring 26-5, all the borings were sampled at 10-foot intervals using the Converse ring sampler. Between this interval and at about every 10 feet, Pitcher Barrel or Shelby tube samples were taken and were followed by the SPT sampler. In Boring 26-5, Pitcher Barrel sampling techniques were utilized at about 20 intervals and the soils were sampled, on the average, twice every 5 feet by alternating the Converse ring and SPT samplers.

Six supplementary rotary wash borings were drilled at various locations along the proposed tunnel alignment in March 1984. These borings were sampled, on the average, every 5 feet by alternating the Pitcher Barrel and SPT samplers. The depths of these holes range from 75 to 137 feet.

The rotary wash borings drilled at the Fairfax/Beverly and Hollywood/Cahuenga Station sites were drilled during the month of November 1983. The borings drilled at these two Station sites have depths ranging from about 75 to 77 feet and 83 to 100 feet, respectively. Borings 28-2 through 28-6 were sampled, on the average, twice every 5 feet by alternating the Converse ring and SPT samplers. Pitcher Barrel sampling techniques were not utilized in these holes. The soils encountered in Borings 23-1 through 23-5 and Boring 28-7 were sampled using nearly the same sampling intervals as were used in Boring 26-5.

All of the sampling intervals described above were sometimes altered during the course of the drilling operations if a change in material types was detected by the geologist logging the hole or if sample recovery of the previous soil sample was poor. The most common cause for loss of samples or altering the sampling interval was when gravels were encountered at the desired sampling depth. Standard Penetration blow count information can often be misleading in this type of formation, and it is difficult to recover an undisturbed sample. Therefore, at some locations borings were advanced until drill response and cuttings suggested a change in formation.

The sampling program was also sometimes modified when dense soil deposits were encountered. In this case, the Converse ring sampler was not used. Instead, the Pitcher Barrel sampler, which is generally a better technique when sampling dense soil deposits, was substituted for the Converse ring sampler in order to obtain higher quality undisturbed samples.

The following symbols were used on the logs to indicate the type of sample and the drilling mode:

Log Symbol	Sample Type	Type of Sampler
B	Bag	-
J	Jar	Split spoon
C	Can	Converse ring
S	Shelby Tube	Pitcher barrel
Box	Box	Pitcher barrel, core barrel

Log Symbol	Drilling Mode
AD	Auger drill
RD	Rotary drill
PB	Pitcher barrel sampling
SS	Split spoon
DR	Converse drive sample
C	Coring

A.3 LARGE-DIAMETER BORINGS

A.3.1 Technical Staff

Personnel of Converse Consultants, Inc. (Converse, 1983) directed the drilling and performed the logging of the large-diameter ("man-size") bucket auger borings. Since the purpose of the large-diameter auger borings was to allow consultants and RTD personnel to make first-hand downhole observations of the geologic conditions along the proposed project route, a number of people participated in this exploration program. They include personnel from the Southern California Rapid Transit District, MRTC, Lindvall Richter & Associates, and other independent consultants.

A.3.2 Drilling Contractor and Equipment

Drilling was performed by A&W Drilling Company of La Habra using a bucket auger drilling rig with a 32- to 36-inch bucket.

A.3.3 Drilling Operations

These operations consisted of drilling the auger borings to depths ranging from 57 to 100 feet. Drilling was stopped when the boring reached the prescribed depth or until significant inflows of water occurred or when the hole experienced caving. Corrugated metal pipes (sections 20 feet long) with windows cut on 5-foot vertical intervals were used to case the completed holes. The windows were 1-foot square and permitted observations of material types, caving, groundwater, and gas/oil conditions. Sections of pipe were bolted to one another as each 20-foot section was lowered into the hole. Casing was installed over the total depth of the hole.

Before entering the holes, a "gas detector" meter was used to evaluate the lack of oxygen and/or the presence of combustible gases. The borings were then logged by personnel of Converse Consultants prior to any other observers entering the hole. Water samples were obtained for subsequent chemical analyses, if needed. Loggers and all observers were equipped with safety equipment as required by the California Occupational Safety and Health Administration.

A.4 FIELD CLASSIFICATION OF SOILS

All soil types were classified in the field by the site geologist using the "Unified Soil Classification System." Based on the characteristics of the soil, this system indicates the behavior of the soil as an engineering construction material.* Particle size distributions were estimated in the field in most cases and are noted in the borehole logs. Although particle size distribution estimates were based on volume rather than weight, the field estimates should fall within an acceptable range of accuracy.

Table A-2 shows the correlation of standard penetration information and the physical description of the consistency of clays (hand-specimen) and the compactness of sands used by the field geologists for describing the materials encountered.

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*For a more complete discussion of the Unified Soil Classification System, refer to Corps of Engineers, Technical Memorandum No. 3-357, March 1953, or Department of the Interior, Bureau of Reclamation, Earth Manual, 1963.

Table A-2 Correlation of N-Values and Consistency/Compactness of Soil Obtained in the Field

TABLE A-2 Correlation of N-Values and Consistency/Compactness of Soil Obtained in the Field

N-Values (blows/foot)	Hand-Specimen (clay only)	Consistency (clay or silt)	Compactness (sand only)	N-Values (blows/foot)
0 - 2	Will squeeze between fingers when hand is closed	Very soft	Very loose	0 - 4
2 - 4	Easily molded by fingers	Soft	Loose	4 - 10
4 - 8	Molded by strong pressure of fingers	Firm	---	---
8 - 16	Dented by strong pressure of fingers	Stiff	Medium dense	10 - 30
16 - 32	Dented only slightly by finger pressure	Very stiff	Dense	30 - 50
32+	Dented only slightly by pencil point	Hard	Very dense	50+

A.5 FIELD DESCRIPTION OF THE FORMATIONS

The description of the formations is subdivided in two parts: lithology and physical condition. The lithologic description consists of:

- o Rock name.
- o Color of wet core (from GSA rock color chart).
- o Mineralogy, textural, and structural features.
- o Any other distinctive features which aid in correlating or interpreting the geology.

The physical condition describes the physical characteristics of the rock believed important for engineering design consideration. The form for the description is as follows:

Physical condition: ______________ fractured, minimum ________, maximum ______________, mostly ______________; ______________ hardness; ______________ strength; ______________ weathered.

Bedrock description terms used on the boring logs are given on Table A-3.

TABLE A-3 Bedrock Description Terms

PHYSICAL CONDITION*	SIZE RANGE	REMARKS
Crushed	-5 microns to 0.1 ft	Contains clay
Intensely Fractured	0.05 ft to 0.1 ft	Contains no clay
Closely Fractured	0.1 ft to 0.5 ft	
Moderately Fractured	0.5 ft to 1.0 ft	
Little Fractured	1.0 ft to 3.0 ft	
Massive	4.0 ft and larger	

HARDNESS**	
Soft	Reserved for plastic material
Friable	Easily crumbled or reduced to powder by fingers
Low Hardness	Can be gouged deeply or carved with pocket knife
Moderately Hard	Can be readily scratched by a knife blade; scratch leaves heavy trace of dust
Hard	Can be scratched with difficulty; scratch produces little powder & is often faintly visible
Very Hard	Cannot be scratched with knife blade

STRENGTH	
Plastic	Easily deformed by finger pressure
Friable	Crumbles when rubbed with fingers
Weak	Unfractured outcrop would crumble under light hammer blows
Moderately Strong	Outcrop would withstand a few firm hammer blows before breaking
Strong	Outcrop would withstand a few heavy ringing hammer blows but would yield, with difficulty, only dust & small fragments
Very Strong	Outcrops would resist heavy ringing hammer blows & will yield with difficulty, only dust & small fragments

WEATHERING	DECOMPOSITION	DISCOLORATION	FRACTURE CONDITION
Deep	Moderate to complete alteration of minerals, feldspars altered to clay, etc.	Deep & thorough	All fractures extensively coated with oxides, carbonates, or clay
Moderate	Slight alteration of minerals, cleavage surfaces lusterless & stained	Moderate or localized & intense	Thin coatings or stains
Little	No megascopic alteration in minerals	Slight & intermittent & localized	Few stains on fracture surfaces
Fresh	Unaltered, cleavage surface glistening	None	

*Joints and fractures are considered the same for physical description, and both are referred to as "fractures"; however, mechanical breaks caused by drilling operation were not included.

**Scale for rock hardness differs from scale for soil hardness.

Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG 23

Proj: DESIGN UNIT A275
Date Drilled 12/31/80 - 1/4/81
Ground Elev. 188'
Drill Rig Failing 1500
Logged By L. Schoeberlein
Total Depth 200.7'
Hole Diameter 4 7/8"
Hammer Weight & Fall 140 lb 30 in.

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.5 CONCRETE				
	CL	0.5-1.5 CLAY: grayish black; trace of fine sand; moist			AD	
2	CL	YOUNG ALLUVIUM 1.5-3.5 SANDY CLAY: brownish black; moist				augered to 10'
4	CL	3.5-6.2 SILTY CLAY: medium bluish grey; stiff; moist				
			J-1	4 5 12	SS	1.5/1.5 recovery
6						
	SC/ CL	6.2-12.0 CLAYEY SAND/SANDY CLAY: light greenish grey			AD	
8						
						ground water at 9.5'
10			C-1		DR	1.0/1.0 recovery 12/31/80
					RD	1/2/81 drilling with 4 7/8" drag bit
12	CL	12.0-14.0 CLAY: greenish grey; stiff				
14	ML	14.0-19.0 CLAYEY SILT: dark greenish grey; dry to moist; very stiff				
			J-2	0 9 15	SS	1.5/1.5 recovery
16					RD	
18						
	CL	19.0-23.5 SANDY CLAY: dark greenish grey;				
20						

Sheet 1 of 9

Project DESIGN UNIT A275 **Date Drilled** 12/31/80-1/4/81 **Hole No.** 23

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	CL	19.0-23.5 SANDY CLAY: continued occasional fine gravel; very stiff; dry to moist	C-2		DR	0.8/1.0 recovery
					RD	
22						
24	SC	23.5-31.0 CLAYEY SAND: dark greenish grey; occasional fine to coarse gravel; dense; moist				
			J-3	11 16 25	SS	1.0/1.5 recovery
26					RD	
28						
30			C-3		DR	0.7/1.0 recovery
	CL	OLD ALLUVIUM 31.0-44.0 SILTY CLAY: dark greenish grey; hard; moist			RD	
32						
34						
			J-4	9 16 23	SS	1.5/1.5 recovery
36					RD	
38						
40			C-4		DR	
					RD	
42						
44						

Project DESIGN UNIT A275 **Date Drilled** 12/31/80 - 1/4/81 **Hole No.** 23

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	SC	44.0-51.0 CLAYEY SAND: dark greenish grey; interbedded with sandy clay; dense; moist to wet			RD	
			J-5	11 14 17	SS	1.3/1.5 recovery
46					RD	
48						
50			C-5		DR	0.8/1.0 recovery
	CL	51.0-64.0 SANDY CLAY: dark greenish grey; interbedded with clayey sand; very stiff; moist			RD	
52						
54						
			C-6		DR	1.0/1.0 recovery
56					RD	
58						
60		becoming hard	J-6	6 18 25	SS	1.1/1.5 recovery
					DR	
62						
64	CL	64.0-88.0 SANDY CLAY: greenish black; hard; contains low petroleum content; dry to moist				
			C-7		DR	0.8/1.0 recovery
66			J-7	33 49 43	SS	gas test 21% O_2, 0% combustibles
					RD	
68						

Sheet 3 **of** 9

Project DESIGN UNIT A275 Date Drilled 12/31/80 - 1/2/81 Hole No. 23

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	CL	64.0-88.0 SANDY CLAY: continued			RD	
70		vertical petroleum streaks	J-8	17 35 40	SS	1.5/1.5 recovery
72					RD	
74						
			J-9	51 46 53	SS	1.5/1.5 recovery
76					RD	
78						
80		6" petroleum rich lens becoming more sandy	J-10	26 45 46	SS	1.5/1.5 recovery
82					RD	
84			C-8		DR	0.8/0.95 recovery
			J-11	30 56	SS	1.0/1.0 recovery gas detector indicates 21% O_2 and 0% combustibles
86					RD	
88	SP	88.0-115.0 TAR SAND: black; fine to medium sand; very dense; petroleum binder				
90			J-12	37 70	SS	0.9/1.0 recovery petroleum sample
92					RD	

Sheet 4 of 9

Project DESIGN UNIT A275 Date Drilled 12-31-80 Hole No. 23

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
92	SP	88.0-115.0 TAR SAND: (continued)			RD	
94						
			J-13	57	SS	0.5'/0.5' recovery
					RD	
96						
	GP	6" gravel lens				rig chatter
98	SP					
100			J-14	55	SS	
					RD	
	GP	6" gravel lens				rig chatter
102	SP					
		fine sand				
104			C-9		DR	0.8/0.9 recovery
			J-15	84	SS	0.5/0.5 recovery
					RD	
106						
108						
110			J-16	52 50	SS	0.7/0.7 recovery
					RD	gas: 6% combustibles 21% O_2 rig chatter
112	GP SP	112.5 6" gravel lens				
114		114.5 6" gravel lens				
		WEATHERED FERNANDO FORMATION				
	CL	115.-122.0 SILTY CLAYSTONE: greenish black	J-17	28 39	SS	
116						

Sheet 5 of 9

Project DESIGN UNIT A275 **Date Drilled** 12-31-80/1-4-81 **Hole No.** 23

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
116	CL	115.0-122.0 SILTY CLAY: (continued)	J-17	50	SS	1.4/1.4 recovery
		very stiff; contains streaks of petroleum rich silt & fine sand; dry to moist			RD	
118						
120	SP	tar sand lens	J-18	58	SS	
	CL				RD	0.5/0.5 recovery
122		FERNANDO FORMATION 122.0-140.2 CLAYEY SILTSTONE: olive black to dark greenish grey; poorly cemented; contains streaks and interbeds of fine tar sand				
124		Physical Condition: closely fractured, soft to friable hardness; plastic to friable strength moderate to little weathered	C-10		DR	
			J-19	28 49 50	SS	
126					RD	
128						
		well cemented				gas: 6% combustibles 21% O_2 1-2-81
130		softer (less cement)				1-3-81 gas: 100% combustibles 18% O_2 bubbling visible foam 1' from ground surface
132			Box 1		PB	changed to 4 7/8 tri-cone 1.6/2.8 recovery
134						
			S-1		PB	damaged tube drilling through highly cemented zone
136	60°	tar sand				2.2/2.2 recovery
138		siltstone	Box 1 Cont.		PB	gas: 100% combustibles, 18% O_2 2.2/2.7 recovery
140						

Project DESIGN UNIT A275 Date Drilled 12-31-80/1-4-81 Hole No. 23

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
140		140.2-200.7 TAR SAND: black; fine sand occasional fine gravel; medium dense to dense; petroleum content varies; siltstone interbeds; becoming dense to very dense and finer with depth, siltstone interbeds as described in 122.0-140.2 interval	Box 1 CONT.		PB	
142					PB	143.1 sample removed for petroleum testing
144		144.6 well cemented siltstone concretions				1.5/2.7 recovery
146					PB	
		147.6 well cemented siltstone lens, moderately to well cemented				
148		148 - concretions			PB	2.1/2.2 recovery
150			Box 2			2.5/2.8 recovery
152			S-2		PB	slow extruding, sample expanding in tube maximum expansion 2-3"
		interbedded siltstone				2.7/2.8 recovery
154		153.9 thin siltstone lens 154.6 siltstone,slicken sides on most fracture surfaces	Box 2 Cont.		PB	pocket penetrometer > 4.5 ksf 2-9-81 2.4/2.8 recovery
156	60°	156.9 very thin cemented zone			PB	2.7/2.7 recovery
158		158.5 clayey siltstone			PB	
160						2.5/2.8 recovery 0.8' extruded, rest could not be extruded
162		siltstone			PB	1.2/2.7 recovery
164						

Sheet 7 of 9

Project DESIGN UNIT A275 Date Drilled 12-31-80/1-4-81 Hole No. 23

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
164		140.2-200.7 TAR SAND: (continued)	Box 2 Cont.		PB PB	pocket penetrometer > 4.5 tsf, 2-9-81 2.8/2.8 recovery
166						
168			S-3		PB	2.8/2.8 recovery
170			Box 2 Cont. Box 3		PB	2.8/2.8 recovery sample expanding in tube & bubbling Ryland & Cummings gas testing 1-3-81 1-4-81
172		thinly interbedded siltstone				
174		siltstone with tar sand streaks			PB	pocket penetrometer 4.0 tsf, 2-9-81 2.8/2.8 recovery
176	50°	176-179.5 possible fault gauge moderately cemented, intensely fractured dominantly tar in sample			PB	strong sulfur odor losing circulation 1.7/2.7 recovery
178		tar sand, loose, coarse sand and fine gravel thin, blue green clay lens no tar, fine grained tar sand			PB	2.8/2.8 recovery
180						
182			S-4		PB	1.9/2.8 recovery pocket penetrometer 2.75 tsf 2-9-81 2.7/2.8 recovery
184			Box 3 Cont.		PB	
186			Box 4		PB	
188						

Sheet 8 of 9

Project DESIGN UNIT A310 Date Drilled 12-31-80 - 1-4-81 Hole No. 23

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
188		140.2-200.7 TAR SAND: cont.	Box 4 (cont)		PB	2.5/2.7 recovery
190		thin gravelly tar and coarse sand lens			PB	2.8/2.8 recovery
192		occasional coarse sand and fine gravel			PB	2.7/2.8 recovery pocket penetrometer 2.75 tsf 2/9/81
194						
					PB	2.8/2.8 recovery
196						
198			S-5		PB	2.7/2.7 recovery
200						
		BH 200.7 ft. Terminated hole 1/4/81; downhole geophysical survey (Bruce Auld) completed 1/4/81; E-logs (ESA) completed 1/4/81; site cleaned and piezometer set to 200' for gas monitoring. Moved off site 1/4/81. Water sampled 2/13/81.				
202						
204						
206						
208						
210						
212						

Sheet 9 of 9

THIS BORING LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.

Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG 23A

CEG 23A

Proj: DESIGN UNIT A310
Date Drilled 2-12-15-81
Ground Elev. 214'
Drill Rig Failing 1500
Logged By S. Slaff
Total Depth 217.5'
Hole Diameter 4 5/8"
Hammer Weight & Fall 140 lbs 20 inches

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.8 CONCRETE			C	15:45 2/12/81
2 4	CL	ALLUVIUM 0.8-6.8 SILTY CLAY: dark yellowish brown; fine to medium sand; sand is subangular; firm to stiff; moist			AD	
6					RD	easy drilling
8	SM	6.8-11.2 SILTY SAND: moderate yellowish brown; medium to fine sand; subangular to subrounded; low plasticity fines; saturated; loose				
10			J-1	18 13 15	SS	1.5/1.5 recovery
12 14	CL	11.2-14.8 SILTY CLAY: dark yellowish brown; fine to medium sand; sand is subangular; firm to stiff; wet			RD	pocket penetrometer 2.75 tons/ft^2
16	SM	14.8-16.6 SILTY SAND: moderate yellowish brown; medium to fine sand; low plasticity fines; loose; saturated				
18	CL	16.6-62.9 SANDY CLAY: dusky yellow; fine to coarse sand; trace gravel; moist; sand is subangular; gravel is subrounded				
20			C-1	2 3	DR	0.8/1.0 recovery

Sheet 1 of 10

Project DESIGN UNIT A310 **Date Drilled** 2-12-13-81 **Hole No.** CEG 23A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	CL	16.6-62.9 SANDY CLAY: continued	J-2	8 19 19	SS	1.5/1.5 recovery pocket penetrometer 1.3 tsf, 17:00 2/12/81
					RD	07:00 2/13/81 water level at 13.6' 0% combustible gas
22		becomes very stiff				
24						
						smooth drilling
26		increasing sand content				
28						
30			J-3	9 10 11	SS	1.2/1.5 recovery pocket penetrometer 1.5 tsf
					RD	
32						
34						
36		decreasing sand content				
38						
		mottled: moderate brown, dark yellowish brown; dusky yellow 39.0 - silty clay; very stiff to hard	C-2	8 10	DR	1.0/1.0 recovery
40			J-4	10 20 23	SS	1.5/1.5 recovery pocket penetrometer 2.2 tsf
		color change to light olive brown			RD	
42						
44						

Sheet 2 of 10

Project DESIGN UNIT A310 Date Drilled 2-13-81 Hole No. CEG 23A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	CL	16.6-62.9 SANDY CLAY: continued			RD	rig chattering slightly
46						
48						
50			J-5	11 17 21	SS	1.5/1.5 recovery pocket penetrometer 3.0 tsf
52					RD	rig chattering slightly
54		sand grading from subangular to angular				
56						
58						
	(SC)	60.0 clayey sand; dense to very dense	C-3	15 27	DR	0.9/1.0 recovery
60			J-6	21 37 39	SS	1.4/1.5 recovery pocket penetrometer 3.1 tsf
62					RD	rig chattering
	CL	62.9-133.9 SILTY CLAY: dusky green; fine sand; mostly subangular quartz; hard; moist				
64						
66						
68						

Sheet 3 of 10

CEG

Project DESIGN UNIT A310 **Date Drilled** 2-13-81 **Hole No.** 23A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	CL	62.9-133.9 SILTY CLAY: continued			RD	
70		decrease in sand content	J-7	19 30 27	SS	1.5/1.5 recovery pocket penetrometer 1.8 tsf
72					RD	
74						
76						
78			C-4	10 14	DR	1.0/1.0 recovery
80	(ML)	80.0 micaceous clayey silt; very dense	J-8	15 25 27	SS	1.4/1.5 recovery pocket penetrometer 1.7 tsf
82					RD	
84						
86						
88		increasing sand content				
90			J-9	29 33 32	SS	1.5/1.5 recovery pocket penetrometer 1.5 tsf
92					RD	

Project DESIGN UNIT A310 Date Drilled 2-13-81 Hole No. CEG 23A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
92	CL	62.9-133.9 SILTY CLAY: continued			RD	
94						
96						
98						
			C-5 T	24 34	DR	0.8/1.0 recovery
100			J-10	15 35 29	SS	0.8/1.5 recovery pocket penetrometer 2.7 tsf
					RD	
102						
104	(SM)	probable thin silty sand lens/layer (trace gravel)				rig chatter
106						
	(SM)	probable thin silty sand lens/layer (trace gravel)				rig chatter
108						
110			J-11	23 29 51	SS	1.5/1.5 recovery pocket penetrometer 1.0 tsf
					RD	
112						
	(SM)	probable thin silty sand lens/layer (trace gravel)				rig chatter
114						
116						

Sheet 5 of 10

Project DESIGN UNIT A310 Date Drilled 2-13-14-81 Hole No. CEG 23A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
116	CL	62.9-133.9 SILTY CLAY: continued			RD	
118						
				23	DR	1.0/1.0 recovery
			C-6	77		
120	(ML)	120.0 clayey silt, very dense	J-11	28	SS	.75/.75 recovery
			A	50		pocket penetrometer 1.5 tsf
					RD	
122						
	(SM)	probable silty sand lens~.5' thick				rig chattering
124						
126						
128						
130			J-12	64	SS	.5/.5 recovery refusal 2/13/81
	SM	130.1-130.8 SILTY SAND: grayish green fine sand; sulfurous-organic odor; very dense; saturated			RD	07:15 2/14/81 water level at 21.3' 0% combustible gas
132						
134	SM	133.9-139.8 SILTY SAND: dusky blue green and medium dark gray; medium plasticity fines; sand is subangular to subrounded; fine to very fine; sulfurous-organic odor; very dense; wet				
136						
		fine content decreasing				
138						
			C-7	100	DR	.5/.5 recovery
140		139.8-143.8 SANDY GRAVEL: mottled- dark	J-13	50	SS	

Project DESIGN UNIT A310 **Date Drilled** 2-14-81 **Hole No.** CEG 23A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
140	GM (GW)	139.8-143.8 SANDY GRAVEL: continued gray; medium light gray; fine gravel; coarse sand with medium plasticity fines; very dense; saturated			RD	.25/.25 recovery
142						
144	SM	143.8-147.5 SILTY SAND: medium dark gray sand; sulfurous-organic odor; very dense; wet				
146						
148	GM (GW)	147.5-152.4 SANDY GRAVEL: mottled - dark gray; medium light grey; fine gravel; coarse sand with medium plasticity fines; very dense; saturated				
150						skipped SS sample due to hardness of formation
152						
	SM (ML)	152.4-198.2 SILTY SAND: dark greenish gray; fine sand; sand is subangular to subrounded; sulfur-organic odor; occasional interbeds of fine sandy silt; very dense; moist				
154						
156						
158						
			C-8	100	DR	.5/.5 recovery
			J-14	50	SS	.4/.4 recovery
160					RD	
162						
164						

Sheet 7 of 10

Project DESIGN UNIT A310 Date Drilled 2-14-81 Hole No. CEG 23A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
164	SM (ML)	152.4-198.2 SILTY SAND: continued			RD	
166						
168						
170			J-15	50	SS	.3/.3 recovery
					RD	12:30
172						
174						
176						
178						
			C-9	67	DR	0.3/0.5 recovery
			J-16	50	SS	.25/.25 recovery
180					RD	
182						
184						
		gravel zone				rig chattering
186						
188						

Sheet 8 of 10

Project DESIGN UNIT A310 Date Drilled 2-14-15-81 Hole No. CEG 23A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
188	CL	152.4-198.2 SILTY SAND: continued			RD	
190			J	50	SS	0.0/0.1 recovery
					RD	silty sand is very dense, making split spoon sampling difficul
192						
194						
196						
198						
	CL	198.2-199.2 SILTY CLAY: dark greenish gray; trace fine; very stiff; moist				flushed out hole, ran electric logs from 18:30-20:30 2/14/81
			J-17	100	SS	
	SM	199.2-216.0 SILTY SAND: dark greenish gray; very dense; moist			RD	7:30 2/15/81 0% combustible gas water level at 19.7' ran downhole seismic survey from 08:15-10:00
200						
202						
204						drilling with clear water rig chattering
206						
208						
210						
212						

Project DESIGN UNIT A310
Date Drilled 2-15-81
Hole No. CEG 23A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
212		199.2-216.0 <u>SILTY SAND</u>: continued			RD	
214						
					PB	2.5/2.5 recovery
216		216.0-217.5 SILTY CLAY lens; dark greenish gray; very stiff; moist				
						15:40 completed 2/15/81
218		B.H. 217.5' Terminated hole.				Set 2" diameter ABS casing from 0.0-217.5', perforated from 110-212.5', and 15.0-50.0 for gas analysis. Water sampled 2/20/81
220						
222						
224						
226						
228						
230						
232						
234						
236						

Sheet 10 of 10

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BORING LOG 23B

Proj: DESIGN UNIT A-275
Date Drilled 2/2/83
Ground Elev. 189.5'
Drill Rig B. Auger
Logged By D. Gillette
Total Depth 75.0'
Hole Diameter 36"
Hammer Weight & Fall N/A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0	AF	0.0-0.5 CONCRETE				Observation hole - no samples required
	CH	0.5-2.0 CLAY: grayish black				H_2S odor & gas bubbles coming through sidewalk joints
2		YOUNG ALLUVIUM				
	CL	2.0-8.0 SANDY CLAY: brownish black and bluish gray; stiff; moist				
4						
6						
8	SC CL	8.0-12.0 CLAYEY SAND/SANDY CLAY: light greenish gray; moist				groundwater at 8.5' after 21 hours
10						
12	CL	12.0-23.0 SANDY CLAY: greenish gray and dark greenish gray; stiff; moist				
14						
16						
18						
20						

Sheet 1 of 4

Project DESIGN UNIT A-275 **Date Drilled** 2/2/83 **Hole No.** 23B

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	CL	12.0-23.0 SANDY CLAY: (continued)				
22						
	SC	23.0-33.0 CLAYEY SAND: dark greenish gray; moist				
24						
26						
28						strong H_2S odor
30						
32						water seep at 32' from northwest side of hole 20.5 gpm (approx.)
	CH	OLD ALLUVIUM 33.0-44.0 CLAY: dark greenish gray; stiff; moist to wet				
34						
36						
38						
40						40.0-75.0 petroleum in formation
42						
44						

Sheet 2 **of** 4

Project DESIGN UNIT A-275 **Date Drilled** 2/2/83 **Hole No.** 23B

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	SC	44.0-52.0 CLAYEY SAND: dark greenish gray; stiff				
46						strong H_2S odor
48						
50						
52	SC/SP	52.0-60.5 CLAYEY SAND/SAND: greenish black and light greenish gray; medium to coarse sand; dense; wet				52.0-62.5 water seeps - 18 gpm (approx.) water rises to 50', 45 min. after drilling to 70'
54						
56						
58						
60						
	CL	60.5-65.0 SANDY CLAY: greenish black; stiff				
62						
64						
	CH	65.0-75.0 CLAY: greenish black; very stiff; slightly moist				harder drilling
66						
68						

Sheet 3 **of** 4

Project DESIGN UNIT A-275 Date Drilled 2/2/83 Hole No. 23B

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	CH	65.0-75.0 CLAY: (continued)				strong H_2S odor
70						
72						
74						
		B.H. 75.0' Terminated hole Special Hole Closure 1. Pea gravel placed from 1' to 50' (hole had caved from 70' to 50' overnight) to act as oil collection sump. 2. Replace concrete on eastside of Fairfax (sidewalk) per LA City Inspector specifications.				Notes: 1. Water at 50' depth by 11:00 AM 2/2/83 2. Water at 8.5' depth by 7:00 AM 2/3/83 3. Water sample obtained 2/3/83 4. Because of shallow water no down hole inspection was conducted.
76						
78						
80						
82						
84						
86						
88						
90						
92						

Sheet 4 of 4

Converse Consultants, Inc.
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BORING LOG 23-1

Proj: DESIGN UNIT A-275
Date Drilled 11/6-7/83
Ground Elev. 189'
Drill Rig Failing 750
Logged By S. Slaff
Total Depth 76.5'
Hole Diameter 4 7/8"
Hammer Weight & Fall SS: 140 lbs @ 30", DR: 320 lbs @ 18

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.3 ASPHALT			(GB)	Drilled 0.0-2.1' with 7" garbage barrel. 6" flight auger from 2.1-5.8'.
	CL	FILL 0.3-2.1 SANDY CLAY with RUBBLE: yellowish brown to brownish black; stiff; dry to moist				
2					AD	(GB): garbage barrel
	CL	YOUNG ALLUVIUM 2.1-4.3 SILTY CLAY: mottled, brownish black and light olive gray; trace of sand; stiff; moist	C-1	7 15	DR	0.9/1.0 recovery
4	CL	4.3-19.4 SILTY CLAY: greenish gray; trace of sand; very stiff; moist			AD	
			J-1	6 8 10	SS	1.5/1.5 recovery
6					RD	drilled on with 4 7/8" drag bit
8		becoming dark greenish gray; petroleum odor	S-1		PB	groundwater level11/7/83 ▽ 2.5/2.5 recovery
10			J-2	4 6 6	SS	1.5/1.5 recovery
12					RD	
		becoming mottled, dusky green and pale green	C-2	7 10	DR	1.0/1.0 recovery
14					RD	
		mottling decreasing - color is predominately dusky green	J-3	6 9 12	SS	1.5/1.5 recovery
16					RD	
18		becoming more sandy	C-3	10 15	DR	1.0/1.0 recovery
20	CL	19.4-30.0 SANDY CLAY: grayish green;			RD	

Project DESIGN UNIT A-275 **Date Drilled** 11/6-7/83 **Hole No.** 23-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	CL	19.4-30.0 <u>SANDY CLAY</u>: (continued) very stiff; sulfurous odor; moist	J-4	6 11 11	SS	1.3/1.5 recovery
22					RD	
				7	DR	1.0/1.0 recovery
			C-4	12		
24		becoming silty, sand content increasing with depth			RD	slight rig chatter
			J-5	4 6 9	SS	1.5/1.5 recovery
26					RD	
28			S-2		PB	2.4/2.5 recovery
30	SM	30.0-32.6 <u>SILTY SAND</u>: grayish green; medium dense; sulfurous odor; wet	J-6	8 10 13	SS	1.5/1.5 recovery
32					RD	
	ML	<u>OLD ALLUVIUM</u> 32.6-57.0 <u>SANDY SILT</u>: grayish green; very stiff; micaceous; moist		8	DR	1.0/1.0 recovery
			C-5	18		
34					RD	
			J-7	4 10 14	SS	1.5/1.5 recovery
36					RD	
38		becoming clayey		18	DR	1.0/1.0 recovery
		thin gravel lens	C-6	31		rig chatter
					RD	
40			J-8	16 24 33	SS	1.5/1.5 recovery
42					RD	
		color change to dusky blue green		19	DR	1.0/1.0 recovery
44		clayey at top of sample	C-7	32		

Sheet 2 of 4

Project DESIGN UNIT A-275 **Date Drilled** 11/6-7/83 **Hole No.** 23-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	ML	32.6-57.0 SANDY SILT: (continued) dusky green			RD	1.5/1.5 recovery
			J-9	6 9 15	SS	
46						11/6/83
					RD	11/7/83
48			S-3		PB	2.5/2.5 recovery
50	(SM)	50.6-51.0 silty sand lens				
	(SM)	51.2-51.6 silty sand lens	J-10	10 20 25	SS	1.0/1.5 recovery
52					RD	
			C-8	13 25	DR	1.0/1.0 recovery
54		dark greenish gray			RD	
			J-11	6 9 14	SS	1.5/1.5 recovery
56					RD	
	SM	57.0-60.2 SILTY SAND: grayish green; dense; occasional fine gravel; wet				
58		becoming clayey	C-9	23 30	DR	1.0/1.0 recovery
					RD	
60	ML/SM	60.2-67.5 SANDY SILT/SILTY SAND: dusky green; hard/dense; wet	J-12	12 22 26	SS	1.0/1.5 recovery
62					RD	
	(SM)	63.0-63.8 silty sand lens	C-10	16 17	DR	1.0/1.0 recovery
64		becoming clayey			RD	
		dark greenish gray	J-13	12 23 25	SS	1.5/1.5 recovery
66						
		top of petroleum-bearing zone			RD	
68	CL	67.5-76.5 SANDY CLAY: greenish black;				

Sheet 3 of 4

Project DESIGN UNIT A-275 **Date Drilled** 11/6-7/83 **Hole No.** 23-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	CL	67.5-76.5 SANDY CLAY: (continued) hard; contains petroleum streaks; moist	S-4		PB	2.5/2.5 recovery
70						
		grayish green	J-14	11 19 24	SS	1.5/1.5 recovery
72					RD	
			C-11	14 28	DR	1.0/1.0 recovery
74					RD	
76			J-15	13 35 50	SS	1.3/1.5 recovery 11/7/83
		B.H. 76.5' Terminated hole				Cleaned and conditioned hole. Tremmied in 5 sack cement grout. Cleaned site. Covered with steel street cover.
78						
80						
82						
84						
86						
88						
90						
92						

Sheet 4 of 5

THIS BORING LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.

Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG 23-2

Proj: DESIGN UNIT A275
Date Drilled 11/5-6/83
Ground Elev. 187'
Drill Rig Failing 750
Logged By S. Slaff
Total Depth 75.9
Hole Diameter 4 7/8"
Hammer Weight & Fall 140 lb. 30" SS., 320 lbs. 18" DR

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.4 APSHALT			GB	Drilled 0.0'-0.6' with 7" garbage barre
	SC	FILL			AD	
	CL	0.4-2.0 CLAYEY SAND/SANDY CLAY: moderate to dark yellowish brown; medium dense to stiff; dry to moist				
2				5	DR	0.8/1.0 recovery
	CH	YOUNG ALLUVIUM 2.0-5.8 SILTY CLAY: grayish black; with sand and fine gravel; very stiff; moist	C-1	9		
					AD	
4			J-1	4 5 7	SS	1.1/1.5 recovery
					AD	
6	CL	5.8-8.4 SILTY CLAY: grayish green; stiff moist				
		becoming sandy	C-2	4 7	DR	1.0/1.0 recovery ▼ ground water entry at 11.0; rose to 8.0 within 5 min.
8					AD	
	CL	8.4-9.6 SANDY CLAY: moderate yellowish brown; soft; moist	J-2	1 2 5	SS	1.4/1.5 recovery
10	SM	9.6-16.5 SILTY SAND: grayish green; wet below 11'; medium dense; micaceous				
					AD	
12		12.7 weak sulfurous odor	C-3	11 19	DR	5" steel surface casing from 0.0-12.2' 1.0/1.0 recovery
					RD	13.0 drilling on with 4 7/8" drag bit
14			J-3	8 12 12	SS	1.3/1.5 recovery
					RD	
16	CL	16.5-28.6 SANDY CLAY: dark greenish gray; very stiff; weak sulfurous odor				
18			S-1		PB	2.5/2.5 recovery
20			J-4	8	SS	

Sheet 1 of 4

Project DESIGN UNIT A275 **Date Drilled** 11-5-6-83 **Hole No.** 23-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	CL	16.5-28.6 SANDY CLAY: continued	J-4	14 21	SS	1.5/1.5 recovery
		increasing sand with depth			RD	
22		becoming silty	C-4	16 26	DR	1.0/1.0 recovery
					RD	
24			J-5	9 24 23	SS	0.7/1.5 recovery
26					RD	
			C-5	9 14	DR	1.0/1.0 recovery
28					RD	
	SM	28.6-31.4 SILTY SAND: grayish green; medium dense; occasional thin gravel lenses; wet	J-6	9 14 11	SS	1.5/1.5 recovery
30					RD	
	ML	31.4-35.8 SANDY SILT: grayish green; occasional gravel; very stiff; wet				
32			C-6	11 22	DR	1.0/1.0 recovery
					RD	
34			J-7	7 13 16	SS	1.5/1.5 recovery
36	SM/ GM	35.8-38.0 SILTY SAND/GRAVELLY SAND: grayish green			RD	slight rig chatter
			S-2		PB	2.0/2.5 recovery
38	ML	OLD ALLUVIUM 38.0-56.6 SANDY SILT: grayish green; very stiff; occasional gravel; wet				
40			J-8	10 11 16	SS	1.2/1.5 recovery
					RD	slight rig chatter
42			C-7	14 29	DR	1.0/1.0 recovery
					RD	
44						

Sheet 2 of 4

Project DESIGN UNIT A275 Date Drilled 11-5-6-83 Hole No. 23-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	ML	38.0-56.6 SANDY SILT: continued	J-9	9 16 23	SS	1.5/1.5 recovery
		weak sulfurous odor				
46					RD	
				21	DR	1.0/1.0 recovery
		zone of coarser sand with clay	C-8	30		
48					RD	
		49.0-50.6 silty sand lens	lost	5 9 11	SS	0.0/1.5 recovery
	SM					
50						
					RD	
	ML					
52				10	DR	1.0/1.0 recovery
		becoming clayey	C-9	16		
					RD	
54			J-10	6 10 15	SS	1.3/1.5 recovery
					RD	
56						
	SM	56.6-59.6 SILTY SAND: grayish green; occasional gravel; medium dense; wet	S-3		PB	2.5/2.5 recovery
58						
			J-11	8 10 14	SS	1.5/1.5 recovery
60	CL	59.6-62.3 SANDY CLAY: grayish green; very stiff; moist				11/5/83
					RD	11/6/83
		top of petroleum-bearing zone				
62				18	DR	
	SM	62.3-66.8 SILTY SAND: mottled-olive black and dark greenish gray; low petroleum content; dense; micaceous; moist	C-10	40		
					RD	0.9/1.0 recovery
64			J-12	10 17 22	SS	1.2/1.5 recovery
					RD	
66						
				20	DR	0.9/1.0 recovery
	CL	66.8-75.9 SANDY CLAY: dark yellowish brown; low petroleum content;	C-11	33		
68						

Project DESIGN UNIT A275 **Date Drilled** 11-5-6-83 **Hole No.** 23-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	CL	66.8-75.9 SANDY CLAY: very stiff; becoming hard; moist			RD	
			J-13	7 12 18	SS	0.4/1.5 recovery
70		becoming mottled - moderate yellowish brown, dark yellowish brown, greenish gray; very dusky red			RD	
72			C-12	26 50	DR	0.8/0.8 recovery refusal at 9-1/2"
					RD	slight rig chatter
74		becoming more sandy				
			J-14	28 50	SS	0.9/0.9 recovery refusal at 11"
76		B.O.H. 75.9 ft Terminated hole				11/6/83 Cleaned and conditioned hole. Tremied 5 sack cement grout into hole; Cleaned site. Placed steel cover over hole. 11/16/83 Removed steel hole cover. Cappped hole with concrete.
78						
80						
82						
84						
86						
88						
90						
92						

THIS BORING LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.

Converse Consultants, Inc.
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BORING LOG 23-3

Proj: DESIGN UNIT A-275 **Date Drilled** 11/4/83 **Ground Elev.** 184.5'

Drill Rig Failing 750 **Logged By** S. Slaff **Total Depth** 75.8'

Hole Diameter 4 7/8" **Hammer Weight & Fall** SS: 140 lbs @ 30", DR: 320 lbs @ 18

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.4 ASPHALT			GB	Drilled 0.0-0.7' with 7" garbage barrel.
		FILL				
		YOUNG ALLUVIUM			AD	Drilled 0.7-6.5' with 6" flight auger.
	CH	0.6-2.6 SILTY CLAY: dusky yellowish brown; trace of sand; stiff; petroleum odor; moist				
2						
	CL	2.6-4.8 SANDY CLAY: dark yellowish brown; very stiff; petroleum odor		8	DR	1.0/1.0 recovery
			C-1	15		
4		3.5' color change to pale yellowish brown			AD	
	CL	4.8-8.8 SANDY CLAY: moderate yellowish brown; trace of gravel; stiff; moist	J-1	4 5 6	SS	1.5/1.5 recovery set 5" steel surface casing from 0.0-6.2', drilling on with 4 7/8" drag bit
6					RD	
8				3	DR	1.0/1.0 recovery
			C-2	5		
	CL SC	8.8-9.8 SANDY CLAY/CLAYEY SAND: light olive gray; trace of gravel; loose; wet			RD	
10	CL SC	9.8-12.6 SANDY CLAY/CLAYEY SAND: dark greenish gray; stiff; medium dense; wet	J-2	4 4 2	SS	1.3/1.5 recovery rig chatter
12		11.0-12.2 gravel lens			RD	
	SM	12.6-29.2 SILTY SAND: dark greenish gray; medium dense; faint petroleum odor; occasional gravel; wet		9	DR	1.0/1.0 recovery
14			C-3	18		
					RD	
			J-3	9 14 14	SS	1.0/1.5 recovery
16		16.6' thin gravel lens			RD	rig chatter
18				12	DR	1.0/1.0 recovery
			C-4	15		
20					RD	

Sheet 1 of 4

Project DESIGN UNIT A-275 **Date Drilled** 11/4/83 **Hole No.** 23-3

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	SM	12.6-29.2 <u>SILTY SAND</u>: (continued)	J-4	10 12 16	SS	0.9/1.5 recovery
22					RD	
24			S-1		PB	1.9/2.5 recovery lost bottom 0.6' due to zone of softer material
26		27.2' small gravel lens	J-5	19 18 11	SS	1.3/1.5 recovery
					RD	rig chatter
28			C-5	7 28	DR	1.0/1.0 recovery
		OLD ALLUVIUM			RD	29.5' drilling harder
30	ML	29.2-46.0 <u>SANDY SILT</u>: grayish green; hard; faint sulfurous odor; wet	J-6	7 14 19	SS	1.5/1.5 recovery
32					RD	
	(GM)	33.3-34.4' sand & gravel lens	C-6	22 32	DR	1.0/1.0 recovery
34					RD	
36			J-7	8 16 22	SS	1.5/1.5 recovery
					RD	
38			C-7	17 27	DR	1.0/1.0 recovery
					RD	
40			J-8	9 22 30	SS	1.5/1.5 recovery
42					RD	
44			PB-2		PB	

Sheet 2 **of** 4

Project DESIGN UNIT A-275 **Date Drilled** 11/4/83 **Hole No.** 23-3

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	ML	29.2-46.0 SANDY SILT: (continued)	S-2		PB	2.0/2.5 recovery
46	SM	46.0-49.6 SILTY SAND: grayish green; dense; occasional fine to coarse gravel; wet	J-9	9 13 25	SS	0.9/1.5 recovery
					RD	
48		top of petroleum-bearing zone	C-8	16 19	DR	0.9/1.0 recovery
					RD	
50	SM	49.6-52.0 SILTY SAND: dusky green; petroleum streaks; very dense; wet	J-10	12 24 28	SS	0.8/1.5 recovery
					RD	
52	CL	52.0-75.8 SILTY CLAY: mottled- olive black, light olive gray, and pale green; some sand lens; low petroleum content; hard; wet	C-9	22 38	DR	1.0/1.0 recovery
54					RD	
56			J-11	11 19 18	SS	0.2/1.5 recovery
		color change to dusky brown			RD	
58		becoming more sandy and silty	C-10	37 50	DR	0.8/1.0 recovery
					RD	
60			J-12	16 36 47	SS	1.0/1.5 recovery
62					RD	
64			S-3		PB	2.5/2.5 recovery
66			J-13	37 50	SS	0.9/0.9 recovery refusal at 11"
68					RD	petroleum froth floating on mud tub

Project DESIGN UNIT A-275 Date Drilled 11/4/83 Hole No. 23-3

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	CL	52.0-75.8 <u>SILTY CLAY:</u> (continued) occasional fine gravel	C-11	55 50	DR	0.75/0.75 recovery
					RD	
70						
			J-14	66	SS	0.5/0.5 recovery
					RD	
72		color also mottled with grayish green				
			C-12	100	DR	0.5/0.5 recovery
74					RD	
			J-15	36 50	SS	0.8/0.8 recovery
76		B.H. 75.8' Terminated hole				
						Tremmied 4 sack cement grout into hole. Covered hole with steel cover.
78						11/8/83 removed steel cover, capped hole with concrete.
80						
82						
84						
86						
88						
90						
92						

Sheet 4 of 4

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BORING LOG 23-4

Proj: DESIGN UNIT A275
Date Drilled 11/3/83
Ground Elev. 183.2
Drill Rig Failing 750
Logged By S. Slaff
Total Depth 76.3'
Hole Diameter 4 7/8"
Hammer Weight & Fall 320 lbs, 18" DR, 140 lbs, 30" SS

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.25 ASPAHLT			GB	Drilled 0.0-0.5 with 7" garbage barrel.
	SC	FILL			AD	Drilled 0.5-3.0 with 6" auger.
	OH	YOUNG ALLUVIUM 0.8-1.8 SILTY CLAY: grayish black; trace of sand; stiff; strong petroluem odor				
2	CH	1.8-3.8 SANDY CLAY: mottled - grayish brown, dusky brown, grayish olive green; very stiff; occasional fine gravel; moist; strong petroleum odor	C-1	14 16	DR	1.0/1.0 reocvery
4	CL	3.8-6.6 SANDY CLAY: dusky yellowish brown; stiff; moist	J-1	3 6 6	SS	1.0/1.5 recovery
6					AD	set 5" steel surface casing from 0.0-6.2'. Drilling on with 4 7/8" drag bit.
	CL	6.6-11.0 SANDY CLAY: light olive gray; stiff; moist	C-2	4 8	DR	1.0/1.0 recovery
8					RD	
			J-2	2 3 3	SS	1.4/1.5 recovery
10	GC				RD	
	CL/SC	11.0-34.0 SANDY CLAY/CLAYEY SAND: grayish green; dense; occasional fine to coarse gravel; wet				
12			S-1		PB	2.5/2.5 recovery
14	SC CL/SC		J-3	5 6 9	SS	0.6/1.5 recovery
16					RD	
18			lost	12 23	DR	0.0/1.0 recovery lost sample, rig chatte
	GC	19.2-20.0 gravel lens			RD	
20						

Sheet 1 of 4

Project DESIGN UNIT A275 **Date Drilled** 11/3/83 **Hole No.** 23-4

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	CL/SC	11.0-34.0 SANDY CLAY/CLAYEY SAND: cont.	J-4	6 18 15	SS	0.5/1.0 recovery
	SP	20.2-22.0 silty sand lens				
					RD	
22	CL/SC					
				4	DR	0.0/1.0 recovery
			lost	15		
24					RD	
			J-5	7 13 18	SS	1.5/1.5 recovery
26						
		color change to dusky green			RD	
28				17	DR	1.0/1.0 recovery
		becoming silty	C-3	28		
					RD	
30			J-6	5 7 12	SS	1.5/1.5 recovery
32						
			S-2		PB	2.5/2.5 recovery tube damaged by grave
34	SP	OLD ALLUVIUM 34.0-38.2 CLAYEY SAND: dusky green; very dense; wet				
36		36.0- weak sulfurous odor	J-7	12 24 33	SS	1.5/1.5 recovery
					RD	rig chatter
38	CL/SC	38.2-49.2 SANDY CLAY/CLAYEY SAND: mottled-dusky green; hard; dense; wet		20	DR	1.0/1.0 recovery
			C-4	38		
					RD	
40						
			J-8	11 20 22	SS	1.3/1.5 recovery
42					RD	
44				15	DR	

Project DESIGN UNIT A275 **Date Drilled** 11-3-83 **Hole No.** 23-4

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	CL/ SC	38.2-49.2 SANDY CLAY/CLAYEY SAND: cont.	C-5	30	DR	1.0/1.0 recovery
					RD	
46			J-9	7 15 19	SS	1.5/1.5 recovery
					RD	
48		48.0- Top of tar-bearing zone; becoming sandy	C-6	43 50	DR	0.9/0.9 recovery
	SC	49.2-50.0 TAR SAND: very dusky red; some fines; low petroleum content; dense; moist			RD	
50	CL	50.0-54.0 SANDY CLAY: mottled - grayish green with blackish red, very dusky red; grayish brown and dusky brown; hard; with petroleum; moist	J-10	10 16 22	SS	1.5/1.5 recovery
52					RD	
54	CL	54.0-63.8 SILTY CLAY: dark greenish gray; trace of fine sand and gravel; low petroleum content; hard; moist	S-3		PB	1.9/2.5 recovery
56			J-11	11 23 30	SS	1.5/1.5 recovery
58					RD	slow drilling zone 57.0-59.0
			C-7	21 43	DR	1.0/1.0 recovery
60					RD	
			J-12	8 20 30	SS	1.5/1.5 recovery petroleum froth forming on top of mud tub
62					RD	
64	CL	63.8-76.3 SILTY CLAY: light olive gray; trace of sand and petroleum; trace of gravel; hard; moist	C-8	55 50	DR	0.8/0.8 recovery refusal at 10"
					RD	
66		66.0- olive black	J-13	23 50	SS	1.0/1.0 recovery refusal at 11-1/2"
					RD	
68						

Sheet 3 **of** 4

Project DESIGN UNIT A275 **Date Drilled** 11-3-83 **Hole No.** 23-4

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	CL	63.8-76.3 SILTY CLAY: continued			RD	
			C-9	65	DR	0.5/0.5 recovery
70					RD	
					PB	2.5/2.5 recovery
72		strong petroleum odor	PB-4			tube damaged by gravel
74					RD	
			J-14	20 35 50	SS	1.3/1.3 recovery refusal at 16" 11/3/83
76		B.O.H. 76.3' Terminated hole.				11/4/83 circulated and conditioned hole. Tremmied grout through drill pipe. Used 5 sacks cement. Covered hole with steel street cover. 11/9/83 removed steel hole cover. Capped with concrete.
78						
80						
82						
84						
86						
88						
90						
92						

Sheet 4 **of** 4

Converse Consultants, Inc.
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BORING LOG 23-5

Proj: DESIGN UNIT A275
Date Drilled 11/2/83
Ground Elev. 184'
Drill Rig Failing 750
Logged By S. Slaff
Total Depth 74.9'
Hole Diameter 4 7/8"
Hammer Weight & Fall 320 lbs. 18" DR, 140 lbs. 30" SS

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.2 ASPHALT			GB	Drilled 0.0-0.4' with 7" garbage barrel.
	GM	FILL: dark yellowish brown; sandy gravel, some fines; med. dense, dry to moist			AD	Drilled 0.4-3.0 with 6" auger.
2	CL	YOUNG ALLUVIUM 1.4-13.6 SANDY CLAY: dark yellowish brown; hard; moist				
				13	DR	1.0/1.0 recovery
			C-1	25		
4					AD	
		4.5-5.4 increasing sand content 4.5 moderate yellowish brown	J-1	10	SS	1.5/1.5 recovery
				17		
6				26		set 5" steel surface casing from 0.0-6.3'.
					AD	Drilling on with 4 7/8" drag bit.
8				16	DR	1.0/1.0 recovery
		becoming very sandy and very stiff	C-2	28		
					RD	
10			J-2	7	SS	1.5/1.5 recovery
		10.8-12.0 sandy zone		11		
				13		
12		12.0-12.5 gravelly zone; moderate yellowish brown to grayish orange			RD	rig chatter
				4	DR	1.0/1.0 recovery
14	SM	13.6-15.2 SILTY SAND: moderate yellowish brown; medium dense; moist	C-3	9		
					RD	
				3	SS	1.5/1.5 recovery
16	CH	15.2-19.4 SILTY CLAY: mottled - moderate yellowish brown to very pale orange; trace of sand; stiff; moist	J-3	5		
				8		
					RD	rig chatter
18		mottled with light brown; becoming hard; becoming sandier		18	DR	1.0/1.0 recovery
			C-4	32		
					RD	
20	CL	19.4-42.6 SANDY CLAY: greenish black				

Sheet 1 of 4

Project DESIGN UNIT A275 **Date Drilled** 11/2/83 **Hole No.** 23-5

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	CL	19.4-42.6 SANDY CLAY: continued hard; occasional fine gravel; moist	J-4	7 18 21	SS	1.5/1.5 recovery
22					RD	
		dark greenish gray; becoming less sandy	C-5	21 36	DR	1.0/1.0 recovery
24					RD	
	(SP)	25.5-26.4 silty sand lens	J-5	11 19 25	SS	1.2/1.5 recovery
26	CL				RD	
28			C-6	28 42	DR	1.0/1.0 recovery
	(SP)	28.9-29.5 silty sand lens			RD	
30	CL	becoming very stiff	J-6	8 15 14	SS	1.5/1.5 recovery
32					RD	
			C-7	26 40	DR	1.0/1.0 recovery
34					RD	
		weak sulfurous odor	J-7	11 13 16	SS	1.5/1.5 recovery
36					RD	
38			S-1		PB	2.5/2.5 recovery
40			J-8	7 9 13	SS	1.5/1.5 recovery
42					RD	
	SC	OLD ALLUVIUM 42.6-49.0 CLAYEY SAND: dark greenish gray;				
44						

Project DESIGN UNIT A275 **Date Drilled** 11/2/83 **Hole No.** 23-5

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	SC	42.6-49.0 CLAYEY SAND: (continued) medium dense; wet	C-8	26 48	DR	1.0/1.0 recovery
46					RD	
48			lost	9 14 16	SS	0.0/1.5 recovery lost sample probably since check ball did not seat.
	CL	49.0-51.4 SANDY CLAY: dark greenish gray; hard; wet			RD	
50			C-9	21 35	DR	1.0/1.0 recovery
					RD	
52	SC	51.4-54.0 CLAYEY SAND: dark greenish gray; very dense; wet	lost	12 22 28	SS	0.0/1.5 recovery
54	CL	54.0-66.3 SANDY CLAY: dark greenish gray; hard; interbedded thin clayey sand lenses; wet			RD	
56			PB-2		PB	2.5/2.5 recovery
58	(SP)	58.1-58.9 silty sand lens	J-9	16 43 46	SS	1.5/1.5 recovery
					RD	
60			C-10	33 60	DR	1.0/1.0 recovery
62					RD	
		mild sulfurous odor				
64			J-10	12 20 24	SS	1.5/1.5 recovery
					RD	
66		top of petroleum-bearing zone				
	CH	66.3-74.9 SILTY CLAY: dark greenish gray; trace of sand, gravel and petroleum; hard; moist;	C-11	22 50	DR	0.9/0.9 recovery refusal at 11"
68					RD	

Sheet 3 **of** 4

Project DESIGN UNIT A275 Date Drilled 11/2/83 Hole No. 23-5

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	CL	66.3-74.9 SILTY CLAY: continued strong petroleum odor	J-11	22 37 50	SS	1.4/1.4 recovery
70					RD	
72			S-3		PB	2.5/2.5 recovery
74			J-12	31 47 50	SS	1.4/1.4 recovery refusal at 17" 11/2/83
76		B.O.H. 74.9' Terminated hole.				Circulated fluid to condition hole. Tremmied in 2 sack cement grout through drill pipe 1' off bottom of hole. Cleaned site, covered hole with steel cover 11/5/83 Removed steel hole cover. Capped hole with concrete.
78						
80						
82						
84						
86						
88						
90						
92						

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BORING LOG 24

Proj: DESIGN UNIT A310 **Date Drilled** January 2, 1981 **Ground Elev.** 285'

Drill Rig FAILING 1500 **Logged By** Gallinatti **Total Depth** 202.5'

Hole Diameter 4 7/8" **Hammer Weight & Fall** DR: 325lb @ 18" SS: 140lb @ 30"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-1.0 CONCRETE			AD	Start drilling at 8:15
	CL	ALLUVIUM 1.0-8.0 CLAY: reddish brown; fine grained sand; moist; soft				Drill thru concrete auger to 5'; set 5' at 5' surface casing and begin rotary drilling
2						
4						
6						
8	ML	8.0-17.0 SANDY SILT: moderate brown fine to coarse sand; loose; moist				
10			J-1	4 4 5	SS	0.7/1.5 recovery pocket penetrometer 2 tsf in all pocket penetrometer measurements
12					RD	
14						
			J-2	3 4 7	SS	1.0/1.5 recovery
16						
	ML/SM	17.0-24.0 SANDY SILT-SILTY SAND: moderate brown fine to coarse angular sand; loose to medium dense; moist			RD	
18						
20						

Sheet 1 of 9

Project DESIGN UNIT A310 **Date Drilled** 1-2-81 **Hole No.** CEG 24

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	ML/	17.0-24.0 SANDY SILT/SILTY SAND: (continued)	C-1	26	DR	.7/1.0 recovery
			J-3	6 8 15	SS	1.3/1.5 recovery
22		grades clayey				
					RD	pocket penetrometer 2.75 tsf (broke apart) 2-9-81 1.5/1.5 recovery
24	CL	24.0-37.0 SANDY CLAY: moderate brown, fine medium sand; occasional scattered pea sized gravel; stiff to very stiff; moist				
			J-4	6 10 15	SS	
26					RD	
28						
30			J-5	4 5 9	SS	1.5/1.5 recovery
		grades more sand content				
32					RD	
34						
			J-6	6 10 14	SS	1.5/1.5 recovery
36						
	SM	37.0-44.0 SILTY SAND: light moderate brown angular sand; occasional scattered sub-angular gravel up to 2"; medium dense; moist			RD	
38						
40			C-2	66	DR	.6/1.0 recovery
			J-7	10 11 12	SS	.1/1.5 recovery
42						
44						

Sheet 2 of 9

Project DESIGN UNIT A310 **Date Drilled** 1-2-81 **Hole No.** CEG 24

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	CL	44.0-52.0 SANDY CLAY: moderate brown; fine to medium sand; stiff to very stiff; moist			RD	
			J-8	6 8 15	SS	
46		grades more sand			RD	1.5/1.5 recovery pocket penetrometer 2.5 tsf (broke apart) 2-9-81 Gas test 0% combustibles 20% oxygen
48						
50			J-9	4 5 8	SS	1.5/1.5 recovery
					RD	
52	SC	52.0-64.0 CLAYEY SAND: light moderate brown fine to coarse sand; medium dense; moist				
54						
			J-10	8 9 13	SS	1.5/1.5 recovery
56					RD	
58						
60		grades less fines and more fine-grained sand	C-3	24	DR	.6/1.0 recovery
				7 10 12	SS	0.0/1.5 recovery
62					RD	no recovery
64	CL	64.0-72.0 SANDY CLAY: dark moderate brown fine sand; stiff; moist				
			J-1	8 9 19	SS	1.5/1.5 recovery pocket penetrometer 2.75 tsf 2-9-81
66					RD	
68						

Sheet 3 of 9

Project DESIGN UNIT A310 Date Drilled 1-2-81 Hole No. CEG 24

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	CL	64.0-72.0 SANDY CLAY: (Continued)			RD	
70			J-12	13 39 55	SS	1.5/1.5 recovery pocket penetrometer 3.75 tsf 2-9-81
72	SC	72.0-84.0 CLAYEY SAND: moderate brown fine to coarse sand; dense; moist			RD	
74						
			J-13	9 18 20	SS	1.0/1.5 recovery
76		grades less clay				
					RD	
78						
80		grades very dense	C-4	55	DR	.4/1.0 recovery
			J-14	13 18 50	SS	1.5/1.5 recovery
82						
					RD	
84	SP	84.0-88.0 SAND: moderate brown; trace silt; fine to coarse sand; wet to saturated; medium dense				partially saturated w/ water
			J-15	21 19 17	SS	1.5/1.5 recovery
86						
					RD	
88	ML	88.0-93.0 CLAYEY SILT: moderate brown; medium dense; moist				
90			J-16	5 6 14	SS	1.5/1.5 recovery
					RD	
92						

Project DESIGN UNIT A310 **Date Drilled** 1-2-81 **Hole No.** CEG 24

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
92	ML	88.0-93.0 CLAYEY SILT: (continued)			RD	
	SM	93.0-108.0 SILTY SAND: moderate brown; fine to coarse sand; dense to very dense; moist				
94						
			J-17	19 37 41	SS	1.5/1.5 recovery
96						Gas test 0% combustibles 20% Oxygen
					RD	
98						
100			C-5	65	DR	0.8/1.4 recovery 1.0/1.5 recovery
			J-18	25 20 20	SS	
102		grades less Silt				
					RD	
104						
			J-19	23 36 50	SS	0.8/1.4 recovery
106						
					RD	106.4'-stop drilling 4:45 1-2-81 Start drilling 7:00 1-3-81
108	CL	108.0-124.0 SANDY CLAY: dark moderate brown; fine to medium grained sand; hard; moist				
110			J-20	15 19 28	SS	1.5/1.5 recovery pocket penetrometer 3.25 tsf (broke apart) 2-9-81
					RD	
112		grades more Sand				
114						
			J-21	19 27	SS	1.5/1.5 recovery
116						

Project DESIGN UNIT A310 **Date Drilled** 1-3-81 **Hole No.** CEG 24

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
116	CL	108.0-124.0 SANDY CLAY: (continued)	J-21	37	SS	
					RD	
118						
120			C-6	60	DR	1.0/1.0 recovery
			J-22	17 25 40	SS	1.5/1.5 recovery
122					RD	
124	SC	124.0-128.0 CLAYEY SAND: moderate brown fine to medium sand; occasional scattered gravel ; very dense; moist				
			J-23	24 41 41	SS	1.5/1.5 recovery
126					RD	
128	CL	128.0-138.0 SANDY CLAY: dark moderate brown; fine to medium sand; hard; moist				
130			J-24	13 17 23	SS	.5/1.5 recovery
132					RD	
134						
			J-25	17 25 40	SS	1.5/1.5 recovery pocket penetrometer 3.5 tsf (broke apart)
136					RD	
138	SC	138.0-149.0 CLAYEY SAND: dark moderate brown; very fine to fine sand; very dense; moist				
140						

Sheet 6 **of** 9

Project DESIGN UNIT A310 **Date Drilled** 1-3-81 **Hole No.** CEG 24

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
140	SC	138.0-149.0 CLAYEY SAND: (continued)	C-7	100	DR	1.0/1.0 recovery
			J-26	19 26 36	SS	1.5/1.5 recovery pocket penetrometer 2.75 tsf
142		grades coarse sand			RD	
144						
		sample:interbedded with varying amount of finds and sand	J-27	17 32 50	SS	1.4/1.4 recovery
146					RD	
148						
	ML	149.0-152.0 SANDY SILT: dark moderate brown fine grained sand; some clayey layers and occasional medium to coarse sand; very dense; moist				
150			J-28	16 22 32	SS	1.5/1.5 recovery
152					RD	
	SC	152.0-178.0 CLAYEY SAND: dark moderate brown; fine grained sand and angular medium sand; very dense; moist				
154						
			J-29	31 50	SS	1.0/1.0 recovery pocket penetrometer 1.5 tsf (broke apart) 2-9-81
156				RD		
158						
160			C-8	93	DR	
			J-30	24 26 35	SS	.9/1.0 recovery 1.0/1.5 recovery
162					RD	
164						

Sheet 7 of 9

Project DESIGN UNIT A310 **Date Drilled** 1-3-81 **Hole No.** CEG 24

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
164	SC	152.0-178.0 CLAYEY SAND: (continued)			AD	
				23 28 34	SS	No recovery 0.0/1.5 recovery 166.5' stop drilling at 4:45 1-3-81
166					RD	start drilling 7:00 1-4-81
168						
170			J-31	32 50	SS	.5/.8 recovery
					RD	
172						
174						
			J-32	39 50	SS	
176					RD	.9/.9 recovery
178	CL	178.0-184.0 SANDY CLAY: dark moderate brown; fine grained sand; hard; moist				
180			C-9	100	DR	0.8/0.9 recovery
			J-33	19 27 50	SS	1.5/1.5 recovery
182					RD	
184	SC	184.0-198.0 CLAYEY SAND: moderate brown; fine grained sand (content varies);occasional medium grained sand; very dense; moist				
			J-34	21 26 41	SS	1.5/1.5 recovery pocket penetrometer 2.75 tsf 2-9-81
186					RD	
188						

Sheet 8 **of** 9

Project DESIGN UNIT A310 Date Drilled 1-3-81 Hole No. CEG 24

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
188	SC	184.0-198.0 CLAYEY SAND: (continued)			RD	
190			J-35	20 33 50	SS	1.3/1.3 recovery pocket penetrometer 2.5 tsf (broke apart) 2-9-81
192					RD	193.5" intense rig chatter
194						
				24 20 39	SS	0.0/1.5 recovery No recovery
196						
					RD	
198	CL	198.0-202.5 SANDY CLAY: dark moderate brown; fine grained sand; hard; moist				
200			C-10	100	DR	1.0/1.0 recovery
			J-36	19 31 40	SS	1.5/1.5 recovery
202						
		B.H. 202.5 Terminated hole 1-5-81				Completed 1-5-81 ream hole to 7" down to 100'; install 4" casing to 100' and grouted and capped.
204						
206						
208						
210						
212						

Sheet 9 of 9

THIS BORING LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.

Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG 24A

Proj: DESIGN UNIT A-310
Date Drilled 10-13-83
Ground Elev. 280'
Drill Rig Bucket
Logged By J. Stellar
Total Depth 74.5'
Hole Diameter 32"
Hammer Weight & Fall

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0	AC	0.0-0.8 AC PAVEMENT and CONCRETE				Hole stands well 0' - 74.5'
	GP	0.8-2.0 BASE MATERIAL: mixed gravel and sand				
2	ML	ALLUVIUM 2.0-9.0 SILT: dark brown; trace clay; medium dense; moist				
4						
6						
8						
	ML	9.0-18.0 SANDY SILT: moderate brown; trace gravel to ½"; medium dense; moist				
10						
12						
14		grading sand				
16						
18						
	SM	18.0-25.0 SILTY SAND: moderate brown; trace gravel to 1"; medium dense; moist				
20						

Sheet 1 of 4

Project DESIGN UNIT A-310 **Date Drilled** 10-13-83 **Hole No.** 24A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	SM	18.0-25.0 SILTY SAND: (continued)				
22		with sandy silt interlayers				
24						
26	ML	25.0-32.0 SANDY SILT: moderate brown; trace gravel to ½"; medium dense; moist				
28						
30						
32	SM	32.0-38.0 SILTY SAND: moderate brown; medium dense; moist				
34						
36						
38	ML	38.0-74.5 SANDY SILT: moderate brown to reddish brown; trace clay; trace gravel to 1"; medium dense to dense; moist				
40						
42	(SP)	occasional coarse sand layers; clean to slightly silty; trace gravel to 1"				
44						

Sheet 2 of 4

Project DESIGN UNIT A-310 **Date Drilled** 10-13-83 **Hole No.** 24A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	ML	38.0-74.5 SANDY SILT: (continued)				
46						
48						
50	(SM)	occasional interlayers of silty coarse sand, gravelly silt and clayey silt				
52						
54		grades trace clayey silt				
56						
58						
60						
62						
64		very moist to wet; alternating layers of soft and firm material				perched water in gravelly layers @ 65-66', no flow from this zone; slight oozing from boring wall
66						
68						

Sheet 3 of 4

Project DESIGN UNIT A-310 **Date Drilled** 10/13/83 **Hole No.** 24A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	ML	38.0-74.5 <u>SANDY SILT</u>: (continued) grade with gravel rich layers; gravel to ½"				
70		gravel layers become wet (perched)				±0.5 gpm form perched zone @ 70'-72'
72						
74						*bag sample 74.5'
		B.H. 74.5' terminated hole				completed hole 10/13; no caving; no gas detected; casing set to 60' Downhole Observers: J. Stellar & H. Aubel
76						
78						
80						
82						
84						
86						
88						
90						
92						

Sheet 4 of 4

THIS BORING LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.

BORING LOG 24-1

Proj: DESIGN UNIT A-310
Date Drilled 10-12-13-83
Ground Elev. 298'
Drill Rig Failing 1500
Logged By L. Schoeberlein
Total Depth 115.0'
Hole Diameter 4 7/8"
Hammer Weight & Fall SS: 140lb @30" DR: 320lb @ 18"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0	AC	0.0-0.4 ASPHALT			GB	Start drilling 8:30
	GP	0.4-1.0 BASEROCK				
	ML	ALLUVIUM 1.0-10.0 CLAYEY SILT: moderate brown; loose; moist				
2				3	DR	0.4/1.0 recovery
			C-1	5		
					AD	
4						
6			PB-1		PB	set up tub and cased to~5.5', mixed mud pocket pen 1.0 tsf 2.5/2.5 recovery
		occasional sand				
8			J-1		SS	pushed 1st 9" 1.0/1.5 recovery
				1		
				4		
10					RD	
	CL	10.0-15.0 SANDY CLAY: moderate brown; fine to medium sand; firm; moist				
12				4	DR	pocket pen 1.75 tsf 0.5/1.0 recovery
			C-2	5		
					RD	
14						cased to 13.5'
	SC	15.0-24.0 CLAYEY SAND: moderate brown; clay content varies; occasional gravelly zones; loose to medium dense; saturated;				
16					PB	washed out no resistance while cutting 0.0/2.5 recovery
18					RD	
			PB-2		PB	1.8/2.5 recovery
20						

Project DESIGN UNIT A-310 **Date Drilled** 10-12-13-83 **Hole No.** 24-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	SC	15.0-24.0 CLAYEY SAND: (continued)			PB	1.0/1.5 recovery
			J-2	4	SS	
				5		
22				8		
					RD	
24	SM	24.0-34.0 SILTY SAND: moderate brown; fine to medium sand; medium dense; saturated				
26			PB-3		PB	1.5/2.3 recovery
28				11	SS	
	(SC)	occasional clayey sand lenses	J-3	12		1.1/1.5 recovery
				14		
					RD	
30						
32	(CL)	6" sandy clay lense		13	DR	0.9/1.0 recovery
			C-3	23		
					RD	
34	CL	34.0-54.5 SANDY CLAY: moderate brown; fine to medium sand; very stiff; wet				
36			PB-4		PB	1.9/2.5 recovery
38			J-4	4	SS	1.2/1.5 recovery
				8		
				11		
					RD	
40		grades more clayey				
42				12	DR	1.0/1.0 recovery
			C-4	19		
					RD	
44						

Sheet 2 of 5

Project DESIGN UNIT A-310 Date Drilled 10-12-13-83 Hole No. 24-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	CL	34.0-54.5 SANDY CLAY: (continued)			RD	
46			PB-5		PB	0.7/2.5 recovery
	(SC) (SM)	clayey sand and silty sand lenses to 6" thick				disturbed?
48			J-5	6 13 24	SS	1.0/1.5 recovery
50					RD	
		grades less sandy				
52			PB-6		PB	2.4/2.5 recovery pocket pen 1.5 tsf
54					RD	
	ML/ SC	54.5-61.0 CLAYEY SILT/CLAYEY SAND: moderate brown; interbedded; stiff to medium dense; moist to wet				
56			PB-7		PB	2.5/2.5 recovery
58			J-6	7 7 9	SS	1.5/1.5 recovery
60					RD	
	CL	61.0-81.0 SANDY CLAY: moderate brown; fine sand; stiff; moist				
62			C-5	10 19	DR	1.0/1.0 recovery
					RD	
64						
66		grades more sandy	PB-8		PB	2.5/2.5 recovery
68						

Sheet 3 of 5

Project DESIGN UNIT A-310 **Date Drilled** 10-12-13-83 **Hole No.** 24-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	CL	61.0-81.0 SANDY CLAY: (continued)	J-7	8 11 18	SS	1.5/1.5 recovery broke rope pulling spoon. 2:00 10/12/83 7:00 10/13/83
70					RD	
		grades less sandy, occasional gravel				
72			C-6	19 48	DR	1.0/1.0 recovery pocket pen > 4.5 tsf
					RD	
74						
76		grades less clay	PB-9		PB	2.5/2.5 recovery
78			J-8	7 14 22	SS	pocket pen 2.0 tsf 1.5/1.5 recovery
80					RD	
82	SM/SP	81.0-91.0 SILTY SAND/SAND: moderate brown; interbedded; fine to medium sand; very dense; moist to wet	C-7	28 55	DR	1.0/1.0 recovery
					RD	
84						
86			PB-10		PB	2.1/2.5 recovery
88			J-9	29 35 45	SS	
90					RD	
92	SC/CL	91.0-115.0 CLAYEY SAND/SANDY CLAY; moderate brown;				

Sheet 4 of 5

Project DESIGN UNIT A-310 **Date Drilled** 10-12-13-83 **Hole No.** 24-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
92				29	DR	1.0/1.0 recovery
	SC/CL	91.0-115.0 CLAYEY SAND/SANDY CLAY: (cont) fine to coarse sand; interbedded zones of sand; dense; moist	C-8	30		
					RD	
94						
96			PB-11		PB	2.4/2.5 recovery
98	(SP)	coarse sand lens 2"	J-10	13 19 30	SS	1.0/1.5 recovery
100					RD	
102				29	DR	1.0/1.0 recovery
			C-9	30		
104					RD	
		probable gravel lens				rig chatter
106			PB-12		PB	1.7/2.1 recovery short sample - gravels rig chatter
108			J-11	15 21 26	SS	1.1/1.5 recovery
					RD	
110						
112		grades more clayey				
			PB-13		PB	2.1/2.5 recovery
114						
116		B.H. 115.0' Terminated hole; installed piezometer to bottom, 75-115' perforated				Sheet 5 of 5

Converse Consultants, Inc.
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BORING LOG 24-2

Proj: DESIGN UNIT A-310
Date Drilled 10/19-20/83
Ground Elev. 291'
Drill Rig Failing 1500
Logged By L. Schoeberlein
Total Depth 115.0'
Hole Diameter 4 7/8"
Hammer Weight & Fall DR: 320 lb @ 18", SS: 140 lb @ 30"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0	AC	0.0-0.4 ASPHALT			GB	start drilling 11:30
	GP	0.4-1.5 ROAD BASE			AD	
2		ALLUVIUM				
	CL	1.5-3.5 SILTY CLAY: greyish brown; stiff; moist	C-1	8 14	DR	0.5/1.0 recovery
					AD	
4	ML	3.5-8.5 CLAYEY SILT: moderate brown; stiff; moist				
6			SH-1		SH	
		grades to sandy clay, then to clayey sand				2.5/2.5 recovery
8						
	SC	8.5-18.5 CLAYEY SAND: moderate brown; fine to medium sand; loose; dry to moist	J-1	2 3 5	SS	0.8/1.5 recovery
10					AD	
12			C-2	4 7	DR	1.0/1.0 recovery
14					RD	set tub and cased to ~13', mixed mud
	(SM)	silty sand lens 6"				
16			PB-1		PB	2.1/2.5 recovery
18						
	CL	18.5-20.0 SILTY CLAY: moderate brown; firm; moist	J-2	2 3 4	SS	1.0/1.0 recovery
20	(SM)	silty sand lens 6"			RD	

Sheet 1 of 5

Project DESIGN UNIT A-310 **Date Drilled** 10/19-20/83 **Hole No.** 24-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	SC	20.0-29.0 <u>CLAYEY SAND</u>: moderate brown; fine to coarse sand; some gravel medium dense; moist			RD	
22			C-3	16 27	DR	0.8/1.0 recovery
24					RD	
26			PB-2		PB	2.3/2.5 recovery
28	(SM)	silty sand lens	J-3	15 11 12	SS	0.9/1.5 recovery
	CL	29.0-51.0 <u>SANDY CLAY</u>: moderate brown; contains thin clayey sand lenses; moist; stiff				
30					RD	
	(SC)					
32			C-4	14 25	DR	0.9-1.0 recovery
34					RD	mixed mud
36			PB-3		PB	2.5/2.5 recovery
38		sand content varies, becomes hard	J-4	10 20 25	SS	1.2/1.5 recovery
40					RD	
42	(SM)	silty sand lens~1'				
	(CL)		C-5	32 25	DR	0.9/1.0 recovery
44					RD	

Sheet 2 **of** 5

Project DESIGN UNIT A-310 **Date Drilled** 10/19-20/83 **Hole No.** 24-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	CL	29.0-51.0 SANDY CLAY: (continued)			RD	
46			PB-4		PB	2.7/2.7 recovery pocket pen 2.25 tsf
48		sand content varies; grades to clayey sand/sandy clay				
			J-5	6 10 18	SS	1.2/1.5 recovery
50					RD	
	SP	51.0-64.5 SAND: moderate brown; interbedded fine sand with fine to medium sand; trace silt; dense; moist;				
52			C-6	30 29	DR	0.9/1.0 recovery
54		numerous interbeds of sandy clay, silty sand, and sandy silt			RD	
	(CL)	grades to sandy clay				
56			PB-5		PB	2.5/2.5 recovery
	(SM)	grades to silty sand				
58			J-6	10 11 16	SS	1.0/1.5 recovery
	(CL)	grades to sandy clay; very stiff				
60					RD	
62	(ML)	grades to sandy silt; dense	C-7	21 34	DR	0.9/1.0 recovery
					RD	
64						
	CL	64.5-74.5 SANDY CLAY: moderate brown; fine to medium sand; hard; moist				
66			PB-6		PB	2.5/2.5 recovery
68						

Sheet 3 of 5

Project DESIGN UNIT A-310 **Date Drilled** 10/19-20/83 **Hole No.** 24-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	CL	64.5-74.5 <u>SANDY CLAY</u>: (continued)	J-7	13 28 36	SS	1.5/1.5 recovery
70					RD	
72		grades to clayey sand; fine to coarse sand; dense to very dense; moist to wet	C-8	30 36	DR	0.9/1.0 recovery 5:00pm 10/19/83 7:00am 10/20/83
					RD	
74						
	SM	74.5-88.5 <u>SILTY SAND</u>: moderate brown; fine to medium sand; interbedded with fine poorly graded sand lenses; very dense; wet				
76			PB-7		PB	2.4/2.5 recovery
	(SP)					
78			J-8	23 48 50-5"	SS	1.0/1.4 recovery
					RD	
80						
82			C-9	55 50-5"	DR	0.8/1.0 recovery
					RD	
84						
86			PB-8		PB	
		grades more fines				2.0/2.5 recovery
88						
	CL	88.5-91.5 <u>SANDY CLAY</u>: moderate brown; plastic fine to coarse sand; very stiff to hard; moist	J-9	7 14 26	SS	1.1/1.5 recovery
90					RD	
92	SM	91.5-105.0 <u>SILTY SAND/SAND</u>: moderate brown;				

Project DESIGN UNIT A-310 Date Drilled 10/19-20/83 Hole No. 24-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
92	SM/ SP	91.5-105.0 SILTY SAND/SAND: (continued) fine to coarse sand; some gravel; very dense; moist	C-10	44 37	DR	0.9/1.0 recovery
94					RD	chatter
96						drilled out further to sample due to coarse nature of soils
98			PB-9		PB	1.0/2.5 recovery fell out of bottom
100			J-10	23 51	SS	0.7/1.0 recovery
	(SP)	grades less silty			RD	
102			C-11	45 50-4.5"	DR	0.4/0.9 recovery
104					RD	
106	CL	105.0-115.0 SANDY CLAY: moderate brown; fine to medium sand; hard; moist	PB-10		PB	2.5/2.5 recovery
108			J-11	12 21 35	SS	1.5/1.5 recovery
110					RD	slight chatter
112			PB-11		PB	2.5/2.5 recovery
114						
116		B.H. 115.0' Terminated hole; tremied grout to surface				Sheet 5 of 5

THIS BORING LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.

Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG 24-3

Proj: DESIGN UNIT A310
Date Drilled 10-21/22-83
Ground Elev. 284'
Drill Rig FAILING 1500
Logged By L. Schoeberlein
Total Depth 110.9'
Hole Diameter 4 7/8"
Hammer Weight & Fall DE: 320 lb @ 18"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0	AC	0.0-0.6 ASPHALT			GB	Start drilling 12:45
	GP	0.6-1.0 BASEROCK				
	CL	ALLUVIUM 1.0-2.8 SILTY CLAY: greyish brown; fines; stiff; moist				
2				4	DR	0.8/1.0 recovery
			C-1	7		
	CL	2.8-9.0 SANDY CLAY: greyish brown; fines; very stiff; moist			AD	
4						
					SH	
6		grades to moderate brown	SH-1			2.5/2.5 recovery pocket penetrometer 2.0 tsf
8			J-1	4 9 11	SS	
10					AD	
	ML	9.0=21.0 SILTY SAND: moderate brown; medium dense; moist				
12				6	DR	
			C-2	8		
					RD	set tub and cased to 13' lost drilling mud
14						
16					PB	
						washed out 0.0/2.5 recovery
18			J-2	2 7 9	SS	1.1/1.5 recovery
	CL	19.0-20.0 sandy clay lens				
20					RD	

Sheet 1 of 5

Project DESIGN UNIT A310 Date Drilled 10-21-22-83 Hole No. 24-3

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	ML	20.0-21.0 SILTY SAND: (continued)			RD	
	SM/ SP (SC)	21.0-25.0 SILTY SAND: moderate brown; fine to coarse sand; some gravel; occasional clayey lenses; dense; moist to wet				
22				11	DR	0.8/1.0 recovery
			C-3	21		
					RD	mixed mud
24						
	CL	25.0-36.5 SANDY CLAY: moderate brown; fine to medium sand; very stiff; moist to wet	PB-1		PB	
26						2.5/2.5 recovery
28			J-3	8 13 19	SS	1.0/1.5 recovery
30					RD	
32				13	DR	0.8/1.0 recovery
			C-4	24		
					RD	
34		grades less clayey				
36			PB-2		PB	2.5/2.5 recovery
	SC	36.5-41.0 CLAYEY SAND: moderate brown; fine to coarse sand; very dense; moist				
38			J-4	19 32 33	SS	1.0/1.5 recovery
40					RD	
	SW	41.0-57.0 SAND: moderate brown; fine to coarse sand; trace silt; very dense; moist to wet				
42				31	DR	0.7/1.0 recovery
	(SC)		C-5	33		
		occasional clayey zones			RD	
44						

Sheet 2 of 5

Project DESIGN UNIT A310 Date Drilled 10-21-22-83 Hole No. 24-3

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	SW	41.0-57.0 SAND: (continued)			RD	
			PB-3		PB	
46						2.1/2.5 recovery
48		grades to fine sand with trace of silt	J-5	13	SS	0.5/1.4 recovery
				40		
				50-	5.5"	
50						
52				34	DR	
			C-6	55		0.7/1.0 recovery
					RD	
54						
56			PB-4		PB	2.4/2.5 recovery
	CL/ML	57.0-61.0 SILTY CLAY/CLAYEY SILT: moderate brown; hard; moist; some very fine sand				
58			J-6	5	SS	0.5/1.5 recovery
				13		
				29		
					RD	
60						
	SC/SP	61.0-65.0 CLAYEY SAND/SAND: moderate brown; fine to coarse sand; low to moderately pastic fines;very dense; moist occasional lenses of increased clay content				
62				52	DR	
			C-7	55		0.9/1.0 recovery
					RD	
64						
	CL	65.0-81.0 SANDY CLAY:moderate brown; fine to medium sand; hard; moist	PB-5		PB	
66						2.5/2.5 recovery
68						

Sheet 3 of 5

Project DESIGN UNIT A310 Date Drilled 10-21-22-83 Hole No. 24-3

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	CL	65.0-81.0 SANDY CLAY: (continued)	J-7	11 25 50-	SS 5"	1.4/1.4 recovery
					RD	
70						
72			C-8	27 57	DR	0.8/1.0 recovery
					RD	
74						
76		grades sand to clayey sand	PB-6		PB	
	(SC)					2.7/2.7 recovery
78			J-8	11 13 21	SS	1.5/1.5 recovery
					RD	
80						
	SC	81.0-85.5 CLAYEY SAND: moderate brown; fine to coarse sand; very dense moist to wet				
82			C-9	53 50-3.5"	DR	0.8/1.0 recovery
					RD	
84		grades less clay				
86	SW (SM) (SC) (CL)	85.5-110.9 INTERBEDDED SAND, SILTS AND CLAY: moderate brown; variable percentages of sand silt and clay; very dense to hard; moist to wet; most contents gradational	PB-7		PB	1.2/2.5 recovery sample marginal
88	(SP)	fine grained sand lens	J-9	28 56	SS	0.5/1.0 recovery
					RD	
90	(CL)	interbeds of silty clay, silty sand, clayey sand, sandy clay				
92						

Sheet 4 of 5

Project DESING UNIT A310 **Date Drilled** 10-21-22-83 **Hole No.** 24-3

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
92	(CL)	85.5-110.9 INTERBEDDED SANDS, SILTS AND CLAYS: (continued)		22	DR	
			C-10	30		1.0/1.0 recovery
					RD	
94						
		sandy clay	PB-8		PB	
96						rig chatter 2.4/2.5 recovery
98	(SC)	clayey sand	J-10	29 44 53	SS	
	(SM)	silty sand				
					RD	0.7/1.5 recovery
100						
102				29	DR	
	(CL)	sandy clay	C-11	61		1.0/1.0
					RD	
104						rig chatter
						drilled further to get past coarse granular material
106			PB-9		PB	
	(SM)	silty sand				1.9/2.5 recovery
108						
	(SW)	sand				
			J-11	29	SS	
110	(ML)	sandy silt		36		
	(SP)	sand		50-4.5"		0.7/0.9 recovery
		B.H. 110.9 Terminate hole; grout to surface				complete drilling 10:00; 10-22-83
112						
114						
116						

Converse Consultants, Inc.
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BORING LOG 24-4

Proj: DESIGN UNIT A310
Date Drilled 10-20-21-83
Ground Elev. 274'
Drill Rig FAILING 1500
Logged By L. Schoeberlein
Total Depth 95.0'
Hole Diameter 4 7/8"
Hammer Weight & Fall DR: 320 lb @ 18"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0	AC	0.0-0.5 ASPHALT		GB		start drilling 2:45
	GP	0.5-1.0 BASE ROCK				
	CL	ALLUVIUM 1.0-6.5 SILTY CLAY: greyish brown; trace fine sand; stiff; moist; color grades to moderate brown with depth				
2				7	DR	0.8/1.0 recovery
			C-1	14		
					AD	
4						
6	ML	6.5-11.0 SANDY SILT: moderate brown; trace of fine sand; stiff; dry to moist; with some sand	SH-1		SH	2.5/2.5 recovery
8			J-1	3 4 6	SS	1.0/1.5 recovery
10					RD	
	CL/ SC"	11.0-16.0 SANDY CLAY/CLAYEY SAND: moderate brown; fine sand; stiff; medium dense; moist				
12				4	DR	0.7/1.0 recovery
			C-2	9		set tub and cased to 13'
					RD	
14						
16	SC	16.0-18.5 CLAYEY SAND: moderate brown; fine to medium sand; medium dense; wet	PB-1		PB	2.5/2.7 recovery
18			J-2	3 5 8	SS	1.2/1.5 recovery
	CL	18.5-30.5 SANDY CLAY: moderate brown; 70% moderately plastic; fine to coarse sand; stiff; moist				
20					RD	

Project DESIGN UNIT A 310 **Date Drilled** 10-20-21-83 **Hole No.** 24.4

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	CL	18.5-30.5 SANDY CLAY: (continued)			RD	
22	(SM)		C-3	12 24	DR	0.5/1.0 recovery pocket penetrometer 4.5 tsf
					RD	
24						
26			PB-2		PB	2.5/2.5 recovery pocket penetrometer 2.0 tsf
28		grades to hard	J-3	7 15 27	SS	1.3/1.5 recovery
30					RD	rig chatter
	SW	30.5-34.0 SAND: moderate brown; fine to coarse sand; silt; trace of fine to medium gravel; dense; wet				
32				30 33	DR	0/1.0 recovery sample fell out
					RD	
34	CL	34.0-65.5 SANDY CLAY: moderate brown; fine to coarse sand, trace silt; some gravelly lenses; hard; moist				
36			PB-3		PB	2.0/2.5 recovery
38		grades more sandy	J-4	8 18 33	SS	0.5/1.5 recovery
40					RD	
42	(ML)	clayey silt	C-4	14 15	DR	1.0/1.0 recovery
		sandy clay/clayey sand grades very stiff			RD	
44						

Project DESIGN UNIT A310 **Date Drilled** 10-20-21-83 **Hole No.** 24-4

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	CL	34.0-65.5 SANDY CLAY: (continued)			RD	
46			PB-4		PB	2.5/2.5 recovery
48	CL/ SC (ML)	grades to clayey sand/sandy clay; very stiff. interbeds 6" thick of clayey silt and sandy clay	J-5	8 12 16	SS	1.5/1.5 recovery
50					RD	
52	(SM)	occasional gravelly sand lens	C-5	22 44	DR	
					RD	1.0/1.0 recovery
54						
56			PB-5		PB	2.1/2.5 recovery
58			J-6	5 8 14	SS	1.5/1.5 recovery 6:00 10-20-83
60					RD	7:00 10-21-83 H_2O @ 42.5' mixed mud
62		grades hard	C-6	27 60	DN	1.0/1.0 recovery
					RD	pocket penetrometer 3.5 tsf
64	SM	grades to silty sand				
	SM	65.5-75.0 SILTY SAND: moderate brown; fine to coarse sand; with silt; very dense; wet contains variable silt content in lenses	PB-6		PB	2.5/2.5 recovery
66						
68						

Sheet 3 of 5

Project DESIGN UNIT A310 **Date Drilled** 1-20-21-83 **Hole No.** 24-4

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	SM	65.5-75.0 SILTY SAND: (continued)	J-7	22 34 42	SS	1.3/1.5 recovery
70					RD	
72			C-7	44 50-3.5"	DR	0.4/0.9 recovery
					RD	partial
74						
	SC	75.0-78.0 CLAYEY SAND: moderate brown; fine to medium sand, very dense; moist	PB-7		PB	2.5/2.5 recovery
76						
78	SW	78.0-85.6 SAND: moderate brown; fine to coarse sand; trace of silt or clay; very dense; moist to wet;		22 54	SS	0.0/1.0 recovery
					RD	lost sample
80	(SC)	contains occasional thin clayey sand lenses, granitic origin				
82			C-8	69 60-4"	DR	
					RD	0.5/0.8 recovery
84						
86	SC	85.6-89.0 CLAYEY SAND: moderate brown; hard; moist	PB-8		PB	2.7/2.7 recovery
88			J-8	12 21 37	SS	1.5/1.5 recovery
90	ML/CL	89.0-95.0 SANDY SILT/SANDY CLAY: moderate brown; variable; silts clays and sands; hard; moist			RD	
92						

Project DESIGN UNIT A310 **Date Drilled** 10-20-21-83 **Hole No.** 24-4

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
92	ML/ CL	89.0-95.0 <u>SANDY SILT/SANDY CLAY:</u> (continued)			RD	
			PB-9		PB	
94						
		B.H. 95.0' terminate hole; installed piezometer (2"ABS) to bottom; 75-95' slotted				Complete drilling 10:45, 10-21-83
96						
98						
100						
102						
104						
106						
108						
110						
112						
114						
116						

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BORING LOG 24-5

Proj: DESIGN UNIT A310
Date Drilled 10-22-83
Ground Elev. 267'
Drill Rig FAILING 1500
Logged By L. Schoeberlein
Total Depth 95.0'
Hole Diameter 4 7/8"
Hammer Weight & Fall DR: 320 lb. @ 18" SS: 140 lb @ 30

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0	AC	0.0-0.5 <u>ASPHALT</u>			GB	START DRILLING 11:30
	GM	0.5-1.0 <u>ROAD BASE</u>				
	CL	ALLUVIUM 1.0-7.0 <u>SANDY CLAY:</u> moderate brown; fine sand; stiff; moist				
2				5	DR	0.6-1.0 recovery pocket penetrometer 4.0 tsf
			C-1	12		
					AD	
4						
6			SH-1		SH	pocket penetrometer 1.75 tsf 2.5/2.5 recovery
	ML	7.0-8.0 <u>SANDY SILT:</u> moderate brown; fine sand; loose; moist				
8			J-1	1 2 4	SS	set tub & cased to 7.5' mixed mud
10	CL	8.0-11.5 <u>SANDY CLAY:</u> moderate brown; fine to medium sand; firm; moist to wet			RD	
12	SC	11.5-15.0 <u>CLAYEY SAND:</u>moderate brown; fine to medium sand; medium dense; moist		5	DR	0.9-1.0 recovery
			C-2	9		
14					RD	
16	SM/SP	15.0-21.0 <u>SILTY SAND/SAND:</u>moderate brown; fine to medium sand; occasional gravel; medium dense to dense; moist			PB	washed out 0.0/2.5 recovery
18			J-2	5 12 18	SS	1.0/1.5 recovery
20					RD	

Sheet 1 of 5

Project DESIGN UNIT A310 Date Drilled 10-22-83 Hole No. 24-5

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	SM/ SP	15.0-21.0 SILTY SAND/SAND			RD	
	CL/ SC	21.0-26.5 CLAYEY SAND/SANDY CLAY: moderate brown; variable % of sands and moderately plastic fines; very stiff to dense; moist				
22			PB-1		PB	2.5/2.5 recovery
24		23.5-24.0 Clayey Sand				
					RD	
26			PB-2		PB	2.0/3.5 recovery
	SM/ SP	26.5-32.6 SILTY SAND/SAND: moderate brown; fine to medium sand; very dense; moist				
28			J-3	14 24 29	SS	1.0/1.5 recovery
30					RD	
32				26	DR	
	SC	32.6-41.0 CLAYEY SAND: moderate brown; fine to medium sand; very dense; moist	C-3	37		0.9/1.0 recovery
34					RD	
36		grades less clayey	PB-3		PB	1.6/2.5 recovery
		gravelly lens; occasional cobbles				rig chatter
38	(SM)	silty sand lens	J-4	14 40 37	SS	0.6/1.5 recovery
40					RD	
	CL	41.0-51.0 SANDY CLAY: moderate brown; moderately plastic fines; fine to coarse sand; hard; moist; occasional gravels				
42				25	DR	
			C-4	47		
44					RD	

Sheet 2 of 5

Project DESIGN UNIT A310 **Date Drilled** 10-22-83 **Hole No.** 24-5

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	CL	41.0-51.0 SANDY CLAY: (continued)			RD	
46			PB-4		PB	pocket penetrometer 2.5 tsf, 2.5/2.5 recovery
48	(SM)	silty sand lenses	J-5	4 6 8	SS	1.5/1.5 recovery
50					RD	packed bentonite around casing to stop leak
	SC/ SM	51.0-56.0 CLAYEY SAND/SILTY SAND: moderate brown; fine to coarse sand; dense; moist				
52			C-5	17 27	DR	
					RD	
54						
56			PB-5		PB	
	CL	56.0-61.0 SANDY CLAY: moderate brown; fine to coarse sand; some gravel hard; moist; contains some clayey sand and sandy silt lenses				pocket penetrometer 4.5 tsf 2.3/2.5 recovery
58	(SC)		J-6	10 17 26	SS	1.5/1.5 recovery
60	(ML)				RD	
	SW	61.0-64.5 SAND: moderate brown; fine to coarse sand; trace silt; very dense; wet				
62				63 50-4"	DR	0.5/0.8 recovery disturbed
					RD	
64						
	CL	64.5-71.0 SANDY CLAY: moderate brown; fine sand; occasional medium sand and gravel; hard; wet				
66			PB-6		PB	2.3/2.5 recovery
68						

Sheet 3 **of** 5

Project DESIGN UNIT A310 **Date Drilled** 10-22-83 **Hole No.** 24-5

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	CL	64.5-71.0 SANDY CLAY: (continued)	J-7	12 20 37	SS	1.5/1.5 recovery
					RD	
70						
	CL	71.0-74.0 SANDY CLAY/SILTY CLAY: moderate brown; occasional sand and silty sand lenses; very stiff to hard; moist				
72				20	DR	1.0/1.0 recovery
	(SM)		C-7	24		
					RD	
74	SC	74.0-81.0 CLAYEY SAND: moderate brown; fine to coarse sand; some gravel; very dense; moist to wet				
			PB-7		PB	
76						2.6/2.6 recovery
78		grades more sandy	J-8	16 30 42	SS	1.3-1.5 recovery
					RD	
80						
	SM	81.0-95.0 SILTY SAND: moderate brown to yellowish grey; fine to coarse sand; very dense; moist				
82				29 60	DR	fell out 0.0/1.0 recovery
					RD	
84						
86			PB-8		PB	
88						2.1/2.5 recovery
			J-9	19 23 31	SS	
90	(CL)	sandy clay interbeds				1.2/1.5 recovery
					RD	
92						

Sheet 4 of 5

Project DESIGN UNIT A310 **Date Drilled** 10-22-83 **Hole No.** 24-5

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
92	SM	81.0-95.0 <u>SILTY SAND:</u> (continued)			RD	
94				48	DR	
			C-8	60		
	B.H.	95.0 Terminate hole grouted to surface				complete drilling 6:30, 10-22-83
96						
98						
100						
102						
104						
106						
108						
110						
112						
114						
116						

Sheet 5 of 5

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BORING LOG 25A

Proj: DESIGN UNIT A310
Date Drilled 1/25-26/83
Ground Elev. 390.0'
Drill Rig B. Auger
Logged By D. Gillette
Total Depth 100.0'
Hole Diameter 36"
Hammer Weight & Fall N/A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-1.0 FILL				Observation hole, No sampling required
	SM	ALLUVIUM 1.0-22.0 SILTY SAND: moderate reddish brown; 3/4" gravel; some minor sandy lenses; medium dense; moist				Borehole stands well
2						
4						
6						
8						
10						
12						
14						
		15.0- moist				
16						
18						
20						

Sheet 1 of 5

Project DESIGN UNIT A310 **Date Drilled** 1-25-26-83 **Hole No.** 25A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	SM	1.0-22.0 SILTY SAND: continued				
22	SP (SM)	22.0-36.0 SAND: with silty sand lenses				
24						
26						
28		28.0-28.6 sand lens				
30						
32						
34		34.0-36.0 increase silty lens				
36	ML (SM) (SP)	36.0-49.0 SANDY SILT: contains sand and silty sand lenses				
38						
40						
		41.0-42.5 content of silt increases and content of sand decreases				
42						
44						

Sheet 2 of 5

Project DESIGN UNIT A310 **Date Drilled** 1-25-26-83 **Hole No.** 25A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	ML (SM) (SP)	36.0-79.0 SANDY SILT: continued				
46						
48						
50	SP (SM)	49.0-70.9 SAND: contains silt, sand and coarse sand lenses with a few weathered boulders; moist				Borehole stands well
52						
54						
56						
58						
60						
62						
64						
66		66.0-69.5 with trace gravel				
68						

Sheet 3 **of** 5

Project DESIGN UNIT A310 **Date Drilled** 1-25-26-83 **Hole No.** 25A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	SP (SM)	49.0-70.0 SAND: continued				
	-- CL	69.0-70.0 clay lens				
70	SM (ML)	70.0-85.0 SILTY SAND: contains medium to coarse sand and silt lenses				
72						
74						
76						
						no water in hole overnight 1/25/83 1/26/83
78						
80						
82						
84						
	SP (SM) (ML)	85.0-100.0 SAND: contains lenses of silty sand and silt				
86						
88						
90						
92						

Sheet 4 of 5

Project DESIGN UNIT A310 Date Drilled 1-25-26-83 Hole No. 25A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
92	SP (SM) (ML)	85.0-100.0 <u>SAND</u>: continued				
94						
96						
98						
	SC	99.0-100.0 clayey sand				
100		B.H. 100.0' Terminated hole				Special Hole Closure completed 9:00 am 1/26/8 <u>Notes</u>: No ground water or seeps encountered No caving Placed 80.0' of 30" CMP casing (9-10:30), downhole inspection (10:30-12:30). Observers - Richard Proctor, Neil Richards Dan Logan, Buzz Spellman, John Moss, Joe Sperry Placed slurry (20 cu. yds.) in hole to within 2" of surface
102						
104						
106						
108						
110						
112						
114						
116						

Sheet 5 of 5

THIS BORING LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.

Converse Consultants, Inc.
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BORING LOG 25B

Proj: DESIGN UNIT A310
Date Drilled 10-12-83
Ground Elev. 358'
Drill Rig Bucket Auger
Logged By J. Stellar
Total Depth 81'
Hole Diameter 32"
Hammer Weight & Fall N/A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0	AC	0.0-0.2 ASPHALT				
	GM	FILL 0.2-2.5 SILTY GRAVEL: (base material)				minor ravelling - 0-10' - hole stands well 10-18'
2						
	ML (SM) (SP)	ALLUVIUM 2.5-6.0 SANDY SILT: dark brown; with lenses of silty sand and sand; loose to medium dense; moist				
4						
6						
	SP	6.0-13.0 SAND: with trace gravel to 1/2"; medium dense; dry to moist				
8						
10						
12						
	ML	13.0-17.0 SANDY SILT: dark brown; with lenses of gravelly silt and silt; loose to medium dense; moist				
14						
16						
	ML	17.0-42.0 SILT: dark brown; with lenses of gravelly and sandy silt; loose to medium dense; moist				
18						
20						

Sheet 1 of 4

Project DESIGN UNIT A310 Date Drilled 10-12-83 Hole No. 25B

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	ML	17.0-42.0 SILT: continued				
22						
24						
26						
28						
30						
32		32.0-42.0 grades to reddish brown and medium dense; slight clay content				
34						
36						
38						
40						
42	ML	42.0-75.0 SANDY SILT: dark reddish brown; with lenses of gravelly silt; medium dense; moist				
44						

Sheet 2 of 4

Project DESIGN UNIT A310 **Date Drilled** 10-12-83 **Hole No.** 25B

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	ML	42.0-75.0 SANDY SILT: continued				
46						
48	(SM)	48.0-75.0 interlayers of silty sand with trace gravel to 1"				
50						
52						
54						
56						
58						
60						
62						
64	(SM) (SP)	63.0-65.0 coarse sand lens				
66						
68						Sheet 3 of 4

Project DESIGN UNIT A310 Date Drilled 10-12-83 Hole No. 25B

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	ML (SM)	42.0-75.0 SANDY SILT: continued				
70						
72						
74		74.0-75.0 increased gravel size to 2"				
	SP	75.0-81.0 SAND: medium brown; clean; trace gravel to 1"; dense; moist				
76						
78		78.0-81.0 lenses of silty sand				
			"bag"			bag sample 79'-80'
80						
		B.H. 81.0 Terminated boring				Notes: No caving No groundwater encountered No gas detected Downhole Observers John Stellar - CCI Harry Audell - LRA B.I. Maduke - MRTC Jim Monsees - MRTC
82						
84						
86						
88						
90						
92						

Sheet 4 of 4

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BORING LOG 26A

Proj: DESIGN UNIT A-310
Date Drilled 2-18, 21-83
Ground Elev. 351'
Drill Rig Mayhew 1000
Logged By G. Halbert
Total Depth 102.5'
Hole Diameter 4 7/8"
Hammer Weight & Fall SPT: 140 lb @ 30" DR: 340 lb @ 24"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		5" Concrete				
	SM	FILL 05.-4.0 SILTY SAND: medium dense			RD	easy drilling
2						
4		ALLUVIUM 4.0-20.0 SANDY SILT: dark yellowish brown; loose; moist to wet				
6						
8						
	ML					
10						1.0/1.5 recovery
			J-1	2 3 3	SS	pocket pen 1.0 tsf
12					RD	
14						
						consistent, smooth
16						
18		contains angular gravel to 1/2"				
20						

Sheet 1 of 5

Project DESIGN UNIT A-310 **Date Drilled** 2-18, 21-83 **Hole No.** 26-A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	SM	20.0-22.0 SILTY SAND: with gravel medium dense, very moist	C-1	2 3	DR	1.0/1.0 recovery
	(ML CL)		J-2	4 18 25	SS	SPT: 1.5/1.5 recovery. harder drilling
22	CL	22.0-28.0 SANDY CLAY: with gravel moderate brown; hard; moist to wet			RD	pocket pen 4.0 tsf
24						
26						
28	SM	28.0-35.0 SILTY SAND: dark yellow brown; medium dense; moist to wet				
30			J-3	6 7 9	SS	1.5/1.5 recovery
32					RD	
34						
	SC	35.0-50.0 CLAYEY SAND: moderate brown; hard; moist				slightly harder drilling
36						
38		trace gravel to 1" diameter				
40	(ML CL)		C-2	5 10	DR	1.0/1.0 recovery
			J-4	13 16 23	SS	1.5/1.5 recovery pocket pen > 4.0 tsf
42	(SM SP)	very sandy zone			RD	
44						

Sheet 2 of 5

Project DESIGN UNIT A-310 **Date Drilled** 2-18, 21-83 **Hole No.** 26-A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44		35.0-50.0 CLAYEY SAND (Continued).			RD	
46						
48						
50	SM	50.0-102.5 SILTY SAND: moderate yellowish brown; medium dense; moist to wet.	J-5	9 17 19	SS	easier drilling @ 50' 1.5/1.5 recovery
					RD	
52						
		less dense than soils between 35 and 50 feet				
54						
56						
58						
60	(ML CL)	grades with fine to coarse sand, occasional fine gravel; dark yellowish brown to moderate brown; dense	C-3	5 5	DR	1.0/1.0 recovery
			J-6	6 12 19	SS	SPT 1.5/1.5 recovery 1" gravel in tip
62					RD	
	(SC)	clayey lenses/layers to 1' thick				
64						
66						drill rate 1'/minute smooth, fairly consistent
68						

Sheet 3 **of** 5

Project DESIGN UNIT A-310 **Date Drilled** 2-18, 21-83 **Hole No.** 26-A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	SM	50.0-102.5 SILTY SAND (continued)			RD	
						harder drilling
70						1.25-1/5 recovery
			J-7	15 30 42	SS	
					RD	
72	(CL)	occasional clayey zones				
74	(SC)	sand content varies				
	(ML)					
76						
78		occasional gravel to 1"				
80			C-4	10 20	DR	0.9/1.0 recovery
	(CL)	grades to silty sand with clay: fine to coarse sands; dense to very dense; slightly cemented; moist	J-8	18 40 60/5	SS	1.4/1.4 recovery pocket pen >4.5 tsf
82						
					RD	
84						
86						quiet, smooth drilling
88	(SC CL)	clay content increases				
90			J-9	17 24 45	SS	1.5/1.5 recovery
92						

Sheet 4 **of** 5

Project DESIGN UNIT A-310 Date Drilled 2-18, 21-83 Hole No. 26A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
92	SM	50.0-102.5 SILTY SAND: (Continued)			RD	
						quiet, smooth drilling
94	(CL)					
	(ML)					
	(SC)	becomes wet				
96						
98						
100			C-5	5 11	DR	0.8/1.0 recovery
			J-10	16 22 40	SS	1.5/1.5 recovery
102						
		B.H. 102.5' Terminated hole				completed 9:20 2/21/83 installed 2" P.V.C. (perf. 60' to 100')
104						
106						
108						
110						
112						
114						
116						

Sheet 5 of 5

Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG 26B

Proj: DESIGN UNIT A-310
Date Drilled 10-11-83
Ground Elev. 351'
Drill Rig BUCKET
Logged By J. Stellar
Total Depth 61'
Hole Diameter 32"
Hammer Weight & Fall

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-1.0 CONCRETE				2.5 hours coring thru concrete gutter
2	ML	FILL 1.0-4.0 SILT/SANDY SILT: dark brown; trace gravel and cobbles to 5"; trace of broken brick; medium dense; moist				
4	ML	ALLUVIUM 4.0-17.0 SILT WITH LAYERS OF SANDY SILT: dark brown; numerous roots; medium dense; moist				
6						
8						
10						
12		few clayey silt lenses				
14		grades more sand				
16						
18	SM	17.0-19.0 SILTY SAND: moderate brown; trace gravel to ½"; medium dense; moist				
20	ML	19.0-42.0 SANDY SILT: reddish brown; medium dense to dense; moist				

Sheet 1 of 3

Project DESIGN UNIT A310 **Date Drilled** 10-11-83 **Hole No.** 26B

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	ML	19.0-42.0 SANDY SILT: (continued				
22						
24						
26						
28		occasional interlayers trace gravels to 1"				
30		occasional layers of silt				
32						
34						
36						
38						
40						
42	SM	42.0-48.0 SILTY SAND: light brown; trace gravel to 1"; medium dense; moist				
44						

Sheet 2 of 3

Project DESIGN UNIT A310 **Date Drilled** 10-11-83 **Hole No.** 26B

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	SM	42.0-48.0 SILTY SAND: (continued)				
	(ML)	interlayers of sandy silt				
46						
48	ML	48.0-54.0 SANDY SILT: medium to dark brown; with interlayers of silty sand; trace gravel to 1"; medium dense; moist				
50		grades wet				
52						
54						ground water
	SP	54.0-58.0 GRAVELLY SAND: dark brown; gravel to ½"; dense; saturated				
56						
58	ML	58.0-61.0 SANDY SILT: dark brown; medium dense; saturated				bag sample 58'-59'
60						
	B.H.	61.0' Terminate hole				Completed Hole 10-11-83 no caving 0'-54' sloughing 54-58' Down hole observers: JRS HAS Harry Audell
62						
64						
66						
68						

Sheet 3 of 3

Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG 26-1

Proj: DESIGN UNIT A310
Date Drilled 11-16-17-83
Ground Elev. 350.0'
Drill Rig Failing 750
Logged By S. Slaff
Total Depth 90.0'
Hole Diameter 4 7/8"
Hammer Weight & Fall 55 SS, 140 lbs, 30" DR 320 lbs, 18"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.8 CONCRETE			GB	
		0.8-1.3 BASE ROCK			AD	
	SC	FILL				
2	CL	1.3-2.0 SANDY CLAY: dark yellowish brown; soft; dry		1	DR	1.0/1.0 recovery
		ALLUVIUM	C-1	3		
		2.0-21.0 SANDY CLAY: moderate brown; sand content varies; trace gravel; firm to stiff; moist; grades more sand and gravel at 3.0 feet			AD	
4						
6		color change to moderate brown			PB	2.5/2.5 recovery
		minor organics: roots	PB-1			
8	(SC)	becomes CLAYEY SAND				
		gravel grades out	J-1	3 4 4	SS	0.5/1.5 recovery
10					RD	
12						
			C-2	4 8	DR	1.0/1.0 recovery
14					RD	
16			lost		PB	0.0/2.5 recovery
18						17:00 11/16/83
			J-2	4 6 8	SS	07:00 11/17/83 1.1/1.5 recovery
20						

Sheet 1 of 4

Project DESIGN UNIT A310 **Date Drilled** 11-16-17-83 **Hole No.** 26-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	CL	2.0-21.0 SANDY CLAY: continued			RD	
	CL (SC)	21.0-30.1 SANDY CLAY: moderate brown; fine sand; trace of gravel; hard; moist				
22			C-3	12 22	DR	1.0/1.0 recovery
					RD	
24						
26		sand content increases	PB-2		PB	2.4/2.5 recovery
28			J-3	16 31 38	SS	0.9/1.5 recovery
30					RD	slight rig chatter
	SM (SC)	30.1-35.2 SILTY SAND: moderate brown; fine to coarse sand; trace of gravel to 2"; very dense; moist				
		30.1-31.0 gravel zone				
32			C-4	25 32	DR	0.9/1.0 recovery
					RD	
34						
	CL/ SC	35.2-65.0 SANDY CLAY/CLAYEY SAND: mod. brown; trace gravel; hard; dense to very dense; moist; sand is angular to subangular; micaceous				
36			PB-3		PB	1.1/2.5 recovery
38			J-4	14 22 25	SS	0.7/1.5 recovery
	SM	39.0-39.8 silty sand lens			RD	rig chatter
40	CL					
		color change to moderate brown				
42	SM	42.0-43.6 silty sand lens	C-5	36 50-4½"	DR	0.8/0.9 recovery
					RD	
44	CL					

Sheet 2 of 4

Project DESIGN UNIT A310 Date Drilled 11-16-17-83 Hole No. 26-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	CL/ SC	35.2-65.0 <u>SANDY CLAY/CLAYEY SAND</u>: cont. sand content varies			RD	
46					PB	1.5/2.5 recovery
			PB-4			
48			J-5	23 24 37	SS	1.3/1.5 recovery
50					RD	
52	(SM)		C-6	18 35	DR	1.0/1.0 recovery
54					RD	
56		very hard zone	PB-5		PB	11:25 1.5/2.5 recovery
58			J-6	27 28 35	SS	1.0/1.5 recovery
60					RD	
62			C-7	28 50	DR	1.0/1.0 recovery
64					RD	
	SM	65.0-67.8 <u>SILTY SAND</u>: moderate brown; fine sand; very dense; saturated				
66			PB-6		PB	1.8/2.5 recovery
68	CL	67.8-75.4 SANDY CLAY: moderate brown; fine				

Sheet 3 of 4

Project DESIGN UNIT A310 Date Drilled 11-16-17-83 Hole No. 26-1

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	CL	67.8-75.4 SANDY CLAY: continued grained sand; trace gravel; very stiff; moist			PB	
			J-7	8 8 11	SS	0.7/1.5 recovery
70					RD	
72				10	DR	1.0/1.0 recovery
			C-8	23		
74					RD	
76	ML	75.4-80.8 SANDY SILT: moderate brown; very fine sand; medium dense; wet				
			PB-7		PB	2.4/2.5 recovery
78			J-8	8 12 14	SS	0.9/1.5 recovery
80					RD	
	CL	80.8-90.0 SANDY CLAY: moderate brown; fine grained sand ;micaceous; trace of gravel; very stiff; moist				
82				10	DR	1.0/1.0 recovery
			C-9	16		
84					RD	
86		grades less sandy except in segregated zones	PB-8		PB	1.5/2.5 recovery
88			J-9	17 23 28	SS	0.8/1.5 recovery 15.50 completed 11/17/83
90		B.H. 90.0 Terminated hole. Installed 2" ABS piezometer from 0.0 to 90.0, perforated from 60.0-80.0. Backfilled w/pea gravel from 10.0-90.0 Bentonite pellet seal 7-10. Soil from 2-7. Concrete from 0.5-2.0.				07:00 11/18/83
92						

Sheet 4 of 4

THIS BORING LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.

Converse Consultants, Inc.
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BORING LOG 26-2

Proj: DESIGN UNIT A-310
Date Drilled 11/15-16/83
Ground Elev. 351'
Drill Rig Failing 750
Logged By S. Slaff
Total Depth 90.0'
Hole Diameter 4 7/8"
Hammer Weight & Fall SS: 140 lb @ 30", DR: 320 lb @ 18"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.8 CONCRETE 0.8-1.0 BASE ROCK			GB	
	CL	FILL 1.0-1.6 CLAY/SANDY CLAY: dark yellowish brown; soft; moist; micaceous			AD	
2	CL	ALLUVIUM 1.6-7.0 SANDY CLAY: moderate brown; fine grained sand; micaceous; soft; dry to moist	PB-1		PB	2.5/2.5 recovery
4		5.0' grades firm and trace gravel up to 0.3"	J-1	1 2 3	SS	0.8/1.5 recovery
6					RD	
	SM ML	7.0-22.8 SILTY SAND/SANDY SILT: moderate brown; micaceous; fine to coarse sand, subrounded to rounded; trace gravel; firm to stiff; loose to medium dense; moist				
8			C-1	5 8	DR	1.0/1.0 recovery
10					RD	
12			PB-2		PB	1.6/2.5 recovery
14			J-2	3 4 4	SS	1.0/1.5 recovery
16					RD	
18			C-2	6 11	DR	1.0/1.0 recovery
20					RD	

Sheet 1 of 4

Project DESIGN UNIT A-310 **Date Drilled** 11/15-16/83 **Hole No.** 26-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	SM ML	7.0-22.8 SILTY SAND/SANDY SILT: (cont.)			RD	
22			PB-3		PB	2.4/2.5 recovery
	CL SC	22.8-31.4 SANDY CLAY/CLAYEY SAND: moderate brown; fine sand, subangular to subrounded; hard to dense; moist				
24			J-3	8 12 20	SS	1.5/1.5 recovery
26	(GC)	26.5-27.2 gravel lens			RD	rig chatter
28			C-3	11 22	DR	0.9/1.0 recovery
30					RD	
	ML	31.4-38.2 SANDY SILT: moderate brown; trace gravel; dense; wet				
32			PB-4		PB	2.1/2.5 recovery
34			J-4	5 12 27	SS	1.2/1.5 recovery
	(SC) (GM)	35.4-35.8 clayey sand lens 35.8-36.3 gravelly sand lens				
36	(GC)	36.3-38.0 gravel lens grade interbedded silty sand, gravelly sand, sandy gravel and sandy silt			RD	rig chatter
38	SM	38.2-49.8 SILTY SAND: moderate brown; trace gravel to 2.0", well rounded to subangular, mostly subrounded; very dense; wet	C-4	37 60	DR	1.0/1.0 recovery
40					RD	
42			PB-5		PB	sporadic rig chatter 1.8/2.5 recovery
44						

Sheet 2 of 4

Project DESIGN UNIT A310 **Date Drilled** 11-15-16-83 **Hole No.** 26-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	SM	38.2-49-8 SILTY SAND: (Continued)			PB	
			J-5	8 27 48	SS	1.5/1.5 recovery
46					RD	
48		grades with more fines				
			C-5	28 47	DR	17:07 11-15-83
50	ML/ SM	49.8-66.2 SANDY SILT/SILTY SAND: moderate brown, sand and silt content varies; sand is fine grained; trace gravel; micaceous; medium dense to dense; wet			RD	07:00 11-16-83 water at 19'
52			PB-6		PB	2.3/2.5 recovery
54			J-6	8 11 17	SS	1.1/1.5 recovery
56					RD	
58	(SM)		C-6	28 40	DR	1.0/1.0 recovery
60					RD	switched to 4 7/8" drill bit
62			PB-7		PB	08:52 2.2/2.5 recovery
64			J-7	19 33 50/4½"	SS	1.2/1.4 recovery
66	SM	66.2-90.0 SILTY SAND: moderate brown; fines and sand content varies; micaceous fine sand; very dense; wet			RD	minor rig chatter
68						

Sheet 3 **of** 4

Project DESIGN UNIT A310 **Date Drilled** 11-15-16-83 **Hole No.** 26-2

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	SM	66.2-90.0 SILTY SAND: (continued) medium grained, subangular to subrounded			RD	
				28	DR	1.0/1.0 recovery
			C-7	40		
					RD	
70		grades more gravel				minor rig chatter
72			PB-8		PB	2.5/2.5 recovery
74						
			J-8	18	SS	
				35		1.2/1.5 recovery
				48		
76					RD	
78						
				21	DR	1.0/1.0 recovery
			C-8	26		
80					RD	
82			PB-9		PB	tube damaged (tip bent) sample disturbed (?) 2.4/2.5 recovery
84						
			J-9	10	SS	
				17		
				23		
86					RD	1.4/1.5 recovery
88						
				26	DR	1.0/1.0 recovery
			C-9	50		11:52 completed 11-16
90	B.H.	90.0' terminated hole 11-20-83 capped hole with concrete				Tremmied in 2 sack cement grout
92						

Sheet 4 **of** 4

THIS BORING LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.

Converse Consultants, Inc.
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BORING LOG 26-3

Proj: DESIGN UNIT A-310 **Date Drilled** 11-14-83 **Ground Elev.** 350'

Drill Rig Failing 750 **Logged By** S. Slaff **Total Depth** 86.0'

Hole Diameter 4 7/8" **Hammer Weight & Fall** SS: 140 lb @ 30" DR: 320 lb @ 18"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.8 CONCRETE			GB	
		0.8-1.0 BASE ROCK			AD	
		ALLUVIUM				
		1.0-20.5 SANDY CLAY: moderate brown; organics (roots); very soft to soft; moist				
2						
			PB-1		PB	2.5/2.5 recovery
4						
		becomes firm	J-1	2	SS	set 5" steel surface
				2		1.5/1.5 recovery
		micaceous		3		
6						
		grades more sand with depth and coarse, trace gravel			RD	
8						
				3	DR	1.0/1.0 recovery
			C-1	4		
10					RD	
12						
			PB-2		PB	
						2.5/2.5 recovery
14						
			J-2	2	SS	1.0/1.5 recovery
				3		
				4		
16						
					RD	
18						
				3	DR	1.0/1.0 recovery
			C-2	4		
20	(GC)	19.8-20.5 gravel lens			RD	

Sheet 1 of 4

Project DESIGN UNIT A-310 **Date Drilled** 11/14/83 **Hole No.** 26-3

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	CL	1.0-20.5 SANDY CLAY: (continued)			RD	slight rig chatter
	CL	20.5-49.2 SANDY CLAY: dark yellowish brown; trace gravel; micaceous; fine to medium grained sand; very stiff to hard; moist				
22			PB-3		PB	0.2/2.5 recovery sample pulled out due to soft, gravelly formation. Cleaned out hole before running standard pen.
24			J-3	7 13 18	SS	1.5/1.5 recovery
26		grades with more fine sand			RD	slight rig chatter
28	(SM)	contains silty sand	C-3	17 35	DR	1.0/1.0 recovery
30					RD	
32		color changes to moderate brown	lost		PB	lost sample, went in with drive sampler
34			C-4	16 35	DR	1.0/1.0 recovery
					RD	
36			J-4	13 25 38	SS	1.5/1.5 recovery
					RD	
38	(SM)	contains silty sand	C-5	20 42	DR	1.0/1.0 recovery
40					RD	rig chatter
42			PB-4		PB	2.5/2.5 recovery
44						

Sheet 2 **of** 4

Project DESIGN UNIT A-310 **Date Drilled** 11/14/83 **Hole No.** 26-3

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	CL	20.5-49.2 SANDY CLAY: (continued)	PB-4		PB	2.5/2.5 recovery
			J-5	11 19 22	SS	0.9/1.5 recovery
46					RD	slight rig chatter
		grades less sand				
48				25	DR	0.9/0.9 recovery
	SW	49.2-52.4 SILTY SAND: grayish orange; fine to coarse sand; very dense; moist	C-6	75/5.5"		
50					RD	
52						
	ML	52.4-57.5 SANDY SILT: moderate brown; fine to medium; sand; very dense; wet	PB-5		PB	2.0/2.5 recovery
54						
			J-6	13 20 33	SS	1.0/1.5 recovery
56					RD	
58	SM	57.5-61.4 SILTY SAND: moderate brown; fine to medium grained sand; very dense; moist		28	DR	1.0/1.0 recovery
			C-7	30		
60					RD	
62	CL	61.4-67.2 SANDY CLAY: moderate brown; fine sand; hard; moist	PB-6		PB	1.9/2.5 recovery
64						
			J-7	11 22 28	SS	1.0/1.5 recovery
66					RD	
68	SC	67.2-73.0 CLAYEY SAND: moderate brown;				

Project DESIGN UNIT A-310 Date Drilled 11/14/83 Hole No. 26-3

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	SC	67.2-73.0 CLAYEY SAND: (continued) trace gravel to 1.6"; very dense; moist			RD	1.0/1.0 recovery
				32	DR	
			C-8	43		
70					RD	
72						
			PB-7		PB	2.5/2.5 recovery
	CL	73.0-78.0 SANDY CLAY: moderate brown; fine sand; trace gravel; hard; moist				
74						
			J-8	15 28 33	SS	1.3/1.5 recovery
76					RD	
78	SC	78.0-86.0 CLAYEY SAND: moderate brown to moderate yellowish brown; fine sand; dense to very dense; moist		20	DR	1.0/1.0 recovery
			C-9	30		
80		80.0-81.2' gravel lens			RD	
82		some sand grains coated with iron oxide				
		minor mica	PB-8		PB	1.7/2.5 recovery
84	(SC/CL)					
			J-9	18 19 22	SS	0.6/1.5 recovery completed 11/14/83
86		B.H. 86.0' Terminated hole				11/15/83 28.2' water level depth. Tremmied in 5 sack cement grout. 11/22/83 Capped hole with concrete.
88						
90						
92						

Sheet 4 of 4

THIS BORING LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.

Converse Consultants, Inc.
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BORING LOG 26-4

Proj: DESIGN UNIT A-310
Date Drilled 11/18-19/83
Ground Elev. 348'
Drill Rig Failing 750
Logged By S. Slaff
Total Depth 86.5'
Hole Diameter 4 7/8"
Hammer Weight & Fall SS: 140 lb @ 30", DR: 320 lb @ 18"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-1.0 CONCRETE			GB	
	CL	ALLUVIUM 1.0-18.5 SANDY CLAY: dark yellowish brown; sand content varies throughout unit; trace gravel; well rounded to rounded pebbles up to 0.5"; soft; moist			AD	
2				2	DR	0.8/1.0 recovery
			C-1	1		
					AD	
4						
			PB-1		PB	2.5/2.5 recovery
		micaceous				
6	(ML)	6.0-6.5 clayey silt				
		becomes firm	J-1	0 1 4	SS	0.8/1.5 recovery
8					RD	
		color change to moderate yellowish brown				
10						
		becomes stiff	C-2	4 6	DR	1.0/1.0 recovery
					RD	
12						
14						
		color change to moderate brown	PB-2		PB	2.5/2.5 recovery
16						
		becomes very stiff	J-2	3 8 14	SS	1.5/1.5 recovery
18					RD	
	CL	18.5-41.3 SANDY CLAY: dark yellowish brown; trace gravel; very stiff; moist				
20						

Sheet 1 **of** 4

Project DESIGN UNIT A-310 **Date Drilled** 11/18-19/83 **Hole No.** 26-4

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	CL	18.5-41.3 SANDY CLAY: (continued)			RD	1.0/1.0 recovery
		color change to moderate brown with scattered thin gravel lenses	C-3	14 36	DR	
22					RD	
24			PB-3		PB	2.1/2.5 recovery disturbed during retrieval
26			J-3	8 13 14	SS	1.5/1.5 recovery
28					RD	slight rig chatter
30		color mottled with moderate yellowish brown; silty clay	C-4	11 20	DR	1.0/1.0 recovery
32		gravel rounded to 0.4"			RD	
34			PB-4		PB	2.3/2.5 recovery tube damaged slightly by gravel
36			J-4	16 33 37	SS	1.5/1.5 recovery
38					RD	slight rig chatter
40			C-5	25 50	DR	1.0/1.0 recovery
42	SM	41.3-44.0 SILTY SAND: moderate yellowish brown; some gravel; dense to very dense; moist			RD	
44						

Project DESIGN UNIT A-310 **Date Drilled** 11/18-19/83 **Hole No.** 26-4

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	CL	44.0-49.0 SANDY CLAY: moderate yellowish brown; trace gravel; micaceous; hard; moist	PB-5		PB	2.4/2.5 recovery tube slightly damaged by gravel
46		color change to moderate brown	J-5	16 31 36	SS	1.4/1.5 recovery
48					RD	
	CL/ML	49.0-59.0 SANDY CLAY/SANDY SILT: moderate brown; fine sand; medium dense to very stiff; moist				
50			C-6	10 16	DR	1.0/1.0 recovery 11/18/83
52		becomes wet and with more sand; very dense to hard			RD	11/19/83 27.0' water level losing fluid to hole added 0.6 sack bentonite.
54			PB-6		PB	2.3/2.5 recovery tube damaged, sample disturbed
56			J-6	11 18 40	SS	1.2/1.5 recovery
58					RD	slight rig chatter still losing fluid to hole. Added another 0.6 sack bentonite.
	CL/SC	59.0-79.4 SANDY CLAY/CLAYEY SAND: moderate brown; fine grained sand, subangular; trace gravel to 0.5", subrounded; hard to very dense; wet				
60			C-7	26 34	DR	1.0/1.0 recovery
62					RD	
64		grades clayey sand	PB-7		PB	2.5/2.5 recovery end of tube slightly damaged
66			J-7	10 23 30	SS	1.2/1.5 recovery
68						

Sheet 3 **of** 4

Project DESIGN UNIT A-310 Date Drilled 11/18-19/83 Hole No. 26-4

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	CL/SC	59.0-79.4 SANDY CLAY/CLAYEY SAND: (cont.)			RD	
70						
				11	DR	0.8/1.0 recovery
	(GC)	71.2-72.0' sand and gravel lens	C-8	20		
72					RD	switched to 4 7/8" tricone (rock) bit
		micaceous				
74						
			PB-8		PB	2.4/2.5 recovery
		sand content varies				
76						
				9	SS	1.2/1.5 recovery
			J-8	12		
				21		
78					RD	
	SC	79.4-82.5 CLAYEY SAND: moderate brown; some gravel; sand/gravel subrounded; very dense; wet				rig chatter
80						
				24	DR	1.0/1.0 recovery
			C-9	30		
82					RD	
	CL	82.5-86.5 SANDY CLAY: moderate yellowish brown; micaceous; hard; moist				
84						
			PB-9		PB	1.9/2.5 recovery rig chatter
86						11:15 completed 11/19/8
		B.H. 86.5' Terminated hole				Tremmied in 3 sack cement grout. 11/25/83, capped hole with concrete.
88						
90						
92						

Sheet 4 of 4

THIS BORING LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.

Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG 26-5

Proj: DESIGN UNIT A310
Date Drilled 11/7-9/84
Ground Elev. 347'
Drill Rig Failing 750
Logged By S. Slaff
Total Depth 85.5
Hole Diameter 4 7/8"
Hammer Weight & Fall 320 lbs, 18" DR, 140 lbs, 30" SS

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.8 <u>CONCRETE</u>			GB	
	SC	FILL 0.8-4.2 <u>SANDY CLAY</u>: grayish brown; micaceous; trace gravel; grades more sand with depth; grades moderate brown; soft; moist				
2					AD	
				1	DR	1.0/1.0 recovery
			C-1	3		
4					AD	
	CL	ALLUVIUM 4.2-14.2 <u>SANDY CLAY</u>: moderate yellowish brown; trace gravel; concentrations (0.25" diameter) of iron oxide-stained quartz sand; firm to stiff; moist				
				3	SS	1.3/1.5 recovery
6			J-1	3		
				3		circulating clear water
					RD	
8		very fine micaceous sand		3	DR	0.6/1.0 recovery
			C-2	4		slight rig chatter
					RD	
10				2	SS	1.1/1.5 recovery
			J-2	4		
				5		
12					RD	
				3	DR	0.9/1.0 recovery
14			C-3	6		rig chatter
					RD	
	GM	14.2-18.4 <u>SILTY GRAVEL</u>: moderate yellowish brown; gravel to 0.25"-1.5", angular to rounded; mostly subangular; loose; saturated				
				3	SS	0.5/1.5 recovery
16			J-3	2		
				3		
					RD	
18						losing drilling fluid to hole
				7	DR	
	CL	18.4-20.0 <u>SILTY CLAY</u>: dark reddish brown; micaceous trace gravel; very stiff; moist	C-4	9		1.0/1.0 recovery, mixed revert drilling fluid
20					RD	

Sheet 1 of 4

Project DESIGN UNIT A310 **Date Drilled** 11/7-9/83 **Hole No.** 26-5

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	CL	20.0-67.2 SANDY CLAY: moderate brown; fine to medium sand; trace gravel; hard; moist	J-4	9 17 22	SS	1.5/1.5 recovery
					RD	
22						
			PB-1		PB	2.5/2.5 recovery advanced 5" steel casing to 25'
24						
			J-5	12 18 25	DR	1.0/1.5 recovery
26		sand and gravel content varies throughout unit				
					RD	
28			C-5	20 30	DR	1.0/1.0 recovery
					RD	
30		palm tree roots	J-6	8 14 22	SS	1.1/1.5 recovery
					RD	rig chatter
32						
			C-6	11 17	DR	1.0/1.0 recovery
34					RD	
	SM	34.8-35.9 silty sand lens	J-7	14 11 11	SS	1.0/1.5 recovery
36	CL					
					RD	
38		micaceous	C-7	27 48	DR	1.0/1.1 recovery
					RD	
40			J-8	11 22 27	SS	0.9/1.5 recovery
					RD	
42						
			PB-2		PB	2.3/2.5 recovery
44						

Sheet 2 **of** 4

Project DESIGN UNIT A310 Date Drilled 11-7-9-83 Hole No. 26-5

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	CL	20.0-67.2 SANDY CLAY: continued	PB-2		PB	2.3/2.5 recovery
	(SC)	grades very stiff				
46			J-9	8 11 12	SS	0.8/1.5 recovery
					RD	rig chatter
48				23	DR	1.0/1.0 recovery
	(SM)	grades hard	C-8	38		
					RD	
50			J-10	9 16 22	SS	1.2/1.5 recovery
					RD	rig chatter
52						
	(ML/CL)			6	DR	1.0/1.0 recovery
54		grades stiff	C-9	9		
					RD	
			J-11	3 6 9	SS	1.5/1.5 recovery
56						
					RD	
58		grades hard		14	DR	1.0/1.0 recovery
			C-10	18		
					RD	rig chattering
60	SC	59.5-61.0 clayey sand lens: moderate brown; trace gravel; very dense; wet	J-12	18 27 34	SS	1.5/1.5 recovery
	CL					
62					RD	
					PB	2.1/2.5 recovery tube slightly damaged
64	(SM)	64.5-65.0 silty sand lens	PB-3			
66			J-13	25 36 50-5½"	SS	1.5/1.5 recovery
						added~5 lbs revert to drilling fluid
68	SM	67.2-77.0 SILTY SAND: moderate yellowish			RD	

Sheet 3 of 4

Project DESIGN UNIT A310 Date Drilled 11-7-9-83 Hole No. 26-5

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	SM	67.2-77.0 SILTY SAND: continued brown; with gravel; very dense; moist		43	DR	1.0/1.0 recovery
			C-11	43		
					RD	
70		gravel and fine content varies throughout unit	J-14	13 28 24	SS	0.7/1.5 recovery
72					RD	
				28	DR	0.85/0.85 recovery
74		becomes saturated	C-12	50-4	"	
					RD	loud rig chatter
76			J-15	6 17 31	SS	0.7/1.5 recovery 17:00 11/8/83
					RD	07:00 11/9/83
	ML	77.0-85.5 SANDY SILT: moderate brown; trace gravel; micaceous; fine sand; very dense; moist				
78				15	DR	1.0/1.0 recovery
			C-13	37		
					RD	rig chattering
80			J-16	10 19 24	SS	1.5/1.5 recovery
82					RD	minor rig chatter
			PB-4		PB	2.5/2.5 recovery
84						09:15 completed 11/9/8
86		B.H. 85.5' Terminated hole.				Conditioned hole then flushed it with clear water for 15 minutes. Set 2" ABS piezometer from 0.0-85.5 with perforated section from 55.5-75.5. Filled annulus with pea gravel from 20.0-85.5. Bentonite seal from 17.0-20.0. Backfilled with cuttings from 2.0-17.0. Concrete from 0.5-2.0
88						
90						
92						

Sheet 4 of 4

Converse Consultants, Inc.
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BORING LOG 27A

Proj: DESIGN UNIT A310 Date Drilled 2-8-9-83 Ground Elev. 350'
Drill Rig B. Auger Logged By D. Gillette Total Depth 95.0'
Hole Diameter 36" Hammer Weight & Fall N/A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-1.0 FILL AND CONCRETE				
2	CL	ALLUVIUM 1.0-40.0 SANDY CLAY: grayish brown; fine to medium sand, trace well rounded 1-1/2" gravel, soft to firm, moist				1.0-55.0 hole stands well
4						RTD photographers at hole
6						
8						
10						
12						
14		14.0-40.0 color changes to light brown				
16						
18						
20						

Sheet 1 of 5

Project DESIGN UNIT A310 **Date Drilled** 2-8-9-83 **Hole No.** 27A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	CL	1.0-40.0 SANDY CLAY: continued				
22						
24						
26						
28						
30						
32						
34						
36						
38						
40	SC	40.0-43.0 CLAYEY SAND: moderate brown; medium sand; medium dense; moist				
42						
	SM	43.0-46.0 SILTY SAND: moderate yellowish brown; fine sand; medium dense				
44						

Sheet 2 of 5

Project DESIGN UNIT A310 **Date Drilled** 2-8-9-83 **Hole No.** 27A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	SM	43.0-46.0 SILTY SAND: continued moist				
46	CL	46.0-47.0 SANDY CLAY: grayish brown; medium sand with coarse sand lenses				
	SC	47.0-55.5 CLAYEY SAND: light brown; medium sand; dense; moist				
48						
50						
52						▼ W.L. 52.4 2/10/83 8.35 am
54						
56	SW	55.5-57.5 SAND: moderate brown; medium to coarse sand; dense; moist				water first encountered at 55'; W.L. rises to 53' 8 hours after drilling to 95' hole ravels from 55.5-57.5'
58	SC (SP) (SM) (GM)	57.5-74.0 CLAYEY SAND: light brown; medium to coarse sand; contains sand and gravel lenses; dense; moist to wet 57.5-60.0' wet 60.0-74.0' moist				
60						
62						
64						
66						
68						

Project DESIGN UNIT A310 Date Drilled 2-8-9-83 Hole No. 27A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	SC (SP) (SM) (GM)	51.5-74.0 CLAYEY SAND: continued				
70						
72						72-95', upon completion of drilling, material caved
74	CL	74.0-87.0 CLAY: dusky yellowish brown; firm; moist				
76						
78						
80						
82						
84						
86						
	CL	87.0-95.0 SANDY CLAY: light brown; firm; moist				
88						
90						
92						

Sheet 4 of 5

Project DESIGN UNIT A310 **Date Drilled** 2-8-9-83 **Hole No.** 27A

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
92 94	CL	87.0-95.0 <u>SANDY CLAY</u>: continued				
96 98 100 102 104 106 108 110 112 114 116		B.H. 95.0' Terminated boring				Special Hole Closure completed 2/9/83 <u>Notes</u>: Water level at 55' 2 hour after drilling Water level at 52.4' 21 hours after drilling Hole filled with pea gravel to 50' and slurry to top

Sheet 5 of 5

THIS BORING LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.

Converse Consultants, Inc.
Earth Sciences Associates
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BORING LOG 28

Proj: DESIGN UNIT A-350 **Date Drilled** 1/5-7/81 **Ground Elev.** 385'

Drill Rig Failing 1500 **Logged By** L. Schoeberlein **Total Depth** 202'

Hole Diameter 4 7/8" **Hammer Weight & Fall** SS 140 lb @ 30" DR: 320 lbs @ 18"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-1.2 ASPHALT			AD	Auger to 10'
2	SC	ALLUVIUM 1.2-9.0 CLAYEY SAND: dark yellowish brown; dry to moist; very loose; occasional fine gravel				
4						
6			J-1	2 1 2	SS	1.5/1.5 recovery
					AD	
8						
	CL	9.0-14.0 SANDY CLAY: dark yellowish brown; moist; stiff				
10			J-2	5 5 5	SS	1.3/1.5 recovery
12					RD	Rotary wash, 4 7/8" drag bit
		becoming more sandy				
14	SC	14.0-19.0 CLAYEY SAND: moderate yellowish brown; moist; loose				
16			J-3	3 3 3	SS	1.2/1.5 recovery
					RD	
18						
	CL	19.0-21.0 SANDY CLAY: moderate yellowish brown;				
20						

Sheet 1 of 9

Project DESIGN UNIT A-350 **Date Drilled** 1/5-7/81 **Hole No.** 28

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	CL	19.0-21.0 SANDY CLAY: (continued) wet; soft	C-1		DR	1.0/1.0 recovery
	SC	21.0-23.0 CLAYEY SAND: moderate yellowish brown; wet; loose	J-4	5 3 6	SS	1.3/1.5 recovery
22						
					RD	rig chatter
	GP	23.0-24.0 GRAVEL: subangular to subrounded; fine to coarse				
24	SP	24.0-31.0 SAND: moderate yellowish brown; dense; occasional gravel; wet				
			J-5	10 15 16	SS	0.7/1.5 recovery
26						
					RD	
28						
30				6 20 24	SS	0.0/1.5 recovery rock stuck in bit
	SC	31.0-54.8 CLAYEY SAND: moderate yellowish brown; medium dense to dense; wet; occasional fine to coarse gravel				
32					RD	
34						
			J-6	9 11 12	SS	0.7/1.5 recovery
36						1/5/81 1/6/81 water at 15'
					RD	
38						
			C-2		DR	0.7/1.0 recovery
40		becoming silty and dense				
				17 19 20	SS	0.0/1.5 recovery
					RD	
42						
44						

Sheet 2 of 9

Project DESIGN UNIT A-350 **Date Drilled** 1/5-7/81 **Hole No.** 28

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	SC	31.0-54.8 CLAYEY SAND: (continued)			RD	
			J-7	8 11 11	SS	1.1/1.5 recovery
46						
					RD	
48						
50			J-8	9 13 13	SS	1.0/1.5 recovery
	(SP)	interbedded sand				
					RD	
52						
54	(GP)	- 54.5 thin gravel lens				
	CL	54.8-59.8 SANDY CLAY: moderate brown; moist; very stiff	J-9	5 8 8	SS	1.1/1.5 recovery
56						
					RD	
58						
			C-3		DR	0.7/1.0 recovery
60	SC	59.8-64.7 CLAYEY SAND: moderate yellowish brown; occasional gravel; moist; dense; interbeds of sandy clay and sand	J-10	11 17 17	SS	1.1/1,5 recovery
					RD	
62						
64						
	SP	64.7-96.5 SAND: moderate yellowish brown; moist; dense; occasional gravel	J-11	20 18 26	SS	1.1/1.5 recovery
66						
					RD	
68						

Sheet 3 **of** 9

Project DESIGN UNIT A-350 Date Drilled 1/5-7/81 Hole No. 28

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	SP	64.7-96.5 SAND: (continued)			RD	
70		becoming very dense	J-12	29 36 34	SS	1.1/1.5 recovery
72	(GW)	71.5-73.5' gravel lens			RD	chatter
74						
76			J-13	30 44 42	SS	0.5/1.5 recovery
					RD	
78						
	(SC)	moderate brown; clay increase	C-4		DR	0.7/1.0 recovery
80			J-14	37 35 40	SS	1.0/1.5 recovery
82		cobbles			RD	rig chatter @ 81.5', cemented sandstone in shoe of SPT
84						rig chatter
		weakly cemented; very dense	J-15	50	SS	0.25/0.25 recovery
					RD	
86		increased cementation				
88		moderate yellowish brown				
90			J-16	50	SS	0.2/0.2 recovery
92						

Sheet 4 of 9

Project DESIGN UNIT A-350 **Date Drilled** 1/5-7/81 **Hole No.** 28

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
92	SP	64.7-96.5 SAND: (continued)			RD	
	(CL)	93.0-94.0' sandy clay				
94						
	(GW)	gravel layer				
			J-17	50	SS	0.3/0.3 recovery
96						intense chatter
	CL	96.5-109.0 SANDY CLAY: moderate brown; moist; very stiff				
98						
			C-5		DR	1.0/1.0 recovery
100				9 11 16	SS	0.0/1.5 recovery
102					RD	intermittent chatter
104						
			J-18	18 18 23	SS	0.6/1.5 recovery
106					RD	
108						
						rig chatter
110	SP GW	109.0-113.5 SAND/GRAVEL: moderate brown; interbedded, sand with occasional well graded gravel	J-19	50 56	SS	0.7/1.0 recovery
					RD	
112						
114	CL	113.5-118.0 SANDY CLAY: moderate brown; interbedded with clayey sand; moist to wet; dense				
116			J-20	18 28	SS	

Sheet 5 **of** 9

Project DESIGN UNIT A-350 **Date Drilled** 1/5-7/81 **Hole No.** 28

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
116	CL	113.5-118.0 SANDY CLAY: (continued)	J-20	28	SS	1.1/1.5 recovery
					RD	
118	SC	118.0-125.0 CLAYEY SAND: moderate yellowish brown; moist; very dense; interbedded with sandy gravel and clayey gravel				
120			C-6		DR	1.0/1.0 recovery
			J-21	22 34 50	SS	1.2/1.3 recovery
122					RD	
124	(GW)	gravel lens				chatter
	SP	125.0-134.0 GRAVELLY SAND: moderate yellowish brown; moist to wet; very dense	J-22	62 51	SS	1.0/1.0 recovery
126					RD	
128						
						chatter
130			J-23	56	SS	0.2/0.5 recovery
					RD	
132						slight chatter
134	SC	134.0-156.0 CLAYEY SAND: moderate brown; occasional gravel; moist to wet; very dense				
			J-24	24 45 59	SS	1.3/1.5 recovery
136					RD	
		increasing clay with depth				
138						
			C-7		SS	1.0/1.0 recovery
140						

Sheet 6 **of** 9

Project DESIGN UNIT A-350 **Date Drilled** 1/5-7/81 **Hole No.** 28

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
140	SC	134.0-156.0 CLAYEY SAND: (continued)	J-25	41 50	SS	0.8/0.8 recovery
		becoming gravelly			RD	
142						
144						
			J-26	28 41 60	SS	1.3/1.5 recovery 1/6/81
146					RD	1/7/81
148						
150			J-27	43 50	SS	0.75/0.75 recovery
					RD	
152		becoming less clayey				
154						
			J-28	50	SS	
					RD	0.3/0.3 recovery
156	SP	156.0-178.6 SAND: moderate yellowish brown; moist; very dense; fine to coarse gravel				
158						
			C-8		DR	1.0/1.0 recovery
160		becoming silty		50	SS	0.0/0.25 recovery
					RD	intense chatter
162						
164						

Sheet 7 **of** 9

Project ______ Date Drilled ______ Hole No. ______

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
164	SP	156.0-178.6 SAND: (continued)			RD	
				50	SS	0.0/0.3 recovery
166						
	(SM)	167.0-168.5' silty sand				
168						
170		interbedded with fine sand		39	SS	1.4/1.5 recovery
			J-29	46		
				46		
172					RD	
174						
		clayey sand with occasional sand lenses		28	SS	0.0/1.5 recovery
				34		
176				42		
					RD	
178						
	SC	178.6-188.4 CLAYEY SAND: moderate yellowish brown; moist; very dense	C-9		DR	1.0/1.0 recovery
180				71	SS	1.0/1.3 recovery
			J-30	41		
				50		
		occasional gravel			RD	
182						chatter
184						
		thin gravel lenses		61	SS	0.0/0.5 recovery
186					RD	
188						

Sheet 8 of 9

Project DESIGN UNIT A-350 **Date Drilled** 1/5-7/81 **Hole No.** 28

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
188	SC	178.6-188.4 CLAYEY SAND: (continued)			RD	intense chatter
	SC GC	188.4-196.0 CLAYEY SAND/GRAVEL: moderate yellowish brown; moist; dense				
190				50	SS	0.0/0.25 recovery
						intense chatter
192						
194						
			J-31	50	SS	0.1/0.1 recovery
					RD	
196	CL	196.0-202.0 SANDY CLAY: moderate yellowish brown; moist; very stiff				
198						
200					DR	0.0/0.5 recovery
			J-32	58 51 36	SS	1.5/1.5 recovery
202		B.H. 202.0' Terminated hole; 1/7/81 downhole geophysical survey (GRC) 1/7/81 E-logs (ESA) 1/7/81 water at 75' 1/12/81 cased (4" PVC) and grouted to 100'				
204						
206						
208						
210						
212						

Sheet 9 of 9

Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG 28C

Proj: DESIGN UNIT A-350
Date Drilled 10-10-83
Ground Elev. 406'
Drill Rig Bucket
Logged By J. Stellar
Total Depth 57'
Hole Diameter 32"
Hammer Weight & Fall

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.2 A.C. PAVEMENT				observation hole no sampling required
	ML	FILL 0.2-4.0 SILT: dark brown; firm; moist; with sand				
2						
4	SP	ALLUVIUM 4.0-12.0 SAND: light reddish brown; slightly moist; loose to medium dense; occasional silt inclusions; trace of fine gravel				
6						
8						
10		coarse gravel				
12	SP	12.0-16.0 GRAVELLY SAND: light reddish brown; moist; medium dense; occasional silt inclusions				
14						
		cobbles				
16	SP/SM	16.0-42.0 SAND: medium brown; moist; medium dense; silty in places				
18						
20						

Sheet 1 of 3

Project DESIGN UNIT A-350 **Date Drilled** 10-10-83 **Hole No.** 28C

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	SP	16.0-42.0 SAND: (continued)				
22						
24						
26						
		becoming silty				
28						
30						
32						
34						
		becoming silty				
36		light greenish brown; very moist				
38						
40						
42	SP	42.0-45.0 GRAVELLY SAND: brown to light greenish brown; very moist; medium dense				
44						

Sheet 2 of 3

Project DESIGN UNIT A-350 Date Drilled 10-10-83 Hole No. 28C

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	SP	42.0-45.0 GRAVELLY SAND: (continued)				
46	ML	45.0-49.0 SILT: light greenish brown to medium brown; firm; very moist; with lenses of silty sand				
48		becoming dark brown slight petroleum odor				
50	ML	49.0-55.0 CLAYEY SILT: dark brown; very moist; firm to stiff				
52		wet; very strong petroleum odor				standing water @ 52.0'
54		becoming sandy and gravelly				
56	SM	55.0-57.0 SILTY SAND: interlaced with sandy silt; wet				bag sample at 55.0'
58		B.H. 57.0' Terminated hole Terminated due to sloughing. Gas in hole is 3% level. Gasoline (±1") on top of GWT.				case hole to 50.0'; hole belled about 6'-8' at 52' (GWT) but did not cave above 52' when casing was pulled
60						
62						
64						
66						
68						

Sheet 3 of 3

Converse Consultants, Inc.
Earth Sciences Associates
Geo/Resource Consultants

BORING LOG 28-6

Proj: DESIGN UNIT A350
Date Drilled 11-16-83
Ground Elev. 385.5'
Drill Rig Failing 1500
Logged By P. Moon
Total Depth 82.5'
Hole Diameter 4 7/8"
Hammer Weight & Fall SS 140 lb 30" DR: 320 lbs. @ 18"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.75 CONCRETE 0.75-1.0 BASE ROCK			GB	
	CL	ALLUVIUM 1.0-3.5 SANDY CLAY: dark yellowish brown; moist; stiff				
2				3	DR	0.6/1.0 recovery
			C-1	6		
					AD	
4	SC	3.5-6.5 CLAYEY SAND: dark yellowish brown; moist; medium dense	J-1	4 4 7	SS	
6					RD	
	CL	6.5-16.0 SANDY CLAY: dark yellowish brown; moist; stiff		6	DR	0.8/1.0 recovery
8			C-2	9		
					RD	
10			J-2	4 6 8	SS	
					RD	
12				9	DR	1.0/1.0 recovery
			C-3	11		
					RD	
14		trace of gravel				
			J-3	3 5 7	SS	
16	SW	16.0-18.5 SAND: moderate yellowish brown; moist; medium dense			RD	
				12	DR	1.0/1.0 recovery
18			C-4	16		
					RD	
	SC	18.5-22.0 CLAYEY SAND: moderate yellowish				
20			J-4	5 10	SS	

Sheet 1 of 4

Project DESIGN UNIT A350 **Date Drilled** 11-16-83 **Hole No.** 28-6

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	SC	18.5-22.0 CLAYEY SAND: continued brown; moist; medium dense	J-4	9	SS	
					RD	
22	CL	22.0-25.5 SANDY CLAY: moderate yellowish brown; moist; medium dense		12	DR	1.0/1.0 recovery
			C-5	13		
					RD	
24			J-5	11 13 19	SS	
					RD	
26	SC	25.5-27.5 CLAYEY SAND: moderate yellowish brown; moist; wet; medium dense to dense				
				22	DR	1.0/1.0 recovery
			C-6	29		
28	SP	27.5-31.5 SAND: moderate yellowish brown; moist; dense			RD	
			J-6	9 22 23	SS	
30						
					RD	
32	SC	31.5-51.5 CLAYEY SAND: moderate yellowish brown; moist; medium dense; with sandy clay		28	DR	1.0/1.0 recovery
			C-7	38		
					RD	
34			J-7	9 14 15	SS	
36					RD	
				17	DR	1.0/1.0 recovery
			C-8	36		
38					RD	
			J-8	7 10 12	SS	
40						
					RD	
42				22	DR	1.0/1.0 recovery
			C-9	37		
					RD	
44						

Sheet 2 of 4

Project DESIGN UNIT A350 **Date Drilled** 11-16-83 **Hole No.** 28-6

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	SC	31.5-51.5 CLAYEY SAND: continued moderate yellowish brown; wet; medium dense to dense; trace of gravel	J-9	7 14 16	SS	
					RD	
46						
				21	DR	1.0/1.0 recovery
			C-10	36		
48					RD	
			J-10	16 20 21	SS	
50					RD	
52	SW SM	51.5-53.5 GRAVELLY SAND: moderate yellowish brown;wet; very dense; silty in places		24	DR	refusal at 11"
			C-11	50		
					RD	
54	GW	53.5-56.0 SANDY GRAVEL: brown; wet; very dense	J-11	50	SS	
					RD	
56	SC	56.0-61.5 CLAYEY SAND: moderate brown; wet; very dense				
				110	DR	no recovery refusal at 4"
58						
			J-12	30 50	SS	11/16/83 11/17/83
60					RD	
62	SW	61.5-67.0 GRAVELLY SAND: moderate brown; wet; very dense		110 50	DR	no recovery refusal at 9"
					RD	
64			J-13	39 50	SS	refusal at 10"
					RD	no recovery
66						
				115	DR	refusal at 9"
68	SC	67.0-81.0 CLAYEY SAND:				

Project DESIGN UNIT A350 **Date Drilled** 11-17-83 **Hole No.** 28-6

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	SC	67.0-81.0 <u>CLAYEY SAND</u>: continued moderate yellowish brown; wet; very dense			RD	
			J-14	12 20 32	SS	
70					RD	
72				44 34		
			P-1			
74						
			J-15	29 33 37		
76						
		scattered fine to coarse gravel				
78						
			C-12	183		refusal at 4"
80						
	SW	81.0-82.5 <u>GRAVELLY SAND</u>: wet; very dense				
82			J-16	63		refusal at 6"
		B.O.H. 82.5'				following sample J-16, boring caved to 58' Attempted to redrill to 82'. Boring continued to cave. Grout seal placed.
84						
86						
88						
90						
92						

Sheet 4 of 4

THIS BORING LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.

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BORING LOG 28-7

Proj: DESIGN UNIT A350 **Date Drilled** 11-19-20-83 **Ground Elev.** 382.5'

Drill Rig FAILING 750 **Logged By** St. Slaff **Total Depth** 99.9'

Hole Diameter 4 7/8" **Hammer Weight & Fall** 140 lbs., 30"SS,320 lb, 18" DR

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.4 ASPHALT			AD	
		0.4-0.7 BASE ROCK				
	CL	0.7-2.8 SANDY CLAY: moderate brown; dry; soft; micaceous				
2		2.5 becoming moist; stiff				
	SC	2.8-9.4 CLAYEY SAND:moderate brown; moist; loose; minor steel debris; trace of fine gravel		2	DR	1.0/1.0 recovery
4			C-1	3		
					AD	
			J-1	3 4 4	SS	1.5/1.5 recovery
6						
					RD	
8		8.8 decreasing fines; moderate yellowish brown		4	DR	0.4/1.0 recovery
			C-2	5		
					RD	
10	CL	ALLUVIUM 9.4-32.5 SANDY CLAY: moderate yellowish brown; moist; stiff; trace of gravel	J-2	2 5 6	SS	
					RD	
12						
		13.0 becoming more sandy		3	DR	0.9/1.5 recovery
14			C-3	5		
					RD	
		becoming less sandy	J-3	2 4 5	SS	1.3/1.5 recovery
16						
					RD	
18			PB-1		PB	0.2/2.5 recovery
20						

Sheet 1 of 5

Project DESIGN UNIT A 350 **Date Drilled** 11-19-20-83 **Hole No.** 28-7

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	CL	9.4-32.5 SANDY CLAY: (continued)			PB	
		increasing sand with depth	J-4	3 6 6	SS	0.8/1.5 recovery
22					RD	
		occasional gravel		9	DR	0.6/1.0 recovery
			C-4	42		
24					RD	
			J-5	5 6 8	SS	0.5/1.5 recovery
26					RD	slight rig chatter
28				6	DR	
			C-5	8		
					RD	
30		becoming very stiff	lost	5 8 11	SS	0.0/1.5 recovery
32					RD	11-19-83 11-20-83 ground water level 15.2'
	SM	32.5-39.6 SILTY SAND: moderate yellowish brown; trace of gravel; moist medium dense		13	DR	0.9/1.0 recovery
34			C-6	16		
					RD	minor rig chatter
			J-6	7 10 10	SS	
36					RD	minor rig chatter
38			PB-2		PB	1.6/2.5 recovery
40	CL	39.6-53.0 SANDY CLAY: moderate yellowish brown; moist; stiff	J-7	5 6 11	SS	0.7/1.5 recovery
42					RD	
		increasing sand with depth		9	DR	0.8/1.0 recovery
44			C-7	17		

Sheet 2 of 5

Project DESIGN UNIT A350 **Date Drilled** 11-19-20-83 **Hole No.** 28-7

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	CL	39.6-53.0 SANDY CLAY: (continued)			RD	
			J-8	5 5 7	SS	0.5/1.5 recovery
46						
		becoming very stiff			RD	
48				10	DR	0.0/1.0 recovery
			lost	14		
					RD	
50			J-9	7 11 18	SS	0.9/1.5 recovery
					RD	
52						
	SM	53.0-54.6 SILTY SAND: moderate yellowish brown; moist; very dense; with gravel	C-8	27 50	DR	0.9-0.9 recovery refusal at 11" rig chatter
54						
	ML/SM	54.6-84-5 SANDY SILT/SILTY SAND: moderate yellowish brown; wet; very stiff to hard, medium dense to very dense; occasional gravel	J-10	8 12 9	SS	0.8/1.5 recovery heavy rig chatter
56						
					RD	
58						
			PB-3		PB	
60						rig chatter 0.5/2.5 recovery tube damaged/sample disturbed
			J-11	37 40 27	SS	0.4/1.5 recovery
62						
					RD	
	GP	63.8-64.0 gravel lens	C-9	22 16	DR	
64					RD	0.5/1.0 recovery
			J-12	27 37 19		0.6/1.5 recovery
66						
					RD	
68						

Sheet 3 of 5

Project DESIGN UNIT A350 **Date Drilled** 11-19-20-83 **Hole No.** 28.7

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	ML/ SM	54.6-84.5 SANDY SILT/SILTY SAND: (continued)	C-10	23 33	DR	1.0/1.0 recovery
					RD	
70			J-13	20 29 17	SS	0.6/1.5 recovery
72	GW	72.0-72.8 sandy gravel lens			RD	rig chatter
			C-11	32 47	DR	0.8/1.0 recovery
74					RD	
			J-14	27 47 40	SS	0.9/1.5 recovery
76					RD	
78			PB-4		PB	
80			J-15	27 50	SS	0.3/0.75 recovery
					RD	
82						violent rig chatter
			C-12	60 50	DR	0.75/0.75 recovery refusal at 9"
84					RD	violent rig chatter
	CL	84.5-87.0 SANDY CLAY: mottled-moderate brown; greyish green and dark grey; moist; hard	J-16	4 14 18	SS	0.7/1.5 recovery
86					RD	rig chatter
	CL	87.0-92.2 SILTY CLAY: mottled moderate brown; light brown; moderate yellowish brown; moist, hard; trace of sand				
88			C-13	35 32	DR	1.0/1.0 recovery
					RD	
90			J-17	13 19 20	SS	
92					RD	

Sheet 4 of 5

Project DESIGN UNIT A310 **Date Drilled** 11-19-20-83 **Hole No.** 28-7

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
92	CL SM	87.0-92.2 SILTY CLAY: (continued) 92.2-99.3 SILTY SAND: moderate brown; wet; very dense; trace of gravel			RD	
			C-14	44 50	DR	0.9/0.9 recovery
94					RD	refusal at 11"
			J-18	19 27 20	SS	0.5/1.5 recovery
96					RD	
98		99.3-99.9 SAND/SILTY SAND: moderate brown; wet; very dense				
	SP/SM		C-15	32 50	DR	0.9/0.9 recovery 11-20-83
100		B.H.99.9' terminate hole				11-21-83 groundwater level 36.3" hole filled with 3 sack cement grout, cleaned site, covered hole with steel street cover 11-29-83 removed steel cover capped hole with concrete
102						
104						
106						
108						
110						
112						
114						
116						

Sheet 5 of 5

BORING LOG CEG 25

Proj: DESIGN UNIT A 310
Date Drilled 12/29-31/80
Ground Elev. 323'
Drill Rig FAILING 1500
Logged By Gallinatti
Total Depth 202.5'
Hole Diameter 4 7/8"
Hammer Weight & Fall DR. 320 lb @ 18" SS 140 lb @ 30"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-1.0 CONCRETE (sidewalk)			AD	Begin drilling 9:15 12-29-80
	SM	1.0-15.0 SILTY SAND: yellowish moderate brown; fine to coarse angular sand; trace rounded gravel; loose; moist				
2						
4					RD	
6						
8		increase in silt content; and less coarse sand and gravel				
10			J-1	2 4 3	SS	1.1/1.5 recovery
12					RD	
14						
	CL	15.0-26.0 SANDY CLAY: yellowish moderate brown; fine to medium grained angular sand; firm; moist				
16						
18						
20						

Project DESIGN UNIT A310 **Date Drilled** 12-29-80 **Hole No.** CEG 25

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	CL	15.0-26.0 SANDY CLAY: (continued)	C-1	11	DR	0.5/1.0 recovery
			J-2	4 6 7	SS	1.2/1.5 recovery
22						
					RD	
24						
26	SM	26.0-49.0 SILTY SAND: yellowish moderate brown; very fine to fine sand; medium dense; moist				
28						
30			J-3	4 6 10	SS	1.1/1.5 recovery
32					RD	
34						
36		36.0-49.0 less fine sand; and some medium to coarse sand				
38						
40		41.0 grades trace clay and dense	C-2	28	DR	0.9/1.0 recovery
			J-4	9 16 17	SS	1.2/1.5 recovery
42					RD	
44						

Sheet 2 **of** 9

Project DESIGN UNIT A310 **Date Drilled** 12-29-80 **Hole No.** CEG 25

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	SM	26.0-49.0 SILTY SAND: (continued)			RD	
46						
48						
	ML	49.0-52.0 SANDY SILT: yellowish moderate brown; fine to coarse sand; trace scattered pea gravel; medium dense; moist				
50			J-5	7 10 16	SS	1.5/1.5 recovery pocket penetrometer 2.0 tsf (broke apart) 2-9-81
52	SM	52.0-58.0 SILTY SAND: yellowish moderate brown; fine to coarse sand; medium dense; moist			RD	
54						
56						
		contact: increase in silt and strength				
58	ML/CL	58.0-97.0 SANDY SILT/SANDY CLAY: moderate brown; dense to stiff; moist				
60			C-3	69	DR	1.0/1.0 recovery
			J-6	7 13 21	SS	1.5/1.5 recovery
62					RD	
64						
66						
68						

Project DESIGN UNIT A310 **Date Drilled** 12-29-80 **Hole No.** CEG 25

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	ML/ CL	58.0-97.0 SANDY SILT/SANDY CLAY:(continued)			RD	
70		gradational increase in grain size with depth; grades predominately medium to coarse sand	J-7	18 17 13	SS	1.3/1.5 recovery
72					RD	
74						
76						
78						
80			C-4	49	DR	
			J-8	17 29 55	SS	1.5/1.5 recovery
82	(SC)	82.0 CLAYEY SAND				
					RD	
84						stop drilling 5:00 12-29-80
86						12-30-80- gas test 7:00 a.m. 20% O_2, 0% combustible
88						
90		medium sand layer ~ 0.1' thick	J-9	18 17 13	SS	1.4/1.5 recovery pocket penetrometer 1.0 tsf (broke apart) 2-9-81
92					RD	

Project DESIGN UNIT A310 **Date Drilled** 12-30-80 **Hole No.** CEG 25

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
92	ML/CL	58.0-97.0 SANDY SILT/SANDY CLAY: (continued)			RD	
94						
96						
	SM	97.0-135.0 SILTY SAND/CLAYEY SAND: moderate brown; fine to coarse sand; very dense; moist				
98						
100	(CL)	100.0-101.0 SANDY CLAY: hard	C-5	54	DR	0.9/1.0 recovery
			J-10	19 37 40	SS	1.2/1.5 recovery
102						
					RD	
104						
106						
108						
110	(SC)	111.0 CLAYEY SAND	J-11	19 13 21	SS	1.5/1.5 recovery
112					RD	
114						
116						

Sheet 5 of 9

Project DESIGN UNIT A 310 **Date Drilled** 12-30-80 **Hole No.** CEG 25

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
116	SM	97.0-135.0 SILTY SAND/CLAYEY SAND: (continued)			RD	
118						
120			C-6	85	DR	
				26	SS	1.0/1.0 recovery
122				20		0.0/1.5 recovery
				26		
					RD	
124						
126						
128						
130				23	SS	
			J-12	46		1.2/1.5 recovery
				38		
132					RD	
134						
	ML	135.0-144.0 SILT: dark moderate brown; trace fine to medium angular sand; very dense; moist				
136						
138						
140						

Sheet 6 of 9

Project DESIGN UNIT A 310 Date Drilled 12-30-80 Hole No. CEG 25

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
140	ML	135.0-144.0 SILT: (continued)	C-7	94	DR	1.0/1.0 recovery
		141.0 CLAYEY SILT	J-13	15 25 29	SS	1.4/1.5 recovery
142						
					RD	
144	SM	144.0-157.0 SILTY SAND: moderate brown; fine to coarse sand; dense; moist				
146						
148						
150			J-14	29 40 37	SS	1.5/1.5 recovery pocket penetrometer 4.5 tsf (broke apart) 2-9-81
152					RD	
154						
156						
	ML	157.0-173.0 SANDY SILT: moderate brown fine to coarse angular sand; dense; moist				
158						
160			C-8	97	DR	1.0/1.0 recovery
			J-15	17 35 40	SS	1.5/1.5 recovery
162					RD	
164						

Sheet 7 of 9

Project DESIGN UNIT A310 Date Drilled 12-30-80 Hole No. CEG 25

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
164	ML	157.0-173.0 <u>SANDY SILT</u>: (continued)			RD	
166						
168						
170			J-16	37 50	SS	1.0/1.0 recovery
					RD	stop drilling: 4:30 12-30-80
172						
	SM	173.0-202.5 <u>SILTY SAND</u>: moderate brown; fine to coarse sand; dense; moist				Begin drilling 7:30 12-31-80
174						
176						
178						
180			C-9	100/ 0.9"	DR	0.7/0.9 recovery
			J-17	34 41 46		1.3/1.5 recovery
182						
					RD	
184						
186						
188						

Sheet 8 of 9

Project DESIGN UNIT A310 **Date Drilled** 12-30-80 **Hole No.** CEG 25

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
188	SM	173.0-202.5 <u>SILTY SAND</u>: (continued)			RD	
190			J-18	26 30 55	SS	1.5/1.5 recovery
192					RD	
194						
196						
198						
200	(SC)	200.0 <u>CLAYEY SAND</u>	C-10	86	DR	0.6/1.0 recovery pocket penetrometer 3.5 tsf (broke apart)
			J-19	26 33 55	SS	2-9-81 /1.5 recovery
202						
	B.H.	202.5 Terminate Hole				completed 11:20,12-31-80. install 2" PVC piezometer to 200' with perforations from 40' to 60'; 100' to 120' and 160' to 195', backfill with pea gravel; water sampled 2-13-81
204						
206						
208						
210						
212						

Sheet 9 of 9

THIS BORING LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.

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BORING LOG CEG 26

Proj: DESIGN UNIT A-310 **Date Drilled** 12/29-31/80 **Ground Elev.** 316'

Drill Rig Failing 1500 **Logged By** Schoeberlein **Total Depth** 209.5'

Hole Diameter 4 7/8" **Hammer Weight & Fall** SS: 140 lb @ 30" DR: 320 lb @ 18"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0	(AC)	0.0-1.0 CONCRETE			AD	hole moved 1' east due to proximity of overhead wires
2	CL	ALLUVIUM 1.0-7.0 SILTY CLAY: olive black, highly plastic fines; stiff; moist				
4		grading sandy				
6		minor color change to greyish brown, less stiff				
8	CL	7.0-36.0 SANDY CLAY: moderate brown; medium to fine grained sand; stiff; dry				
10			J-1	9 10 11	SS	1.3/1.5 recovery
12					RD	
		13'-14' sand lense				
14						
		15'-16' clay lense sand content decreasing				
16						
18						
20			C-1	20 31	DR	0.8/1.0 recovery

Sheet 1 **of** 9

Project DESIGN UNIT A-310 **Date Drilled** 12/29-31/80 **Hole No.** CEG-26

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	CL	7.0-36.0 SANDY CLAY: (Continued)	J-2	26 28 31	SS	0.7/1.5 recovery
	(SM)	21.0- silty sand lens/layer very dense				
22					RD	
24						
26						
28						
		very stiff	J-3	14 13 10	SS	0.9/1.5 recovery
30					RD	losing circulation mixed in 1/2 bag bentonite
32						
34						
		35' gravel lense 1' thick				
36	SM	36.0-48.0 SILTY SAND: moderate brown; fine to medium sand; dense, saturated				
38						
			C-2	9 12	DR	1.0/1.0 recovery
40				25 19 25	SS	0/1.5 recovery saturated samples
					RD	
42						
44						

Sheet 2 **of** 9

Project DESIGN UNIT A-310 Date Drilled 12/29-31/80 Hole No. CEG-26

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	SM	36.0-48.0 CLAYEY SAND: (Continued)			RD	
46						
48	CL	48.0-66.0 SANDY CLAY: moderate brown; fine to medium grained sand; hard; moist				
50			J-4	11 14 21	SS	1.5/1.5 recovery
52					RD	
54	(GM)	53.5' - gravel lense				chatter
56						
58						
			C-3	11 17	DR	1.0/1.0 recovery
60			J-5	22 29 48	SS	1.1/1.5 recovery
62					RD	
64						
66	GP	66.0-68.0 gravel lense				
68						

Sheet 3 of 9

Project DESIGN UNIT A-310 **Date Drilled** 12/29-31/80 **Hole No.** CEG-26

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	SC	68.0-71.0 CLAYEY SAND: moderate brown; dense; moist. 69.0-69.5 gravel lens			RD	
70			J-6	29 21 18	SS	1.3/1.5 recovery
	CL	71.0-114.0 SANDY CLAY/SILTY CLAY: moderate brown; moderately plastic fines; very fine grained sand; very stiff to hard; moist			RD	
72						
74						
76						
78		sand content decreases plasticity of fines increases				
		79.0-80.0 SILTY CLAY: very stiff to hard; moist	C-4	17 26	DR	0.7/1.0 recovery drove rock ahead
80				21 17 23	SS	0/1.5 recovery
82					RD	
84						
86						
88						
90		90.0-91.5 SILTY CLAY/SANDY CLAY: very stiff; moist	J-7	11 14 19	SS	1.5/1.5 recovery
92					RD	

Project DESIGN UNIT A-310 Date Drilled 12/29-31/80 Hole No. CEG-26

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
92	CL	71.0-114.0 SANDY CLAY/SILTY CLAY: (Continued)			RD	
94						
96						
98		98.0-102.0 sandy clay with gravel				chatter
		clayey sand interbed	C-5	21 25	DR	0.9/1.0 recovery 1.5/1.5 recovery
100			J-8	14 19 22	SS	
102	CL				RD	
104						
106						
108	SP	108.0-110.0 sandy lens				
110	CL	110.0-114.0 clayey sand	J-9	25 21 21	SS	1.5/1.5 recovery 12/29/80
					RD	12/30/80 water at 20' in a.m.
112						
114	CL (SM) (SC)	114.0-164.0 SILTY CLAY: moderate reddish brown; moderately plastic fines, medium grained sand in interbeds				
116						

Sheet 5 of 9

Project DESIGN UNIT A-310 **Date Drilled** 12/29-31/80 **Hole No.** CEG-26

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
116	CL (SM) (SG)	114.0-164.0 SILTY CLAY: (Continued) hard to very dense; moist; interbeds of sand, sandy clay and clayey sand			RD	
118						
		119.0-120.0 CLAYEY SILT	C-6	17 25	DR	1.0/1.0 recovery
120			J-10	19 21 42	SS	1.4/1.5 recovery
					RD	
122						
124						
126						
128						
130			J-11	7 9 30	SS	1.5/1.5 recovery
					RD	
132						
	GP	134.0' - thin gravel lens				minor chatter
134						
	CL					
136						
			S-1		PB	changed to pitcher barrel to ease the sampling process 1.8/2.0 recovery
138	CL-SC	138.0' - silty fine to coarse sand and gravel samples: clayey sand to sandy clay, dense moist variable throughout				
140			J-12	36	SS	

Sheet 6 **of** 9

Project DESIGN UNIT A-310 **Date Drilled** 12/29-31/80 **Hole No.** CEG-26

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
140	CL	114.0-164.0 SILTY CLAY: (Continued) increased content of sand, decreased content of clay/ sandy silt	J-12	31 38	SS	1.1/1.5 recovery
	(ML)				RD	
142						
144						
146						
148						
150			J-13	15 20 33	SS	1.5/1.5 recovery
					RD	
152						
154	GP	155 - thin gravel lens 0.5'				chatter
	CL					
156						
			S-2		PB	1.7/2.0 recovery
158	(SC GC)	158.0-159.0 clayey coarse sand and gravel				
	SC	159.5-160.6 clayey sand lense very dense, occasional gravel to .75'	J-14	35 50	SS	0.8/0.9 recovery
160					RD	
162						
164						

Sheet 7 of 9

Project DESIGN UNIT A-310 **Date Drilled** 12/20-31/80 **Hole No.** CEG-26

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
164	ML	164.0-173.0 SANDY SILT: moderate brown; non-plastic fines; fine to medium sand with occasional gravel; very dense; moist; gradational contact			RD	
166						
168						
170			J-15	17 26 32	SS	1.5/1.5 recovery
					RD	
172						
	SC/ SM	173.0-190.0 CLAYEY SAND/SILTY SAND: moderate brown; well graded sand in places; moist; very dense				
174		174.0 - thin gravel lens 175.0 - thin gravel lens				rig chatter
176						
178			S-3		PB	1.8/2.5 recovery
	(SM)	180.0 - silty fine to coarse sand with gravel				
180			J-16	24 53	SS	1.0/1.0 recovery
					RD	
182		clay content decreases				
184						
186						
	GC	187.0' - thin gravel lens				chatter drill rate slowed
188						

Project DESIGN UNIT A-310 Date Drilled 12/29-31/80 Hole No. CEG-26

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
188	SC	173.0-190.0 CLAYEY SAND: (Continued)			RD	drill rate increase
190	SW/SM	190.0-198.0 SAND/SILTY SAND: grey and white; contains gravel to 1/2", very dense; gravels and coarse sand subround to round, medium sand subangular to angular		85	SS	0.0/0.5 recovery
					RD	
192						
194						
196						
198	ML	FERNANDO FORMATION 198.0-209.5 SILTSTONE: dusky yellow; low plasticity fines; very dense; moist				
			C-7	64 100-	DR 0.45'	.95/.95 recovery drilling to 210 then PB possible bedrock
200					RD	
202						
204		204.0' - color change to dusky green				minor chatter
206						
208			S-4		PB	1.8/2.0 recovery
210		B.H. 209.5 terminated hole				completed 12/31/80 water sampled 2/12/81
212						

Sheet 9 of 9

THIS BORING LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.

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BORING LOG CEG 27

Proj: DESIGN UNIT A310 **Date Drilled** 12/15-18/80 **Ground Elev.** 322'

Drill Rig Failing 1500 **Logged By** L.S. **Total Depth** 201.0'

Hole Diameter 4 7/8" **Hammer Weight & Fall** 140 lb/30" SS, 350 lb/24" DR

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0	CL	ALLUVIUM			AD	
		0.0-19.0 SILTY CLAY: greyish brown; interbedded with silt, clay, sand and gravel; interbeds from 1/2" to 8" average thickness				
	(ML)					
2	(SC)					
		3.6-4.5 clayey sand				
4		4.5-11.0 silty clay; dark yellowish brown				
6						
8						
		increasing silt and sand content with depth				
10			J-1	4 5	SS	1.2/1.5 recovery pocket penetrometer 3.0 tsf (broke apart) 2/9/81
	(SC)	11.0-11.5 clayey sand lens		4		
12					RD	
14		small amount of gravel and coarse sand				minor chatter
16		16.0 sandy clay				
18	(ML)	18.0 clayey silt				
	SM	19.0-26.0 SILTY SAND:				minor chatter
20						

Sheet 1 **of** 9

Project DESIGN UNIT A310 **Date Drilled** 12-15-18-80 **Hole No.** CEG-27

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	SM	19.0-26.0 SILTY SAND: continued moderate yellowish brown; fine grained sand; occasional coarse sand; medium dense; moist to wet; slight mica	PB-1		PB	2.0/2.0 recovery
22			J-2	5 4 7	SS	1.2/1.5 recovery
					RD	
24	(CL)	24.0-26.0 silty clay, dark greyish black				
26	SP	26.0-40.2 SAND: moderate yellowish brown; medium coarse sand; trace gravel; dense				
28						
30			J-3	8 18 25	SS	1.2/1.5 recovery
		31.0-32.0 coarse sand and gravel lense ~ 1' thick				
32						
34	(SM)	silty sand interbedded with fine sand lenses 1/2" thick				
36						
38		38.0-38.5 coarser sand, no fines; minor fine gravel				
40	SW	40.2-53.0 GRAVELLEY SAND: moderate yellowish brown; well graded fine to coarse sand; very dense	PB-2		PB	1.7/1.7 recovery
42			J-4	25 32 33	SS	1.2/1.5 recovery
					RD	
44						

Project DESIGN UNIT A310 **Date Drilled** 12-15-18-80 **Hole No.** CEG-27

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	SW	40.2-53.0 GRAVELLY SAND: continued			RD	
46						
48	(SM)	48.5-49.0 sitly sand, less gravel				
50			J-5	45 14 12	SS	0.2/1.5 recovery
					RD	chatter
52						
	SM	53.0-70.0 SILTY SAND: moderate yellowish brown; fine grained sand; subangular grains; occasional coarse sand or gravel lenses; medium dense; moist				
54						
56						
	(CL)	57.0- silty clay, 6" thick				checked for gas; none registered
58			PB-3		PB	extruded, partially disturbed due to deformed tube
60			J-6	9 10 13	SS	1.5/1.5 recovery
62					RD	
64						
66						
68						

Sheet 3 of 9

Project DESIGN UNIT A310 **Date Drilled** 12-15-18-80 **Hole No.** CEG-27

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	SM	53.0-70.0 SILTY SAND: continued			RD	
	(CL)	68.5- thin clay lens				
70	CL (SC)	70.0-120.0 SANDY CLAY: moderate yellowish brown; very stiff to hard; moist; interbedded with clayey sand	J-7	12 17 20	SS	1.5/1.5 recovery
72					RD	
74						
76						
78			PB-4		PB	2.75/2.75 recovery
	(SC)	79.0- clayey sand				
80						
			J-8	11 17 20	SS	1.5/1.5 recovery
82					RD	change to 4 7/8" drag bit
84						
	(SC)	sand lens				
86						
	(SC)	sand lens				
88						
90			J-9	12 20 23	SS	1.5/1.5 recovery
	(SC)	91.0 clayey sand				
92						

Project DESIGN UNIT A310 Date Drilled 12-15-18-83 Hole No. CEG-27

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
92	CL	70.0-120.0 SANDY CLAY: continued			RD	occasional chatter
		93.0-96.0 occasional sand lenses (thin)				
94						
96						
98			PB-5		PB	2.75/2.75 recovery
100			J-10	12 16 24	SS	1.5/1.5 recovery sample contained voids probably due to rock obstruction
102					RD	
104						
106						
108						
110			J-11	12 18 24	SS	1.5/1.5 recovery
					RD	end of day 12/17/80 water at 25' in a.m.
112						
114	(SC)	clayey sand lens				
116						

Sheet 5 of 9

Project DESIGN UNIT A310 **Date Drilled** 12-15-18-80 **Hole No.** CEG-27

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
116	CL	70.0-120.0 SANDY CLAY: continuned			RD	
118						
		119.0-120.0 silty clay				
			C-1	12 18	DR	1.0/1.0 recovery
120	SP	120.0-137.0 SAND: moderate brown; medium grained sand; interbedded with clays and gravels; very dense; moist;	J-12	48 50	SS	1.0/1.0 recovery
					RD	
122		122.0-123.0 coarse sand lens				
124						
126	(CL)	126.5- stiff silty clay				
128						
130			J-13	14 22 44	SS	1.5/1.5 recovery
	(CL)	131.0- 3" thick sandy clay lense				
132					RD	
134						
136						
	CL (SM) (SC)	137.0-175.0 SANDY CLAY: moderate brown; interbeds of sand and gravel; very stiff to hard; moist				
138						
			C-2	12 30	DR	1.0/1.0 recovery
140						

Sheet 6 of 9

Project DESIGN UNIT A310 Date Drilled 12-15-18-80 Hole No. CEG-27

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
140	CL	137.0-175.0 SANDY CLAY: continued	J-14	14 19 30	SS	1.5/1.5 recovery
					RD	
142						
		143.0-145.0 coarse sand and gravel				
144						
146						
148						
			J-15	21 23 25	SS	1.5/1.5 recovery
150						
					RD	
152						
154						
156						
158					PB	attempted PB, tube dented, washed out 2.5', no recovery
160	(SM)	thin coarse sand lens				
					RD	fished out rock (basalt) 3" diameter w/PB washed out 2.5'
162						
			PB-6		PB	2.5/2.5 recovery
164						

Project DESIGN UNIT A310 **Date Drilled** 12-15-18-80 **Hole No.** CEG-27

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
164	CL	137.0-175.0 SANDY CLAY: continued 164.0- silty clay			RD	
			J-16	20	SS	1.5/1.5 recovery
166				28		
				37		
					RD	
168						
170						
172						
174						
	SC	175.0-201.0 CLAYEY SAND: moderate brown; fine to medium sand with occasional gravels; very dense; moist; some gravel friable				rig chatter
176						
178						
180			PB-7		PB	1.0/2.0 recovery tube turned on barrel
182			J-17	40 62	SS	1.0/1.0 recovery
					RD	
184		clay content decreases				
186						
188						

Sheet 8 of 9

Project DESIGN UNIT A310 **Date Drilled** 12-15-18-80 **Hole No.** CEG-27

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
188	CL	175.0-201.0 <u>CLAYEY SAND</u>: continued			RD	
190				50	SS	1.0/1.0 recovery
			J-8	55		12/17/80
					RD	12/18/80
192						
		193.0-195.0 less fines				
194						
196						
198		198.0-200.0 sand				
200		200.0-201.0 sandy clay		63	DR	1.0/1.0 recovery
			C-3	100		
		B.H. 201.0 Terminated hole				completed 12/18/80 water sampled 2/13/81
202						
204						
206						
208						
210						
212						

Sheet 9 of 9

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BORING LOG 23C

Proj: DESIGN UNIT A310 **Date Drilled** 3-2-84 **Ground Elev.** 202'

Drill Rig FAILING 1500 **Logged By** M. Schluter **Total Depth** 76.0'

Hole Diameter 4 7/8" **Hammer Weight & Fall** SPT 140 lbs @ 30"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.6 A. C. PAVEMENT			AD	start drilling 0630
	CL	ALLUVIUM 0.6-3.5 SANDY CLAY: dusky brown; fine to medium sand; medium-low plasticity; very soft to soft; moist				
2					RD	rotary wash tri-cone bit
4	SC	3.5-6.0 CLAYEY SAND: olive grey; fine to medium sand; low plasticity; soft; moist				
			PB 1		PB	shelby tube-pushed 1.3/1.8 recovery
6	SM	6.0-10.5 SILTY SAND: light olive grey; fine sand; well graded; trace gravel; grains subangular; loose				
8					RD	
10		increasing clay content		4	SS	
		10.5-14.0 SANDY CLAY: light olive grey; fine to medium sand; low medium plasticity; moist		9		1.4/1.5 recovery
	CL		J-1	18		
12					RD	
14	SC	14.0-19.0 CLAYEY SAND: dusky green; fine to medium sand; low-medium plasticity; trace gravel; moist				
16			PB 2		PB	shelby tube-pushed 1.6/1.8 recovery
18					RD	
20	CH/CL	19.0-24.0 CLAY: greyish green; cont. next page				Sheet 1 of 4

Project DESIGN UNIT A310 **Date Drilled** 3-2-84 **Hole No.** 23-C

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	CH/ CL	19.0-24.0 CLAY: (continued) trace fine to medium sand; medium-high plasticity; stiff- very stiff; moist $CaCO_3$ infillings and cemented nodule, 10-40%, light bluish grey 58 7/1	J-2	10 21 35	SS	1.5/1.5 recovery
22					RD	
24	CL	24.0-29.0 SANDY CLAY: dark greenish grey; fine to medium sand; medium plasticity; stiff-very stiff; moist				
			PB 3		PB	2.3-2.5 recovery
26						
28					RD	
	SC	29.0-31.0 CLAYEY SAND: dark greenish grey; fine to coarse sand; trace sub-angular gravel; medium dense; moist				
30			J-3	8 19 28	SS	1.3/1.5 recovery
	CL	31.0-35.0 SANDY CLAY: dark greenish grey; fine to medium sand; stiff-very stiff; slight $CaCO_3$ infilling; moist				
32					RD	
34						
	SC/ CL	35.0-39.0 CLAYEY SAND/SANDY CLAY: dark greenish grey; trace fine sand; stiff to very stiff; moist	PB 4		PB	1.8/2.5 recovery
36						
					RD	
38						
	SW	39.0-40.5 SAND: dark greenish grey; fine to coarse sand; sub-angular; trace silt; medium dense; sulfurous odor				
40			J-4	9 9 13	SS	1.1/1.5 recovery
	CL	40.5-49.0 SANDY CLAY:greenish black; fine to medium sand; low plasticity; stiff; moist			RD	
42						
44						

Sheet 2 of 4

Project DESIGN UNIT A310 **Date Drilled** 3-2-84 **Hole No.** 23-C

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	CL	40.5-49.9 SANDY CLAY: (continued)			RD	
46			PB 5		PB	2.5/2.5 recovery
					RD	
48						
	SM	49.0-59.0 SILTY SAND:dark greenish grey; trace clay; fine to medium sand; clay binder; medium dense; moist				
50				7	SS	
			J-5	12		1.4/1.5 recovery
				23		
					RD	
52						
54						
			PB 6		PB	
56	(SC)	trace clay, predominantly silt				2.5/2.5 recovery
58						
	ML	59.0-66.0 SANDY SILT: dark greenish grey; fine sand; medium dense; moist occasional sand (SW) dense 1-3" thick				
60				23	SS	
				20	140	
			J-6	32		1.3/1.4 recovery
					RD	
62						
64						
			PB 7		PB	2.4/2.5 recovery
66	ML	66.0-69.0 CLAYEY SILT: greenish black; trace fine sand; low plasticity; medium dense to dense; moist				
68					RD	

Sheet 3 of 4

Project DESIGN UNIT A310 Date Drilled 3-2-84 Hole No. 23-C

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	ML	66.0--69.0 CLAYEY SILT (continued)			RD	
	CL	69.0-73.0 SANDY CLAY: dark greenish grey; fine to medium sand; low plasticity; very stiff-hard; moist				
70			J-7	25 34 37	SS	0.2/1.5 recovery
72					RD	
	SW	73.0-76.0 SAND: greyish green; fine to coarse sand; well graded; medium dense to dense; trace fine subangular gravel	PB8		PB	1.6/2.5 recovery
74						
76	B.H. 76.0' terminate hole					completed drilling 3-2-84, flushed hole installed pnuematic tranducers
78						
80						
82						
84						
86						
88						
90						
92						

Sheet 4 of 4

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BORING LOG 23D

Proj: DESIGN UNIT A310 **Date Drilled** 3-1-84 **Ground Elev.** 243'

Drill Rig FAILING 1500 **Logged By** M. Schluter **Total Depth** 76.0'

Hole Diameter 4 7/8" **Hammer Weight & Fall** SPT 140 lb @ 30"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.5 A.C. PAVEMENT			AD	Started drilling @ 12:50
	GW	0.5/1.0 SANDY GRAVEL: Grey, 3/4" gravel road base - imported fill-				
		ALLUVIUM				
2	SC	1.0-9.0 CLAYEY SAND: moderate brown; trace gravel; fine to coarse sand; loose; moist			RD	Rotary Wash Tri Cone Bit
4						
			PB-1		PB	Shelby tube-pushed 1.8/1.8 recovery
6						Drag Bit
8					RD	
	SM	9.0-14.0 SILTY SAND: moderate yellowish brown; trace clay; fine to coarse sand; trace subangular gravel; includes highly weathered granitic rock; loose to medium dense; moist				
10			J-1	4 7 14	SS	1.2/1.5 recovery
12					RD	slight-moderate drill rig chatter
14	SM	14.0-20.5 SILTY SAND: moderate yellowish brown; fine to coarse sand; trace fine subangular gravel; loose to medium dense; moist				
16			PB-2		PB	Shelby tube-pushed 1.8/1.8 recovery
18					RD	
20						

Sheet 1 of 4

Project DESIGN UNIT A 310 **Date Drilled** 3-1-84 **Hole No.** 23-D

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	SM	14.0-20.5 SILTY SAND: (continued)		4	SS	1.3-1.5 recovery
	CL	20.5-25.0 SANDY CLAY: moderate brown; fine to medium sand; firm-stiff; moist		6		
			J-2	10		
22					RD	
24						
	SC	25.0-29.0 CLAYEY SAND: moderate yellowish brown; trace gravel; medium dense; moist	PB-3		PB	2.1/2.5 recovery sample loose in barrel
26						
					RD	
28						
	SC	29.0-39.0 CLAYEY SAND: moderate brown; fine to coarse sand; medium dense; moist; highly weathered sand size granitic rock; trace gravel		8	SS	
30			J-3	22		1.0/1.5 recovery
				35		
32					RD	
34						
	(SC/CL)	trace fine subangular gravel	PB-4		PB	2.5/2.5 recovery sampled with little resistance
36						
		37.5 CLAYEY SAND/SANDY CLAY				
38					RD	
	SW	39.0-41.0 SAND: dark yellowish brown; trace fines; fine to coarse sand; well graded; trace gravel; subangular; medium dense		15	SS	1.2/1.5 recovery
40			J-4	18		
	ML	41.0-43.0 CLAYEY SILT: moderate yellowish brown; low plasticity; trace fine sand; moist		21		
42					RD	
	SM	43.0-49.0 SILTY SAND: dark yellowish brown fine to coarse sand; well-mod-				
44						

Sheet 2 of 4

Project DESIGN UNIT A310 **Date Drilled** 3-1-84 **Hole No.** 23-D

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	SM	43.0-49.0 SILTY SAND: (continued) trace fine subangular gravel; trace clay binder; medium dense; moist			RD	
			PB-5		PB	2.1/2.5 recovery
46						
48						
	SC	49.0-51.5 CLAYEY SAND: moderate brown; fine to medium sand; low plasticity; gravel-cobbles of highly weathered grandiorite; medium dense; moist				
50				9	SS	
			J-5	22 22		1.2/1.5 recovery
	CL	51.5-55.0 SANDY CLAY: dark yellowish brown to light olive grey; with fine to coarse sand; low-medium plasticity; stiff to very stiff; moist			RD	
52						
54						
	SM	55.0-59.5 SILTY SAND: moderate brown; fine to coarse sand; trace gravel; medium dense; moist				
56			PB-6		PB	2.2/2.5 recovery
	(CL)	57.0'-sandy clay				
58						
	CL	59.5-64.5 SANDY CLAY: moderate yellowish brown; fine to coarse sand; low-medium plasticity; moist; stiff				
60				7	SS	1.5/1.5 recovery
			J-6	11 18		
62					RD	
64						
	SC/ CL	64.5-71.0 CLAYEY SAND/SANDY CLAY: moderate brown; fine to coarse sand; trace gravel; occasional sand lens; medium dense; moist				
66	(SM)		PB-7		PB	2.4/2.5 recovery
					RD	
68						

Sheet 3 of 4

Project DESIGN PROJECT A310 **Date Drilled** 3-1-84 **Hole No.** 23-D

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	SC/ CL (SM)	CLAYEY SAND: (continued)			RD	
70				13 17	SS	1.3/1.5 recovery
	CL	71.0-73.5 SANDY CLAY: moderate brown; fine to medium sand; medium-low plasticity; stiff-very stiff; moist	J-7	23		
72					R	
74	SC/ CL	73.5-76.0 CLAYEY SAND/SANDY CLAY: moderate brown; fine to coarse sand; trace gravel, medium dense, moist	PB-8		PB	2.1/2.2 recovery
76	BH	76.0' Terminate Hole				completed at 15:50 3-1-84 flushed hole, installed ±75' peizometer, 20' perforated, 55' non-perforated
78						
80						
82						
84						
86						
88						
90						
92						

Sheet 4 **of** 4

Converse Consultants, Inc.
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BORING LOG 24B

Proj: DESIGN UNIT A310
Date Drilled 2-28-84 3-1-84
Ground Elev. 357'
Drill Rig FAILING 1500
Logged By M. Schluter
Total Depth 137'
Hole Diameter 4 7/8"
Hammer Weight & Fall 140 lb @ 30" SPT

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0/0.35 A.C. PAVEMENT			AD	started drilling 1315
	SM	0.35-6.0 SILTY SAND: moderate brown; fine to coarse sand; trace; subangular fine gravel; loose; medium dense; moist				
2						
					RD	rotary wash drag bit
4						
			PB 1		PB	shelby sample-pushed sampling pressure 1.4/1.4 recovery 17/36
6	SM	6.0-9.5 Buried structure, (probable 3'dia storm drain) not located on surface, trends east/west, deflects drill stem northward. No indications of concrete or steel in cuttings, observed 1-2mm sand size granitic rock fragment cuttings. Did not appear to penetrate drain with boring, drill stem deflected & drain ±5' S/N curb, hole deflected closer to curb, 3.0hrs delay			RD	end of barrel damaged cobble at 6.4' moderate heavy drill rig chatter used tri-cone bit boulder, elected to move hole 5' west and start over
8						
		9.5-24.0 SILTY SAND: dark yellowish brown; fine to coarse sand; trace subangular fine gravel; includes highly weathered granitic rock; black silty inclusions; loose moist; micaceous				
10			J-1	2 3 4	SS 140	continued chatter at 6' 1.0/1.5 recovery
					RD	variable drill rig chatter
12						
14						
			PB 2		PB	1.6/2.5 recovery loose slough removed from top of barrel installed 16' of casing
16						
					RD	
18						
20						

Sheet 1 of 6

Project DESIGN UNIT A310 **Date Drilled** 2-28/29-84 **Hole No.** 24B

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	SM	915-24.0 SILTY SAND: (continued)		6	SS	0.8/1.5 recovery
				7		
			J-2	10		shutdown @1730 2-28-84
22					RD	started drilling @ 2-29-84 Tri-cone bit
24	SC	24.0-29.0 CLAYEY SAND: moderate yellowish brown; fine to coarse sand; trace gravel, 5-20mm, including weathered granitic rock; loose; medium dense; moist				lost pitcher barrel in hole, 0.5 hr delay
26			PB 3		PB	1.5/2.5 recovery
28						
	SM	29.0-35.0 SILTY SAND: moderate yellowish brown; trace subangular gravel; including highly weathered granitic rock; fine to coarse sand; medium dense; moist				
30				6	SS	
				10		
			J-3	14		0.7/1.5 recovery
					RD	
32						
34						
	SC	35.0-40.0 CLAYEY SAND: moderate yellowish brown; fine to coarse sand; trace gravel; moist; medium dense	PB 4		PB	
36						1.8/2.5 recovery
38						
40	SM	40.0-50.0 SILTY SAND: moderate yellowish brown; highly weathered and soft granitic rock, (cobbles) decomposing granite; fine to coarse sand; medium dense; moist		12	SS	
				18		
			J-4	22		
42					RD	0.6/1.5 recovery
44						

Sheet 2 of 6

Project DESIGN UNIT A310 **Date Drilled** 2-28-84 **Hole No.** 24-B

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	SM	40.0-50.0 SILTY SAND: (continued)			RD	
46		trace to little gravel, 5-30mm; subangular trace clay binder	PB 5		PB	2.0/2.5 recovery
48						
50	CL	50.0-55.0 SANDY CLAY: moderate brown; low-medium plasticity; fine to medium sand; firm-stiff; moist	J-5	3 6 9	SS	1.8/1.5 recovery
52					RD	
54						
56	SM	55.0-60.5 SILTY SAND:moderate yellowish brown;fine to coarse sand; trace to little gravel; gravel: 5-25mm, subangular, including highly weathered granitic rock	PB 6		PB	2.4/2.5 recovery
58					RD	
60	SC	60.5-69.0 CLAYEY SAND: moderate brown; fine to coarse sand; low plasticity; dense; moist	J-6	9 15 26	SS	1.4/1.5 recovery
62					RD	
64		trace of little gravel				
66			PB 7		PB	
68					RD	

Sheet 3 of 6

Project DESIGN UNIT A310 Date Drilled 2-29-84 Hole No. 24B

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	SC	60.5-69.0 CLAYEY SAND: (continued)			RD	
	SM	69.0-74.0 SILTY SAND: moderate yellowish brown; fine to coarse sand; trace subangular gravel, includes, highly weathered granitic rock; some cobble size. decomposing granitic rock				
70				17	SS	
				31		
			J-7	43		0.9/1.5 recovery
72					RD	
74	SC	74.0-85.0 CLAYEY SAND:moderate brown; fine to coarse sand; trace gravel; dense; moist				
			PB 8		PB	2.2/2.5 recovery
76						
	(CL)	77.5- SANDY CLAY:				
78					RD	
80		grades with depth; increasing sand content		11	SS	1.4/1.5 recovery
				16		
			J-8	23		
82					RD	
84						
	CL/SC	85.0-94.0 SANDY CLAY/SILTY CLAYEY SAND: moderate brown; fine to coarse sand; stiff-very stiff; moist	PB 9		PB	2.5/2.5 recovery
86						
88						
90				11	SS	
				15		
			J-9	22		
92						

Sheet 4 of 6

Project DESIGN UNIT A310 Date Drilled 2-29-84 Hole No. 24B

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
92	CL/ SC	85.0 94.0 SANDY CLAY/CLAYEY SAND:(continued)			RD	slight drill rig chatter
94	SC	94.0-103.5 CLAYEY SAND: moderate brown; trace subangular gravel; fine to coarse sand; medium dense; dense; moist				
96			PB 10		PB	2.3/2.5 recovery
98					RD	
100		color change to moderate yellowish brown; gravel; including highly weathered granitic rock increased sand content		16 25	SS	
			J-10	38		1.3/1.5 recovery
102					RD	
104	SM	103.5-114.0 SILTY SAND: moderate brown; fine to medium; trace gravel; dense; moist				
106			PB 11		PB	1.1/1.5 recovery
108						slight drill rig chatter/shimmy
110				34	SS	SPT refusal @ 11" highly weathered granitic rock in tip of barrel
		111.0 cobble size rock of highly weathered granitic rock; soft	J-11	50/5		0.7-0.9 recovery
112					RD	
114	GM	114.0-119.0 SILTY GRAVEL:. moderate brown trace clay binder; subangular gravel; fine to coarse sand; dense; moist				slight to moderate drill rig chatter
116			PB 12		PB	

Sheet 5 of 6

Project DESIGN UNIT A310 **Date Drilled** 2-29-84/3-1-84 **Hole No.** 24B

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
116	GM	11.4-119.0 <u>SILTY SANDY GRAVEL</u>: (cont.)	PB 12		PB	0.9/2.5 recovery
118					RD	
	CL	119.0-124.0 <u>SANDY CLAY</u>:moderate yellowish brown; fine to coarse sand; very stiff to hard; moist				
120				8	SS	1.3/1.5 recovery
				15	140	
			J-12	27		shutdown @1710,2-29
122					RD	started drilling 0705 3-1-84
124	SM	124.0-130.0 <u>SAND</u>: moderate brown; well to moderately graded; trace fine subangular gravel; dense moist				
126			PB 13		PB	2.3/2.5 recovery slight chatter during sampling
128					RD	
130	SM	130.0-134.0 <u>SILTY SAND</u>: moderate yellowish brown; fine to coarse sand; trace gravel; including highly weathered granitic rock		16	SS	1.2/1.5 recovery
				25	140	
			J-13	29		
132						
134	SC	134.0-137.0 <u>CLAYEY SAND</u>: moderate yellowish brown; fine to coarse sand trace gravel; medium dense; moist				
136			PB 14		PB	
	B.H.	137.0 terminate hole				completed at 0945 3-1-84 installed 137' peizometer, 20' perforated 11.7' Pea gravel backfill
138						
140						

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BORING LOG 25C

Proj: DESIGN UNIT A-310 **Date Drilled** 2-28-84 **Ground Elev.** 340'

Drill Rig Failing 1500 **Logged By** M. Schluter **Total Depth** 75'

Hole Diameter 4 7/8" **Hammer Weight & Fall** 140 lb @ 30"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.2 A.C. PAVEMENT			AD	started drilling 7:05
	SC	ALLUVIUM 0.2-4.0 CLAYEY SAND: dusky brown; fine to coarse sand; trace gravel; medium dense; moist				
2						
4	SC	4.0-14.0 CLAYEY SAND: moderate brown; low plasticity; fine to coarse sand; trace of gravel; medium dense; moist; sand fraction includes highly weathered granitic rock			RD	rotary wash drag bit
6			PB-1		PB	shelby tube - pushed sample loose in barrel 2.0/2.2 recovery
8					RD	
10		color change to moderate brown to moderate yellowish brown and increasing sand content	J-1	12 23 33	SS	1.1/1.5 recovery
12					RD	
14	SC/SM	14.0-41.5 CLAYEY SAND/SILTY SAND: moderate brown; fine to coarse sand; low plasticity; predominately clayey sand with silty sand; trace subangular; fine gravel; hightly weathered granitic rock; medium dense; moist				
16	(SM)		PB-2		PB	pitcher sampler 2.4/2.5 recovery
18					RD	
20						

Sheet 1 of 4

Project DESIGN UNIT A-310 **Date Drilled** 2-28-84 **Hole No.** 25C

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	SC SM	14.0-41.5 <u>CLAYEY SAND/SILTY SAND:</u> (cont)	J-2	5 13 16	SS	1.2/1.5 recovery
22					RD	
24						
26	(SM)	increased sand content trace gravel, includes highly weathered granitic rock	PB-3		PB	2.5/2.5 recovery
28					RD	
30	(SC)	30.0' clayey sand; trace fine gravel; very dense; moist	J-3	10 20 33	SS	1.3/1.5 recovery
32					RD	
34						
36			PB-4		PB	2.5/2,5 recovery
38					RD	
40			J-4	12 22 31	SS	1.3/1.5 recovery
42	CL	41.5-45.0 <u>SANDY CLAY:</u> moderate brown; fine to coarse sand; low-medium plasticity; trace gravel; very stiff; moist			RD	slight drill rig chatter
44						

Project DESIGN UNIT A-310 **Date Drilled** 2-28-84 **Hole No.** 25C

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	CL	41.5-45.0 SANDY CLAY: (continued)			RD	
46	SC	45.0-75.0 CLAYEY SAND: moderate brown; fine to coarse sand; trace fine gravel, including highly weathered granitic rock; medium dense to dense; moist	PB-5		PB	2.5/2.5 recovery
	(SC/SM)					
48		47.0' clayey sand/silty sand			RD	
50		color change to moderate yellowish brown; slightly less sand	J-5	8 16 20	SS	1.2/1.4 recovery
52					RD	
54						
56			PB-6		PB	2.5/2.5 recovery
	(SC)	57.0' clayey sand				
58					RD	
60		61.0' becomes very dense	J-6	13 22 30	SS	1.4/1.5 recovery
62					RD	
64						
66			PB-7		PB	1.9/2.5 recovery
68					RD	

Sheet 3 of 4

Project DESIGN UNIT A-310 **Date Drilled** 2-28-84 **Hole No.** 25C

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	SC	45.0-75.0 CLAYEY SAND: (continued)			RD	
70		increased sand content; trace fine gravel including weathered granitic rock	J-7	50/5"	SS	SPT refusal at 5" 0.4/0.5 recovery
72						
			PB-8		PB	2.5/2.5 recovery
74		75.0' gravel becomes subangular to subrounded				
		B.H. 75.0' Terminated hole				Completed 2/28/84 Flushed hole Installed 75' piezometer: 20' perforated, 55' non-perforated, pea gravel backfill
76						
78						
80						
82						
84						
86						
88						
90						
92						

Sheet 4 of 4

THIS BORING LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.

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BORING LOG 26C

Proj: DESIGN UNIT A-310 **Date Drilled** 2-27-84 **Ground Elev.** 343'

Drill Rig Failing 1500 **Logged By** M. Schluter **Total Depth** 80'

Hole Diameter 4 7/8" **Hammer Weight & Fall** 140 lb @ 30"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.6 A.C. PAVEMENT			AD	started drilling 7:30
	SC	ALLUVIUM 0.6-9.0 CLAYEY SAND: dusky brown; fine to medium sand; trace gravel; medium dense; moist				
2						
4				8	SS	1.1/1.5 recovery
			J-1	12		
				16		
6					AD	
8					RD	
	CL SC	9.0-15.0 SANDY CLAY/CLAYEY SAND: moderate brown; fine to coarse sand; low-medium plasticity; trace fine gravel; loose-firm; moist				
10			PB-1		PB	shelby tube - pushed 2.5/2.5 recovery
12					RD	
14						
	SC	15.0-20.0 CLAYEY SAND: moderate brown; fine to coarse sand; trace gravel; medium dense; moist		4	SS	0.9/1.5 recovery
16			J-2	7		
				11		
					RD	
18						
20						

Sheet 1 of 4

Project DESIGN UNIT A-310 **Date Drilled** 2-27-84 **Hole No.** 26C

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	SC	20.0-29.0 CLAYEY SAND: dusky brown; fine to coarse sand; dense to very dense; moist	PB-2		PB	shelby tube - pushed 1.5/1.5 recovery
	(CL)	21.0'-sandy clay lens				
22						
					RD	
24						
				15 29	SS	1.4/1.5 recovery
26			J-3	41		
					RD	
28						
	CL SC	29.0-47.0 SANDY CLAY/CLAYEY SAND: moderate brown; fine to medium sand; hard/dense; moist				
30						
			PB-3		PB	pitcher sampler 2.3/2.5 recovery
32						
					RD	
34						
				7 15	SS	1.4/1.5 recovery
36		trace subangular gravel black silty inclusions 1-4mm	J-4	21		
					RD	
38						
40						
			PB-4		PB	2.5/2.5 recovery
42						
					RD	
44						

Sheet 2 **of** 4

Project DESIGN UNIT A-310 Date Drilled 2-27-84 Hole No. 26C

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	CL SC	29.0-47.0 SANDY CLAY/CLAYEY SAND: (cont)			RD	
				6	SS	gravels reduced recovery, partially blocked sampler
46		subangular gravel lenses, medium to highly weathered	J-5	23 50		1.0/1.5 recovery
	GM	47.0-54.0 SANDY GRAVEL: moderate yellowish brown; subangular gravel; medium dense to dense; moist			RD	drill rig chatter variable chatter
48						
50						
			PB-5		PB	2.1/2.5 recovery
52		52.0'- gravelly sand				
					RD	
54	SM GM	54.0-65.0 SILTY SAND/SILTY GRAVEL: moderate yellowish brown; fine to coarse sand; subangular gravel in random lenses; moderate-well graded; moist; medium dense to dense; moist		19	SS	SPT refusal at 17" 1.2/1.5 recovery
56			J-6	31 50/5"		
		gravels and cobbles stratified			RD	moderate to heavy drill rig chatter
58						
60			PB-6		PB	moderate chatter during sampling barrel damaged, sample loose 1.3/2.5 recovery
62		62.0'- silty sand with gravel				
					RD	moderate to heavy drill rig chatter
64						
	SC	65.0-74.0 CLAYEY SAND: moderate yellowish brown; fine to coarse sand; trace subangular gravel; very dense; moist		22	SS	1.1/1.5 recovery
66			J-7	33 43		
					RD	
68						

Sheet 3 of 4

Project DESIGN UNIT A-310 **Date Drilled** 2-27-84 **Hole No.** 26C

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	SC	65.0-74.0 CLAYEY SAND: (continued)			RD	
70			PB-7		PB	2.5/2.5 recovery
72		sand content increases				
					RD	
74	CL	74.0-80.0 SANDY CLAY: moderate yellowish brown; fine to medium sand; hard; moist		10	SS	1.3/1.4 recovery
76	(SM)	stratified with sand lenses 1-3"	J-8	23 28		
78			PB-8		PB	2.5/2.5 recovery
80		B.H. 80.0' Terminated hole				Completed 2/27/84 Flushed boring Installed piezometer 10' perforated 70' non-perforated pea gravel backfill
82						
84						
86						
88						
90						
92						

Sheet 4 of 4

THIS BORING LOG IS BASED ON FIELD CLASSIFICATION AND VISUAL SOIL DESCRIPTION, BUT IS MODIFIED TO INCLUDE RESULTS OF LABORATORY CLASSIFICATION TESTS WHERE AVAILABLE. THIS LOG IS APPLICABLE ONLY AT THIS LOCATION AND TIME. CONDITIONS MAY DIFFER AT OTHER LOCATIONS OR TIME.

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BORING LOG 26D

Proj: DESIGN UNIT A310
Date Drilled 2-25/26-84
Ground Elev. 351'
Drill Rig Failing 1500
Logged By M. Schluter
Total Depth 76.0'
Hole Diameter 4 7/8"
Hammer Weight & Fall SPT 140 lb/30"

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
0		0.0-0.5 A.C. PAVEMENT			AD	started drilling @ 14:10
	SM	ALLUVIUM 0.5-9.0 SILTY SAND: moderate brown; fine to coarse sand; trace gravel; some clay binder; loose; moist				
2			J-1	1 2 3	SS	1.5/1.5 recovery
4					RD	rotary wash - tri cone casing slipped into boring, erosion reduced skin friction
6			PB-1		PB	2.2/2.5 recovery
	(CL)	7.0- SANDY CLAY: fine to medium sand				
8					RD	shutdown 15:00- 2/25/84 need additional bentonite started drilling 07:00 installed additional casing; 9' total in ground with bentonite sealing
	SC	9.0-15.0 CLAYEY SAND: moderate brown; fine to coarse sand; trace gravel; loose; moist				
10			J-2	2 3 4	SS	
12					RD	
14						
	SM	15.0-20.0 SILTY SAND: moderate brown; fine to coarse sand; trace subangular gravel; loose to medium dense; moist	PB-2		PB	2.3/2.5 recovery sample loose in barrel; sample disturbed near bottom
16						
18						
20						

Sheet 1 of 4

Project DESIGN UNIT A310 **Date Drilled** 2-26-84 **Hole No.** 26-D

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
20	SM (SW)	20.0-24.0 SILTY SAND: moderate brown; fine to coarse sand; medium dense; moist; predominantly (SM) with lenses of (SW); trace of subangular gravel	J-3	10 11 12	SS	1.0/1.5 recovery
22					RD	
24	CL	24.0-34.0 SANDY CLAY: moderate yellowish brown; fine to medium sand; firm to stiff; moist				
			PB-3		PB	2.4/2.5 recovery
26						
	(SM)	27.0- silty sand lenses				
28					RD	
30				8	SS	0.0/1.5 recovery
		31.0- becomes very stiff		10 12		
32					RD	
34	SM SC	34.0-60.0 SILTY SAND/CLAYEY SAND: moderate brown; fine to coarse sand; trace gravel; medium dense; moist				
			PB-4		PB	2.3/2.5 recovery
36						
38					RD	
40		40.0- becomes medium dense to dense; predominantly (SC) with (SM); trace subangular gravel; (weathered granite); mottled moderate brown and dark silty inclusions	J-4	5 12 20	SS	1.1/1.5 recovery
42					RD	
44						

Sheet 2 of 4

Project DESIGN UNIT A310 **Date Drilled** 2-26-84 **Hole No.** 26D

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
44	SM SC	34.0-60.0 SILTY SAND/CLAYEY SAND: cont.			RD	
	(SM)		PB-5		PB	2.2/2.5 recovery
46						
		47.0- silty fine to coarse sand				
48					RD	
50		becomes very dense	J-5	4 25 34	SS	1.2/1.5 recovery
	(SW)	color change to moderate yellowish brown; (SM) with lenses of well graded (SW); trace gravel				
52					RD	
54						
			PB-6		PB	1.4/2.5 recovery
56						
58		58.0- gravel lenses			RD	slight drill rig chatter
60	SM	60.0-62.0 SILTY SAND: moderate yellowish brown; trace fine gravel	J-6	19 32 31	SS	1.0/1.5 recovery
62	GW SW	62.0-68.0 SANDY/SANDY GRAVEL: moderate yellowish brown; well graded; subangular; some cobbles; predominantly (GW) with (SW); medium dense to dense			RD	variable drill rig chatter - moderate to heavy
64						
			PB-7		PB	1.0/1.5 recovery end of barrel damaged; moderate to heavy chatter during sampling; gravels; cobble
66						
					RD	
68						

Sheet 3 of 4

Project DESIGN UNIT A310 Date Drilled 2-26-84 Hole No. 26D

DEPTH	USCS	MATERIAL CLASSIFICATION	SAMPLE	BLOWS (6")	DRILL MODE	REMARKS
68	GM	68.0-76.0 SILTY GRAVEL: moderate yellowish brown; subangular; some cobbles; medium dense-dense; cobbles			RD	variable moderate to heavy drill rig chatter
70			J-17	25 40 50-	SS 4"	SPT refusal @ 16"
72		cobbles and boulders to 2'+			RD	heavy to moderate drill rig chatter
74						
			PB-8		PB	0.1/.08 recovery moderate to heavy chatte during sampling; barrel severly damaged
76		B.H. 76.0' Terminated hole				completed 14:30 2/26/84 Installed 75' piezometer flushed hole, placed 10' perforated with 65' of nonperforated 2" PVC, backfilled with pea gravel
78						
80						
82						
84						
86						
88						
90						
92						

Sheet 4 of 4

Appendix B

Geophysical Explorations

APPENDIX B GEOPHYSICAL EXPLORATIONS

B.1 DOWNHOLE SURVEY

B.1.1 Summary

Downhole shear wave velocity surveys were performed in Borings CEG-23, CEG-23A, CEG-24, and CEG-28. These surveys were performed as part of the 1981 Geotechnical Investigation of the Metro Rail Project. It should be noted that Borings CEG-23 and CEG-28 are not within the bounds of Design Unit A310 but instead are at the extreme southern and northern ends of this design unit, respectively. The results of the surveys conducted in these two boreholes are, however, included in this appendix since they are considered reasonably representative of the types of soil conditions present along the tunnel alignment of Design Unit A310. Measurements were made at 5-foot intervals from the ground surface to depths up to 200 feet. A description of the technique and a summary of the results are presented in this appendix.

B.1.2 Field Procedure

Shearing energy was generated by using a sledge hammer source on the ends of a 4- by 6-inch timber positioned under the tires of a station wagon, tangential to each borehole. A 12-channel signal enhancement seismograph (Geometrics Model ES 1210) allowed the summing of several blows in one direction when necessary to increase the signal-to-noise ratio. Shear waves were identified by recording wave arrivals with opposite first motions on adjacent channels of the seismograph.

B.1.3 Data Analysis

The downhole travel time profiles for both compressional and shear waves obtained from the downhole surveys are shown in Figures B-1 through B-4. Velocity estimates are based on selection of linear portions of these downhole arrival time profiles. The slopes of the linear portions yield the average compressional and shear velocities for the appropriate depth interval. Although it is possible to calculate the velocity for each 5-foot interval, this procedure would result in an assumed accuracy for velocity estimates that is unwarranted by the limitations of the survey techniques. More meaningful shear velocity estimates are made by averaging a series of arrivals that appear to be associated with materials of similar physical properties.

B.1.4 Discussions of Results

Estimated velocity profiles for the four downhole surveys are summarized in Table B-1. Velocity estimated are based on selections of linear portions of the downhole arrival time curves.

The error analysis performed for these surveys involved a least squares fit of these data by estimating the mean of the slope ($\overline{V}$ in Table B-1) and the standard deviation of this estimate of the slope. This estimate of the standard deviation was combined with an estimate of the overall accuracy to produce the best estimated velocity (V*). Vp* and Vs* are the values to be used for studies of the response of these sites. N is the number of data points used for the straight line fit for each velocity estimate.

B.2 CROSSHOLE SURVEY

B.2.1 Summary

Crosshole measurements for the determination of seismic wave velocities were performed in Borings CEG-24 and CEG-28 during the 1981 geotechnical investigation of the Metro Rail Project. The crosshole technique for determining shear wave velocities in-situ was utilized in a three-borehole array at the locations of these two boreholes. As in the case of the downhole survey, the crosshole survey conducted in Boring CEG-28 is not actually within the bounds of Design Unit A310. However, the crosshole velocity measurements obtained from this survey are considered reasonably representative of the soil conditions present along the tunnel alignment of Design Unit A310 and are therefore included in this appendix. Both compressional and shear velocity estimates were performed in an array of three boreholes spaced approximately 15 feet apart up to depths of 100 feet. Compressional wave and shear wave velocities obtained from the two surveys are summarized in Table B-2.

B.2.2 Field Procedure

The shear wave hammer is placed in an end hole of the array, and geophones are placed in the remaining two boreholes. The shear wave generating hammer and the two geophones are lowered to the same depth in all boreholes. The hammer is coupled to the wall of the hole by means of hydraulic jacks, and the geophones are coupled to the walls by means of expanding heavy rubber balloons which protrude from one side of the geophone housings. The hammer is then used to create vertically polarized shear waves with either an up or down first motion. A 12-channel signal enhancement seismograph with oscilloscope and electrostatic paper camera is used as a signal storage device.

B.2.3 Data Analysis

Actual crosshole distances were measured within ±0.01 feet. These distances were computed between each of the three boreholes at the elevations of shear measurements. From the crosshole records (seismograms), the travel times for both compressional and shear wave arrivals at each borehole and at each depth were measured. Shear wave arrivals were identified by the reversed first motion on the seismograms.

B.2.4 Discussion of Results

Seismic wave velocity determinations were made at 5-foot intervals from 10 feet below ground surface to a depth of 100 feet. The wave velocity is equal to the difference in travel path distance from the generating source to each geophone divided by the difference in shear wave arrival times. The results of the compressional and shear wave velocity analyses are shown in Figures B-5 through B-8 and are summarized in Table B-2.

TABLE B-1

DOWN-HOLE VELOCITIES

Boring No.	Depth (ft)	COMPRESSIONAL WAVE					SHEAR WAVE				
		$\overline{V}p$	σp	Ep	Np	Vp*	$\overline{V}s$	σs	Es	Ns	Vs*
23	10-200	4134	323	207	33	4130±530	1828	34	600	4	1830±630
23A	10-188	6103	359	305	37	6110±660	1151	20	56	37	1150±80
24	10-135	2586	277	129	36	2590±410	305	32	65	25	1305±100
	135-175	2938	---	---	11	2940±1500	2569	595	128	9	2570±720
	175-195	2938	---	---	11	2940±1500	1333	97	67	5	1330±160
28	15-55	1579	22	79	9	1580±100	943	87	47	8	940±130
	55-85	2233	134	112	7	2230±250	1138	200	57	7	1140±260
	85-135	5169	255	258	11	5170±510	1448	39	72	11	1450±110
	135-190	6788	386	339	11	6790±420	1380	114	69	11	1380±180

$\overline{V}p$ = mean estimate of compressional wave velocity

$\overline{V}s$ = mean estimate of shear wave velocity

σp = standard deviation of estimated compressional wave velocity

σs = standard deviation of estimated shear wave velocity

Ep = estimated accuracy of compressional survey

Es = estimated accuracy of shear survey

Np = number of points used for straight line fit of compressional wave

Vp* = overall accuracy of compressional wave velocity estimate

Vs* = overall accuracy of shear wave velocity estimate

Ns = number of points used for straight line fit of shear wave velocity data

TABLE B-2
CROSS-HOLE VELOCITIES

Boring No.	Depth (ft)	COMPRESSIONAL WAVE					SHEAR WAVE				
		$\overline{V}p$	σp	Ep	Np	Vp*	$\overline{V}s$	σs	Es	Ns	Vs*
24	10	2400	98	120	2	2400±220	1272	72	64	8	1270±140
	15	2310	0	115	3	2310±120	1251	39	63	8	1250±100
	20	2288	263	114	4	2290±390	1187	32	59	8	1190±90
	25	----				---------	1413	28	71	12	
	30	2216	13	111	4	2220±120	1276	67	64	8	
	35	2400	0	120	2	2400±120	1352	4	68	12	
	40	----				---------	1273	5	64	8	
	45	2152		220	3	2150±220	1253	41	63	12	
	50	----				---------	1262	10	63	12	
	55						1332	8	67	12	
	60						1295	12	65	12	
	65	2356	103	118		2360±220	1552	43	78	12	
	70	2530	482	127	4	2530±610	1790	36	90	12	
	75	2438	45	122	5	2440±170	1808	47	90	11	
	80	2549	210	127	3	2550±340	1522	43	76	12	
	85	2591	511	130	3	2590±700	1350	78	67	8	
	90						1445	169	72	8	
	95						1725	87	61	10	
	97	2320	270	116	2	2320±340	1267	42	63	10	

$\overline{V}p$ = mean estimate of compressional wave velocity

$\overline{V}s$ = mean estimate of shear wave velocity

σp = standard deviation of estimated compressional wave velocity

σs = standard deviation of estimated shear wave velocity

Ep = estimated accuracy of compressional survey

Es = estimated accuracy of shear survey

Np = number of points used for straight line fit of compressional wave

Vp* = overall accuracy of compressional wave velocity estimate

Vs* = overall accuracy of shear wave velocity estimate

Ns = number of points used for straight line fit of shear wave velocity data

TABLE B-2
CROSS-HOLE VELOCITIES (continued)

Boring No.	Depth (ft)	COMPRESSIONAL WAVE					SHEAR WAVE				
		$\overline{V}p$	σp	Ep	Np	Vp*	$\overline{V}s$	σs	Es	Ns	Vs*
28	10	----					765	17	38	8	770+60
	15	3000				3000±300	834	11	42	12	830±50
	20	2500				2500±250	749	18	37	8	750+60
	25	----					925	44	46	16	930±90
	30	2220				2000±200	973	28	49	16	970±80
	35	2300				2300±200	993	74	50	16	990±120
	40						1039	76	52	12	1040±130
	45	2140				2100±200	1036	36	52	10	1040±90
	50	1880				1900±200	1102	46	55	12	1100±100
	55	2140				2100±200	1123	16	56	16	1120±70
	60	2000				2000±200	1097	8	55	16	1100±60
	65	2100				2100±200	1018	8	51	16	1020±60
	70	2000				2000±200	1274	61	64	12	1270±130
	75	1800				1800±200	1222	38	61	16	1200±100
	80	1800				1800±200	1477	114	74	16	1480±190
	85	2300				2300±200	1863	106	93	16	1860±200
	90	6000				6000±600	1712	476	86	16	1712±560
	95	7500				7500±750	1550	204	77	4	1550±280
	97	7500				7500±750	1730	79	86	12	1710±170

$\overline{V}p$ = mean estimate of compressional wave velocity

$\overline{V}s$ = mean estimate of shear wave velocity

σp = standard deviation of estimated compressional wave velocity

σs = standard deviation of estimated shear wave velocity

Ep = estimated accuracy of compressional survey

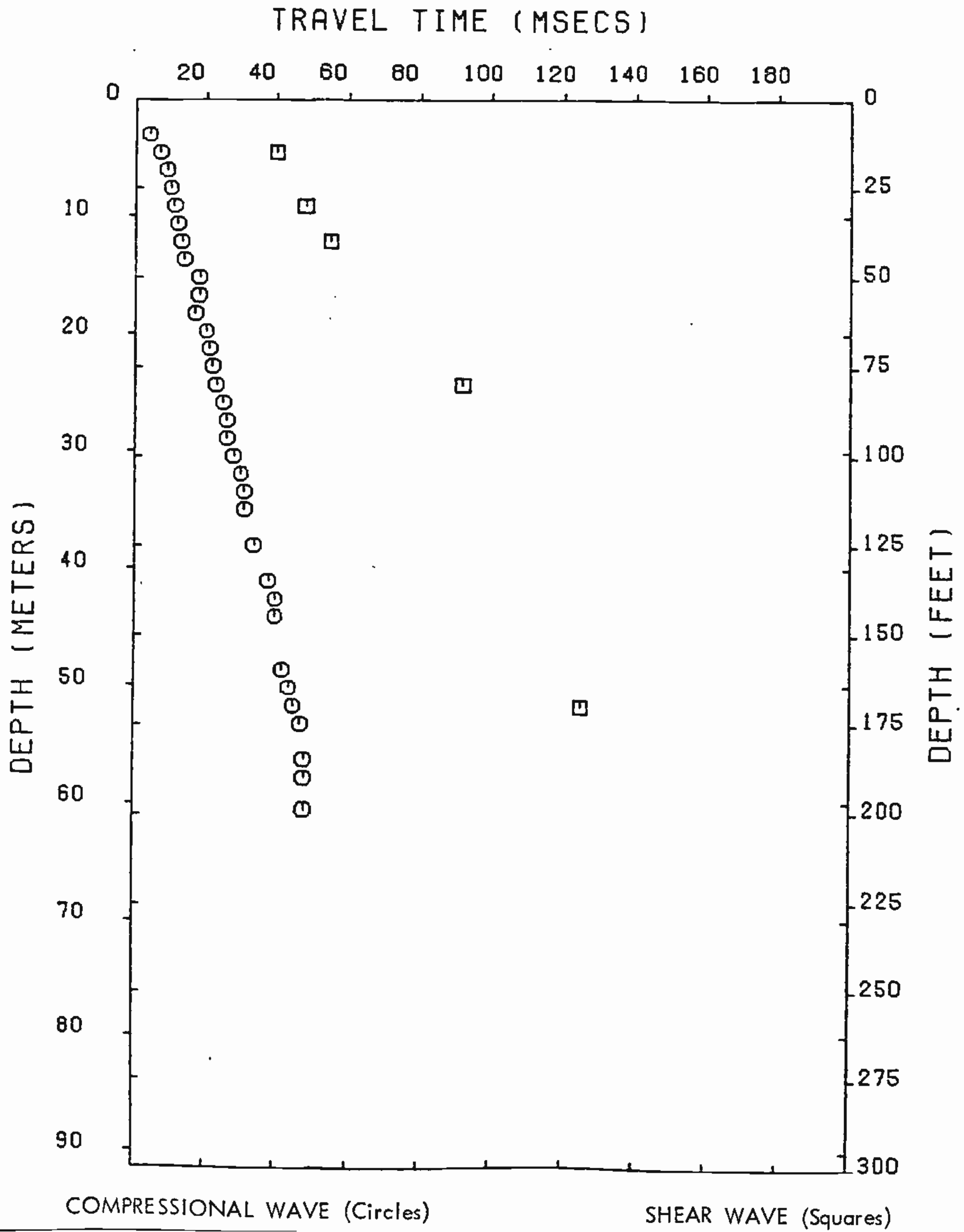
Es = estimated accuracy of shear survey

Np = number of points used for straight line fit of compressional wave

Vp* = overall accuracy of compressional wave velocity estimate

Vs* = overall accuracy of shear wave velocity estimate

Ns = number of points used for straight line fit of shear wave velocity data



DOWNHOLE TRAVEL TIME PROFILE - BORING 23

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Figure No.
B-1

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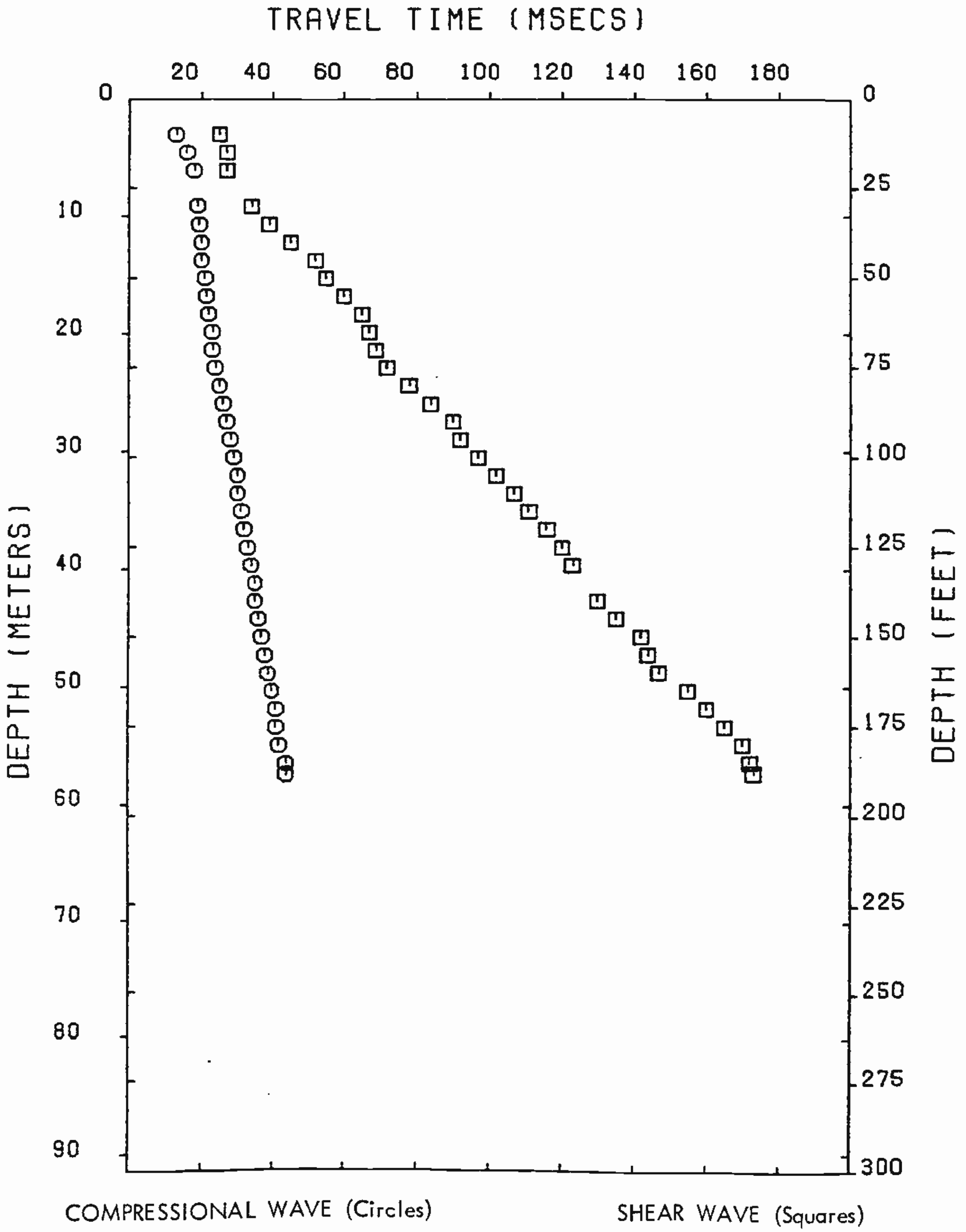

DOWNHOLE TRAVEL TIME PROFILE - BORING 23A

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Figure No.
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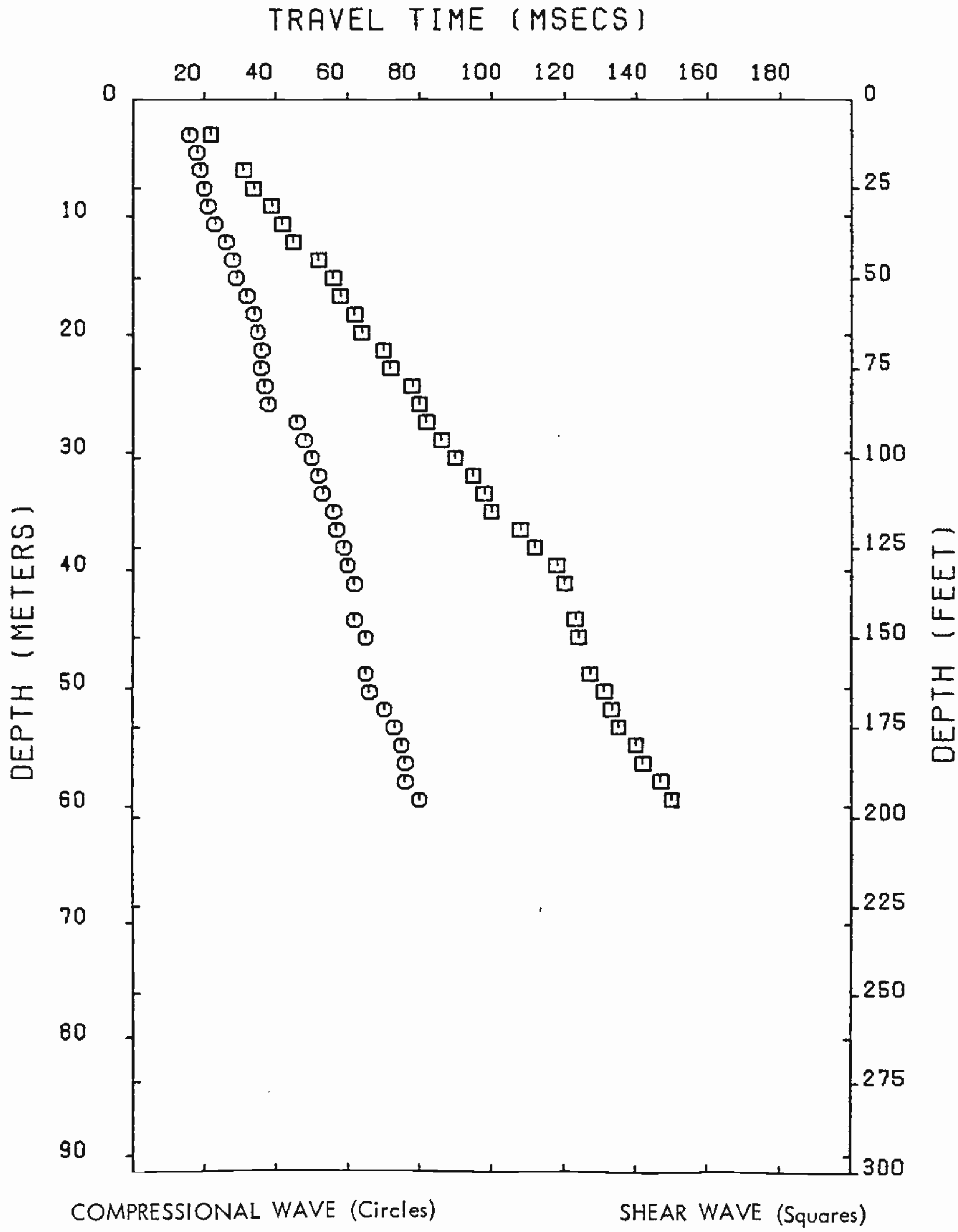

DOWNHOLE TRAVEL TIME PROFILE - BORING 24

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Figure No. B-3

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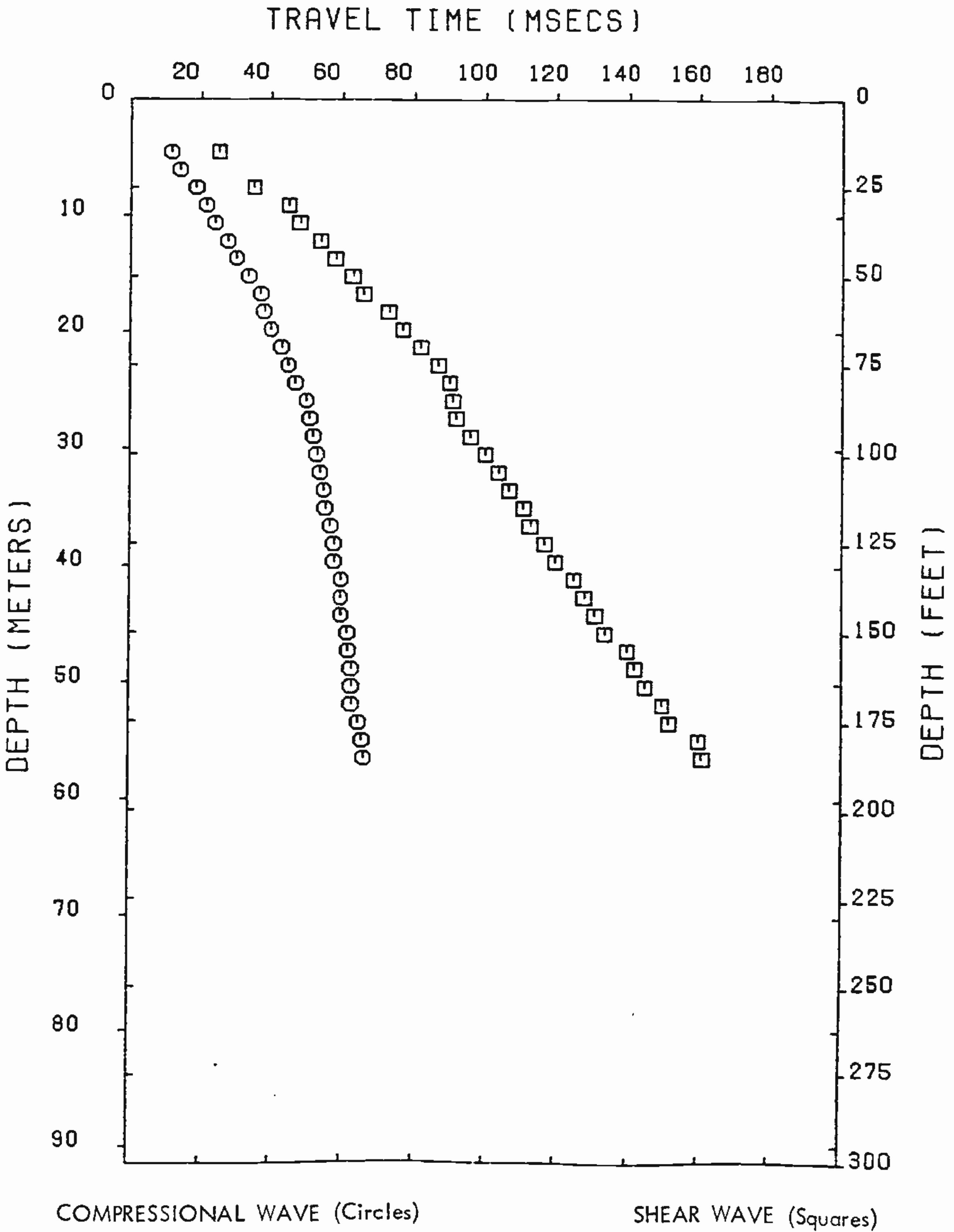

DOWNHOLE TRAVEL TIME PROFILE - BORING 28

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Figure No.
B-4

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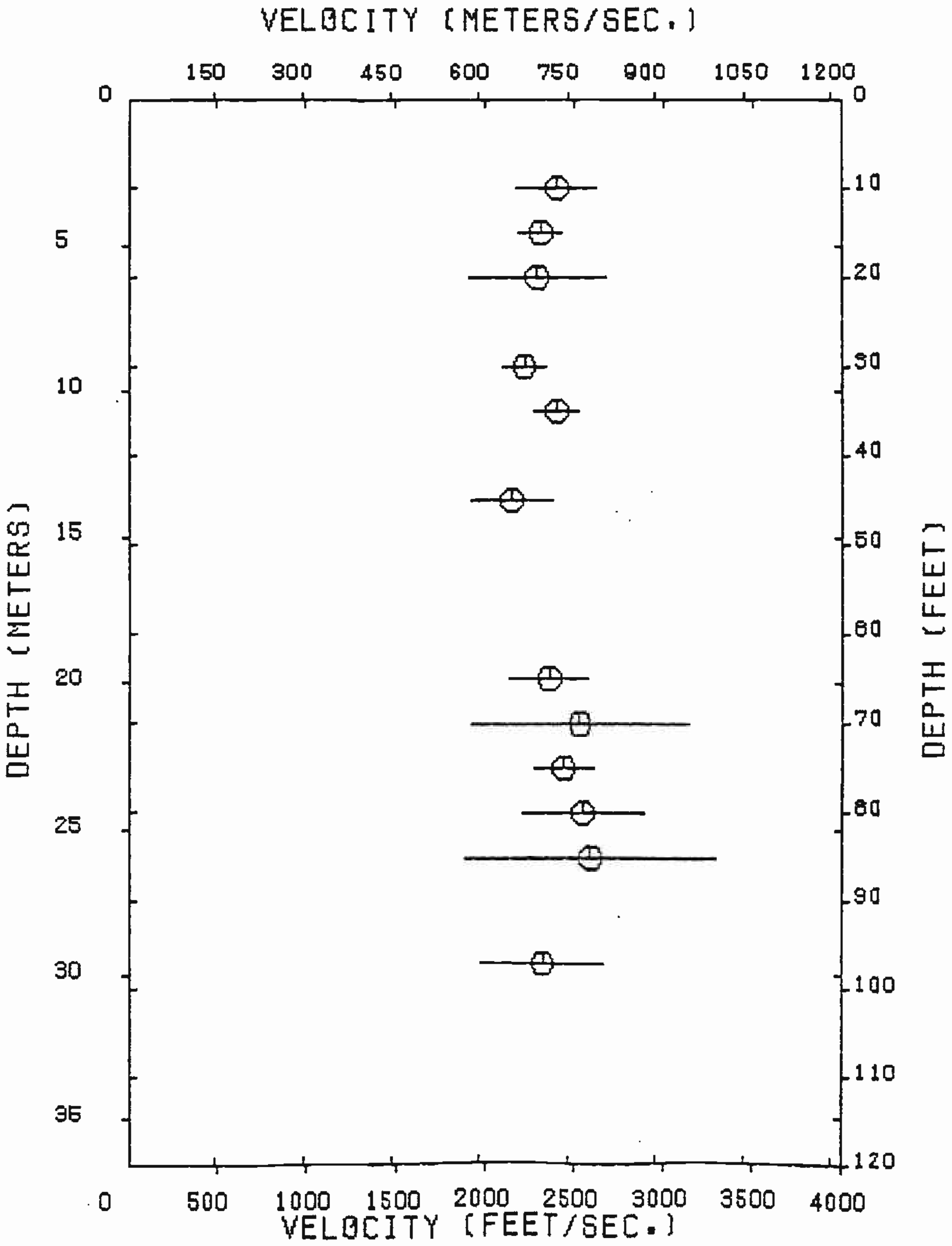

COMPRESSIONAL WAVE VELOCITY/DEPTH PROFILE - BORING SITE 24

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Figure No.
B-5

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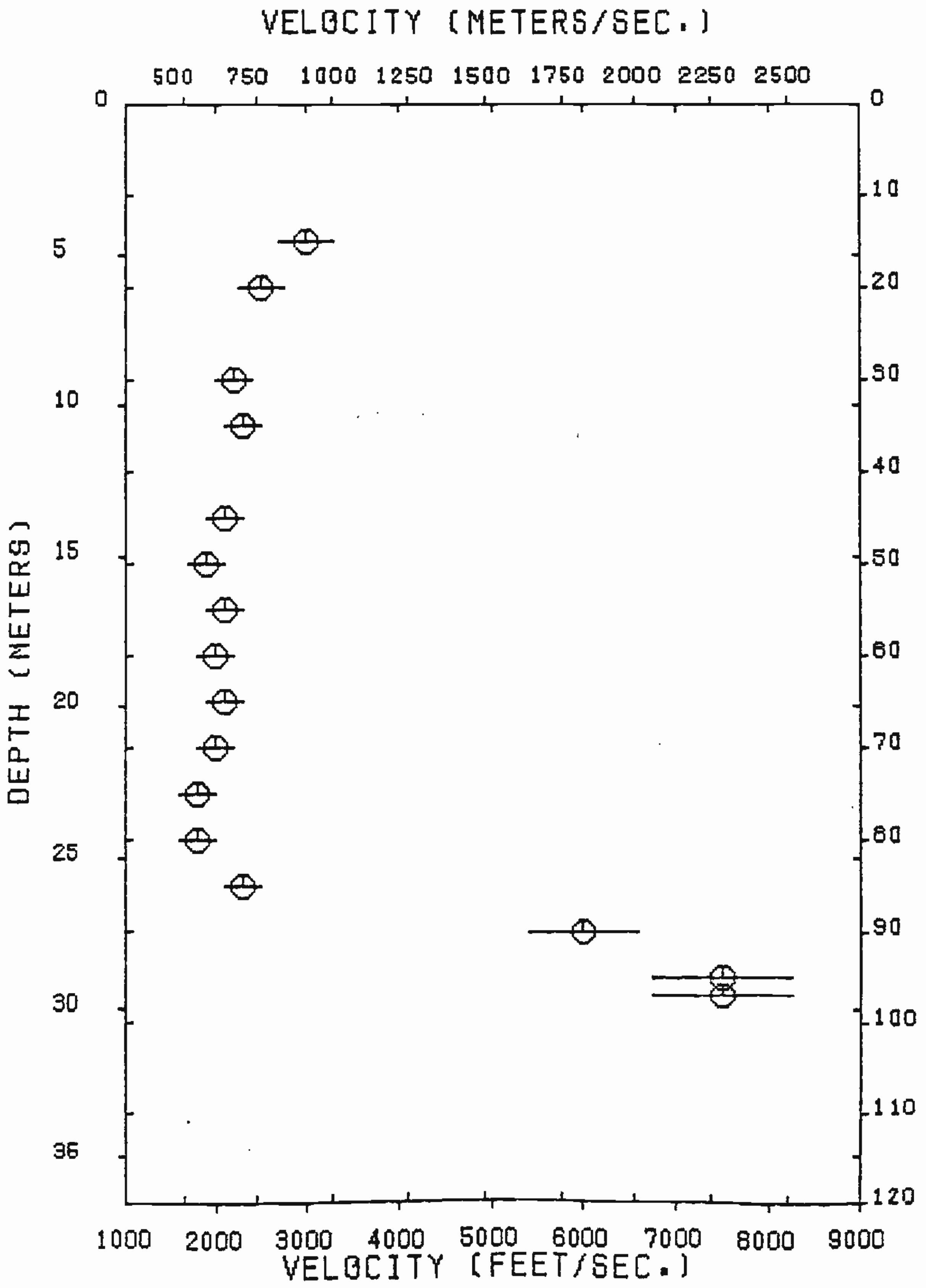

COMPRESSIONAL WAVE VELOCITY/DEPTH PROFILE - BORING SITE 28

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Figure No.
B-6

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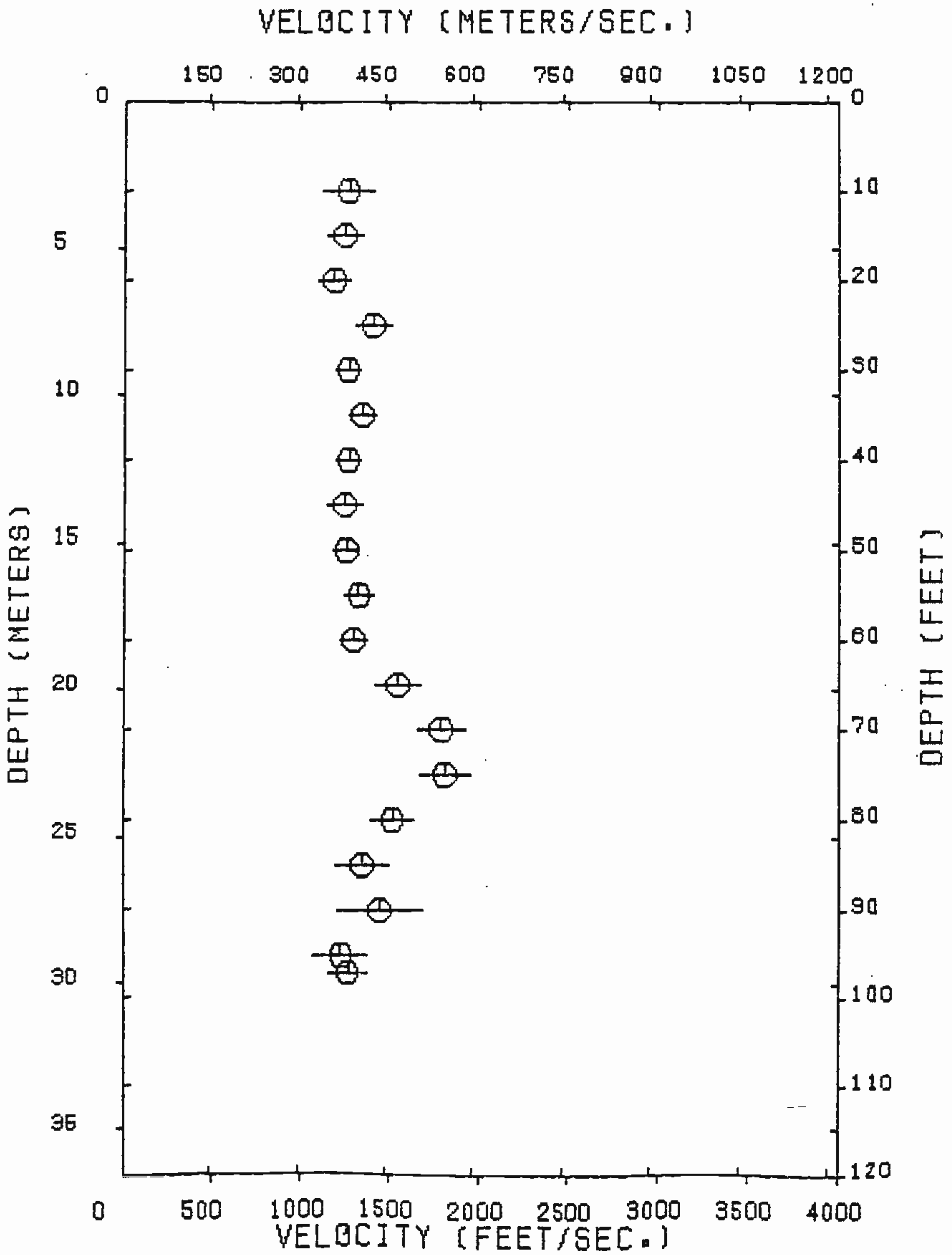

SHEAR WAVE VELOCITY/DEPTH PROFILE - BORING SITE 24

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Figure No.
B-7

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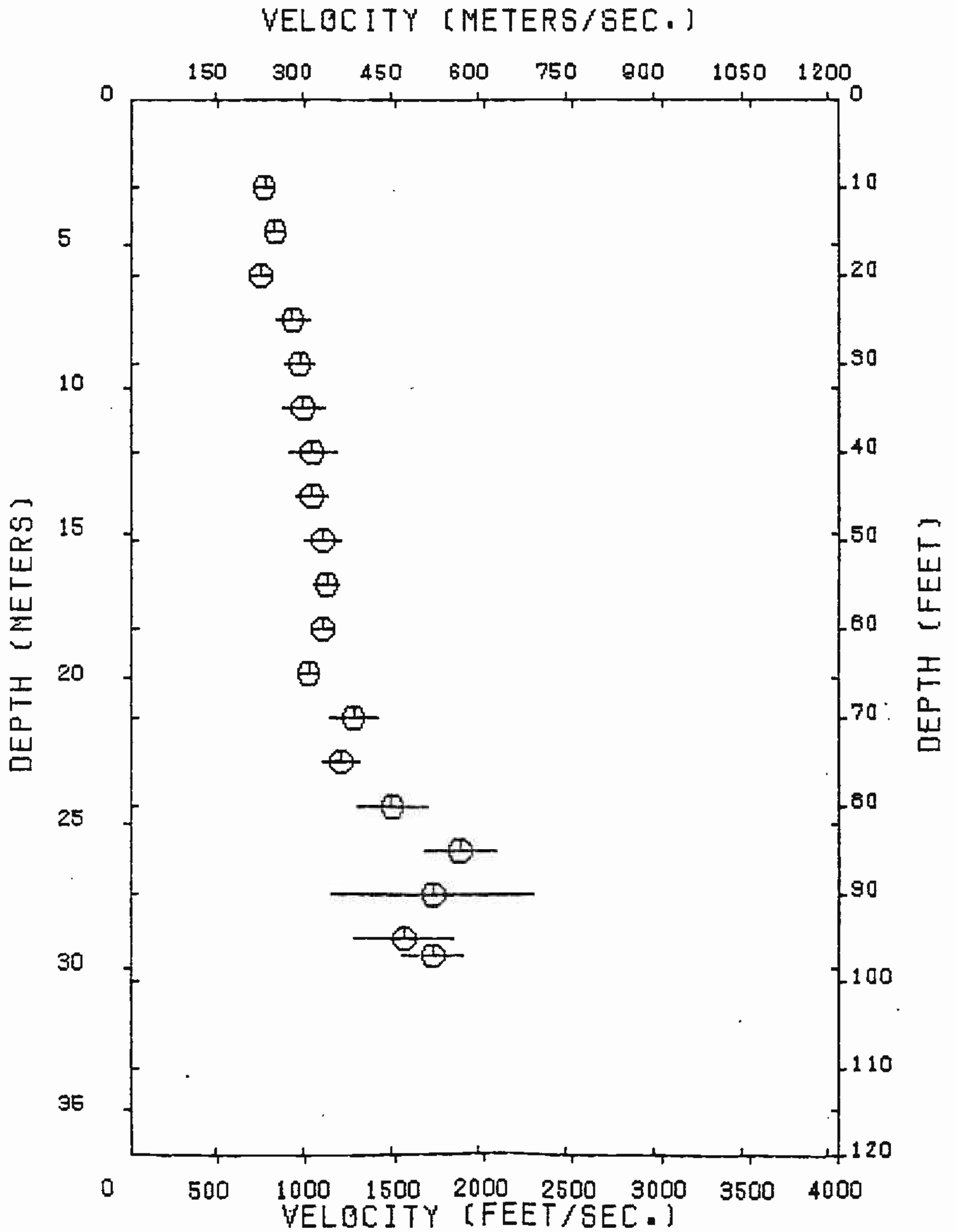

SHEAR WAVE VELOCITY/DEPTH PROFILE - BORING SITE 28

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Figure No.
B-8

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Appendix C

Gas Chromatographic Analyses

APPENDIX C GAS CHROMATOGRAPHIC ANALYSIS

C.1 INTRODUCTION

Concentrations of certain gases are known to result in fires and explosions in tunnels; methane is the gas most commonly associated with such hazards. Methane and other natural hydrocarbon gases are expected to occur along the proposed Metro Rail tunnel alignment, especially where the alignment crosses oil fields. Certain non-hydrocarbon gases can be corrosive or result in health hazards to the miners, and these gases are also expected. These gases include hydrogen sulfide, carbon monoxide, and carbon dioxide. To provide a measure of the distribution and extent of the hazardous hydrocarbon and non-hydrocarbon gases, a program of in-situ quantitative analyses was conducted by Converse's special consultant, RYLAND-CUMMINGS, INC.

The hydrocarbon gases tested were: methane; ethane; propane; n-butane; isobutane; n-pentane; isopentane; and C_6+, undifferentiated. The non-hydrocarbon gases tested were: nitrogen; oxygen; carbon monoxide; carbon dioxide; and hydrogen sulfide.

C.2 FIELD PROGRAM

During the 1981 geotechnical investigation, specific hydrocarbon and non-hydrocarbon gases were collected at shallow depths at Borings CEG-23 and CEG-23A which are located near the extreme southern end of the tunnel alignment of Design Unit A310 (Stations 573 and 589, respectively). At the time the tests were performed, samples of air were also analyzed to provide an ambient base. Approximately 10 ml of gas were analyzed for each sample. All samples were analyzed in the field using an analytical gas chromatograph.

During the drilling of the large-diameter borehole, 23B, in February 1983, hydrogen sulfide odors were detected in this hole and a gas detector measured explosive limits. Samples of the gas reported coming from this hole were not, however, tested by chromatographic analysis.

Gas and/or gasoline odors were also reported during the drilling and logging of the large-diameter borehole, 28C. This boring was drilled in October 1983 and is located near the extreme northern end of the tunnel alignment of Design Unit A310. About 1 inch of gasoline was reported floating on top of the groundwater that collected in this hole. A possible source of this gasoline is believed to be an abandoned service station which is located about 150 feet north of this borehole location. While this borehole is located somewhat outside the boundary of Design Unit A310, the occurrence of this gasoline and potentially hazardous condition so close to the proposed tunnel line is worth noting. Gas was measured in this hole using a gas detector and was at a 3% LEL.

The following text describes the methods used to analyze the gases collected from selected borings drilled during the 1981 geotechnical investigation.

Gas Collection - Air Samples

Samples of air were collected during the 1981 investigation using a syringe specifically designed for gas chromatographic analysis. The air sample was injected into the gas chromatographic and analyzed in the field.

Gas Collection - Borehole Samples

Most of the natural hydrocarbon gases are heavier than air and must be pumped to the surface to be sampled. One gas, methane, is lighter than air; and another gas, ethane, has approximately the same density as air.

The gas in the borehole was collected through a perforated tube that was inserted into the borehole, and the gas was pumped to the surface by a vacuum pump. The vacuum pump was operated by a portable 120-volt, 1500-watt generator; the generator also supplied power to the gas chromatograph and strip chart recorder. The borehole was temporarily sealed above the level of sampling using an inflated bicycle inner tube. The seal prevented contamination of air or gases from the surface.

The hole was pumped for several minutes; the air and gases wasted before a representative sample was collected for analysis. The purpose for wasting these gases was to purge the borehole of any anomalous accumulations of gas or air due to the drilling operation. After this purge, a sample of gas was collected using the special syringe, and the gas was inserted into the gas chromatograph for analysis in the field.

C.3 DESCRIPTION OF ANALYTICAL GAS CHROMATOGRAPH

The instrument used for quantitative analysis was a Carle thermal conductivity analytical gas chromatograph, Series-S, with a minimum detectability limit of 5×10^{-10} g/ml of propane at 150°C. The unit uses a built-in valve programmer that automatically actuates the correct sequence of internal switching events that are required to perform the complete analysis. Because the instrument is fully automated, errors that might be introduced during the analysis by the operator are eliminated. The gases that were detected were recorded on a strip chart; the written record is called a chromatogram. Chromatograms of the samples and a legend are included in this appendix.

Chromatographic System and Operation

A sample of gas is injected into the chromatograph. The injected sample is carried through the instrument by an inert gas (helium) at a constant temperature (70°C), at a constant pressure (60 psi), and at a constant flow rate (30 ml/min). The gas flows through a series of columns, or tubes, that are packed with materials that have specific adsorptive properties; these properties help to separate individual gases from the sample as it flows through the instrument. Each column is designed to separate and identify specific gases. A pressure regulator is used to assure uniform pressure to the column inlet, thereby resulting in a constant rate of flow throughout the analysis.

Depending on the complexity of the gas to be detected, the gas stream may be shunted through a series of valves that direct the gas sample into different columns containing the appropriate adsorptive materials for proper separation.

The column selectively retards the gas components according to their molecular weight and polar characteristics until the components form separate concentrations, or bands, in the carrier (helium) gas. These bands are recorded on a strip chart as a function of time.

The Chromatograph; Methods of Interpretation

The record of the gases is printed on a strip chart; the abscissa is time, and the ordinate is millivolts. The chromatogram can be used immediately to qualitatively identify the gases in the sample. Quantitative analyses require additional steps and auxiliary operations. Several different methods can be used to quantify the data; each method has advantages and disadvantages, and not every method is applicable to a particular problem.

A series of gas standards that have different, known percents of the components are allowed to flow through the instrument; the components are recorded on a strip chart. The areas and heights of the peaks are calculated for each different component and for each percent; these data are used to draw a set of graphs of percent of gas vs. peak area of peak height. These graphs provide a basis for comparison to the unknown volumes of gas sampled in the field. The procedure would be as follows: the area corresponding to a gas depicted on the field chromatogram is measured (using, for example, a compensating polar planimeter); that area can be compared to the standard to determine the volume percent of gas in the unknown sample.

To determine weight percent, the data on the field chromatogram must be normalized with respect to the total area of all components. To convert the field data to weight percent, a correction factor corresponding to the gas must be used. The correction factor is necessary because the areas on the graph corresponding to each component are not directly proportional to the percent composition. This is so because different compounds have different responses to the detector depending on the molecular weight of the gas. To determine the correction factor, the relative thermal response per mole of the gas is divided into the molecular weight.

C.4 RESULTS

The chromatogram for Borings CEG-23 and CEG-23A are attached. The results of the analyses, reported as parts per million, are given in Table C-1. The reason for selecting "parts per million" to report the results is because this measure provides the most direct conversion to percent by volume; percent by volume is the basis for classifying tunnels in terms of safety (California Administrative Code, Title 8, Article 8, Section 8422). Table C-1 also identified (1) the lower limit of flammability, (2) tunnel classification at the 5 percent and 20 percent lower explosive limit (LEL), and (3) the threshold limit values of selected non-hydrocarbon gases. These columns, abstracted from the more complete Tables C-2 and C-3, are included in Table C-1 for convenience. Table C-2 indicates the limits of flammability for the gases. Table C-3 indicates the threshold limit value (TLV) of selected non-hydrocarbon gases.

Samples Collected in Air

None of the gases detected during the 1981 investigation reached a value that would be considered hazardous (Table C-1).

Hydrocarbon gases in air are not necessarily from natural sources, such as emanations from oil fields. Automobile exhaust is a major source. Exhaust from automobiles includes ethane, propane, isobutane, n-butane, isopentane, n-pentane, C_6+ (California Air Resources Board, November 1980, Hydrocarbon profile of motor vehicle exhaust, 1980, Project HS-11-SHC, 4 p). Hydrogen sulfide can come from either natural or industrial sources. There is no need for differentiating the sources for this project. However, they can be differentiated by studying the isotropic composition of the gases.

Methane is likely to have a natural source. Because the gas is lighter than air, it can work its way up through the rocks and soils, eventually reaching the surface. Some of the hydrogen sulfide undoubtedly has a natural source. The gas could be smelled near some of the open boreholes and from the water pumped from the subsurface; the gas is highly soluble in water (Table C-4). During our testing, we noticed that the gas did not flow continuously out of the boreholes; rather, it came out in pulses. Detection of hydrogen sulfide by smell does not necessarily indicate a hazardous condition; the lower limit of detection can be less than 10 ppm (Table C-3), depending on the sensitivity of the individual.

Samples Collected in Boreholes

Gas samples were collected in the boreholes from levels above the uppermost perched water table or within the saturated zone of the uppermost perched water table. Samples from Borings CEG-23 and CEG-23A were collected in a cased piezometer; perforations in the casings were within the saturated zone and the gas sampling point was above the line of the water in the cased piezometer. Field conditions did not allow for sampling of gas below the perched water table or at tunnel level or at the point of origin of the gas. Details of the sampling depth and the depth of the water at the time of sampling are given in Table C-1.

Sources of Gas

Geologic exploration for natural gas fields clearly indicates that perched groundwater acts to seal the gases below the water (Masters, 1979). The water inhibits the upward migration of the gases. In some field examples discussed in Masters (1979), the gases and water are in the same permeable sandstone, and no impermeable barrier or lithology exists between the water and the gases. Although small amounts of hydrocarbon gases can be adsorbed in the water, the limit of saturation for these gases is extremely low, not exceeding 65 ppm (Table C-4). Among the non-hydrocarbon gases, only carbon dioxide and hydrogen sulfide are significantly soluble (1449 ppm and 3375 ppm, respectively; Table C-4). Because these gases have difficulty entering the water, the gases tend to accumulate at and below the lower level of the perched water table. And, because small amounts of gas are present in the water, not much gas is available to leak out of the water. Thus, only a very small amount of hydrocarbon gases detected in the boreholes came from within the water. The gases can enter the water and bubble up through it if the gases are subjected to a high differential pressure. Gases can also enter the water-saturated zone and bubble up through it if the source of the gases is within the saturated zone.

A review of the lithologic logs of the boreholes along the proposed alignment indicates geologic conditions analogous to those described in Master (1979). Direct evidence of such conditions along the alignment comes from reports of the drilling operations. The gas "sniffers" detected gas concentrations during the drilling and after the holes had been capped temporarily. The lower level of detection of the "sniffers" was above the lowest limit of sensitivity of the gas chromatograph; the chromatograph recorded levels of gas concentrations lower than that which would trigger the "sniffers." Apparently, the "sniffers" detected the pulse of the gas that was trapped below the water table when the water table was pierced by the drilling. These geologic conditions have significance along the proposed alignment because the natural gases that formed at depth and related to the oil fields are likely to be trapped below the perched water tables. The gases that accumulate along the base of the perched water would likely migrate laterally. Because the gases can migrate laterally below the perched water table, the gases may be present outside the immediate vicinity of known oil fields. The concentrations of gas would depend on the permeability of the rock and soils as well as the concentration and production of gases at the source. Consequently, gases may also be present along the alignment in areas away from the known oil fields. The gases can accumulate in pockets of zones in the soils or bedrock, against faults, or against other impermeable barriers such as igneous dikes. These accumulations can be miles away from known or suspected sources.

The lateral migration of gases from their source in one oil field can cause them to mix with other gases from another oil field. A gas sample from a borehole may not provide a characteristic signature of the gases produced by the nearby oil field due to contamination related to the lateral migration of these gases.

C.5 CONCLUSIONS

In oil field areas such as the Fairfax/Beverly Station and the extreme southern end of the tunnel alignment of Design Unit A310, gas will likely be encountered in the subsurface. These areas should be classified as gassy (5% lower explosive limit) adjacent areas should be classified as gassy and/or potentially gassy.

Because of the lateral migration of gases below the zones of perched water, it is likely that gases have accumulated under pressure in the stratigraphic and structural traps (e.g., faults of igneous dikes along the southern part of the Santa Monica Mountains) at distances away from the immediate areas of known oil fields. Such areas should be approached cautiously with appropriate testing of gases during the driving of the tunnel. In addition, extreme caution should be exercised whenever the driving of the tunnel approaches the area below a perched water zone, and appropriate gas testing should be done.

REFERENCE:

Master, J. A., 1979, Deep basin gas trap, western Canada: Bull. AAPG, v. 63, no. 2, p. 152-181.

TABLE C-1

SUMMARY OF DATA FROM GAS CHROMATOGRAMS

GAS	Lower Limit of Flammability* (ppm)	TUNNEL CLASSIFICATION** GASSY	TUNNEL CLASSIFICATION** EXTRA HAZARDOUS	BORING NUMBER 1		2		10		11		19		21		22		23		23A	
		5% LEL (ppm)	70% LEL (ppm)	Air (ppm)	Cased Piezometer Sampled @ 10' Water Level @ 10' (ppm)	Air (ppm)	Cased Piezometer Sampled @ 18' Water Level @ 20' (ppm)	Air (ppm)	Cased Piezometer Sampled @ 15' Water Level @ 20' (ppm)	Air (ppm)	Cased Piezometer Sampled @ 40' Water Level @ 45' (ppm)	Air (ppm)	Cased Piezometer Sampled @ 9' Water Level @ 10' (ppm)	Air (ppm)	Refer to Notes a, b, c† (ppm)	Air (ppm)	Alluvium Open Hole Sampled @ 15' Water Level @ 20' (ppm)	Air (ppm)	Cased Piezometer Sampled @ 13' Water Level @ 15' (ppm)	Air (ppm)	Cased Piezometer Sampled @ 13' Water Level @ 15' (ppm)
Methane	50,000	2,500	10,000	-	100	-	200	-	-			-	trace	-	a trace b - c -	trace	trace	-	-	-	trace
Ethane	30,000	1,500	6,000	trace†	300	-	300	-	-			-	2,000	100	a trace b trace c trace	100	1,800	-	-	150	350
Propane	21,200	1,060	4,240	-	trace	-	trace	-	-			-	-	-	a trace b - c -	-	-	-	-	trace	-
n-Butane	18,600	930	3,720	-	trace	-	trace	-	-			-	trace	-	a trace b - c -	-	trace	-	trace	trace	-
Isobutane	18,000	900	3,600	-	trace	-	trace	-	-			-	150	-	a trace b - c -	-	trace	-	trace	trace	-
n-Pentane	14,000	700	2,800	-	trace	-	trace	-	-			-	trace	-	a trace b - c -	-	-	-	trace	trace	-
Isopentane	15,200	660	2,640	-	trace	-	trace	-	-			-	trace	-	a trace b - c -	-	-	-	trace	trace	-
C_6+	‡	-	-	800	1,000	1,600	1,600	400	1,200			2,000	4,500	500	a 300 b 2,000 c trace	100	1,000	3,500	3,500	2,500	2,500
Nitrogen	-	-	-	772,000	771,000	770,000	770,000	770,000	770,000			770,000	766,000	770,000	a 770,000 b 770,000 c 770,000	770,000	770,000	769,000	764,000	768,000	768,000
Oxygen	-	-	-	200,000	200,000	200,000	200,000	201,000	200,000			200,000	199,000	201,000	a 201,000 b 200,000 c 201,000	201,000	200,000	200,000	200,000	200,000	200,000
Carbon monoxide	125,000	6,250	25,000	-	trace	-	trace	-	-			trace	trace	trace	a trace b - c -	-	trace	-	trace	trace	trace
Carbon dioxide	-	-	-	27,000	28,000	28,000	28,000	28,000	28,000			28,000	28,000	28,000	a 28,000 b 27,000 c 28,000	28,000	27,000	27,000	27,000	29,000	27,000
Hydrogen sulfide	43,000	2,175	8,700	trace	trace	-	trace	-	trace			trace	trace	trace	a trace b trace c 100	trace	trace	trace	trace	trace	trace

GAS	THRESHOLD LIMIT VALUES OF SELECTED NON-HYDROCARBON GASES		BORING NUMBER 1		2		10		11		19		21		22		23		23A	
	ppm §	ppm §§	Air (ppm)	Cased Piezometer @ 10' (ppm)	Air (ppm)	Cased Piezometer @ 18' (ppm)	Air (ppm)	Cased Piezometer @ 15' Water Level @ 20' (ppm)	Air (ppm)	Hole (ppm)	Air (ppm)	Hole (ppm)	Air (ppm)	Hole (ppm)	Air (ppm)	Hole (ppm)	Air (ppm)	Hole (ppm)	Air (ppm)	Hole (ppm)
Carbon monoxide	50	100; 200; 400; 1,200, 2,000	-	trace	-	trace	-	-			trace	trace	trace	a trace b - c -	-	trace	-	trace	trace	trace
Carbon dioxide	5,000	5,000; 50,000, 90,000	27,000	28,000	28,000	28,000	28,000	28,000			28,000	28,000	28,000	a 28,000 b 27,000 c 28,000	28,000	27,000	27,000	27,000	29,000	29,000
Hydrogen sulfide	10	10; 100; 200	trace	trace	-	trace	-	trace			trace	trace	trace	a trace b trace c 100	trace	trace	trace	trace	trace	trace
Oxygen	#	-	200,000	200,000	200,000	200,000	201,000	200,000			200,000	199,000	201,000	a 201,000 b 201,000 c 201,000	201,000	200,000	200,000	200,000	200,000	200,000

* See Table F1-2 for levels of selected gases.

** Based on information in Table F1-2; see California Administrative Code, Title 8, Article 3, Appendix B, Part 3, section 7955a, 55b, 7955c, 7955d. NOTE. Samples normalized to indicate ppm. Small errors result from rounding of values.

† Less than 100 ppm.

‡ Not differentiated.

§ Title 8, California Administrative Code, General Industry Safety Order. NOTE: Nitrogen dioxide not tested. TLV requirements: not more than 5 ppm.

§§ See Table F1-3 for details of different levels.

\# Not less than 180,000 ppm.

Notes for Boring 21 Description
a = Alluvium Open Hole Sampled @ 13'
b = Cased 3/4" Piezometer Sampled @ 15'; water @ 16'
c = Cased 2" Piezometer Sampled @ 53'; water @ 55'

TABLE C - 2
LIMITS OF FLAMMABILITY

Gas	Formula	Limits of Flammability in Air			
		Percent by Volume*		Parts per Million	
		Lower	Upper	Lower	Upper
Methane	CH_1	5.00	15.00	50,000	150,000
Ethane	C_2H_6	3.00	12.50	30,000	125,000
Propane	C_3H_8	2.12	9.35	21,200	93,500
n-Butane	C_4H_{10}	1.86	8.41	18,600	84,100
Isobutane	C_4H_{10}	1.80	8.44	18,000	84,400
n-Pentane	C_5H_{12}	1.40	7.80	14,000	78,000
Isopentane	C_5H_{12}	1.32	-	13,200	-
Hexane**	C_6H_{14}	1.18	7.40	11,800	74,000
Heptane (C_7)	-	1.10	6.70	11,000	67,000
Octane (C_8)	-	0.95	-	9,500	-
Nonane (C_9)	-	0.83	-	8,300	-
Decane (C_{10})	-	0.77	5.35	7,700	53,000
Carbon monoxide	CO	12.50	74.20	125,000	742,000
Hydrogen sulfide	H_2S	4.30	28.50	43,000	285,000

*Handbook of Chemistry and Physics, 41st ed., p. 1927-1929.

**Instrument used in analyses combined all hydrocarbon gases, C_6 and greater, including those greater than C_{10}.

TABLE C - 3
THRESHOLD LIMIT VALUE OF SELECTED NON-HYDROCARBON GASES

Gas	Concentration by Volume in Air* Parts per Million	Comments*
Carbon monoxide	100	Threshold limit value (TLV); no adverse effects.
	200	Headache after about 7 hours if resting; about 2 hours of work.
	400	Headache and discomfort, possibility of collapse after 2 hours at rest or 45 minutes of exertion.
	1,200	Palpitation after 30 minutes rest or 10 minutes of exertion.
	2,000	Unconsciousness after 30 minutes rest or 10 minutes of exertion.
Carbon dioxide	5,000	TLV; lung ventilation slightly increased.
	50,000	Breathing is labored.
	90,000	Depression of breathing begins.
Hydrogen sulfide	10	TLV.
	100	Irritation to eyes and throat; headache.
	200	Maximum concentration tolerable for one hour.
	1,000	Immediate unconsciousness.
Sulfur dioxide (not tested)	1 to 5	Can be detected by taste at lower level, by smell at upper level.
	5	TLV; onset or irritation to nose and throat.
	20	Irritation to eyes.
	400	Immediately dangerous to life.

*National Coal Board, 1978, Spoil Heaps and Lagoons, Technical Handbook, N.C.B., London.

TABLE C-4
SOLUBILITY OF GASES IN WATER

Gas	Solubility in Water Parts per Million
Hydrocarbon*	
Methane	24.4 ± 1.0
Ethane	60.4 ± 1.3
Propane	6.24 ± 2.1
n-Butane	61.4 ± 2.6
Isobutane	48.9 ± 2.1
n-Pentane	38.5 ± 2.0
Isopentane	48.9 ± 1.6
(C_6)	9.5 ± 1.3
(C_7)	2.93 ± 0.20
(C_8)	0.66 ± 0.06
Non-Hydrocarbon**	
Nitrogen	17.5
Oxygen	39.3
Carbon monoxide	26.0
Carbon dioxide	1,449
Hydrogen sulfide	3,375

*McAuliffe, C., 1963, Solubility in Water of C_1 - C_9 hydrocarbons: Nature, v. 200, no. 4911, p. 1092-1093.

**Handbook of Chemistry and Physics, 41st ed., p. 1706-1707.

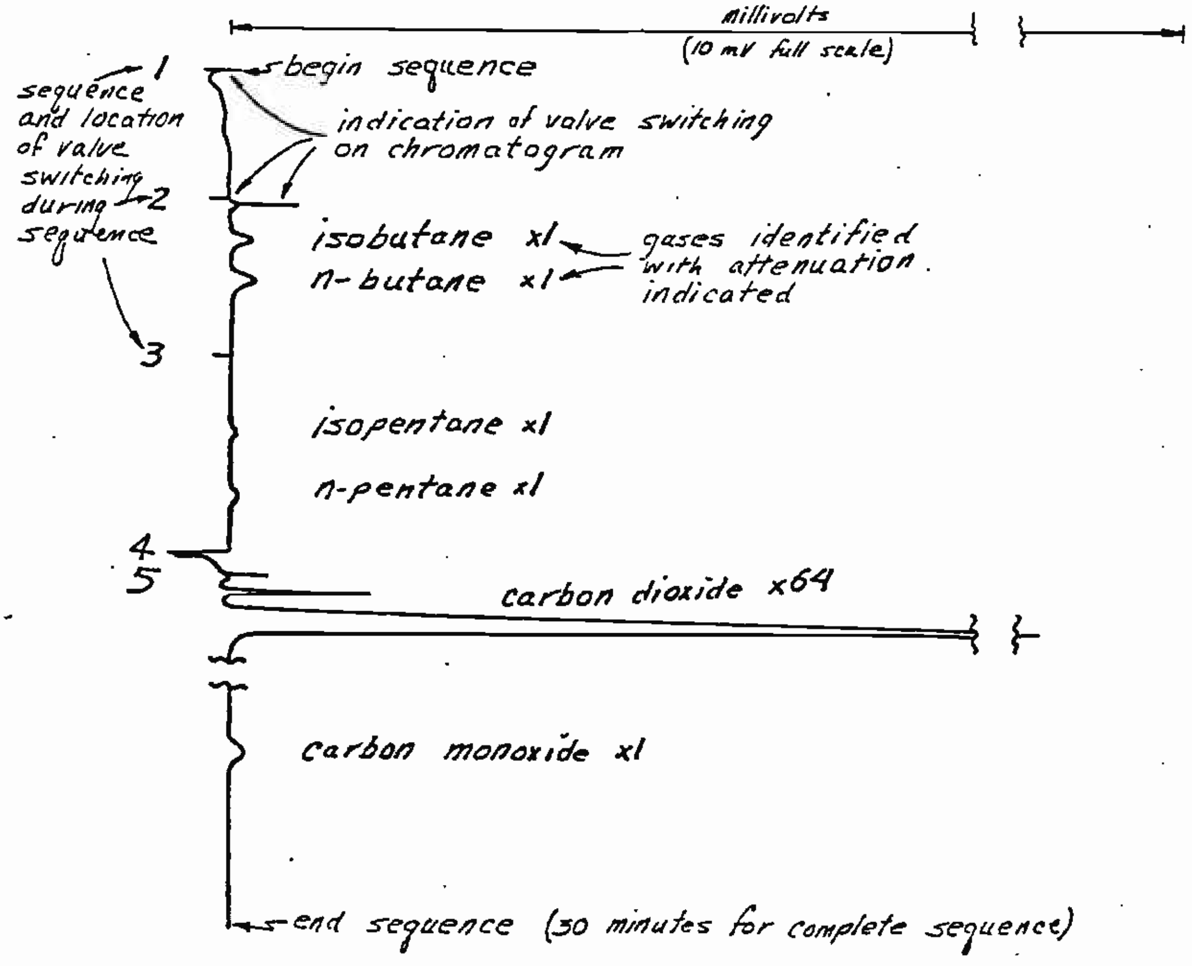
ConverseWardDavisDixon
Earth Sciences Associates
Geo/Resource Consultants

Ryland-Cummings, Inc.

Gas Chromatography
Boring No. ____

Date Sampled ____ Tested by ____
Depth of Sample ____ Column Temp. ____ Chart Speed ____
Formation ____ Helium ____
Sample Size ____ Attenuation Range ____

LEGEND



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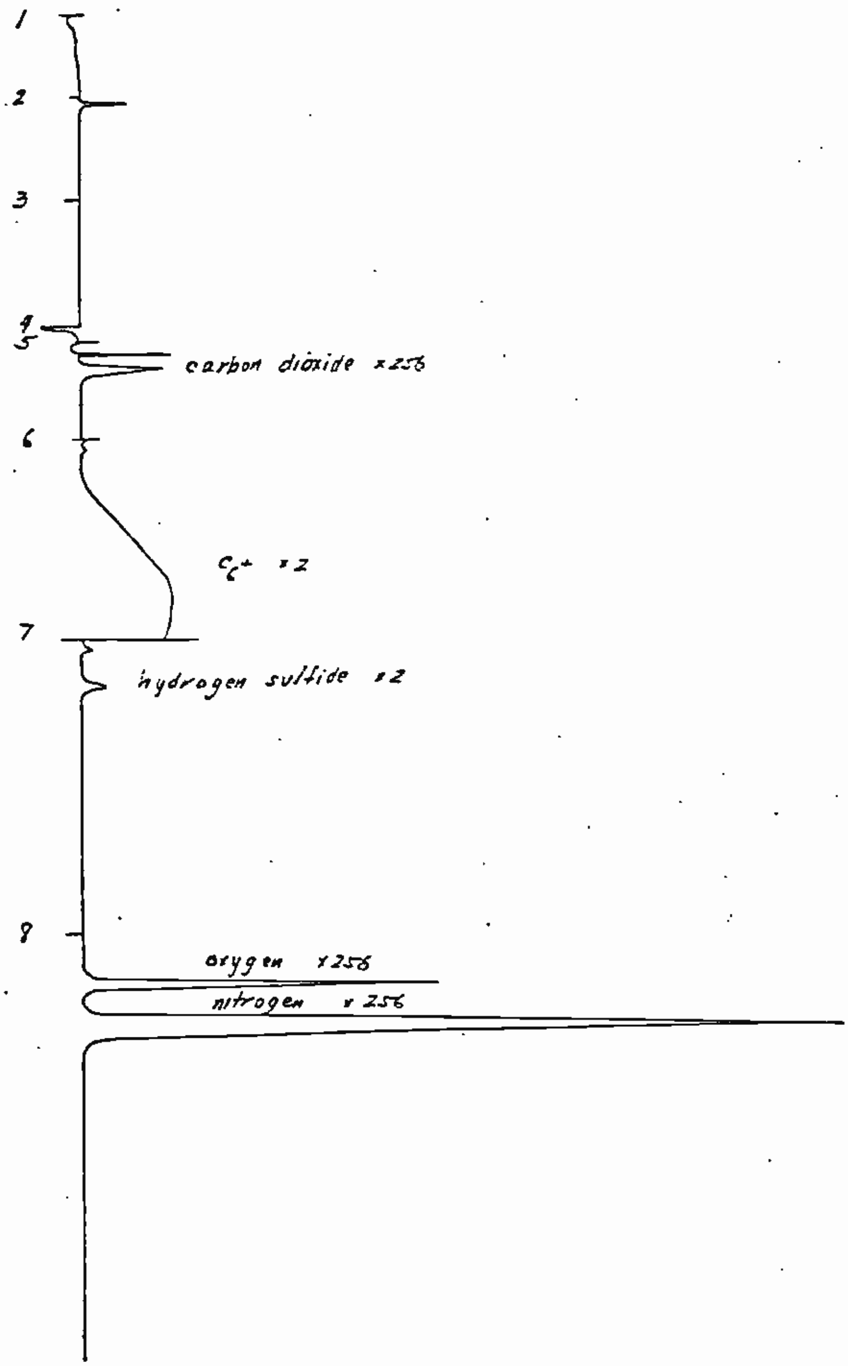
Geo/Resource Consultants

Ryland-Cummings, Inc.

Gas Chromatography
Boring No. 23

Date Sampled 1/3/81
Tested by D.C., S.L.R
Depth of Sample Air
Column Temp. 70°C
Chart Speed 0.5 in/mi
Formation
Helium 30 ml/min flow rate @ 60 psig
Sample Size 10 ml
Attenuation Range as shown



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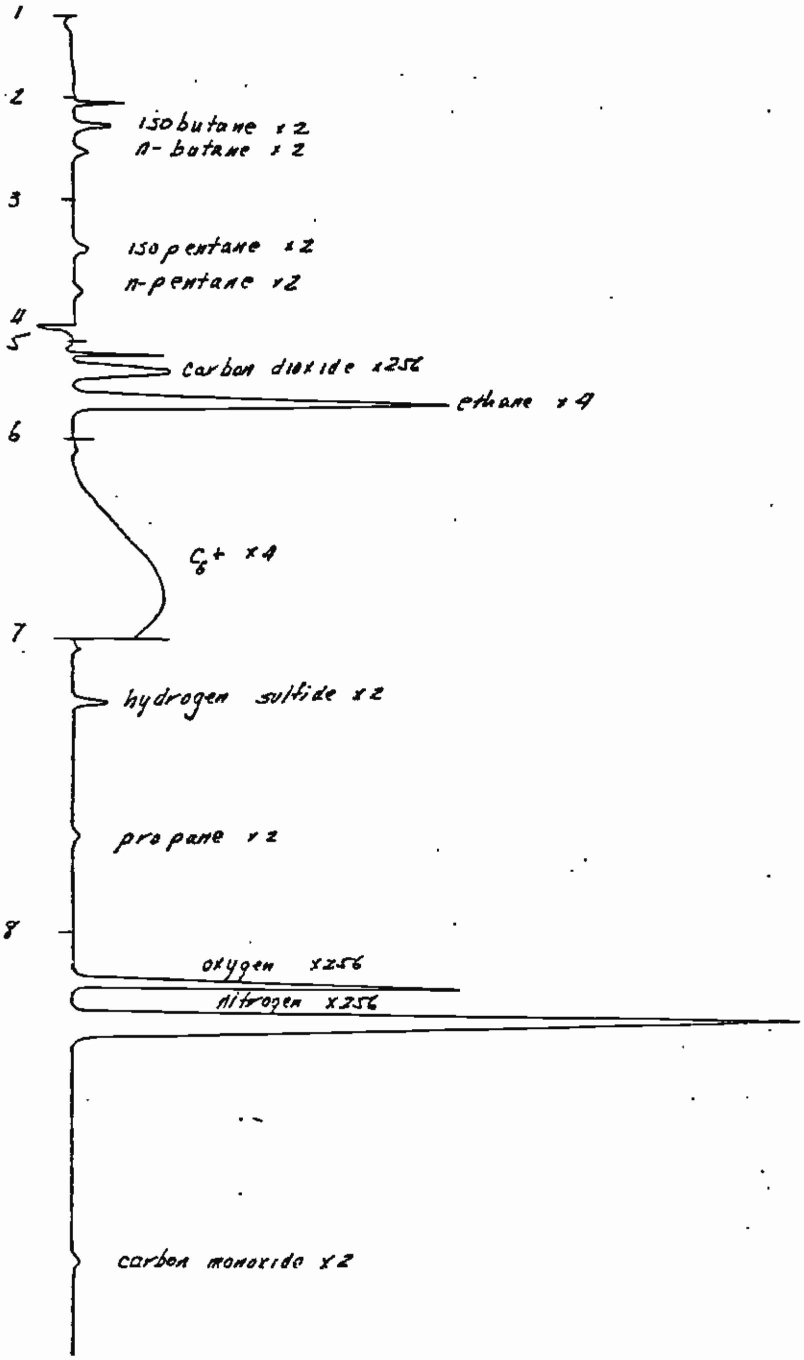
Gas Chromatography
Boring No. 23

Date Sampled 1/3/81
Tested by DC
Depth of Sample 12 ft water @ 15 ft
Column Temp. 70°C
Chart Speed 0.5 in/min
Formation cased piezometer
Helium 30 ml/min flow rate @ 60 psig
Sample Size 10 ml
Attenuation Range as shown



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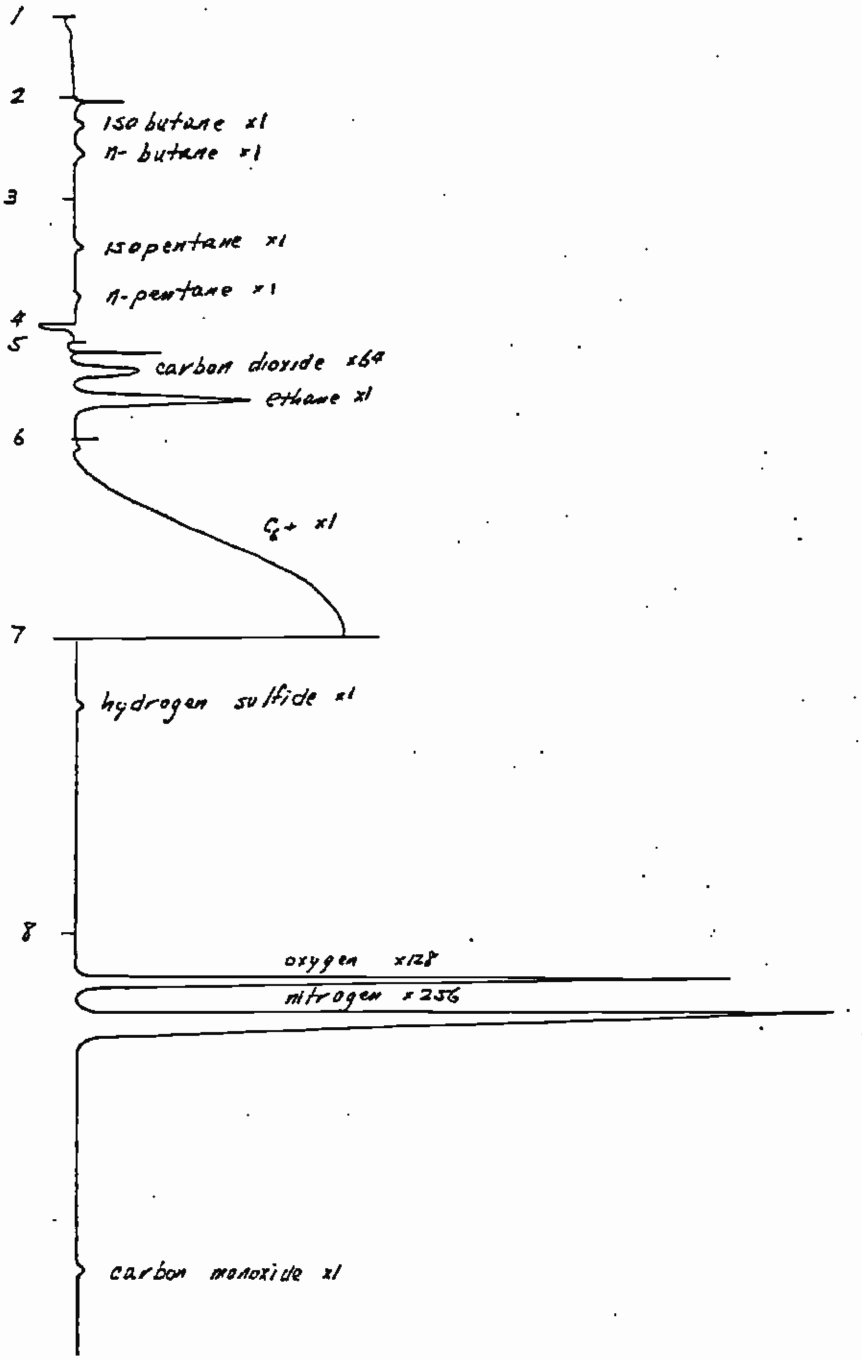
Gas Chromatography
Boring No. 23A

Date Sampled 2/20/81
Tested by D.C., SLR
Depth of Sample Air
Column Temp. 70°C
Chart Speed 0.5 in/m
Formation
Helium 30 ml/min flow rate @ 60 psig
Sample Size 10 ml
Attenuation Range as shown



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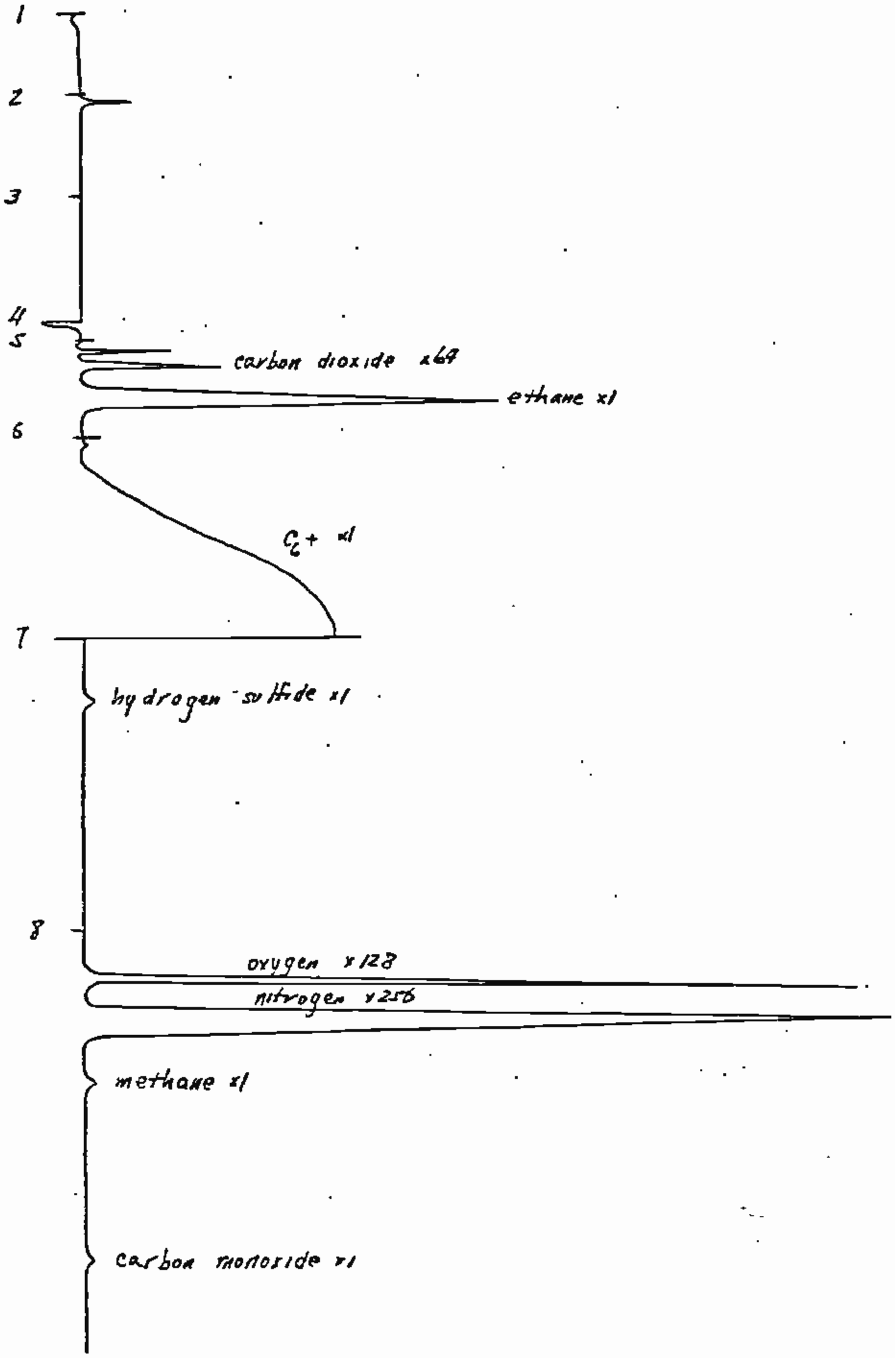
Gas Chromatography
Boring No. 23A

Date Sampled 2/20/81
Tested by D.C., SLR
Depth of Sample 10 feet; water @ 15 feet
Column Temp. 70°C
Chart Speed 0.5 in/min
Formation cased piezometer
Helium 30 ml/min flow rate @ 60 psig
Sample Size 10 ml
Attenuation Range as shown



Appendix D

Water Quality Analysis

APPENDIX D WATER QUALITY ANALYSIS

D.1 INTRODUCTION

Water samples from 7 selected borings were subjected to chemical analysis by Jacobs Laboratories (formerly PJB Laboratories) in Pasadena, California as part of the 1981 geotechnical investigation (see Table D-1). Three of the borings (CEG-25, CEG-26, and CEG-27) from which water samples were collected and tested are about 1200 to 1300 feet away from the proposed tunnel alignment and station structure locations of Design Unit A310. The water quality test results for these samples are included in this appendix; however, since they are considered representative of the groundwater quality along the proposed alignment. Two additional water samples taken from Borings 23B and 27A were tested by Brown and Caldwell, Consulting Engineers in Pasadena, California. These samples were tested during February-March, 1983. The primary purposes of obtaining and testing the water samples were as follows:

- o Develop a current chemical constituent baseline for the groundwater along the subject Metro Rail Project alignment.
- o Evaluate water chemicals that could have significant influence on design requirements.
- o Identify chemical constituents for compliance with EPA requirements for future tunneling activities.

Chemical constituents tested by PJB Laboratories and Brown and Caldwell include:

- o Major cations.
- o Major anions.
- o pH special test for boron.
- o Conductivity.
- o TDS.

D.2 ANALYSIS AND RESULTS

In our opinion, neither a complicated chemical analysis nor interpretation were required for the purpose of the 1981 and 1983 geotechnical studies. Therefore, standard water chemical analysis tests were performed by PJB Laboratories and Brown and Caldwell, the results of which are presented herein. The results of the water quality tests are summarized in the following data summary sheets.

TABLE D-1

SELECTED WATER QUALITY PARAMETERS

Boring No.	PVC Diam. (In.)	Depth Water Sampled (ft)	Date Sampled	pH @ 25° C	Total Dissolved Solids (ppm)	Sulfate SO_4 (ppm)	Boron, B (ppm)	Possible Water Type & Comments
23	2	7.5	02-13-81	7.5	589	6	0.22	Na/HCO_3
23A	2	20.0	02-20-81	7.7	863	154	0.38	Na/HCO_3
25	2	109.0	02-13-81	7.6	494	65	0.12	Na/HCO_3
26	1	31.0	02-12-81	7.4	660	161	0.20	Na/HCO_3
27	2	27.5	02-13-81	7.8	725	245	0.32	Na/HCO_3
28A	2	30.0	03-19-81	7.8	805	272	1.16	Na/HCO_3
29	2	84.5	02-25-81	8.0	5,996	2,600	2.6	Na/SO_4

ConverseWardDavisDixon
Earth Sciences Associates
Geo/Resource Consultants

Jacobs Laboratories

Water Quality

April 6, 1981

Converse Ward Davis Dixon
126 W. Del Mar Blvd.
P.O. Box 2268D
Pasadena, CA 91105

Lab No. P81-02-123
P81-02-142
P81-02-159
P81-02-186
P81-03-017

Attention: Buzz Spellman

Report of Chemical Analysis

The enclosed analytical results are for thirty (30) samples of ground water received by this laboratory on February 12, 17, 18, 20 and March 3, 1981. The samples were collected and delivered by Converse, Ward, Davis, Dixon personnel.

Cation/Anion balance was not acheived on many of the samples due to the presence of an unmeasured cation, probably aluminum or barium. This fact is reflected in the large difference between the milliequivalents of total hardness, (Milligrams $CaCO_3$/1 ÷ 50 = milliequivalents) and the summed milliequivalents of calcium and magnesium. These samples balance electrically using the total hardness in place of the calcium and magnesium. This indicates a cation (or cations) was not measured. The most common ions are aluminum and barium. If you so desired, we may analyze these samples for the missing element(s).

Respectfully submitted,

William, R. Ray
Manager, Water Laboratory

asl

Converse Ward Davis Dixon

Lab No. P81-02-142-4

No. Samples : 7
Sampled By : Client
Brought By : Client
Date Received: 2-17-81

Sample labeled: HOLE 23-2"

Conductivity: 1,020 µ mhos/cm

Turbidity: NTU

pH 7.5 @ 25°C
pHs @ 60°F (15.6°C)
pHs @ 140°F (60°C)

	Milligrams per liter (ppm)	Milli-equivalents per liter
Cations determined:		
Calcium, Ca	1.8	0.09
Magnesium, Mg	43	3.54
Sodium, Na	119	5.18
Potassium, K	3.8	0.10
		Total 8.91
Anions determined:		
Bicarbonate, as HCO_3	595	9.75
Chloride, Cl	74	2.09
Sulfate, SO_4	6	0.12
Fluoride, F	0.3	0.02
Nitrate, as N	0.1	0.01
		Total 11.99
Carbon dioxide, CO_2, Calc.	27	
Hardness, as $CaCO_3$	342	
Silica, SiO_2	44	
Iron, Fe	< 0.01	
Manganese, Mn	< 0.01	
Boron, B	0.22	
Total Dissolved Minerals, (by addition: $HCO_3 \rightarrow CO_3$)	589	

Converse Ward Davis Dixon

Lab No. P81-02-186-3

No. Samples : 7
Sampled By : Client
Brought By : Client
Date Received: 2-20-81

Sample labeled: HOLE 23A

Conductivity: 1,300 µ mhos/cm

Turbidity: NTU

pH 7.7 @ 25°C
pHs @ 60°F (15.6°C)
pHs @ 140°F (60°C)

	Milligrams per liter (ppm)		Milli-equivalents per liter
Cations determined:			
Calcium, Ca	61		3.04
Magnesium, Mg	44		3.61
Sodium, Na	160		6.96
Potassium, K	5.8		0.15
		Total	13.76
Anions determined:			
Bicarbonate, as HCO_3	389		6.38
Chloride, Cl	120		3.50
Sulfate, SO_4	154		3.21
Fluoride, F	0.7		0.04
Nitrate, as N	18.59		1.33
		Total	14.46
Carbon dioxide, CO_2, Calc.	11		
Hardness, as $CaCO_3$	333		
Silica, SiO_2	42		
Iron, Fe	< 0.01		
Manganese, Mn	< 0.01		
Boron, B	0.38		
Total Dissolved Minerals, (by addition: $HCO_3 \rightarrow CO_3$)	863		

Converse W. Davis Dixon

Lab No. P81-02-142-6

No. Samples : 7
Sampled By : Client
Brought By : Client
Date Received: 2-17-81

Sample labeled: HOLE 25-2"

Conductivity: 949 µ mhos/cm

Turbidity: NTU

pH 7.6 @ 25°C
pHs @ 60°F (15.6°C)
pHs @ 140°F (60°C)

	Milligrams per liter (ppm)		Milli-equivalents per liter
Cations determined:			
Calcium, Ca	12		0.58
Magnesium, Mg	32		2.63
Sodium, Na	74		3.22
Potassium, K	2.5		0.06
		Total	6.49
Anions determined:			
Bicarbonate, as HCO_3	365		5.98
Chloride, Cl	41		1.15
Sulfate, SO_4	65		1.35
Fluoride, F	0.4		0.02
Nitrate, as N	7.6		0.54
		Total	9.04
Carbon dioxide, CO_2, Calc.	13		
Hardness, as $CaCO_3$	298		
Silica, SiO_2	51		
Iron, Fe	0.09		
Manganese, Mn	< 0.01		
Boron, B	0.12		
Total Dissolved Minerals, (by addition: HCO_3 -> CO_3)	494		

Converse Ward Davis Dixon

Lab No. P81-02-142-3

No. Samples : 7
Sampled By : Client
Brought By : Client
Date Received: 2-17-81

Sample labeled: HOLE 26-1", 86'

Conductivity: 1,020 µ mhos/cm

Turbidity: NTU

pH 7.4 @ 25°C
pHs @ 60°F (15.6°C)
pHs @ 140°F (60°C)

	Milligrams per liter (ppm)	Milli-equivalents per liter
Cations determined:		
Calcium, Ca	9.9	0.50
Magnesium, Mg	40	3.29
Sodium, Na	112	4.87
Potassium, K	1.6	0.04
		Total 8.70
Anions determined:		
Bicarbonate, as HCO_3	385	6.31
Chloride, Cl	54	1.53
Sulfate, SO_4	161	3.35
Fluoride, F	0.6	0.03
Nitrate, as N	8.1	0.58
		Total 11.80
Carbon dioxide, CO_2, Calc.	22	
Hardness, as $CaCO_3$	374	
Silica, SiO_2	53	
Iron, Fe	< 0.01	
Manganese, Mn	< 0.01	
Boron, B	0.20	
Total Dissolved Minerals, (by addition: HCO_3 -> CO_3)	660	

Converse Ward Davis Dixon

Lab No. P81-02-142-5

No. Samples : 7
Sampled By : Client
Brought By : Client
Date Received: 2-17-81

Sample labeled: HOLE 27-2"

Conductivity: 1,200 µ mhos/cm

Turbidity: NTU

pH 7.8 @ 25°C
pHs @ 60°F (15.6°C)
pHs @ 140°F (60°C)

	Milligrams per liter (ppm)	Milli-equivalents per liter
Cations determined:		
Calcium, Ca	26	1.30
Magnesium, Mg	52	4.28
Sodium, Na	76	3.31
Potassium, K	1.7	0.04
	Total	8.93
Anions determined:		
Bicarbonate, as HCO_3	329	5.39
Chloride, Cl^-	75	2.12
Sulfate, $SO_4^=$	245	5.10
Fluoride, F	0.5	0.03
Nitrate, as N	7.4	0.52
	Total	13.16
Carbon dioxide, CO_2, Calc.	7	
Hardness, as $CaCO_3$	504	
Silica, SiO_2	52	
Iron, Fe	< 0.01	
Manganese, Mn	< 0.01	
Boron, B	0.32	
Total Dissolved Minerals, (by addition: HCO_3 -> CO_3)	725	

Converse Ward Davis Dixon

Lab No. P81-03-152-2

No. Samples : 4
Sampled By : Client
Brought By : Client
Date Received: 3-19-81

Sample labeled: Hole 28A-2"

Conductivity: 920 µ mhos/cm

Turbidity: NTU

pH 7.8 @ 25°C
pHs @ 60°F (15.6°C)
pHs @ 140°F (60°C)

	Milligrams per liter (ppm)	Milli-equivalents per liter
Cations determined:		
Calcium, Ca	37	1.83
Magnesium, Mg	16.5	1.36
Sodium, Na	224	9.74
Potassium, K	5.8	0.15
	Total	13.08
Anions determined:		
Bicarbonate, as HCO_3	312	5.11
Chloride, Cl	76	2.13
Sulfate, SO_4	272	5.67
Fluoride, F	0.82	0.06
Nitrate, as N	0.39	0.01
	Total	12.98
Carbon dioxide, CO_2, Calc.	7.1	
Hardness, as $CaCO_3$	174	
Silica, SiO_2	12	
Iron, Fe	1.6	
Manganese, Mn	< 0.05	
Boron, B	1.16	
Total Dissolved Minerals, (by addition: HCO_3->CO_3)	805	

Converse Ward Davis Dixon

Lab No. P81-03-017-6

No. Samples : 7
Sampled By : Client
Brought By : Client
Date Received: 3-3-81

Sample labeled: HOLE 29-2"

Conductivity: 8,220 µ mhos/cm

Turbidity: NTU

pH 8.0 @ 25°C
pHs @ 60°F (15.6°C)
pHs @ 140°F (60°C)

	Milligrams per liter (ppm)	Milli-equivalents per liter
Cations determined:		
Calcium, Ca	43	2.16
Magnesium, Mg	20	1.65
Sodium, Na	2,025	88.09
Potassium, K	14	0.36
		Total 92.26
Anions determined:		
Bicarbonate, as HCO_3	385	6.31
Chloride, Cl	1,066	30.06
Sulfate, SO_4	2,600	54.16
Fluoride, F	0.8	0.04
Nitrate, as N	0.2	0.01
		Total 90.58
Carbon dioxide, CO_2, Calc.	6	
Hardness, as $CaCO_3$	190	
Silica, SiO_2	31	
Iron, Fe	< 0.01	
Manganese,Mn	0.08	
Boron, B	2.6	
Total Dissolved Minerals (by addition: HCO_3 -> CO_3)	5,996	

BROWN AND CALDWELL
CONSULTING ENGINEERS
ANALYTICAL SERVICES DIVISION

D. H. CALDWELL, PE Chairman
T. V. LUTGE, PE President
R. C. ABERLEY, PE Exec Vice Pres
S. A. FISHER, Vice Pres

March 18, 1983

Lab No. P83-02-105
P83-02-162

Converse Consultants
126 West Del Mar Avenue
Pasadena, California 91105

Attention: Al Minas

No. Samples : 3
Sampled By : Client
Brought By : Client
Date Received : February 15, 1983
February 23, 1983

Report of Chemical Analysis

Six (6) water samples labeled, 1) Hole 23B-8.5', 2) Hole 27A-52.4', 3) Hole 6A-30.0', 4) 8A-15', 5) BH 16A-45', 6) BH 30B-24.5' were analyzed for selected mineral content. The samples were passed through a 0.45 micron filter and analyzed for dissolved cations and anions. The analyses were performed according to Standard Methods for the Examination of Water and Wastewater, 15th Edition, 1980.

Prepared by,

Jane E. Freemyer
Supervising Chemist

Approved by,

Edward Wilson
Laboratory Director

lah

Invoice 0295, separate cover

GENERAL MINERAL ANALYSIS*

BROWN AND CALDWELL
CONSULTING ENGINEERS
ANALYTICAL SERVICES DIVISION
373 SOUTH FAIR OAKS AVE.
PASADENA, CA 91105
PHONE (213) 795-7553

Log No. P83-02-105-1
Date Sampled 2/3/83
Date Received
Date Reported

Reported To:
Converse Consultants
126 West Del Mar Avenue
Pasadena, CA 91105

Attn: Al Minas

cc.

Laboratory Director

Sample Description 83-1101-21 Hole 23B-8 -8.5'

Anions	Miligrams per liter	Milliequiv. per liter	Determination	Milligrams per liter	Determination	Milligra per lit
Nitrate Nitrogen (as NO_3)	<0.1	<0.002	Hydroxide Alkalinity (as $CaCO_3$)	0.0		
Chloride	55	1.56	Carbonate Alkalinity (as $CaCO_3$)	0.0		
Sulfate (as SO_4)	11	0.24	Bicarbonate Alkalinity (as $CaCO_3$)	750		
[illegible]bonate (as HCO_3)	910	14.90	Calcium Hardness (as $CaCO_3$)	340		
Carbonate (as CO_3)	0.0	0.0	Magnesium Hardness (as $CaCO_3$)	260		
Total Milliequivalents per Liter		16.84	Total Hardness (as $CaCO_3$)	600		
Cations	Milligrams per liter	Milliequiv. per liter	Iron			
Sodium	110	4.79	Manganese			
Potassium	3.2	0.08	Copper			
Calcium	140	6.79	Zinc			
Magnesium	63	5.18	Foaming Agents (MBAS)			
Total Milliequivalents per Liter		16.84	Dissolved Residue, Evaporated @ 180°C	853		
			Specific Conductance, micromhos @ 25°C	1360	pH 7.9	

*Conforms to Title 22, California Administrative Code (California Domestic Water Quality and Monitoring Regulations)

GENERAL MINERAL ANALYSIS*

BROWN AND CALDWELL
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Log No. P83-02-105-2

Date Sampled 2/10/83
Date Received
Date Reported

Reported To:
Converse Consultants
126 West Del Mar Avenue
Pasadena, CA 91105

Attn: Al Minas

cc.

Labratory Director

Sample Description 83-1101-21 Hole 27A -52.4'

Anions	Miligrams per liter	Milliequiv. per liter	Determination	Milligrams per liter	Determination	Milligra per lit
Nitrate Nitrogen (as NO_3)	64	1.03	Hydroxide Alkalinity (as $CaCO_3$)	0.0		
Chloride	58	1.64	Carbonate Alkalinity (as $CaCO_3$)	13		
Sulfate (as SO_4)	140	2.84	Bicarbonate Alkalinity (as $CaCO_3$)	280		
B[illegible]onate (as HCO_3)	340	5.54	Calcium Hardness (as $CaCO_3$)	310		
Carbonate (as CO_3)	7.4	0.25	Magnesium Hardness (as $CaCO_3$)	170		
Total Milliequivalents per Liter		11.3	Total Hardness (as $CaCO_3$)	480		
Cations	Milligrams per liter	Milliequiv. per liter	Iron			
Sodium	58	2.52	Manganese			
Potassium	3.5	0.08	Copper			
Calcium	122	6.12	Zinc			
Magnesium	40	3.30	Foaming Agents (MBAS)			
Total Milliequivalents per Liter		12.0	Dissolved Residue, Evaporated @ 180°C	714		
			Specific Conductance, micromhos @ 25°C	1000	pH 8.3	

*Conforms to Title 22, California Administrative Code (California Domestic Water Quality and Monitoring Regulations)

Appendix E

Geotechnical Laboratory Testing

APPENDIX E GEOTECHNICAL LABORATORY TESTING

E.1 INTRODUCTION

Laboratory geotechnical tests were performed on selected soil and bedrock samples obtained from the borings.

The soil tests performed may be classified into two broad categories:

- Index or identification tests which included visual classification, grain-size distribution, Atterberg Limits, moisture content, and unit weight testing.
- Engineering properties testing which included unconfined compression, triaxial compression, direct shear, consolidation, permeability, porosity, resonant column, cyclic triaxial, and dynamic triaxial tests.

The laboratory test data from the present investigation are presented in Table E-1, while data from the 1981 geotechnical investigation are presented in Table E-2. The soils listed in these tables are described in Section 5.0 of the report.

E.1.1 Data Analysis

The summary of laboratory test results is presented in Tables E-1 and E-2. Figures E-1 and E-2 summarize strength data for coarse-grained Alluvium. Figures E-3 through E-5 summarize strength and modulus data for fine-grained Alluvium. Figure E-6 is a compilation of modulus data from laboratory tests performed on both the fine-grained and coarse-grained Alluvium. It should be noted that test results from this investigation and from other design units have been combined when, in our judgment, it was considered appropriate to do so.

E.2 INDEX AND IDENTIFICATION

E.2.1 Visual Classification

Field classification was verified in the laboratory by visual examination in accordance with the Unified Soil Classification System and ASTM D-2487-69 test method. When necessary to substantiate visual classifications, tests were conducted in accordance with the ASTM D-2487-69 test method.

E.2.2 Grain Size Distribution

Grain size distribution tests were performed on representative samples of the geologic units to assist in the soils classification and to correlate test data between various samples. Sieve analyses were performed on that portion of the sample retained on the No. 200 sieve in accordance with ASTM D-422-63 test method. Combined sieve and hydrometer analyses were performed on selected samples which had a significant percentage of soil particles passing the No. 200 sieve. Results of these analyses are presented in the form of grain-size distribution or gradation curves on Figures E-7 through E-29.

It should be noted that the grain-size distribution tests were performed on samples secured with 2.42- and 2.87-inch ID samplers. Thus, material larger than those dimensions may be present in the natural deposits although not indicated on the gradation curves.

E.2.3 Atterberg Limits

Atterberg Limit Tests were performed on selected soil samples to evaluate their plasticity and to aid in their classification. The testing procedure was in accordance with ASTM D-423-66 and D-424-59 test methods. Test results are presented on Figures E-30 through E-34 and Tables E-1 and E-2.

E.2.4 Moisture Content

Moisture content determinations were performed on selected soil samples to assist in their classification and to evaluate groundwater location. The testing procedure was a modified version of the ASTM D-2216 test method. Test results are presented on Tables E-1 and E-2.

E.2.5 Unit Weight

Unit weight determinations were performed on selected undisturbed soil samples to assist in their classification and in the selection of samples for engineering properties testing. Samples were generally the same as those selected for moisture content determinations.

The test procedure entailed measuring specimen dimensions with a precision ruler or micrometer. Weights of the sample were then determined at natural moisture content. Total unit weight was computed directly from data obtained from the two previous steps. Dry density was calculated from the moisture content found in Section E.2.4 and the total unit weight. Results of the unit weight tests are presented as dry densities on Tables E-1 and E-2.

E.3 ENGINEERING PROPERTIES: STATIC

E.3.1 Unconfined Compression

Unconfined compression tests were performed on selected samples of cohesive soils and bedrock from the test borings for the purpose of evaluating the undrained, unconfined shear strength of the various fine-grained geologic units. The tests were performed in accordance with the ASTM D-2166-66 test method. Results of the unconfined compression tests are presented in Tables E-3 and E-4.

E.3.2 Triaxial Compression

Consolidated undrained triaxial compression tests with pore pressure measurements were performed on selected undisturbed soil samples. The tests were conducted in the following manner:

E.3.2.1 Consolidated Undrained (CU) Tests

- The undisturbed test specimen was trimmed to a length to diameter ratio of approximately 2.0.
- The specimen was then covered with a rubber membrane and placed in the triaxial cell.
- The triaxial cell was filled with water and pressurized, and the specimen was saturated using back-pressure.
- When saturation was complete, the specimen was consolidated at the desired effective confining pressure.
- After consolidation, an axial load was applied at a controlled rate of strain. In the case of the undrained test, flow of water from the specimen was not permitted, and the resulting pore water pressure change was measured.
- The specimen was then sheared to failure or until a desired maximum strain was reached.

Some of the tests were performed as progressive tests. The procedure was the same as above except that, when the soil specimen approached but did not reach failure (usually to peak effective stress ratio), the axial load was removed and the specimen was consolidated at a higher confining pressure. The axial load was again applied at a constant rate of strain, and the sample was loaded until failure occurred. Results of the triaxial compression tests are presented in Figures E-35 through E-53.

E.3.3 Direct Shear

Direct shear tests were performed on selected undisturbed soil samples using a constant strain rate direct shear machine.

Each test specimen was trimmed, soaked, and placed in the shear machine, a specified normal load was applied, and the specimen was sheared until a maximum shear strength was developed. Fine-grained samples were allowed to consolidate prior to shearing.

Progressive direct shear tests were performed on selected undisturbed samples. After the soil specimen had developed maximum shear resistance under the first normal load, the normal load was removed and the specimen was pushed back to its original undeformed configuration. A new normal load was then applied, and the specimen was sheared a second time. This process was repeated for several different normal loads. Results of the direct shear tests are summarized on Tables E-1 and E-2.

E.3.4 Free Swell

Free swell tests were performed on selected undistured samples of cohesive, potentially expansive soils. The test procedure entailed placing the undisturbed soil sample in a consolidometer, applying a vertical confining load, and inundating the sample with tap water. The resulting one-dimensional swell of the sample was measured and recorded. Results of these tests are presented on Table E-2.

E.3.5 Consolidation

Consolidation tests were performed on selected undisturbed soil samples placed in 1-inch high by 2.42-inch diameter brass rings, or 3-inch diameter Shelby tubes trimmed to a 2.42-inch diameter.

Apparatus used for the consolidation test is designed to receive the 1-inch high brass rings directly. Porous stones were placed in contact with both sides of the specimens to permit ready addition or release of water. Loads are applied to the test specimens in several increments, and the resulting settlements recorded.

Results of consolidation tests on the undisturbed samples are presented on Figures E-54 through E-65.

E.3.6 Permeability

Permeability tests were performed on undisturbed specimens selected for testing, or in conjunction with the static and cyclic triaxial tests, using the same selected undisturbed samples of soil. Permeability was measured during back-pressure saturation by applying a differential pressure to the ends of the sample and measuring the resulting flow. Results of the tests are tabulated on Tables E-1 and E-2.

E.3.7 Porosity

Porosity, or void ratio, of selected undisturbed samples was determined by measuring the dry unit weight and specific gravity, then calculating the void ratio, e, and porosity, n, using the following formula:

$$e = (1 - Vs)/Vs, \text{ where } Vs = (\gamma_d)/(G \times \gamma_w) \text{ and } n = e/(1 + e)$$

γ_w = unit weight of water

γ_d = unit dry weight of the soil

G = specific gravity of soil solids.

In some cases, an assumed average value for the specific gravity, based on the measured values for other specimens, was used for the porosity calculation.

E.4 ENGINEERING PROPERTIES: DYNAMIC

E.4.1 Resonant Column

The resonant column test evaluates the shear modulus and damping of soil specimens at shear strains of approximately 10^{-6} to 10^{-4} inches per inch.

A solid cylindrical soil specimen is encased in a thin membrane, placed in a pressure cell, and subjected to the desired ambient stress conditions. The specimen is caused to vibrate at resonance in torsion by fixing one end and applying sinusoidally varying torque to the free end. The response of the soil specimen is measured using an accelerometer coupled to the free end. Shear modulus and damping values are calculated from the response data.

E.4.1.1 Sample Preparation and Handling

The test apparatus used for this procedure accepts a 1.4-inch diameter by approximately 3.5-inch length specimen. Undisturbed samples were prepared by trimming the 1.4-inch diameter samples from the larger Shelby, Pitcher, or Converse ring samples.

E.4.1.2 Test Conditions and Parameters

The resonant column test is considered non-destructive because the shear strain amplitudes are relatively small. Therefore, a single specimen may be used for several tests. For this test program, several of the specimens were tested at confining pressures (σ_{3c}), varying from 15 to 50 psi. Although the apparatus is capable of applying anisotropic consolidation stresses, specimens for this program were consolidated isotropically. The specimens were tested beginning at the lower confining pressure, shear modulus and damping data were obtained at several different values of shear strain within the limiting range of the test apparatus. Damping data were obtained for steady state vibration conditions. A summary of pertinent resonant column test data is presented on Figures E-66 through E-71.

E.4.1.3 Data Reduction

Data obtained from the resonant column tests were reduced in accordance with the ASTM "Suggested Methods of Test for Shear Modulus and Damping of Soils by the Resonant Column."*

E.4.2 Cyclic Triaxial--Dynamic Properties

This test is designed to evaluate the stress-strain properties of the soils under dynamic loading conditions. This test is designed to obtain dynamic stress-strain data at various strain levels. Shear strain data is obtained generally in the range of 10^{-4} to 10^{-2} inch/inch.

E.4.2.1 Sample Preparation and Handling

These tests were performed on undisturbed cylindrical samples obtained from rotary borings using a sampler lined with either brass rings or Shelby tubes. Samples from the brass rings were 2.42 inches in diameter by 5 inches in length; those from the Shelby tubes were 2.87 inches in diameter by 6 inches in length. The samples were extruded, weighed, and placed in the test cell.

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*ASTM Special Technical Publication 479.

E.4.2.2 Test Conditions and Parameters

Test conditions and parameters may vary in the dynamic triaxial test. The procedures followed for this project were:

- Saturation: The specimens were artificially saturated using flushing and back pressure techniques. Typical back pressures of 60 to 100 psi were required to saturate the specimens. The degree of saturation was measured using Skempton's B parameter, u/σ_{3c}. A minimum value of B = 0.95 was obtained for all test specimens which were saturated.

- A few of the test specimens were tested in their in-situ moisture condition, without artificial saturation, in order to evaluate the stress-strain properties of unsaturated samples. The tests which were not saturated are identified on the figures.

- Consolidation: Specimens were allowed to consolidate under the specified static ambient stress levels. Consolidation was monitored either by measuring specimen volume changes or by closing the drainage lines and verifying that buildup or pore pressures did not occur. A consolidation ratio ($K_c = \sigma_{1c}/\sigma_{3c}$) of 1.0 was used for this program.

- Waveform and Frequency: A sinusoidal waveform at a frequency of 0.5 Hz was used for this test program.

E.4.2.3 Data Reduction

The following methods and definitions were employed in the reduction of test data from the dynamic triaxial tests.

- Axial stress: Given in terms of axial load and the unconsolidated specimen cross sectional area.

- Axial strain: Given in terms of the unconsolidated specimen length.

- Dynamic axial strain: The peak-to-peak axial strain for any given loading cycle.

- Shear modulus and shear strain conversion: Axial stress, axial strain, and Young's modulus, E, were converted to equivalent shear stress, shear strain, and shear modulus, G, using a Poisson's ratio of 0.5 (undrained, zero volume change condition) for tests on saturated samples, and an assumed Poisson's ratio of 0.40 for tests on unsaturated specimens tested at their in-situ moisture contents. Shear strain values are the strains on a plane located at 45 degrees to the principal stress plane, which has been shown to be the plane of maximum shear strength during triaxial loading.

- Modulus: Shear modulus values are defined as the equivalent linear modulus corresponding to the straight line connecting the end points of the hysteresis loop of each loading cycle.

- Shear strain: Shear strain values given are the maximum shear strains between the end points of the hysteresis loop for a given cycle. The maximum shear strain is calculated according to the equations of solid body mechanics as 1.5 x the maximum axial strain.

Results of the dynamic triaxial tests are presented on Figures E-72 through E-83.

E.4.3 Cyclic Triaxial Compression--Dynamic Shear Strength

This test evaluates soil shear strength, liquefaction, and deformation characteristics under cyclic loading conditions. A cylindrical specimen of soil is encased in a thin rubber membrane, subjected to a confining pressure in a closed cell, brought to the desired equilibrium stress and saturation conditions, and cyclically loaded in the axial direction.

E.4.3.1 Sample Preparation and Handling

These tests were performed on undisturbed cylindrical samples obtained from rotary borings using a sampler lined with either brass rings or Shelby tubes. Samples from the brass rings were 2.42 inches in diameter by 5 inches in length; those from the Shelby tubes were 2.87 inches in diameter by 6 inches in length. The samples were extruded, weighed, and placed in the test cell.

E.4.3.2 Test Conditions and Parameters

Test conditions and parameters may vary in the cyclic triaxial test. The procedures followed for this project were:

- Stress controlled: Cyclic axial loads of relatively constant magnitude and loading frequency were applied, and the resulting axial strains and specimen pore pressures were measured.

- Saturation: The specimens were artificially saturated using flushing and back pressure techniques. Typical back pressures of 60 to 100 psi were required to saturate the specimens. The degree of saturation was measured using Skempton's B parameter, $\Delta u/\Delta\sigma_{3c}$. The saturation level criterion for this project was a minimum B value of 0.95, except for a few tests which reached a minimum of 0.94.

- Consolidation: Specimens were allowed to consolidate under the specified static ambient stress levels. Consolidation was monitored either by measuring specimen volume changes or by closing the drainage lines and verifying that buildup of pore pressures did not occur. A consolidation ratio ($K_c = \sigma_{1c}/\sigma_{3c}$) of 1.0 was used for this program.

E.4.3.3 Apparatus

The pneumatic loading system used for these tests was custom-designed and built for Converse Consultants. The device consists of the four main component groups described below.

- Triaxial Chambers and Cyclic Loading Device: The triaxial chambers are comprised of stainless steel and aluminum cells designed for operating procedures up to 400 psi. (Pressures of up to 160 psi were used for this project.) A pneumatic, double-acting piston, capable of applying both static and cyclic loads, is mounted above the triaxial chamber and connected to the specimen load cap by a low-inertia stainless steel rod. The rod passes through the top of the chamber and is held in place by low friction bushings and pressure seals.

- Control Console: This unit contains the various pressure regulators and reservoir systems for controlling cell pressure, back pressures, and sample saturation and drainage. The controls on the console regulate the wave form, frequency, and magnitude of the static and cyclic axial loads.

- Transducer System and Signal Conditioners: The electronic transducers produce electrical voltages in proportion to the key parameters being measured during the test. Parameters monitored and transducer type employed for this program are:

PARAMETER MONITORED	TRANSDUCER TYPE
Axial displacement	- Linear variable differential transformers (LVDT's) mounted internally to the specimen load caps
Soil pore water pressure	- Unbonded wire resistance strain-gauge-type transducers mounted external to the chamber on sample drainage lines
Axial load	- Bonded resistance strain-gauge-type load cell mounted between double-acting piston and rod connected to specimen load cap

  Signal conditioners such as power supplies and variable gain amplifiers are used to excite the transducers and amplify the signals to recordable levels.

- Recording Devices: These include (a) a 4-channel continuous strip chart recorder, thermal pens, and heat-sensitive paper, frequency response adequate for frequencies normally employed in cyclic triaxial testing, and (b) a cathode ray oscilloscope.

E.4.3.4 Data Reduction

The following methods and definitions were used in the reduction of test data from the continuous strip chart recording:

- Axial stress: Given in terms of axial load and the unconsolidated specimen cross section area.

- The cyclic testing apparatus is designed to maintain relatively constant axial loads, and no correction is made for changing cross sectional areas of the sample during the test. This is common practice for this type of test.

- Axial stress: Given in terms of the consolidated specimen length. No correction is made for changing specimen length during the test.

- Cyclic axial strain: The larger of the zero-to-peak axial strain or the double amplitude, peak-to-peak, strain for the given cycle of loading.

- Pore pressure ratio: Ratio of the maximum net pore pressure change recorded during the cycle, divided by the net confining pressure, σ_{3c}.

- Failure criteria: A 10% double amplitude axial strain in the cyclic triaxial tests was selected for plotting.

Graphs of the test results appear on Figures E-84 through E-86.

TABLE E-1
LABORATORY TEST DATA

BORING NO.	SAMPLE NO.	DEPTH (ft)	VISUAL CLASSIFICATION	GEOLOGIC UNIT	DRY DENSITY (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		Kv, COEFFICIENT OF PERMEABILITY (cm/sec) (Confining Pressure, psi)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	DIRECT SHEAR STRENGTH ENVELOPE		ONE-DIMENSIONAL SWELL (%) (Normal Load, ksf)	SWELL PRESSURE (ksf)	SIEVE ANALYSIS	HYDROMETER ANALYSIS	OEDOMETER	TRIAXIAL COMPRESSION
							LL	PI			ø, deg	c, ksf						
24-1	PB-1	8.0	Clayey Silt	A	83	29				0.77								
	C-2	13.0	Sandy Clay	A	102	22					21	0.30						
	PB-3	27.8	Sand/Silty Sand	A	116	15									X			X
	PB-6	53.5	Sandy Silt/Sandy Clay	A	103	20				0.99								
	C-5	63.0	Sandy Clay	A	114	17					23	1.10						
	C-6	73.0	Sandy Clay	A	124	16				2.76								
	C-7	83.0	Silty Sand	A	111	18					29	0.75						
	PB-10	88.0	Silty Sand	A	113	15			7.7×10^{-7} (70)						X	X		X
	C-8	93.0	Sandy Clay	A	104	24				4.16					X			
	C-9	103.0	Clayey Sand	A	100	26									X		X	
24-2	C-2	13.0	Clayey Sand	A	114	14				2.43								
	C-4	33.0	Clayey Sand	A	117	13												
	C-5	43.0	Silty Sand	A	115	15					32	0.50						
	PB-4	48.2	Clayey Sand/Sandy Clay	A	105	21									X			X
	C-6	53.0	Silty Sand	A	110	16					32	0.30						

TABLE E-1
(CONTINUED)
LABORATORY TEST DATA

BORING NO.	SAMPLE NO.	DEPTH (ft)	VISUAL CLASSIFICATION	GEOLOGIC UNIT	DRY DENSITY (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		Kv, COEFFICIENT OF PERMEABILITY (cm/sec) (Confining Pressure, psi)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	DIRECT SHEAR STRENGTH ENVELOPE		ONE-DIMENSIONAL SWELL (%) (Normal Load, ksf)	SWELL PRESSURE (ksf)	SIEVE ANALYSIS	HYDROMETER ANALYSIS	OEDOMETER	TRIAXIAL COMPRESSION
							LL	PI			ø, deg	c, ksf						
24-2	C-8	73.0	Clayey Sand	A	120	14				5.88					X			
	C-9	82.9	Silty Sand	A'	118	14					35	0.10					X	
24-3	C-2	13.0	Silty Sand	A	109	12									X			
	C-3	23.0	Silty Sand	A	120	12					37	0.40						
	C-4	33.0	Sandy Clay	A	105	23				5.73								
	PB-3	48.0	Sand/Silty Sand	A	104	18									X			X
	C-6	53.0	Sand	A	116	9					31	0.90						
	C-7	63.0	Sand	A	122	9												
	C-8	73.0	Sandy Clay	A	115	16	37	15			17	1.95			X	X	X	
	PB-6	78.2	Clayey Sand	A	107	21	35	11	5.3×10^{-7} (70)						X	X		X
	C-10	92.0	Sandy Clay	A	110	21				4.12					X			
	C-11	103.0	Sandy Clay	A	116	16					29	0.70					X	
24-4	C-2	13.0	Clayey Sand/Sandy Clay	A	105	19												
	C-3	23.0	Silty Sand	A	123	13					27	1.00						
	C-4	43.0	Sandy Clay/Clayey Sand	A	104	23				2.56								

TABLE E-1
(CONTINUED)
LABORATORY TEST DATA

BORING NO.	SAMPLE NO.	DEPTH (ft)	VISUAL CLASSIFICATION	GEOLOGIC UNIT	DRY DENSITY (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		Kv, COEFFICIENT OF PERMEABILITY (cm/sec) (Confining Pressure, psi)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	DIRECT SHEAR STRENGTH ENVELOPE		ONE-DIMENSIONAL SWELL (%) (Normal Load, ksf)	SWELL PRESSURE (ksf)	SIEVE ANALYSIS	HYDROMETER ANALYSIS	OEDOMETER	TRIAXIAL COMPRESSION
							LL	PI			ø, deg	c, ksf						
24-4	PB-4	48.0	Clayey Sand	A	104	21									X	X		X
	C-6	63.0	Sandy Clay	A	109	20					18	1.05					X	
	PB-6	68.0	Silty Sand	A	114	14			2.9x10^{-6}(60)						X			X
	C-7	72.8	Sand	A	110	18					32	0.65						
	PB-8	88.4	Silty, Clayey Sand	A	95	30				2.42								
24-5	C-2	13.0	Clayey Sand	A	108	18					35	0.00						
	PB-1	24.4	Clayey Sand	A	115	18				1.05								
	C-4	43.0	Sandy Clay	A	117	16				5.71								
	C-5	53.0	Silty Sand/Clayey Sand	A	115	16					33	0.25					X	
	C-7	73.0	Sandy Clay/Silty Clay	A	95	30				2.72								
	PB-7	78.2	Clayey Sand	A	122	13	33	13							X	X		X
	C-8	95.0	Silty Sand	A	114	16									X		X	

TABLE E-1
(CONTINUED)
LABORATORY TEST DATA

BORING NO.	SAMPLE NO.	DEPTH (ft)	VISUAL CLASSIFICATION	GEOLOGIC UNIT	DRY DENSITY (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		Kv, COEFFICIENT OF PERMEABILITY (cm/sec) (Confining Pressure, psi)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	DIRECT SHEAR STRENGTH ENVELOPE		ONE-DIMENSIONAL SWELL (%) (Normal Load, ksf)	SWELL PRESSURE (ksf)	SIEVE ANALYSIS	HYDROMETER ANALYSIS	OEDOMETER	TRIAXIAL COMPRESSION
							LL	PI			ø, deg	c, ksf						
26-1	PB-1	8.5	Clayey Sand	A	94	14	32	10							X	X		X
	C-2	13.5	Clayey Sand	A							35	0.10						
	C-3	23.5	Clayey Sand/Sandy Clay	A	118	12				6.34								
	C-4	33.5	Clayey Sand	A							35	0.10						
	PB-4	48.5	Clayey Sand	A	116	14			1.2×10^{-7}						X	X		X
	C-6	53.5	Silty Sand	A	129	9											X	
	PB-5	58.5	Clayey Sand	A	122	10												
	C-7	63.5	Clayey Sand	A	131	10					35	0.10					X	
	PB-8	88.5	Sandy Clay	A	105	20				11.84								
26-2	C-1	9.5	Silty Sand	A							37	0.0						
	PB-2	14.5	Clayey Sand/Sandy Clay	A	103	23			9.1×10^{-7}						X			X
	C-3	29.5	Clayey Sand	A	105	22				4.91								
	C-5	49.5	Silty Sand	A							37	0.0						
	PB-6	54.5	Clayey Sand	A	98	25			1.9×10^{-5}						X	X		X
	C-6	59.5	Silty Sand	A	129	12											X	

TABLE E-1
(CONTINUED)
LABORATORY TEST DATA

BORING NO.	SAMPLE NO.	DEPTH (ft)	VISUAL CLASSIFICATION	GEOLOGIC UNIT	DRY DENSITY (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		Kv, COEFFICIENT OF PERMEABILITY (cm/sec) (Confining Pressure, psi)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	DIRECT SHEAR STRENGTH ENVELOPE		ONE-DIMENSIONAL SWELL (%) (Normal Load, ksf)	SWELL PRESSURE (ksf)	SIEVE ANALYSIS	HYDROMETER ANALYSIS	OEDOMETER	TRIAXIAL COMPRESSION
							LL	PI			ø, deg	c, ksf						
26-2	C-8	79.5	Silty Sand	A							37	0.0						
26-3	PB-2	14.5	Sandy Clay	A	102	23				0.36								
	C-2	19.5	Sandy Clay	A	118	14											X	
	C-3	27.5	Silty Sand	A							37	0.0						
	PB-4	34.5	Sandy Clay	A	98	26	38	17							X			X
	C-4	35.5	Sandy Clay	A	110	20				10.12								
	C-5	39.5	Silty Sand	A							37	0.0						
	C-7	59.5	Silty Sand	A							37	0.0						
	C-9	79.5	Clayey Sand	A	121	15											X	
	PB-8	84.5	Clayey Sand/Sandy Clay	A	118	13				2.71								
26-4	PB-1	6.5	Clayey Silt	A	95	24				1.02								
	C-2	11.5	Sandy Clay	A							29	0.25						
	PB-2	16.5	Sandy Clay	A	103	26	27	8	5.9×10^{-6}						X	X		X
	C-4	31.5	Silty Clay	A	100	25											X	
	PB-4	36.5	Sandy Clay with Gravel	A	105	20												

TABLE E-1
(CONTINUED)
LABORATORY TEST DATA

BORING NO.	SAMPLE NO.	DEPTH (ft)	VISUAL CLASSIFICATION	GEOLOGIC UNIT	DRY DENSITY (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		Kv, COEFFICIENT OF PERMEABILITY (cm/sec) (Confining Pressure, psi)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	DIRECT SHEAR STRENGTH ENVELOPE		ONE-DIMENSIONAL SWELL (%) (Normal Load, ksf)	SWELL PRESSURE (ksf)	SIEVE ANALYSIS	HYDROMETER ANALYSIS	OEDOMETER	TRIAXIAL COMPRESSION
							LL	PI			ø, deg	c, ksf						
26-4	C-6	51.5	Sandy Clay	A							29	0.25						
	C-7	61.5	Clayey Sand	A	117	16											X	
	PB-7	66.5	Clayey Sand	A	106	20									X	X		X
	PB-7	66.5	Clayey Sand	A	101	24				1.12								
	PB-9	86.5	Sandy Clay	A	113	17				2.21								
26-5	C-4	19.0	Sandy Clay	A	111	19												
	PB-1	25.5	Sandy Clay/Clayey Sand	A	105	22									X	X		X
	C-5	29.0	Silty Sand	A							37	0.0						
	C-7	39.0	Sandy Clay	A	104	19				10.02								
	PB-2	45.5	Sandy Clay/Clayey Sand	A	96	25	33	13							X			X
	C-8	49.0	Silty Sand	A							37	0.0						
	C-9	54.0	Clayey Silt	A	101	25											X	
	PB-3	65.5	Sand	A	108	19												
	C-11	69.0	Silty Sand	A							37	0.0						

T[illegible]LE E-1
(CONTINUED)
LABORATORY TEST DATA

BORING NO.	SAMPLE NO.	DEPTH (ft)	VISUAL CLASSIFICATION	GEOLOGIC UNIT	DRY DENSITY (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		Kv, COEFFICIENT OF PERMEABILITY (cm/sec) (Confining Pressure, psi)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	DIRECT SHEAR STRENGTH ENVELOPE		ONE-DIMENSIONAL SWELL (%) (Normal Load, ksf)	SWELL PRESSURE (ksf)	SIEVE ANALYSIS	HYDROMETER ANALYSIS	OEDOMETER	TRIAXIAL COMPRESSION
							LL	PI			ø, deg	c, ksf						
23-C	PB-2	16.8	Clayey Sand	A	108	20	27	10		0.52(1)					X			
	PB-3	27.5	Sandy Clay	A	102	24	48	26		2.49					X			
	PB-4	37.5	Clayey Sand/Sandy Clay	A	97	26				1.58(1)					X			
	PB-5	47.5	Sandy Clay	A	93	25	58	30		0.39(2)					X			
	PB-6	57.5	Clayey Sand	A	99	24	32	8		1.37					X			
	PB-8	76.0	Sand	A	107	18									X			
23-D	PB-3	27.5	Clayey Sand	A	114	14									X			
	PB-4	37.5	Clayey Sand/Sandy Clay	A	107	21	29	10		1.77					X			
	PB-5	47.5	Silty Sand	A	117	14			5.1 X 10^{-5}						X			
	PB-6	57.5	Sandy Clay	A	106	22									X			
	PB-7	67.5	Clayey Sand/Sandy Clay	A	105	21	32	14		3.01					X			
	PB-8	76.0	Clayey Sand/Sandy Clay	A	116	14	30	13		4.10					X			
24-B	PB-8	77.5	Sandy Clay	A	115	15				2.18					X			
	PB-9	87.5	Clayey Sand/Sandy Clay	A	107	20	29	8		1.17					X			
	PB-10	97.5	Clayey Sand	A	110		27	8		0.63(1)					X			

NOTES:
1) Low strength possibly due to high sand content.
2) Sample buldged upon extrusion.

TABLE E-1
(CONTINUED)
LABORATORY TEST DATA

BORING NO.	SAMPLE NO.	DEPTH (ft)	VISUAL CLASSIFICATION	GEOLOGIC UNIT	DRY DENSITY (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS LL	ATTERBERG LIMITS PI	Kv, COEFFICIENT OF PERMEABILITY (cm/sec) (Confining Pressure, psi)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	DIRECT SHEAR STRENGTH ENVELOPE ø, deg	DIRECT SHEAR STRENGTH ENVELOPE c, ksf	ONE-DIMENSIONAL SWELL (%) (Normal Load, ksf)	SWELL PRESSURE (ksf)	SIEVE ANALYSIS	HYDROMETER ANALYSIS	OEDOMETER	TRIAXIAL COMPRESSION
24-B	PB-11	106.0	Silty Sand	A	114	14			1.7 X 10^{-5}						X			
	PB-13	127.5	Silty Sand	A	117	15			3.6 X 10^{-5}						X			
25-C	PB-4	37.5	Clayey Sand	A	122	13	26	7							X			
	PB-5	47.5	Clayey Sand/Silty Sand	A	121	11	22	0.2		1.03					X			
	PB-6	57.5	Clayey Sand	A	115	16									X			
	PB-7	67.5	Clayey Sand	A	126	11									X			
	PB-8	76.0	Clayey Sand	A	113	16												
26-C	PB-1	12.5	Sandy Clay /Clayey Sand	A	88	30												
	PB-2	21.5	Sandy Clay	A	99	24	58	32		0.82					X			
	PB-3	32.5	Sandy Clay/Clayey Sand	A	102	21				1.21					X			
	PB-4	42.5	Sandy Clay/Clayey Sand	A	103	17	36	10		1.25					X			
	PB-5	57.5	Gravelly Sand	A	102	19			5.2 X 10^{-2}						X			
	PB-6	62.5	Silty Sand with Gravel	A	105	25			2.2 X 10^{-5}						X			
	PB-7	72.5	Clayey Sand	A	106	17	32	7		1.91					X			
	PB-8	80.0	Sandy Clay	A	101	23	43	20		6.34					X			

TABLE E-1
(CONTINUED)
LABORATORY TEST DATA

BORING NO.	SAMPLE NO.	DEPTH (ft)	VISUAL CLASSIFICATION	GEOLOGIC UNIT	DRY DENSITY (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS		Kv, COEFFICIENT OF PERMEABILITY (cm/sec) (Confining Pressure, psi)	UNCONFINED COMPRESSIVE STRENGTH (ksf)	DIRECT SHEAR STRENGTH ENVELOPE		ONE-DIMENSIONAL SWELL (%) (Normal Load, ksf)	SWELL PRESSURE (ksf)	SIEVE ANALYSIS	HYDROMETER ANALYSIS	OEDOMETER	TRIAXIAL COMPRESSION
							LL	PI			ø, deg	c, ksf						
26-D	PB-1	7.5	Sandy Clay	A	104	20									X			
	PB-2	17.5	Silty Sand	A	103	19									X			
	PB-3	27.5	Silty Sand	A	98	20	23	2							X			
	PB-4	37.5	Clayey Sand	A	100	22									X			
	PB-5	47.5	Silty Sand	A	101	28									X			
	PB-6	57.5	Clayey Sand	A	97	17			8.6×10^{-6}						X			

TABLE E-2
COMPREHENSIVE LIST OF SOILS ENGINEERING PROPERTIES FROM LABORATORY TESTS

CEG Boring No.	Sample No.	Depth (ft)	Visual Classification	Geologic Unit	Dry Density (pcf)	Moisture Content (%)	Atterberg Limits		Particle Size Cumulative % Passing Sieve No.			Unconfined Compression Strength (psi)	Kv, Coefficient of Permeability (cm/sec)	Coefficient of Consolidation Cc (in/in per Log Cycle)	Specific Gravity	Porosity (n)	Undrained Quick Direct Shear		One-Dimensional Swell (ksf Normal Load) σ_{sw}	Cyclic Triaxial (Liquefaction)	Dynamic Triaxial (Stress/Strain)	Resonant Column Test	Triaxial Compression Test
							LL	PI	4	40	200						φ, deg	c, ksf					
23	C2	20	Sandy clay	A_2	107	20									2.70	36.5	35	1.30					
	C3	30	Sandy clay	A_2			35	14															
	C4	40	Silty clay	A_4	95	31																	
	C4	41	Claystone	A_4	100	24															X		
	C5	50	Clayey sand	A_3	99	25	47	22															Q
	C6	55	Sandy clay	A_4	88	33											30.5	1.44					
	C6	56	Sandy clay	A_4	86	34															X		
	C7	65	Sandy clay	A_4	95	28											35	1.20					
	C8	85	Sandy clay	A_4	110	16											29	2.64					
	C9	104	Tar sand	SP	72	3						1.2											
23A	C1	20	Sandy clay	A_2	101	23											15	0.54					
	C2	39	Silty clay	A_2	105	23																X	
	C2	40	Silty clay	A_2	101	24															X		
	C2	40	Silty clay	A_2	105	23	53	28														X	
	C3	60	Silty, clayey sand	A_3	118	16	35	12	93	85	30		2.0E-7			29.8				X			
	C4	80	Micaceous clayey silt	A_4	115	26											28.5	0.91	2.14				
	C5	100	Silty clay	A_4	91	32	46	17						.065									
	C6	120	Clayey silt	A_4	101	25	32	6															Q
	C7	139	Silty sand	A_5	94	26											33.5	0.26					
	C8	159	Silty sand	SP	114	13							3.1E-5		2.70	32.3							
	C8	159	Silty sand	SP	114	14											33	0.56					
	C9	179	Silty sand	SP	110	18											33	0.45					

TABLE E-2
(CONTINUED)
COMPREHENSIVE LIST OF SOILS ENGINEERING PROPERTIES FROM LABORATORY TESTS

CEG Boring No.	Sample No.	Depth (ft)	Visual Classification	Geologic Unit	Dry Density (pcf)	Moisture Content (%)	Atterberg Limits		Particle Size Cumulative % Passing Sieve No.			Unconfined Compression Strength (psi)	Kv, Coefficient of Permeability (cm/sec)	Coefficient of Consolidation Cc (in/in Per Log Cycle)	Specific Gravity	Porosity (n)	Undrained Quick Direct Shear		One-Dimensional Swell % Swell (ksf Normal Load)	Cyclic Triaxial (Liquefaction)	Dynamic Triaxial (Stress/Strain)	Resonant Column Test	Triaxial Compression Test
							LL	PI	4	40	200						ø, deg	c, ksf					
24	C1	20	Micaceous silty sand	A_1	124	13			93	60	32		2.3E-5		2.61					X			
	C2	40	Silty sand	A_1	121	12											37.5	0.92					
	C3	60	Sandy clay	A_2	94	28											26	0.81					
	C4	80	Clayey sand	A_3	116	17											35.5	0.75					
	C5	100	Silty sand	A_3	117	13											39.5	0.48					
	C6	120	Sandy clay	A_4	105	19																	
	C7	140	Clayey sand	A_3	113	16											32	1.77					
	C7	141	Clayey sand	A_4																	X		
	C10	200	Sandy clay	A_4	116	18											5.5	1.63					

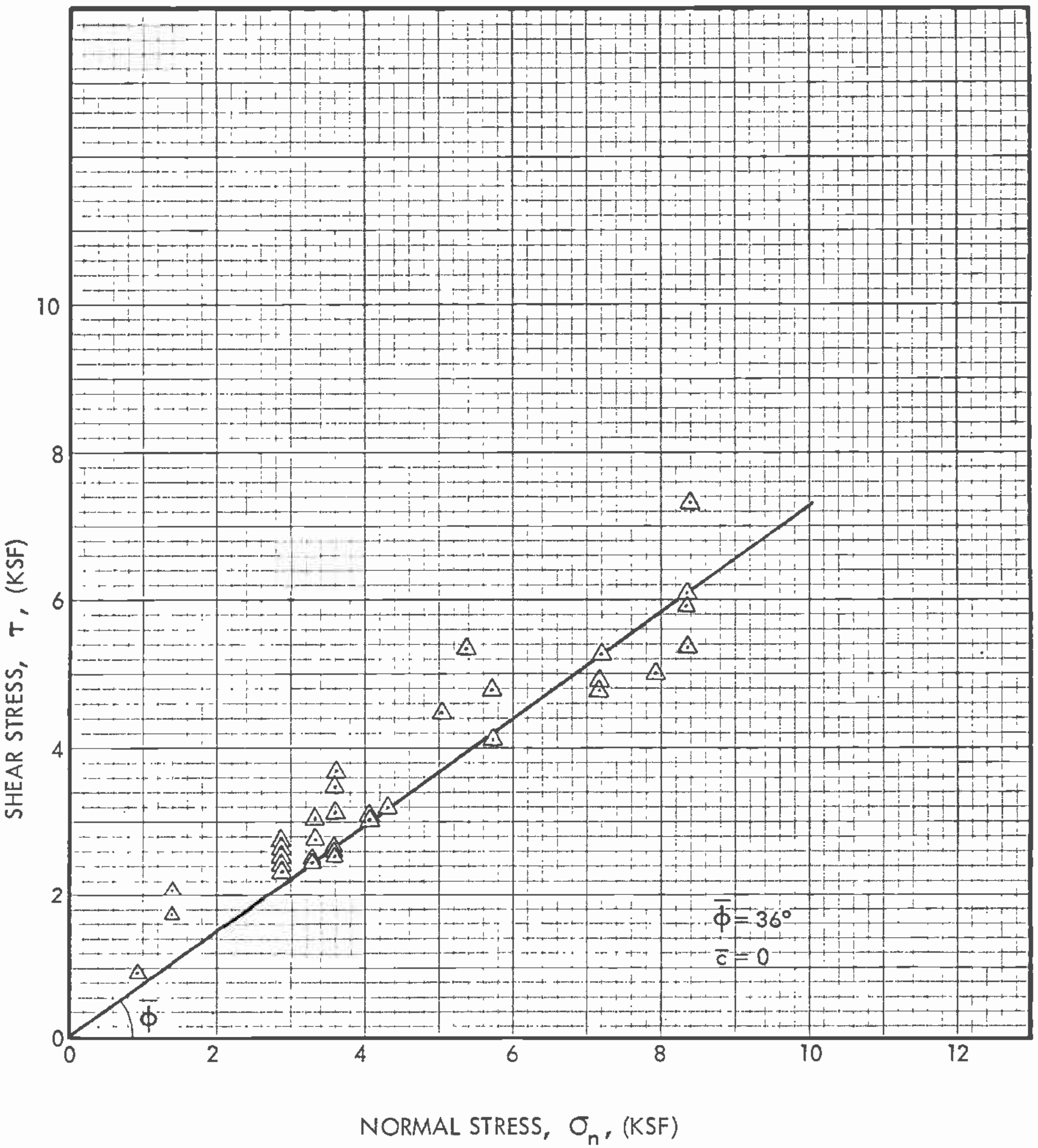
TABLE E-2 (CONTINUED) COMPREHENSIVE LIST OF SOILS ENGINEERING PROPERTIES FROM LABORATORY TESTS

CEG Boring No.	Sample No.	Depth (ft)	Visual Classification	Geologic Unit	Dry Density (pcf)	Moisture Content (%)	Atterberg Limits		Particle Size Cumulative % Passing Sieve No.			Unconfined Compression Strength (psi)	Kv, Coefficient of Permeability (cm/sec)	Coefficient of Consolidation Cc (in/in Per Log Cycle)	Specific Gravity	Porosity (n)	Undrained Quick Direct Shear		One-Dimensional Swell Sw (ksf Normal Load)	Cyclic Triaxial (Liquefaction)	Dynamic Trixial (Stress/Strain)	Resonant Column Test	Triaxial Compression Test
							LL	PI	4	40	200						φ, deg	c, ksf					
25	C1	20	Silty clay	A_2	96	26			100	90	73												Q
	C2	40	Silty, clayey fine sand	A_1	119	12	28	10	100	54	23		1.0E-7			29.1							cup
	C2	40	Silty, clayey fine sand	A_1			29	13	99	64	35												
	C3	60	Sandy clay	A_4	111	14																X	
	C3	60	Sandy clay	A_4	110	14																X	
	J8	82	Clayey sand	A_3					97	63	37												
	C5	100	Sandy clay	A_4	121	14							3.3E-8		2.74	29.1							
	C5	100	Sandy clay	A_4	121	14											27	2.00					
	J11	111	Clayey sand	A_3			33	12	98	78	41												
	C6	120	Clayey sand	A_3	120	11							5.1E-7		2.67	23.4							
	C6	120	Clayey sand	A_3	128	11											38.5	1.03					
	C7	140	Clayey silt	A_4	112	19								.033			28	1.63					
	C7	140	Clayey silt	A_4	120	13							2.6E-7										
	C8	160	Sandy silt	A_4	118	15						28.4											
	C9	180	Silty fine sand	A_3	135	6											39.5	0.64					
	C10	200	Clayey sand	A_3	116	18											35.5	1.54					
26	C1	20	Sandy clay	A_2	103	23						71.8											
	J2	21	Silty sand	A_1					91	59	33												
	C2	40	Silty fine sand	A_1	91	31											39.5	0.38					
	C4	80	Silty clay	A_4	102	24								.077									
	J7	91	Silty clay	A_4			59	34	100	100	62												
	C5	100	Sandy clay with gravel	A_4	107	21						45.3											
	C6	120	Clayey silt	A_4	103	23							1.1E-7			38.1							
	C6	120	Clayey silt	A_4	105	23			100	88	71	50.3											
	S1	138	Silty fine to coarse sand & gravel	A_3	124	13																	Q
	S1	138	Silty fine to coarse sand & gravel	A_3	115	17	32	7	91	61	35	31.3											
	J12	141	Sandy silt	A_4			36	6	98	74	45												

TABLE E-2 (CONTINUED)

COMP IENSIVE LIST OF SOILS ENGINEERING PROPERTIES FROM LABORATORY TESTS

CEG Boring No.	Sample No.	Depth (ft)	Visual Classification	Geologic Unit	Dry Density (pcf)	Moisture Content (%)	Atterberg Limits		Particle Size Cumulative % Passing Sieve No.			Unconfined Compression Strength (psi)	Kv, Coefficient of Permeability (cm/sec)	Coefficient of Consolidation Cc (in/in Per Log Cycle)	Specific Gravity	Porosity (n)	Undrained Quick Direct Shear		One-Dimensional Swell % Swell (ksf Normal Load)	Cyclic Triaxial (Liquefaction)	Dynamic Triaxial (Stress/Strain)	Resonant Column Test	Triaxial Compression Test
							LL	PI	4	40	200						φ, deg	c, ksf					
26	S2	158	Clayey coarse sand & gravel	A_3	115	16															X		
	S2	159	Clayey coarse sand & gravel	A_3	111	18						50.4											
	S3	180	Silty fine to coarse sand & gravel	A_3	119	15																	Q
	S3	180	Silty fine to coarse sand & gravel	A_3	108	21																	Q
	S4	208	Siltstone	C	106	21						68.7											
27	S1	21	Silty fine sand	A_1	102	22	25	1	100	82	35		1.1E-5			39.6							cup
	S1	21	Silty fine sand	A_1	100	21														X			
	S4	79	Clayey sand & gravel	A_3	113	18	34	14	100	82	45		5.0E-7		2.69	32.6							Q
	J9	91	Clayey sand	A_3			36	19	99	75	46												
	S5	99	Sandy clay	A_4	105	11	39	16				32.0		.059									
	C1	120	Silty clay	A_4	114	18											26	0.82					
	C2	140	Silty clay	A_4	113	18											33.5	1.35					
	J15	150	Sandy clay	A_4			53	27	100	98	55												
	S6	164	Silty clay	A_4	108	20																	Q
	S6	164	Silty clay	A_4	106	22			100	94	74	66.4											
	C3	200	Sandy clay	A_4	118	15						93.8											
28	C1	20	Clayey silt	A_2	90	28											20	0.18					
	C2	40	Silty sand	A_1	110	10											30.5	0.77					
	C3	60	Sandy clay	A_2	103	17											28	1.12					
	C4	80	Clayey silty sand	A_3	107	13											37.5	0.35					
	C5	100	Sandy clay	A_4	101	20											14.5	0.94					
	C6	120	Clayey sand	A_3	125	13											34	2.58					
	C7	139	Sandy clay	A_4	122	13																X	
	C7	140	Sandy clay	A_4	120	13							2.6E-7		2.69	28.3							
	C8	160	Silty sand	A_4	120	13							8.6E-5			28.3							
	C9	180	Clayey sand	A_1	123	12															X		



SUMMARY OF DIRECT SHEAR TEST RESULTS: COARSE-GRAINED ALLUVIUM

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Figure No.
E-1

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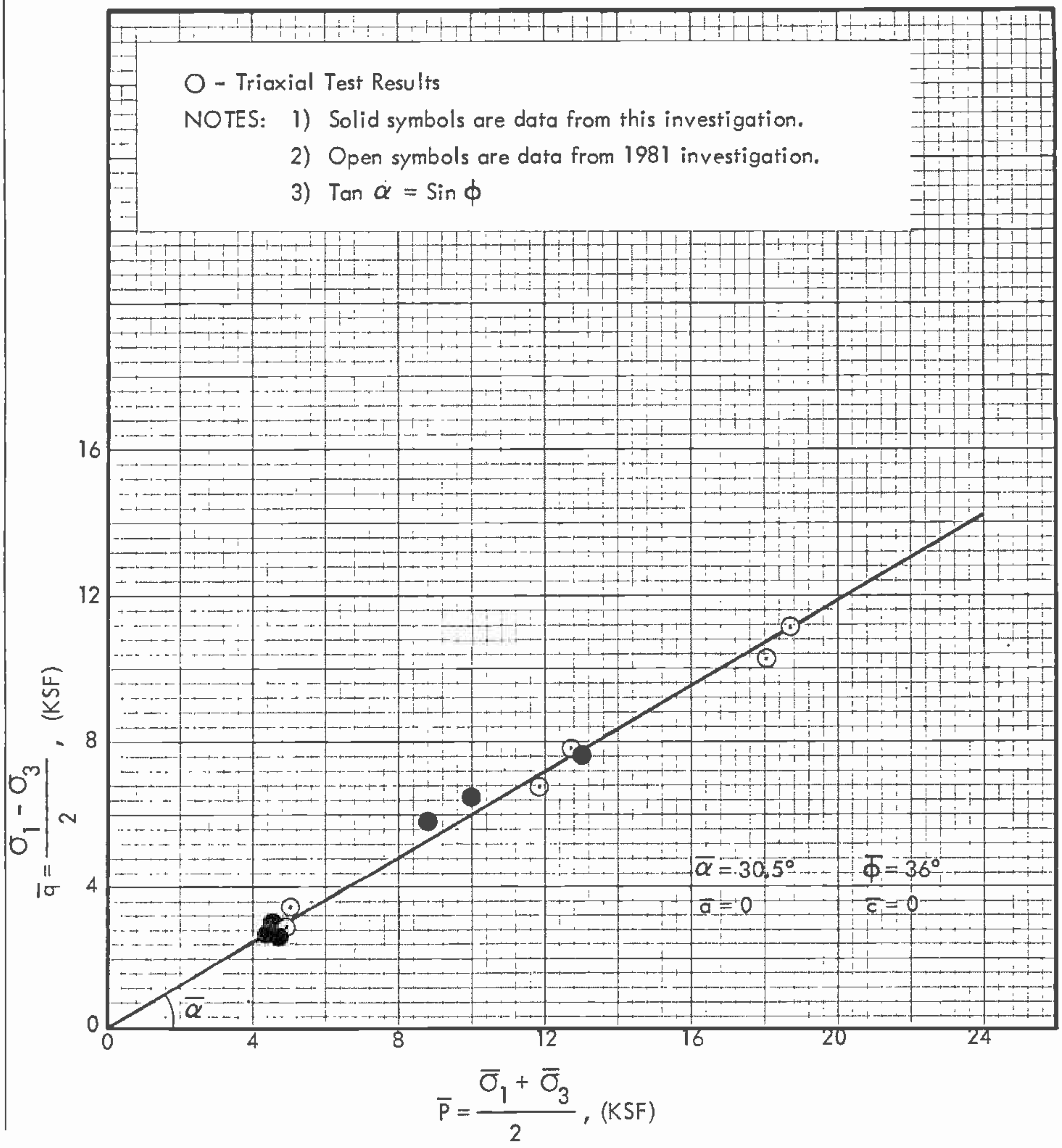

O - Triaxial Test Results

NOTES:
1) Solid symbols are data from this investigation.
2) Open symbols are data from 1981 investigation.
3) Tan α = Sin ϕ

SUMMARY OF EFFECTIVE STRENGTH DATA - COARSE-GRAINED ALLUVIUM

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Figure No.
E-2

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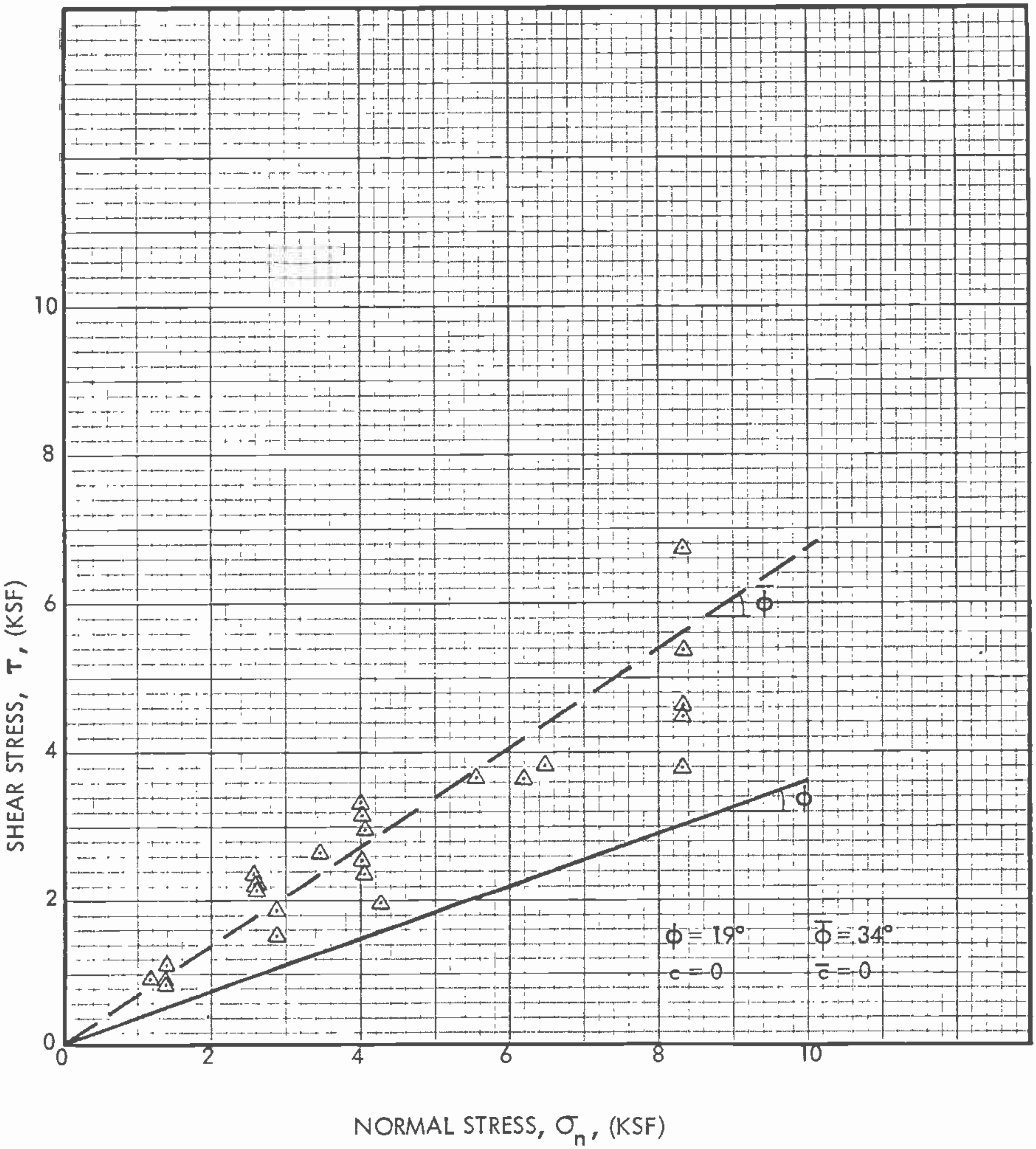

SUMMARY OF DIRECT SHEAR TEST RESULTS - FINE-GRAINED ALLUVIUM

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Figure No.
E-3

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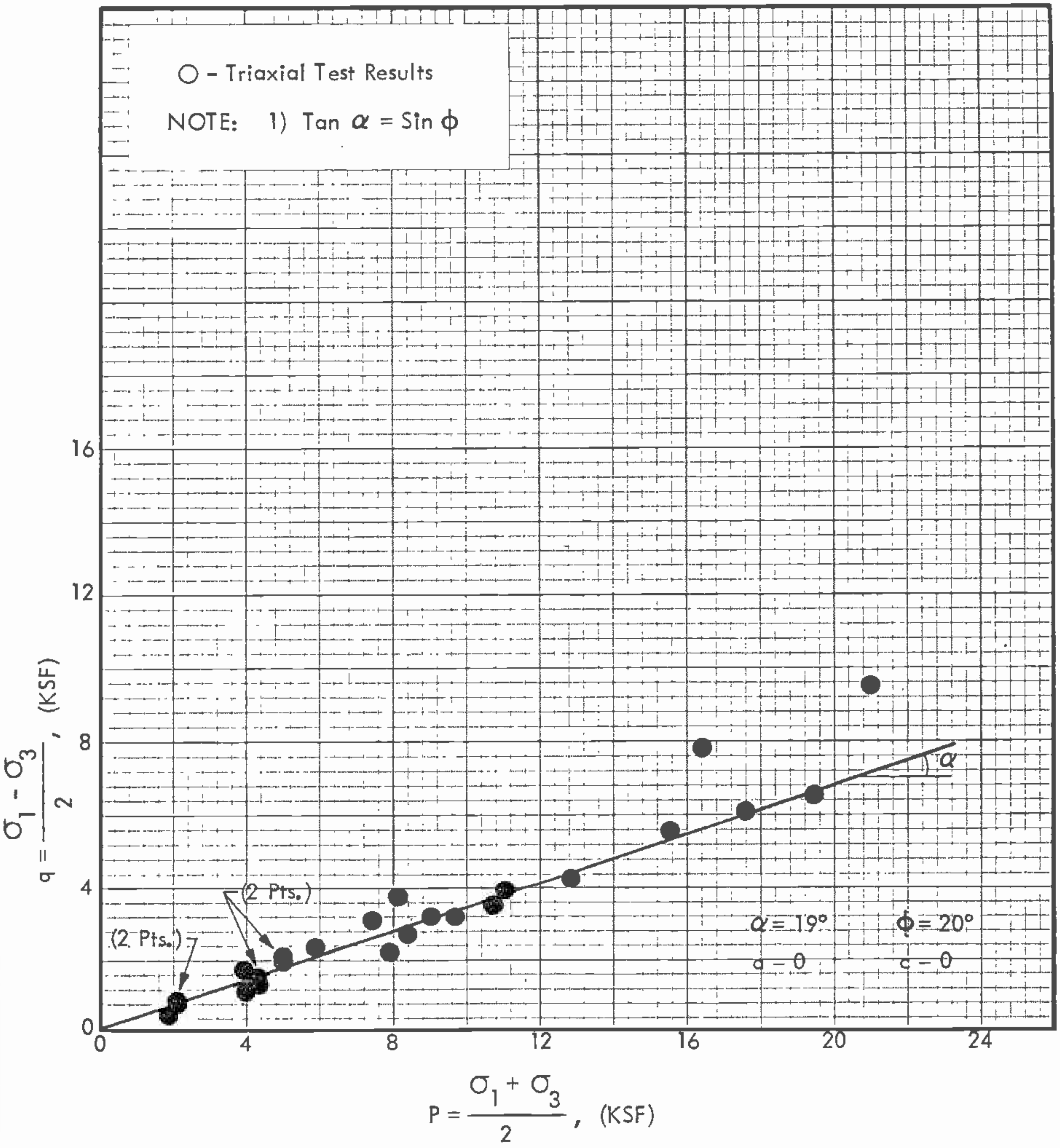

SUMMARY OF TOTAL STRENGTH DATA - FINE-GRAINED ALLUVIUM

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Figure No.
E-4

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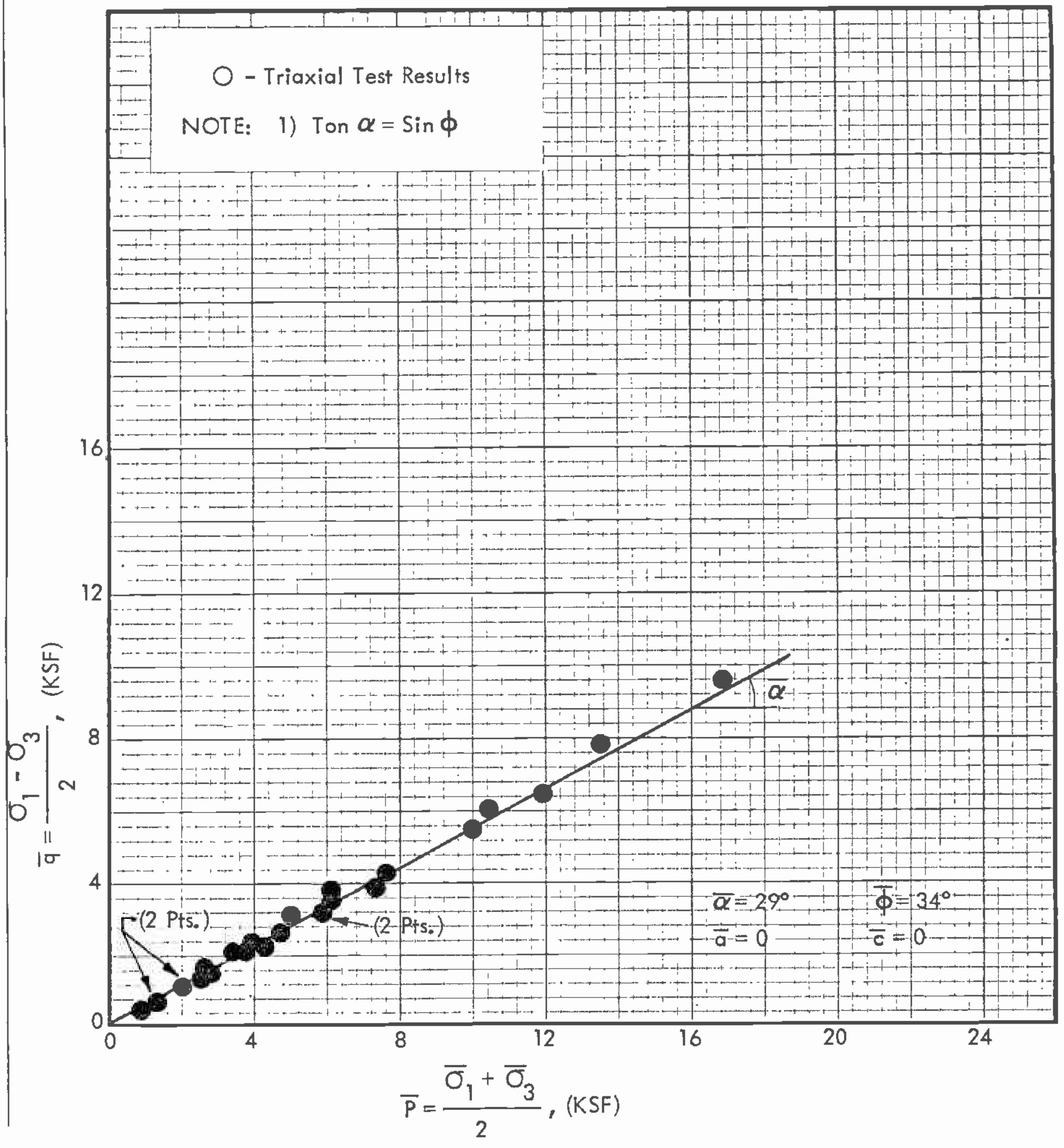

SUMMARY OF EFFECTIVE STRENGTH DATA - FINE-GRAINED ALLUVIUM

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Figure No.
E-5

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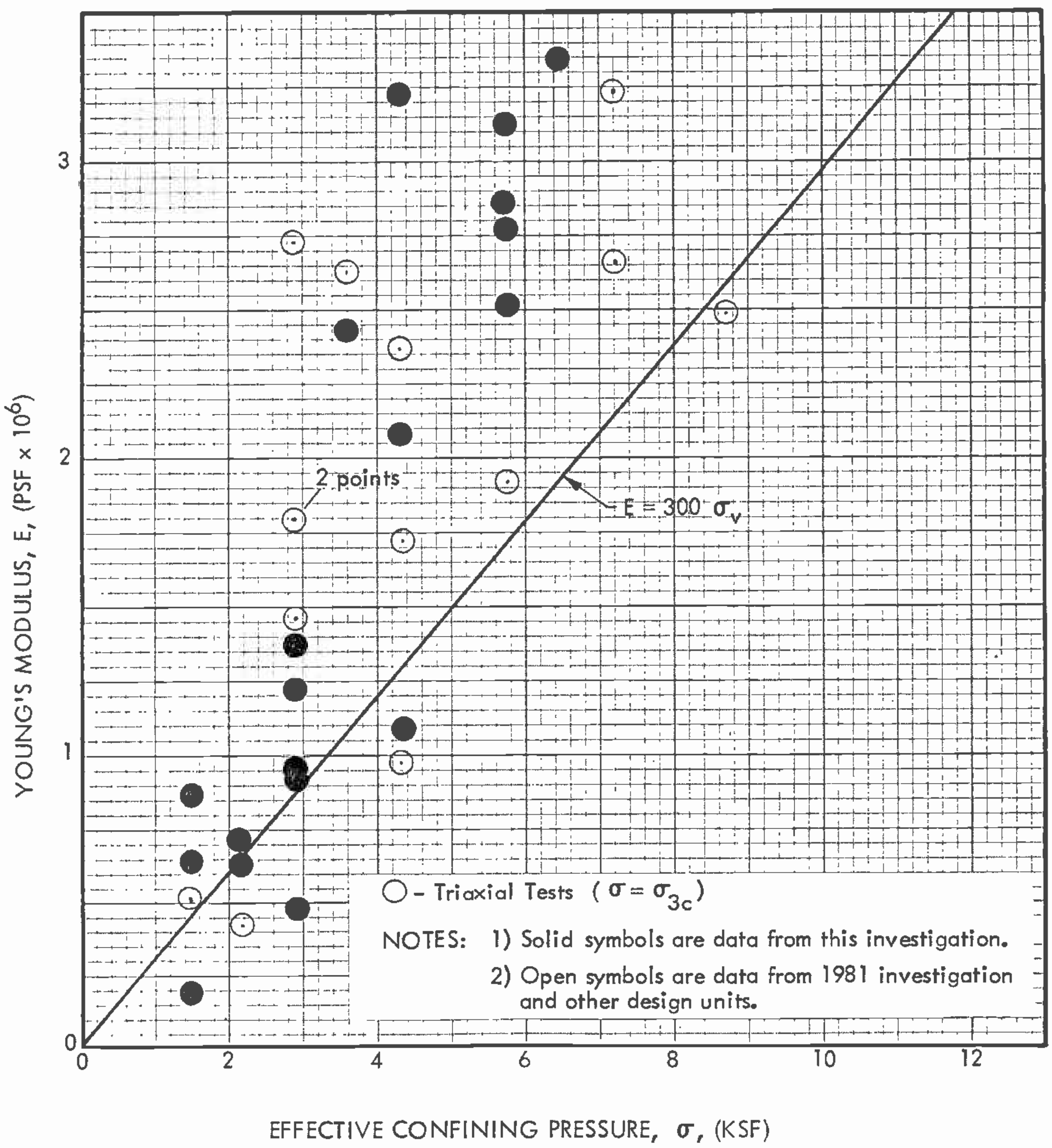

NOTES: 1) Solid symbols are data from this investigation.
2) Open symbols are data from 1981 investigation and other design units.

SUMMARY OF MODULUS DATA - COARSE & FINE-GRAINED ALLUVIUM

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Figure No.
E-6

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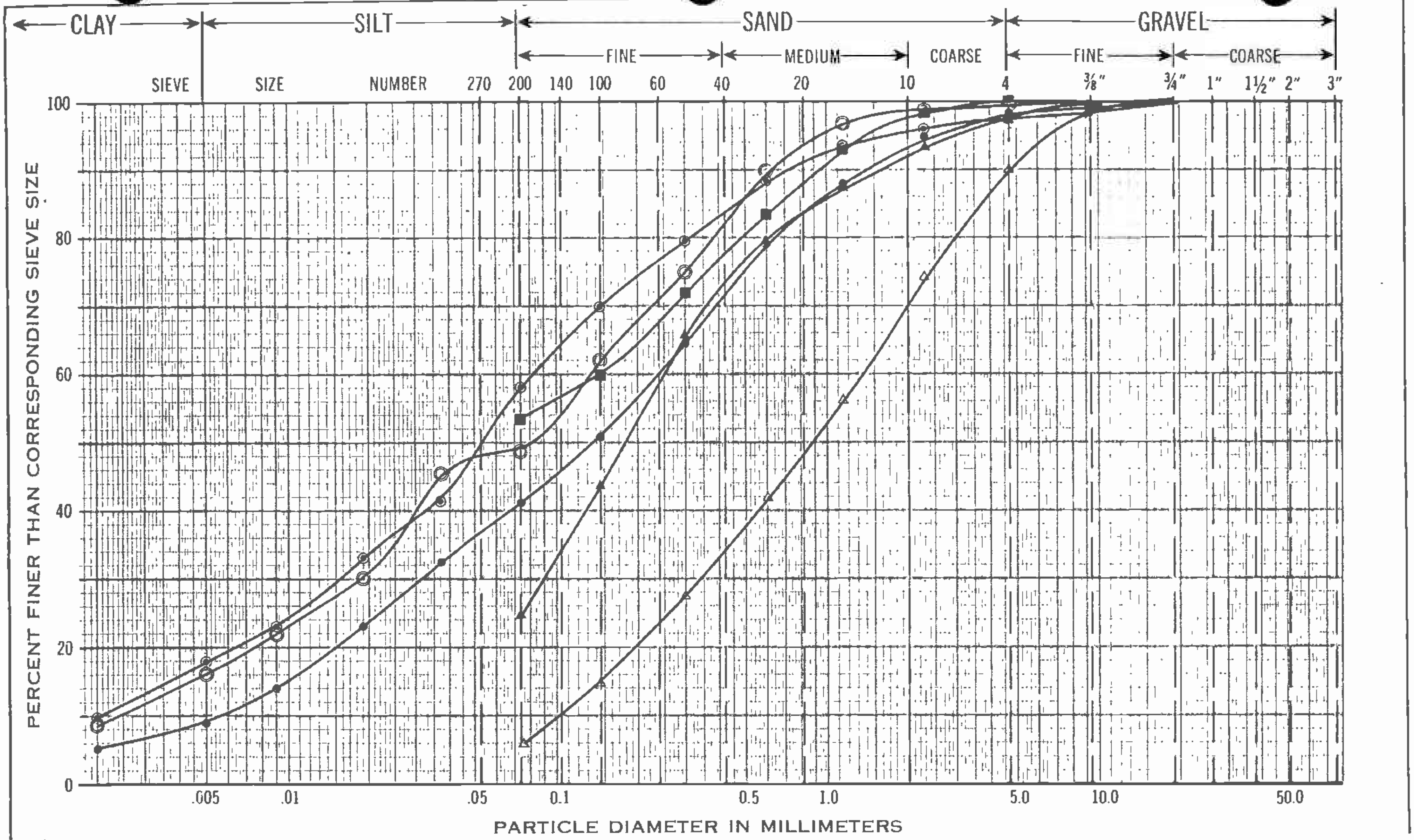

SYMBOL	BORING	SAMPLE	DEPTH,ft.
●	23-C	PB-2	15.0-16.8
◉	23-C	PB-3	25.0-27.5
○	23-C	PB-4	35.0-37.5
■	23-C	PB-5	45.0-47.5
▲	23-C	PB-6	55.0-57.5
△	23-C	PB-8	75.0-76.0

GRAIN-SIZE DISTRIBUTION CHART

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Figure No.
E-7

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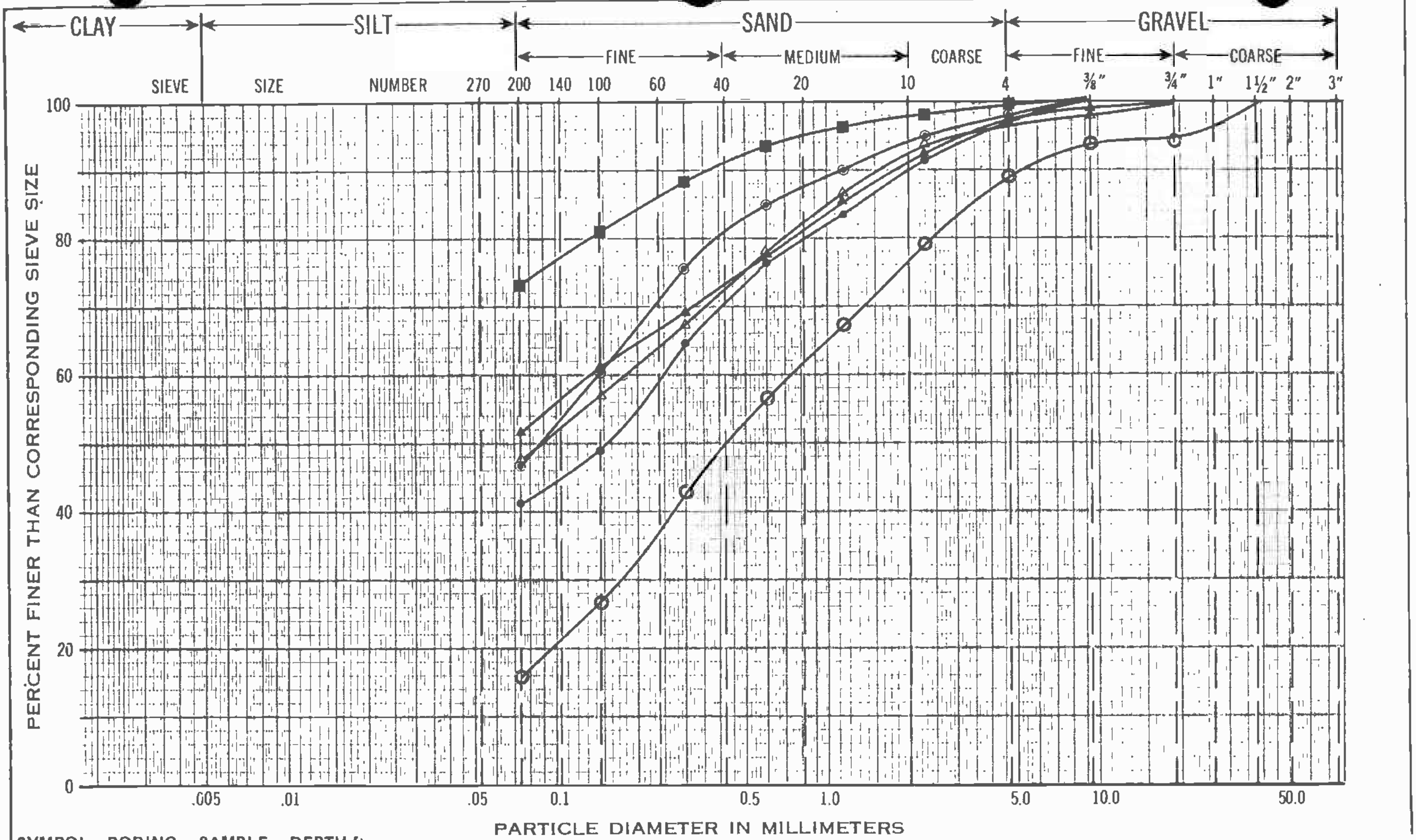

SYMBOL	BORING	SAMPLE	DEPTH,ft.
●	23-D	PB-3	25.0-27.5
◉	23-D	PB-4	35.0-37.5
○	23-D	PB-5	45.0-47.5
■	23-D	PB-6	55.0-57.5
▲	23-D	PB-7	65.0-67.5
△	23-D	PB-8	73.5-76.0

GRAIN-SIZE DISTRIBUTION CHART

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Figure No.
E-8

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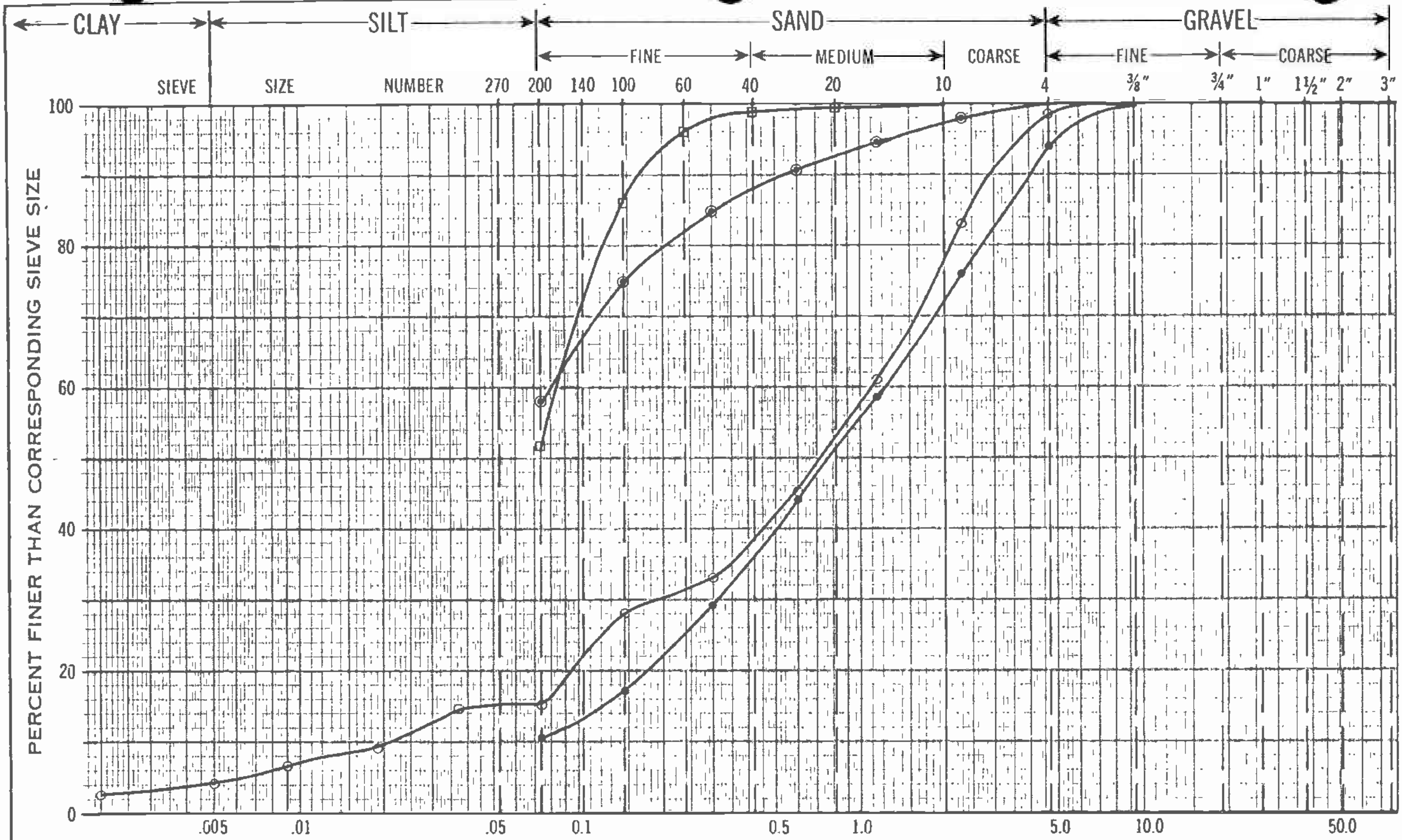

SYMBOL	BORING	SAMPLE	DEPTH FT
●	24-1	PB-3	25.5-27.8
○	24-1	PB-10	85.5-88.0
◉	24-1	C-8	92.5-93.0
□	24-1	C-9	102.5-103

GRAIN-SIZE DISTRIBUTION CHART

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Figure No.
E-9

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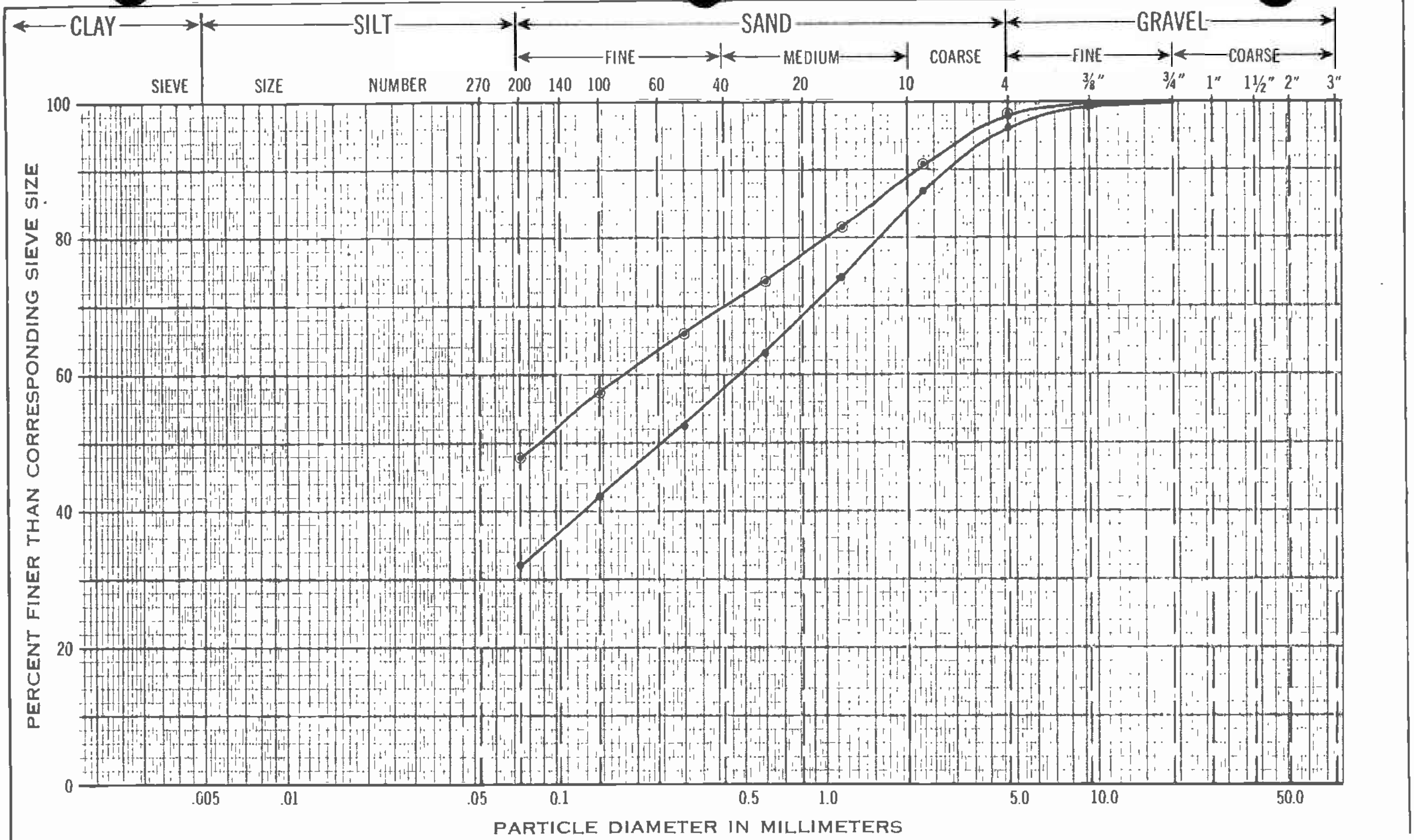

SYMBOL	BORING	SAMPLE	DEPTH FT
◉	24-2	PB-4	45.5-48.2
●	24-2	C-8	72.5-73.0

GRAIN-SIZE DISTRIBUTION CHART

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Southern California Rapid Transit District
METRO RAIL PROJECT

Project No.
83-1140

Figure No.
E-10

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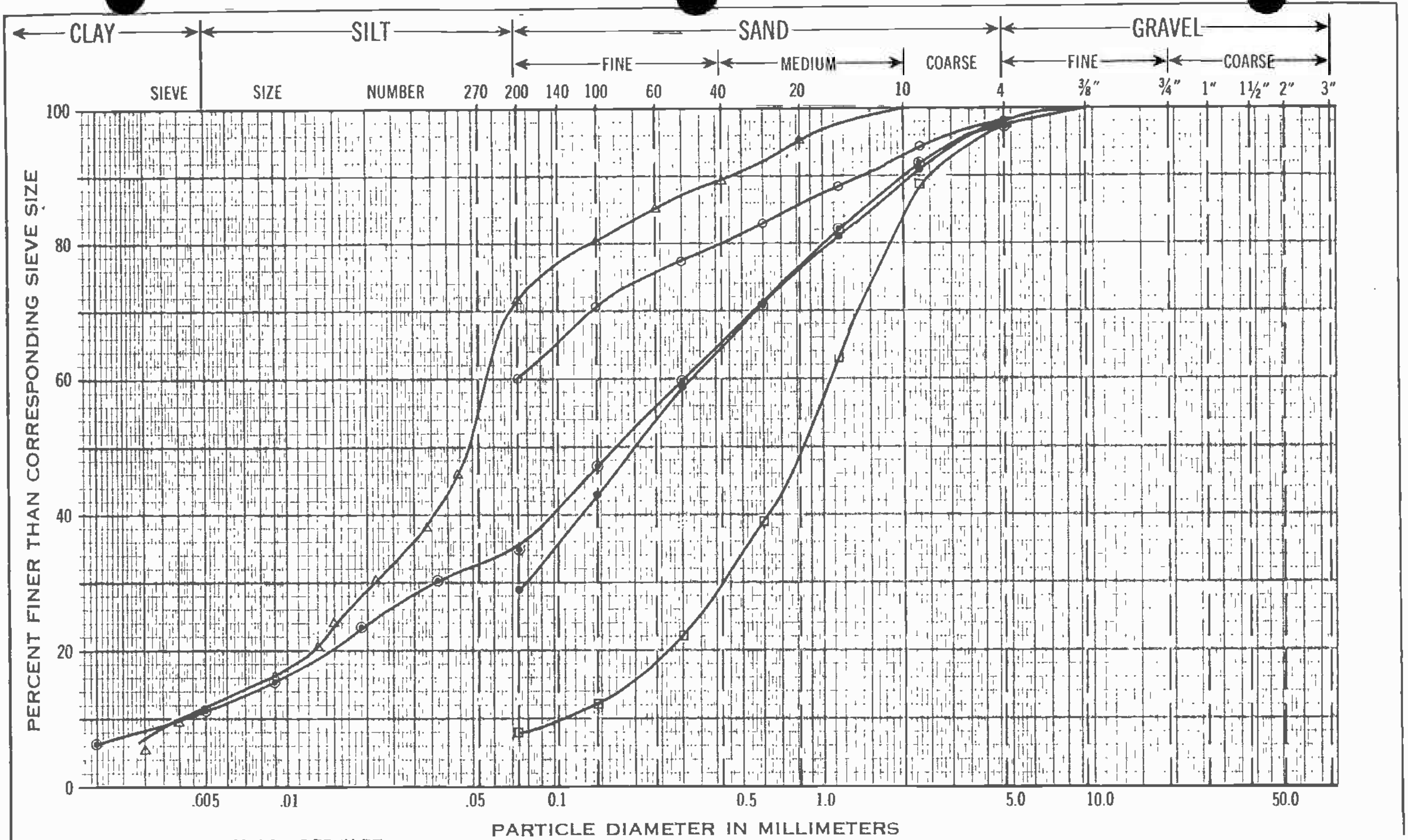
FORM NO. D-3-10 Approved for publication ________ by ________



SYMBOL	BORING	SAMPLE	DEPTH FT
●	24-3	C-2	12.5-13.0
□	24-3	PB-3	45.5-48.0
△	24-3	C-8	72.5-73.0
◉	24-3	PB-6	75.5-78.2
○	24-3	C-10	92.5-93.0

GRAIN-SIZE DISTRIBUTION CHART

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Project No.
83-1140

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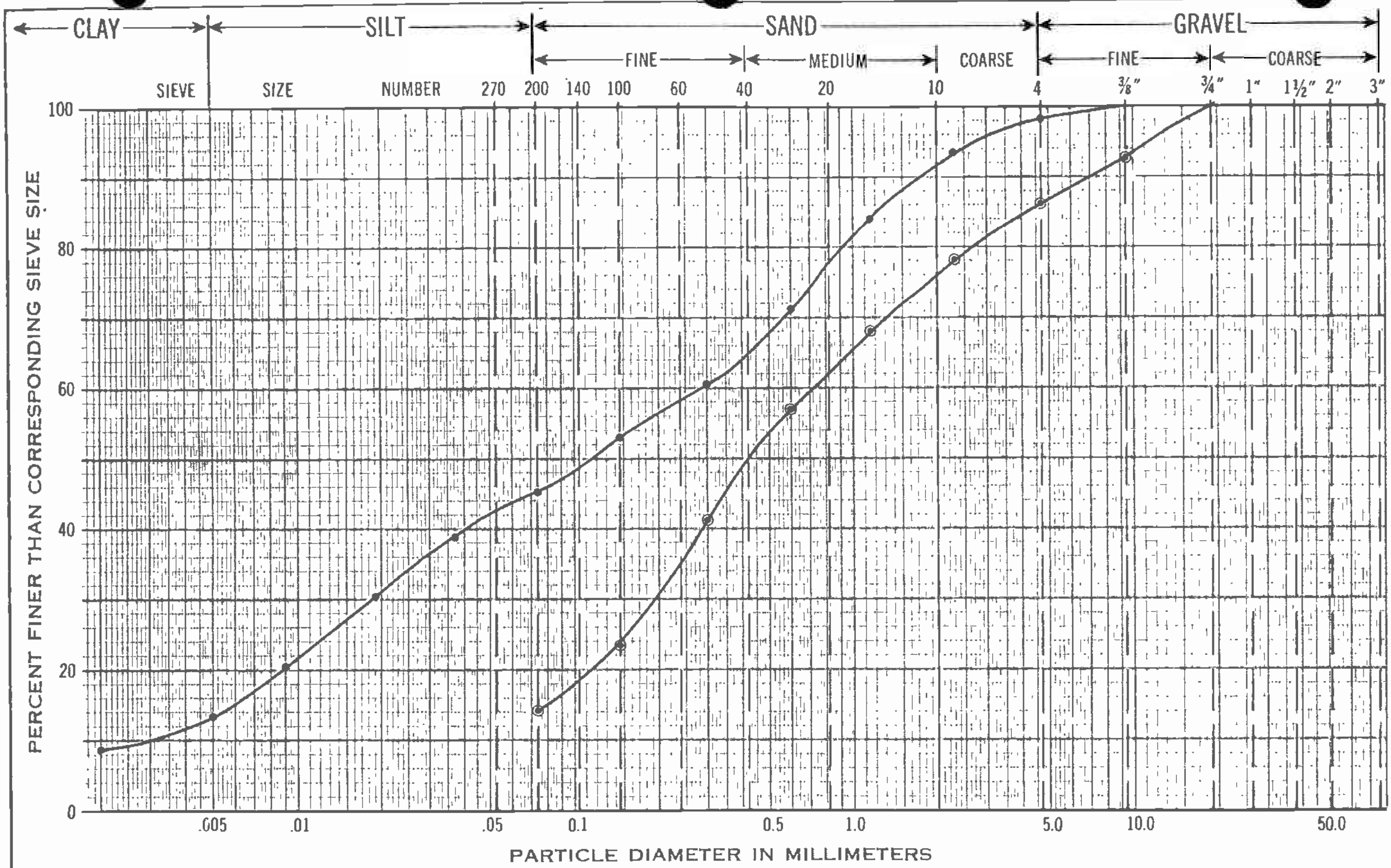
Figure No.
E-11

FORM NO. D-3-10/[illegible] Approved for publication ________ by ________



SYMBOL	BORING	SAMPLE	DEPTH FT
•	24-4	PB-4	45.5-48.0
◉	24-4	PB-6	65.5-68.0

GRAIN-SIZE DISTRIBUTION CHART

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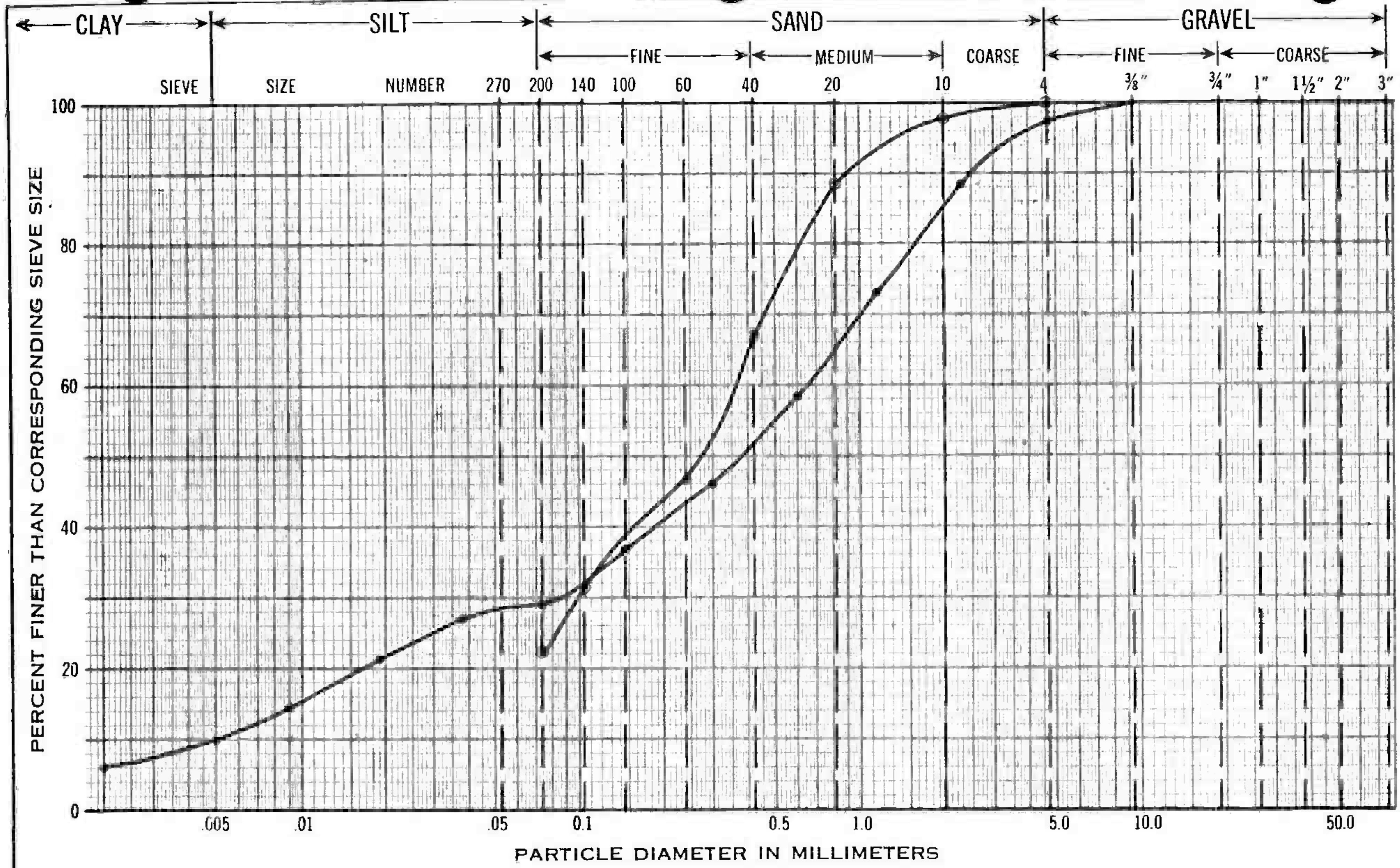
METRO RAIL PROJECT

Project No.
83-1140

Converse Consultants Geotechnical Engineering and Applied Sciences

Figure No.
E-12

FORM NO. D-3-10/ Approved for publication ________ by ________



SYMBOL	BORING	SAMPLE	DEPTH FT
●	24-5	PB-7	74.5-78.2
◉	24-5	C-8	52.5-53.0

GRAIN-SIZE DISTRIBUTION CHART

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Project No.
83-1140

Figure No.
E-13

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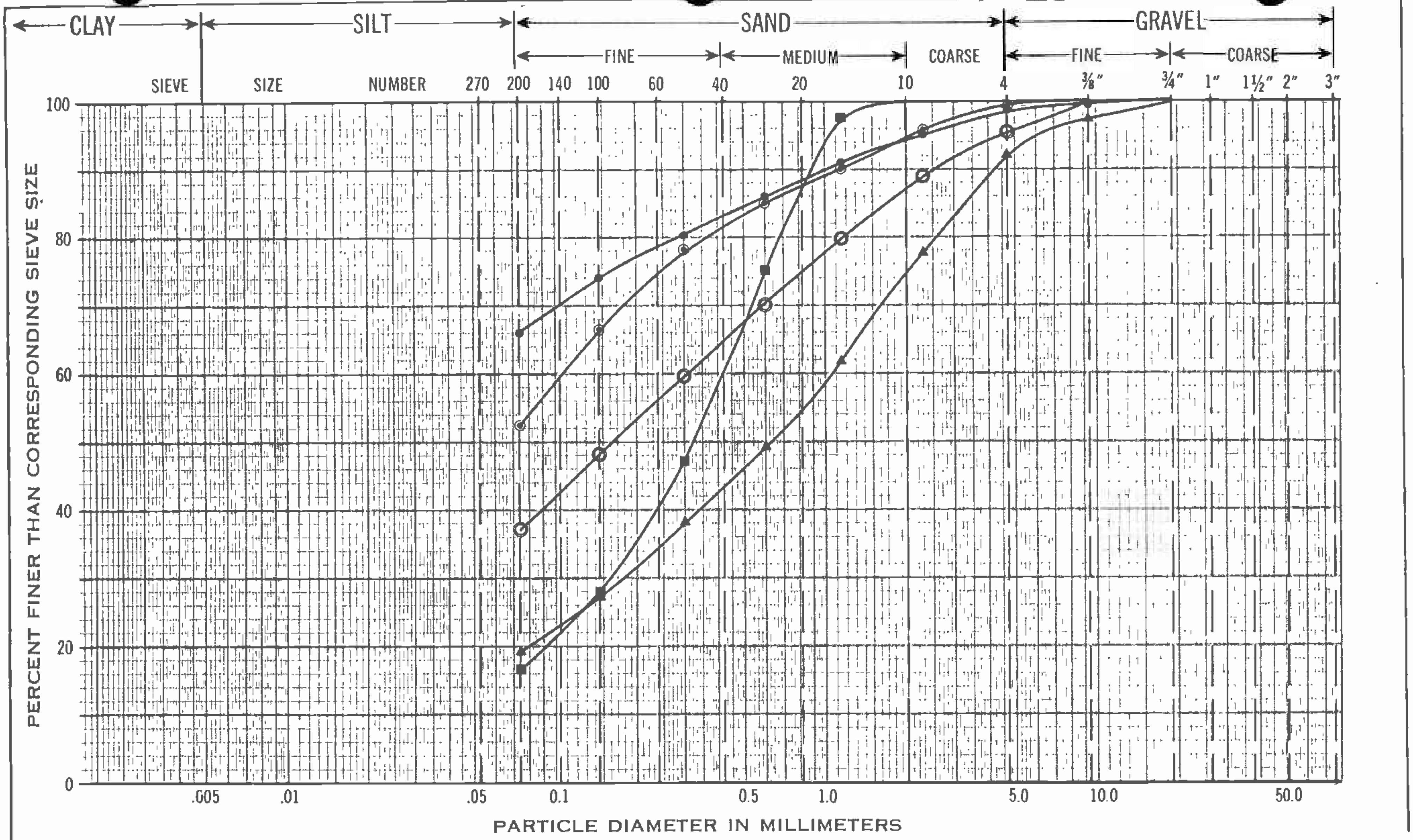
FORM NO. D-3-10 Approved for publication ____________ by ____________



GRAIN-SIZE DISTRIBUTION CHART

SYMBOL	BORING	SAMPLE	DEPTH,ft.
●	24-B	PB-8	75.0-77.5
◉	24-B	PB-9	85.0-87.5
○	24-B	PB-10	95.0-97.5
■	24-B	PB-11	105.0-106.0
▲	24-B	PB-13	125.0-127.5

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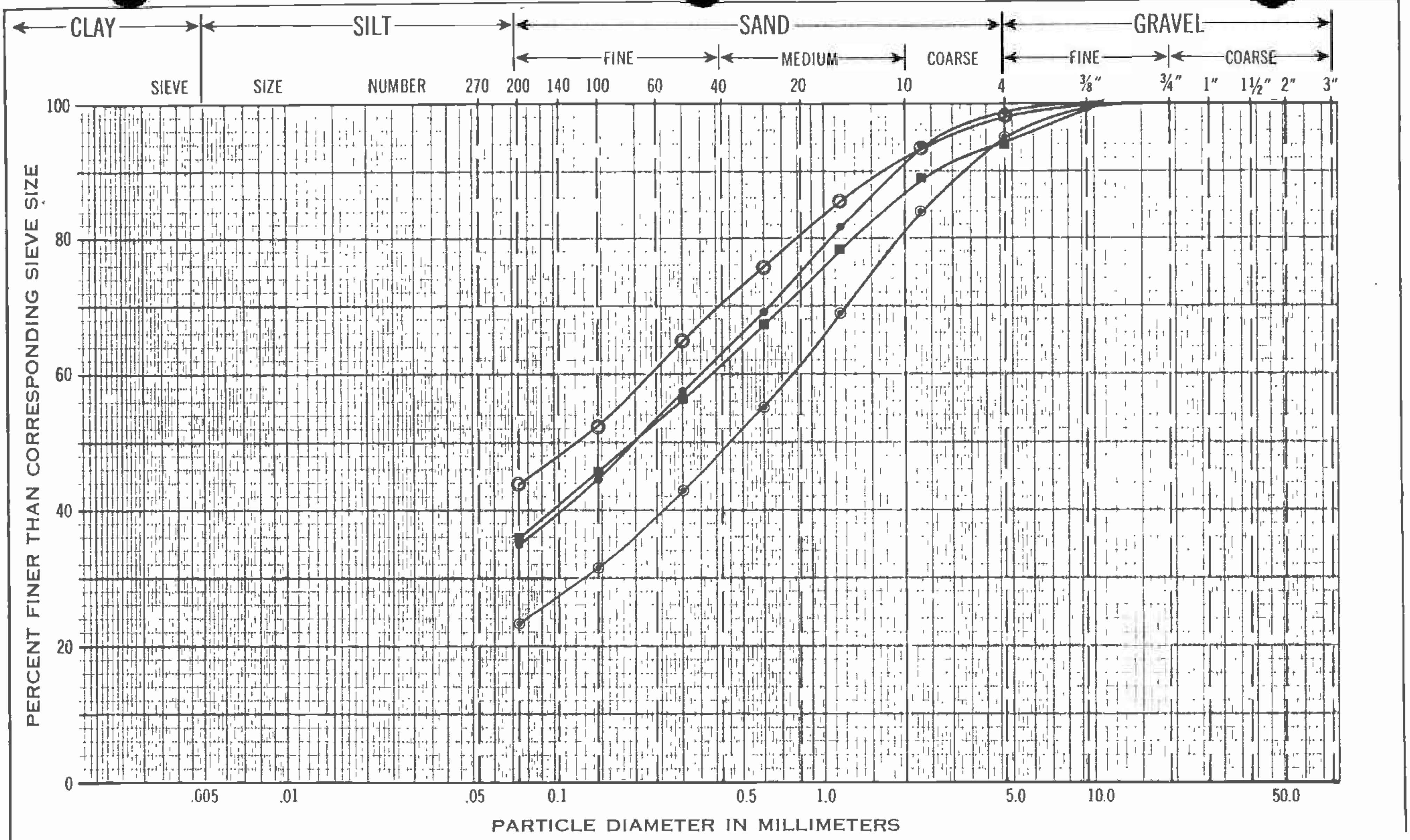
Figure No
E-14

FORM NO. D-3-10/0 Approved for publication ______ by ______



GRAIN-SIZE DISTRIBUTION CHART

SYMBOL	BORING	SAMPLE	DEPTH,ft.
●	25-C	PB-4	35.0-37.5
◉	25-C	PB-5	45.0-47.5
○	25-C	PB-6	55.0-57.5
■	25-C	PB-7	65.0-67.5

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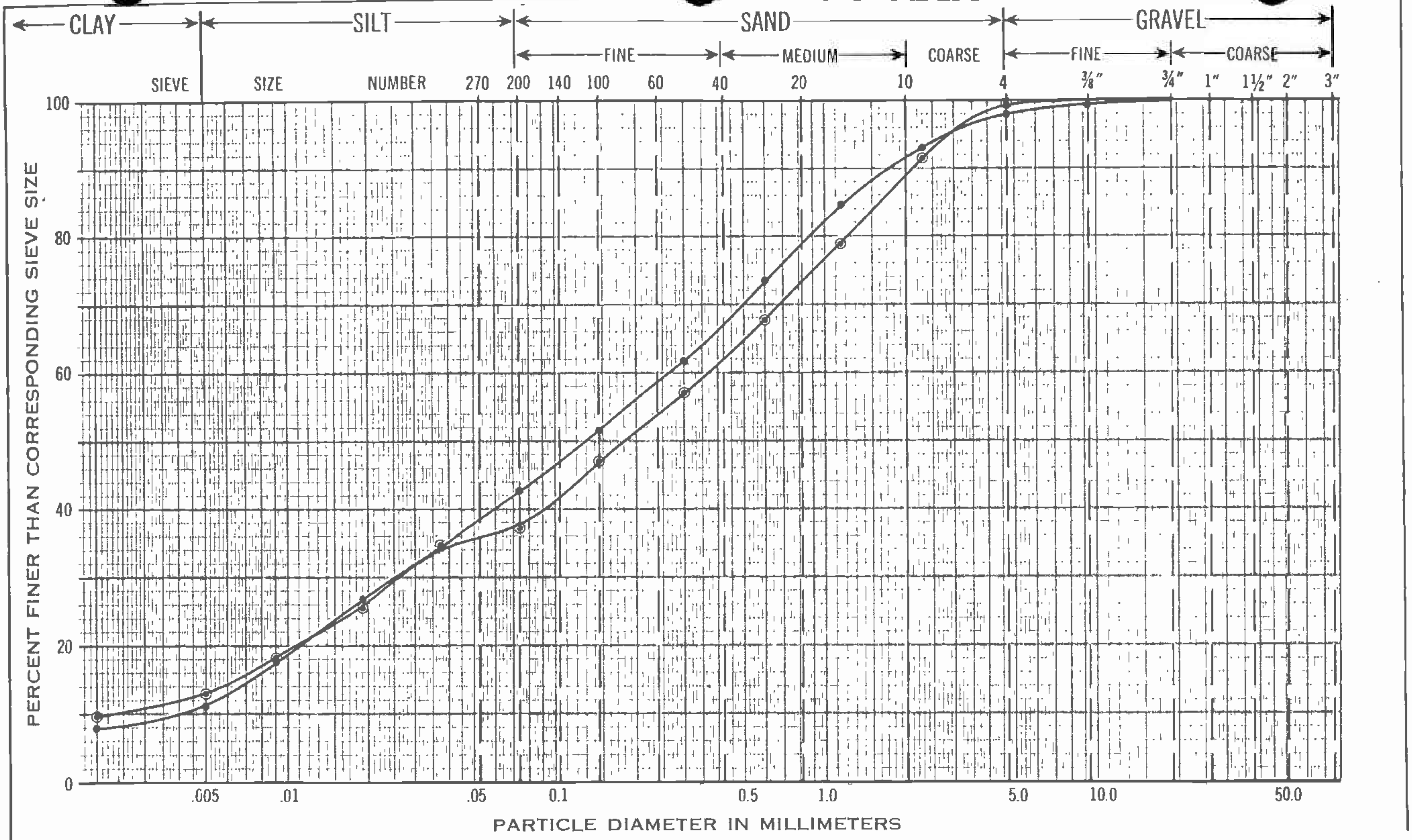
Figure No.
E-15

FORM NO. D-3-10(8) Approved for publication ________ by ________



SYMBOL	BORING	SAMPLE	DEPTH feet
●	26-1	PB-1	6.0-8.5
◉	26-1	PB-4	46.0-48.5

GRAIN-SIZE DISTRIBUTION CHART

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Project No.
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Figure No
E-16

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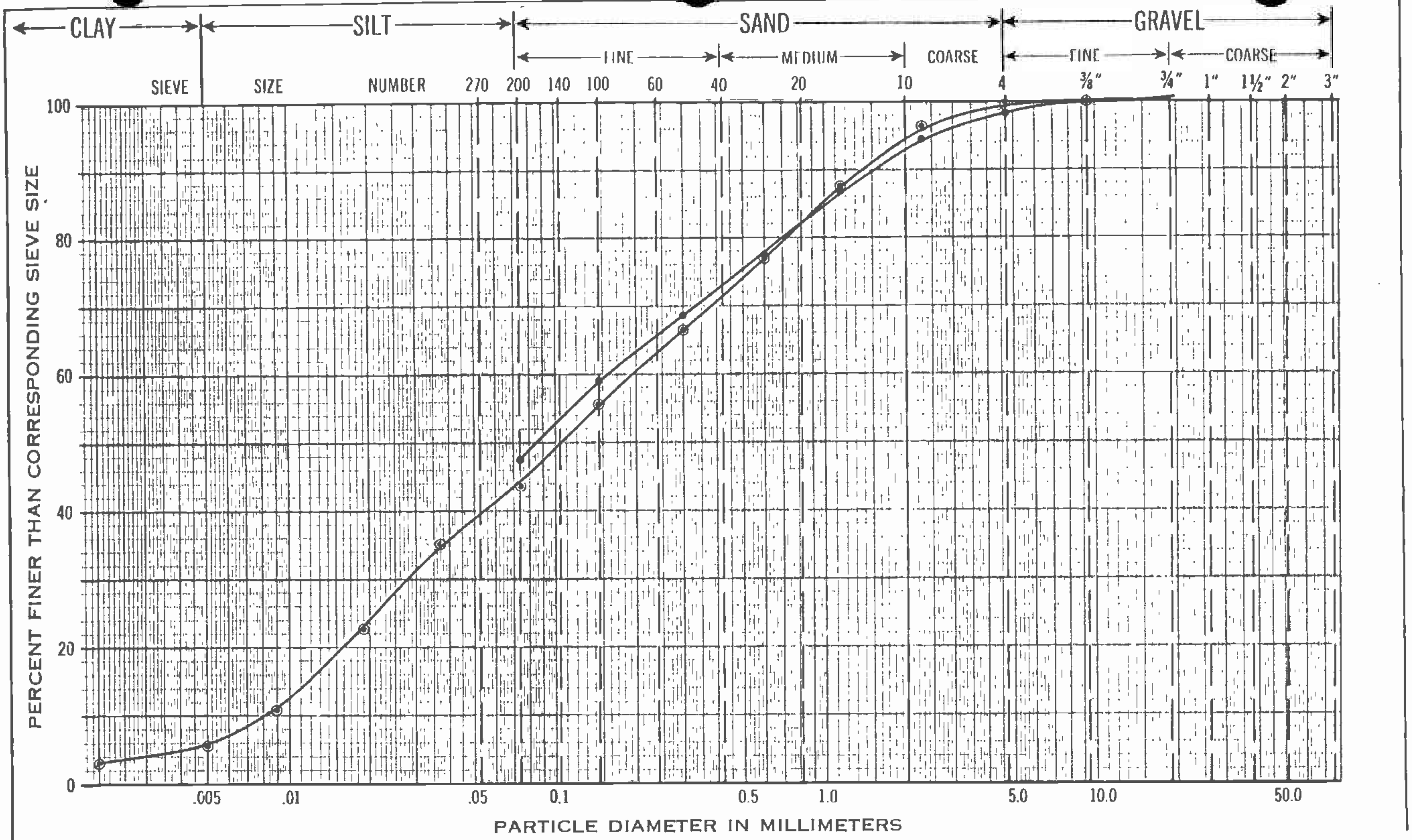
FORM NO. D-3-10 Approved for publication ________ by ________



SYMBOL	BORING	SAMPLE	DEPTH feet
●	26-2	PB-2	12.0-14.5
◉	26-2	PB-6	52.0-54.5

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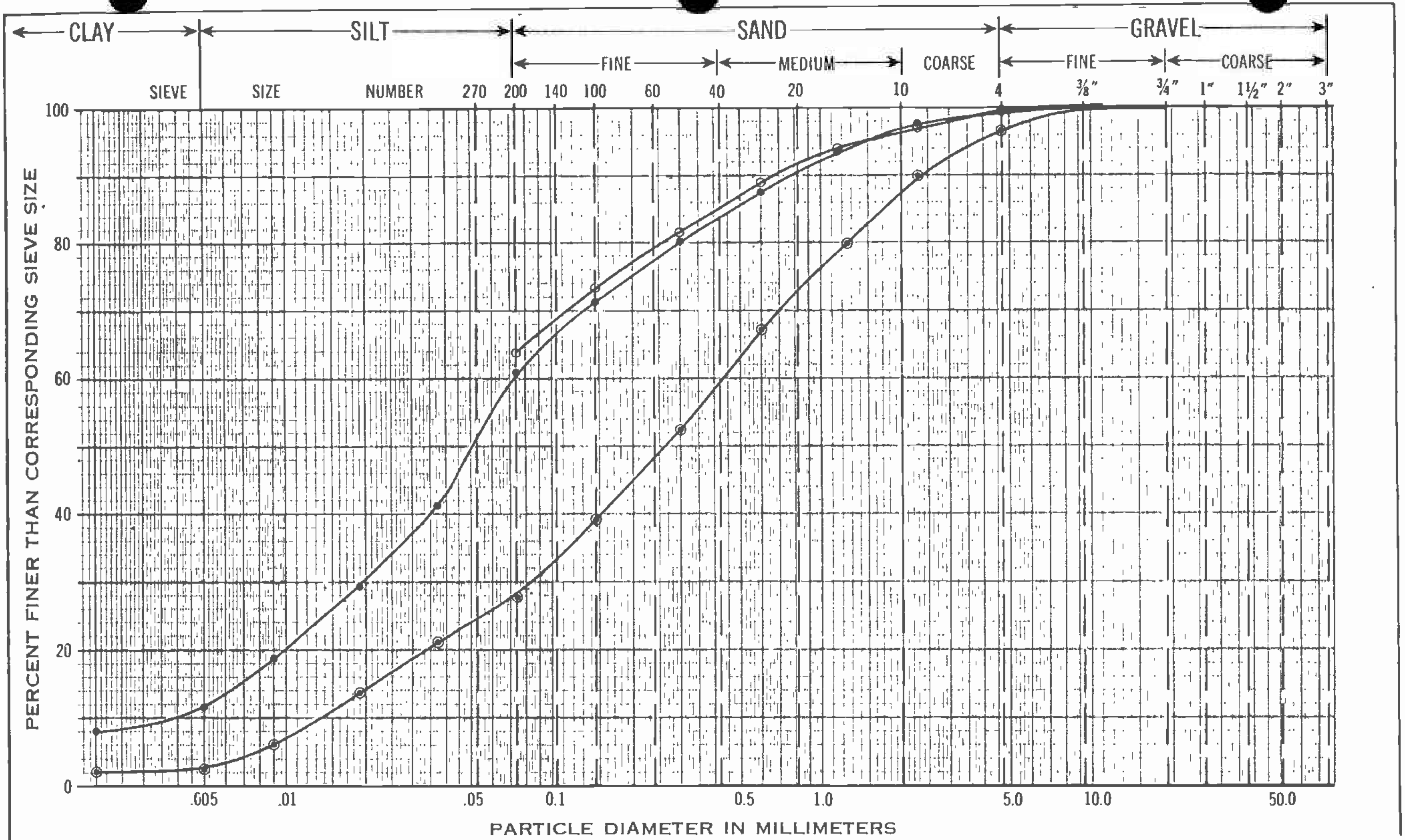
Figure No
E-17

FORM NO. D-3-10/8 Approved for publication ____________ by ____________



SYMBOL	BORING	SAMPLE	DEPTH feet
○	26-3	PB-4	32.0-34.5
●	26-4	PB-2	12.0-14.5
◉	26-4	PB-7	64.0-66.5

GRAIN-SIZE DISTRIBUTION CHART

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Figure No.
E-18

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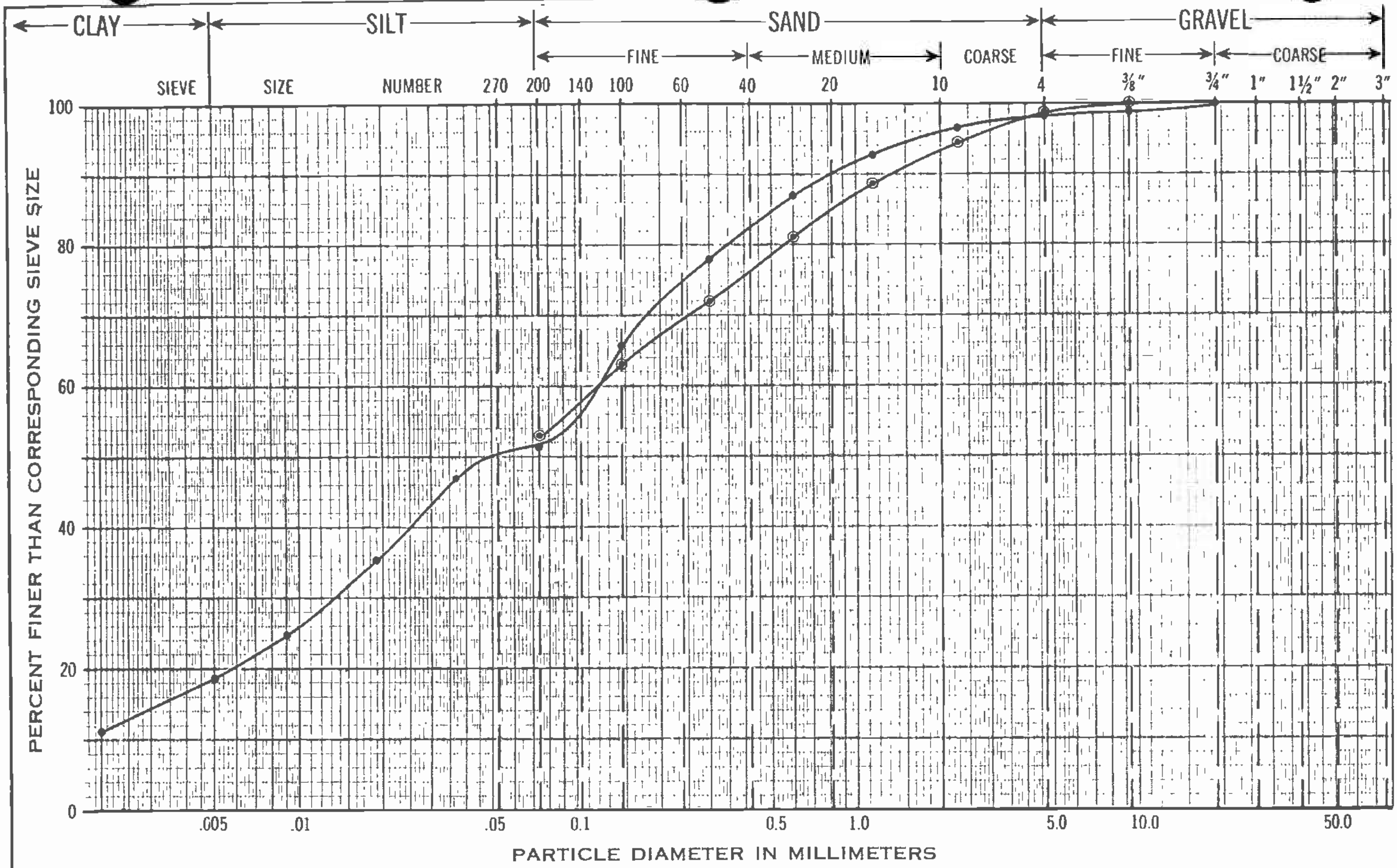
FORM NO. 0-3-19 Approved for publication ________ by ________



SYMBOL	BORING	SAMPLE	DEPTH feet
●	26-5	PB-1	23.0-25.5
◉	26-5	PB-2	43.0-45.5

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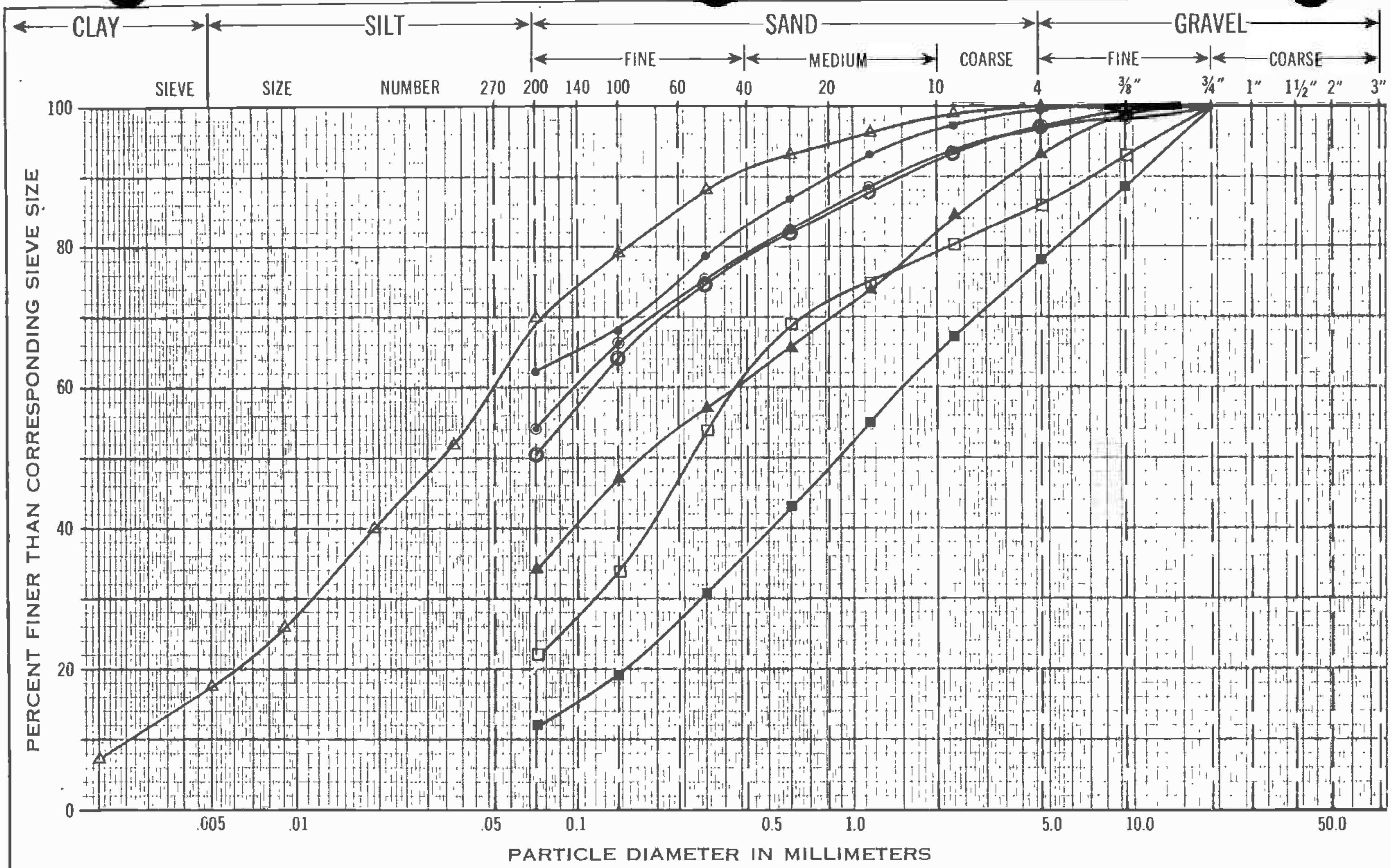
Figure No.
E-19

FORM NO. D-3-10 Approved for publication __________ by __________



SYMBOL	BORING	SAMPLE	DEPTH,ft.
●	26-C	PB-2	20.0-21.5
◉	26-C	PB-3	30.0-32.5
○	26-C	PB-4	40.0-42.5
■	26-C	PB-5	50.0-57.5
□	26-C	PB-6	60.0-62.5
▲	26-C	PB-7	70.0-72.5
△	26-C	PB-8	77.5-80.0

GRAIN-SIZE DISTRIBUTION CHART

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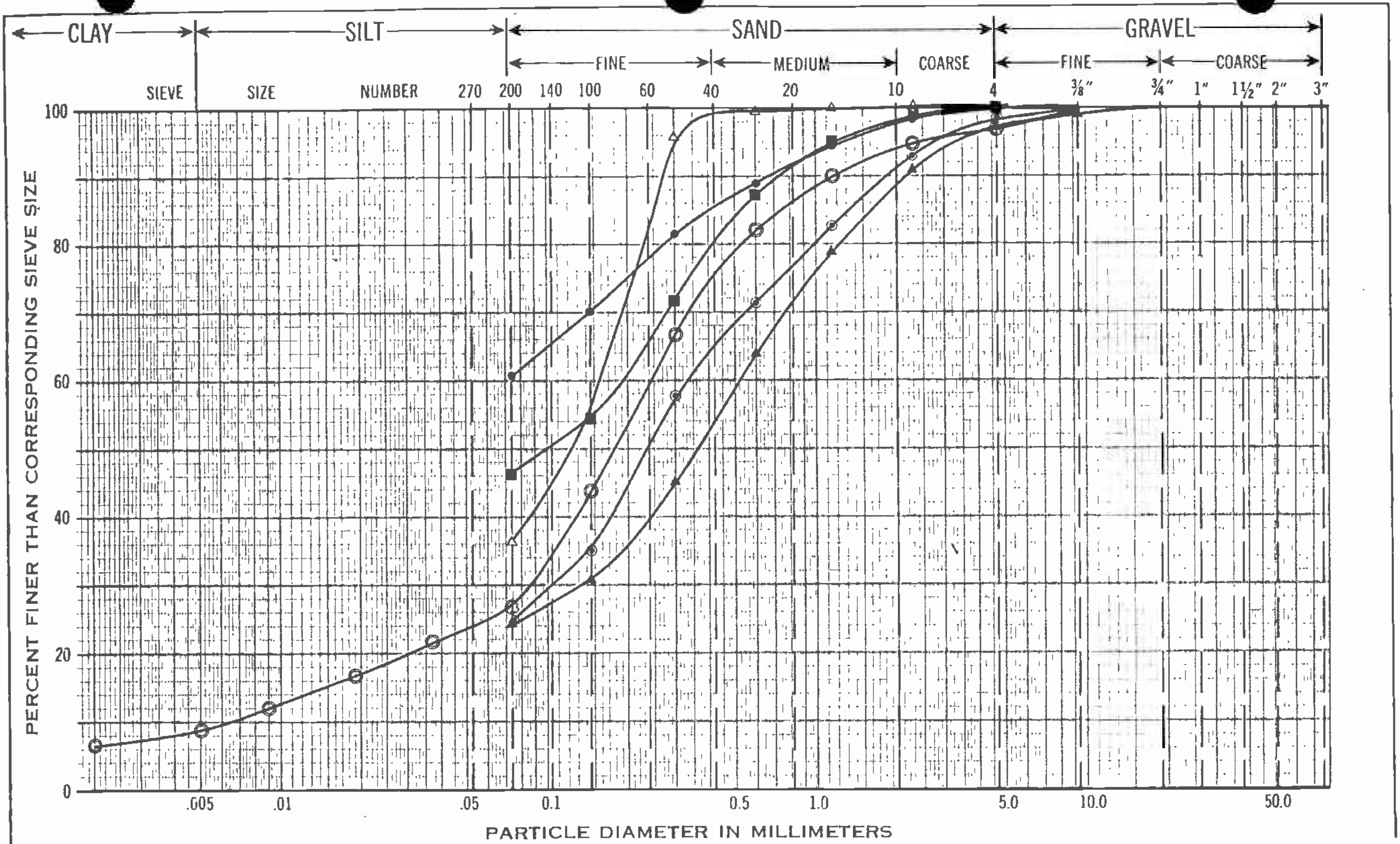
Figure No.
E-20

FORM NO. D-3 Approved for publication ____________ by ____________



SYMBOL	BORING	SAMPLE	DEPTH,ft.
●	26-D	PB-1	5.0-7.5
◉	26-D	PB-2	15.0-17.5
○	26-D	PB-3	25.0-27.5
■	26-D	PB-4	35.0-37.5
▲	26-D	PB-5	45.0-47.5
△	26-D	PB-6	55.0-57.5

GRAIN-SIZE DISTRIBUTION CHART

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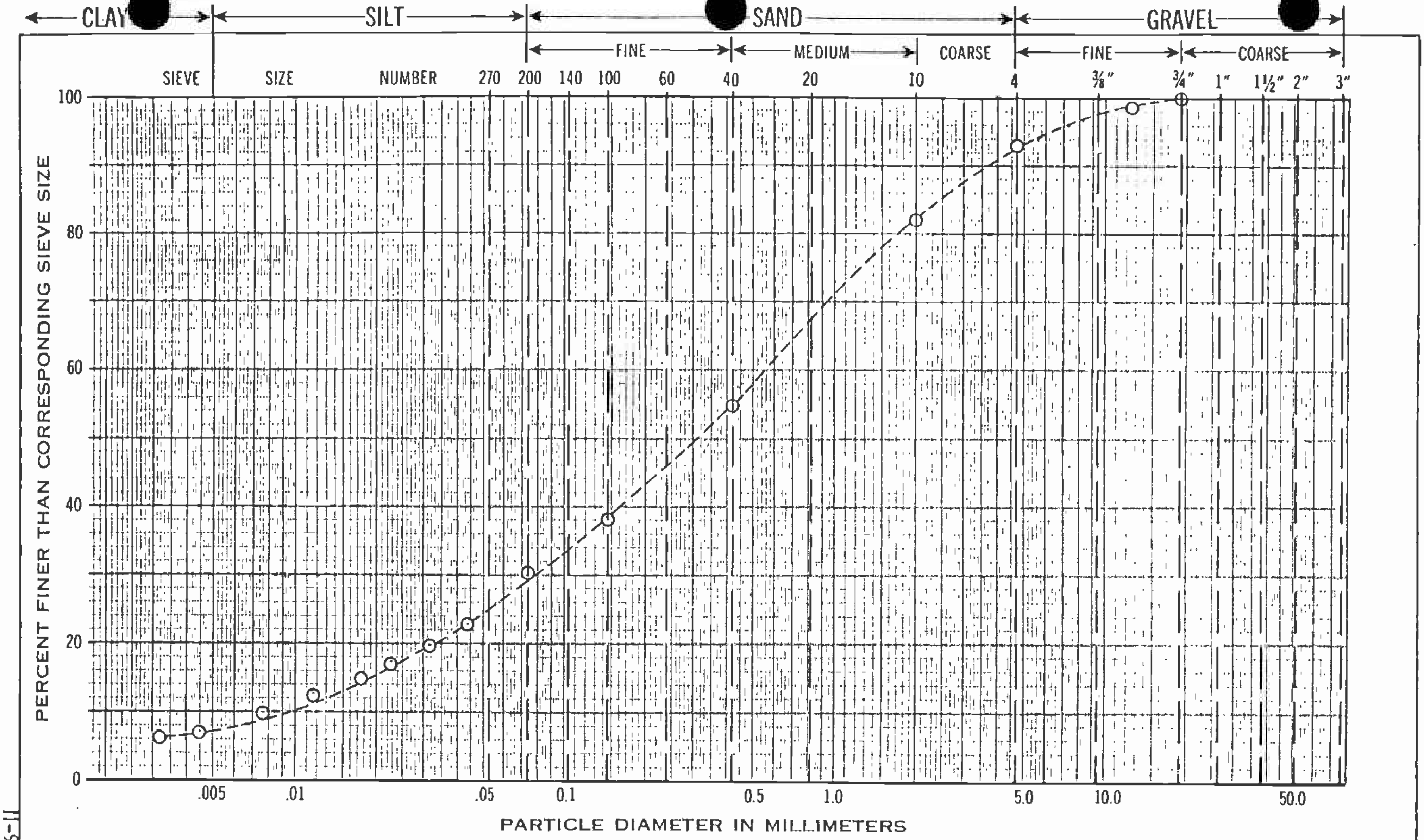
Figure No.
E-21

FORM NO. 022/[illegible] Approved for publication ____________ by ____________

GRAIN-SIZE ANALYSIS OF SOILS ASTM D[illegible]NATION: D422



11-905

SYMBOL	BORING	SAMPLE	DEPTH
---O---	23A	C-3	60'

GRAIN-SIZE DISTRIBUTION CHART

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Project No.
83-1140

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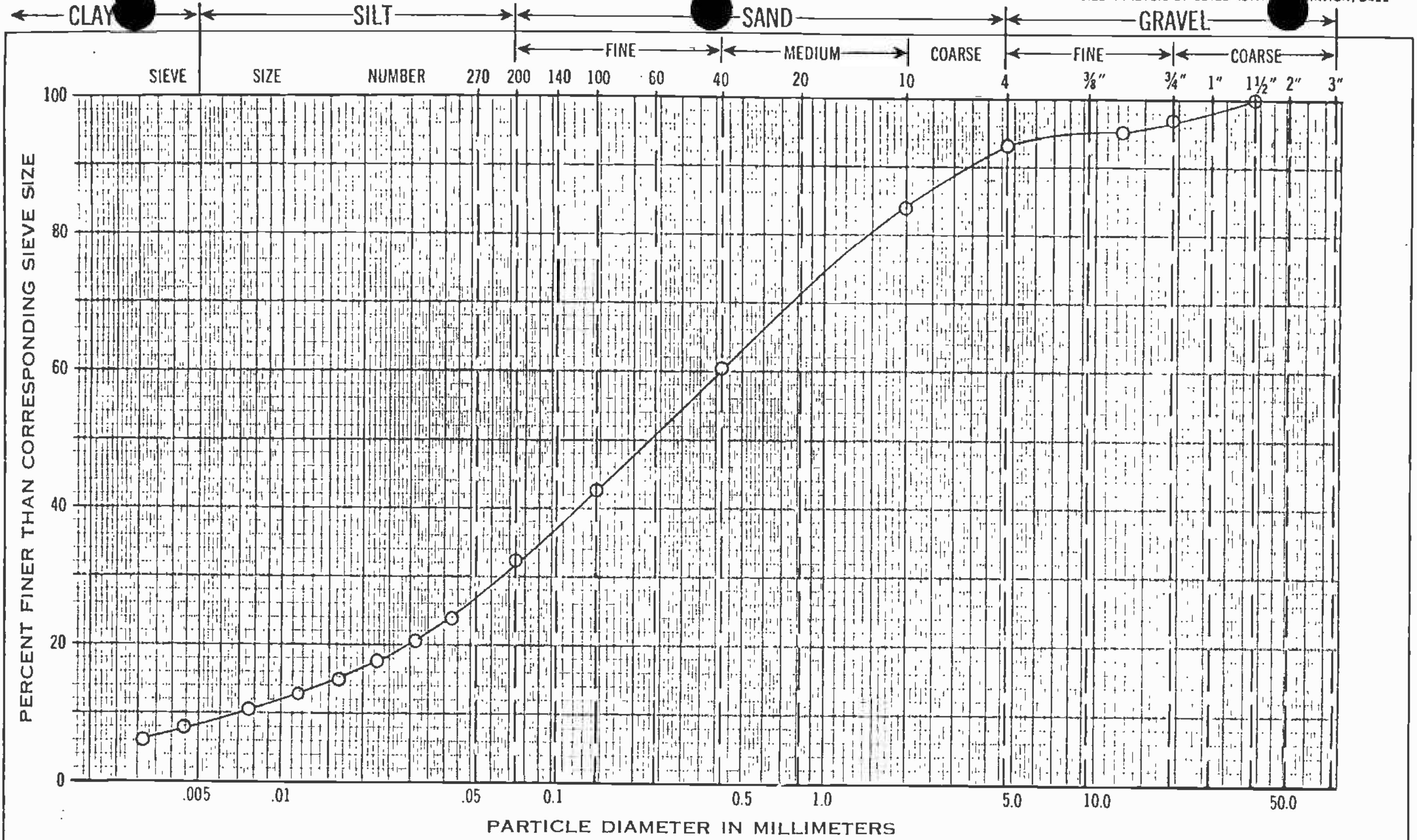
Figure No.
E-22

FORM NO. D22/7 Approved for publication ____________ by ____________

GRAIN-SIZE ANALYSIS OF SOILS ASTM NATION: D422



11-906

SYMBOL	BORING	SAMPLE	DEPTH
—○—	24	C-1	21'

GRAIN-SIZE DISTRIBUTION CHART

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Project No.
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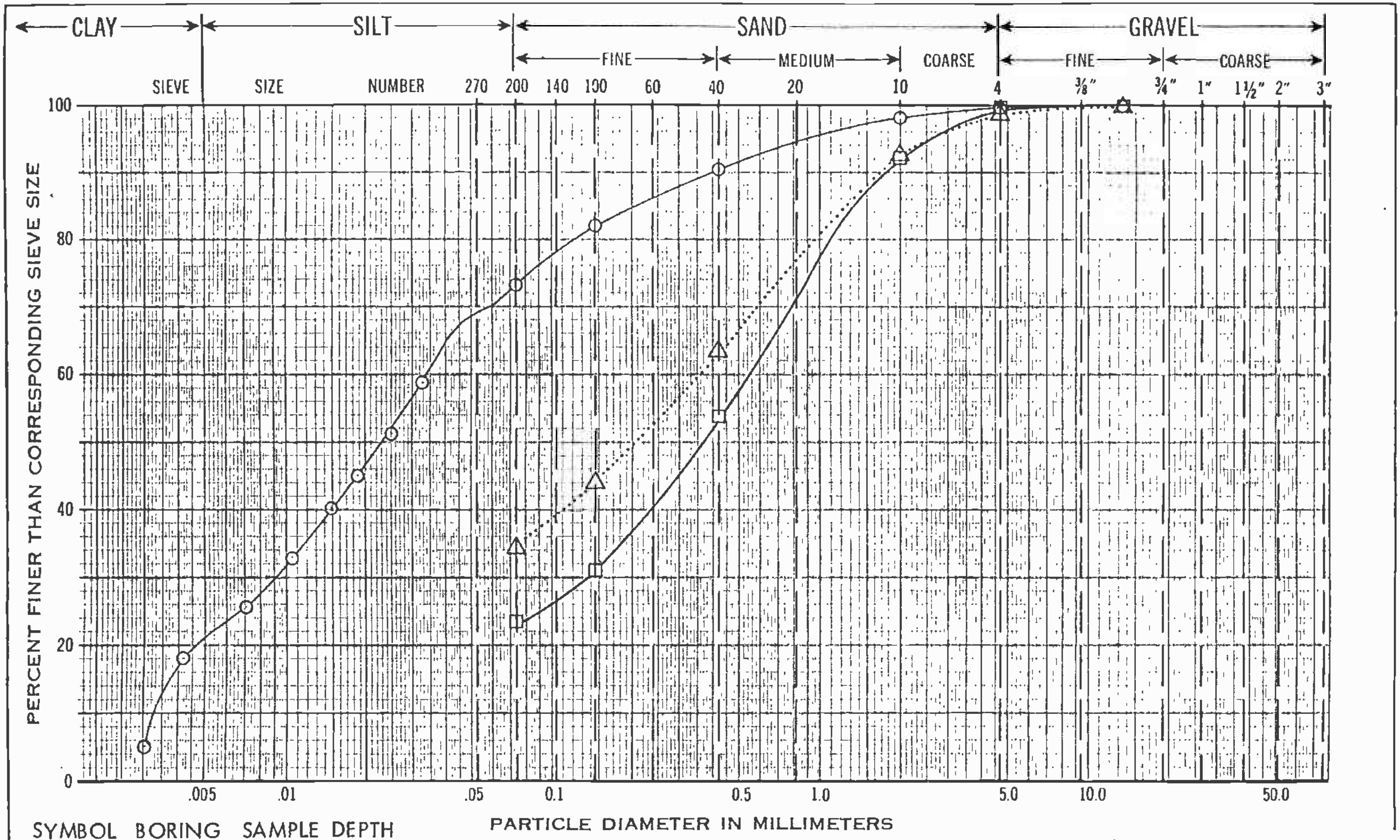
Figure No.
E-23



11-907

SYMBOL	BORING	SAMPLE	DEPTH
—○—	25	C-1	20'
—□—	25	C-2	40'
·····△·····	25	C-2	41'

GRAIN-SIZE DISTRIBUTION CHART

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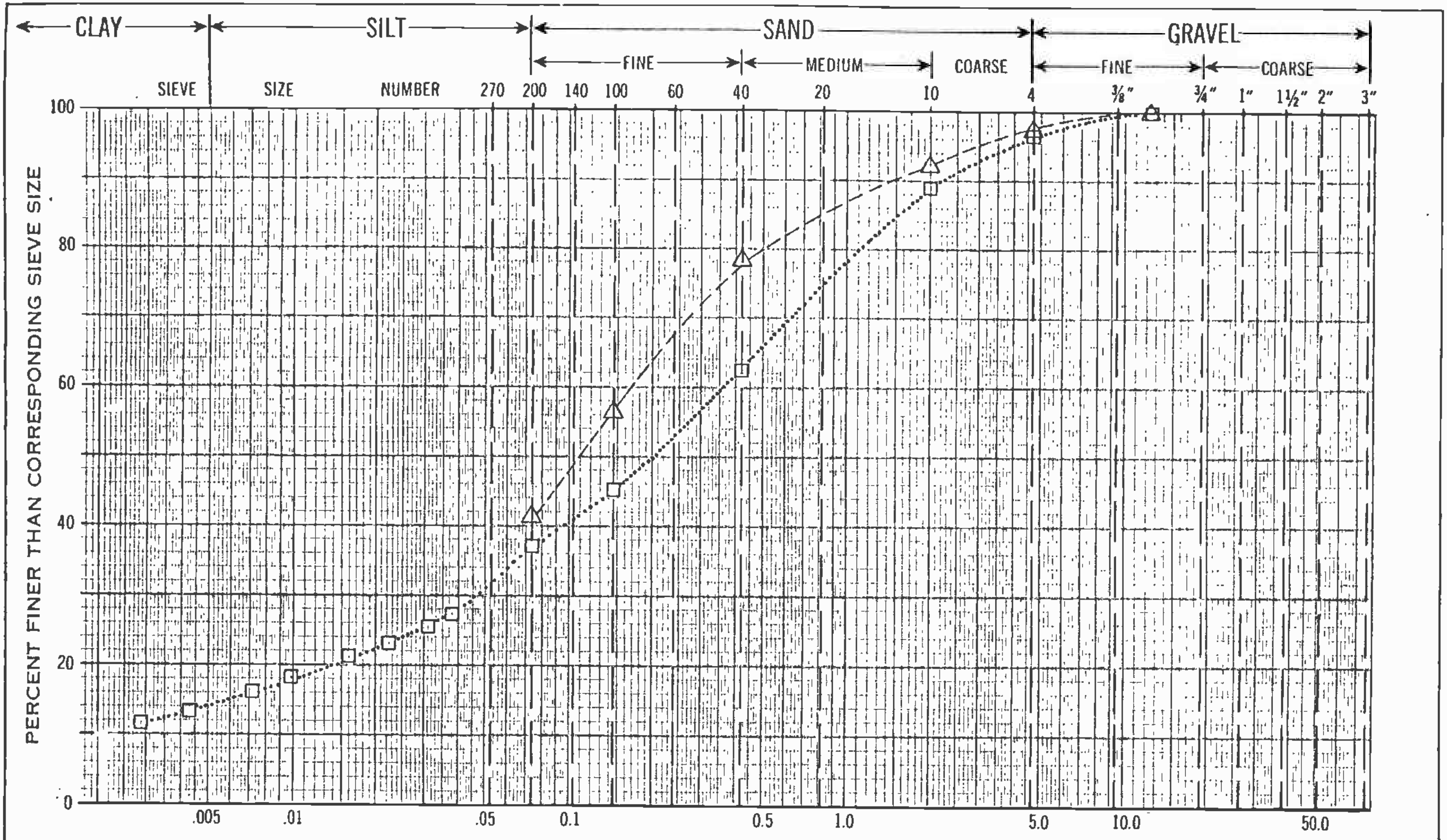
Figure No.
E-24

FORM NO. D22 Approved for publication __________ by __________

GRAIN-SIZE ANALYSIS OF SOILS AST NATION: D422



11-908

SYMBOL	BORING	SAMPLE	DEPTH
·····□·····	25	J-8	82'
---△---	25	J-11	111'

GRAIN-SIZE DISTRIBUTION CHART

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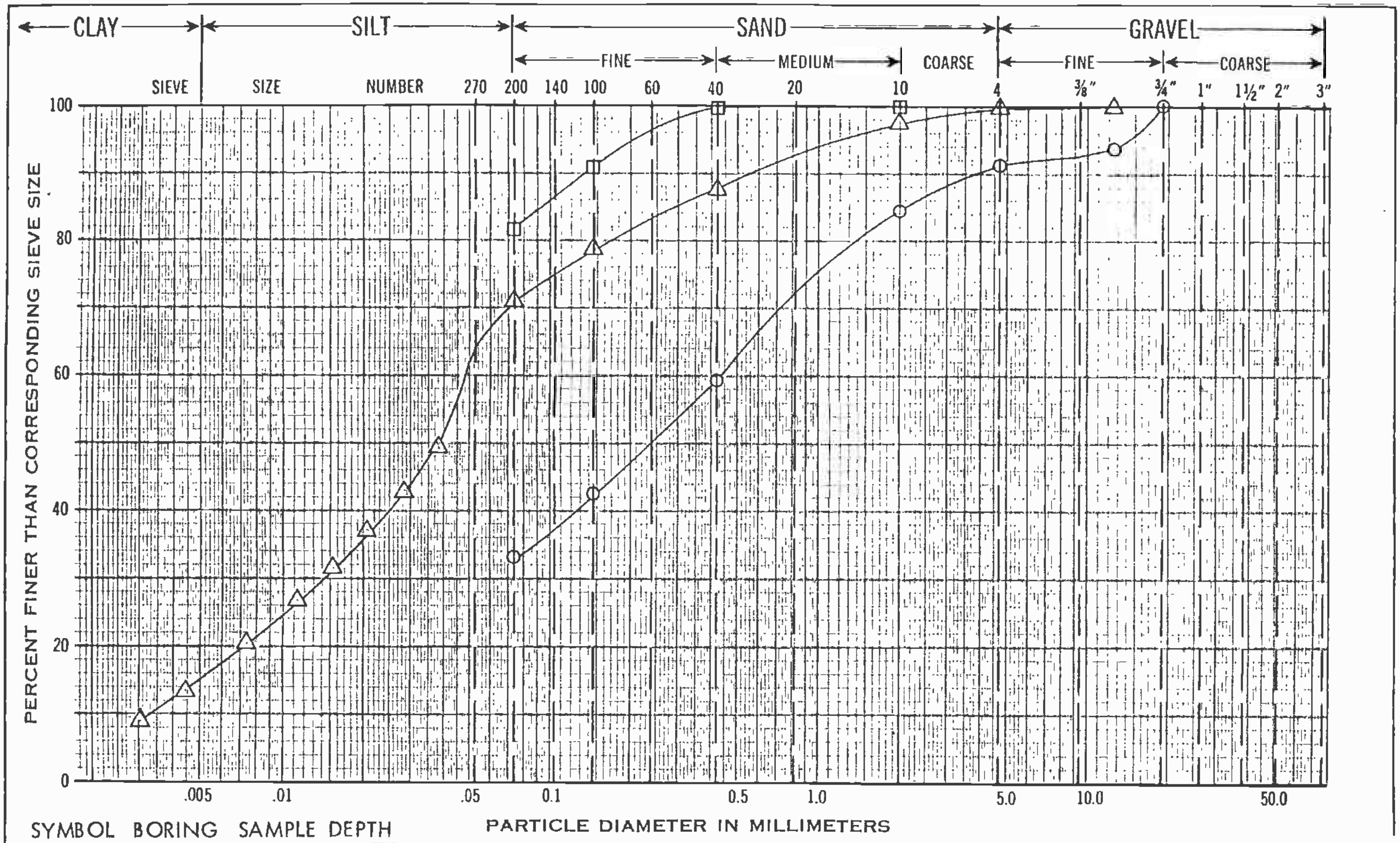
Figure No.
E-25

FORM NO. D22 Approved for publication ________ by ________

GRAIN-SIZE ANALYSIS OF SOILS ASTM NATION: D422



SYMBOL	BORING	SAMPLE	DEPTH
─○─	26	J-2	21'
─□─	26	J-7	91'
─△─	26	C-6	119'

GRAIN-SIZE DISTRIBUTION CHART

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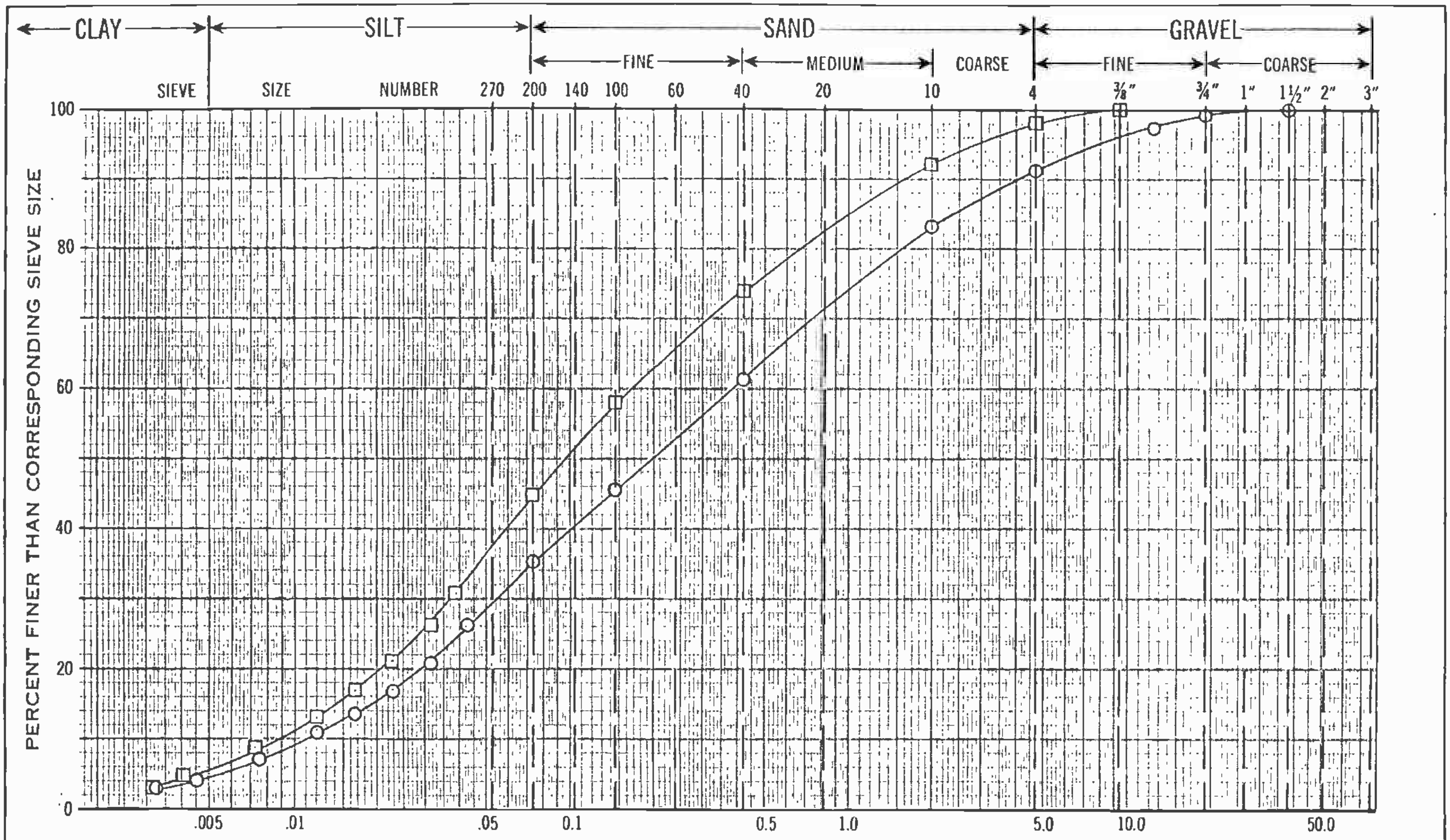
Figure No.
E-26

FORM NO. D22 Approved for publication ________ by ________

GRAIN-SIZE ANALYSIS OF SOILS ASTM NATION: D422



SYMBOL	BORING	SAMPLE	DEPTH
—○—	26	S-1	139'
—□—	26	J-12	140'

GRAIN-SIZE DISTRIBUTION CHART

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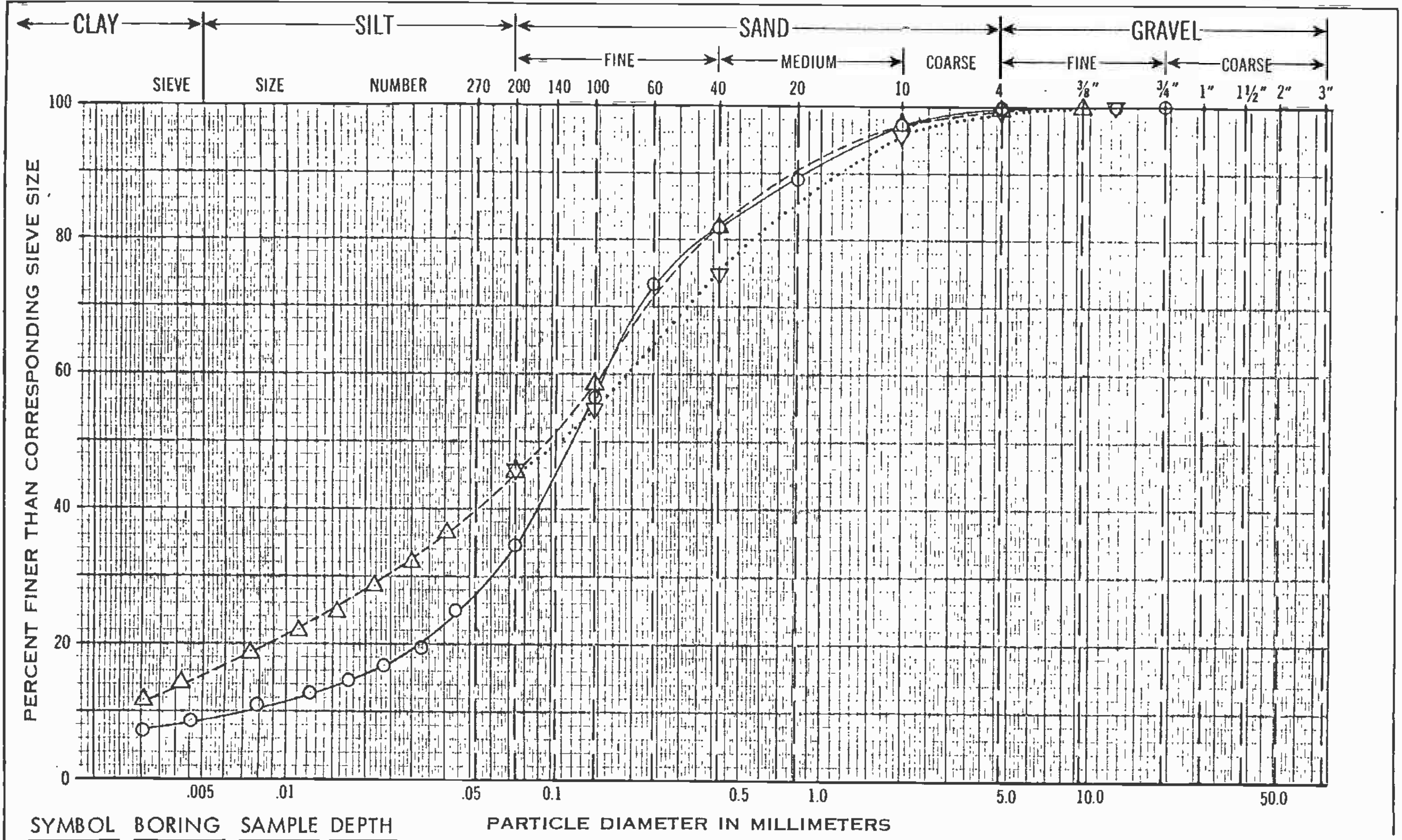
Figure No.
E-27

11-910

FORM NO. D22/ Approved for publication ________ by ________

GRAIN-SIZE ANALYSIS OF SOILS AST GNATION: D422



SYMBOL	BORING	SAMPLE	DEPTH
—○—	27	S-1	22'
- - △ - -	27	S-4	80'
·····▽······	27	J-9	91'

GRAIN-SIZE DISTRIBUTION CHART

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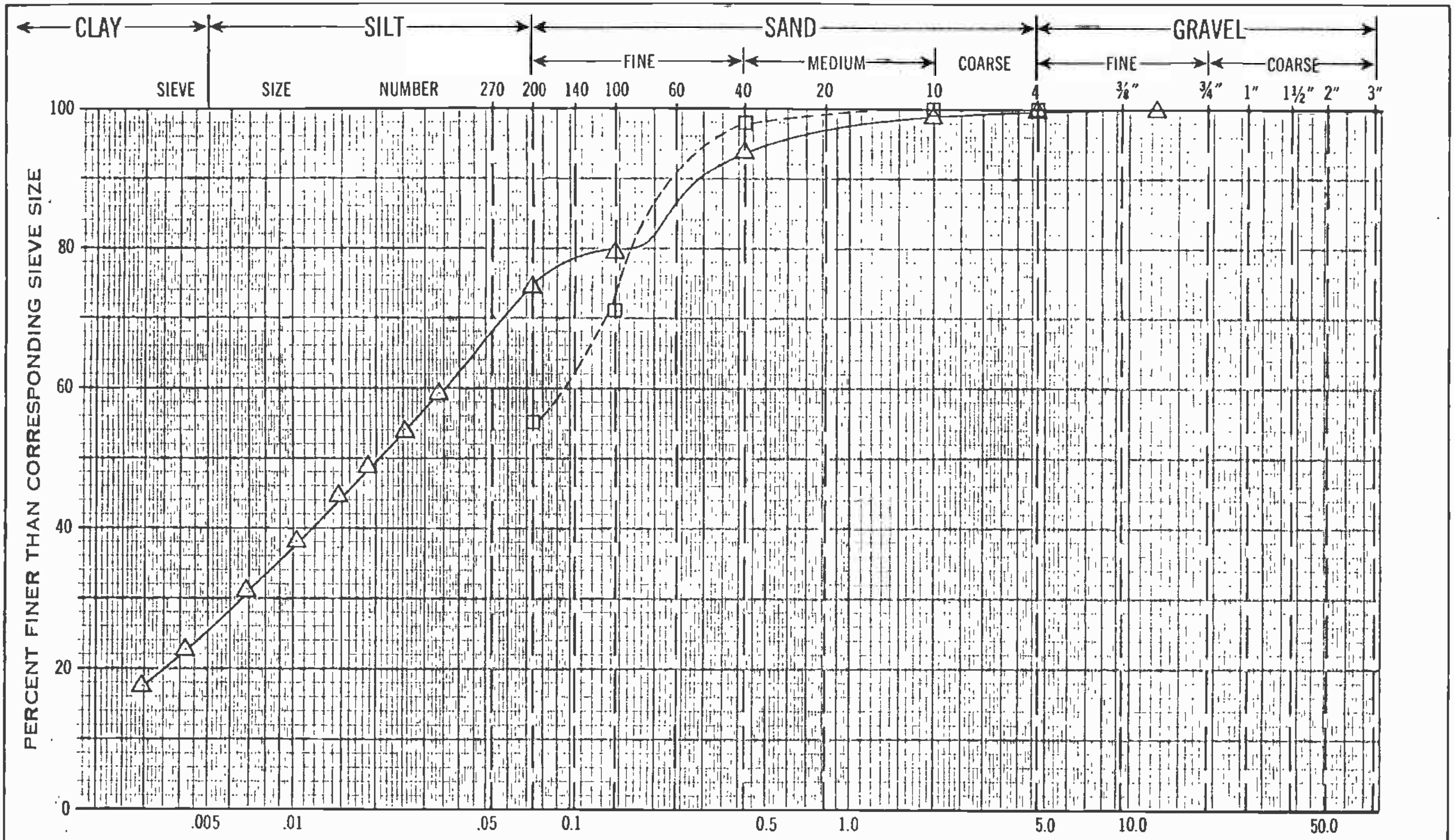
Figure No.
E-28

FORM NO. D22 Approved for publication ________ by ________

GRAIN-SIZE ANALYSIS OF SOILS ASTM NATION: D422



PARTICLE DIAMETER IN MILLIMETERS

SYMBOL	BORING	SAMPLE	DEPTH
---□---	27	J-15	150'
—△—	27	S-6	165'

GRAIN-SIZE DISTRIBUTION CHART

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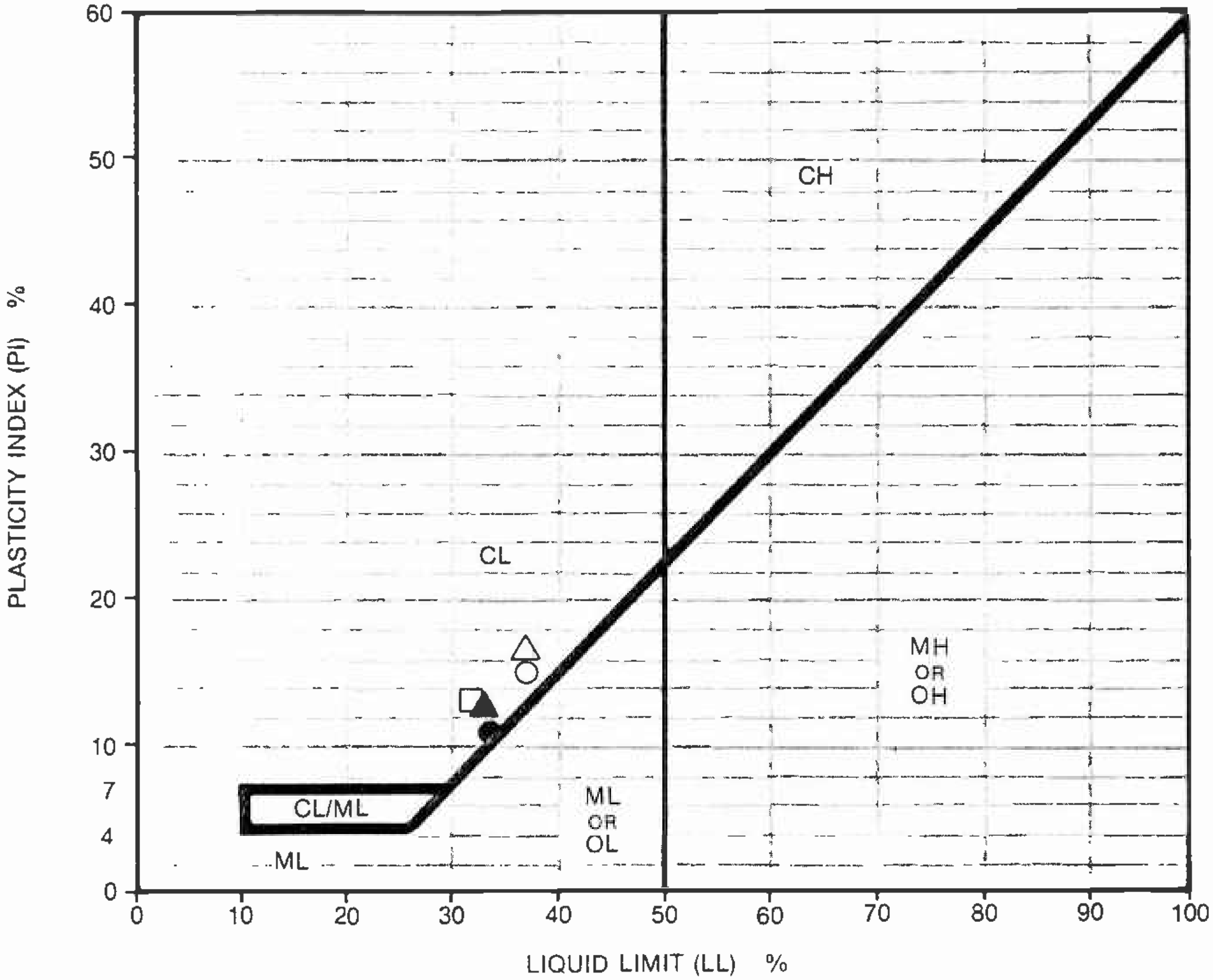
Figure No.
E-29

11-912



Symbol	Classification and Source	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% Passing 200 Seive
○	BH 24-3, 72.5'-73.0' (CL)	36.9	21.6	15.3	71.2
●	BH 24-3, 75.5'-78.2' (CL/ML)	34.5	23.4	11.1	34.8
□	BH 24-5, 74.5'-78.2' (CL)	32.5	19.5	13.0	29.2
△	BH 26-3, 32.0'-34.5' (CL)	38.0	21.5	16.5	63.6
▲	BH 26-5, 43.0'-45.5' (CL)	33.3	20.5	12.8	52.9

PLASTICITY CHART

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METRO RAIL PROJECT

Project No.
83-1140

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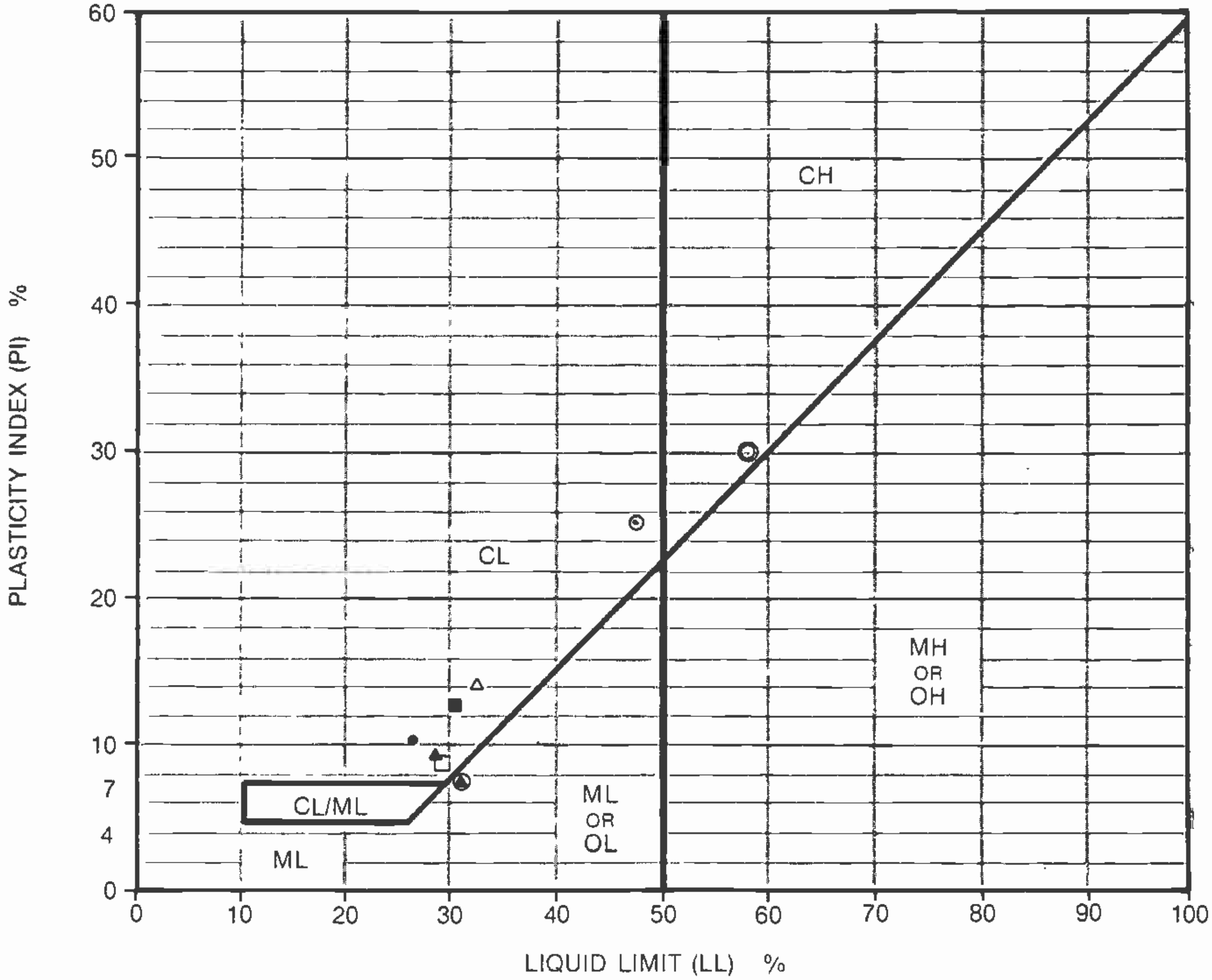
Figure No.
E-30

Approved for publication ____ by ____



Symbol	Classification and Source	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% Passing 200 Seive
●	23-C, PB-2, 15.0-16.8 ft., SC	26.9	16.5	10.4	40.9
⊙	23-C, PB-3, 25.0-27.5 ft., CL	47.8	22.0	25.8	57.9
○	23-C, PB-5, 45.0-47.5 ft., CH	57.6	27.5	30.1	53.4
◬	23-C, PB-6, 55.0-57.5 ft., SC	31.7	23.9	7.8	24.5
▲	23-D, PB-4, 35.0-37.5 ft., SC/CL	28.7	18.9	9.8	46.5
△	23-D, PB-7, 65.0-67.5 ft., SC/CL	32.4	18.1	14.3	51.8
■	23-D, PB-8, 73.5-76.0 ft., SC/CL	30.3	17.3	13.0	47.2
□	24-B, PB-9, 85.0-87.5 ft., SC/CL	29.0	20.9	8.1	52.5

PLASTICITY CHART

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METRO RAIL PROJECT

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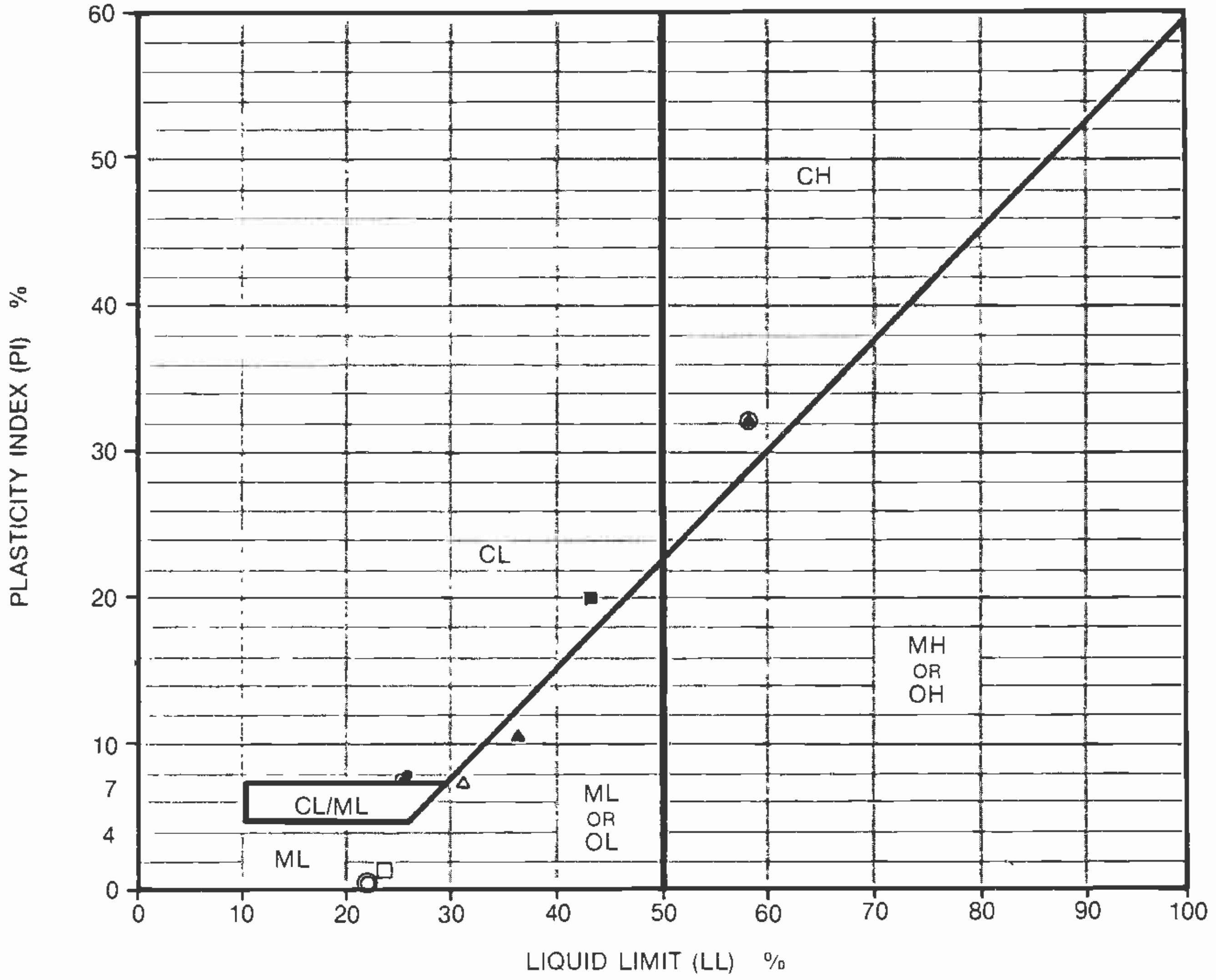
83-1140

Converse Consultants Geotechnical Engineering and Applied Sciences

Figure No.
E-31

Approved for publication ______ by ______



Symbol	Classification and Source	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% Passing 200 Seive
•	24-B, PB-10, 95.0-97.5 ft., SC	26.8	19.2	7.6	37.1
⊙	25-C, PB-4, 35.0-37.5 ft., SM/SC	26.5	19.4	7.1	34.8
○	25-C, PB-5, 45.0-47.5 ft., SC/SM	22.0	21.8	0.20	23.2
◉	26-C, PB-2, 20.0-21.5 ft., CH	58.2	26.1	32.1	62.2
▲	26-C, PB-4, 40.0-42.5 ft., ML/SM	36.0	25.5	10.5	50.5
△	26-C, PB-7, 70.0-72.5 ft., SC	31.6	24.7	6.9	34.2
■	26-C, PB-8, 77.5-80.0 ft., CL	43.5	23.5	20.0	69.8
□	26-D, PB-3, 25.0-27.5 ft., SM	23.5	22.0	1.5	26.6

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PLASTICITY CHART

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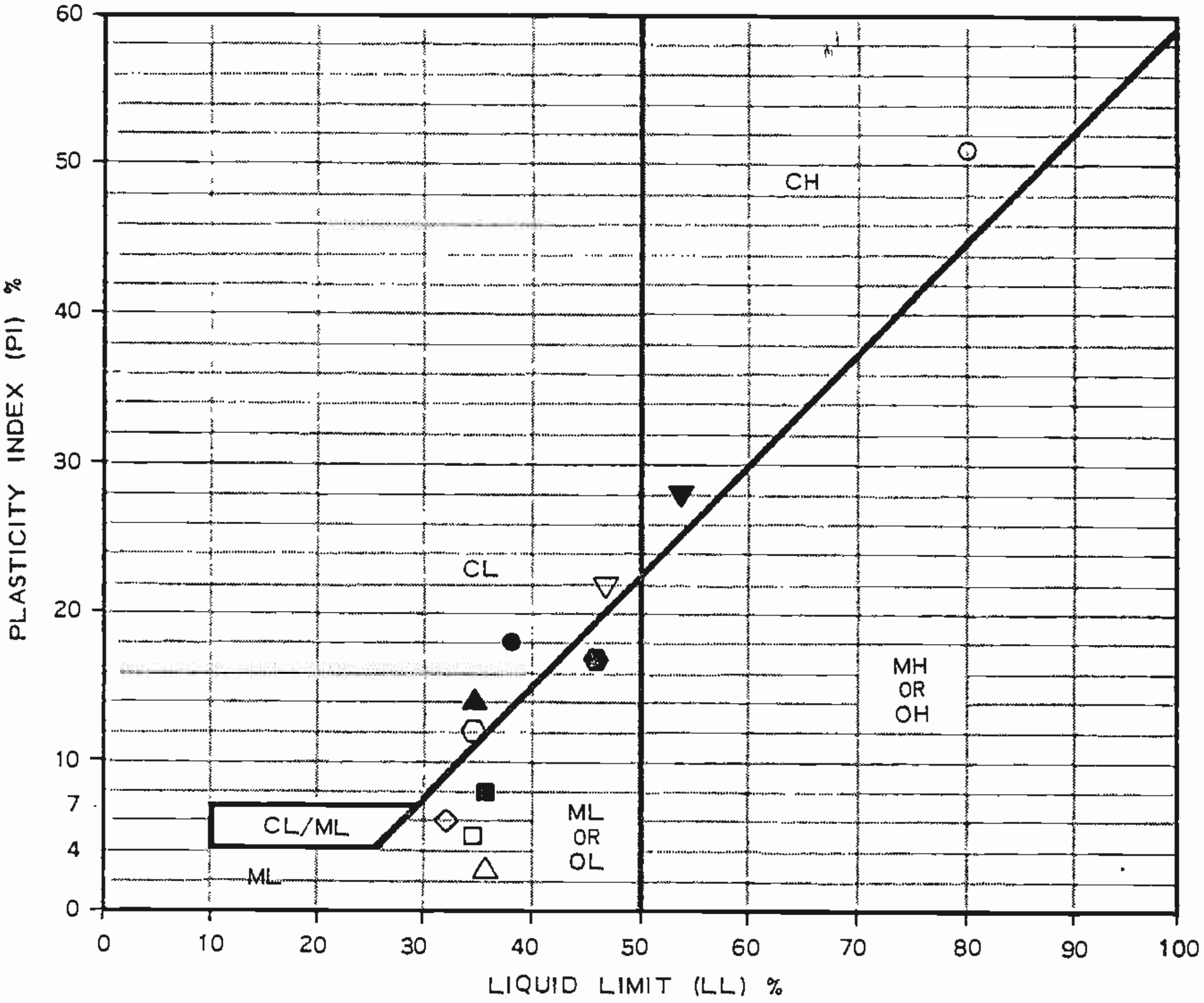
Figure No
E-32



PLASTICITY CHART

Symbol	Classification and Source	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% Passing No. 200 Seive
○	BH 22, 42' (CH)	80	29	51	60
●	BH 22, 62' (CL)	38	20	18	41
□	BH 22, 155' (ML)	35	30	5	60
■	BH 22, 170' (ML)	36	29	8	99
△	BH 22, 198' (ML)	36	33	3	99
▲	BH 23, 31' (CL)	35	21	14	-
▽	BH 23, 50' (CL)	47	25	22	-
▼	BH 23A, 40' (CH)	53	25	28	-
⬡	BH 23A, 59' (CL)	35	23	12	30
⬢	BH 23A, 99' (ML)	46	29	17	-
◇	BH 23A, 119' (ML)	32	26	6	-

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Figure No.
E-33

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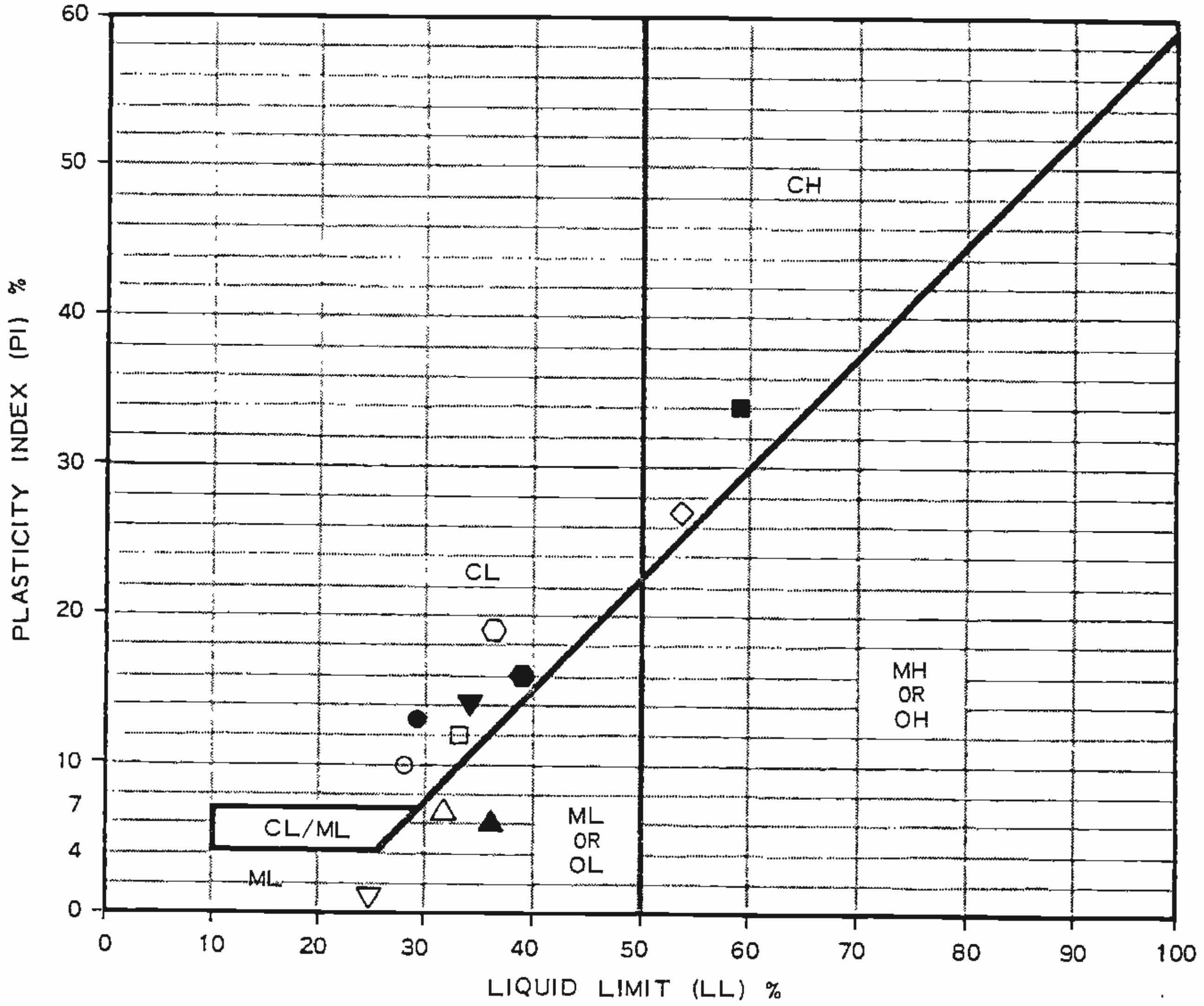

PLASTICITY CHART

Symbol	Classification and Source	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% Passing No. 200 Seive
○	BH 25, 40' (CL)	28	18	10	23
●	BH 25, 41' (CL)	29	16	13	35
□	BH 25, 111' (CL)	33	21	12	41
■	BH 26, 91' (CH)	59	25	34	82
△	BH 26, 139' (ML)	32	25	7	35
▲	BH 26, 140' (ML)	36	30	6	45
▽	BH 27, 22' (ML)	25	24	1	35
▼	BH 27, 78' (CL)	34	20	14	45
⬡	BH 27, 91' (CL)	36	17	19	46
⬢	BH 27, 100' (CL)	39	23	16	-
◇	BH 27, 150' (CH)	53	26	27	55

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Figure No.
E-34

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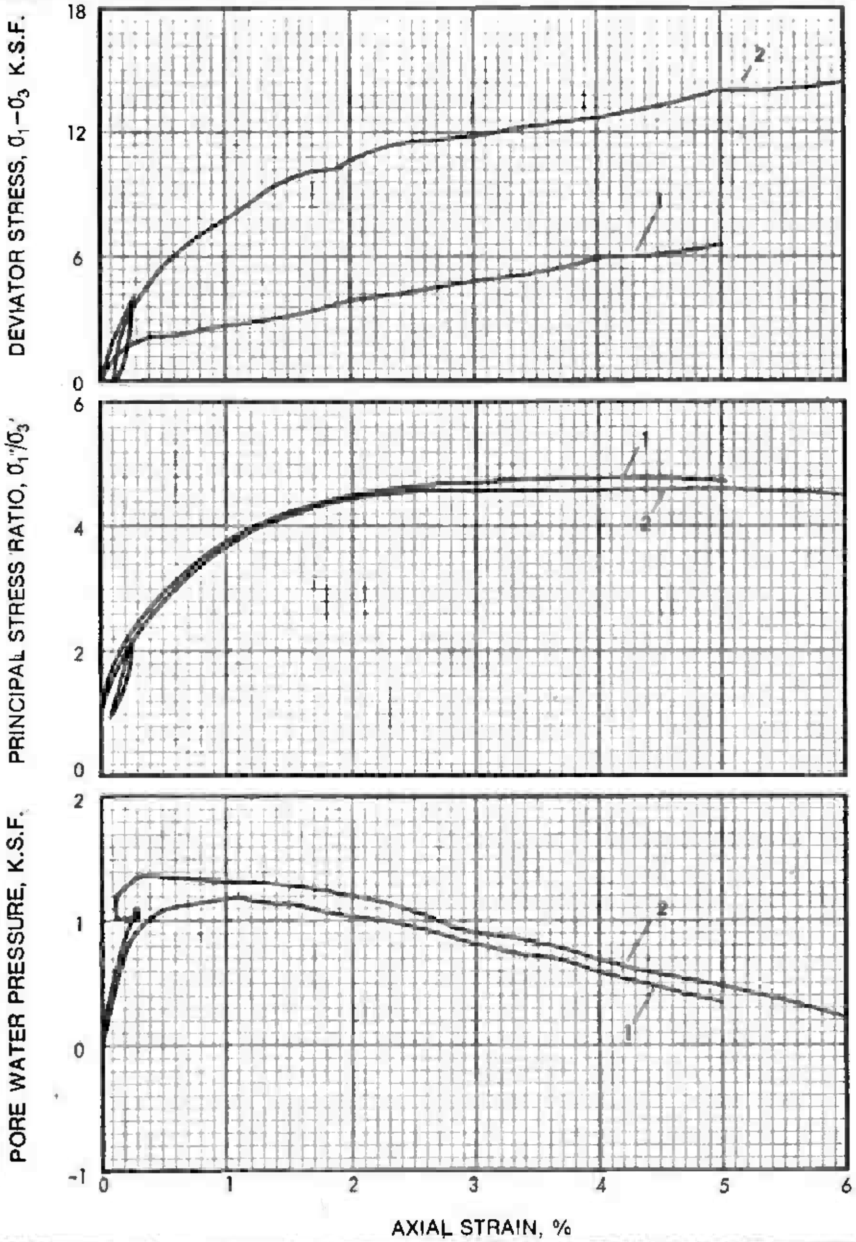

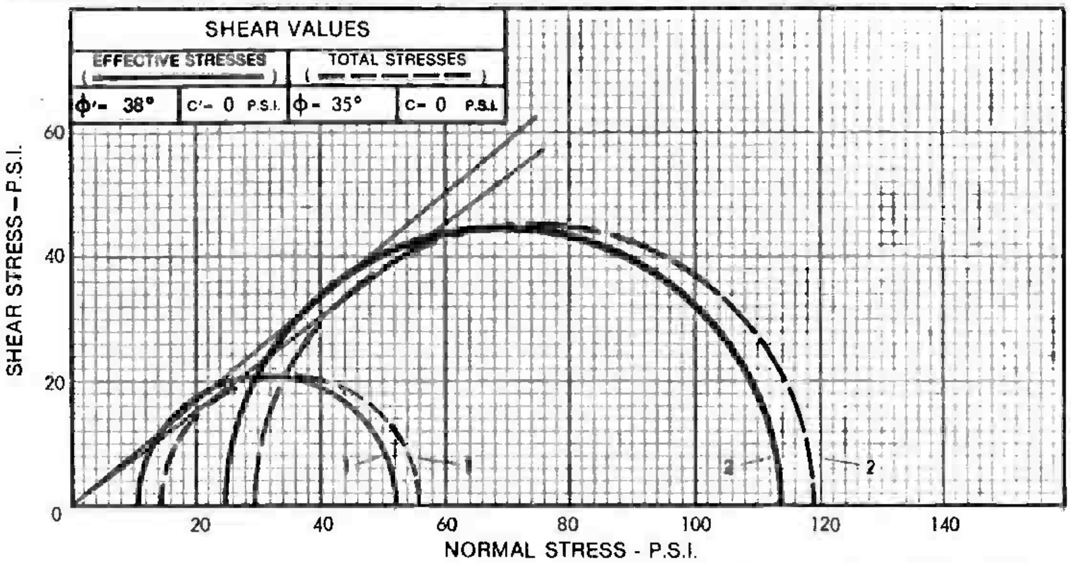

SPECIMEN NUMBER	SPECIMEN LOCATION			INITIAL SPECIMEN DATA					SAMPLE TYPE
	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	SOIL CLASSIFICATION	LENGTH (INCHES)	DIAMETER (INCHES)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (PERCENT)	
PB-3	24-1	PB-3	25.5-27.8	SM/SP	5.992	2.88	116.2	-	Stage 1
PB-3	24-1	PB-3	25.5-27.8	SM/SP	5.751	2.92	118.1	14.6	Stage 2
									Pitcher – Undisturbed
				Initial	6.000	2.88	116.1	14.6	

SPECIMEN NUMBER	SYMBOL	EFFECTIVE CONSOL. PRESSURE σ_{3C} (P.S.I.)	TEST VALUES AT FAILURE (MAXIMUM σ_1'/σ_3')				TEST TYPE
			TOTAL DEVIATOR STRESS σ_1-σ_3 (P.S.I.)	PORE PRESSURE CHANGE ΔU (P.S.I.)	MINOR EFFECTIVE STRESS σ_3' (P.S.I.)	MAJOR EFFECTIVE STRESS σ_1' (P.S.I.)	
PB-3	1	15	41	4	11	52	Two- Stage ICU with Pore Pressure Measurement
PB-3	2	30	89	5	25	114	

TRIAXIAL COMPRESSION TESTS

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Figure No.
E-35

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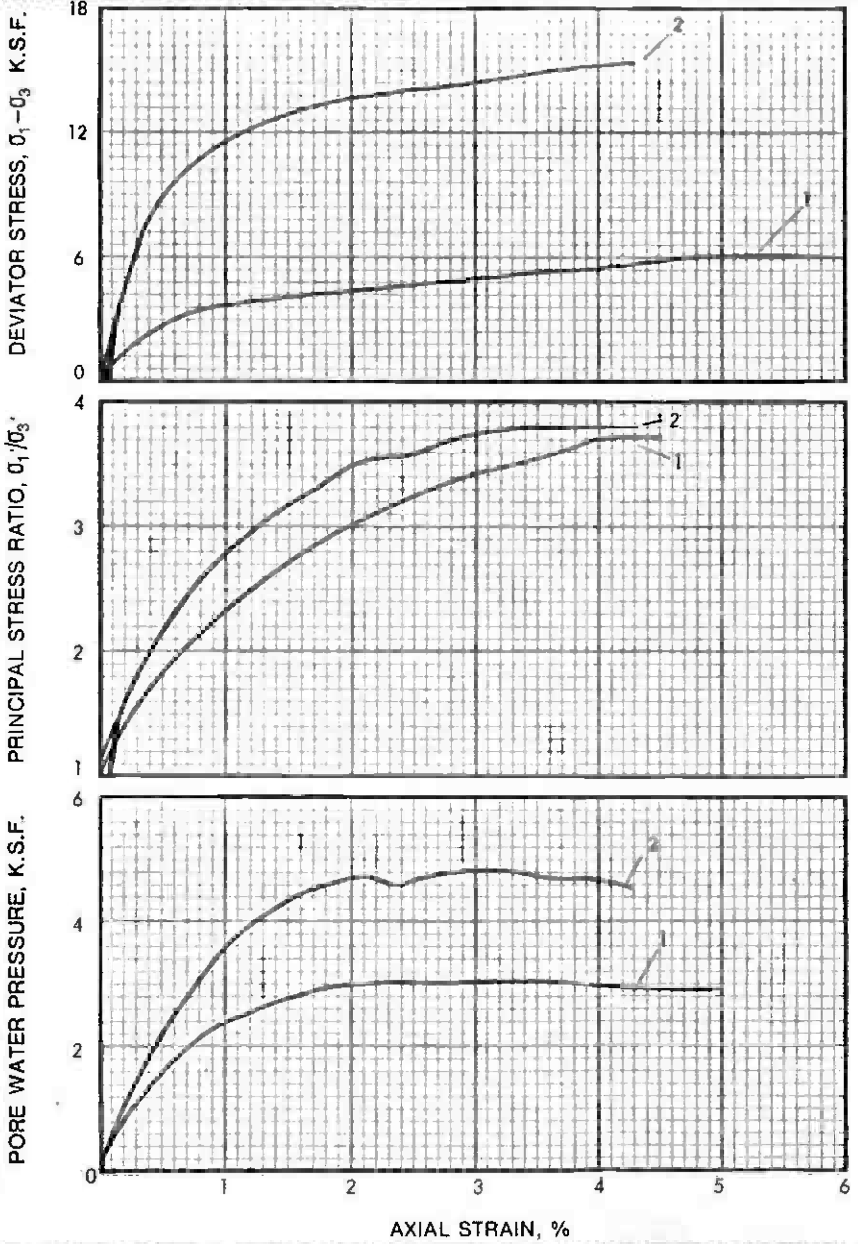

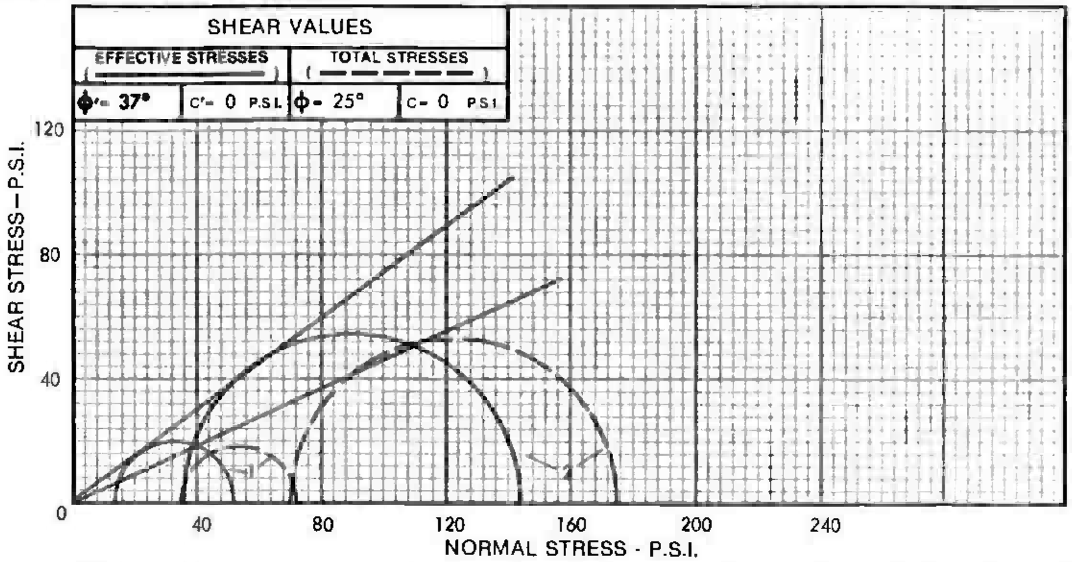

SHEAR VALUES			
EFFECTIVE STRESSES (━━━━━)		TOTAL STRESSES (━ ━ ━ ━ ━)	
ϕ'= 37°	C'= 0 P.S.I.	ϕ= 25°	C= 0 P.S.I.

SPECIMEN NUMBER	SPECIMEN LOCATION			INITIAL SPECIMEN DATA					SAMPLE TYPE
	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	SOIL CLASSIFICATION	LENGTH (INCHES)	DIAMETER (INCHES)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (PERCENT)	
PB-10	24-1	PB-10	85.5-88.0	SM	5.823	2.91	113.3	-	Stage 1
PB-10	24-1	PB-10	85.5-88.0	SM	5.647	2.94	114.7	15.9	Stage 2
									Pitcher - Undisturbed
				Initial	5.906	2.90	112.6	14.8	

SPECIMEN NUMBER	SYMBOL	EFFECTIVE CONSOL. PRESSURE σ_{3C} (P.S.I.)	TEST VALUES AT FAILURE (MAXIMUM σ_1'/σ_3')				TEST TYPE
			TOTAL DEVIATOR STRESS $\sigma_1-\sigma_3$ (P.S.I.)	PORE PRESSURE CHANGE ΔU (P.S.I.)	MINOR EFFECTIVE STRESS σ_3' (P.S.I.)	MAJOR EFFECTIVE STRESS σ_1' (P.S.I.)	
PB-10	1	35	39	19	14	53	Two- Stage ICU with Pore Pressure Measurements
PB-10	2	70	106	33	37	143	

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Figure No
E-36

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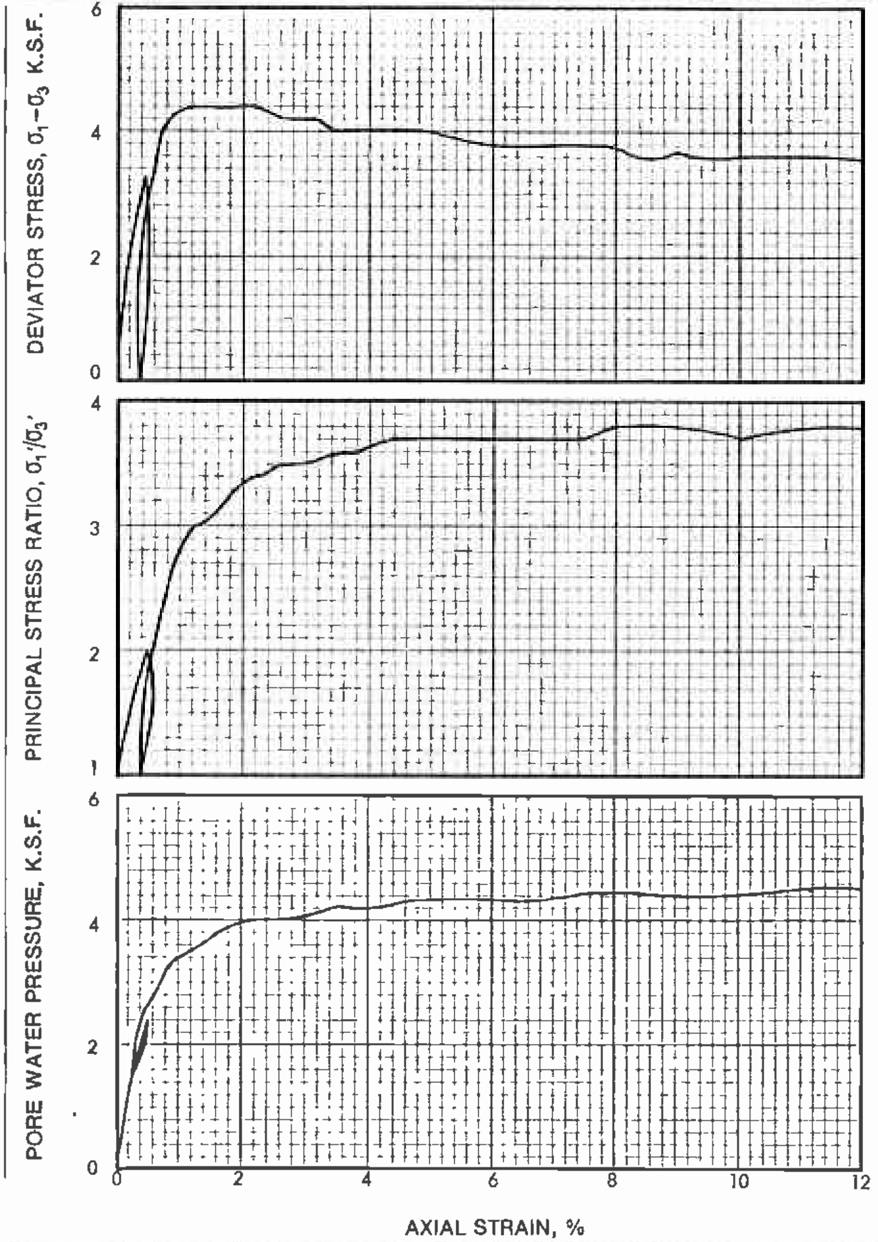

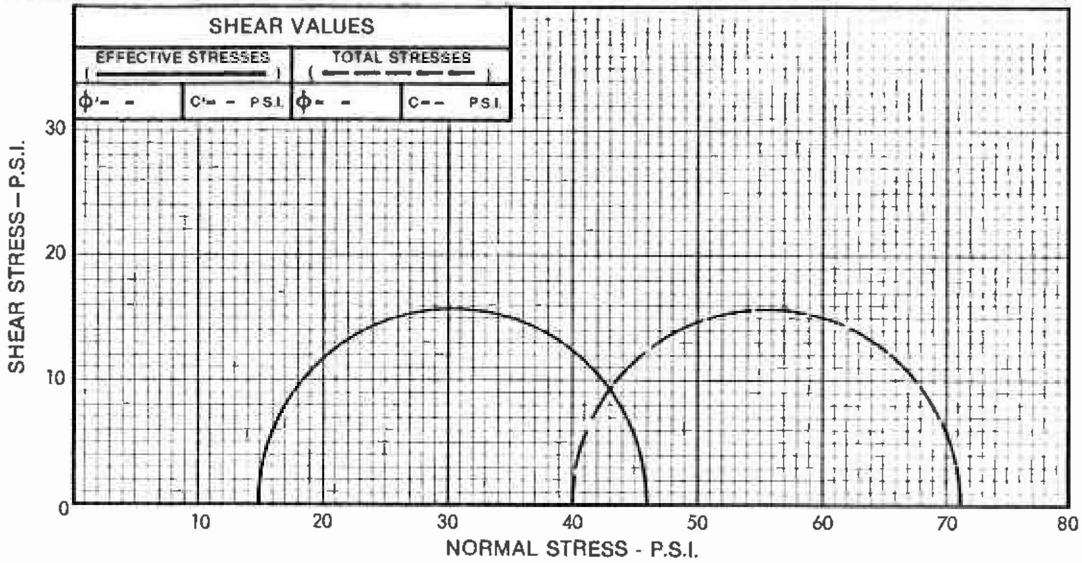

SPECIMEN NUMBER	SPECIMEN LOCATION			INITIAL SPECIMEN DATA					SAMPLE TYPE
	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	SOIL CLASSIFICATION	LENGTH (INCHES)	DIAMETER (INCHES)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (PERCENT)	
PB-4	24-2	PB-4	45.5-48.2	SC/CL	5.883	2.89	105.3	20.6	
				Initial	5.969	2.87	104.7	21.2	Pitcher - Undisturbed

SPECIMEN NUMBER	SYMBOL	EFFECTIVE CONSOL. PRESSURE σ_{3c} (P.S.I.)	TEST VALUES AT FAILURE (MAXIMUM σ_1'/σ_3')				TEST TYPE
			TOTAL DEVIATOR STRESS $\sigma_1-\sigma_3$ (P.S.I.)	PORE PRESSURE CHANGE ΔU (P.S.I.)	MINOR EFFECTIVE STRESS σ_3' (P.S.I.)	MAJOR EFFECTIVE STRESS σ_1' (P.S.I.)	
PB-4	-	40	31	25	15	46	ICU with Pore Pressure Measurements

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Figure No
E-37

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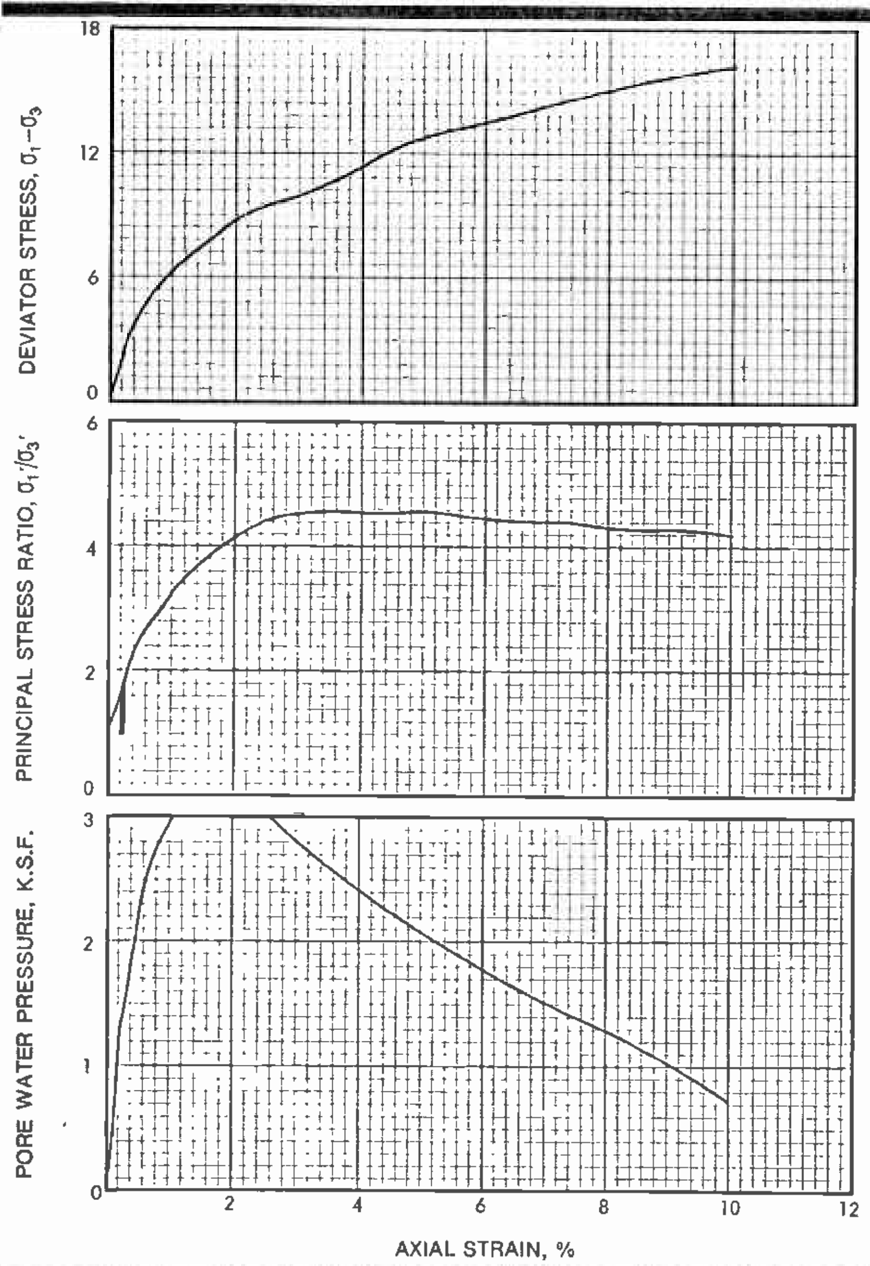

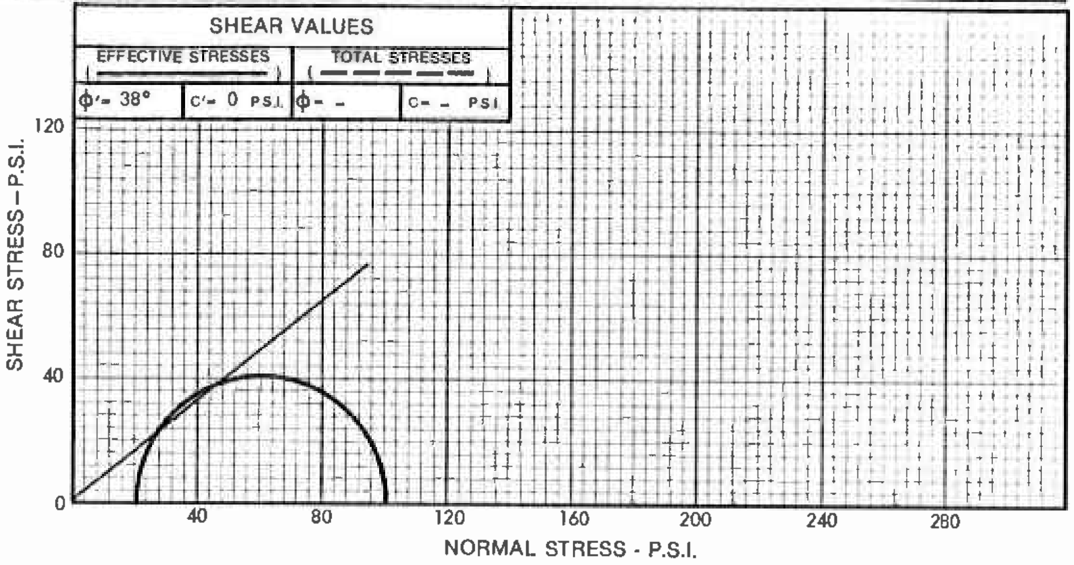

SPECIMEN NUMBER	SPECIMEN LOCATION			INITIAL SPECIMEN DATA					SAMPLE TYPE
	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	SOIL CLASSI-FICATION	LENGTH (INCHES)	DIAMETER (INCHES)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (PERCENT)	
PB-3	24-3	PB-3	45.5-48.0	SP/SM	6.170	2.87	104.2	18.1	
				Initial	6.200	2.87	104.0	17.7	Pitcher-Undisturbed

SPECIMEN NUMBER	SYMBOL	EFFECTIVE CONSOL. PRESSURE σ_{3c} (P.S.I.)	TEST VALUES AT FAILURE (MAXIMUM σ_1'/σ_3')				TEST TYPE
			TOTAL DEVIATOR STRESS σ_1-σ_3 (P.S.I.)	PORE PRESSURE CHANGE ΔU (P.S.I.)	MINOR EFFECTIVE STRESS σ_3' (P.S.I.)	MAJOR EFFECTIVE STRESS σ_1' (P.S.I.)	
PB-3	-	40	79	18	22	101	ICU with Pore Pressure Measurement

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Figure No
E-38

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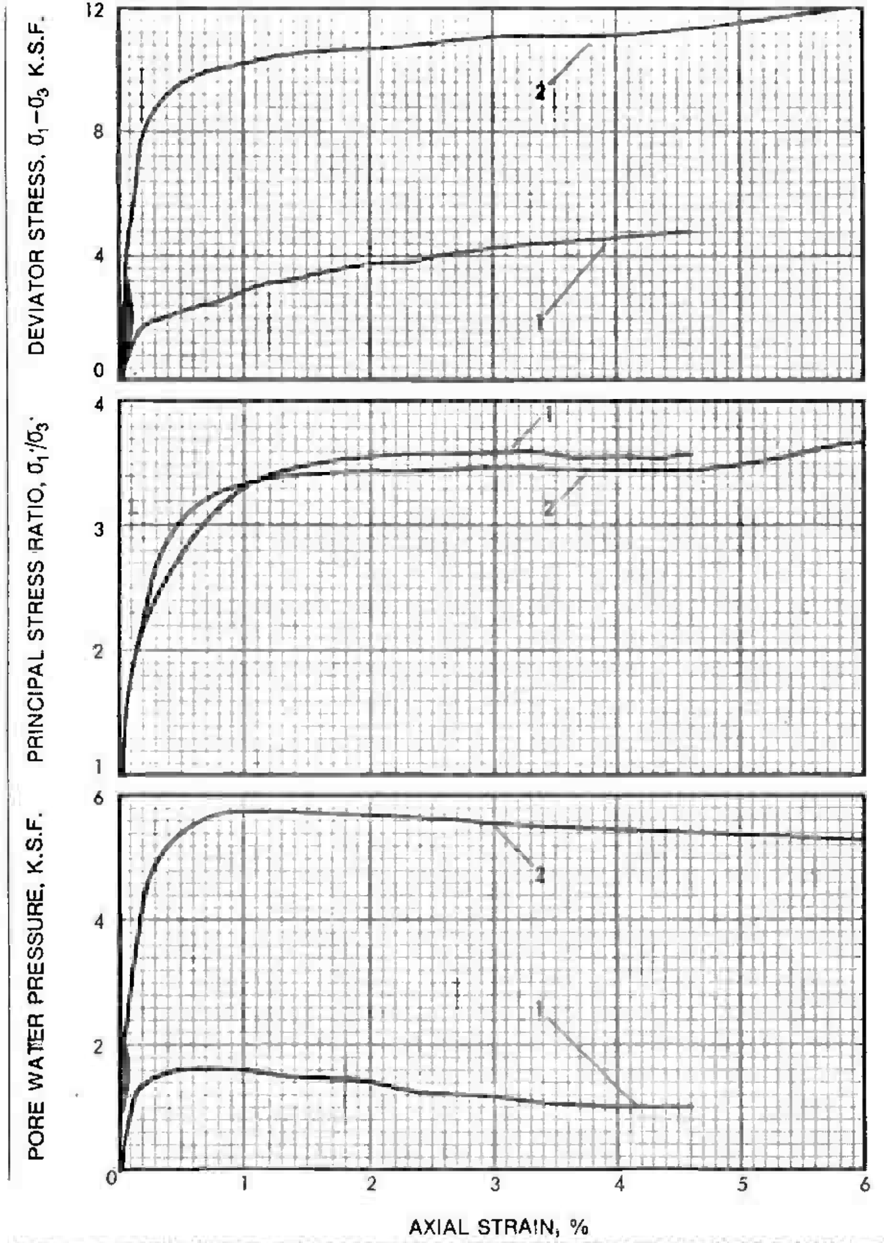

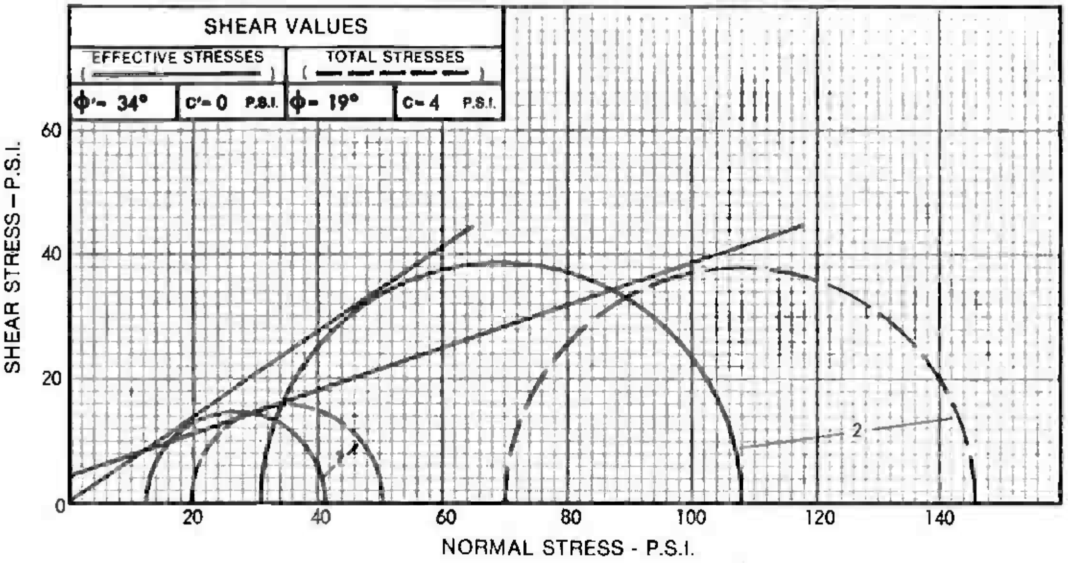

SPECIMEN NUMBER	SPECIMEN LOCATION			INITIAL SPECIMEN DATA					SAMPLE TYPE
	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	SOIL CLASSI-FICATION	LENGTH (INCHES)	DIAMETER (INCHES)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (PERCENT)	
PB-6	24-3	PB-6	75.5-78.2	SC	5.970	2.87	106.7	--	Stage 1
PB-6	24-3	PB-6	75.5-78.2	SC	5.771	2.91	108.7	18.6	Stage 2
									Pitcher -
				Initial	6.000	2.87	106.6	20.7	Undisturbed

SPECIMEN NUMBER	SYMBOL	EFFECTIVE CONSOL. PRESSURE σ_{3C} (P.S.I.)	TEST VALUES AT FAILURE (MAXIMUM σ_1'/σ_3')				TEST TYPE
			TOTAL DEVIATOR STRESS σ_1-σ_3 (P.S.I.)	PORE PRESSURE CHANGE ΔU (P.S.I.)	MINOR EFFECTIVE STRESS σ_3' (P.S.I.)	MAJOR EFFECTIVE STRESS σ_1' (P.S.I.)	
PB-6	1	20	29	8	12	41	Two - Stage ICU with Pore Pressure Measurements
PB-6	2	70	77	39	31	108	

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Figure No
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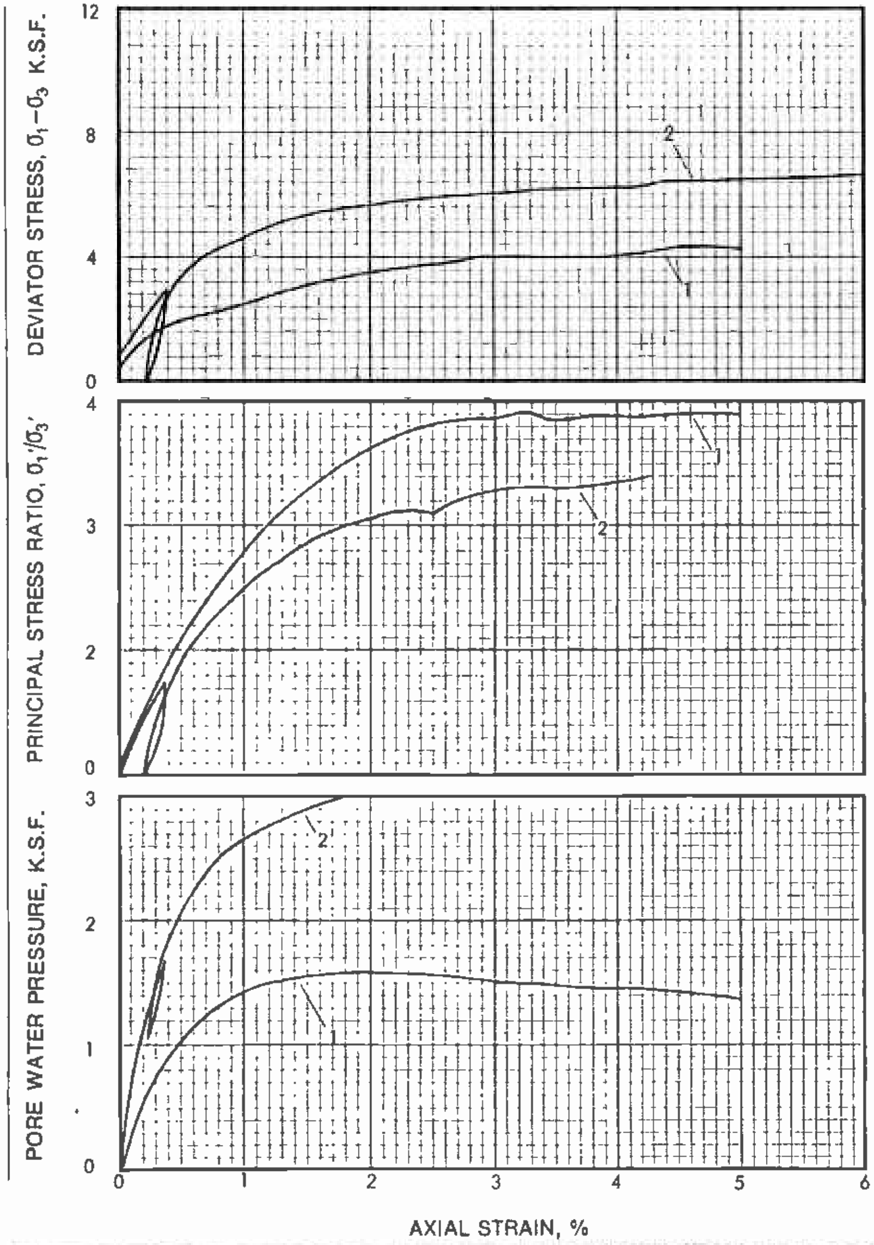

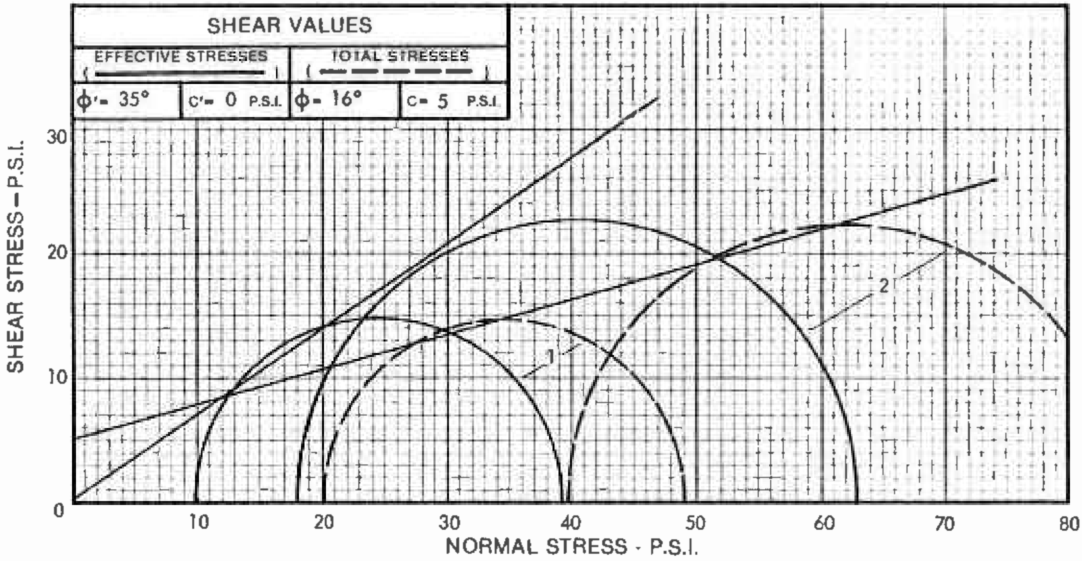

SHEAR VALUES			
EFFECTIVE STRESSES		TOTAL STRESSES	
$\phi' = 35°$	C' = 0 P.S.I.	$\phi = 16°$	C = 5 P.S.I.

SPECIMEN NUMBER	SPECIMEN LOCATION			INITIAL SPECIMEN DATA					SAMPLE TYPE
	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	SOIL CLASSI-FICATION	LENGTH (INCHES)	DIAMETER (INCHES)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (PERCENT)	
PB-4	24-4	PB-4	45.5-48.0	SC/CL	5.905	2.89	104.4	-	Stage 1
PB-4	24-4	PB-4	45.5-48.0	SC/CL	5.109	3.02	110.3	19.8	Stage 2
				Initial	6.000	2.87	103.7	21.3	Pitcher-Undisturbed

SPECIMEN NUMBER	SYMBOL	EFFECTIVE CONSOL PRESSURE σ_{3C} (P.S.I.)	TEST VALUES AT FAILURE (MAXIMUM σ_1'/σ_3')				TEST TYPE
			TOTAL DEVIATOR STRESS σ_1-σ_3 (P.S.I.)	PORE PRESSURE CHANGE ΔU (P.S.I.)	MINOR EFFECTIVE STRESS σ_3' (P.S.I.)	MAJOR EFFECTIVE STRESS σ_1' (P.S.I.)	
PB-4	1	20	29	10	10	39	Two-Stage ICU with Pore Pressure Measurements
PB-4	2	40	45	22	18	63	

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Figure No
E-40

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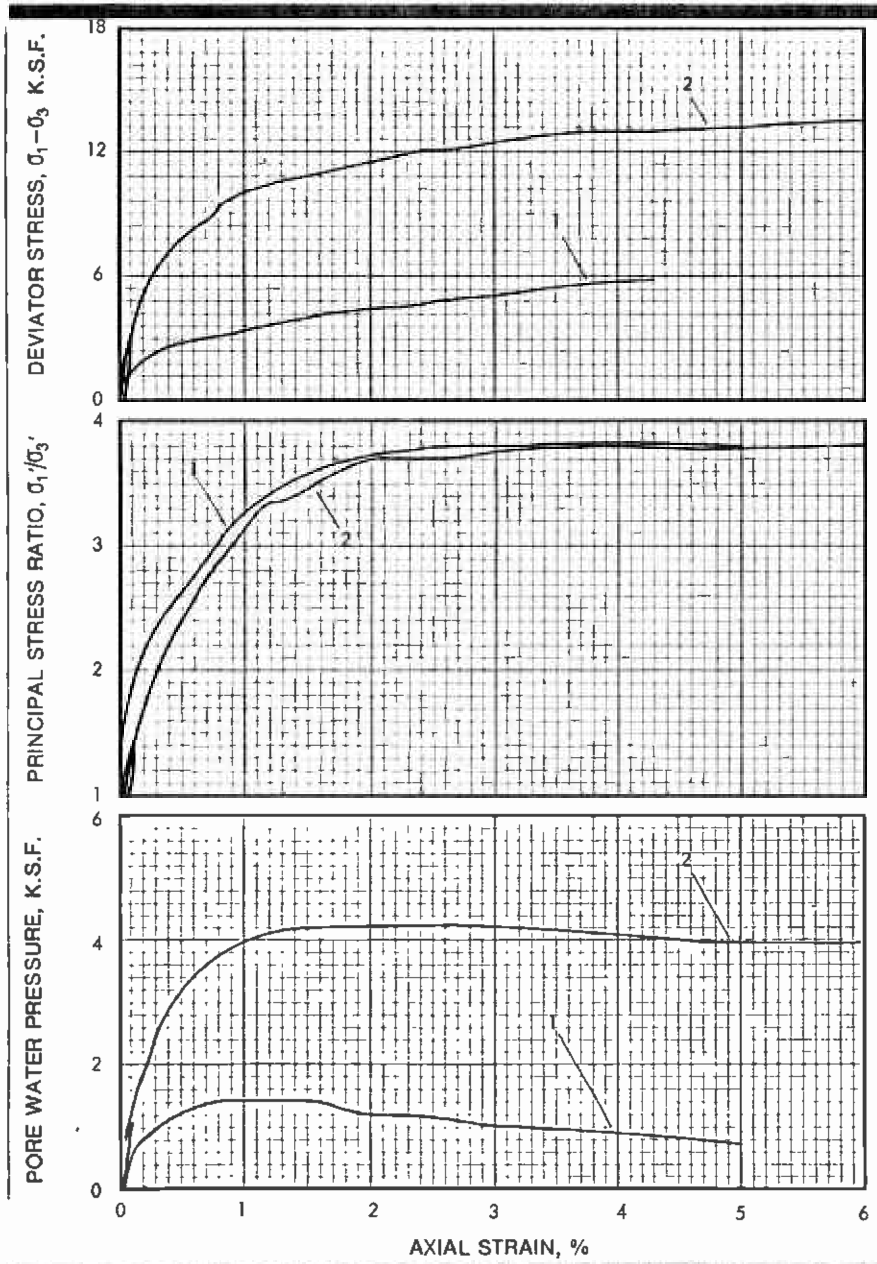

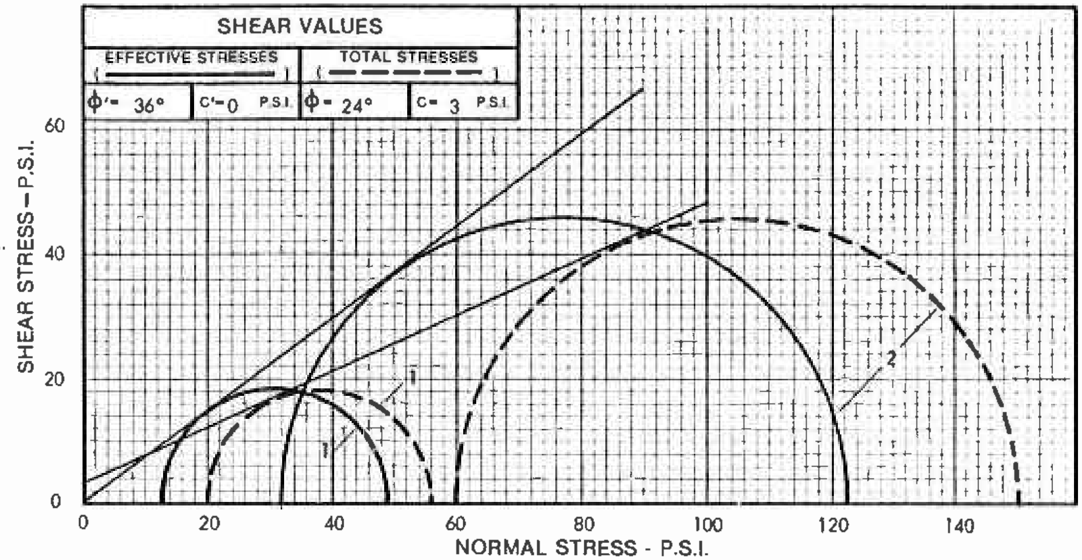

SHEAR VALUES

EFFECTIVE STRESSES (———)		TOTAL STRESSES (— — —)	
$\phi' = 36°$	$c' = 0$ P.S.I.	$\phi = 24°$	$c = 3$ P.S.I.

SPECIMEN NUMBER	SPECIMEN LOCATION			INITIAL SPECIMEN DATA					SAMPLE TYPE
	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	SOIL CLASSIFICATION	LENGTH (INCHES)	DIAMETER (INCHES)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (PERCENT)	
PB-6	24-4	PB-6	65.5-68.0	SM	6.195	2.88	114.0	–	Stage 1
PB-6	24-4	PB-6	65.5-68.0	SM	5.928	2.92	116.0	15.1	Stage 2
									Pitcher-Undisturbed
				Initial	6.250	2.87	113.6	14.0	

SPECIMEN NUMBER	SYMBOL	EFFECTIVE CONSOL. PRESSURE σ_{3c} (P.S.I.)	TEST VALUES AT FAILURE (MAXIMUM σ_1'/σ_3')				TEST TYPE
			TOTAL DEVIATOR STRESS $\sigma_1-\sigma_3$ (P.S.I.)	PORE PRESSURE CHANGE ΔU (P.S.I.)	MINOR EFFECTIVE STRESS σ_3' (P.S.I.)	MAJOR EFFECTIVE STRESS σ_1' (P.S.I.)	
PB-6	1	20	36	7	13	49	Two-Stage ICU with Pore Pressure Measurement
PB-6	2	60	91	28	32	123	

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Figure No
E-41

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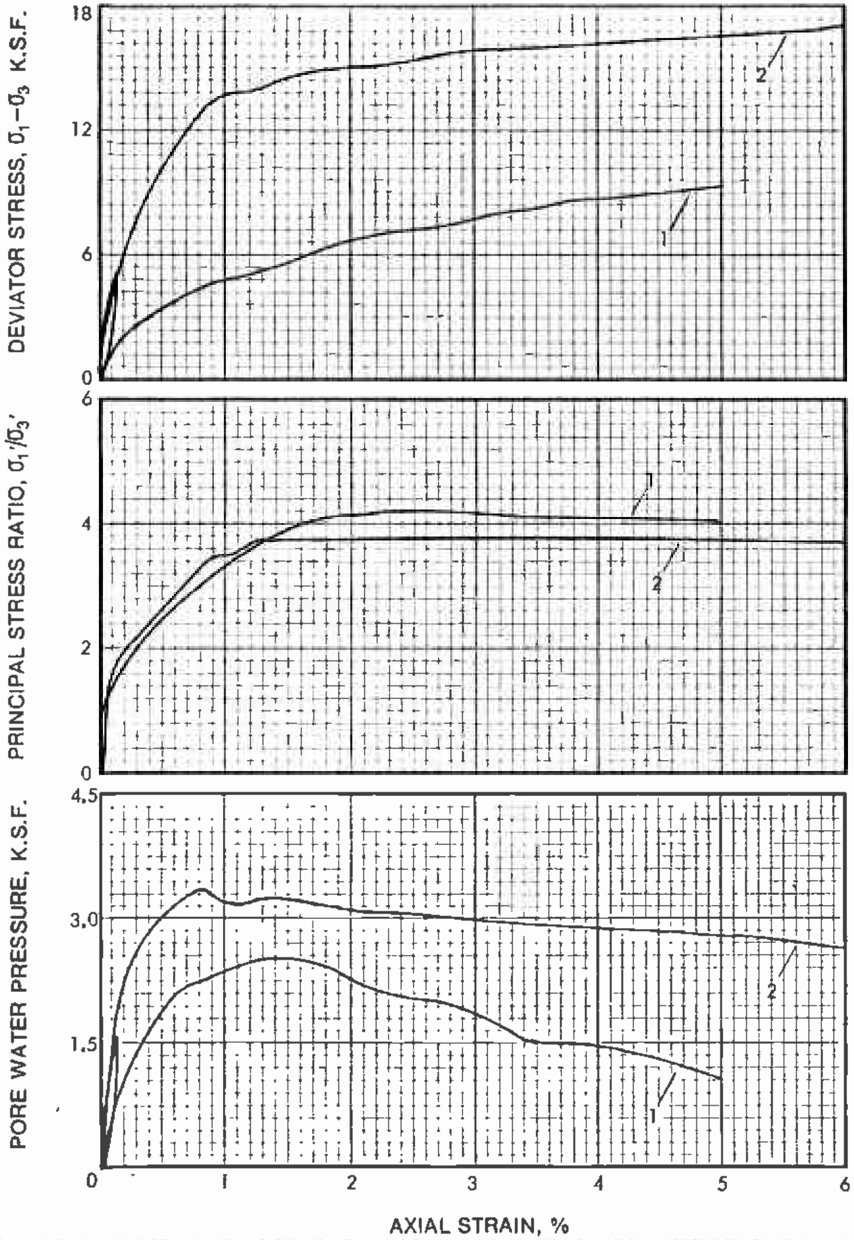

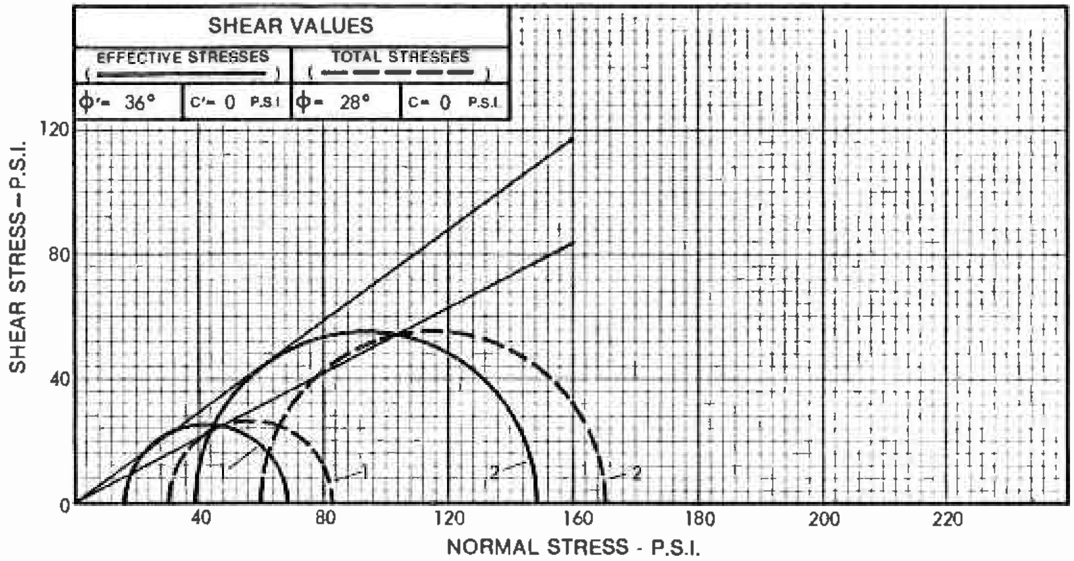

SPECIMEN NUMBER	SPECIMEN LOCATION			INITIAL SPECIMEN DATA					SAMPLE TYPE
	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	SOIL CLASSIFICATION	LENGTH (INCHES)	DIAMETER (INCHES)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (PERCENT)	
PB-7	24-5	PB-7	74.5-78.2	SC	5.936	2.88	122.1	--	Stage 1
PB-7	24-5	PB-7	74.5-78.2	SC	5.668	2.93	124.3	14.3	Stage 2
									Pitcher-Undisturbed
				Initial	6.000	2.88	121.8	13.3	

SPECIMEN NUMBER	SYMBOL	EFFECTIVE CONSOL. PRESSURE σ_{3c} (P.S.I)	TEST VALUES AT FAILURE (MAXIMUM σ_1'/σ_3')				TEST TYPE
			TOTAL DEVIATOR STRESS σ_1-σ_3 (P.S.I)	PORE PRESSURE CHANGE ΔU (P.S.I)	MINOR EFFECTIVE STRESS σ_3' (P.S.I)	MAJOR EFFECTIVE STRESS σ_1' (P.S.I)	
PB-7	1	30	53	14	16	69	Two-Stage ICU with Pore Pressure Measurements
PB-7	2	60	109	21	39	148	

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Figure No
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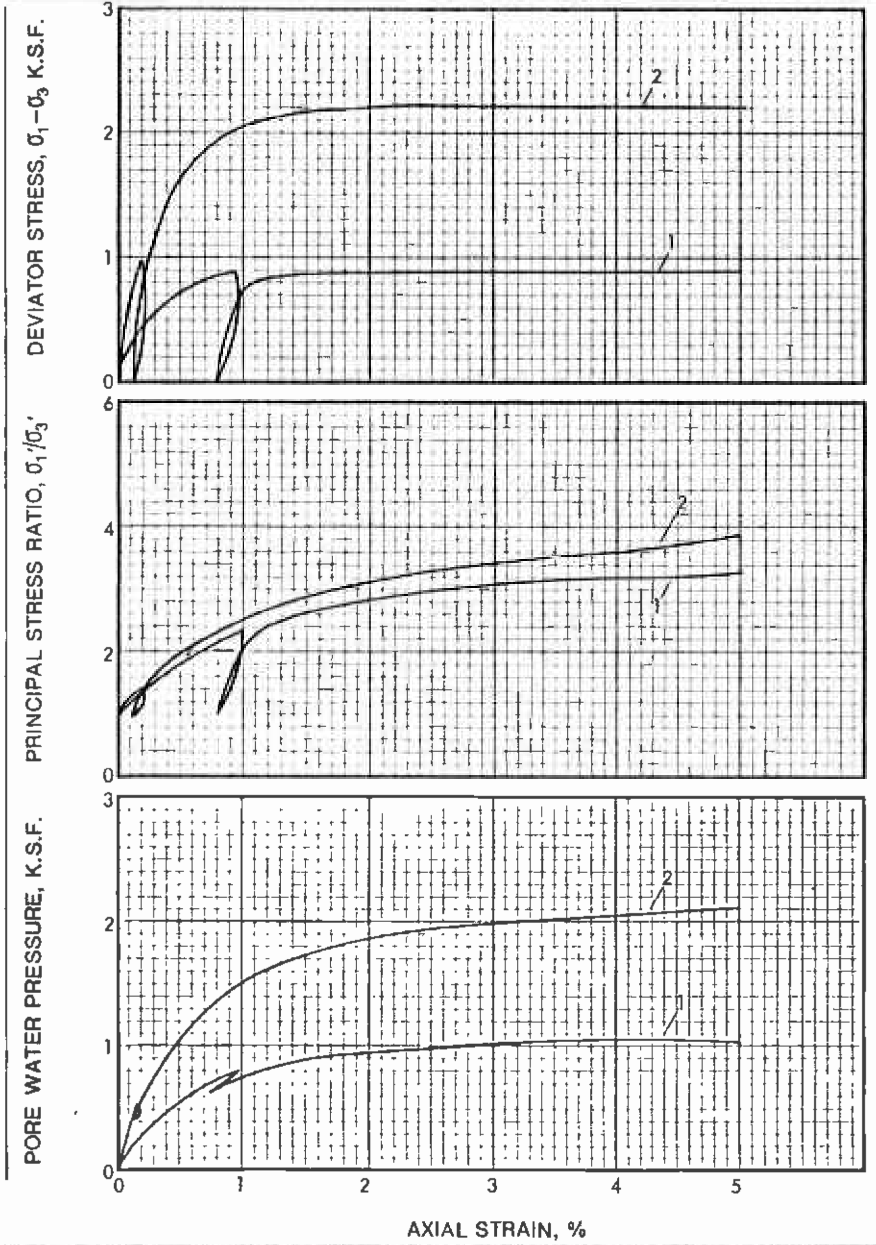

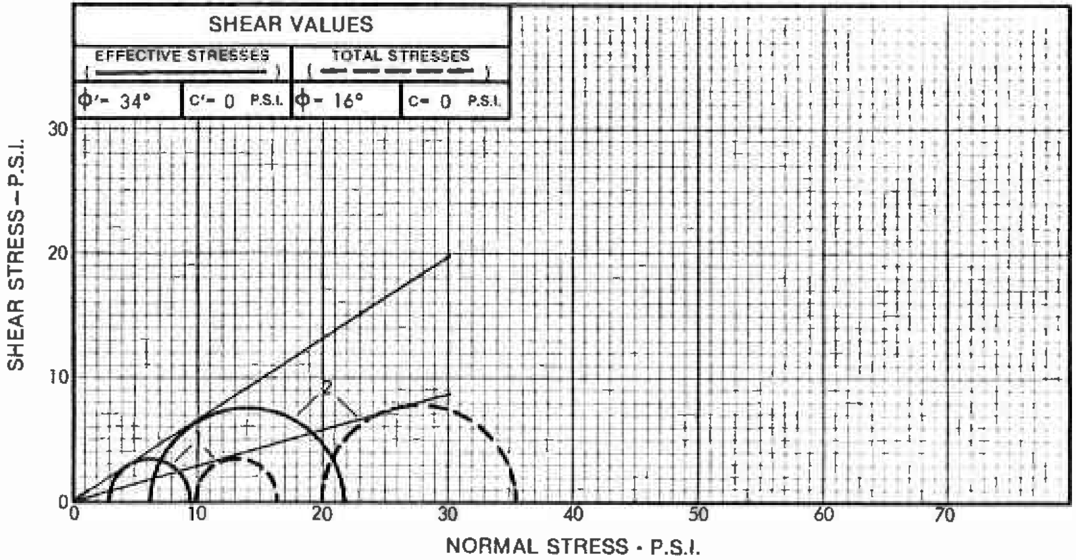

SHEAR VALUES			
EFFECTIVE STRESSES (——————)		TOTAL STRESSES (— — — — —)	
$\phi' = 34°$	$C' = 0$ P.S.I.	$\phi = 16°$	$C = 0$ P.S.I.

SPECIMEN NUMBER	SPECIMEN LOCATION			INITIAL SPECIMEN DATA					SAMPLE TYPE
	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	SOIL CLASSIFICATION	LENGTH (INCHES)	DIAMETER (INCHES)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (PERCENT)	
PB-1	26-1	PB-1	6.0-8.5	SC	5.603	2.89	95.0	-	Stage 1
PB-1	26-1	PB-1	6.0-8.5	SC	5.327	2.93	96.9	21.8	Stage 2
									Pitcher-Undisturbed
				INITIAL	5.700	2.88	94.4	14.3	

SPECIMEN NUMBER	SYMBOL	EFFECTIVE CONSOL. PRESSURE σ_{3C} (P.S.I.)	TEST VALUES AT FAILURE (MAXIMUM σ_1'/σ_3')				TEST TYPE
			TOTAL DEVIATOR STRESS $\sigma_1-\sigma_3$ (P.S.I.)	PORE PRESSURE CHANGE ΔU (P.S.I.)	MINOR EFFECTIVE STRESS σ_3' (P.S.I.)	MAJOR EFFECTIVE STRESS σ_1' (P.S.I.)	
PB-1	1	10	6.2	6.9	3.1	9.3	Two-Stage ICU with Pore Pressure measurements
PB-1	2	20	15.3	13.5	6.5	21.8	

TRIAXIAL COMPRESSION TESTS

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Figure No
E-43

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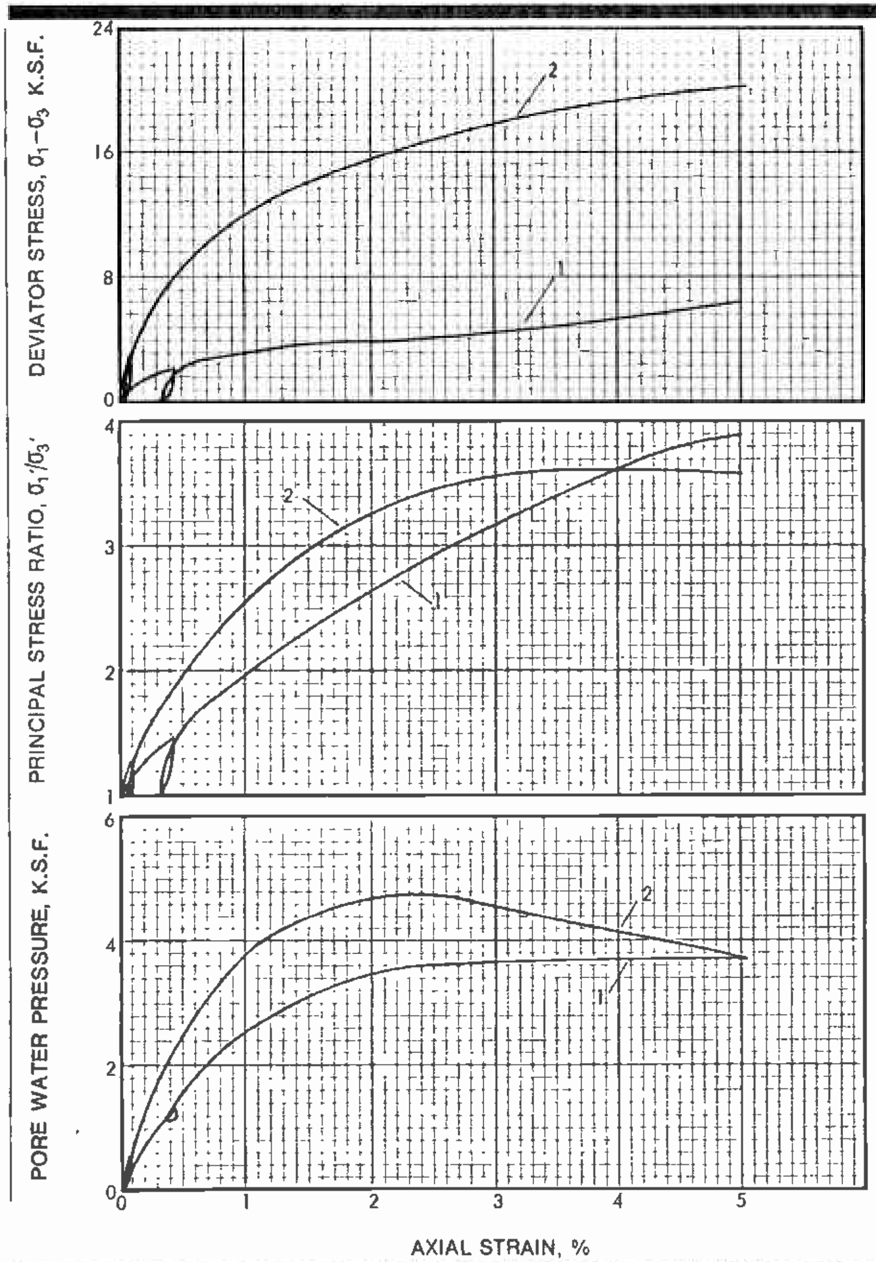

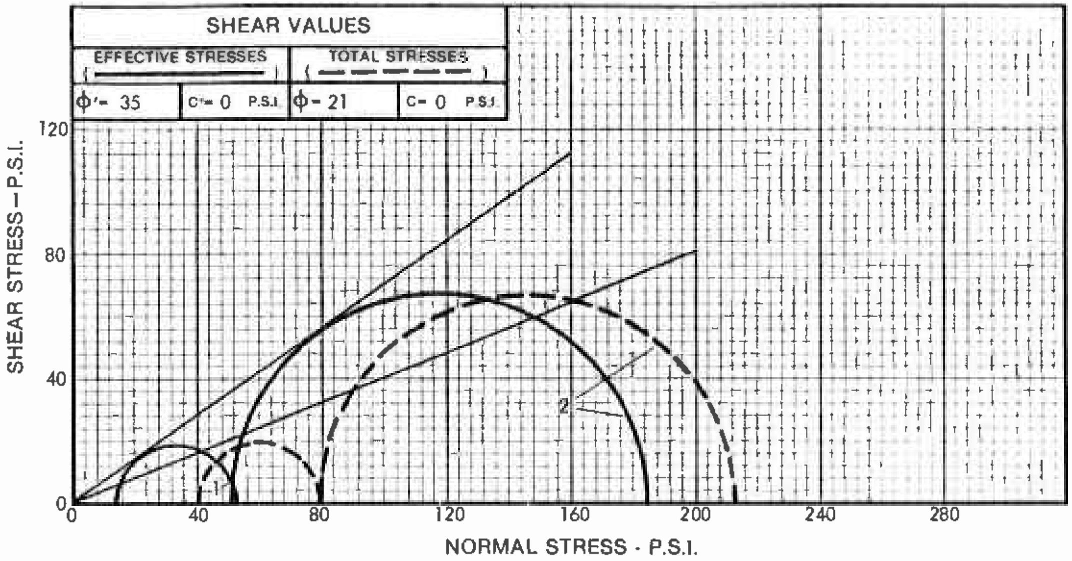

SPECIMEN NUMBER	SPECIMEN LOCATION			INITIAL SPECIMEN DATA					SAMPLE TYPE
	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	SOIL CLASSIFICATION	LENGTH (INCHES)	DIAMETER (INCHES)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (PERCENT)	
PB-4	26-1	PB-4	46.0-48.5	SC	5.712	2.88	117.7	-	Stage 1
PB-4	26-1	PB-4	46.0-48.5	SC	5.453	2.89	122.1	13.1	Stage 2
									PITCHER- UNDISTURBED
				INITIAL	5.990	2.84	115.6	14.3	

SPECIMEN NUMBER	SYMBOL	EFFECTIVE CONSOL. PRESSURE σ_{3C} (P.S.I.)	TEST VALUES AT FAILURE (MAXIMUM σ_1'/σ_3')				TEST TYPE
			TOTAL DEVIATOR STRESS $\sigma_1-\sigma_3$ (P.S.I.)	PORE PRESSURE CHANGE ΔU (P.S.I.)	MINOR EFFECTIVE STRESS σ_3' (P.S.I.)	MAJOR EFFECTIVE STRESS σ_1' (P.S.I.)	
26-1	1	40	37	25.5	14.5	51.5	Two-Stage ICU with pore pressure measurements
26-1	2	80	132	29.0	51.0	183.0	

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Figure No
E-44

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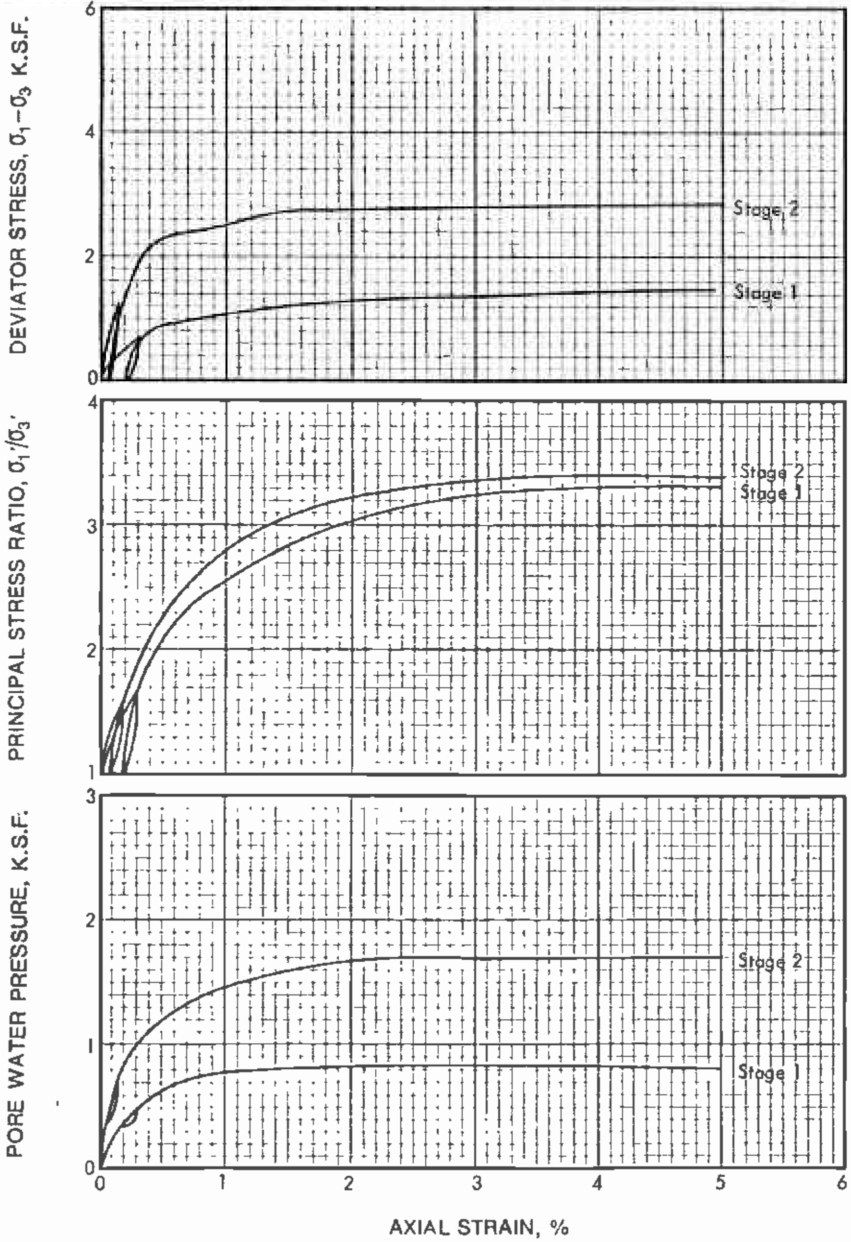

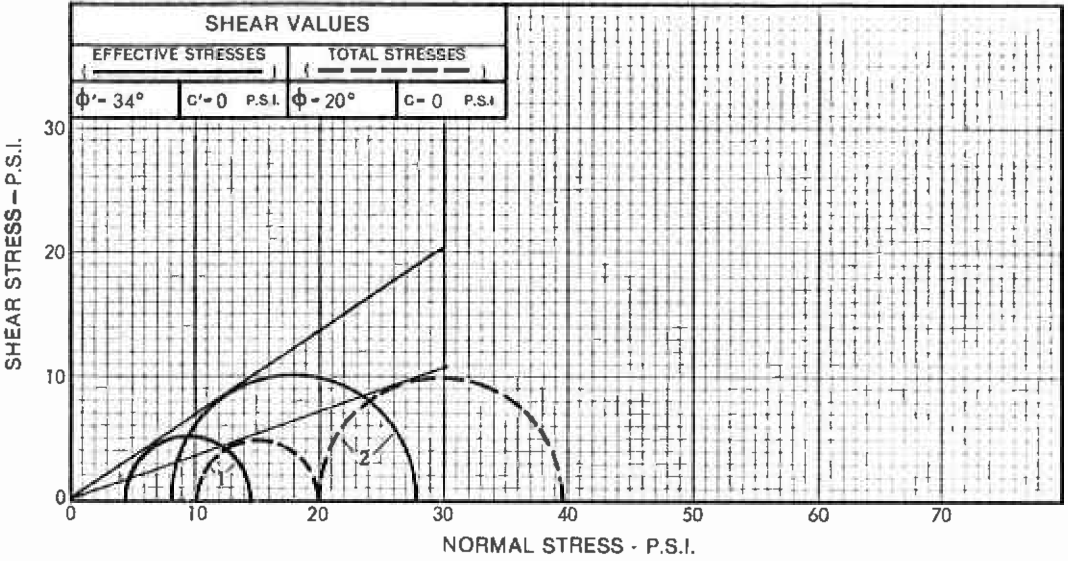

SHEAR VALUES			
EFFECTIVE STRESSES (———)		TOTAL STRESSES (— — —)	
φ'= 34°	c'= 0 P.S.I.	φ = 20°	c = 0 P.S.I.

SPECIMEN NUMBER	SPECIMEN LOCATION			INITIAL SPECIMEN DATA					SAMPLE TYPE
	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	SOIL CLASSIFICATION	LENGTH (INCHES)	DIAMETER (INCHES)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (PERCENT)	
PB-2	26-2	PB-2	12.0-14.5	SM/ML	6.182	2.84	103.1	-	Stage 1
PB-2	26-2	PB-2	12.0-14.5	SM/ML	5.912	2.88	104.9	22.3	Stage 2
				INITIAL	6.250	2.83	102.6	22.9	Pitcher-Undisturbed

SPECIMEN NUMBER	SYMBOL	EFFECTIVE CONSOL PRESSURE σ_{3c} (P.S.I.)	TEST VALUES AT FAILURE (MAXIMUM σ_1'/σ_3')				TEST TYPE
			TOTAL DEVIATOR STRESS $\sigma_1-\sigma_3$ (P.S.I.)	PORE PRESSURE CHANGE ΔU (P.S.I.)	MINOR EFFECTIVE STRESS σ_3' (P.S.I.)	MAJOR EFFECTIVE STRESS σ_1' (P.S.I.)	
26-2	1	10	9.9	5.7	4.3	14.2	Two-Stage ICU with pore pressure measurements
26-2	2	20	19.8	11.8	8.2	28.0	

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Figure No
E-45

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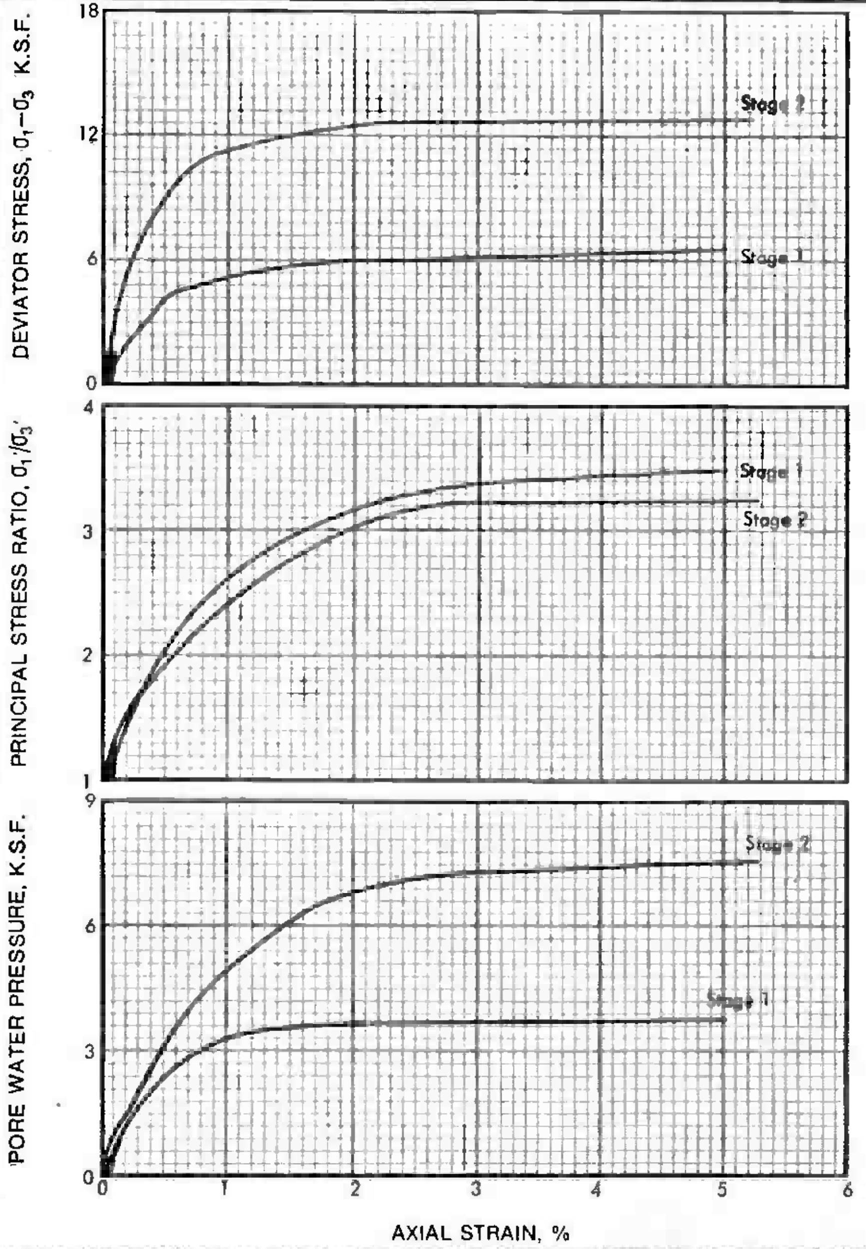

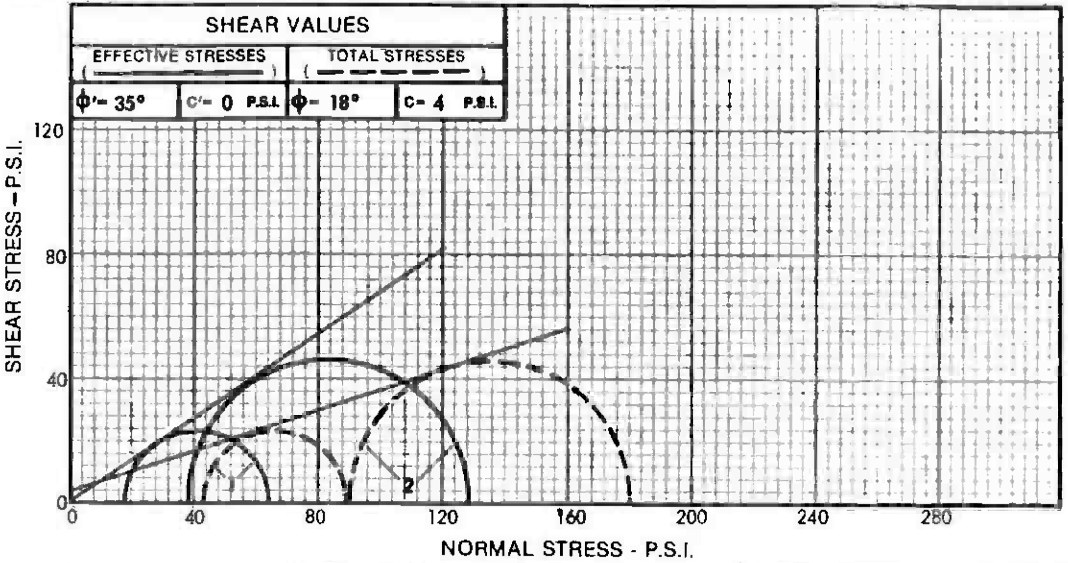

SPECIMEN NUMBER	SPECIMEN LOCATION			INITIAL SPECIMEN DATA					SAMPLE TYPE
	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	SOIL CLASSIFICATION	LENGTH (INCHES)	DIAMETER (INCHES)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (PERCENT)	
PB-6	26-2	PB-6	52.0-54.5	SM	5.815	2.86	99.0	-	Stage 1
PB-6	26-2	PB-2	52.0-54.5	SM	5.557	2.90	100.8	22.6	Stage 2
									Pitcher-Undisturbed
				INITIAL	6.000	2.84	97.8	25.0	

SPECIMEN NUMBER	SYMBOL	EFFECTIVE CONSOL. PRESSURE σ_{3C} (P.S.I.)	TEST VALUES AT FAILURE (MAXIMUM σ_1'/σ_3')				TEST TYPE
			TOTAL DEVIATOR STRESS $\sigma_1-\sigma_3$ (P.S.I.)	PORE PRESSURE CHANGE ΔU (P.S.I.)	MINOR EFFECTIVE STRESS σ_3' (P.S.I.)	MAJOR EFFECTIVE STRESS σ_1' (P.S.I.)	
PB-6	1	45	45	27	18	63	Two-Stage ICU with pore pressure measurements
PB-6	2	90	90	52	38	128	

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Figure No
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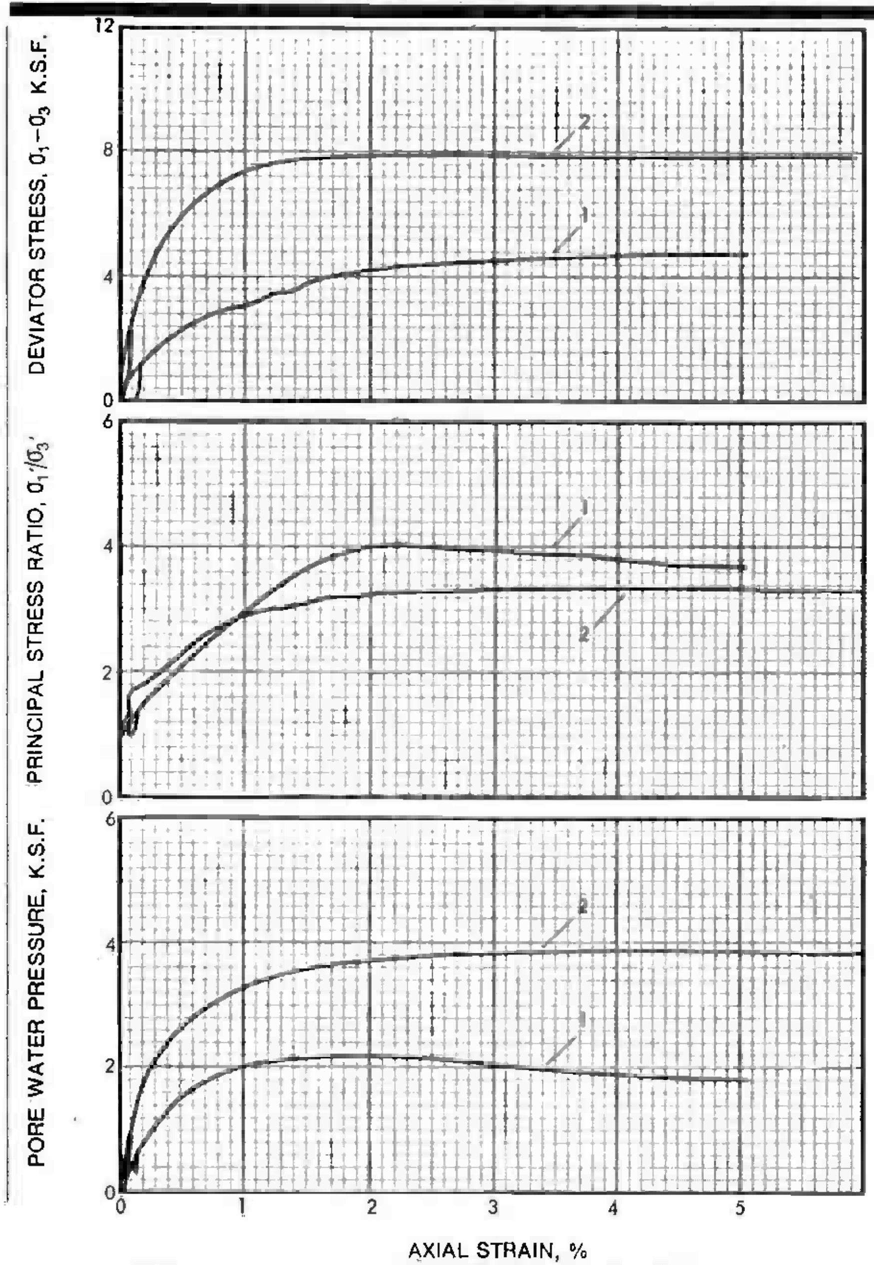

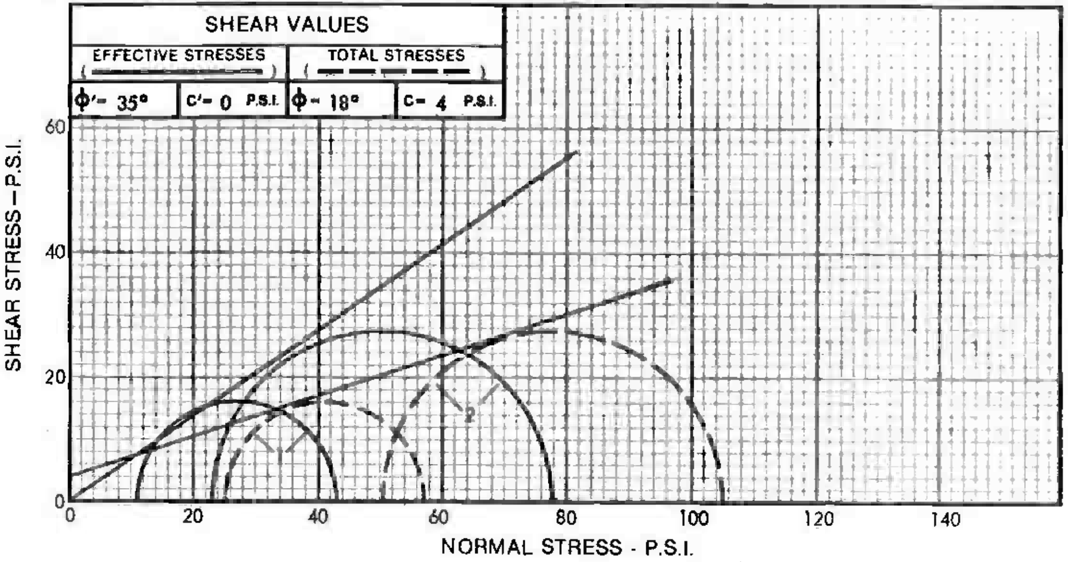

SPECIMEN NUMBER	SPECIMEN LOCATION			INITIAL SPECIMEN DATA					SAMPLE TYPE
	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	SOIL CLASSIFICATION	LENGTH (INCHES)	DIAMETER (INCHES)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (PERCENT)	
PB-4	26-3	PB-4	32.0-34.5	CL	5.869	2.87	99.1	-	Stage 1
PB-4	26-3	PB-4	32.0-34.5	CL	5.606	2.91	100.9	22.2	Stage 2
				INITIAL	6.000	2.85	98.3	25.9	Pitcher-Undisturbed

SPECIMEN NUMBER	SYMBOL	EFFECTIVE CONSOL. PRESSURE σ_{3C} (P.S.I.)	TEST VALUES AT FAILURE (MAXIMUM σ_1'/σ_3')				TEST TYPE
			TOTAL DEVIATOR STRESS σ_1-σ_3 (P.S.I.)	PORE PRESSURE CHANGE ΔU (P.S.I.)	MINOR EFFECTIVE STRESS σ_3' (P.S.I.)	MAJOR EFFECTIVE STRESS σ_1' (P.S.I.)	
26-3	1	25	32.0	14	11	43.0	Two-Stage ICU with Pore Pressure measurements
26-3	2	50	54.9	26.7	23.3	78.2	

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Figure No
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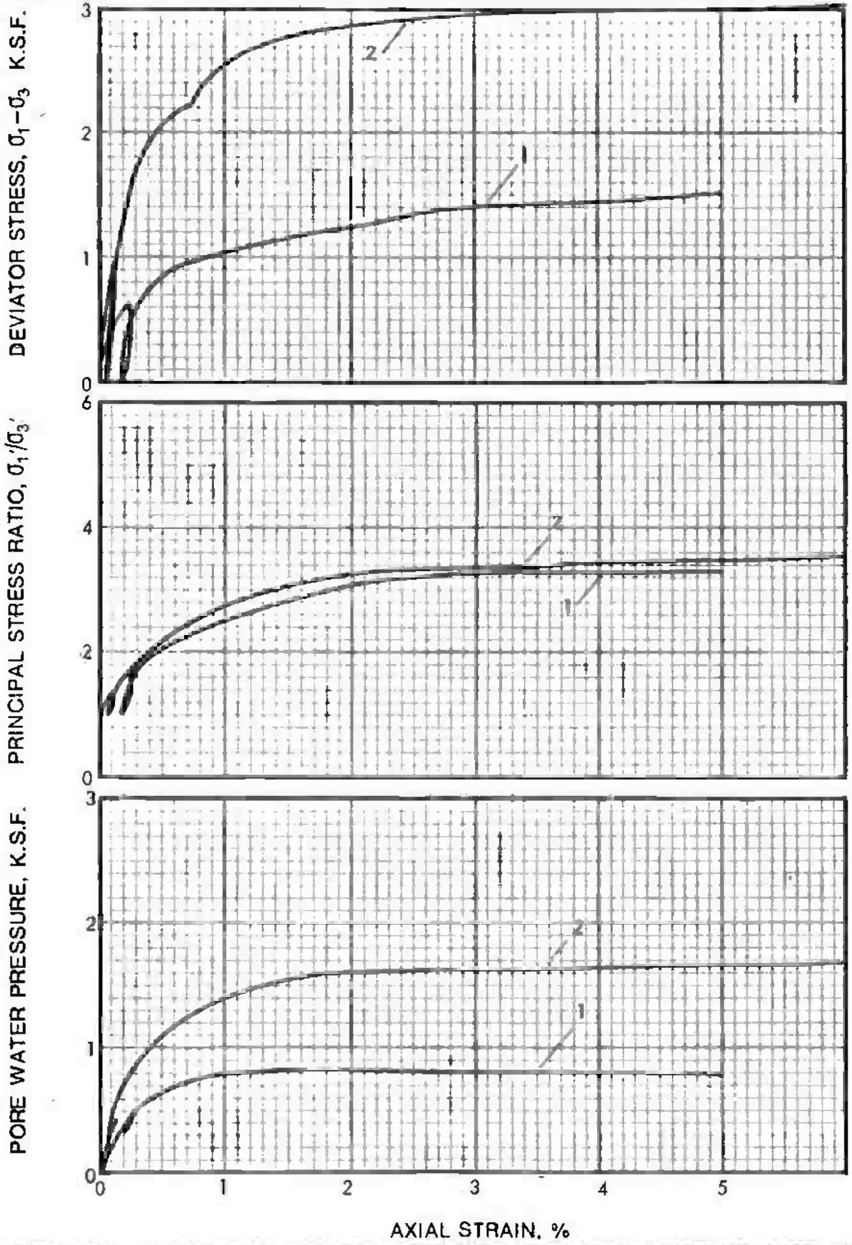

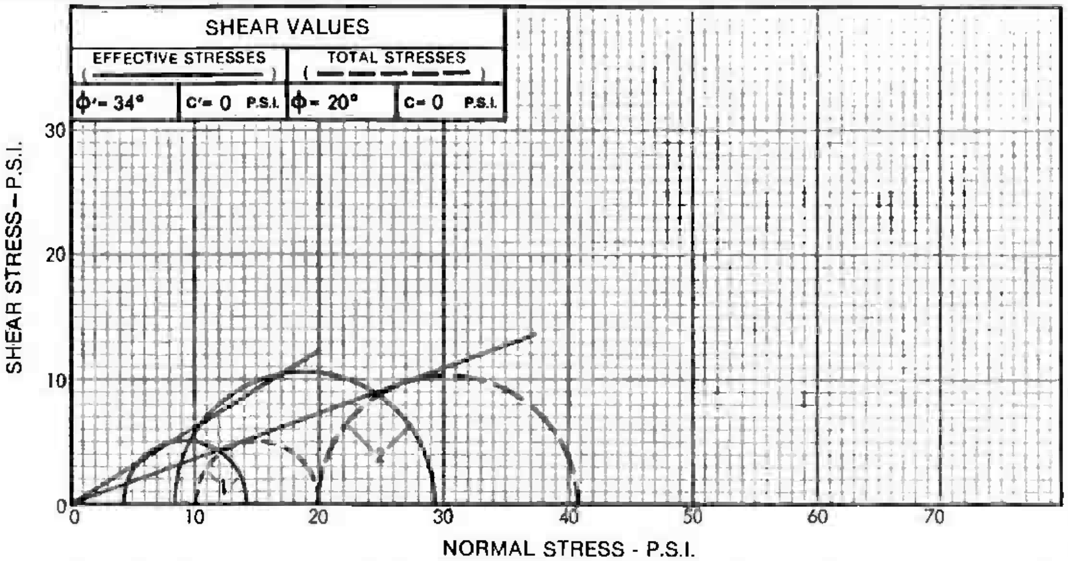

SHEAR VALUES			
EFFECTIVE STRESSES (———)		TOTAL STRESSES (— — — —)	
φ'= 34°	c'= 0 P.S.I.	φ= 20°	c= 0 P.S.I.

SPECIMEN NUMBER	SPECIMEN LOCATION			INITIAL SPECIMEN DATA					SAMPLE TYPE
	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	SOIL CLASSIFICATION	LENGTH (INCHES)	DIAMETER (INCHES)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (PERCENT)	
PB-2	26-4	PB-2	12.0-14.5	CL	6.172	2.89	103.7	-	Stage 1
PB-2	26-4	PB-2	12.0-14.5	CL	5.909	2.92	105.5	22.0	Stage 2
									Pitcher-Undisturbed
				INITIAL	6.250	2.875	103.2	25.9	

SPECIMEN NUMBER	SYMBOL	EFFECTIVE CONSOL. PRESSURE σ_{3C} (P.S.I.)	TEST VALUES AT FAILURE (MAXIMUM σ_1'/σ_3')				TEST TYPE
			TOTAL DEVIATOR STRESS σ_1-σ_3 (P.S.I.)	PORE PRESSURE CHANGE ΔU (P.S.I.)	MINOR EFFECTIVE STRESS σ_3' (P.S.I.)	MAJOR EFFECTIVE STRESS σ_1' (P.S.I.)	
PB-2	1	10	9.9	5.7	4.3	14.2	Two-Stage ICU with Pore Pressure measurements
PB-2	2	20	20.5	11.4	8.6	29.2	

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Figure No
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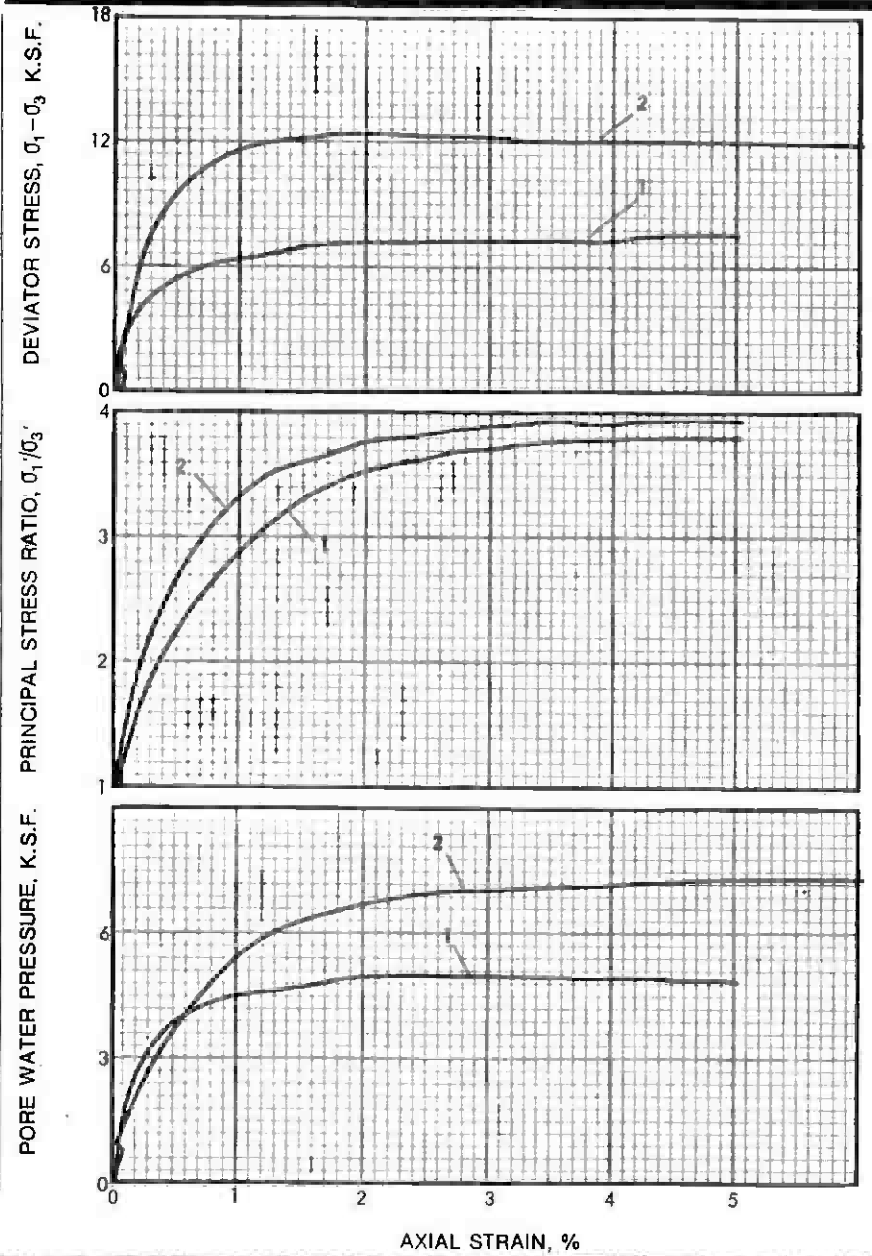

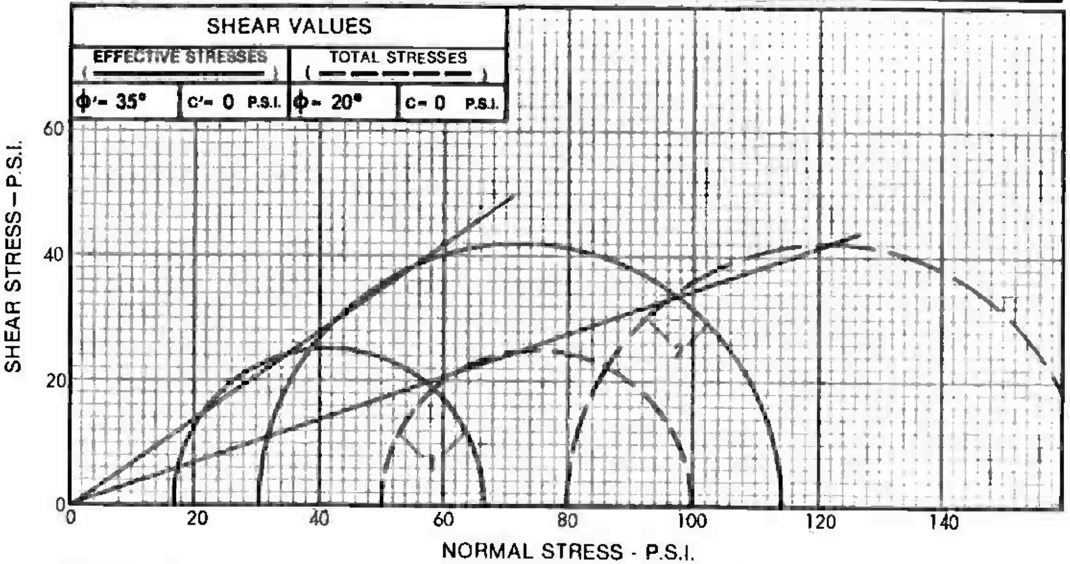

SHEAR VALUES			
EFFECTIVE STRESSES (———)		TOTAL STRESSES (— — —)	
ϕ' = 35°	c' = 0 P.S.I.	ϕ = 20°	c = 0 P.S.I.

SPECIMEN NUMBER	SPECIMEN LOCATION			INITIAL SPECIMEN DATA					SAMPLE TYPE
	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	SOIL CLASSIFICATION	LENGTH (INCHES)	DIAMETER (INCHES)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (PERCENT)	
PB-7	26-4	PB-7	64.0-66.5	SC	5.928	2.86	106.4	-	Stage 1
PB-7	26-4	PB-7	64.0-66.5	SC	5.660	2.90	108.4	17.9	Stage 2
									Pitcher – Undisturbed
				INITIAL	6,000	2.85	105.9	20.2	

SPECIMEN NUMBER	SYMBOL	EFFECTIVE CONSOL. PRESSURE σ_{3C} (P.S.I.)	TEST VALUES AT FAILURE (MAXIMUM σ_1'/σ_3')				TEST TYPE
			TOTAL DEVIATOR STRESS σ_1-σ_3 (P.S.I.)	PORE PRESSURE CHANGE ΔU (P.S.I.)	MINOR EFFECTIVE STRESS σ_3' (P.S.I.)	MAJOR EFFECTIVE STRESS σ_1' (P.S.I.)	
PB-7	1	50	49.6	33	17	66.6	Two-Stage ICU with Pore Pressure measurements
PB-7	2	80	84.2	49.4	30.6	114.8	

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Figure No
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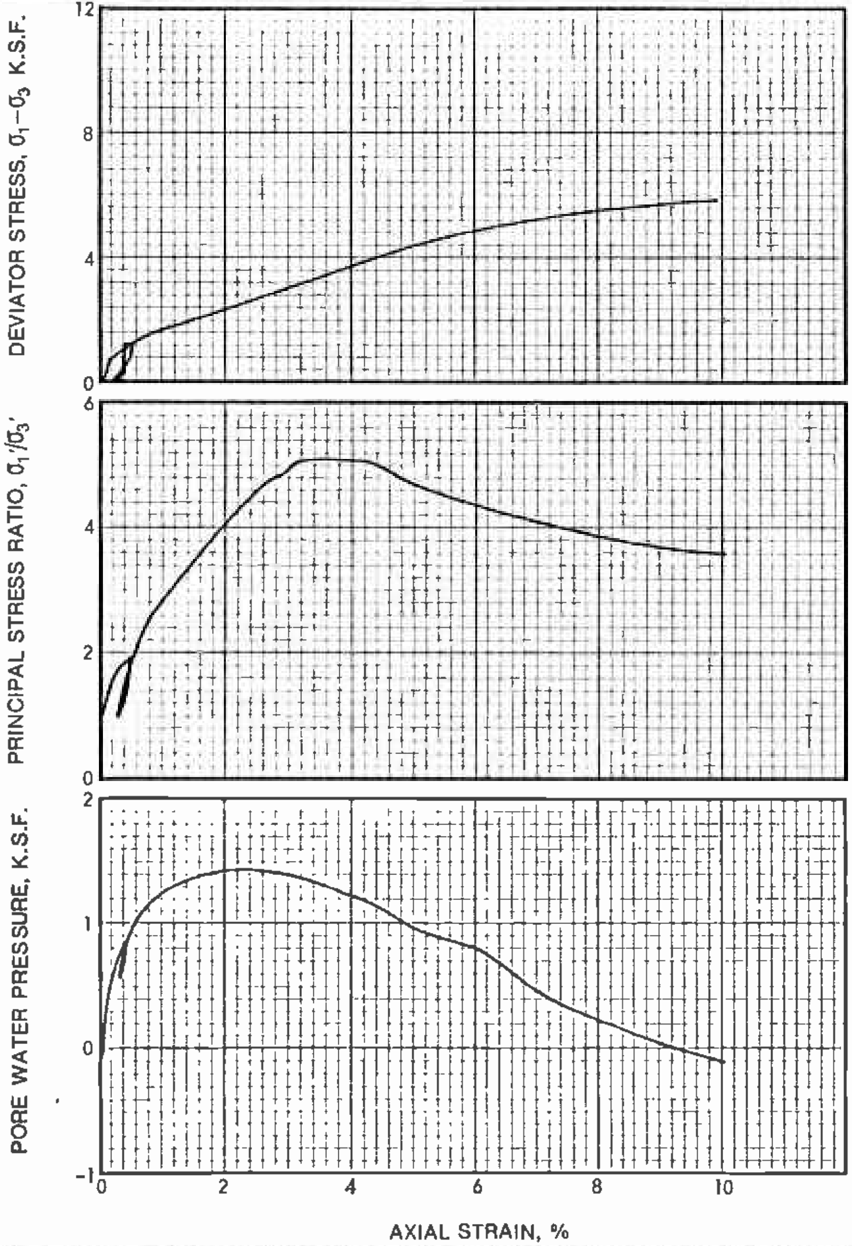

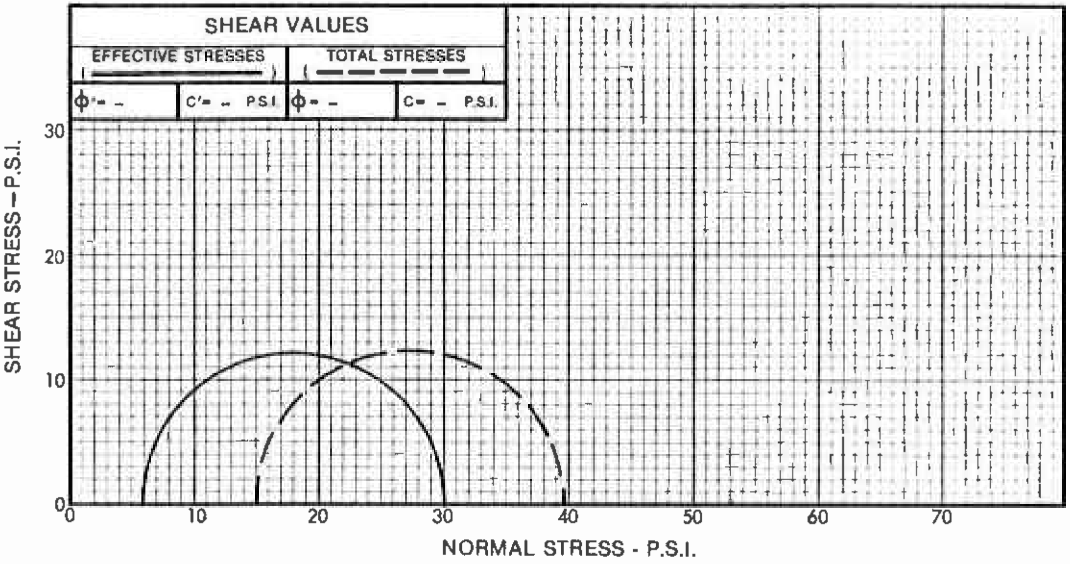

SPECIMEN NUMBER	SPECIMEN LOCATION			INITIAL SPECIMEN DATA					SAMPLE TYPE
	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	SOIL CLASSI-FICATION	LENGTH (INCHES)	DIAMETER (INCHES)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (PERCENT)	
PB-1	26-5	PB-1	23.0-25.5	CL/SC	5.859	2.87	106.2	20.4	
				INITIAL	6.000	2.85	105.3	22.2	Pitcher-Undisturbed

SPECIMEN NUMBER	SYMBOL	EFFECTIVE CONSOL. PRESSURE σ_{3C} (P.S.I.)	TEST VALUES AT FAILURE (MAXIMUM σ_1'/σ_3')				TEST TYPE
			TOTAL DEVIATOR STRESS σ_1-σ_3 (P.S.I.)	PORE PRESSURE CHANGE ΔU (P.S.I.)	MINOR EFFECTIVE STRESS σ_3' (P.S.I.)	MAJOR EFFECTIVE STRESS σ_1' (P.S.I.)	
PB-1	-	15	24.3	9.1	5.9	30.2	ICU with Pore Pressure measurements

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Figure No
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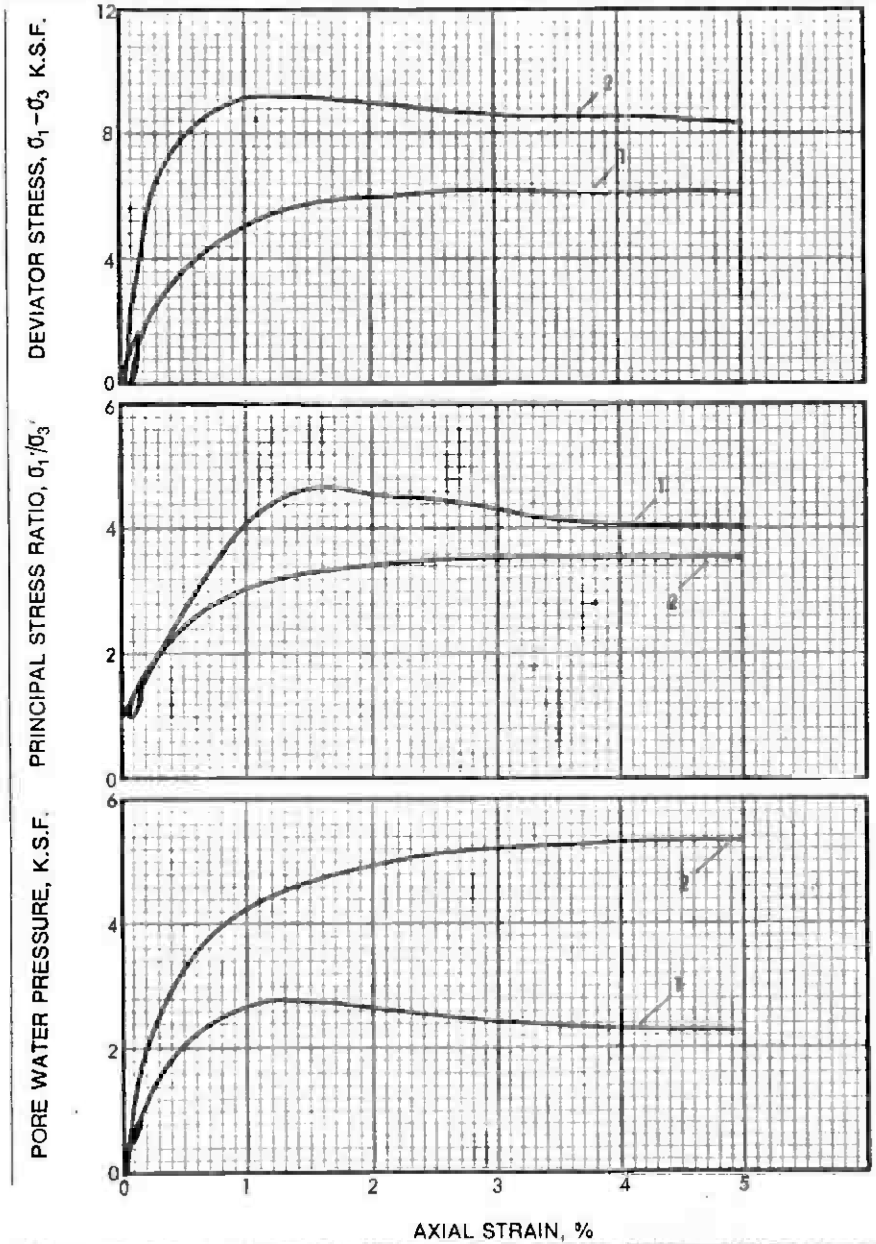
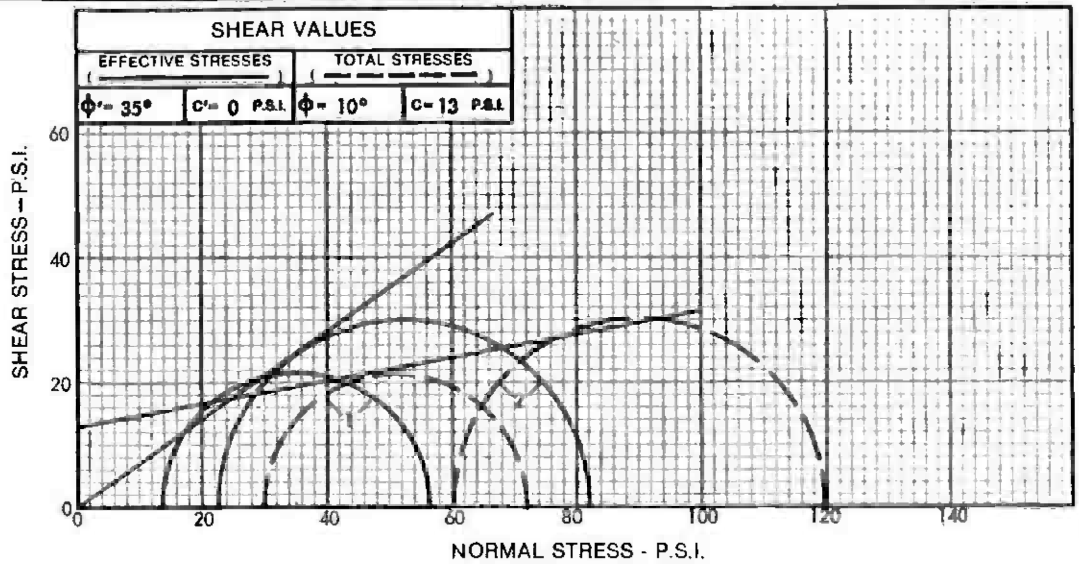


SHEAR VALUES			
EFFECTIVE STRESSES (———)		TOTAL STRESSES (— — — —)	
ϕ'= 35°	C'= 0 P.S.I.	ϕ= 10°	C= 13 P.S.I.



SPECIMEN NUMBER	SPECIMEN LOCATION			INITIAL SPECIMEN DATA					SAMPLE TYPE
	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	SOIL CLASSI-FICATION	LENGTH (INCHES)	DIAMETER (INCHES)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (PERCENT)	
PB-2	26-5	PB-2	43.0-45.5	CL/SC	5.886	2.87	96.7	-	Stage 1
PB-2	26-5	PB-2	43.0-45.5	CL/SC	5.621	2.97	98.5	25.1	Stage 2
									Pitcher- Undisturbed
				INITIAL	6.000	2.85	96.0	25.1	

SPECIMEN NUMBER	SYMBOL	EFFECTIVE CONSOL. PRESSURE σ_{3C} (P.S.I.)	TEST VALUES AT FAILURE (MAXIMUM σ_1'/σ_3')				TEST TYPE
			TOTAL DEVIATOR STRESS σ_1-σ_3 (P.S.I.)	PORE PRESSURE CHANGE ΔU (P.S.I.)	MINOR EFFECTIVE STRESS σ_3' (P.S.I.)	MAJOR EFFECTIVE STRESS σ_1' (P.S.I.)	
PB-2	1	30	42	16	14	56	Two- Stage ICU with Pore Pressure measurements
PB-2	2	60	59	37	23	82	

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Figure No
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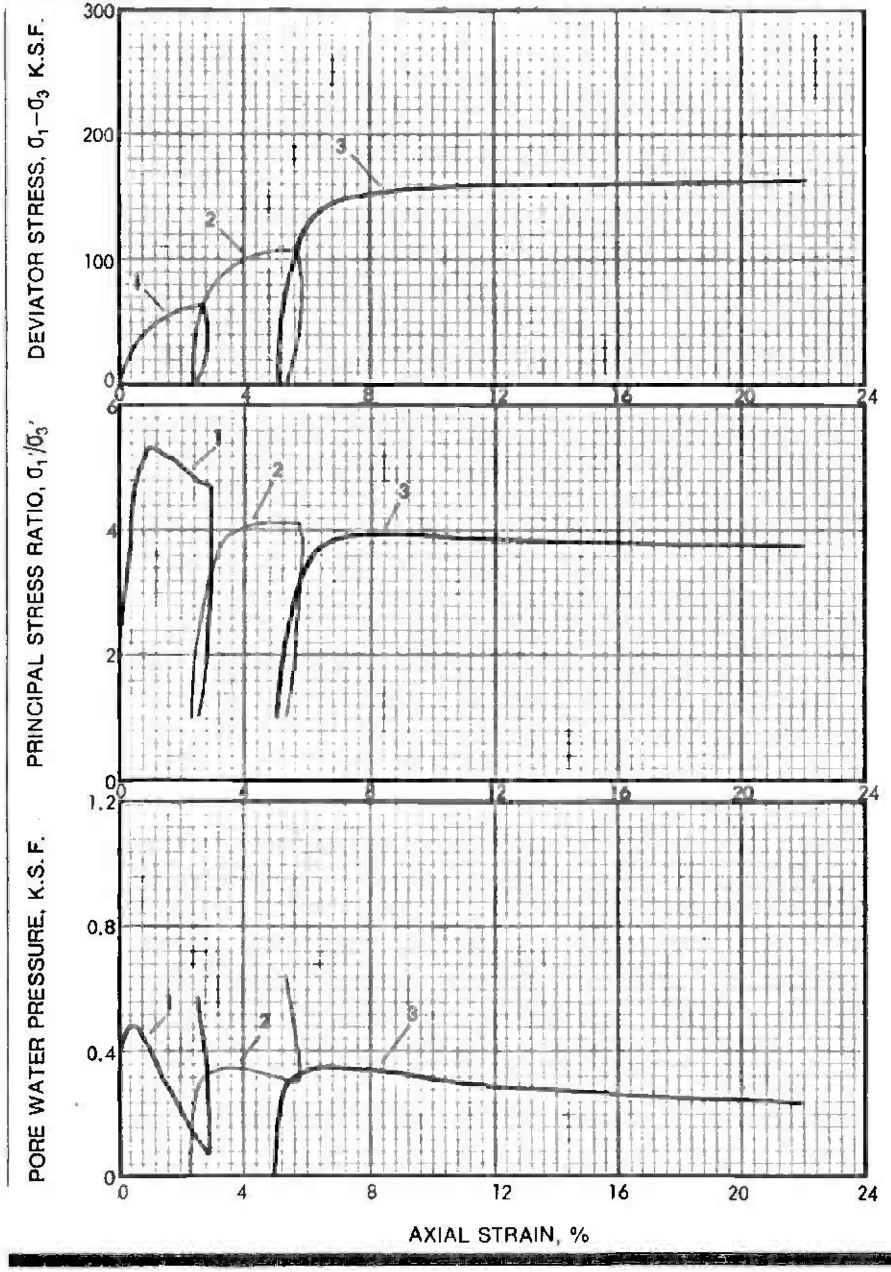

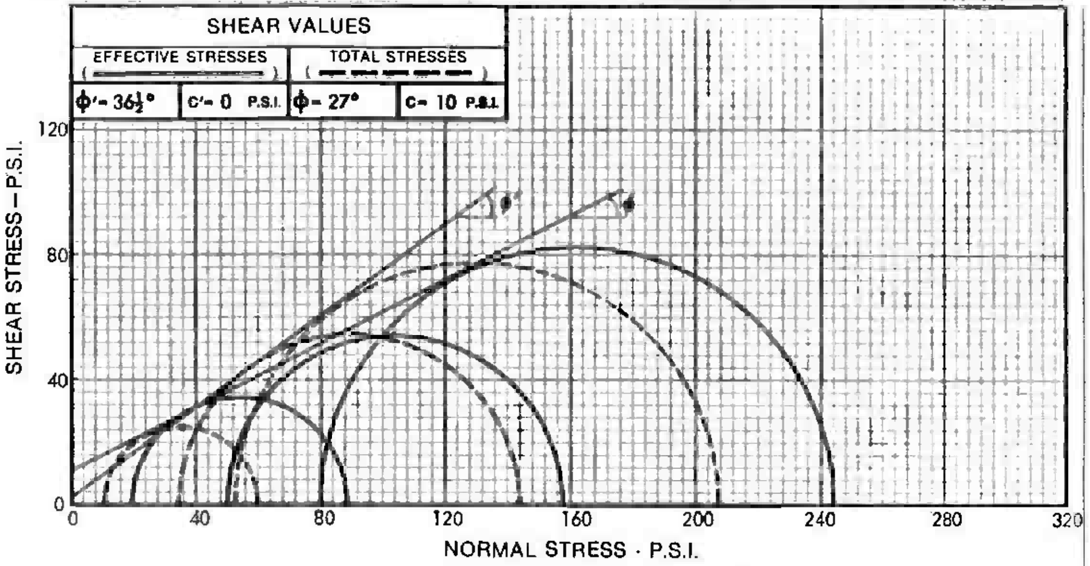

SHEAR VALUES			
EFFECTIVE STRESSES (———)		TOTAL STRESSES (— — —)	
$\phi' = 36\frac{1}{2}°$	C′= 0 P.S.I.	$\phi = 27°$	C= 10 P.S.I.

SPECIMEN NUMBER	SPECIMEN LOCATION			INITIAL SPECIMEN DATA					SAMPLE TYPE
	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	SOIL CLASSI-FICATION	LENGTH (INCHES)	DIAMETER (INCHES)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (PERCENT)	
C-2	25	C-2	41	SM/SC	5.97	2.42	119.00	12.20	UNDISTURBED
C-2	25	C-2	41	SM/SC	5.97	2.42	119.00	12.20	UNDISTURBED
C-2	25	C-2	41	SM/SC	5.97	2.42	119.00	12.20	UNDISTURBED

SPECIMEN NUMBER	SYMBOL	EFFECTIVE CONSOL. PRESSURE σ_{3C} (P.S.I.)	TEST VALUES AT FAILURE (MAXIMUM σ_1'/σ_3')				TEST TYPE
			TOTAL DEVIATOR STRESS σ_1-σ_3 (P.S.I.)	PORE PRESSURE CHANGE ΔU (P.S.I.)	MINOR EFFECTIVE STRESS σ_3' (P.S.I.)	MAJOR EFFECTIVE STRESS σ_1' (P.S.I.)	
Stage 1	-	20	48.8	8.6	11.4	60.2	CU PROGRESSIVE
Stage 2	-	50	107.7	15.0	35.0	142.7	CU PROGRESSIVE
Stage 3	-	80	154.0	26.8	53.2	207.2	CU PROGRESSIVE

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Figure No
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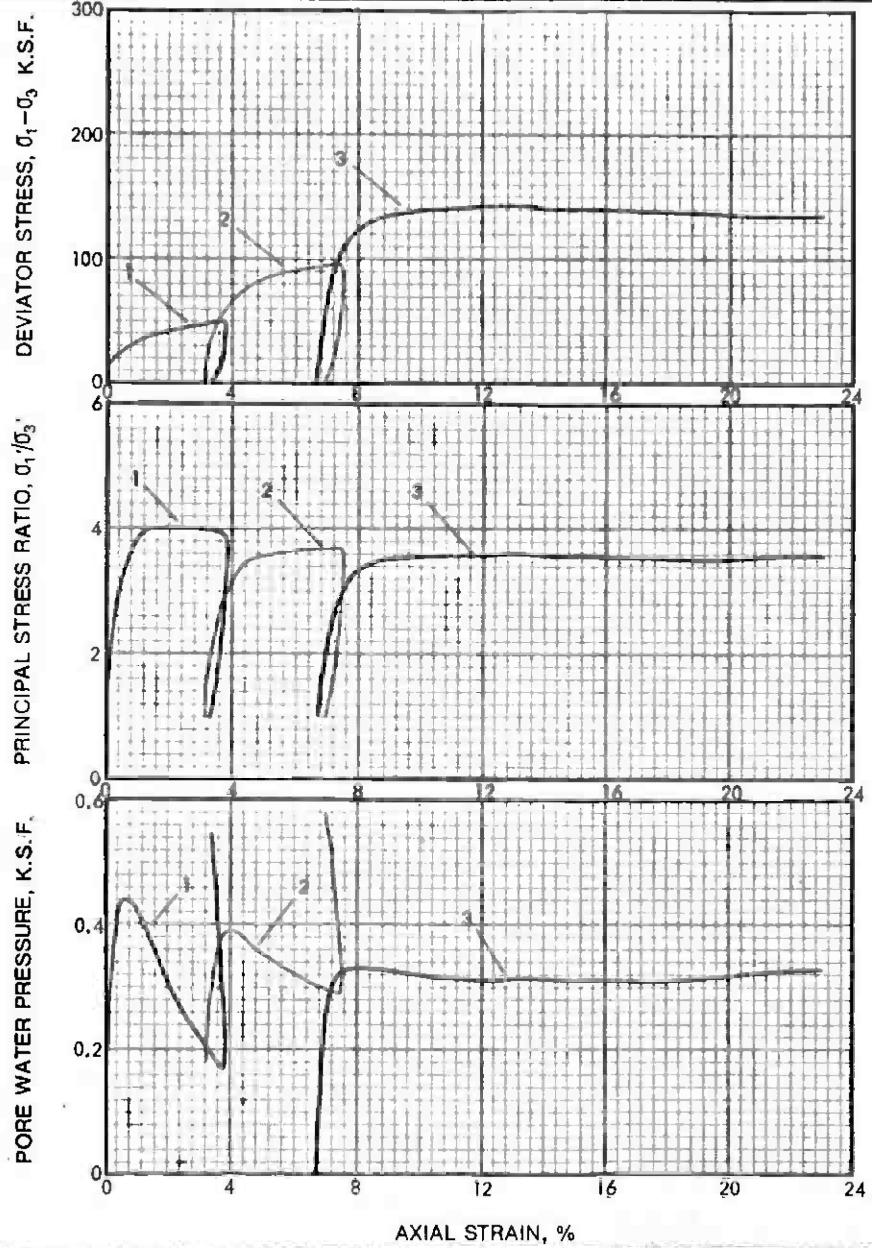

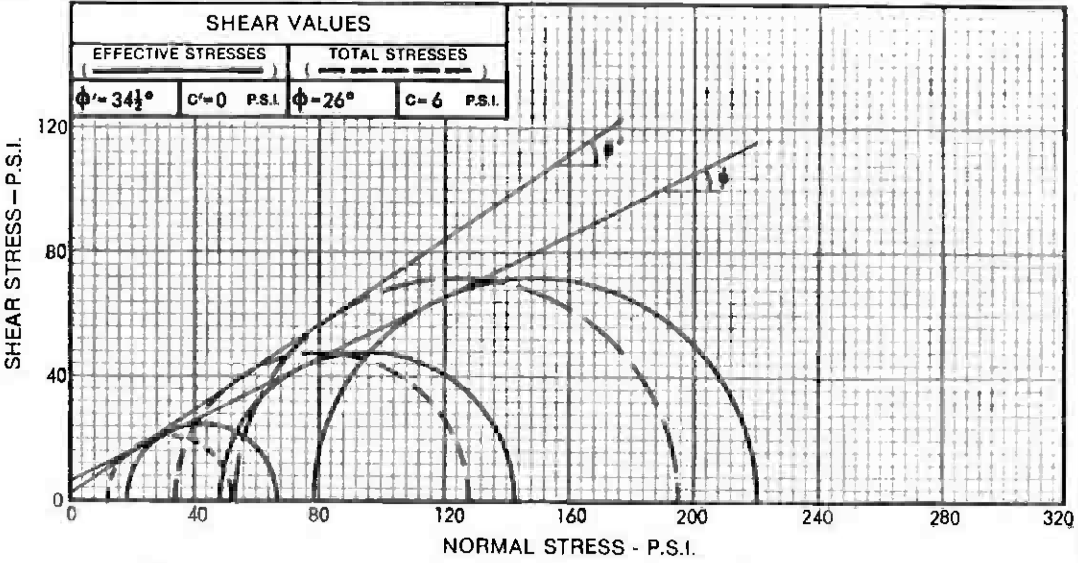

SHEAR VALUES			
EFFECTIVE STRESSES (———)		TOTAL STRESSES (— — —)	
$\phi' = 34\frac{1}{2}°$	$C' = 0$ P.S.I.	$\phi = 26°$	$C = 6$ P.S.I.

SPECIMEN NUMBER	SPECIMEN LOCATION			INITIAL SPECIMEN DATA					SAMPLE TYPE
	BORING NUMBER	SAMPLE NUMBER	DEPTH (FEET)	SOIL CLASSIFICATION	LENGTH (INCHES)	DIAMETER (INCHES)	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (PERCENT)	
S-1	27	S-1	22	SM	5.98	2.87	102.40	21.60	UNDISTURBED
S-1	27	S-1	22	SM	5.98	2.87	102.40	21.60	UNDISTURBED
S-1	27	S-1	22	SM	5.98	2.87	102.40	21.60	UNDISTURBED

SPECIMEN NUMBER	SYMBOL	EFFECTIVE CONSOL. PRESSURE σ_{3C} (P.S.I.)	TEST VALUES AT FAILURE (MAXIMUM σ_1'/σ_3')				TEST TYPE
			TOTAL DEVIATOR STRESS σ_1-σ_3 (P.S.I.)	PORE PRESSURE CHANGE ΔU (P.S.I.)	MINOR EFFECTIVE STRESS σ_3' (P.S.I.)	MAJOR EFFECTIVE STRESS σ_1' (P.S.I.)	
Stage 1	-	20	41.0	6.4	13.6	54.6	CU PROGRESSIVE
Stage 2	-	50	93.8	14.7	35.3	129.1	CU PROGRESSIVE
Stage 3	-	80	141.7	25.3	54.7	196.4	CU PROGRESSIVE

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Figure No
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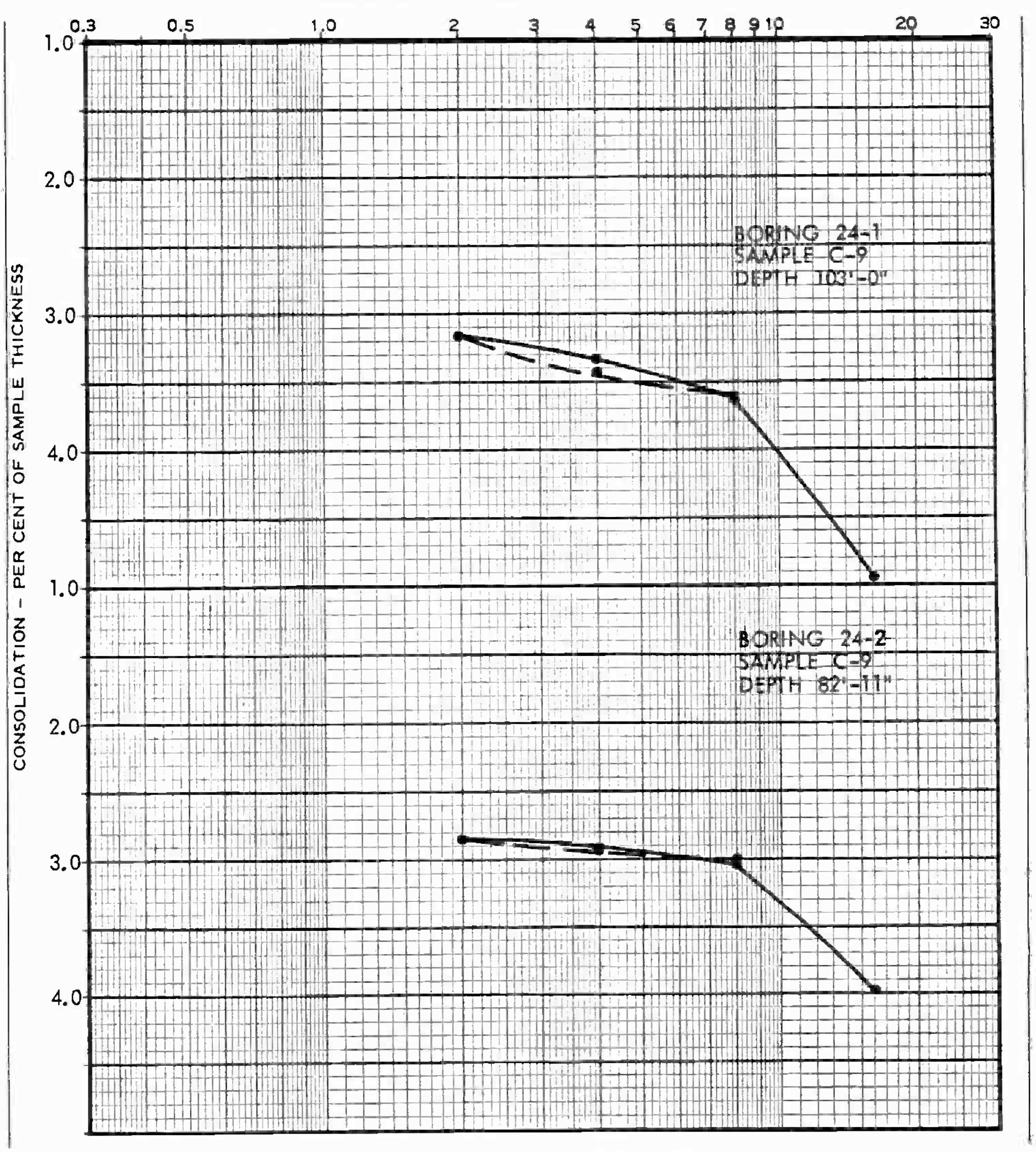

● READINGS AFTER SATURATION WITH WATER

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Figure No.
E-54

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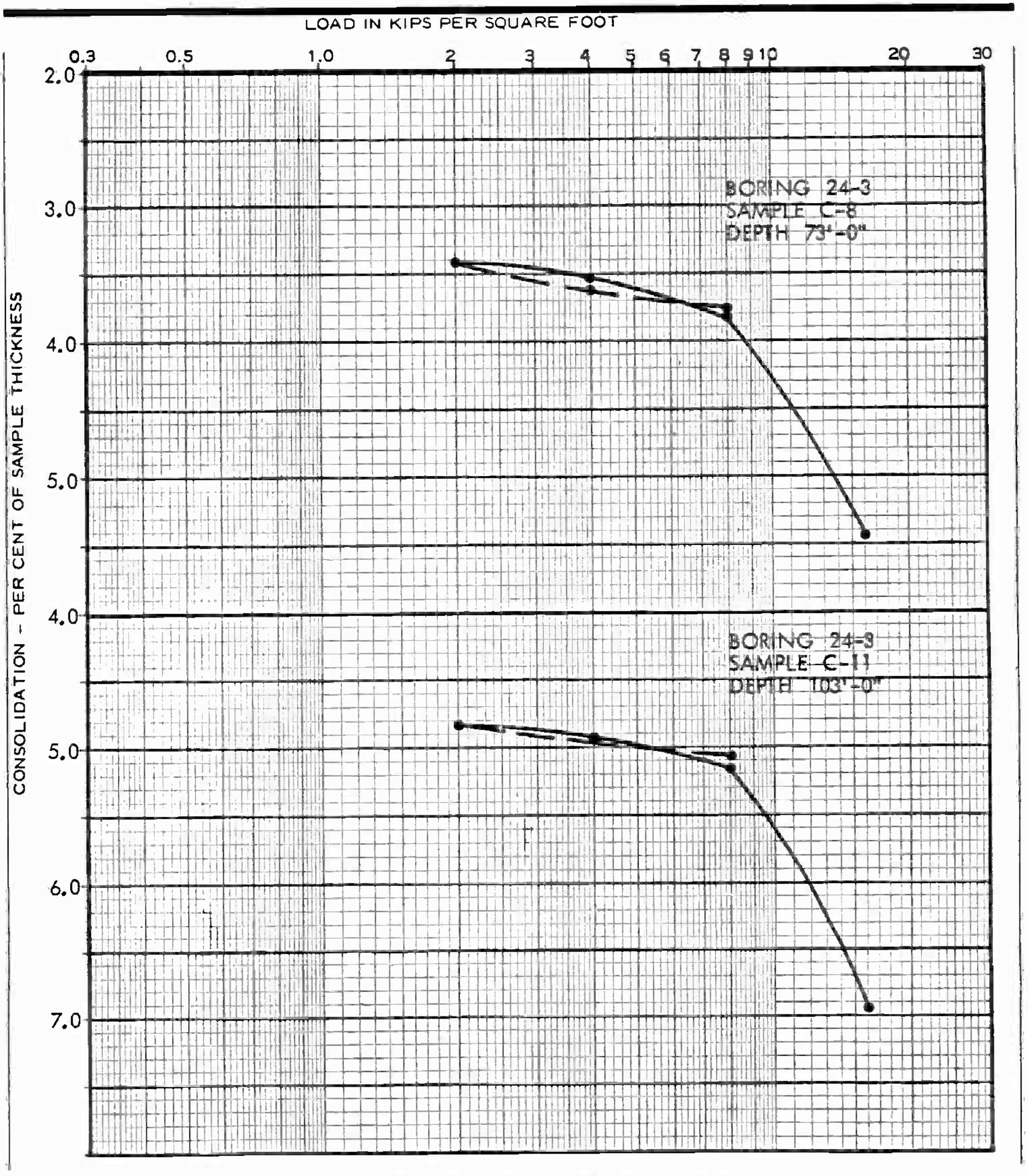

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TESTS

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Figure No.
E-55

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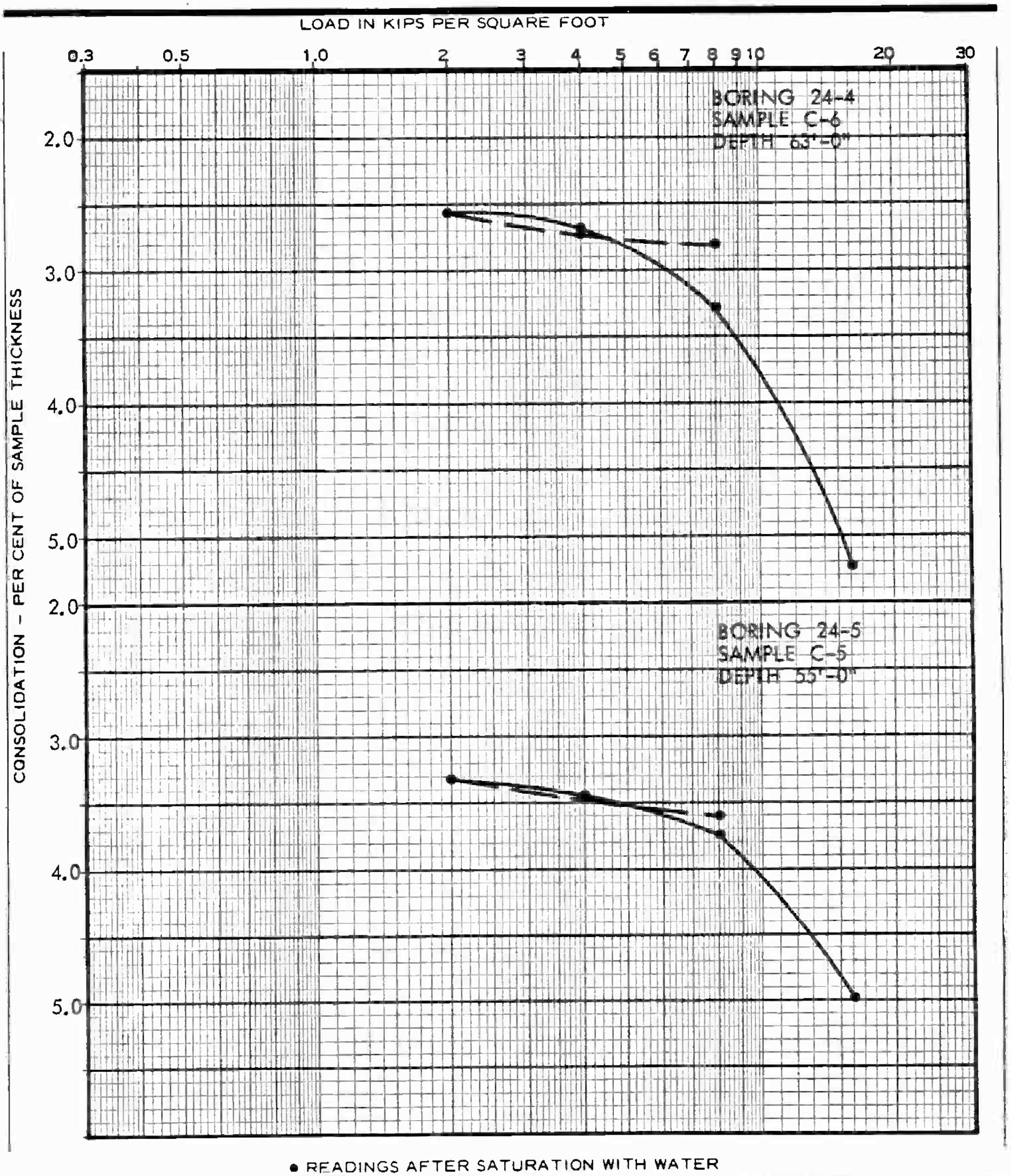

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Figure No.
E-56

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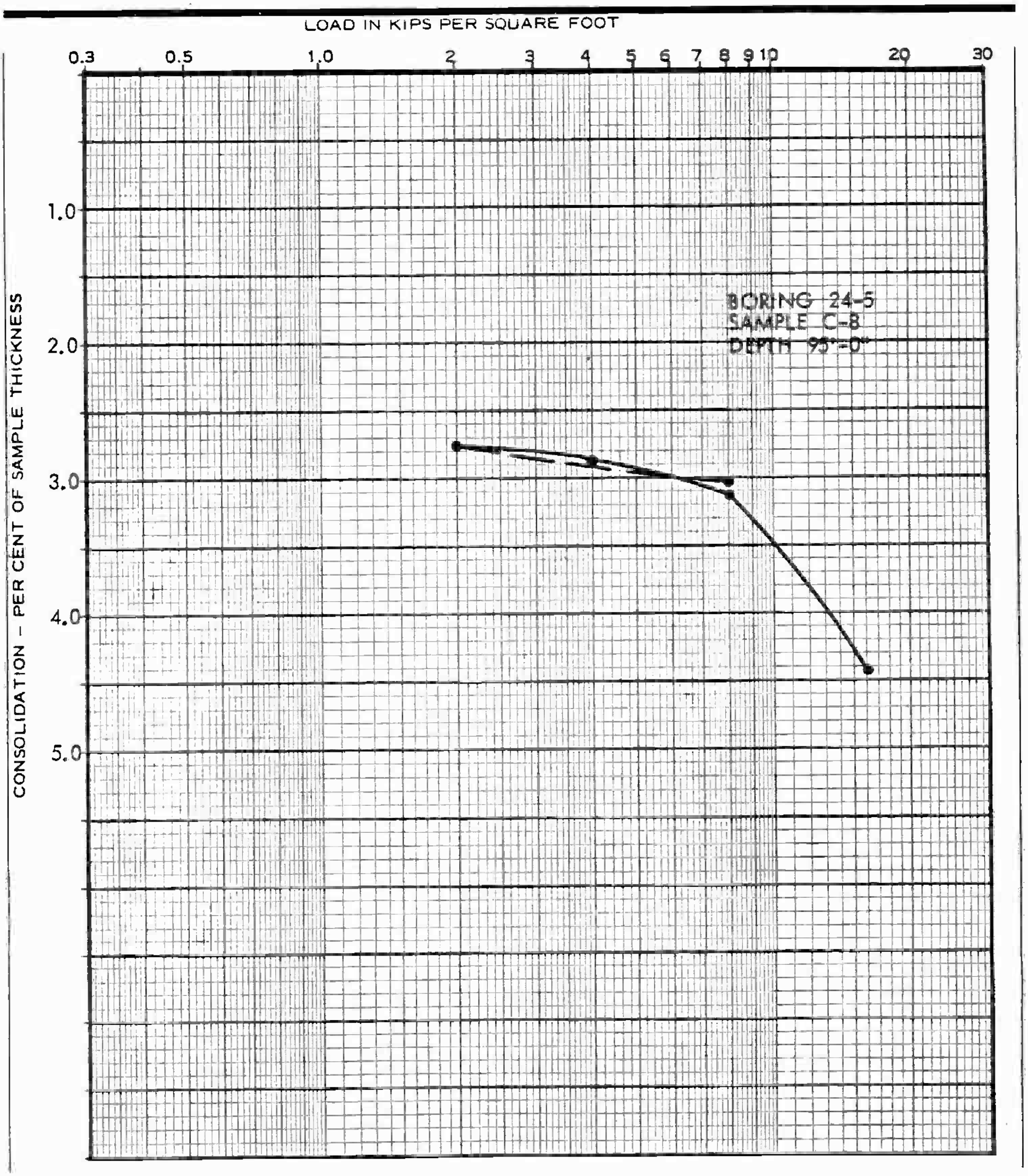

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TESTS

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Figure No.
E-57

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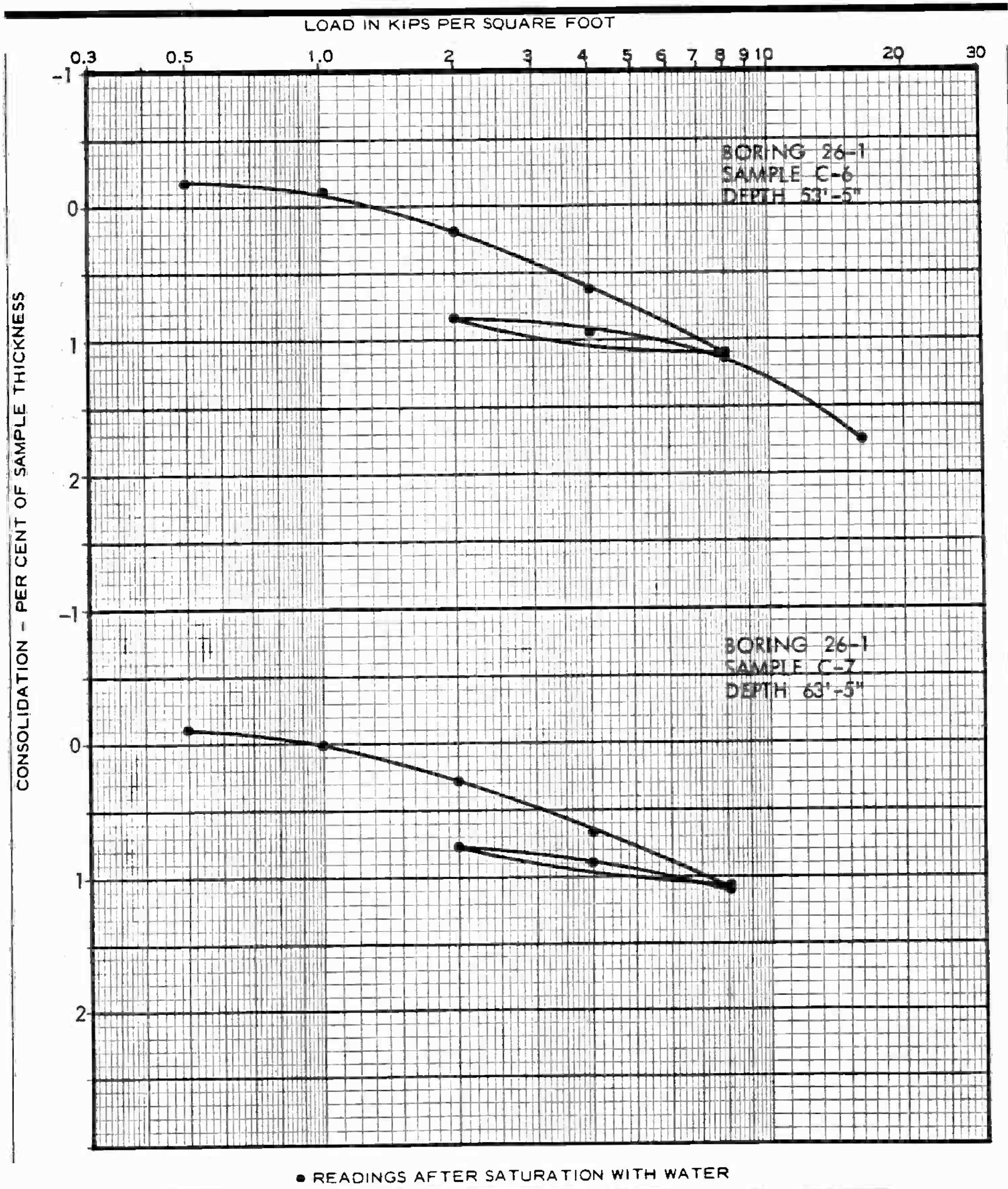

CONSOLIDATION TESTS

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Figure No.
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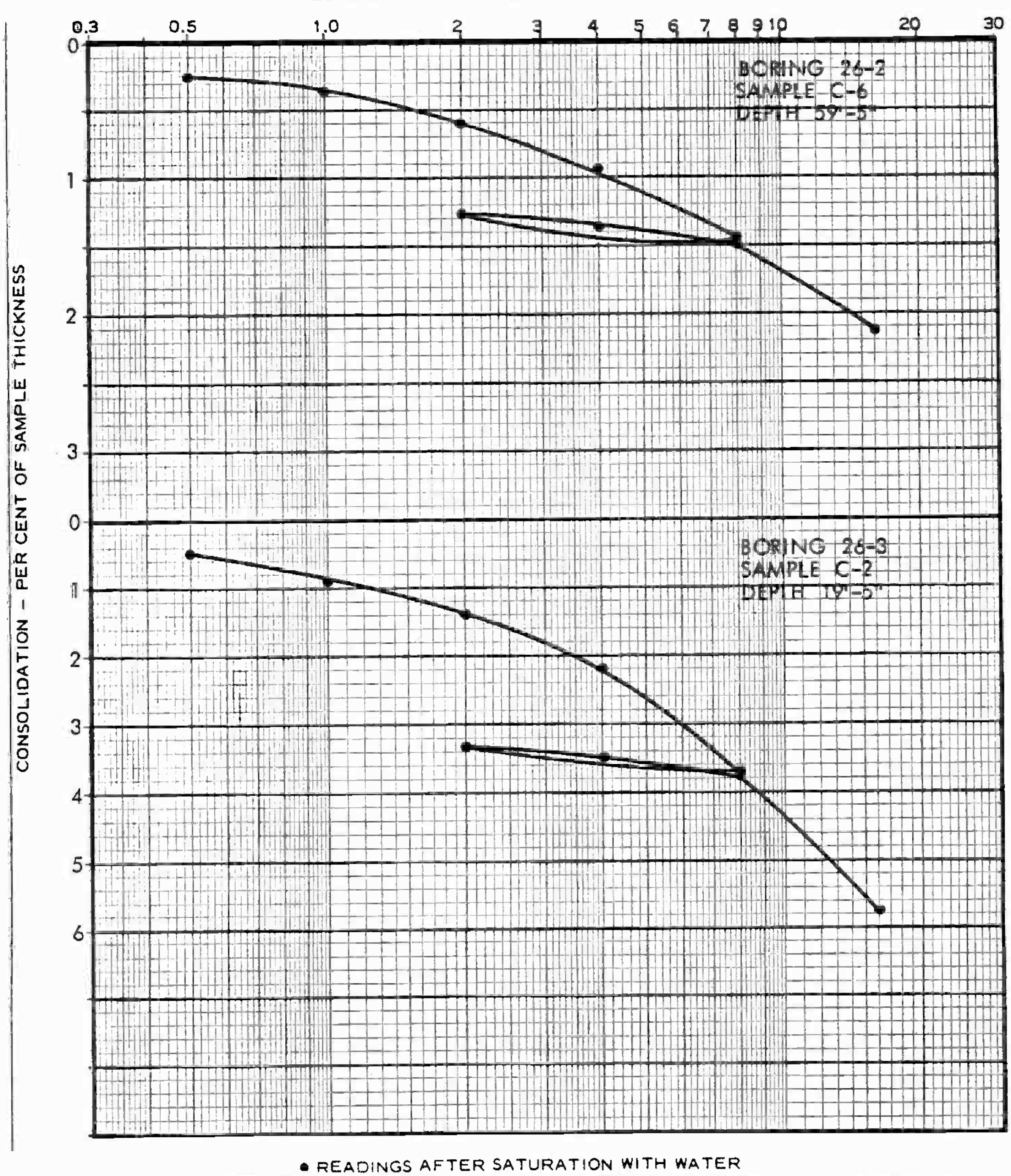

● READINGS AFTER SATURATION WITH WATER

CONSOLIDATION TESTS

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Figure No.
E-59

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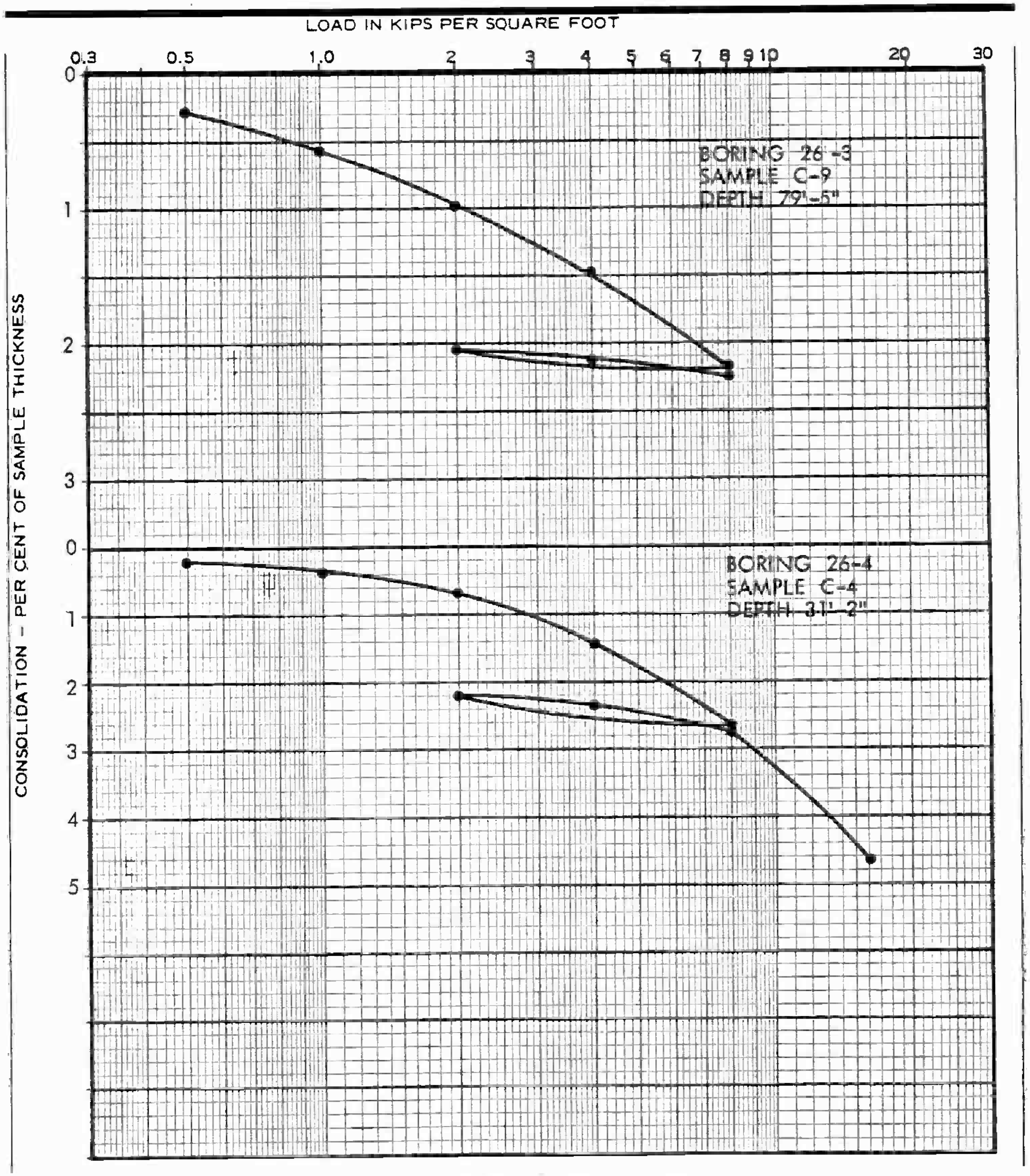

● READINGS AFTER SATURATION WITH WATER

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Figure No.
E-60

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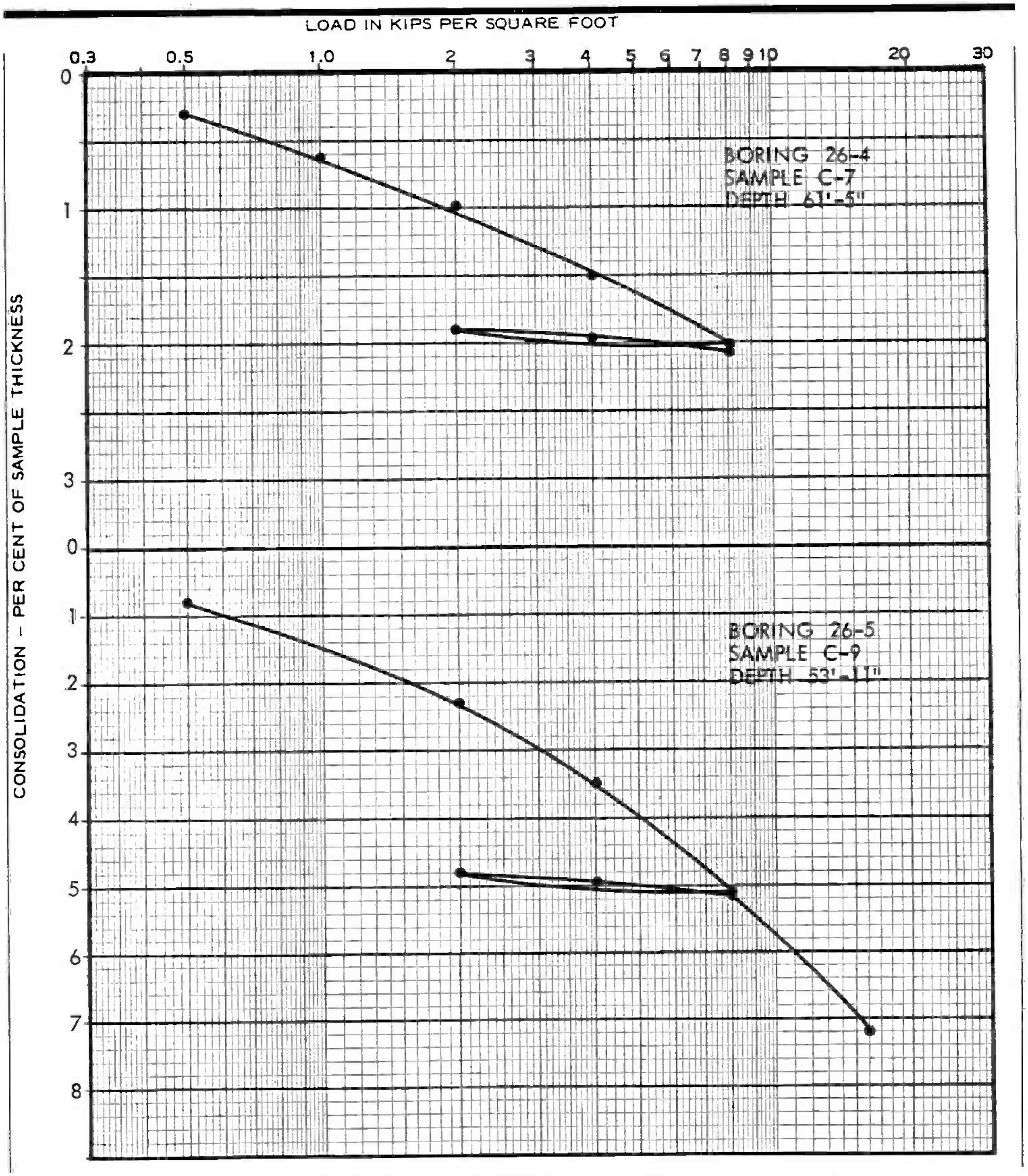

● READINGS AFTER SATURATION WITH WATER

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Figure No.
E-61

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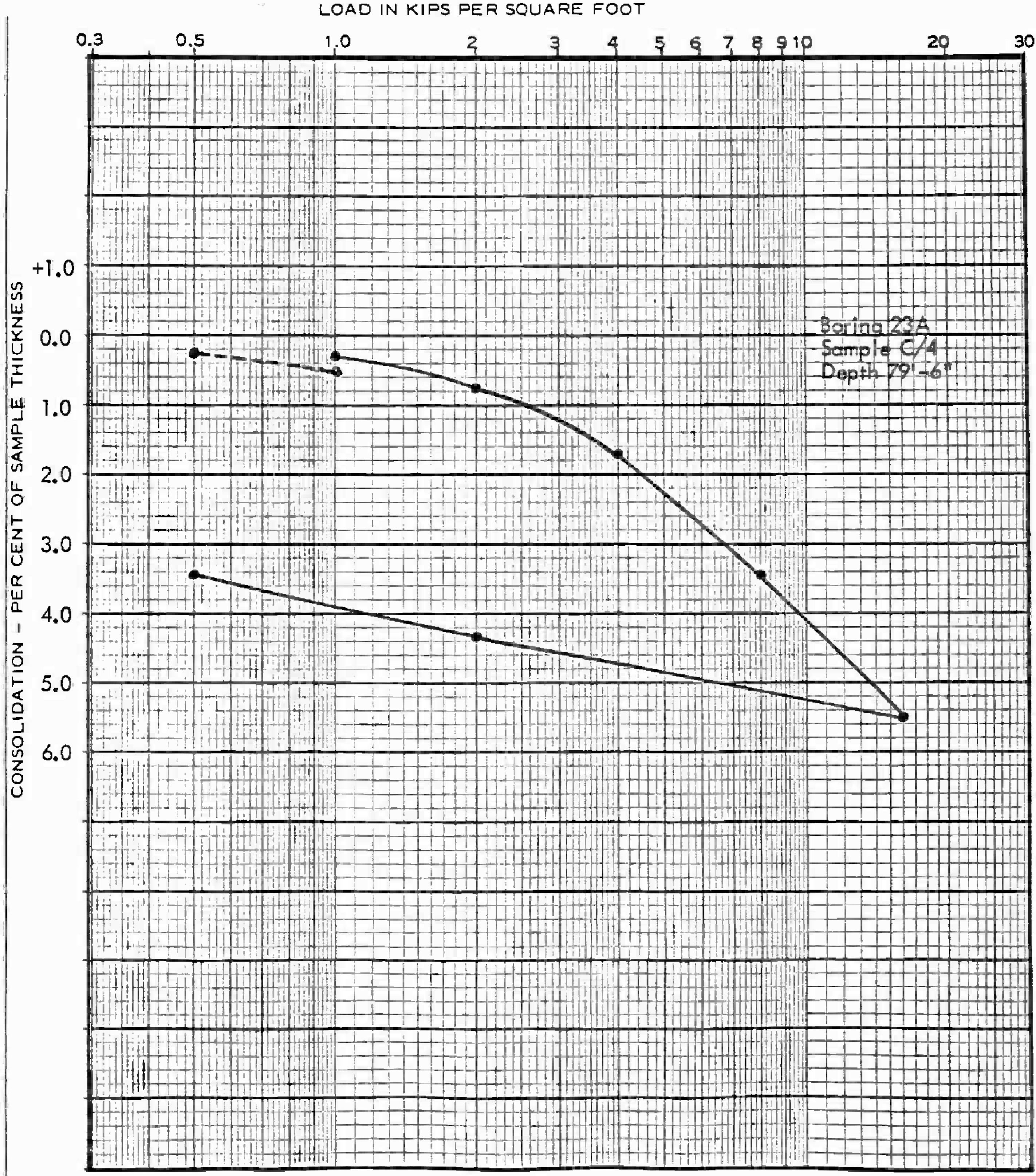

● READINGS AFTER SATURATION WITH WATER

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Figure No.
E-62

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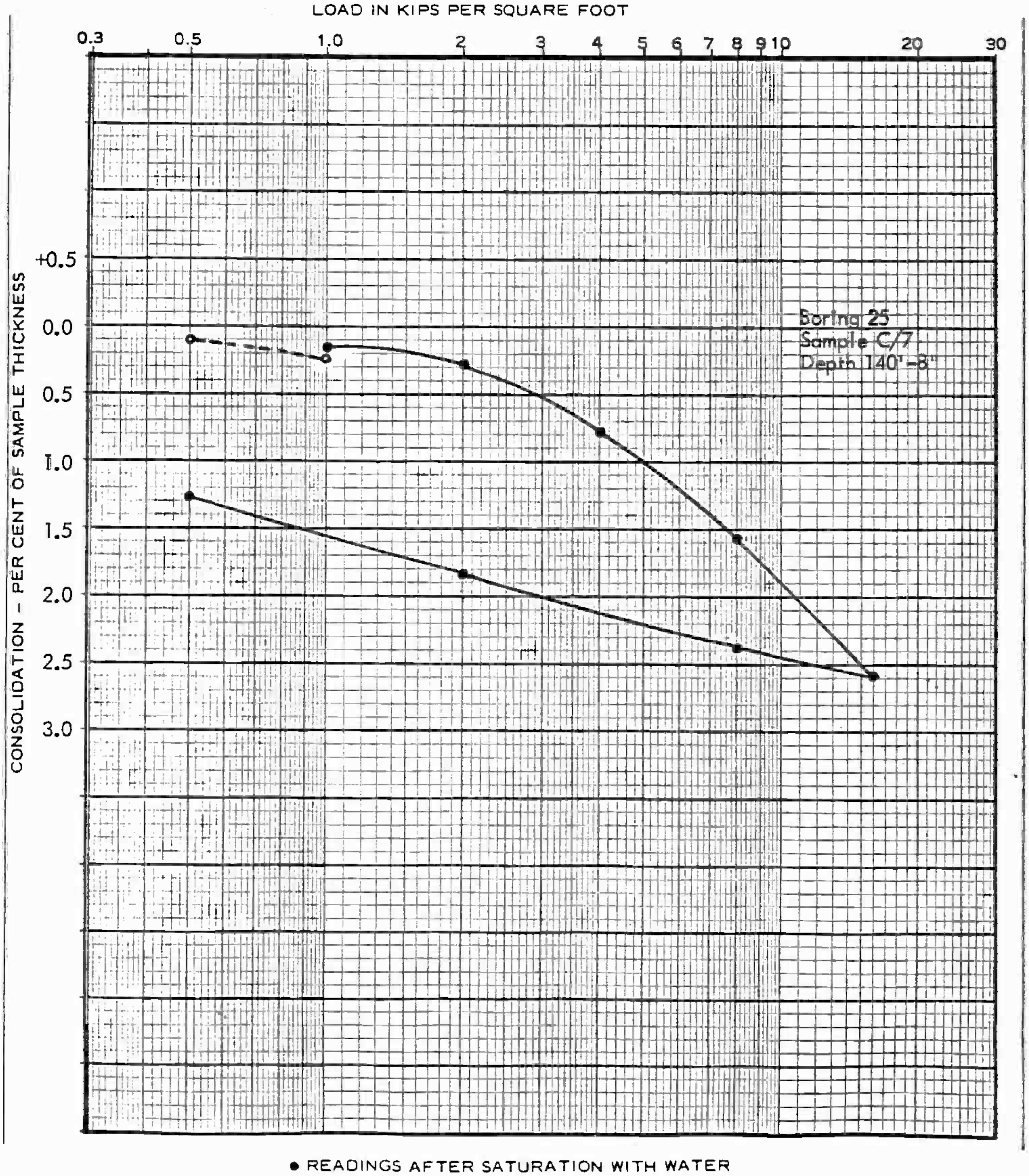

● READINGS AFTER SATURATION WITH WATER

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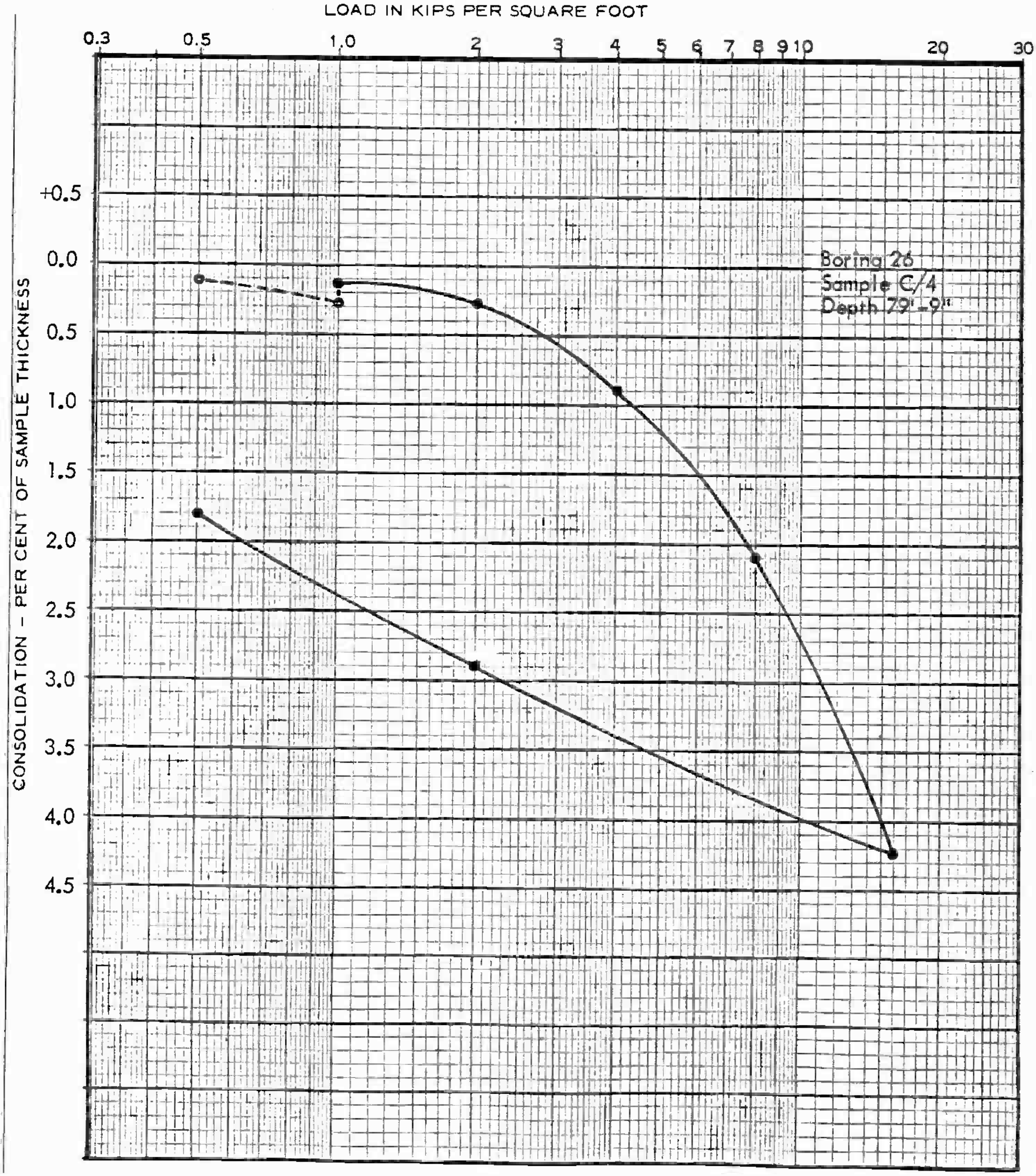
Figure No.
E-63

FORM NO. D1 Approved for publication ______ by ______



● READINGS AFTER SATURATION WITH WATER

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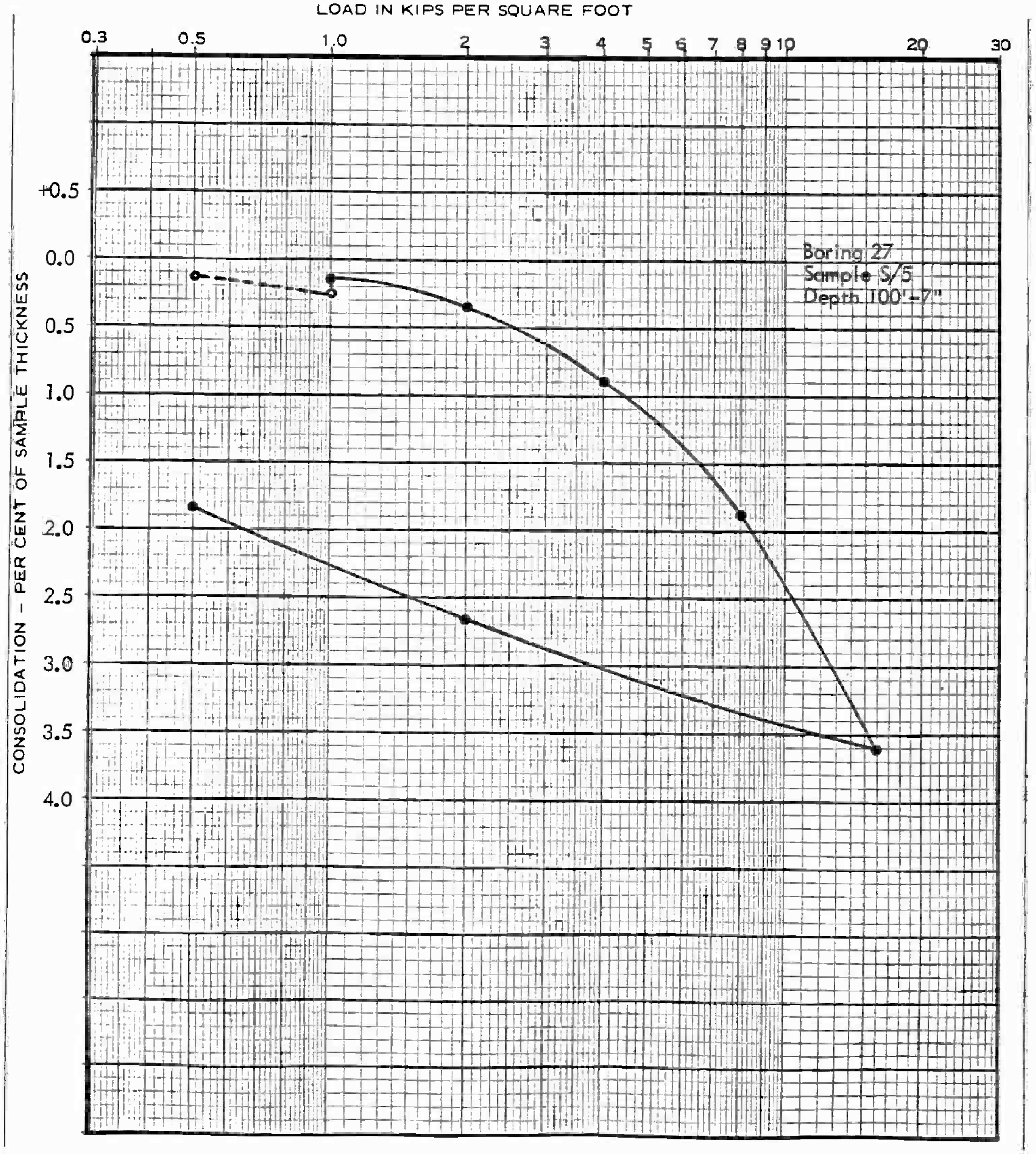
Figure No.
E-64

FORM NO. D Approved for publication ________ by ________



● READINGS AFTER SATURATION WITH WATER

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Figure No.
E-65

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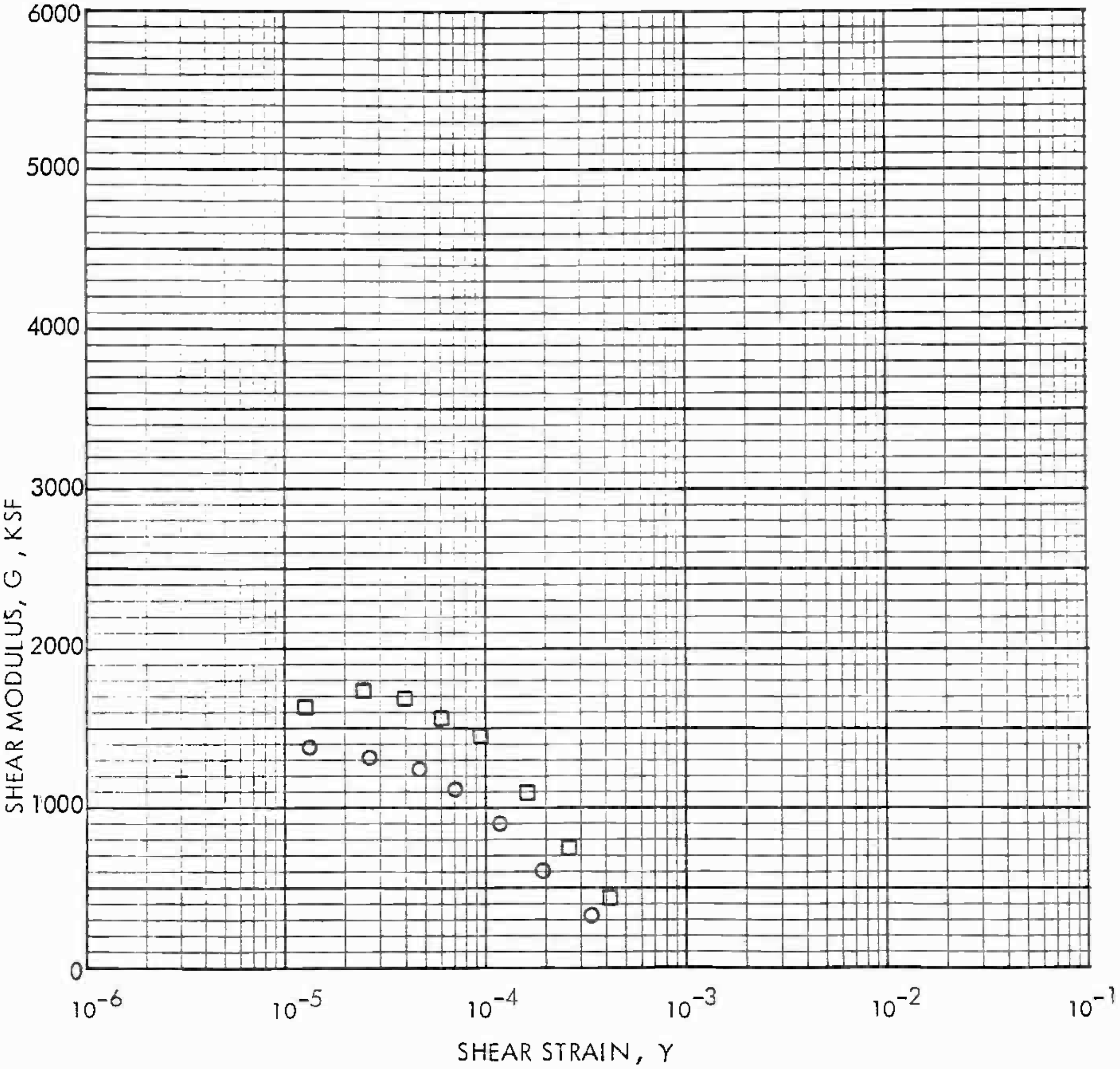
FORM NO. DI Approved for publication by

STRAIN DEPENDENT DYNAMIC SHEAR MODULUS



BORING	SAMPLE	DEPTH(FT)	γ_d(PCF)	w_o(%)	$\bar{\sigma}_c$(PSI)	SYMBOL
23A	C-2	39	105	23	30	○
					50	□

Sample Description: Brown Silty Clay; trace coarse sand and gravel, moist; stiff

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RESONANT COLUMN TEST

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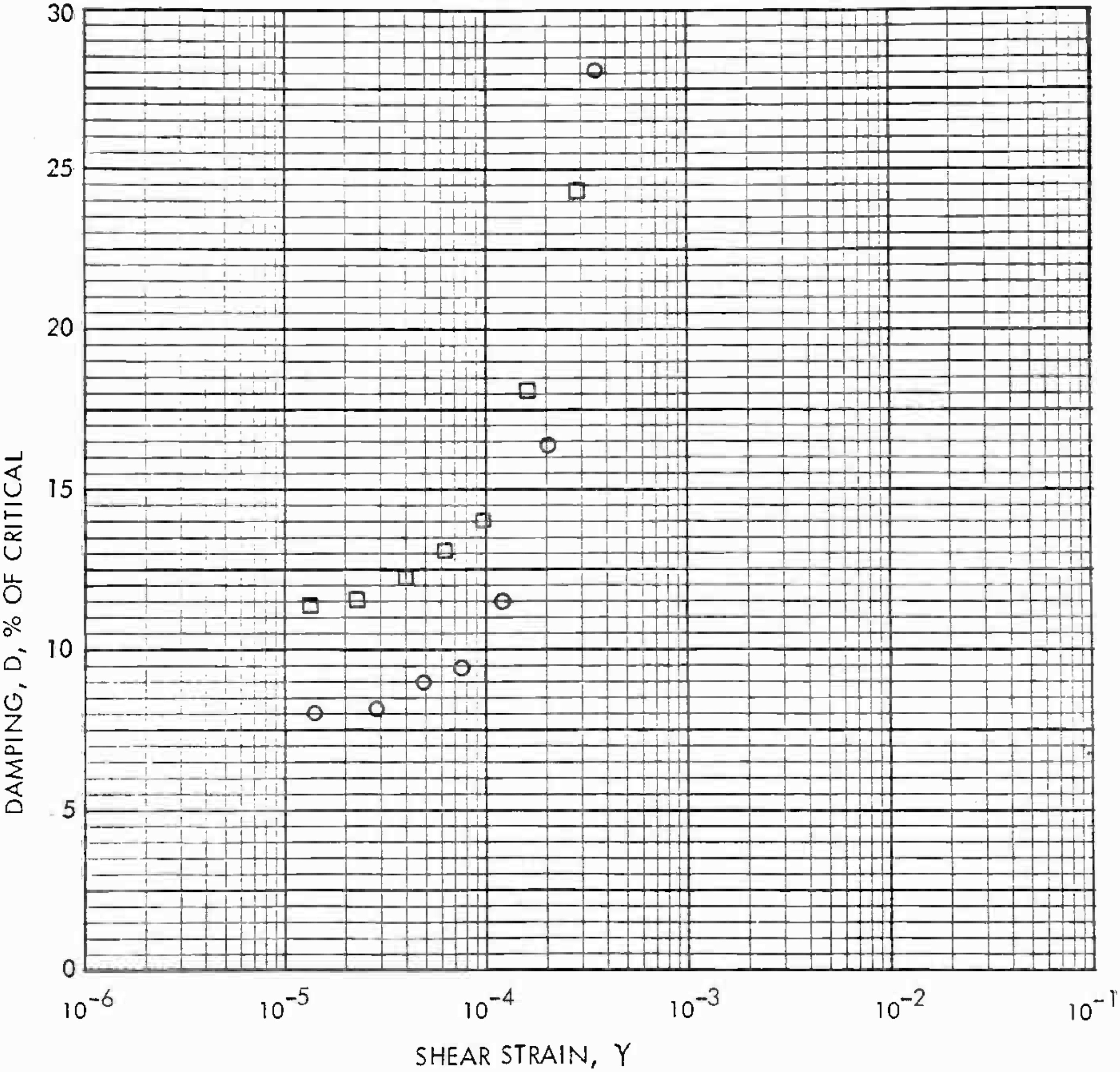
Figure No.
E-66

STRAIN DEPENDENT DAMPING



BORING	SAMPLE	DEPTH(FT)	γ_d(PCF)	w_o(%)	$\bar{\sigma}_c$(PSI)	SYMBOL
23A	C-2	39	105	23	30	○
					50	□

Sample Description: Brown Silty Clay; trace coarse sand and gravel, moist, stiff

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RESONANT COLUMN TEST

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83-1140

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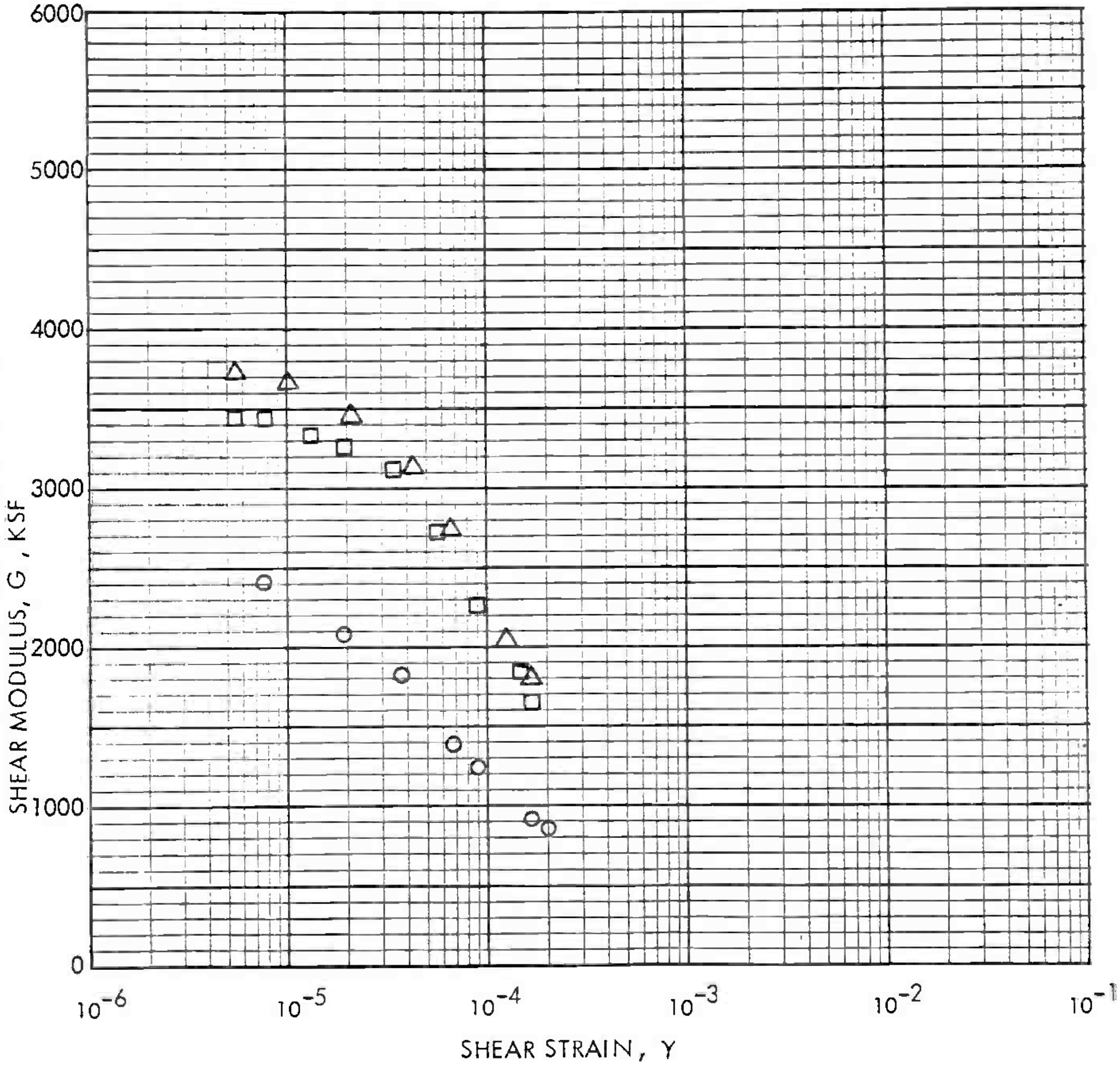
Figure No.
E-67

STRAIN DEPENDENT DYNAMIC SHEAR MODULUS



BORING	SAMPLE	DEPTH(FT)	γ_d(PCF)	w_o(%)	$\bar{\sigma}_c$(PSI)	SAMPLE
25	C-3	60	110	14	15	○
					25	□
					50	△

Sample Description: Brown Fine to Coarse Sandy Clay, trace gravel; moist, stiff

RESONANT COLUMN TEST

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Converse Consultants Geotechnical Engineering and Applied Sciences

Figure No.
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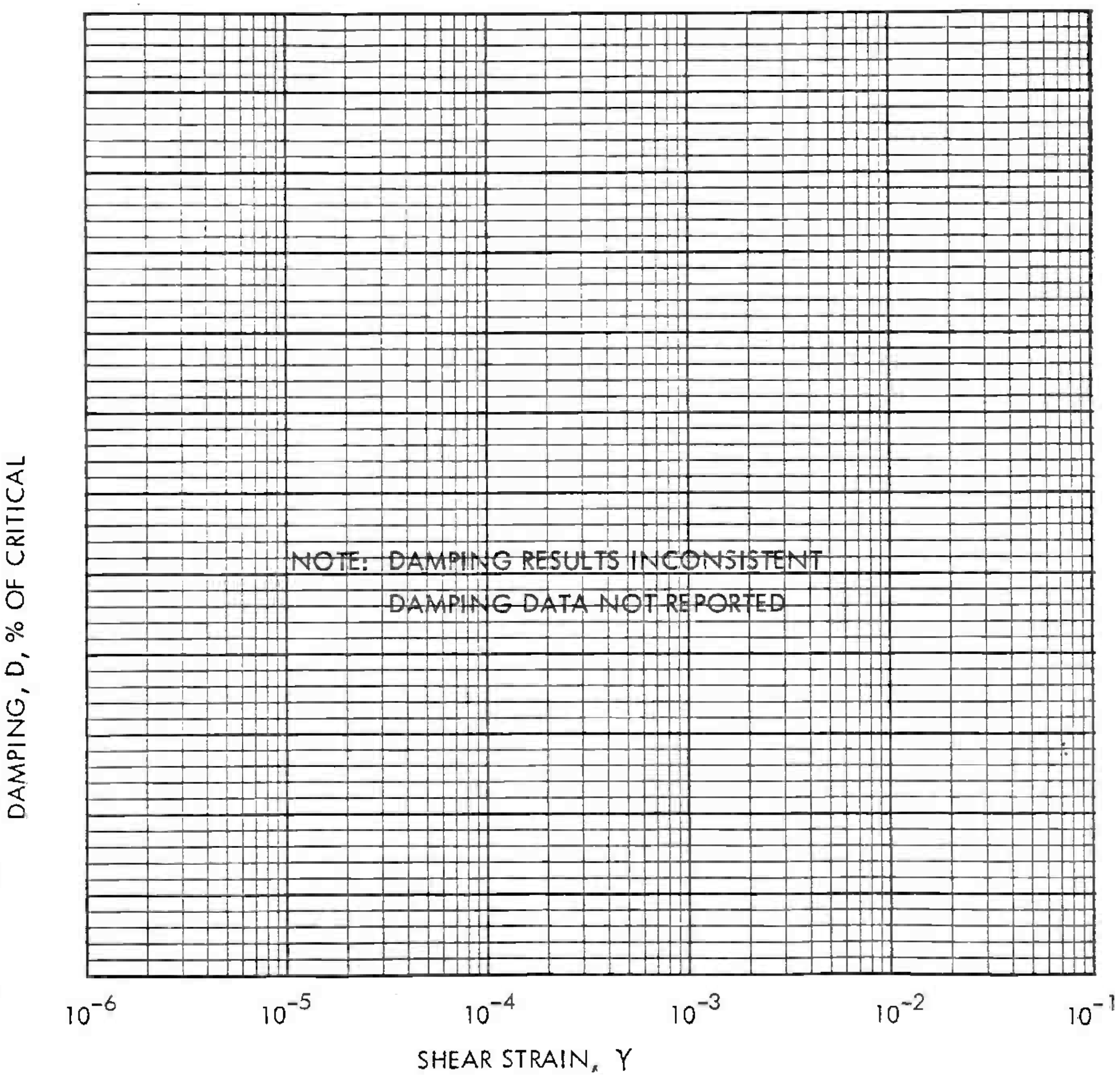
STRAIN DEPENDENT DAMPING



NOTE: DAMPING RESULTS INCONSISTENT
DAMPING DATA NOT REPORTED

BORING	SAMPLE	DEPTH(FT)	γ_d(PCF)	w_o(%)	$\bar{\sigma}_c$(PSI)	SYMBOL
25	C-3	60	110	14	15	○
					25	□
					50	△

Sample Description: Brown Fine to Coarse Sandy Clay, trace gravel; moist, stiff

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RESONANT COLUMN TEST

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Figure No.
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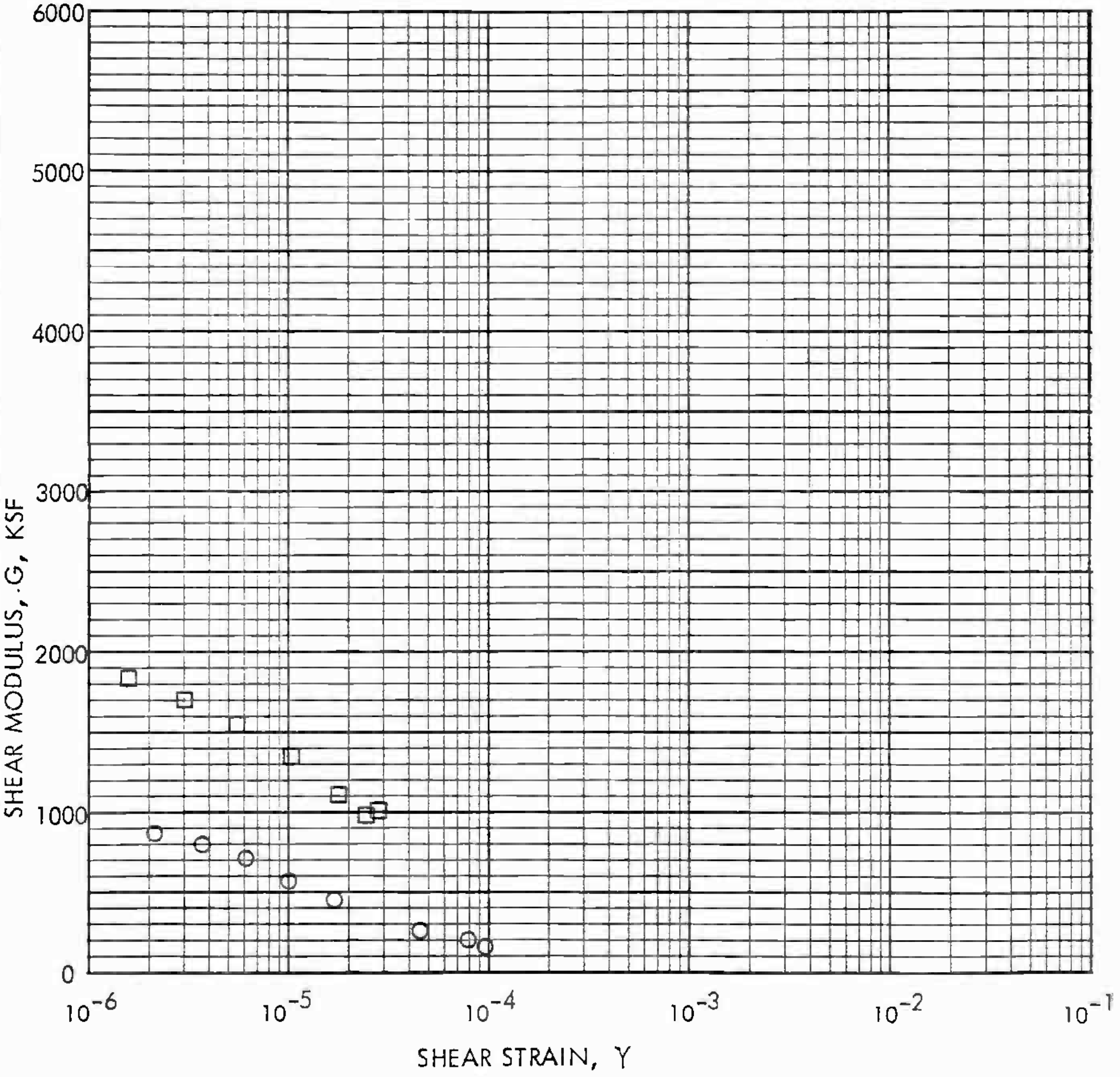
STRAIN DEPENDENT DYNAMIC SHEAR MODULUS



BORING	SAMPLE	DEPTH(FT),	γ_d(PCF)	w_o(%)	$\bar{\sigma}_c$(PSI)	SYMBOL
28	C-7	139	122	13	15	○
					50	□

Sample Description: Red-Brown Clayey fine to coarse Sand, dense

RESONANT COLUMN TEST

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Figure No.
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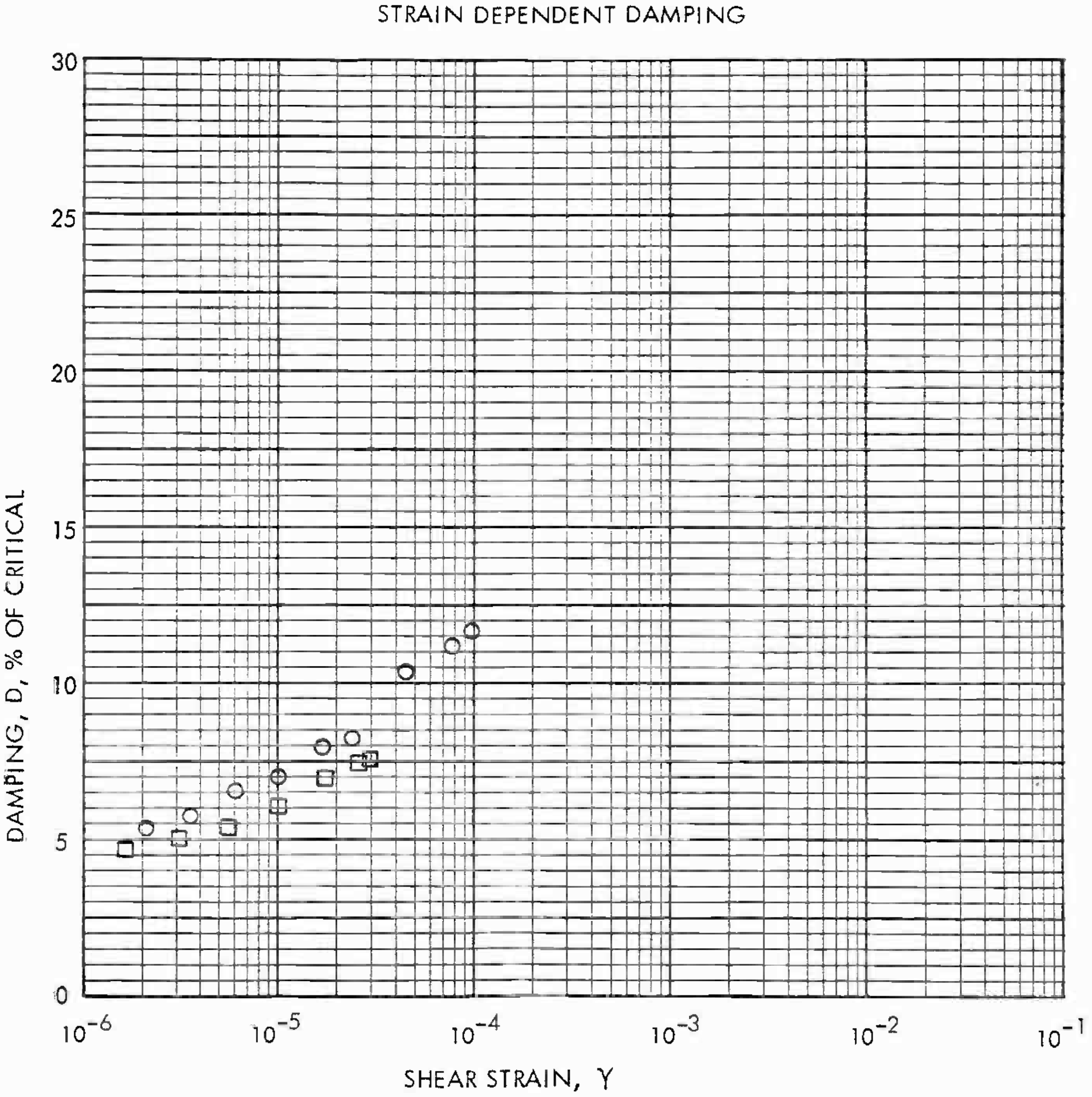

BORING	SAMPLE	DEPTH(FT)	γ_d(PCF)	w_o(PSI)	$\bar{\sigma}_c$(PSI)	SYMBOL
28	C-7	139	122	13	15	○
					50	□

Sample Description: Red-Brown Clayey fine to coarse Sand, dense

RESONANT COLUMN TEST

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Figure No.
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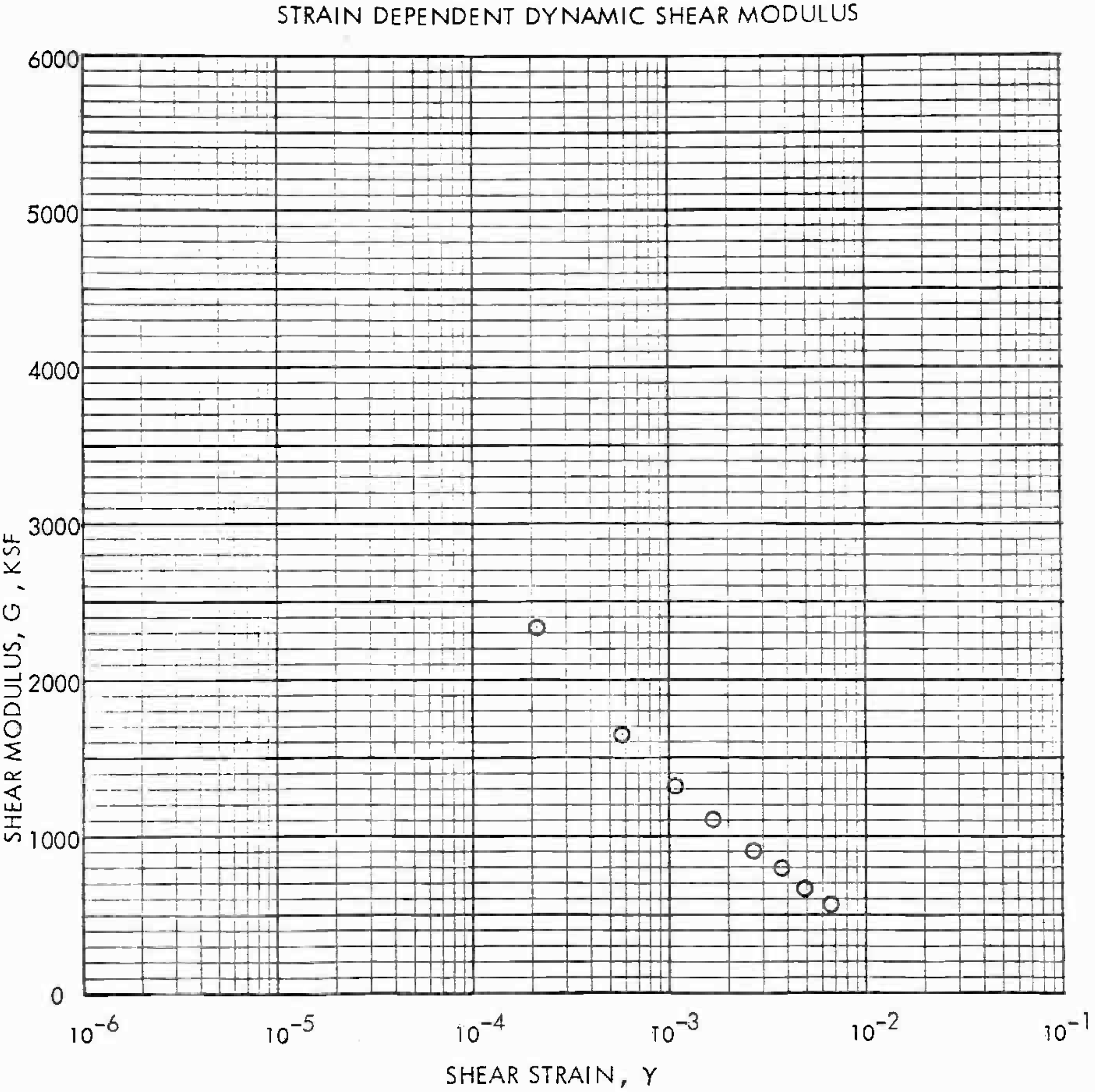

BORING	SAMPLE	DEPTH(FT)	γ_d(PCF)	w_o(%)	$\bar{\sigma}_c$(PSI)
23	C-4	41	100	24	30

Sample Description: Dark Gray Claystone; stiff

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DYNAMIC TRIAXIAL TEST

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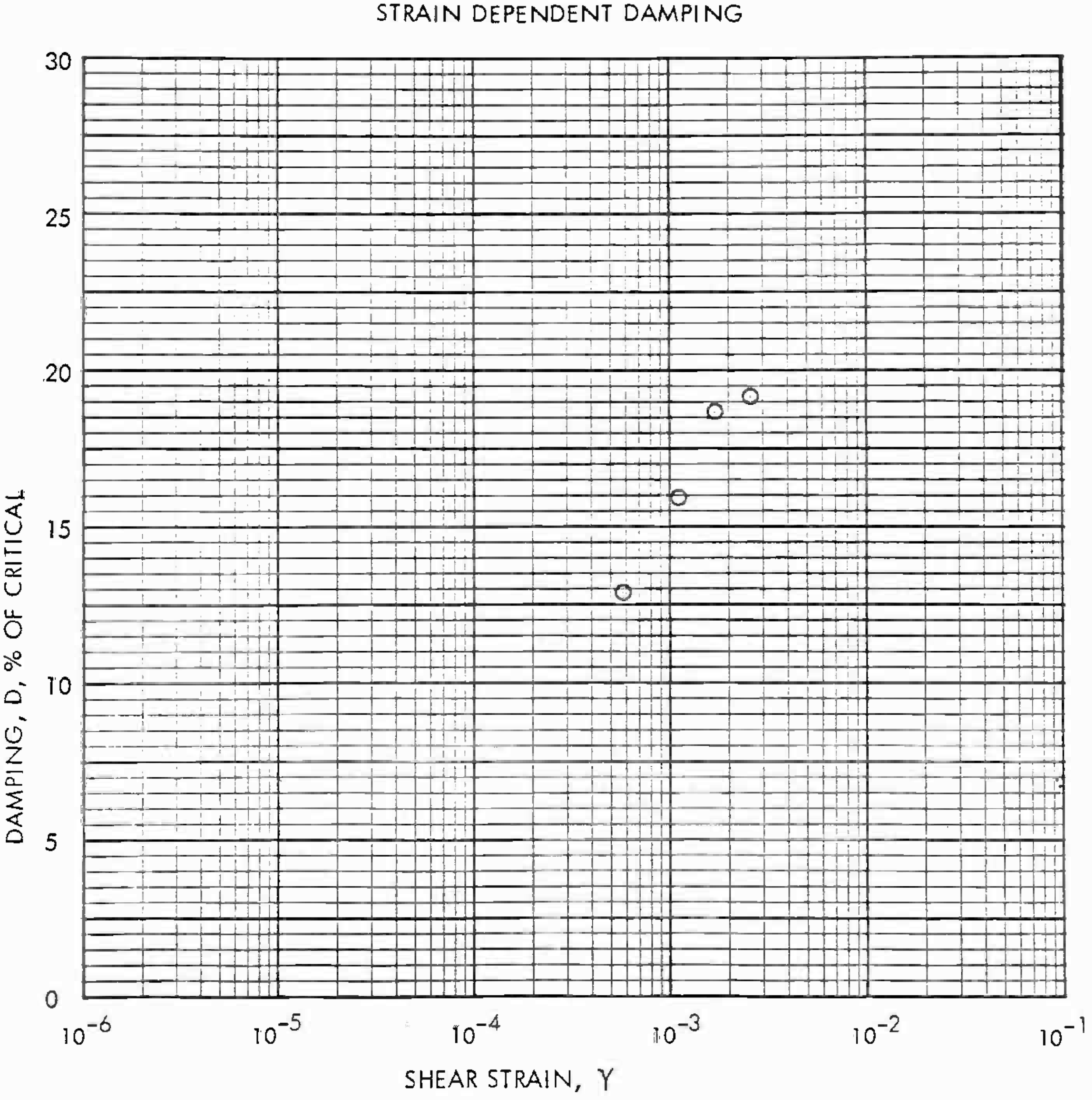
83-1140

Converse Consultants Geotechnical Engineering and Applied Sciences

Figure No.
E-72



BORING	SAMPLE	DEPTH(FT)	γ_d(PCF)	w_o(%)	$\bar{\sigma}_c$(PSI)
23	C-4	41	100	24	30

Sample Description: Dark Gray Claystone; stiff

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DYNAMIC TRIAXIAL TEST

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METRO RAIL PROJECT

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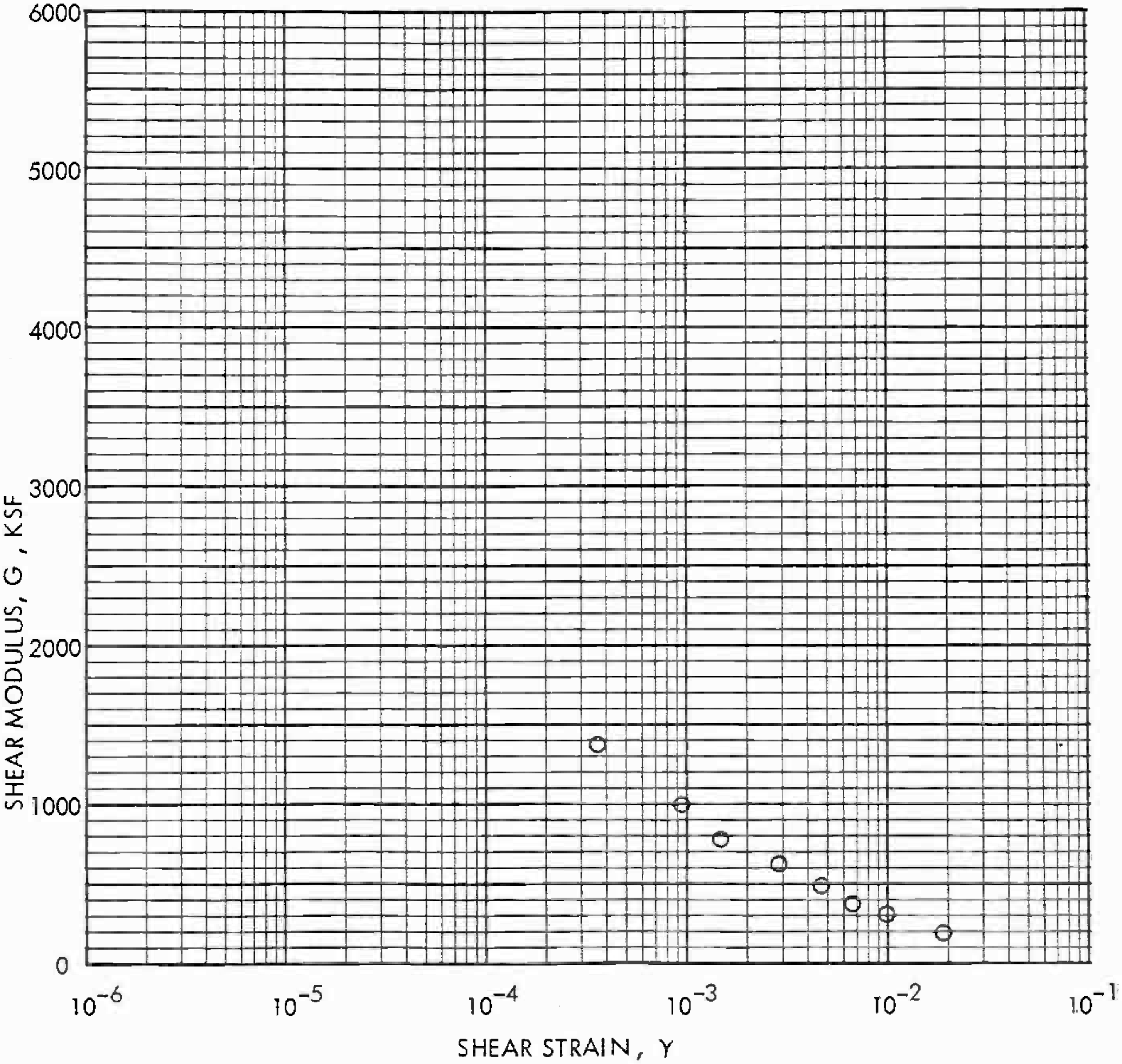
83-1140

Converse Consultants Geotechnical Engineering and Applied Sciences

Figure No.
E-73

STRAIN DEPENDENT DYNAMIC SHEAR MODULUS



BORING	SAMPLE	DEPTH(FT)	γ_d(PCF)	w_o(%)	$\bar{\sigma}_c$(PSI)	SYMBOL
23	C-6	56	86	34	30	○

Sample Description: Green-Brown slightly Clayey, Sandy Silt; firm

DYNAMIC TRIAXIAL TEST

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Figure No.
E-74

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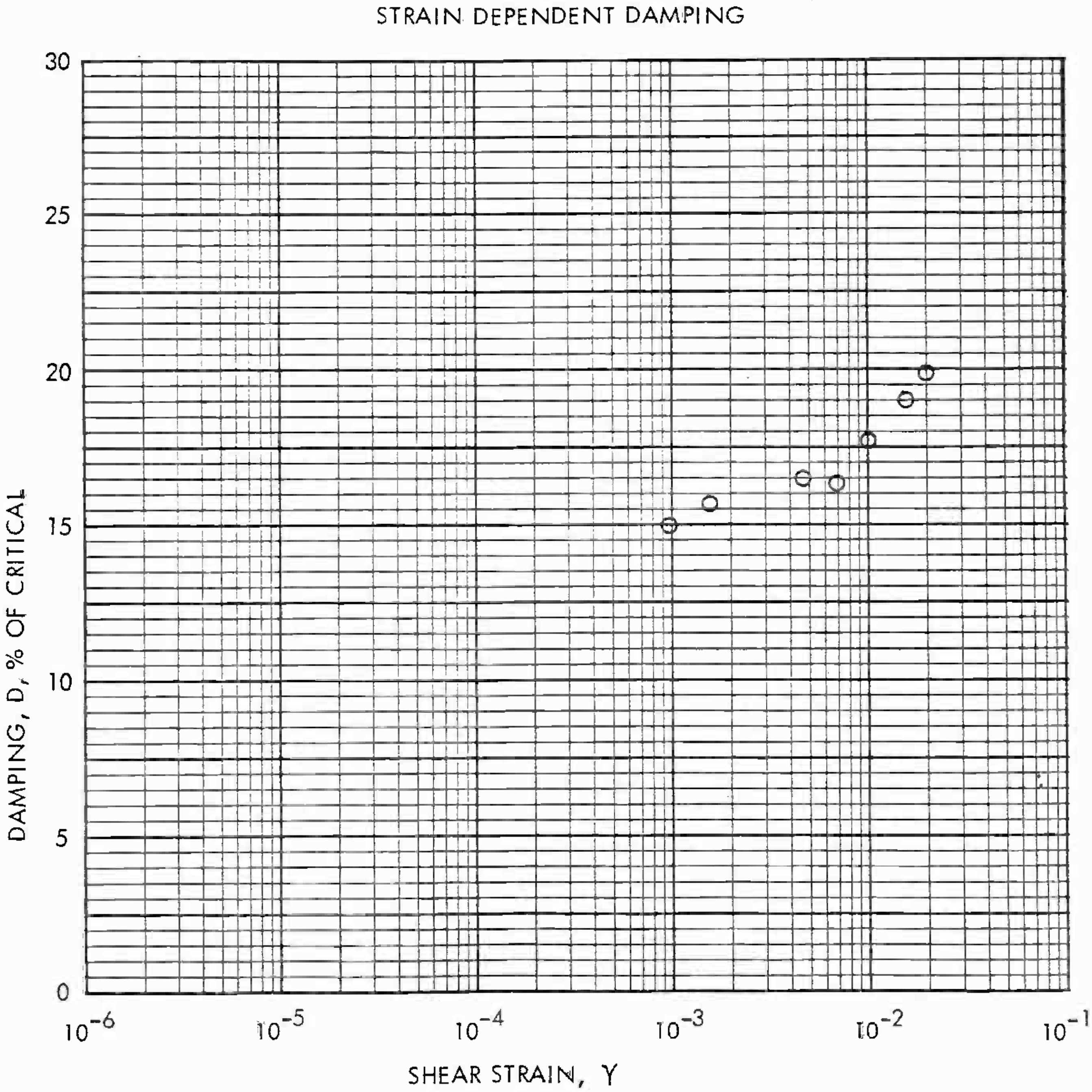

BORING	SAMPLE	DEPTH(FT)	γ_d(PCF)	w_o(%)	$\bar{\sigma}_c$(PSI)	SYMBOL
23	C-6	56	86	34	30	○

Sample Description: Green-Brown slightly Clayey, Sandy Silt; firm

DYNAMIC TRIAXIAL TEST

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Project No.
83-1140

Figure No.
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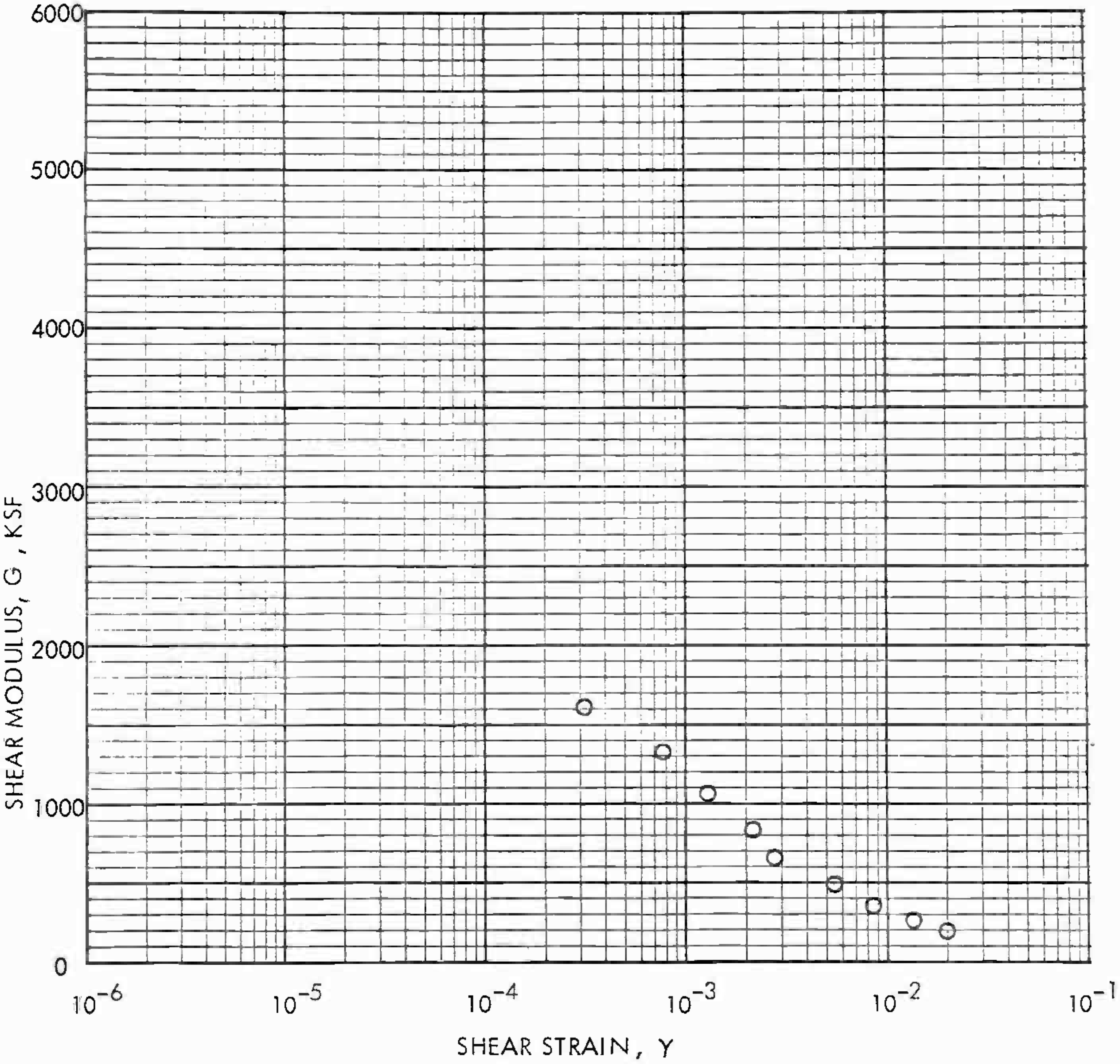
STRAIN DEPENDENT DYNAMIC SHEAR MODULUS



BORING	SAMPLE	DEPTH(FT)	γ_d(PCF)	w_o(%)	$\bar{\sigma}_c$(PSI)
23A	C-2	40	101	24	30

Sample Description: Silty Clay, slightly sandy; stiff

DYNAMIC TRIAXIAL TEST

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Figure No.
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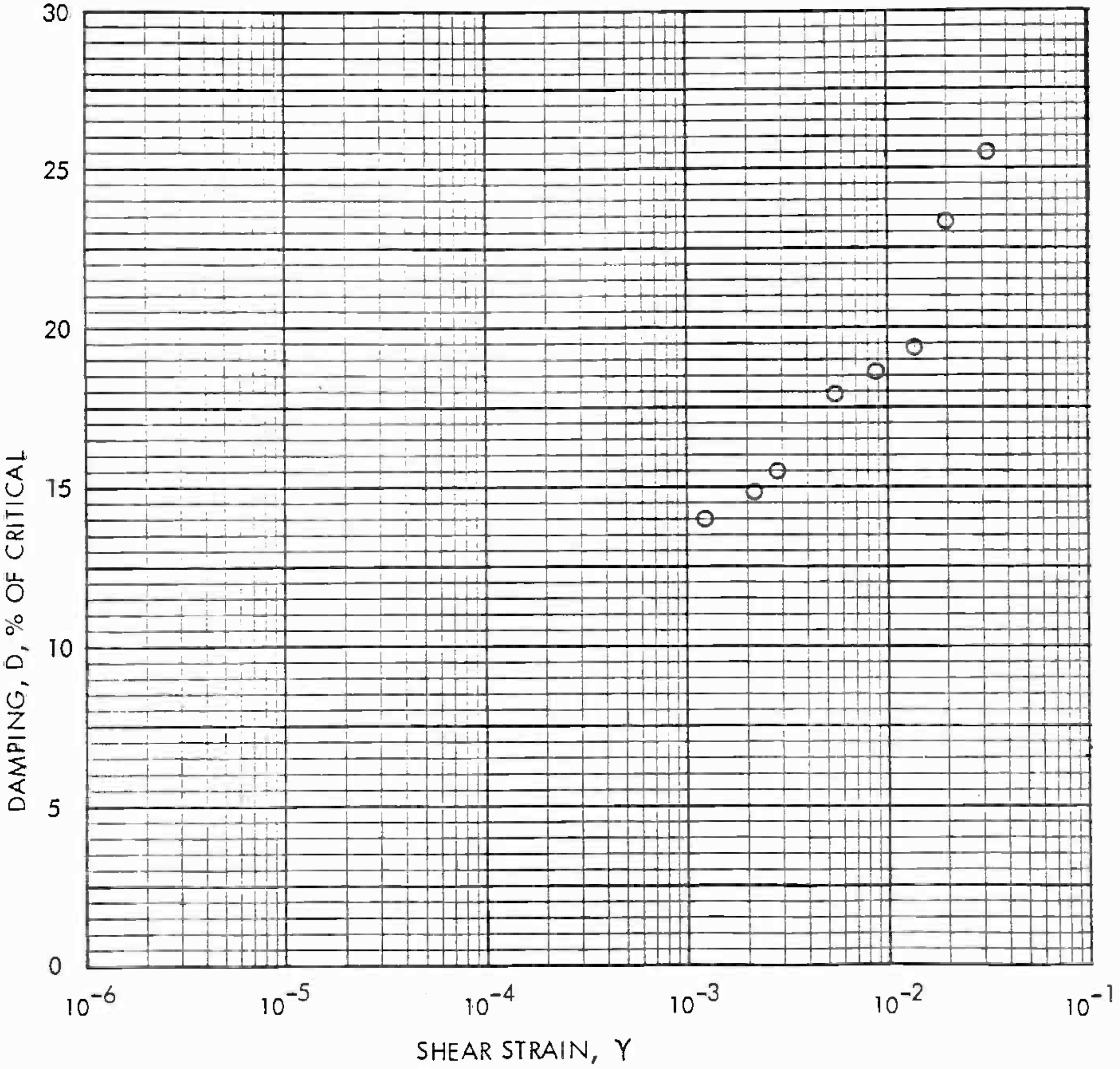
STRAIN DEPENDENT DAMPING



BORING	SAMPLE	DEPTH(FT)	γ_d(PCF)	w_o(%)	$\bar{\sigma}_c$(PSI)
23A	C-2	40	101	24	30

Sample Description: Silty Clay, slightly sand; moist

DYNAMIC TRIAXIAL TEST

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Figure No.
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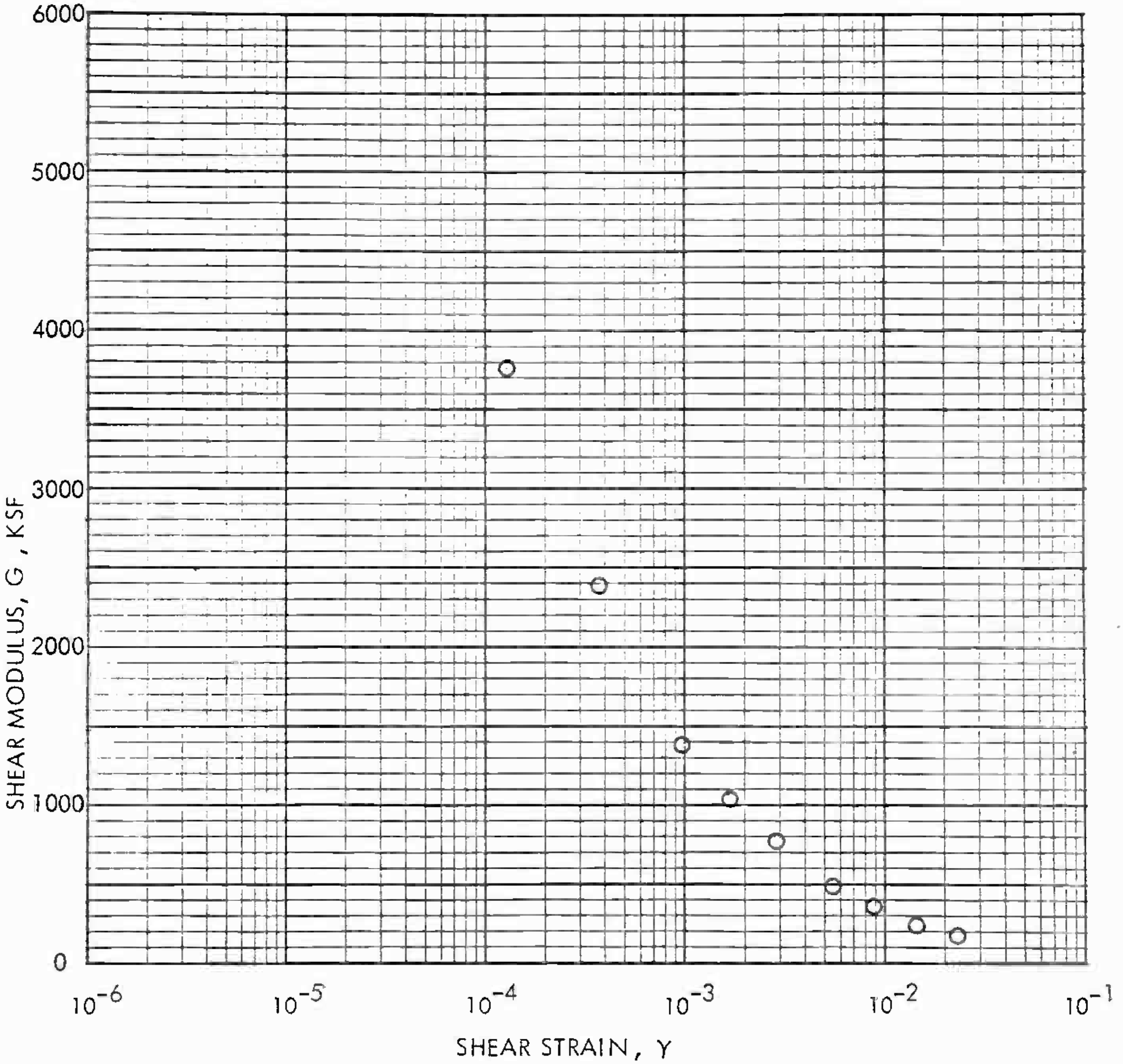
STRAIN DEPENDENT DYNAMIC SHEAR MODULUS



BORING	SAMPLE	DEPTH(FT)	γ_d(PCF)	w_o(%)	$\bar{\sigma}_c$(PSI)
24	C-7	141			30

Sample Description: Brown slightly Clayey Sand; dense, fine to coarse graded

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Figure No.
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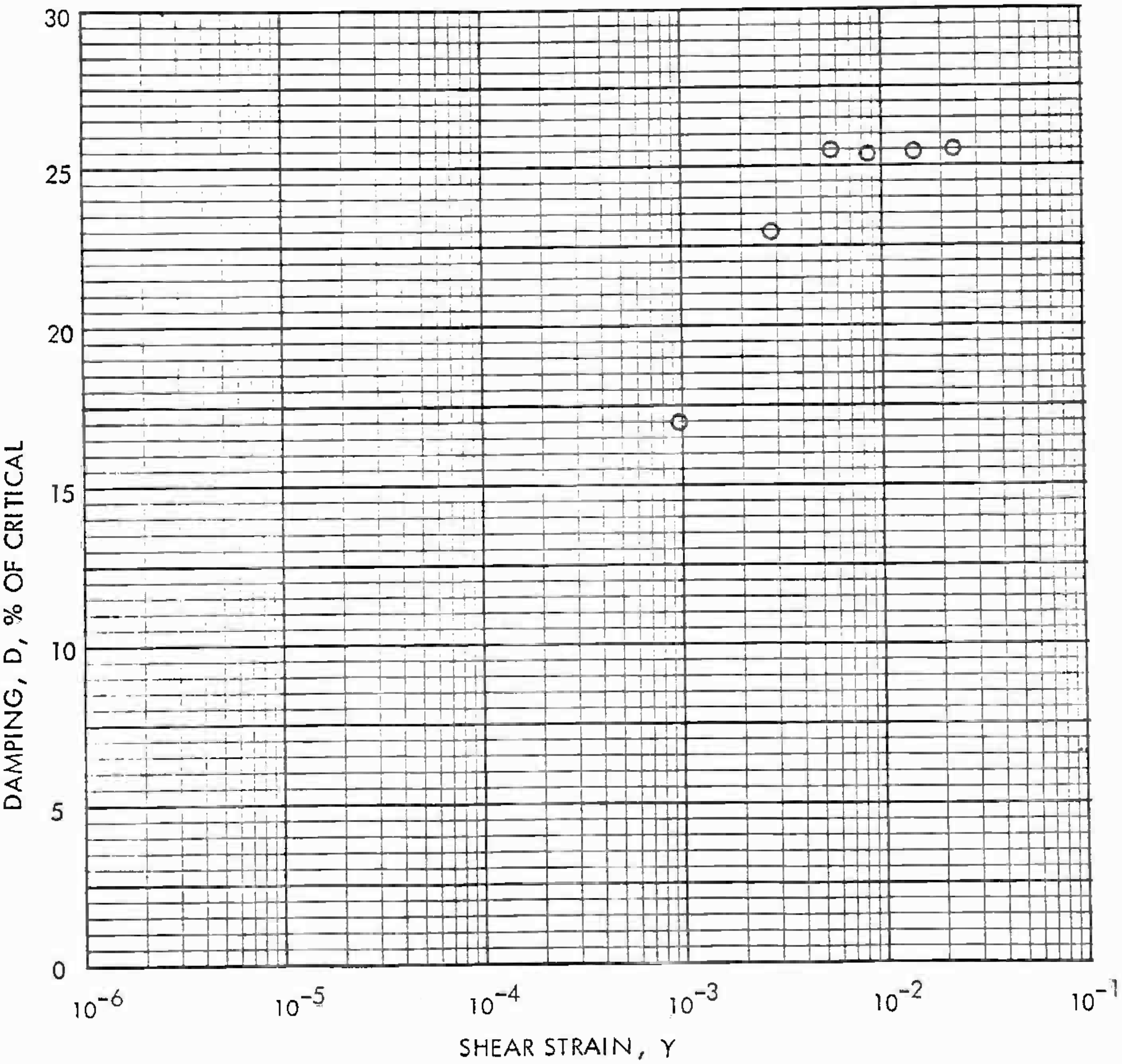
STRAIN DEPENDENT DAMPING



BORING	SAMPLE	DEPTH(FT)	γ_d(PCF)	w_o(%)	$\bar{\sigma}_c$(PSI)
24	C-7	141			30

Sample Description: Brown slightly Clayey Sand; dense, fine to coarse graded

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Figure No.
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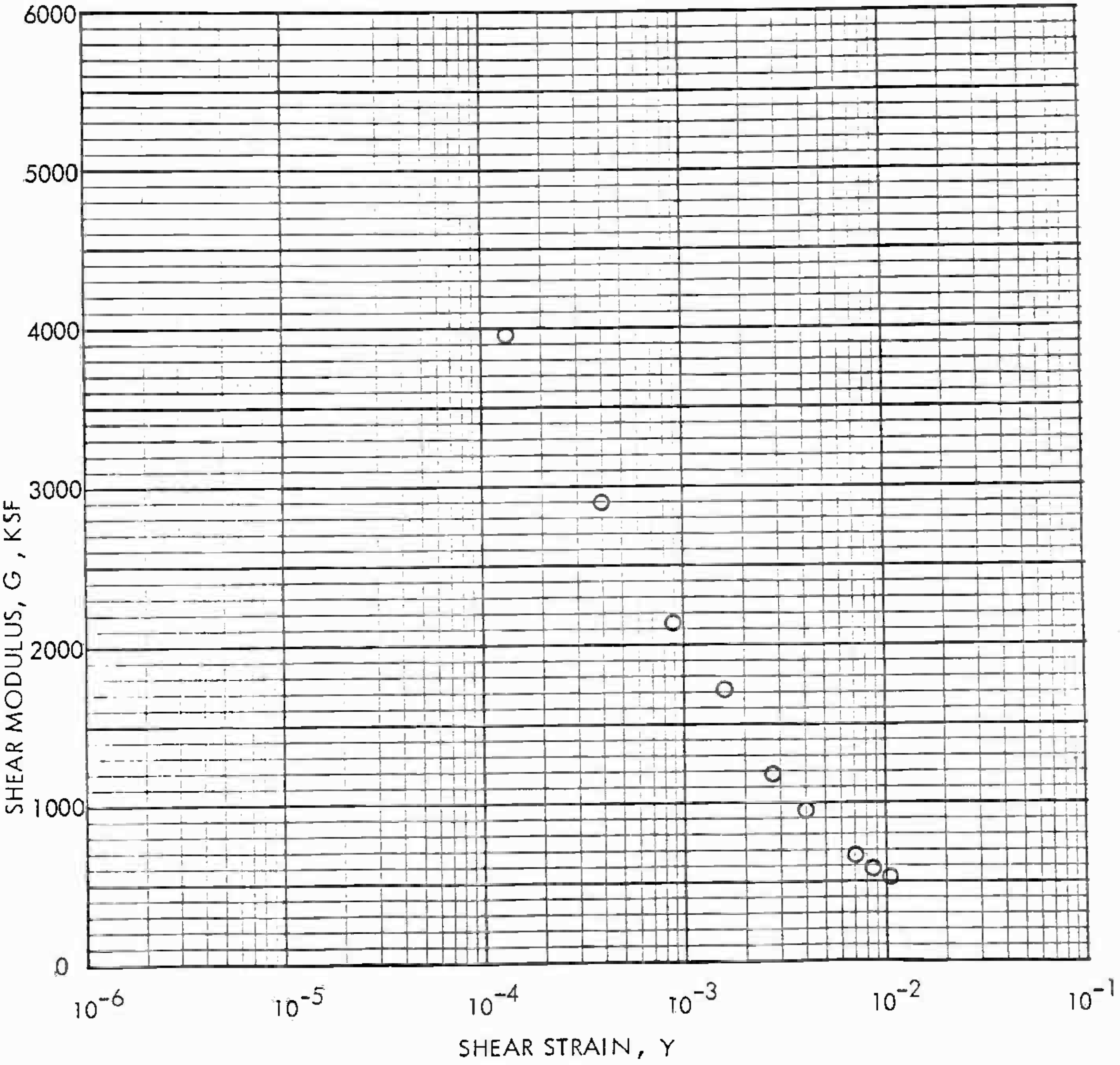
STRAIN DEPENDENT DYNAMIC SHEAR MODULUS



BORING	SAMPLE	DEPTH(FT)	γ_d(PCF)	w_o(%)	$\bar{\sigma}_c$(PSI)
26	S-2	158	115	16	50

Sample Description: Brown Silty Clayey Sand; very dense, fine to coarse graded

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DYNAMIC TRIAXIAL TEST

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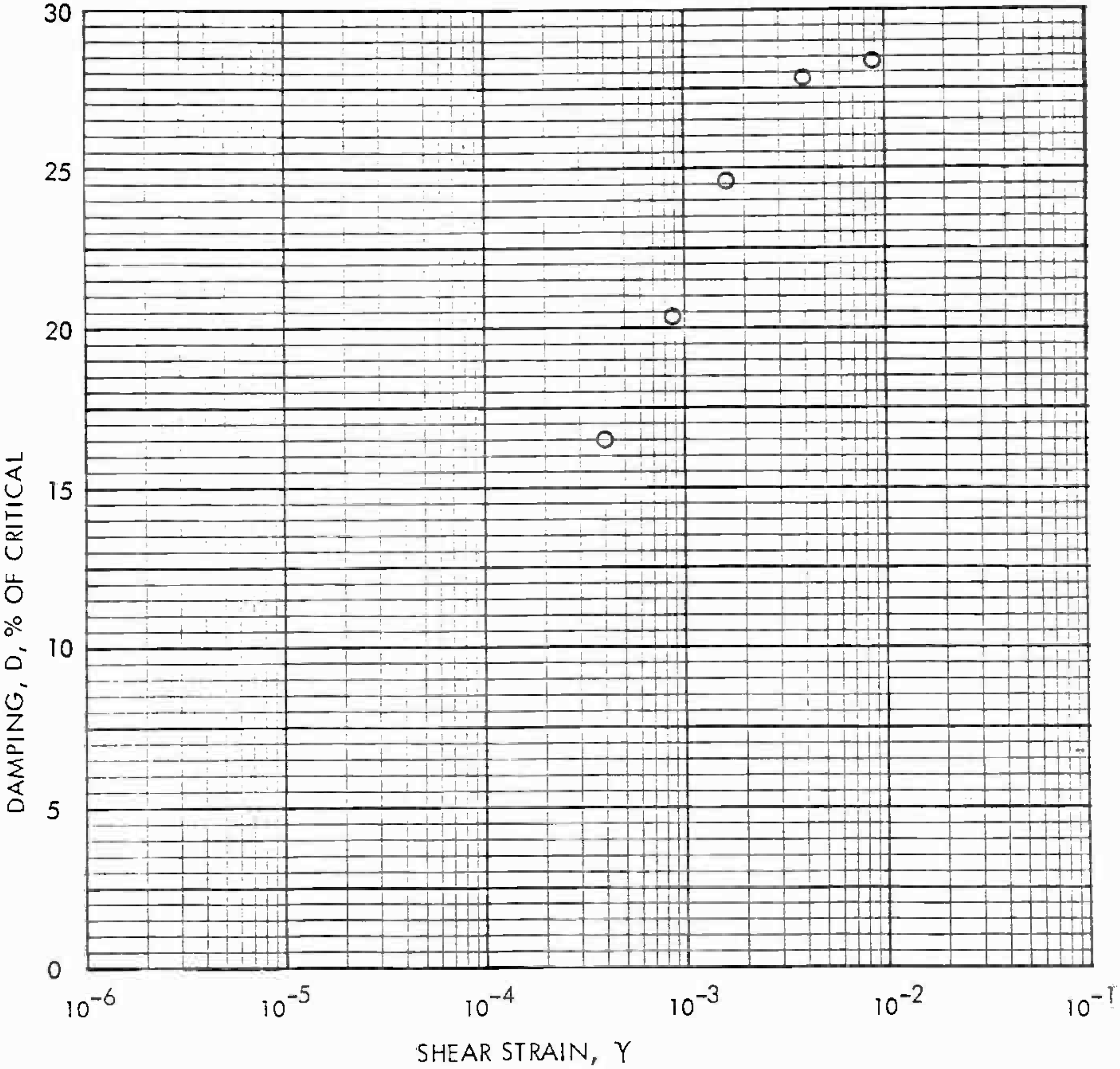
Figure No.
E-80

STRAIN DEPENDENT DAMPING



BORING	SAMPLE	DEPTH(FT)	γ_d(PCF)	w_o(%)	$\bar{\sigma}_c$(PSI)
26	S-2	158	115	16	50

Sample Description: Brown Silty Clayey Sand; very dense, fine to coarse graded

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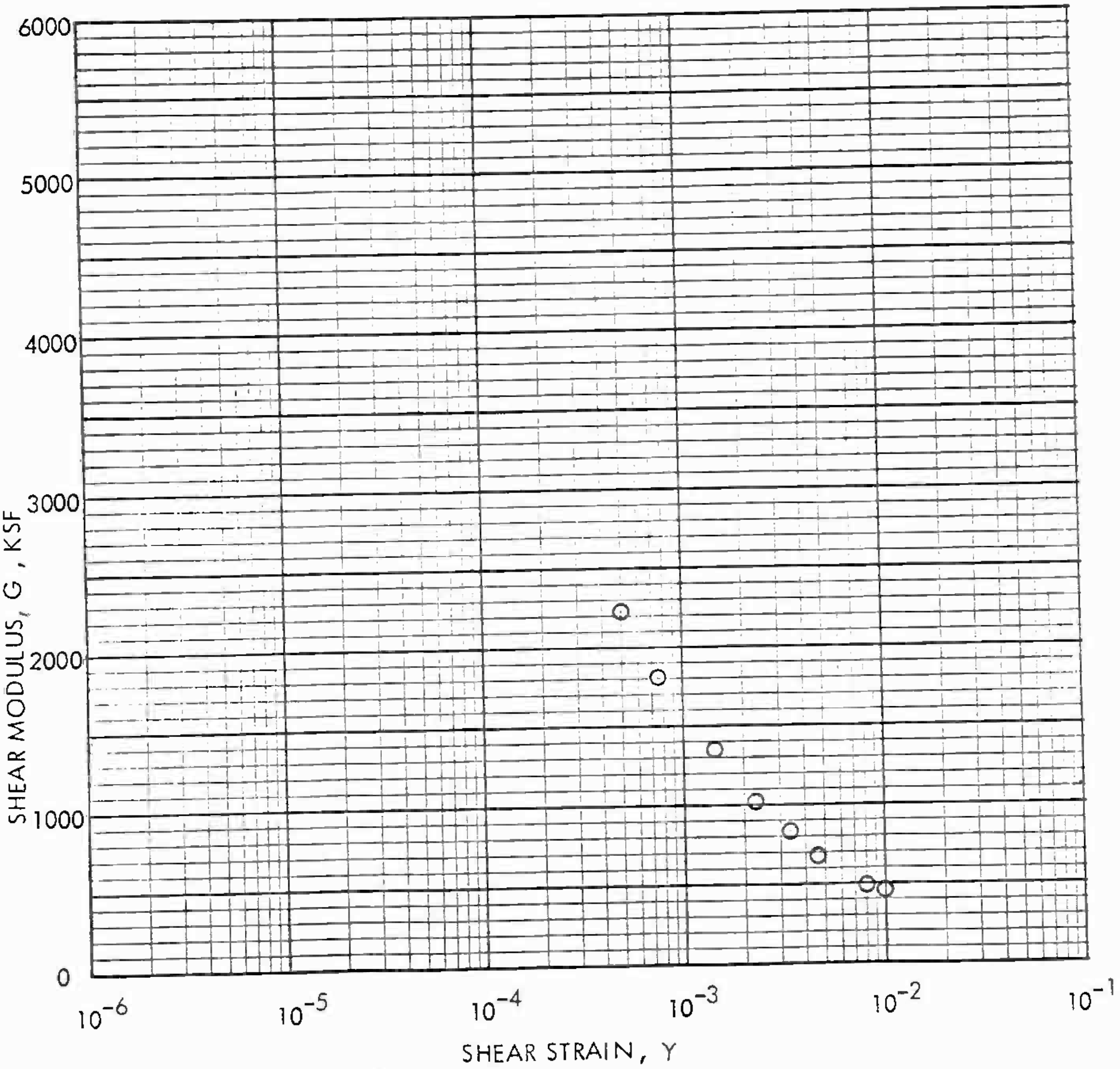
Figure No.
E-81

STRAIN DEPENDENT DYNAMIC SHEAR MODULUS



BORING	SAMPLE	DEPTH(FT)	γ_d(PCF)	w_o(%)	$\bar{\sigma}_c$(PSI)
28	C-9	180	123	12	30

Sample Description: Brown Clayey Sand; dense, medium graded

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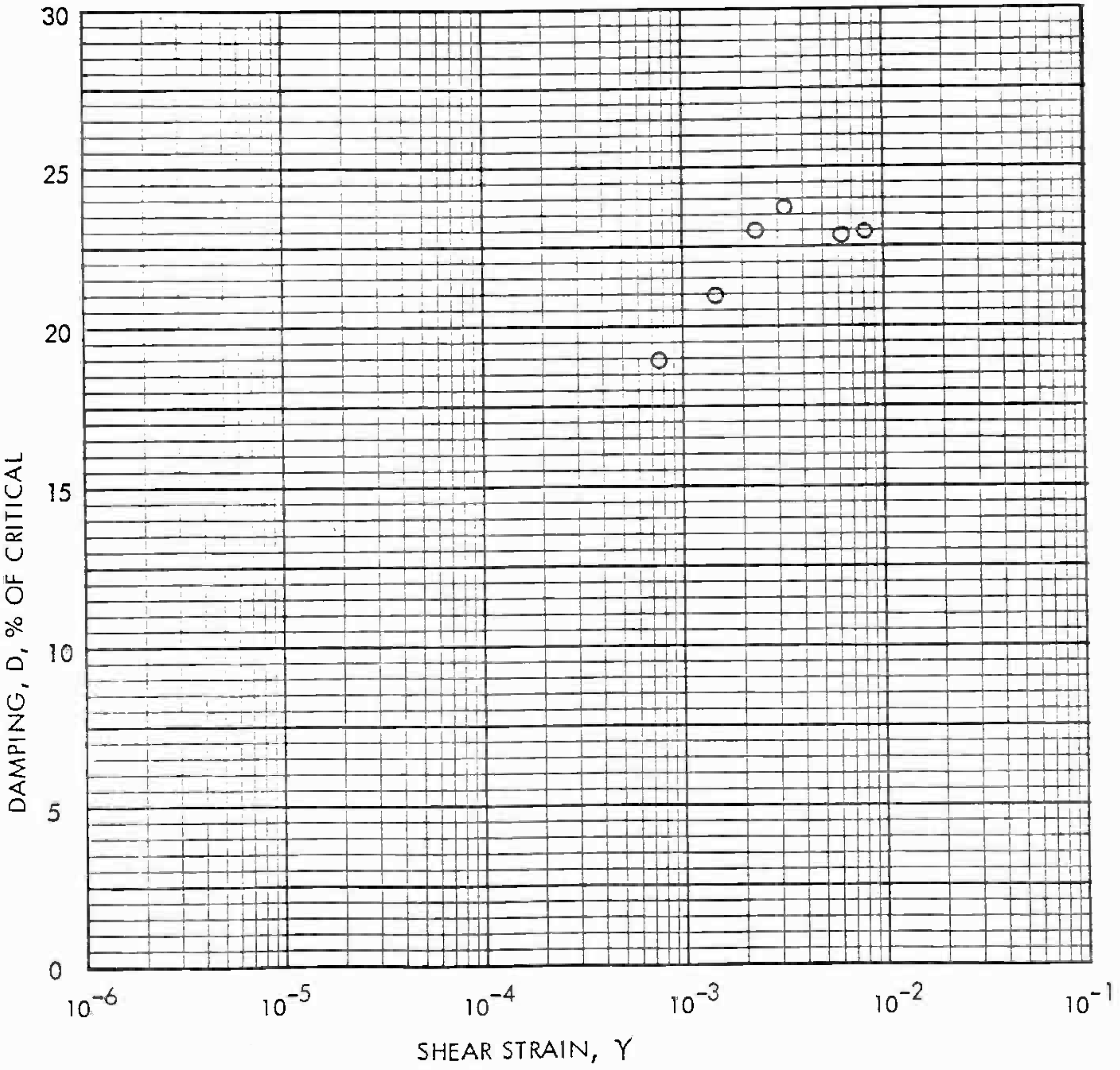
Figure No.
E-82

STRAIN DEPENDENT DAMPING



BORING	SAMPLE	DEPTH(FT)	γ_d(PCF)	w_o(%)	$\bar{\sigma}_c$(PSI)
28	C-9	180	123	12	30

Sample Description: Brown Clayey Sand; dense, medium graded

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DYNAMIC TRIAXIAL TEST

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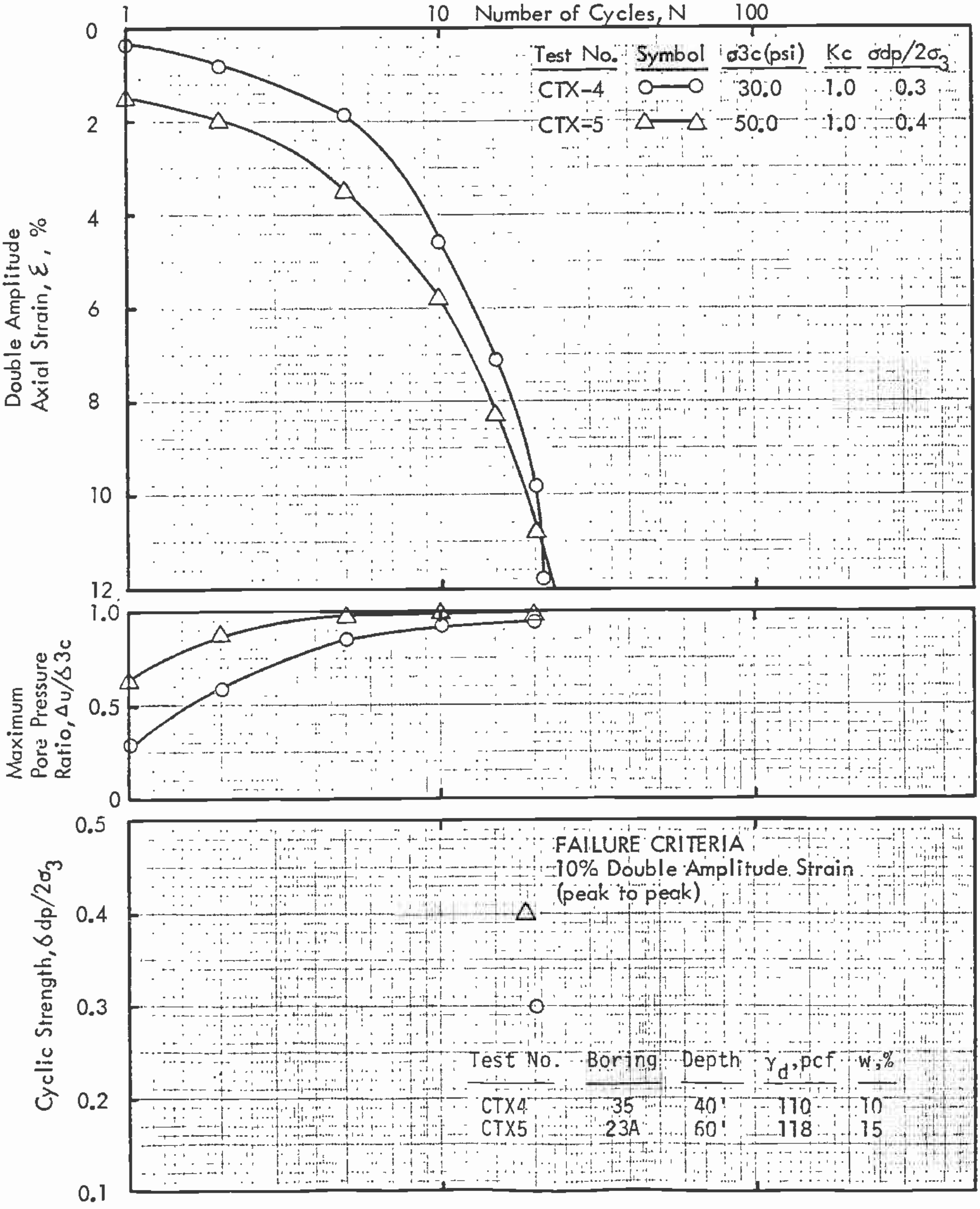
Figure No.
E-83



CYCLIC TRIAXIAL COMPRESSION TEST RESULTS

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METRO RAIL PROJECT

Project No.
83-1140

Figure No.
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FORM NO. D55/7

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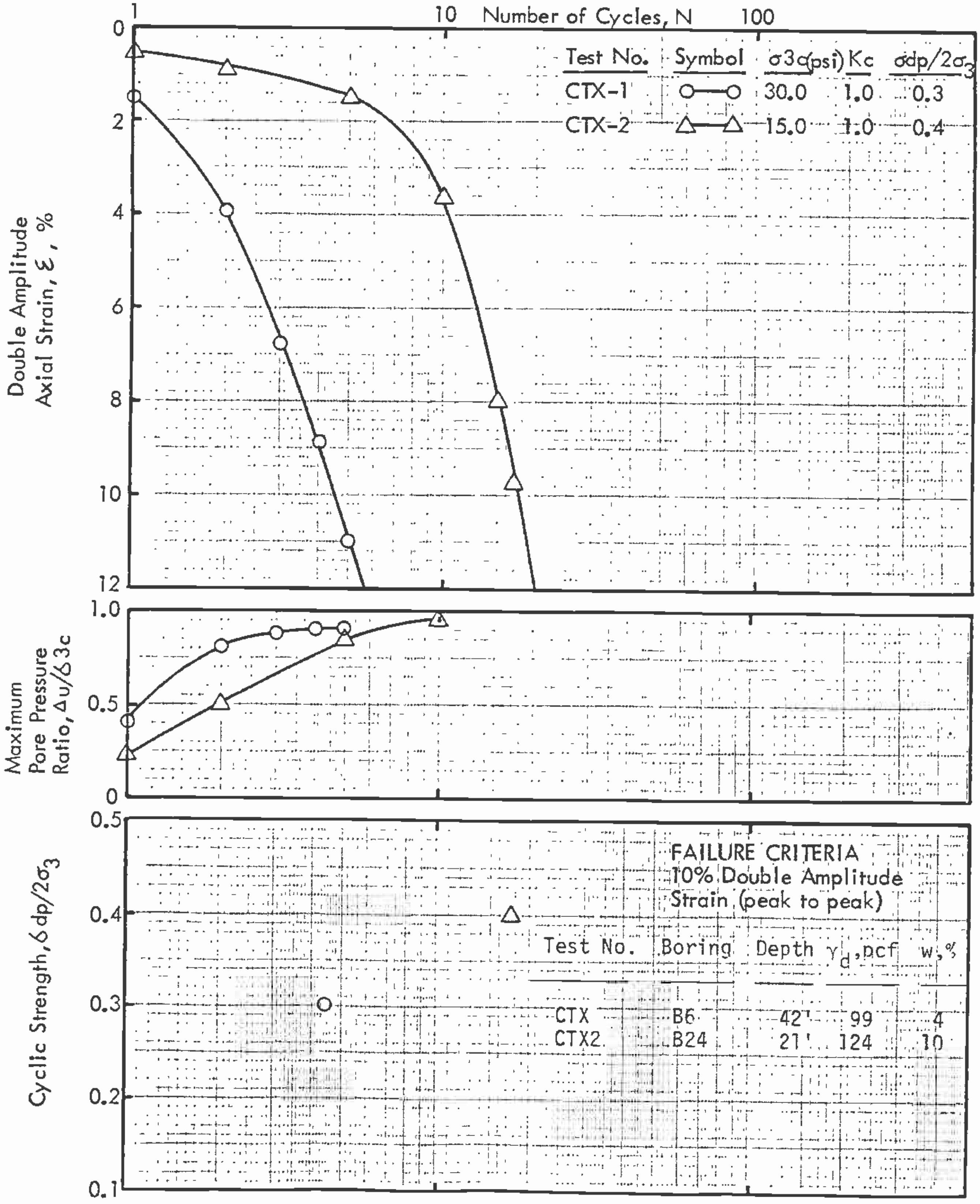

CYCLIC TRIAXIAL COMPRESSION TEST RESULTS

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METRO RAIL PROJECT

Project No.
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Figure No.
E-85

FORM NO. D55/

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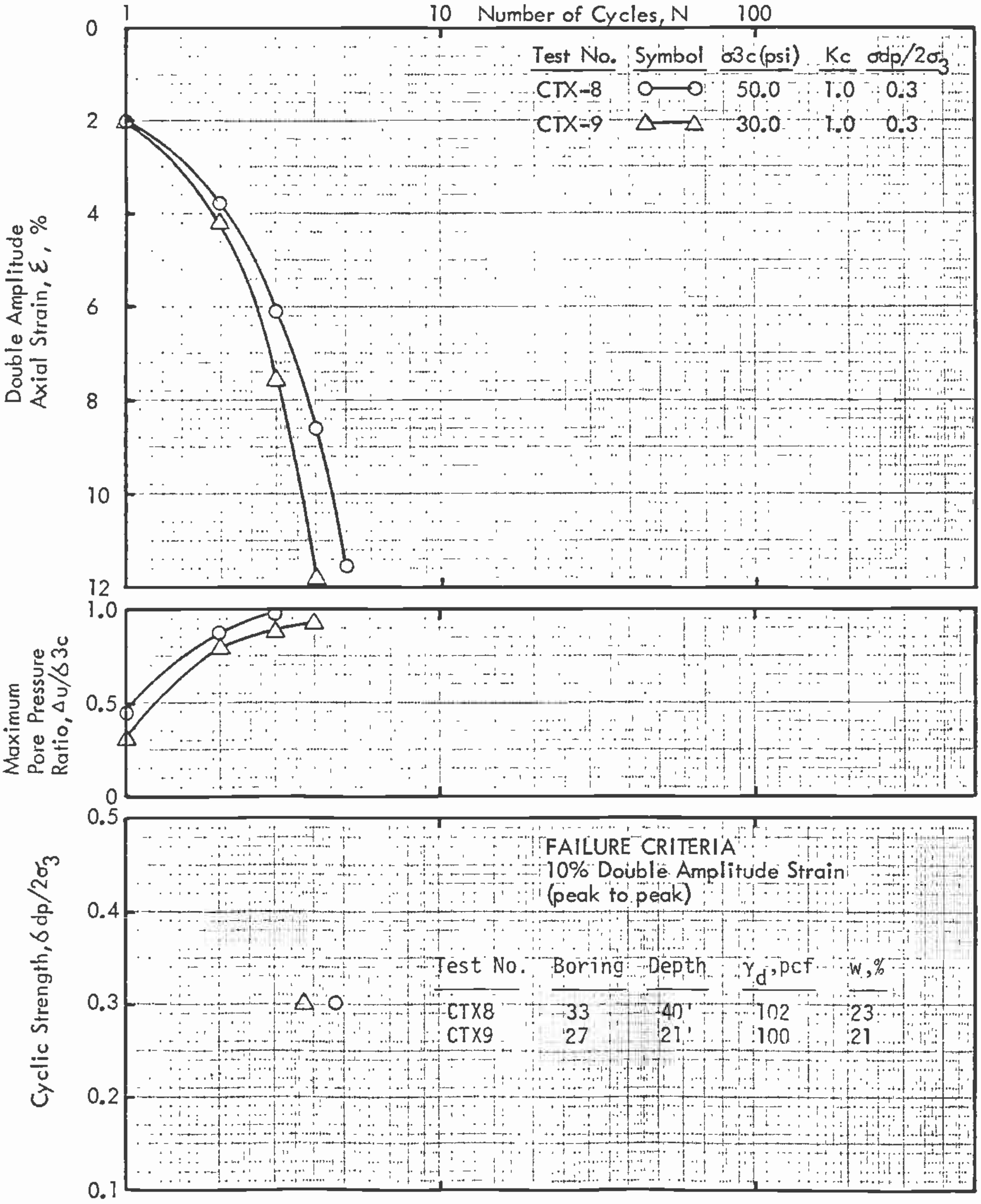

Test No.	Boring	Depth	γ_d, pcf	w, %
CTX8	33	40'	102	23
CTX9	27	21'	100	21

CYCLIC TRIAXIAL COMPRESSION TEST RESULTS

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Figure No.
E-86

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Appendix F

Technical Considerations

APPENDIX F: TECHNICAL CONSIDERATIONS

F.1 SHORING PRACTICES IN THE LOS ANGELES AREA

F.1.1 General

Deep excavations for building basements in the Los Angeles area are commonly supported with soldier piles with tieback anchors. Three case studies involving deep excavations into materials similar to those anticipated at the proposed site are presented below.

F.1.2 Atlantic Richfield Project (Nelson, 1973)

This project involved three separate shored excavations up to 112 feet in depth in the siltstones of the Fernando Formation. The project is located just north of Boring CEG 9, and the proposed location of the Flower Street Station. Key elements of the design and construction included:

- Basic subsurface material was a soft siltstone with a confined compressive strength in the range of 5 to 10 ksf. It contained some very hard layers, seldom more than 2 feet thick. All materials were excavated without ripping, using conventional equipment. Up to 32 feet of silty and sandy alluvium overlaid the siltstone.
- Volume of water inflow was small and excavations were described as typically dry.
- Shoring system consisted of steel, wide flange (WF) soldier piles set in pre-drilled holes, backfilled with structural concrete in the "toe" and a lean concrete mix above. The soldier pile spacing was typically 6 feet.
- Tieback anchors consisted of both belled and high-capacity friction anchors.
- On the side of one of the excavations a 0.66H:1V (horizontal:vertical) unsupported cut, 110 feet in height, was excavated and sprayed with an asphalt emulsion to prevent drying and erosion.
- Timber lagging was not used between the soldier piles in the siltstone unit. However, an asphalt emulsion spray and wire mesh welded to the piles was used.

The garage excavation (when 65 feet deep) survived the February 9, 1971 San Fernando earthquake (6.4 Richter magnitude) without detectable movement. The excavation is about 20 miles from the epicenter and experienced an acceleration of about 0.1 g. The shoring system at the plaza, using belled anchors, moved laterally an average of about 4 inches toward the excavation at the tops of the piles, and surface subsidence was on the order of 1 inch; surface cracks developed on the street, but there was no structural damage to adjacent buildings. Subsequent shoring used high capacity friction anchors and reportedly moved laterally less than 2 inches.

F.1.3 Century City Theme Towers (Crandall, 1977)

This project involved a shored excavation from 70 to 110 feet deep in the Old Alluvium deposit. Immediately adjacent to the excavation (about 20 feet away) was a bridge structure supported on piles 60 feet below the ground surface. The project is located about one mile west of Boring CEG-20 and the proposed location of the Fairfax Avenue Station. Key elements of the design and construction included:

- Basic subsurface materials were stiff clays and dense silty sands and sands. The permanent groundwater table was below the level of excavation, although minor seeps from perched groundwater were encountered.
- Shoring system consisted of steel WF soldier piles placed in 36-inch-diameter drilled holes spaced 6 feet on center.
- As the excavation proceeded, pneumatic concrete was placed incrementally in horizontal strips to create the finished exterior wall. The concrete which was shot against the earth acted as the lagging between soldier piles.
- Tieback anchors consisted of high-capacity 12- and 16-inch-diameter friction anchors.
- Actual load imposed on the wall by the adjacent bridge was computed and added to the design wall pressures as a triangular pressure distribution.
- Maximum horizontal deflection at the top of the wall was 3 inches, while the typical deflection was less than 1 inch. Adjacent to the exiting bridge, the deflections were essentially zero, with the tops of most of the soldier piles actually moving into the ground due to the high prestress loads in the anchors.
- Survey of the bridge pile caps indicated practically no movement.

F.1.4 St. Vincent's Hospital (Crandall, 1977)

This project involved a shored excavation up to 70 feet deep into the claystones and siltstones of the Puente Formation. Immediately adjacent to the excavation (about 25 feet away) was an existing 8-story hospital building with one basement level supported on spread footings. The project is located about 1/3 mile north of Boring CEG-11 and the proposed location of the Alvarado Street Station. Key elements of the design and construction included:

- Basic subsurface materials were shale and sandstone, with a bedding dip to the south at angles ranging from 20° to 40°. Although the permanent groundwater level was below the excavation level, perched zones of significant water seepage were encountered.

- Shoring system consisted of steel WF soldier piles placed in 20-inch-diameter drilled holes spaced at 6 feet on center.
- Tieback anchors consisted of high-capacity friction anchors.
- Theoretical load imposed on the wall by the adjacent building was computed and added to the design wall pressure. The existing building was not underpinned; thus, the shoring system was relied upon to support the existing building loads.
- Shoring performed well, with maximum lateral wall deflection of about 1 inch and typical deflections less than 1/4 inch. There was no measurable movement of the reference points on the existing building.

F.1.5 Design Lateral Load Practices

Table F-1 summarizes the design lateral loads used for eight shored excavations in the general site vicinity. Based on these projects, the average equivalent uniform pressure for excavations in alluvium is 15.6H-psf (H = depth of the excavation). For excavations in the Puente or Fernando the average value is 14.5H-psf.

According to Terzaghi and Peck's rules, the design pressure in granular soils would be equal to 0.65 times the active earthpressure. Assuming a friction angle of 37 degrees, the equivalent design pressure should equal about 22H-psf. For hard clays, the recommended value ranges from 0.15-0.30 (equivalent rectangular distribution) times the soils unit weight or at least 18H-psf.

Thus, the local design practices are some 20% less than those indicated by Peck's rules.

F.2 SEISMICALLY INDUCED EARTHPRESSURES

The increase in lateral earth pressure due to earthquake forces has usually been taken into consideration by using the Monobe-Okabe method which is based on a modification of Coulomb's limit equilibrium earth pressure theory. This simple pseudo-static method has been applied to the design of retaining structures both in the U.S. and in numerous other countries around the world, mainly because it is simple to use. However, just as the use of the pseudo-static method is not really appropriate for evaluating the seismic stability of earth dams, those same shortcomings are also applicable when using the method to evaluate dynamic lateral pressures.

During an earthquake the inertia forces are cyclic in nature and are constantly changing throughout its duration. It is unrealistic to replace these inertia forces by a single horizontal (and/or vertical) force acting only in one direction. In addition, the selection of an appropriate value of the horizontal seismic coefficient is completely arbitrary.

Table F-1

SHORING LOADS IN LOS ANGELES AREA

Project Location	Excavation Depth (ft)	Soil Conditions	Actual Design Pressure (P)	Equivalent Design Pressure (P')
Broadway Plaza Near 7th/Flower Station	15-30	Fill over Alluvium Sands	19.0H	15.2H
500 S. Hill	25	Fill over Sands and Gravel	22.0H	17.6H
Tishman Building Near CEG-14	25	Alluvium-Clays, Sand, Silt	19.0H	15.2H
Equitable Life Near CEG-14	55	Alluvium Sand/ Siltstone	20.0H	17.5H
Arco Near CEG-9	70-90	Alluvium over Claystone	16.0H	12.0H
Century City Near CEG-20	70-110	Alluvium-Clays and Sands	18.0H	14.4H
St. Vincent's Near 3rd & Lk.	70	Thin Alluvium over Puente	15.0H	12.0H
Oxford Plaza Near 7th/Flower	40	Fill & Alluvium over Siltstone	21.0H	16.8H

Notes: All shoring systems were soldier piles.

All pressure diagrams were trapezoidal.

Equivalent pressure equals a uniform rectangular distribution.

Nevertheless, the pseudo-static method is still used today since it provides a simple means for assessing the additional hazard to stability imposed by earthquake loadings.

Monobe-Okabe originally developed an expression for evaluating the magnitude of the total (static plus dynamic) active earth pressure acting on a rigid retaining wall backfilled with a dry cohesionless soil. The method was developed for dry cohesionless materials and based on the assumptions that:

- o The wall yields sufficiently to produce minimum active pressures.
- o When the minimum active pressure is attained, a soil wedge behind the wall is at the point of incipient failure, and the maximum shear strength is mobilized along the potential sliding surface.
- o The soil behind the wall behaves as a rigid body so that accelerations are uniform throughout the mass.

Monobe-Okabe's method gives only the total force acting on the wall. It does not give the pressure distribution nor its point of application. Their formula for the total active lateral force on the wall, P_{AE}, is as follows:

$$P_{AE} = 1/2 \ \gamma \ H^2(1-k_v)K_{AE}$$

where:

$$K_{AE} = \frac{\cos^2(\phi-\theta-\beta)}{\cos\theta \ \cos^2\beta \ \cos(\delta+\beta+\theta)\left(1+\sqrt{\frac{\sin(\phi+\delta)\ \sin(\phi-\theta-i)}{\cos(\delta+\beta+\theta)\ \cos(i-\beta)}}\right)^2}$$

$\theta = \tan^{-1} (k_h)/(1-k_v)$

γ = unit weight of soil

ϕ = angle of internal friction of soil

i = angle of soil slope to horizontal

β = angle of wall slope to vertical

k_h = horizontal earthquake coefficient

k_v = vertical earthquake coefficient

γ = angle of wall friction.

For a horizontal ground surface and a vertical wall,

$$i = \beta = 0$$

The expression for K_{AE} then becomes

$$K_{AE} = \frac{\cos^2(\phi-\theta-\beta)}{\cos\theta\cos(\delta+\theta)\left(1+\sqrt{\frac{\sin(\theta+\delta)\sin(\phi-\theta)}{\cos(\theta+\delta)}}\right)^2}$$

The seismic component, ΔP_{AE}, of the total lateral load P_{AE} can be determined by the following equation:

$$\Delta P_{AE} = 1/2\ \gamma\text{total}\ H^2\ \Delta K_{AE}$$

where:

$$\Delta K_{AE} = K_{AE}\ (\text{static + seismic}) - K_{AE}\ (\text{static})$$

Inspection of actual acceleration time histories recorded during strong motion earthquakes indicates that the accelerations are quite variable both in amplitude and with time. For any given acceleration component the values fluctuate significantly during the entire duration of the record. Statistical analyses of the positive and negative peaks do indicate, however, that when one considers the entire record there are generally an equal number of positive and negative peaks of equal intensity. In the past it has been common practice to use the peak value of acceleration recorded during the earthquake as a value of engineering significance. However, this peak value might occur only once during the entire earthquake duration and is usually not representative of the average acceleration which might be established for the entire duration of shaking.

It has been common practice in the past to ignore the effects of the vertical acceleration and to set the value of the vertical earthquake coefficient, k_v, equal to zero when using Monobe-Okabe's equation. This appears reasonable as the peak values of horizontal and vertical accelerations do not occur at the same instant of time during an earthquake and are usually at different frequencies. The vertical earthquake component usually contains much higher frequencies than the horizontal component.

It has also been common practice to set the value of the horizontal seismic coefficient, k_h, equal to the peak ground acceleration. This is conservative since the peak acceleration only acts on the wall for an instant of time. In addition, for a deep excavation the soil mass behind the wall will not move as a rigid body and will have a seismic coefficient significantly less than the peak ground acceleration (analogous to a horizontal seismic coefficient acting on a failure surface for an earth dam).

For evaluating dynamic earth pressures for this study, we recommend that the value of the horizontal seismic coefficient be taken equal to 65% of the peak ground acceleration and that the vertical seismic coefficient, k_v, be set equal to zero.

In a saturated soil medium the change in water pressure during an earthquake has usually been established on the basis of the method of analysis originally developed by Westergaard (1933). His method of analysis was intended to apply to the hydrodynamic forces acting of the face of a concrete dam during an earthquake. However, it was used by Matsuo and

O'Hara (1960) to determine the dynamic water pressure (due to the pore fluid within the soil) acting on quay walls during earthquakes, and has been used by various other engineers for evaluating dynamic water pressures acting on retaining walls backfilled with saturated soil. Unless the soil is extremely porous, it is difficult to visualize that the pore water can actually move in and out quick enough for it to act independently of the surrounding soil media. For most natural soils, the soil and pore water would move together in phase during the duration of the earthquake such that the dynamic pressure on the wall would be due to the combined effect of the soil and water. Thus, the total weight of the saturated soil should be used in calculating dynamic earth pressure values.

The allowable Building Code stress increase for seismic loading (33%) translates into an allowable uniform seismic earth pressure on the temporary shoring of about magnitude 6H. This earth pressure corresponds to a seismic coefficient (K_h) of about 0.15g and a peak ground acceleration of about 0.23g (using the recommended procedures).

Appendix G

Earthwork Recommendations

APPENDIX G: EARTHWORK RECOMMENDATIONS

The following guidelines are recommended for earthwork associated with site development. Recommendations for dewatering and major temporary excavations are presented in the text Sections 6.2 and 6.4 respectively.

- Site Preparation (Surface Structures):

  Existing vegetation, debris, and soft or loose soils should be stripped from the areas that are to be graded. Soil containing more than 1% by weight of organics may be re-used in planter areas, but should not be used for fill beneath building and paved areas. Organic debris, trash, and rubble should be removed from the site. Subsoil conditions on the site may vary from those encountered in the borings. Therefore, the soils engineer should observe the prepared graded area prior to the placement of fill.

- Minor Construction Excavations:

  Temporary dry excavations for foundations or utilities may be made vertically to depths up to 5 feet. For deeper dry excavations in existing fill or natural materials up to 15 feet, excavations should be sloped no steeper than 1.5:1 (horizontal to vertical).

- Structural Fill and Backfill:

  Where required for support of near surface foundations or where subterranean walls and/or footings require backfilling, excavated onsite soils or imported granular soils are suitable for use as structural fill. Loose soil, formwork, and debris should be removed prior to backfilling the walls. Onsite soils or imported granular soils should be placed and compacted in accordance with "Recommended Specifications for Fill Compaction." In deep fill areas or fill areas for support of settlement-sensitive structures, compaction requirements could be increased from the normal 90% to 95% or 100% of the maximum dry density to reduce fill settlement.

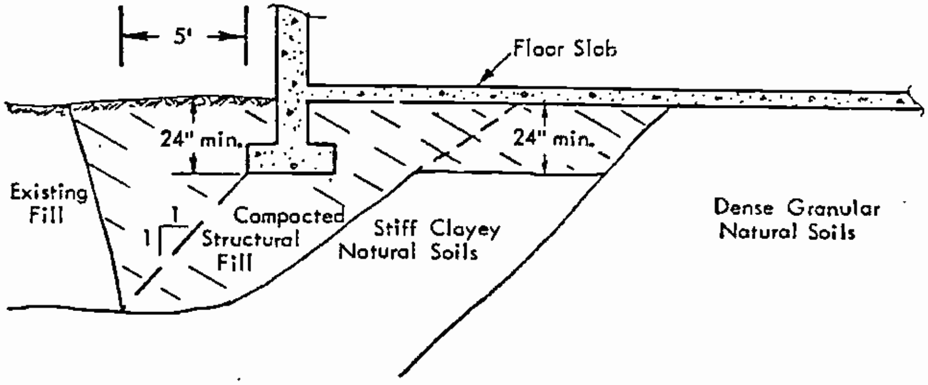
  Where space limitations do not allow for conventional backfill compaction operations, special backfill materials and procedures may be required. Sand-cement slurry, pea gravel or other selected backfill can be used in limited space areas. Sand-cement slurry should contain at least 1-1/2 sacks cement per cubic year. Pea gravel should be placed in a moist condition or should be wetted at the time of placement. Densification should be accomplished by vibratory equipment; e.g., hand-operated mechanical compactor, backhoe mounted hydraulic compactor, or concrete vibrator. Lift thickness should be consistent with the type of compactor used. However, lifts should never exceed 5 feet. A soils engineer experienced in the placement of pea gravel should observe the placement and densification procedures to render an opinion as to the adequate densification of the pea gravel.

If granular backfill or pea gravel is placed in an area of surface drainage, the backfill should be capped with at least 18 inches of relatively impervious type soil; i.e., soils containing at least 40 percent passing the No. 200 sieve.

- Foundation Preparation:

  Where foundations for near surface appurtenant structures are underlain by existing fill soils, the existing fill should be excavated and replaced with a zone of properly compacted structural fill. The zone of structural fill should extend to undisturbed dense or stiff natural soils. Horizontal limits of the structural fill zone should extend out from the footing edge a distance equal to 5 feet or 1/2 the depth of the zone beneath the footing whichever is larger. The structural fill should be placed and compacted as recommended under "Structural Fill and Backfill."

FOUNDATION/SUBGRADE PREPARATION



- Subgrade Preparation:

  Concrete slabs-on-grade at the subterranean levels may be supported directly on undisturbed dense materials. The subgrade should be proof rolled to detect soft or disturbed areas, and such areas should be excavated and replaced with structural fill. If existing fill soils are encountered in near surface subgrade areas, these materials should be excavated and replaced with properly compacted granular fill. Where clayey natural soils (near existing grade) are exposed in the subgrade, these soils should be excavated to a depth of 24 inches below the subgrade level and replaced with properly compacted granular fill. Where dense natural granular soils are exposed at slab subgrade, the slab may be supported directly on these soils. All structural fill for support of slabs or mats should be placed and compacted as recommended under "Structural Fill and Backfill."

- Site Drainage:

  Adequate positive drainage should be provided away from the surface structures to prevent water from ponding and to reduce percolation of water into the subsoils. A desirable slope for surface drainage is 2% in landscaped areas and 1% in paved areas. Planters and landscaped areas adjacent to the surface structures should be designed to minimize water infiltration into the subsoils.

- Utility Trenches

  Buried utility conduits should be bedded and backfilled around the conduit in accordance with the project specifications. Where conduit underlies concrete slabs-on-grade and pavement, the remaining trench backfill above the pipe should be placed and compacted in accordance with "Structural Fill and Backfill."

- Recommended Specifications for Fill Compaction:

  The following specifications are recommended to provide a basis for quality control during the placement of compacted fill:

  1. All areas that are to receive compacted fill shall be observed by the soils engineer prior to the placement of fill.

  2. Soil surfaces that will receive compacted fill shall be scarified to a depth of at least 6 inches. The scarified soil shall be moisture-conditioned to obtain soil moisture near optimum moisture content. The scarified soil shall be compacted to a minimum relative compaction of 90%. Relative compaction is defined as the ratio of the inplace soil density to the maximum dry density as determined by the ASTM D1557-70 compaction test method.

  3. Fill shall be placed in controlled layers the thickness of which is compatible with the type of compaction equipment used. The thickness of the compacted fill layer shall not exceed the maximum allowable thickness of 8 inches. Each layer shall be compacted to a minimum relative compaction of 90%. The field density of the compacted soil shall be determined by the ASTM D1556-64 test methods or equivalent.

  4. Fill soils shall consist of excavated onsite soils essentially cleaned of organic and deleterious material or imported soils approved by the soils engineer. All imported soil shall be granular and non-expansive or of low expansion potential (plasticity index less than 15%). The soils engineer shall evaluate and/or test the import material for

its conformance with the specifications prior to its delivery to the site. The contractor shall notify the soils engineer 72 hours prior to importing the fill to the site. Rocks larger than 6 inches in diameter shall not be used unless they are broken down.

5. The soils engineer shall observe the placement of compacted fill and conduct inplace field density tests on the compacted fill to check for adequate moisture content and the required relative compaction. Where less than 90% relative compaction is indicated, additional compactive effort shall be applied and the soil moisture-conditioned as necessary until 90% relative compaction is attained. The contractor shall provide level testing pads for the soils engineer to conduct the field density tests on.

Appendix H
Geotechnical Reports References

APPENDIX H GEOTECHNICAL REPORTS REFERENCES

REPORT No.	REPORT DATE	LOCATION	CONSULTANT
31	09/30/65	South of Wilshire, between Spaulding & Ogden	L.T. Evans
32	02/23/53	North of Wilshire between Ogden & Orange Grove	L.T. Evans
33	04/30/68	Southeast corner Wilshire/Fairfax	LeRoy Crandall
34	04/16/68	6200 Wilshire	Nilcola
35	01/02/51	CBS - southeast corner Beverly & Fairfax	L.T. Evans
36	04/24/51	CBS - southeast corner Beverly & Fairfax	L.T. Evans
37	12/04/56	CBS - southeast corner Beverly & Fairfax	L.T. Evans
38	08/28/68	CBS - southeast corner Beverly & Fairfax	L.T. Evans
39	04/15/75	CBS - southeast corner Beverly & Fairfax	L.T. Evans
40	10/22/76	CBS - southeast corner Beverly & Genese	L.T. Evans