2000-3 Arapaho Road

Realignment Geotechnical Investigation - 1994

REPORT

GEOTECHNICAL INVESTIGATION

ARAPAHO ROAD REALIGNMENT

DALLAS NORTH TOLLWAY TO ADDISON ROAD

ADDISON, TEXAS

TMI REPORT NO. DE94-040

TO

HUITT - ZOLLARS, INC.

DALLAS, TEXAS

BY

TERRA-MAR, INC.

DALLAS/FORT WORTH/HOUSTON

SEPTEMBER 1994

TERRA-MAR

Consulting Engineers • Geotechnical • Environmental • Construction Materials Testing

DALLAS • FORT WORTH • HOUSTON

September 29, 1994
Report No. DE94-040

Mr. Ken Roberts, P.E.

Huitt-Zollars, Inc.
3131 McKinney Avenue
Suite 600
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GEOTECHNICAL INVESTIGATION
ARAPAHO ROAD REALIGNMENT
DALLAS NORTH TOLLWAY TO ADDISON ROAD
ADDISON, TEXAS

Gentlemen:

Submitted herewith is our report for the above referenced project. This investigation was authorized by Mr. Ken Roberts on August 2, 1994. This report presents results of the field and laboratory investigations together with recommendations concerning the design and construction of the proposed realigned roadway and the associated utility improvements.

PROJECT DESCRIPTION

It is planned to realign Arapaho Road between the Dallas North Tollway and Addison Road. In addition to a new realigned roadway, new intersections will be constructed at Spectrum, Quorum, Old Arapaho Road and Addison Road. It is understood that the new realigned Arapaho Road will be a four lane divided roadway. A retaining wall is proposed east of Quorum to support a three (3) to four (4) foot high roadway embankment near an existing parking garage. Utility improvements are also planned along the realigned section of Arapaho Road. It is understood that excavation depths for underground utility construction will not exceed 15 feet.

The new alignment will extend across an old rail spur and industrial development requiring demolition of existing pavement areas and buildings. Environmental evaluations of subsurface conditions were performed in the area of the abandoned rail spur and near an area containing existing underground petroleum storage tanks. The surficial soils in the area of the abandoned rail spur (Borings B-4 through B-8) were evaluated for the presence of toxic contaminants caused by possible industrial spills which may have occurred years ago when the rail spur was active. Composite soil samples were obtained at boring locations drilled near existing underground fuel storage tanks at the Seven-Eleven Store (Borings B-1 and B-2) to evaluate the possibility of leaking tanks. The results of these environmental evaluations are discussed in the following sections of this report.

FIELD INVESTIGATION

Subsurface conditions along the proposed roadway section were evaluated by 13 sample borings. Approximate locations of the borings drilled are shown on the Plan of Borings, Figure 1. Sample depth, soil and rock description and classification (based on the Unified Soil Classification System) are shown on the Logs of Borings, Figures 2 through 14. A key to the descriptive terms and symbols used on the logs is presented on Figure 15. Elevations indicated on boring logs were provided by Huitt-Zollars.

Surficial soils were sampled using a thin walled Shelby tube sampler. The consistency of the clay soils was evaluated in the field using a calibrated hand penetrometer. Texas Department of Transportation (TxDOT) cone penetrometer tests were performed in the rock formation to evaluate rock hardness and the compressive strength characteristics of the bedrock. These results are reported at the appropriate depths on the boring logs.

Borings B-1 and B-2 were drilled near the existing Seven-Eleven gas station containing existing underground fuel storage tanks. Borings B-4 through B-8 were drilled in the area of the abandoned railroad spur. These borings were drilled to evaluate both environmental and geotechnical aspects of subsurface conditions. The remaining borings were drilled along the new roadway alignment to evaluate the geotechnical engineering aspects of subsurface conditions.

Groundwater observations were conducted at each boring location during drilling and at completion of drilling operations. These observations are reported on the boring logs. All borings were backfilled after the final groundwater level measurements were obtained. Borings drilled in the area of the existing gas station and abandoned rail spur were grouted with bentonite. Borings drilled in paved areas were patched with concrete.

LABORATORY INVESTIGATION

The laboratory testing program was directed primarily toward evaluation of the physical and engineering characteristics of the overburden soils. Identification tests consisted of liquid and plastic limits, natural moisture content, unit dry weight and unconfined compressive strength determinations. These test results are tabulated at the appropriate sample depths on the boring logs.

Absorption pressure swell tests were performed to evaluate the potential swell characteristics of the subgrade clay soils. In this test, a sample is placed in a consolidometer and consolidated at its existing overburden pressure. The sample is then inundated and restrained from swelling by application of additional pressure. The maximum swelling pressure is recorded. The restraining pressure is then reduced to the in-situ (or proposed) overburden pressure, and the sample is allowed to freely swell. These results are reported in the form of logarithmic pressure-swell graphs on Figures 16 through 21.

A series of liquid and plastic limit tests was performed on a representative subgrade soil sample in order to determine optimum lime additives for subgrade stabilization. In these tests, soil plasticity index was evaluated as a function of lime additive, expressed as a percentage of dry soil weight. Results of the lime series tests are presented on Figure 22.

Results of the analytical laboratory tests performed for environmental evaluations are presented in Appendix C.

SITE CONDITIONS

Site Geology and Subsurface Stratigraphy

The site is geologically located in the mapped outcrop of the Austin Chalk Limestone Formation as indicated on the Dallas Sheet of the Geologic Atlas of Texas. Detailed descriptions of subsurface stratigraphy are provided on the Boring Logs, Figures 2 through 14.

Fill soils consisting of clay, sandy clay, sand and sandy gravel were generally encountered to depths ranging from one (1) to four (4) feet below existing grade. The clay fill soils are highly active (CH clay) with a plasticity index (PI) of about 37, and are generally stiff to hard in consistency. Fill material consisting of broken rock, clay soil and miscellaneous debris was encountered at Boring B-10 (east of Quorum Drive) to a depth of four (4) feet below existing grade.

Natural soils consisting of dark gray, brown and tan clay were generally encountered to depths ranging from two (2) to fifteen (15) feet below existing grade. The natural clay soils are moderately to highly active (CL-CH) with plasticity indices ranging from 17 to 58. These soils are stiff to hard in consistency with pocket penetrometer readings ranging from 1.0 tons per square foot (tsf) to in excess of 4.5 tsf. The on-site clay soils beneath the existing paved areas are moist and only potentially slightly expansive as evidenced by swell test results shown on Figures 16 through 21. On the other hand, the subgrade clay soils beneath the unpaved areas could have a moderate to high swell potential at the time of construction if the clay soils are relatively dry at that time. At the time of this report, the clay soils in the unpaved areas are fairly moist and have a slight to moderate swell potential in their present moisture condition.

The overburden soils are underlain by the Austin Chalk Limestone Formation. Moderately hard tan weathered limestone was encountered west of Quorum Drive at depths ranging from about two (2) to six (6) feet below existing grade, El 623 to El 628. The weathered limestone stratum was encountered east of Quorum Drive at depths about 5 to 15 feet below existing grade, El 602 to El 617. The weathered limestone formation is fractured with iron staining and contains clay layers. Moderately hard to hard gray unweathered limestone was encountered at most boring locations at depths ranging from about 7 to 13 feet below existing grade, El 608 to El 624.

Groundwater

Short term groundwater observations were made at each boring location as reported on the boring logs. The groundwater levels at the time of this investigation generally ranged from about 7 to 13 feet below existing grade, El 606 to El 623. It should be recognized that groundwater conditions will fluctuate with seasonal precipitation and surficial runoff. It should be anticipated that groundwater will be encountered in the form of seepage through the fissures and fractures within the overburden clay soils and weathered limestone formation. Shallower groundwater levels may be encountered if construction occurs during or after periods of heavy rainfall.

ANALYSES AND RECOMMENDATIONS

Pavements

Subgrade Design Parameters

Topography along the proposed alignment generally slopes in an eastward direction with ground surface elevations ranging from about El 629 to El 617. From our discussion with Huitt-Zollars, it is understood that cuts up to three (3) feet below existing grade will be required within the west half of the alignment between Addison Road and Quorum Drive. Fill depths up to three (3) to four (4) feet are intended east of Quorum Drive. Exposed subgrade soils are anticipated to consist generally of highly active (CH) clay, both fill and natural. The final grading plans were not available at the time of this investigation.

Pavement design requires the use of soil properties or the results of specific tests to determine appropriate design parameters. Based on the results of the field and laboratory investigation, the following subgrade parameters were used during our design studies:

Subgrade Soil:	Clay Soil
Classification by USCS:	CH Clay
Modulus of Subgrade Reaction:	100 pci
Modified Modulus of Subgrade Reaction using a 6" Lime Stabilized Subgrade:	150 pci

Pavement Design and Analyses

Pavement Design was performed in accordance with AASHTO Guide for Design of Pavement Structures (1986). Based on the traffic data provided by the Town of Addison (Public Works Department) the following parameters were used in the pavement design and analyses:

Roadway Class:	Major Arterial
Total Traffic Count (1993):	16,000 Vehicles Per Day (VPD)
Heavy Truck Traffic:	2.1%
Annual Traffic Growth	3.5%
Traffic Lanes:	Four Lane Divided Roadway

Design Life:	20 years	
Total Design Traffic:	6,600,000	18 kip ESAL
Terminal Serviceability Index:	2.5	
Reliability:	90%	

Rigid Pavement (Integral with Curb and Gutter)

Based on the above design parameters, the pavement section should consist of ten (10) inches of reinforced Portland Cement Concrete (PCC) over a six (6) inch lime treated subgrade. Adequate subgrade stabilization and drainage is essential to pavement performance in accordance with the design criteria. Specifications for construction are included in Appendix B.

Standard Paving Section

The Town of Addison standard paving section consists of an eight (8) inch PCC section over a six (6) inch lime stabilized subgrade. The standard paving section was evaluated based on the pavement design parameters indicated above. Our studies indicate that this section will not meet the design life criterion based on the traffic data provided by the Town of Addison. Our studies indicate that the standard Addison Pavement section would have a design life of about eight and one-half (8.5) years.

Subgrade Stabilization

Subgrade stabilization should be used in all pavement areas to improve the long term performance of the pavement. A stabilized subgrade also aids in minimizing moisture losses in the moderately to highly active clay soils during construction. If possible, it would be beneficial to stabilize the subgrade soils at least one foot beyond pavement edges.

Lime should be added to the subgrade after the removal of all surface vegetation and debris. A minimum of six (6) percent hydrated lime (30 psy) should be used to stabilize the on-site surficial clay soils.

Specifications for construction: See Appendix B.

Removal of Fill Debris

Fill material consisting of broken rock, clay soil and miscellaneous debris (paper, grass, wood and plastic) was encountered east of Quorum Drive in the area of Boring B-10. This material should be removed and replaced with on-site soils compacted in lifts according to the earthwork specifications in Appendix B.

Potential Vertical Rise (PVR) Studies

Clay soils overlain by existing buildings and pavement slabs are usually very moist and at or near optimum moisture levels with low swell potentials (low PVR values). On the other hand, clay soils in unpaved areas can be much drier and have a high swell potential (high PVR value). Under these variable conditions, differential upward pavement movements can occur over short distances due to the non uniformity of subgrade moisture conditions beneath the new pavement section. Cracks and separations can develop soon after construction if excessive differential subgrade movement occurs and the flexural capacity of the reinforced pavement section is exceeded.

Sample borings were drilled along the new roadway alignment in both existing paved and unpaved areas to determine the differential PVR between the existing paved and unpaved areas. Based on the absorption pressure swell test results, shown on Figures 16 through 21, swell studies were performed to determine the magnitude of differential subgrade movement along the alignment. Our studies indicate that due to the anticipated shallow clay depths west of Quorum Drive, differential subgrade movements west of Quorum should be tolerable (less than one to two inches). However, deeper clay soils were encountered east of Quorum in the area of Borings B-11, B-12 and B-13. At the present time, the clay soils in the unpaved areas are moist and only slightly to moderately expansive. If construction begins prior to May, 1995, the subgrade moisture condition should not change significantly (and become drier) assuming normal winter and spring rainfall occurs. This could be confirmed by shallow soil borings at the time of construction. Under moist subgrade soil conditions, differential subgrade movements east of Quorum should also be tolerable (less than one to two inches). However, if construction occurs after a prolonged period of dry weather and the subgrade soils are dry and potentially expansive at the time of construction, differential subgrade movements east of Quorum could be excessive and on the order of four (4) to six (6) inches.

If a dry subgrade condition is present at the time of construction, injection stabilization to depths of seven (7) feet below final pavement subgrade should be considered. The need for injection stabilization should be evaluated by Terra-Mar based on a few shallow soil borings drilled at the start of construction.

If injection stabilization is required, it should be performed according to the specifications outlined in Appendix A and B. This work should be inspected on a full-time basis by Terra-Mar throughout the entire injection operation to assure compliance with the specifications. One (1) to three (3) injections should be sufficient to reduce the soil PVR to less than two (2) inches if injection is found to be required due to dry subgrade soil conditions at the time of construction.

After satisfactory completion and approval of injection stabilization operations per specification requirements, ponding water should be removed and the subgrade re-excavated to final grade. Two (2) to six (6) inches of soil swelling should be anticipated after injection stabilization. The construction area should then be proofrolled according to the recommended subgrade preparation specifications. A tight non yielding subgrade should be achieved in preparation for lime stabilization operations.

Subgrade moisture content and density must be maintained during excavation and subgrade preparation operations.

Retaining Wall

A retaining wall is proposed east of Quorum to support a three (3) to four (4) foot high roadway embankment near an existing parking garage. Sample Boring B-10 was drilled at the proposed retaining wall location. At Boring B-10, fill material consisting of broken limestone and miscellaneous debris was encountered to depths of four (4) feet below existing grade and is underlain by a natural silty clay soil layer to depths of six (6) feet. The moderately hard tan weathered limestone stratum was encountered at a depth of about six (6) feet below existing grade, El 616.

It is recommended that the fill material in this area be removed and replaced with on-site soils compacted in lifts as indicated above. The retaining wall may then be founded in the compact fill soils or in the underlying weathered limestone bedrock. Allowable bearing capacity of the foundation soils and friction factors at the foundation depths are indicated below:

Founding Depth	*Soil Type*	*Bearing Capacity*	*Friction Factor*
24" below lower adjacent final grade	Fill Soil	2,000 psf	0.30
6 " into bedrock*	Bedrock*	5,000 psf	0.50

* Moderately hard tan weathered limestone.

Note: Retaining wall supported by clay soils or weathered bedrock should be subject to settlements of less than one inch.

A key-way should be provided below the base of the footing if additional sliding resistance is required. The key should be designed for a passive lateral resistance of 200 psf per foot of key-way depth (below the footing) in the compact fill soils and a passive lateral resistance of 400 psf per foot of key-way depth (below the footing) in the weathered limestone formation.

Fill placed in a 45° wedge beginning at the base of the wall should consist of select fill soils (clayey sand) having a PI of 4 to 12. The fill soils should be placed in eight inch lifts and compacted to between 95% and 100% Standard Proctor Density within a moisture range of plus to minus three percent of optimum moisture. Compaction within five (5) feet of the wall should be achieved using hand compaction equipment. Over compaction should not be allowed. Weepholes should be used to provide drainage from behind the walls. The lowest weepholes should be six (6) inches above the ground surface at the base of the wall. A minimum of 12 inches of free draining coarse sand or gravel should be placed adjacent to the retaining walls to provide rapid drainage of the backfill.

The upper 8 inches of backfill should consist of on-site clay or sandy clay soil having a PI in excess of 15 in order to minimize surface water infiltration. Clay and sandy clay fill soils should be placed at one to four percentage points above optimum moisture and compacted to between 95% and 100% Standard Proctor Density.

Based on the design criteria outlined above, for drained conditions, the retaining wall may be designed using an equivalent fluid pressure (EFP) of 45 pcf beginning from the ground surface. These pressures do not include any surcharge load or traffic live load which should be included during wall design. It should be noted that these design pressures are for active conditions which assume some lateral wall displacements will occur. If it is desired to reduce lateral wall movements, the wall should be designed for an at-rest EFP of 60 pcf.

Utility Installations

The allowable soil bearing capacity for underground utilities placed within the overburden clay soils or in the weathered to unweathered limestone formation is listed below:

Foundation Material	Allowable Bearing Capacity
Overburden Soils	2,000 psf
Tan Weathered Limestone	5,000 psf
Gray Unweathered Limestone	15,000 psf

Trench Excavations

Trench excavations will be performed for water, sanitary sewer and storm drains installations to depths of 15 feet below existing grade. Excavations in unweathered (unfractured) limestone can be made near vertical (90°). For excavations less than five (5) feet in depth, and in stable clay and sandy clay material, walls may be cut near vertical in accordance with OSHA Specifications. For excavations to any depth in weathered (fractured) limestone, sand, gravel, rock fill, debris or submerged soil or to depths in excess of five (5) feet in clay and sandy clay soils, it will be necessary to employ either sloped sidewalls or temporary bracing. General guidelines for the design of these two alternatives are discussed in the following paragraphs.

Open Cuts

Recommended slope ratios for the respective soil conditions are presented on Figure 23. It should be noted that free standing slopes will be less stable when influenced by groundwater or saturated by rain. Surcharge loads, such as those resulting from excavation spoil or equipment, should be placed no closer than two (2) feet from the crest of the slope, in accordance with OSHA regulations. Vehicle traffic should be maintained at least five (5) feet from the edge of the crest.

Trench excavations may encounter non-compact clayey or sandy fill soils placed during previous construction of underground utilities or organic fill placed during past earthwork (see Boring B-3). These fill soil should be sheeted, shored and braced or laid back on slopes no steeper than 1-1/2(H) to 1(V).

Bracing

Where site limitations require excavations to have vertical side walls, an internal bracing system will be necessary. Bracing may consist of timber or steel shoring or manufactured steel trench braces. The lateral pressure distribution to be used in the design of trench bracing may be determined as presented on Figures 24 and 25, depending on the type of soils penetrated. It should be noted that pressures are not included from surcharge loads or traffic live loads at trench sidewalls which, if present, must be included in bracing design. In lieu of a shoring system, a trench shield consisting of a prefabricated rigid steel unit, adequate to withstand anticipated lateral pressures, may be used.

Dewatering

Groundwater was encountered during our field investigation at depths ranging from 8 to 14 feet below existing grade. It should be anticipated that groundwater seepage may be encountered in trench excavations at shallower depths if construction occurs during or after periods of heavy rainfall. In areas where groundwater is encountered, a system of ditches, sumps and pumping will be required to provide groundwater control.

Utility Trench Backfill

The excavated soils can be used for trench backfill. Use of rock fragments greater than six (6) inches in any dimension should be prohibited, since attaining a uniform moisture and density without voids would be difficult. Fill should be placed in maximum eight inch lifts and compacted to between 95% and 100% Standard Proctor density (ASTM D698). Clay soils should be compacted at a moisture content ranging from optimum to four (4) percentage points above the optimum Proctor value. Granular soils or broken rock should be compacted at a moisture content ranging from plus to minus three percent of optimum moisture.

Environmental Concerns

Results of the environmental borings and the analytical investigation, as presented in Appendix C, indicate that only traces of hydrocarbon contamination were detected within borings drilled near the Seven-Eleven Store containing petroleum UST's. The levels detected were well below any hazardous threshold level. Toxic materials were not encountered in the area of the abandoned rail spur. Based on the field monitoring and analytical results obtained to date, soil removed from trenching at the site should not expose construction personnel to hazardous vapor levels or toxic materials. Therefore, Level D personal protective equipment should be adequate. However, due to the presence of underground petroleum storage tanks (UST's) at the Seven-Eleven Convenience Store in close proximity to the proposed widened alignment, a potential for petroleum hydrocarbons emanating from this source during construction is possible, particularly if trench excavations are made near the north R.O.W. line or if pockets of severely fractured limestone are encountered containing trapped petroleum. Caution should therefore be taken during trenching operations in the event more concentrated vapors or free petroleum flows are encountered within pockets of severely fractured limestone.

Due to the presence of shallow groundwater levels within the fractured limestone layers at the time of our investigation (present at 7 to 9 foot depths at Borings B-1 and B-2), dewatering will be required during trench excavations. Due to the presence of trace amounts of hydrocarbons and volatile vapors, it is recommended that three (3) monitoring wells be installed near the Seven-Eleven Store to allow water samples to be obtained and analyzed. Unexpected petroleum encountered during dewatering operations would create problems during construction. Issues associated with safety and disposal would have to be addressed.

INSPECTION AND TESTING

Many problems can be avoided or solved in the field if proper inspection and testing services are provided. It is recommended that all site preparation, injection and subgrade stabilization, pavement construction and installation of retaining wall footings be monitored by a qualified engineering technician. Density tests should be performed to verify compaction and moisture content of any earthwork. Inspection should be performed prior to and during concrete placement procedures. TERRA-MAR employs a group of experienced, well-trained technicians for inspection and materials testing. We would be pleased to assist on this project phase.

LIMITATIONS

The recommendations presented in this report are based on a discrete number of soil test borings. Although our field personnel visually survey the site for surface features indicative of variable soil conditions, subsurface conditions may be encountered that differ from these data. In this case, our office should be notified immediately so that the effects of these conditions on design and construction can be addressed.

This study was conducted for the exclusive use of Huitt-Zollars, Inc. and the Town of Addison Public Works Department. The reproduction of this report or any part thereof, in plans or other documents supplied to persons other than the owner, should bear language indicating that the information contained therein is for general design purposes. All contractors referring to this geotechnical report should draw their own conclusions for bidding purposes.

We appreciate the opportunity to assist on this project and trust that our recommendations will lead to cost effective construction. Please call us if we can be of further assistance.

Sincerely,

TERRA-MAR, INC.

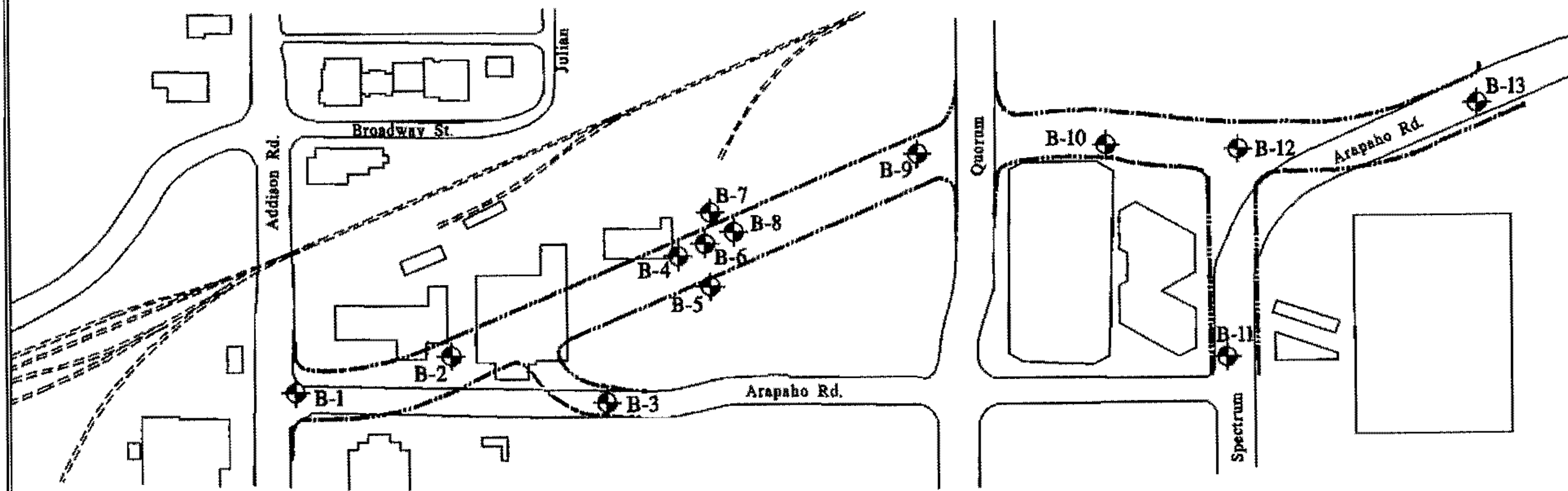
Nasir H. Syed
Project Manager

Mark J. Farrow, P.E.
Vice President

Copies Submitted: (5) Huitt-Zollars, Inc.
Mr. Ken Roberts, P.E.

ILLUSTRATIONS

APPENDIX



LEGEND

Boring Location

Railroad Tracks

Proposed Realignment of Arapaho Rd.

NORTH

NOT TO SCALE

Arapaho Road Realignment
Addison, Texas

PLAN OF BORINGS

TERRA-MAR, INC.

DE94-040

FIGURE 1

FIGURE 1

LOG OF BORING

BORING B-1

Project: **Arapaho Road Realignment - Addison, Texas** Project No.: **DE94-040**

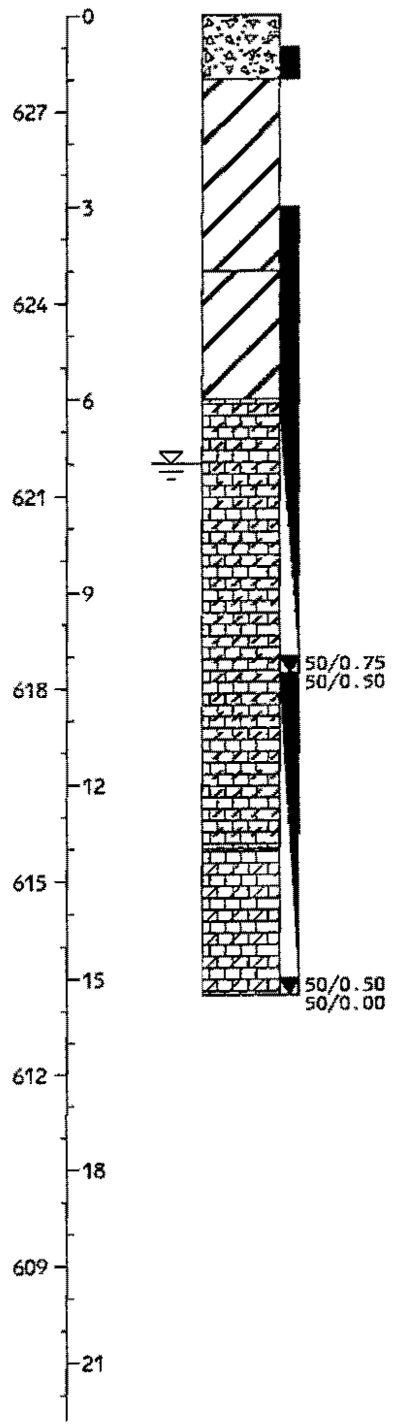
Date: **8-11-94** Elev.: **628.50 +/-** Location: **N 9752.98 E 7349.17 (See Figure 1)**

Depth to water at completion of boring: **7.0'**

Depth to water when checked: **NA** was: **NA**

Depth to caving when checked: **NA** was: **NA**

ELEVATION/ DEPTH (feet) — SOIL SYMBOLS SAMPLER SYMBOLS & FIELD TEST DATA



DESCRIPTION	MC %	LL %	PL %	PI	-200 %	D.D. pcf	P.PEN tsf	UNCON. tsf
6" concrete over 6" lime treated gravelly sandy clay Base							4.5++	
Stiff dark gray CLAY w/ trace sand & calcareous nodules (CH)							1.0 1.25	
Stiff dark brownish gray CLAY w/ trace sand & calcareous nodules (CH)	38	80	22	58		83.7	1.25 1.25	1.01
Moderately hard tan & gray weathered LIMESTONE, fractured w/ iron stains & clay seams & layers								
Moderately hard to hard gray slightly weathered LIMESTONE w/ occasional iron stained fractures & tan weathered limestone seams								

Notes: **Completion Depth: 15.0'**

FIGURE NO.: 2

LOG OF BORING

BORING B-2

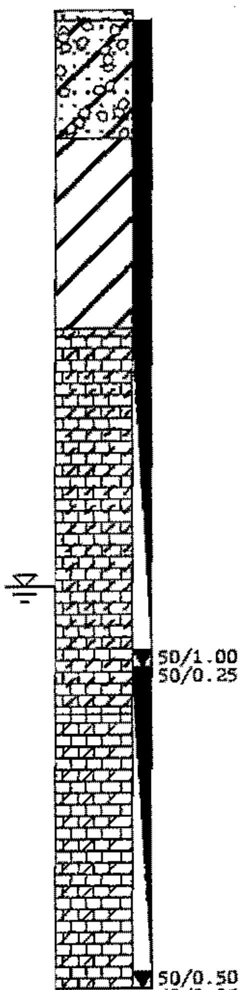
Project: **Arapaho Road Realignment - Addison, Texas** Project No.: **DE94-040**

Date: **8-11-94** Elev.: **629.90 +/-** Location: **N 9802.90 E 7533.08 (See Figure 1)**

Depth to water at completion of boring: **9.0'**

Depth to water when checked: **NA** was: **NA**

Depth to caving when checked: **NA** was: **NA**



ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS & FIELD TEST DATA	DESCRIPTION	MC %	LL %	PL %	PI	-200 %	D.D. pcf	P.PEN tsf	UNCON. tsf
0		2" asphaltic concrete							2.0	
		Stiff dark gray to brown gravelly sandy CLAY (FILL) (CL-SC)								
		Very stiff dark gray CLAY w/ trace sand & calcareous nodules	37	75	24	51		82.8	2.4	
627 / 3										
									2.8	
		(CH)								
		Moderately hard tan weathered LIMESTONE, fractured w/ iron stains & clay seams & layers								
624 / 6										
621 / 9	(water level)									
	50/1.00 50/0.25									
		Moderately hard gray slightly weathered LIMESTONE w/ occasional iron stained fractures & tan weathered limestone seams								
618 / 12										
615 / 15	50/0.50 50/0.25									
612 / 18										
609 / 21										

Notes: **Completion Depth: 15.0'**

FIGURE NO.: 3

LOG OF BORING
BORING B-3

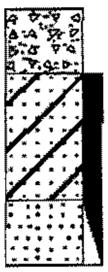
Project: **Arapaho Road Realignment - Addison, Texas** Project No.: **DE94-040**

Date: **8-11-94** Elev.: **630.70 +/-** Location: **N 9748.71 E 7795.20 (See Figure 1)**

Depth to water at completion of boring: **Dry**

Depth to water when checked: **N/A** was: **N/A**

Depth to caving when checked: **N/A** was: **N/A**



ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS & FIELD TEST DATA	DESCRIPTION	MC %	LL %	PL %	PI	-200 %	D.D. pcf	P.PEN tsf	UNCON. tsf
0		6" concrete over 6" lime treated gravelly sandy clay Base								
630		Very stiff gray & brown sandy CLAY w/ limestone fragments (FILL) (CL-GP)							3.0 3.0	
3 627		Reddish brown fine SAND w/ little gravel (FILL) (SP)								

Depth scale: 0, 3, 6, 9, 12, 15, 18, 21; Elevation scale: 630, 627, 624, 621, 618, 615, 612, 609

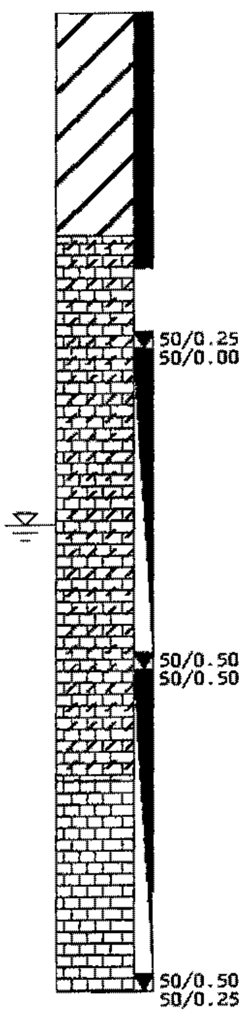
Notes: **Completion Depth: 4.0'**
(Boring terminated in utility backfill)

FIGURE NO.: 4

TERRA-MAR, INC.

LOG OF BORING
BORING B-4

Project: **Arapaho Road Realignment - Addison, Texas** Project No.: **DE94-040**
Date: **8-09-94** Elev.: **630.60 +/-** Location: **N 9977.31 E 7911.13 (See Figure 1)**
Depth to water at completion of boring: **8.0'**
Depth to water when checked: **NA** was: **NA**
Depth to caving when checked: **NA** was: **NA**



ELEVATION/ DEPTH (feet)	DESCRIPTION	MC %	LL %	PL %	PI	-200 %	D.D. pcf	P.PEN tsf	UNCON. tsf
630.6 / 0 – 3	Very stiff dark gray <u>CLAY</u> w/ trace sand, calcareous nodules, gravel & limestone fragments (POSSIBLE FILL) (CH)	27	60	23	37		92.5	2.75 2.75	
3 – 12	Moderately hard tan <u>weathered LIMESTONE</u>, fractured w/ iron stains & clay seams & layers -w/ gray limestone seams & layers below 8' -free water encountered @ 10'								
12 – 15	Moderately hard to hard gray <u>unweathered LIMESTONE</u>								

Elevation scale: 630, 627, 624, 621, 618, 615, 612, 609; Depth scale: 0, 3, 6, 9, 12, 15, 18, 21

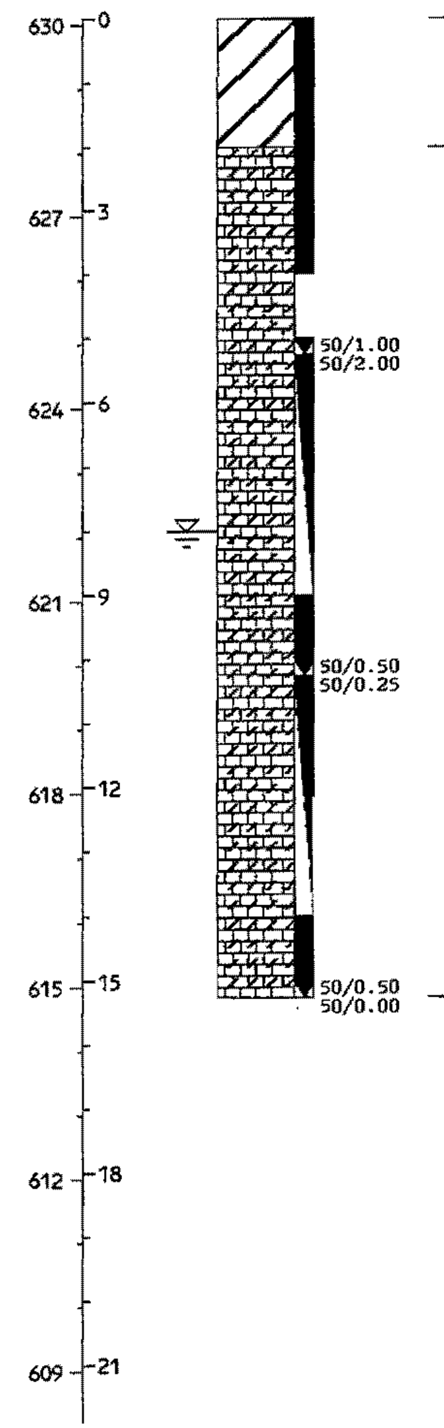
Notes: **Completion Depth: 15.0'**

FIGURE NO.: 5

LOG OF BORING
BORING B-5

Project: **Arapaho Road Realignment - Addison, Texas** Project No.: **DE94-040**
Date: **8-09-94** Elev.: **630.10 +/-** Location: **N 9933.02 E 7937.03 (See Figure 1)**
Depth to water at completion of boring: **8.0'**
Depth to water when checked: **NA** was: **NA**
Depth to caving when checked: **NA** was: **NA**

ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS & FIELD TEST DATA



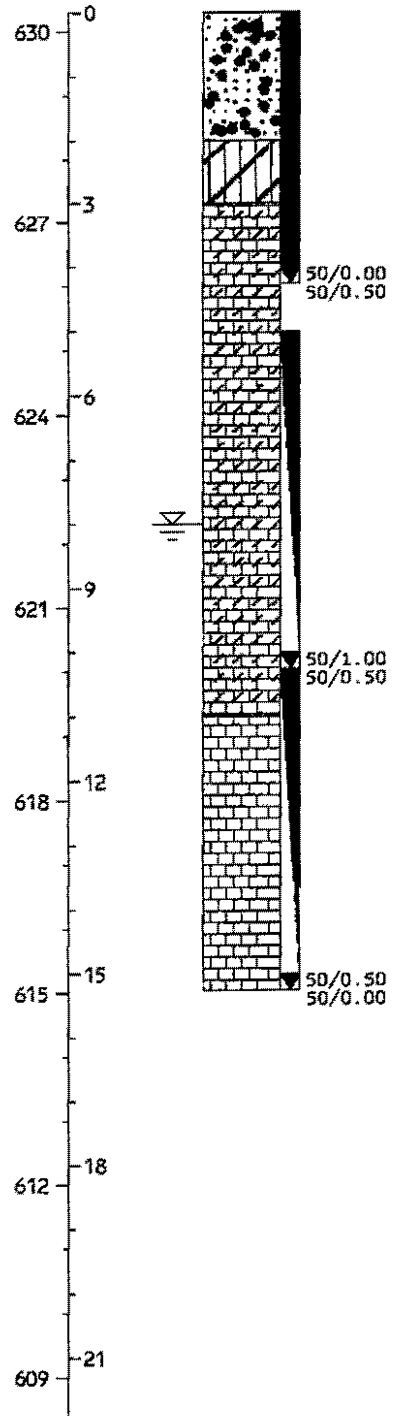
DESCRIPTION	MC %	LL %	PL %	PI	-200 %	D.D. pcf	P.PEN tsf	UNCON. tsf
Hard dark gray CLAY w/ trace sand, gravel, tan clay inclusoins & some calcareous nodules (CH)	27	60	22	38		95.6	4.5	
Moderately hard tan weathered LIMESTONE, fractured w/ iron stains & clay seams & layers							4.5+	
							4.5+	
-w/ 6" medium stiff clay layer @ 14'							0.75	
							4.5+	

Notes: **Completion Depth: 15.0'**

FIGURE NO.: 6

LOG OF BORING
BORING B-6

Project: **Arapaho Road Realignment - Addison, Texas** Project No.: **DE94-040**
Date: **8-09-94** Elev.: **630.30 +/-** Location: **N 10006.30 E 7933.38 (See Figure 1)**
Depth to water at completion of boring: **8.0'**
Depth to water when checked: **NA** was: **NA**
Depth to caving when checked: **NA** was: **NA**



ELEVATION/ DEPTH (feet)	DESCRIPTION	MC %	LL %	PL %	PI	-200 %	D.D. pcf	P.PEN tsf	UNCON. tsf
0	Gray to brown sandy GRAVEL (FILL) (GP)								
	Hard tan silty CLAY (CL)	19	36	19	17		106.7	4.5+	
3	Moderately hard tan & gray weathered LIMESTONE, fractured w/ iron stains & clay seams & layers								
	Moderately hard to hard gray unweathered LIMESTONE								

Notes: **Completion Depth: 15.0'**

FIGURE NO.: 7

TERRA-MAR, INC.

LOG OF BORING
BORING B-7

Project: **Arapaho Road Realignment - Addison, Texas** Project No.: **DE94-040**

Date: **8-09-94** Elev.: **630.00 +/-** Location: **N 10057.93 E 7945.03 (See Figure 1)**

Depth to water at completion of boring: **Dry**

Depth to water when checked: **NA** was: **NA**

Depth to caving when checked: **NA** was: **NA**

ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS & FIELD TEST DATA	DESCRIPTION	MC %	LL %	PL %	PI	-200 %	D.D. pcf	P.PEN tsf	UNCON. tsf
630 — 0		Hard dark grayish brown sandy CLAY w/ gravel & sand layers (FILL) (CL)							4.5 4.5+	
627 — 3	50/0.25 50/0.00	Moderately hard tan weathered LIMESTONE, fractured w/ iron stains & clay seams & layers							4.5++	
624 — 6										
621 — 9	50/0.50 50/0.00	Moderately hard to hard gray unweathered LIMESTONE								
618 — 12										
615 — 15	50/0.25 50/0.25									
612 — 18										
609 — 21										

Notes: **Completion Depth: 15.0'**

FIGURE NO.: 8

LOG OF BORING
BORING B-8

Project: **Arapaho Road Realignment - Addison, Texas** Project No.: **DE94-040**

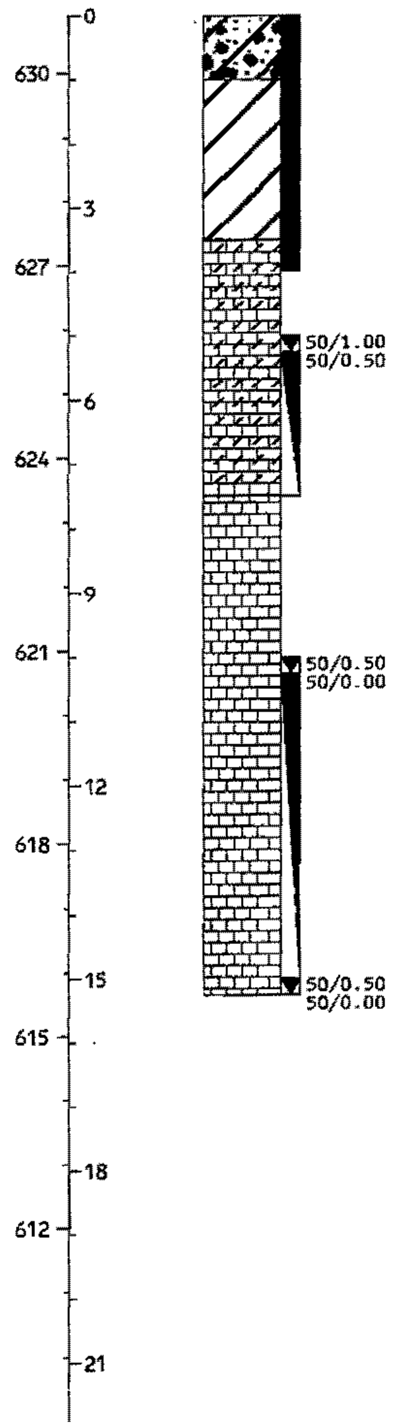
Date: **8-09-94** Elev.: **630.90 +/-** Location: **N 10023.67 E 7969.37 (See Figure 1)**

Depth to water at completion of boring: **Dry**

Depth to water when checked: **NA** was: **NA**

Depth to caving when checked: **NA** was: **NA**

ELEVATION/ DEPTH (feet) | SOIL SYMBOLS SAMPLER SYMBOLS & FIELD TEST DATA



DESCRIPTION	MC %	LL %	PL %	PI	-200 %	D.D. pcf	P.PEN tsf	UNCON. tsf
Very dense gray clayey sandy GRAVEL (FILL) (GP)								
Hard dark gray CLAY w/ trace sand & calcareous nodules (CH)	25	60	24	36		94.9	4.5 4.2	
Moderately hard tan weathered LIMESTONE, fractured w/ iron stains & clay seams & layers								
Moderately hard to hard gray unweathered LIMESTONE								

Notes: **Completion Depth: 15.0'**

FIGURE NO.: 9

LOG OF BORING

BORING B-9

Project: **Arapaho Road Realignment - Addison, Texas** Project No.: **DE94-040**

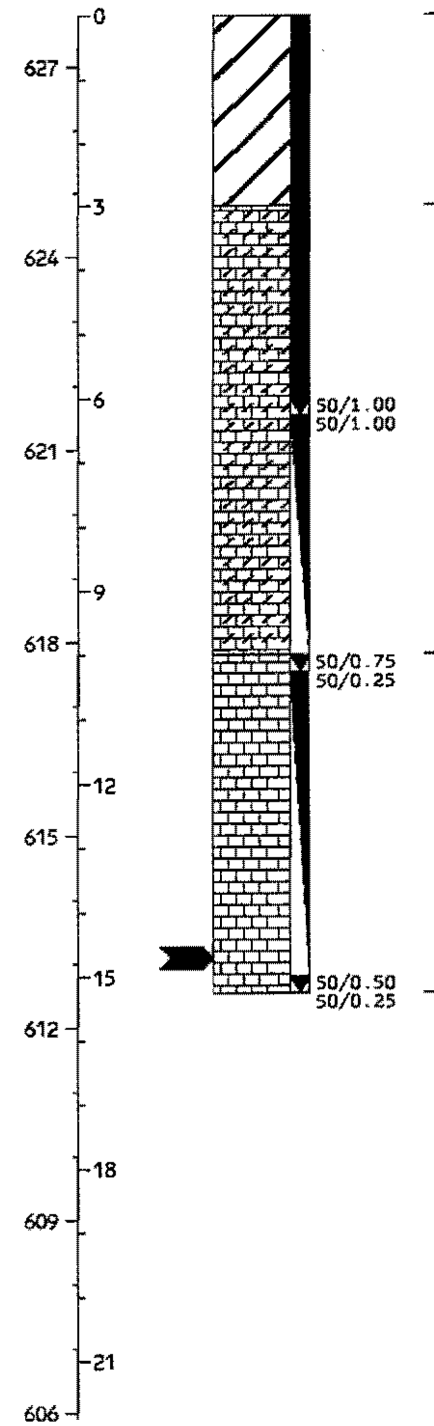
Date: **8-09-94** Elev.: **627.80 +/-** Location: **N 10165.69 E 8278.63 (See Figure 1)**

Depth to water at completion of boring: **Dry**

Depth to water when checked: **8-15-94** was: **Dry**

Depth to caving when checked: **8-15-94** was: **14.7'**

ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS & FIELD TEST DATA	DESCRIPTION	MC %	LL %	PL %	PI	-200 %	D.D. pcf	P.PEN tsf	UNCON. tsf
0–3		Very stiff dark gray CLAY w/ trace sand & calcareous nodules (CH)							3.5	
3–9.3	50/1.00, 50/1.00	Moderately hard tan weathered LIMESTONE, fractured w/ iron stains & clay seams & layers							4.5+ 4.5+	
9.3–15.0	50/0.75, 50/0.25; 50/0.50, 50/0.25	Moderately hard to hard gray unweathered LIMESTONE								



Notes: **Completion Depth: 15.0'**

FIGURE NO.: 10

TERRA-MAR, INC.

LOG OF BORING

BORING B-10

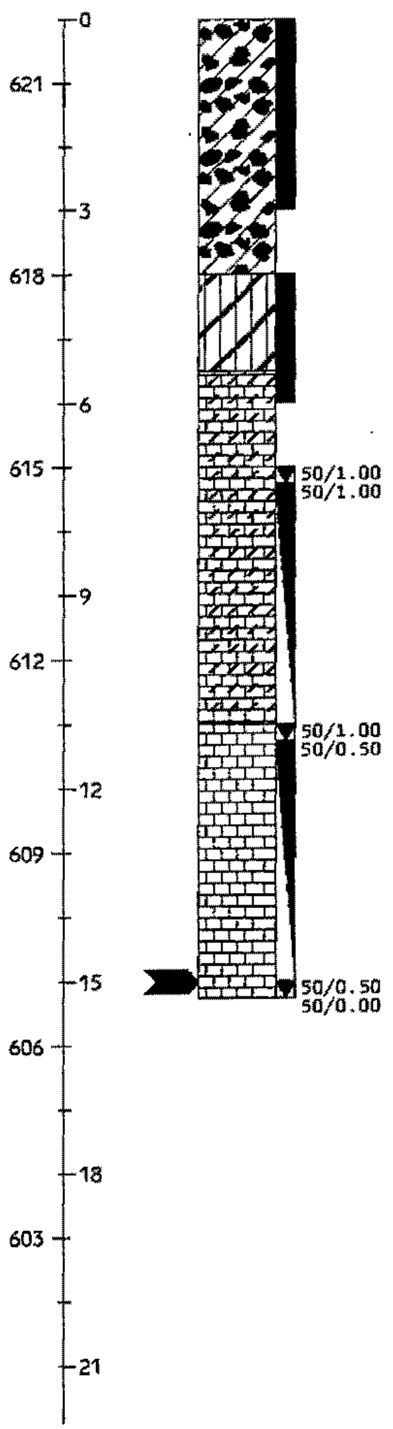
Project: **Arapaho Road Realignment - Addison, Texas** Project No.: **DE94-040**

Date: **8-11-94** Elev.: **622.00 +/-** Location: **N 10213.82 E 8623.72 (See Figure 1)**

Depth to water at completion of boring: **Dry**

Depth to water when checked: **8-15-94** was: **Dry**

Depth to caving when checked: **8-15-94** was: **15.0'**



ELEVATION/ DEPTH (feet)	SOIL SYMBOLS SAMPLER SYMBOLS & FIELD TEST DATA	DESCRIPTION	MC %	LL %	PL %	PI	-200 %	D.D. pcf	P.PEN tsf	UNCON. tsf
622 / 0 – 618 / 4		Broken limestone w/ brown clay layers, grass, paper, wood & plastic -limestone boulder @ 3' (FILL)								
618 / 4 – 616.5 / 5.5		Very stiff tan & brown silty CLAY w/little limestone gravel (CL-CH)							3.0 2.75	
616.5 / 5.5 – 611 / 11	50/1.00 50/1.00	Moderately hard tan weathered LIMESTONE, fractured w/ iron stains & clay seams & layers								
611 / 11 – 607 / 15	50/1.00 50/0.50 50/0.50 50/0.00	Moderately hard to hard gray unweathered LIMESTONE								

Notes: **Completion Depth: 15.0'**

FIGURE NO.: 11

LOG OF BORING

BORING B-11

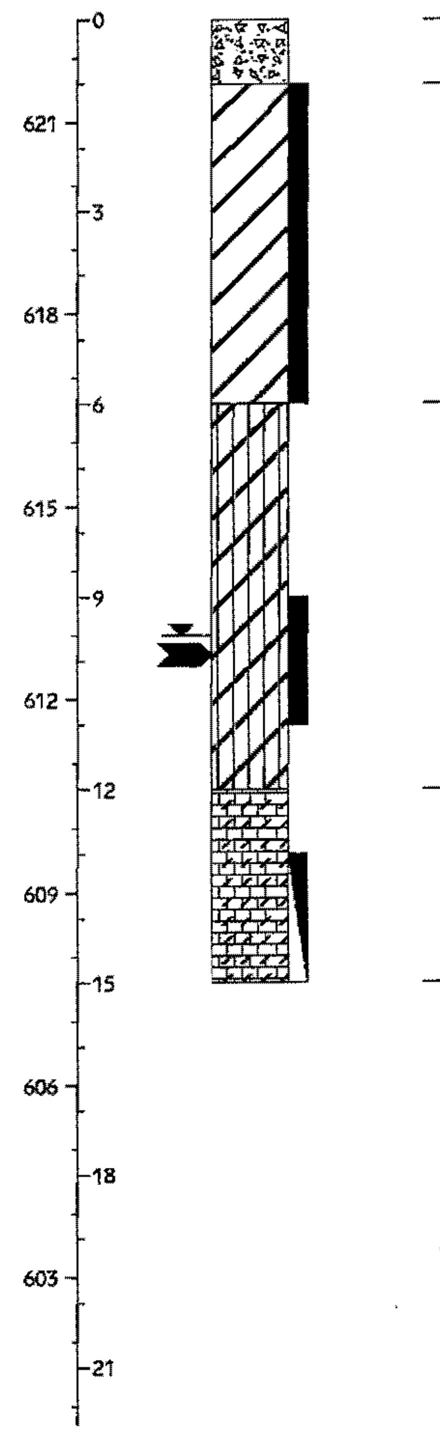
Project: **Arapaho Road Realignment - Addison, Texas** Project No.: **DE94-040**

Date: **8-11-94** Elev.: **622.60 +/-** Location: **N 9873.66 E 8782.39 (See Figure 1)**

Depth to water at completion of boring: **Dry**

Depth to water when checked: **8-15-94** was: **9.6'**

Depth to caving when checked: **8-15-94** was: **9.9'**



DESCRIPTION	MC %	LL %	PL %	PI	-200 %	D.D. pcf	P.PEN tsf	UNCON. tsf
6" concrete over 6" lime treated gravelly sandy clay Base								
Very stiff dark gray <u>CLAY</u> w/trace sand & calcareous nodules							2.75	
	36	71	24	47		84.3	2.75	
							2.5	
	37					83.6	2.5	1.48
(CH)							2.5	
Very stiff tan & gray <u>silty CLAY</u> w/ trace calcareous nodules & iron stains								
	26	40	19	21		103.0	2.5	1.32
-free water encountered @ 11'							2.5	
(CL)								
Moderately hard tan <u>weathered LIMESTONE</u>, fractured w/ iron stains & clay seams & layers								

Notes: **Completion Depth: 15.0'**

FIGURE NO.: 12

LOG OF BORING

BORING B-12

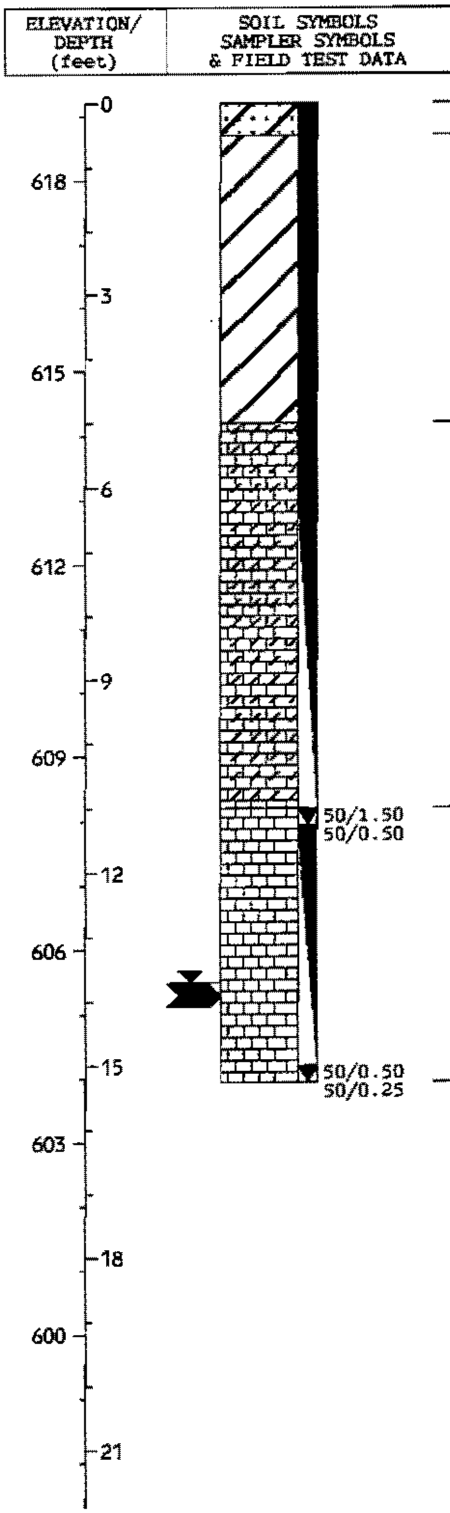
Project: **Arapaho Road Realignment - Addison, Texas** Project No.: **DE94-040**

Date: **8-11-94** Elev.: **619.20 +/-** Location: **N 10238.57 E 8821.28 (See Figure 1)**

Depth to water at completion of boring: **Dry**

Depth to water when checked: **8-15-94** was: **13.7'**

Depth to caving when checked: **8-15-94** was: **13.9'**



DESCRIPTION	MC %	LL %	PL %	PI	-200 %	D.D. pcf	P.PEN tsf	UNCON. tsf
Hard tan sandy CLAY w/ some limestone gravel (CL)							4.5	
Hard dark gray CLAY w/ trace sand & calcareous nodules	25	60	21	39		98.4	4.0	
-w/ calcareous inclusions @ 0.5'-1'	27					97.0	4.0	3.71
							4.0	
(CH)							4.0	
Moderately hard tan weathered LIMESTONE, fractured w/ iron stains & clay seams & layers							4.5	
Moderately hard to hard gray unweathered LIMESTONE								

Notes: **Completion Depth: 15.0'**

FIGURE NO.: 13

TERRA-MAR, INC.

LOG OF BORING

BORING B-13

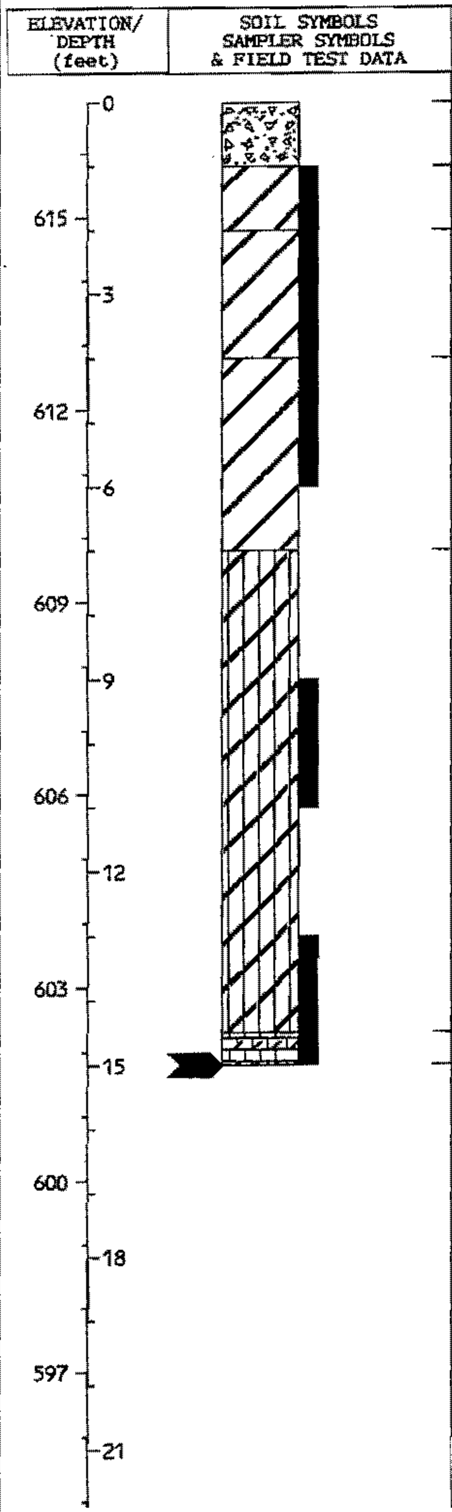
Project: **Arapaho Road Realignment - Addison, Texas** Project No.: **DE94-040**

Date: **8-11-94** Elev.: **616.80 +/-** Location: **N 10279.17 E 9222.26 (See Figure 1)**

Depth to water at completion of boring: **Dry**

Depth to water when checked: **8-15-94** was: **Dry**

Depth to caving when checked: **8-15-94** was: **15.0'**



DESCRIPTION	MC %	LL %	PL %	PI	-200 %	D.D. pcf	P.PEN tsf	UNCON. tsf
6" concrete over 6" lime treated gravelly sandy clay Base								
Very stiff dark gray & tan CLAY w/ some limestone gravel (FILL) (CH)							3.0	
Very stiff dark gray CLAY w/ trace sand & calcareous nodules (CH)							2.25	
							2.25	
Very stiff dark grayish brown CLAY w/ trace sand & calcareous nodules (CH)	29	67	22	45		93.3	3.0	1.46
							2.25	
Stiff to very stiff tan to light tan silty CLAY w/ some fine limestone gravel (CH)							3.5	
							2.75	
	30	59	18	41		90.6	1.5	0.74
Moderately hard tan weathered LIMESTONE, fractured w/ iron stains & clay seams & layers							4.5	

Notes: **Completion Depth: 15.0'**

FIGURE NO.: 14

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KEY TO LOG TERMS & SYMBOLS

Symbol	Description

Strata symbols

- PAVEMENT w/ base
- CLAY
- LIMESTONE, weathered
- LIMESTONE, slightly weathered
- CLAY, sand, gravelly
- CLAY, sandy
- LIMESTONE
- GRAVEL, sandy
- CLAY, silty
- GRAVEL, clayey, sandy
- GRAVEL, clayey
- SAND

Misc. Symbols

- Depth to caving
- Water table when checked

Soil Samplers

- Thin wall Shelby Tube
- Bulk/Grab sample
- THD penetration test

Notes:

1. Exploratory borings were drilled on dates indicated using truck mounted drilling equipment.

2. Water level observations are noted on boring logs.

3. Results of tests conducted on samples recovered are reported on the boring logs. Abbreviations used are:

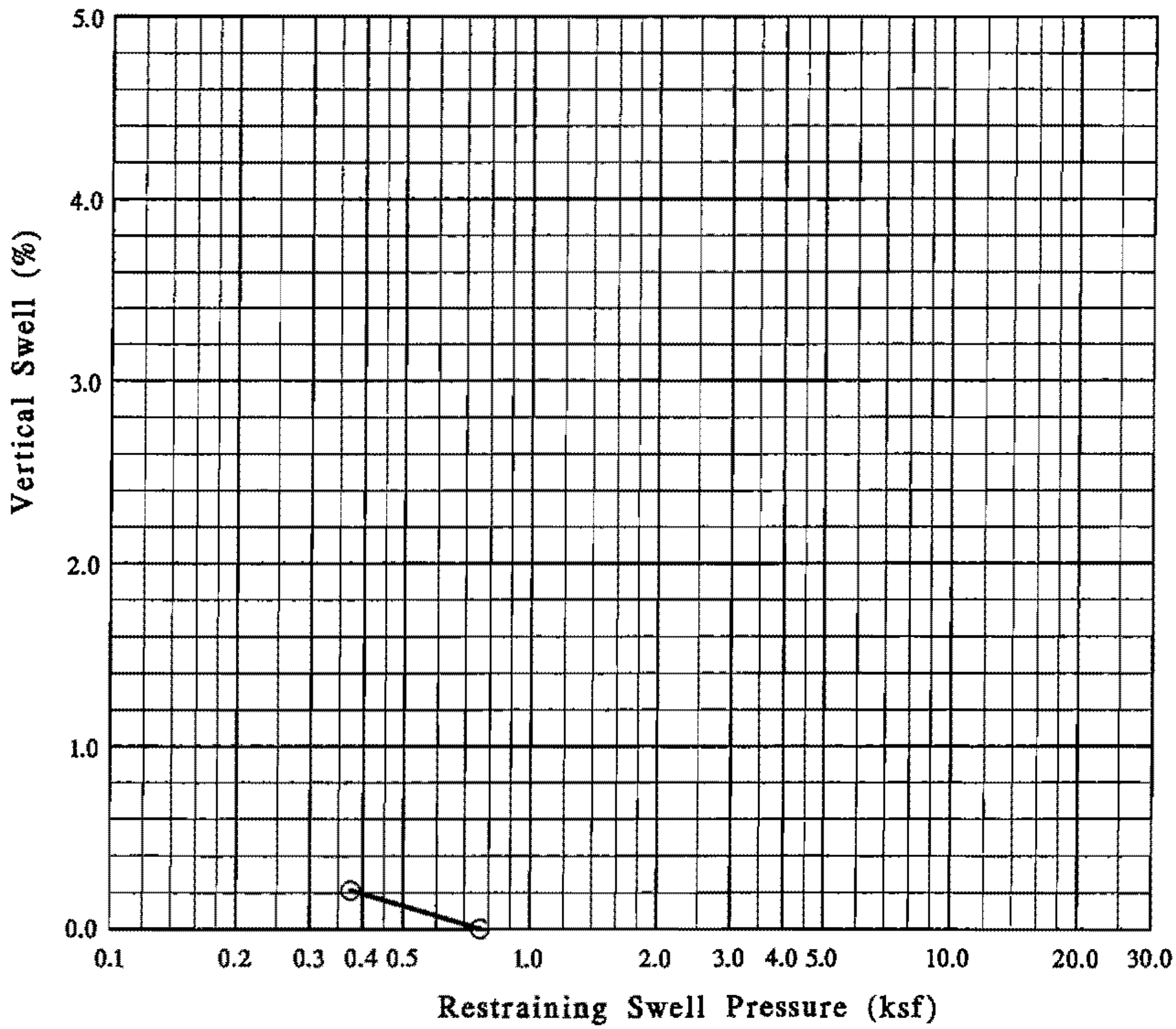
DD = natural dry density (pcf)	LL = liquid limit (%)
MC = natural moisture content (%)	PL = plastic limit (%)
Uncon.= unconfined compression (tsf)	PI = plasticity index
P.Pen.= hand penetrometer (tsf)	-200 = percent passing #200

4. Rock Cores
   Recovery = sum of core sample recovered divided by length of run, expressed as percentage.
   RQD = (Rock Quality Designation) sum of core sample recovery 4" or greater in length divided by the run, expressed as percentage.

FIGURE NO.: 15

Absorption Pressure Swell Test

Boring No.	B-2
Depth (ft)	2-4
Soil Desc. Dark gray CLAY	
Unit Dry Weight (pcf)	82.8
Initial Moisture Content (%)	37.3
Final Moisture Content (%)	38.2
Maximum Swell Pressure (ksf)	0.76
Vertical Swell (%)	0.21
Final Swell Pressure (Overburden)(ksf)	0.38
Liquid Limit (%)	75
Plasticity Index (PI)	51
Initial Penetrometer Reading (tsf)	2.5
Final Penetrometer Reading (tsf)	2.0



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DE94-040

FIGURE 16

Absorption Pressure Swell Test

Boring No.	B-6
Depth (ft).	2-4
Soil Desc.	
Unit Dry Weight (pcf)	106.7
Initial Moisture Content (%).	18.9
Final Moisture Content (%)	20.7
Maximum Swell Pressure (ksf)	0.95
Vertical Swell (%).	0.17
Final Swell Pressure (Overburden)(ksf)	0.38
Liquid Limit (%).	36
Plasticity Index (PI).	17
Initial Penetrometer Reading (tsf)	4.5+
Final Penetrometer Reading (tsf).	3.75

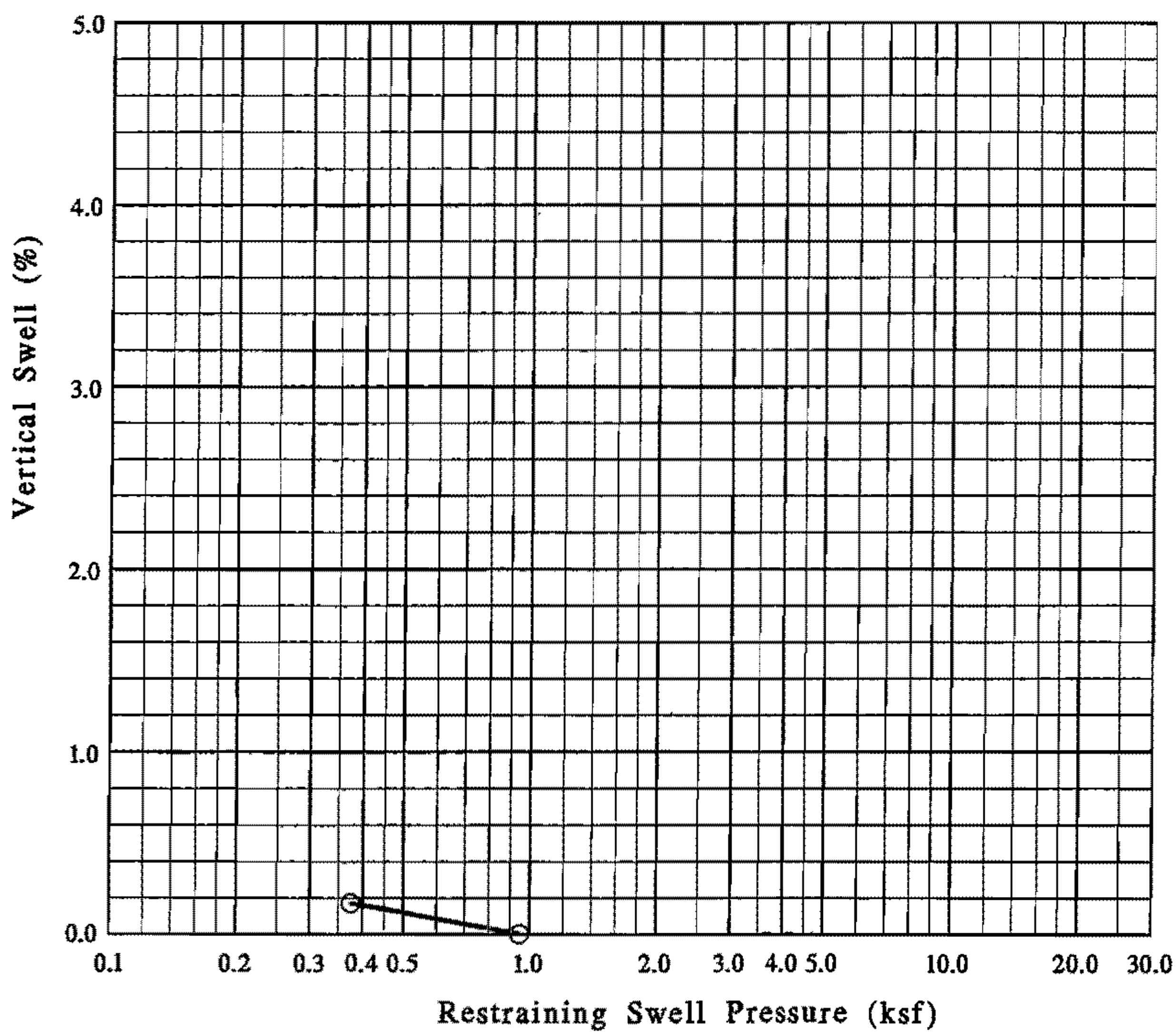

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FIGURE 17

Absorption Pressure Swell Test

Boring No.	B-8
Depth (ft)	1-2
Soil Desc. Dark gray CLAY	
Unit Dry Weight (pcf)	94.9
Initial Moisture Content (%)	25.4
Final Moisture Content (%)	29.1
Maximum Swell Pressure (ksf)	3.08
Vertical Swell (%)	3.20
Final Swell Pressure (Overburden)(ksf)	0.25
Liquid Limit (%)	60
Plasticity Index (PI)	36
Initial Penetrometer Reading (tsf)	4.4
Final Penetrometer Reading (tsf)	3.0

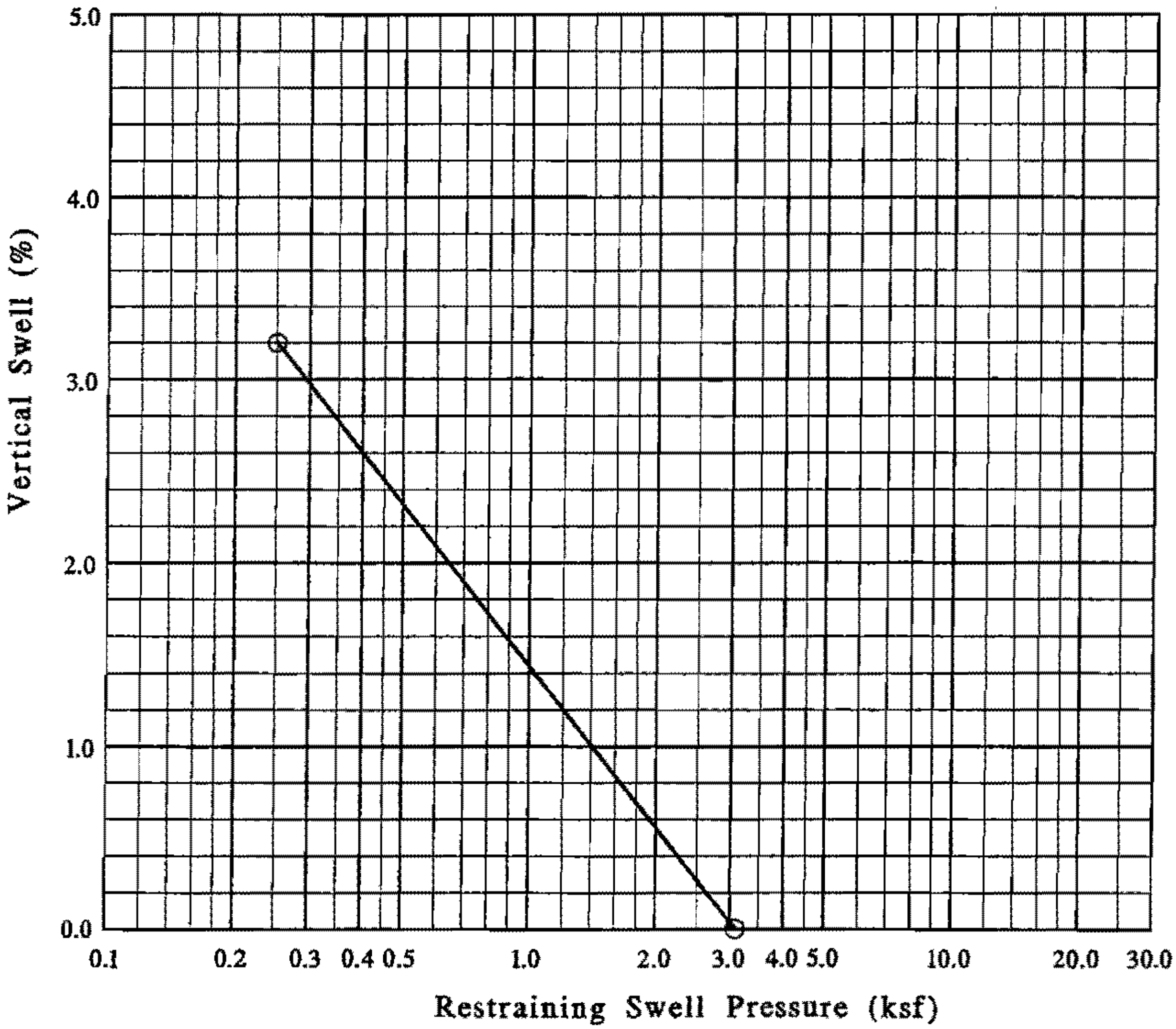

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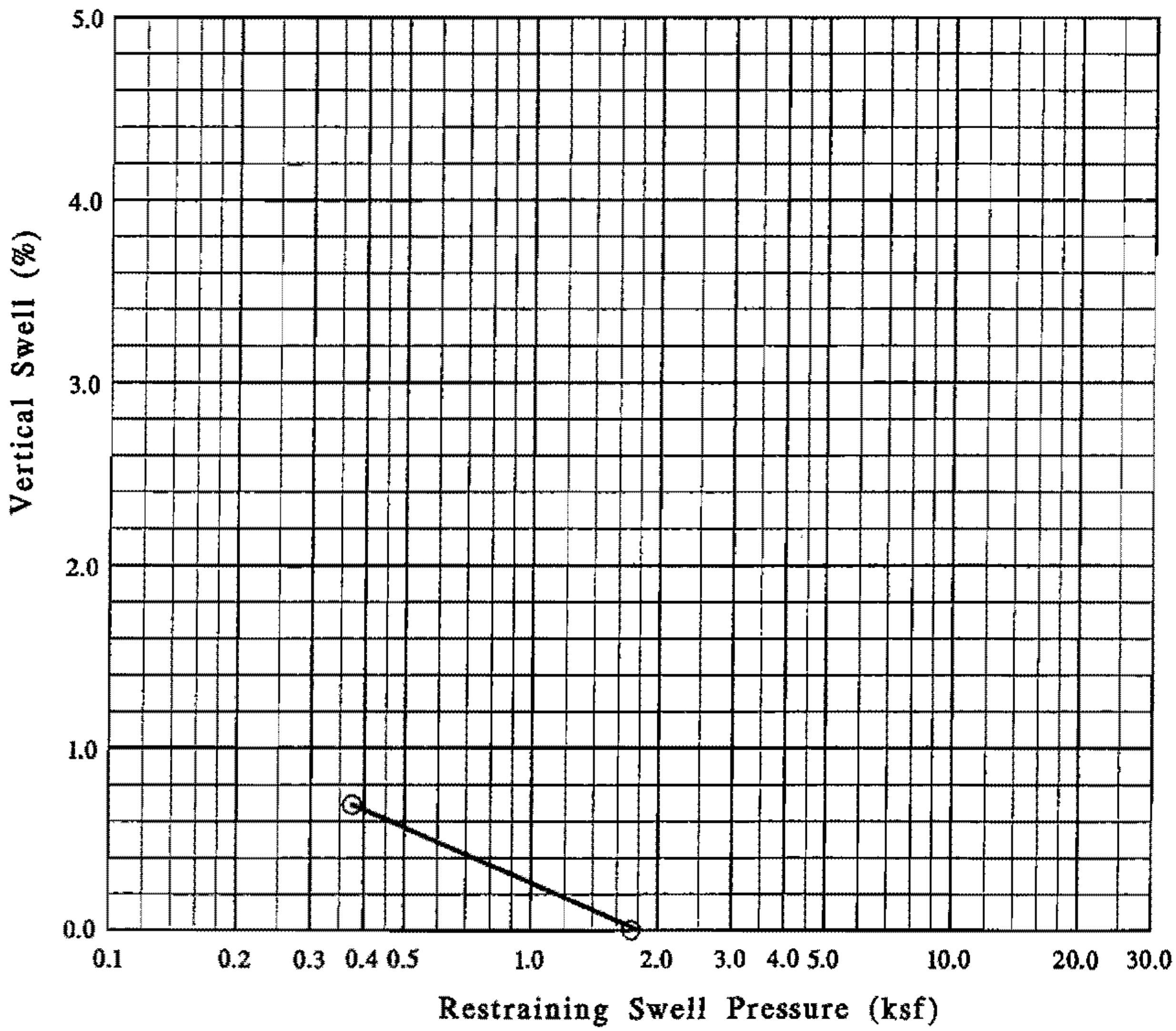
FIGURE 18

Absorption Pressure Swell Test

Boring No.	B-11
Depth (ft).	2-4
Soil Desc. Dark gray CLAY	
Unit Dry Weight (pcf)	84.6
Initial Moisture Content (%).	35.6
Final Moisture Content (%)	36.2
Maximum Swell Pressure (ksf)	1.73
Vertical Swell (%).	0.69
Final Swell Pressure (Overburden)(ksf)	0.38
Liquid Limit (%).	71
Plasticity Index (PI).	47
Initial Penetrometer Reading (tsf)	2.7
Final Penetrometer Reading (tsf)..	2.0



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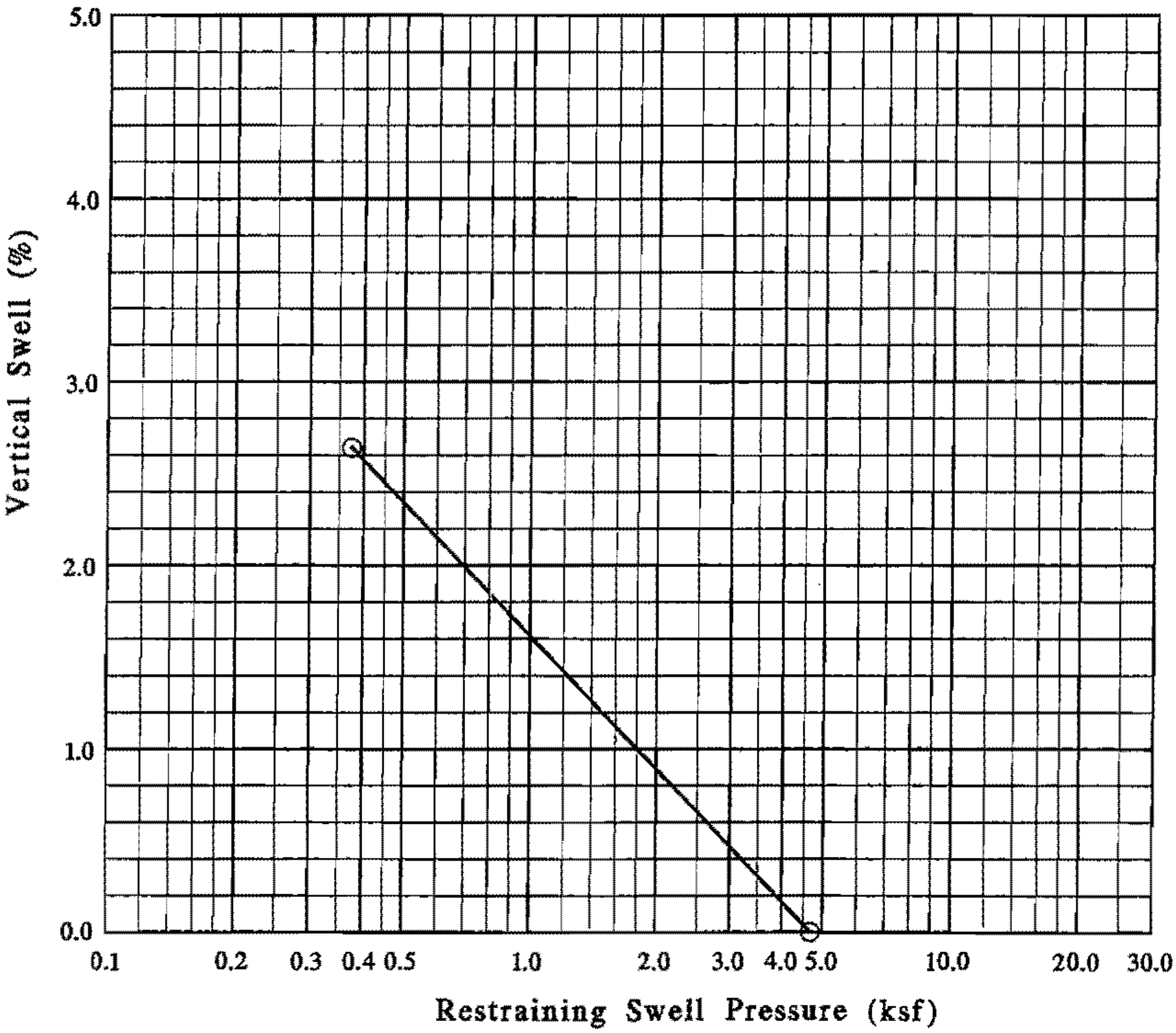
DE94-040

FIGURE 19

Absorption Pressure Swell Test

Boring No.	B-12
Depth (ft)	2-4
Soil Desc. Dark gray CLAY	

Unit Dry Weight (pcf)	97.1
Initial Moisture Content (%)	26.9
Final Moisture Content (%)	29.3
Maximum Swell Pressure (ksf)	4.67
Vertical Swell (%)	2.64
Final Swell Pressure (Overburden)(ksf)	0.38
Liquid Limit (%)	60
Plasticity Index (PI)	39
Initial Penetrometer Reading (tsf)	4.0
Final Penetrometer Reading (tsf)	2.6



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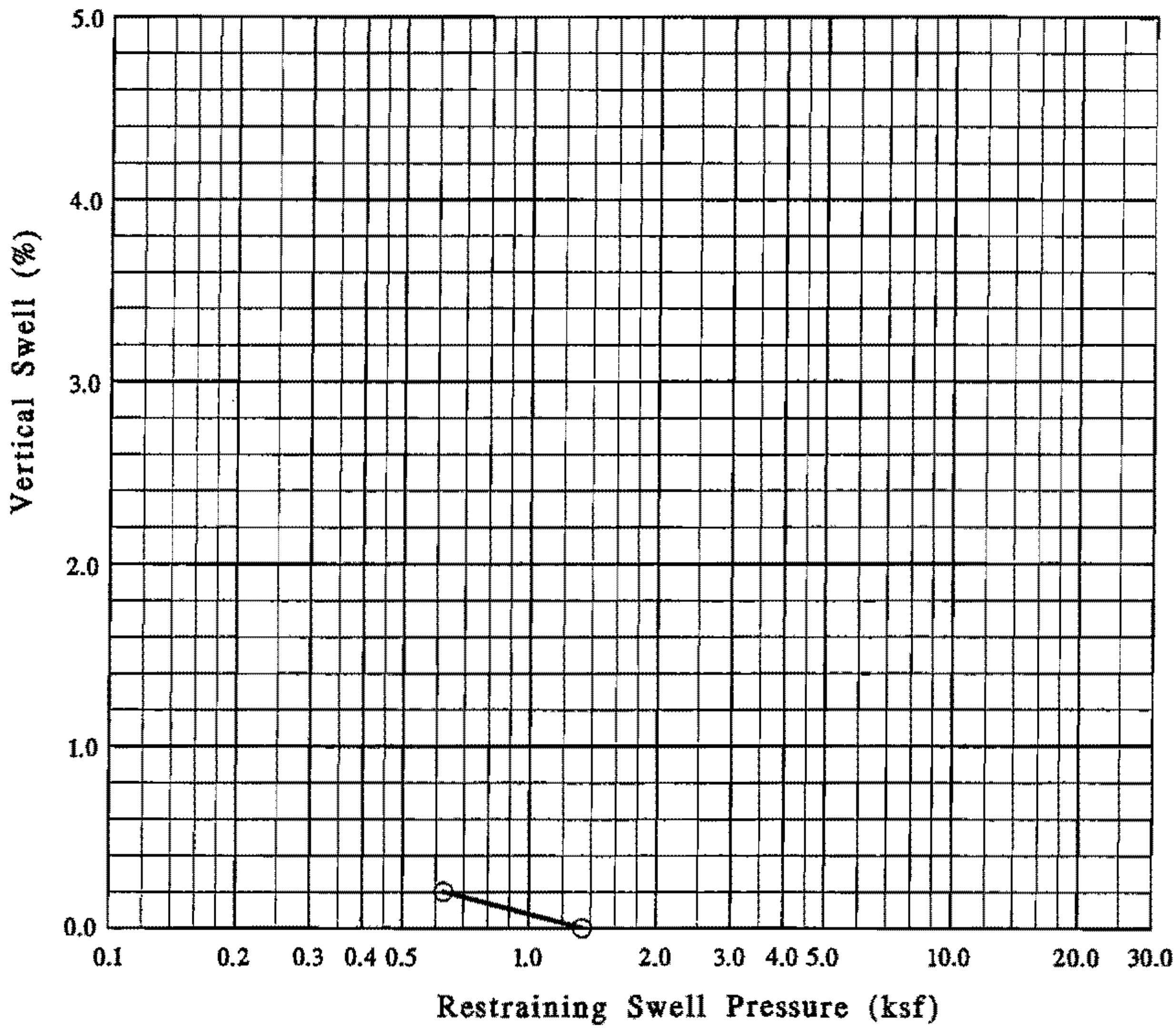
DE94-040

FIGURE 20

Absorption Pressure Swell Test

Boring No.	B-13
Depth (ft).	4-6
Soil Desc. Dark grayish brown CLAY	
Unit Dry Weight (pcf)	93.4
Initial Moisture Content (%).	29.0
Final Moisture Content (%)	29.7
Maximum Swell Pressure (ksf)	1.34
Vertical Swell (%).	0.20
Final Swell Pressure (Overburden)(ksf)	0.63
Liquid Limit (%).	67
Plasticity Index (PI).	45
Initial Penetrometer Reading (tsf)	2.6
Final Penetrometer Reading (tsf).	1.9



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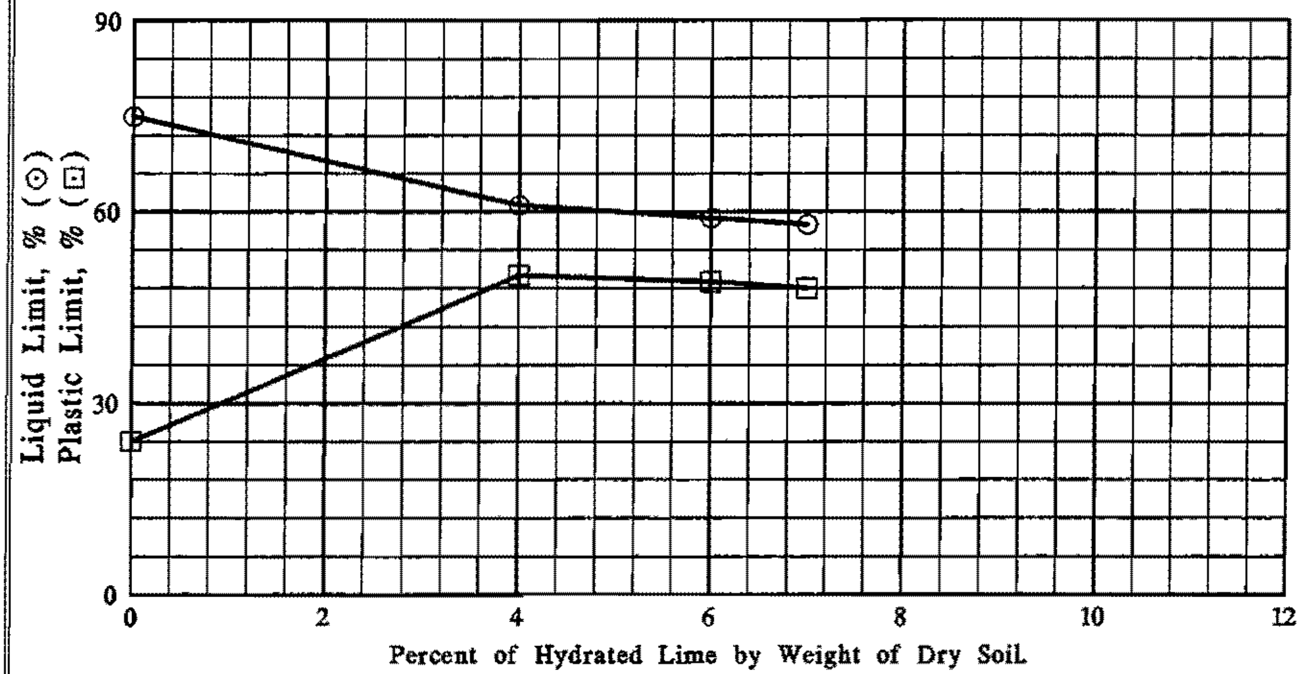
DE94-040

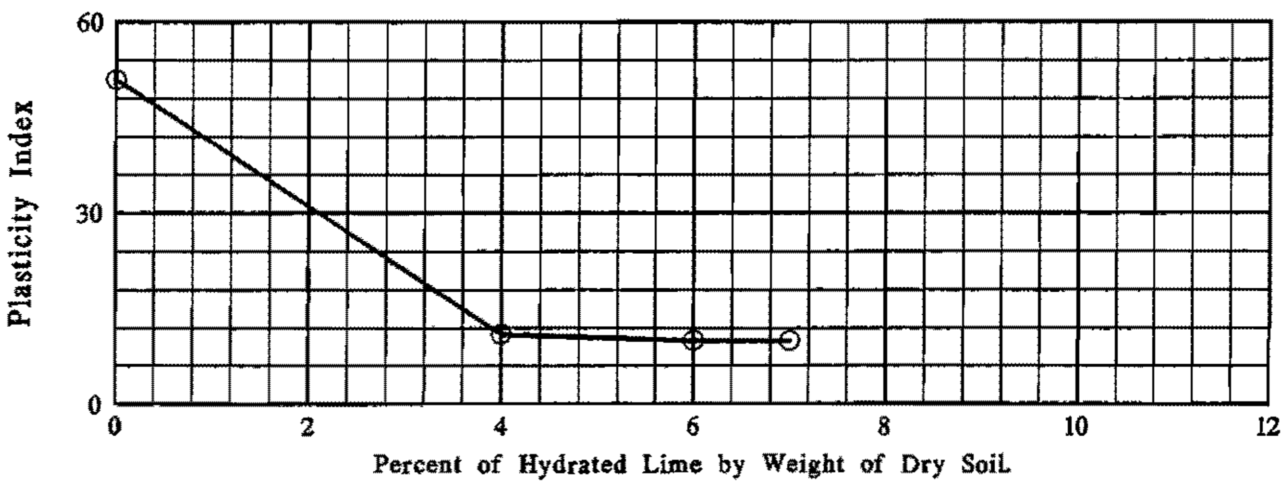
FIGURE 21

OPTIMUM STABILIZATION ADDITIVE DETERMINATION

LOCATION: Boring B-2, 2'-4'

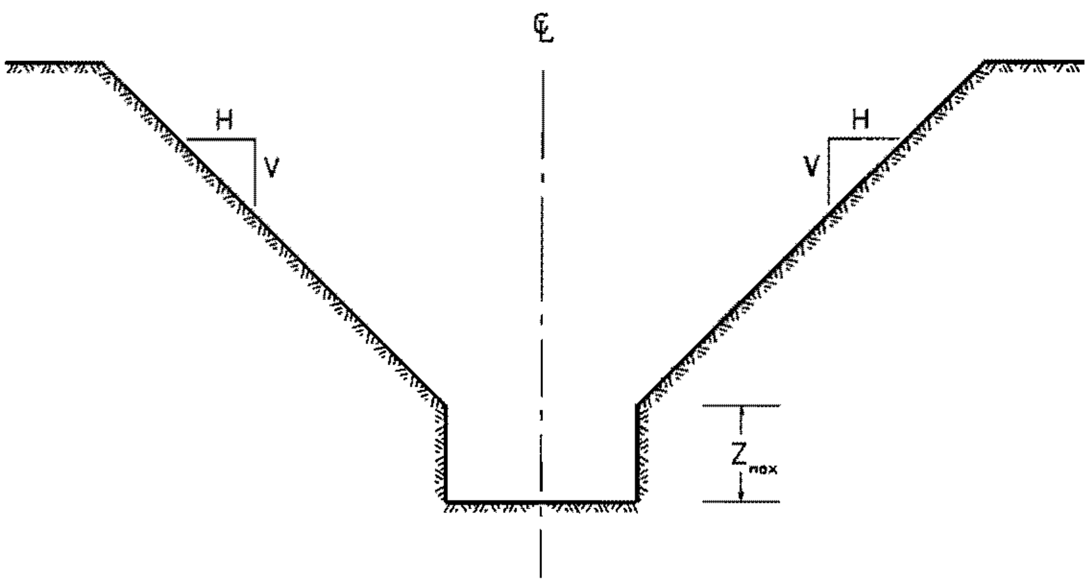
MATERIAL DESCRIPTION: Dark gray CLAY





Arapaho Road Realignment Plano, Texas	
Optimum Stabilization Additive Determination	
TERRA-MAR, INC.	DE94-040 FIGURE 22

	RECOMMENDED SLOPE RATIOS				
	Short Term (under 12 hours)		Long Term (over 12 hours)		Bedding Cut*
SOIL / ROCK	H	V	H	V	Z (Ft)
Submerged soil & submerged fractured rock ** & ***	1½	1	2	1	0
Stiff hard CLAY & sandy CLAY, both fill & natural, tan weathered LIMESTONE, fractured gray LIMESTONE	1	1	1	1	0
Loose to very dense clayey SAND, sandy GRAVEL, gravelly CLAY & broken rock fill ***	1½	1	1½	1	0
Moderately hard to hard unweathered LIMESTONE (unfractured competent rock)	Vertical (90°)		Vertical (90°)		



* Maximum bedding cut for trench excavations 12 feet in depth or less in dry soil and/or rock which are open less than 8 hours.

** In accordance with the best interpretation of OSHA regulations, submerged soil is defined as water bearing granular soils, fissured clay soils or fractured shale & limestone (unstable rock) from which groundwater is seeping.

*** Excavation sideslopes required for all un-shored excavations regardless of depth.

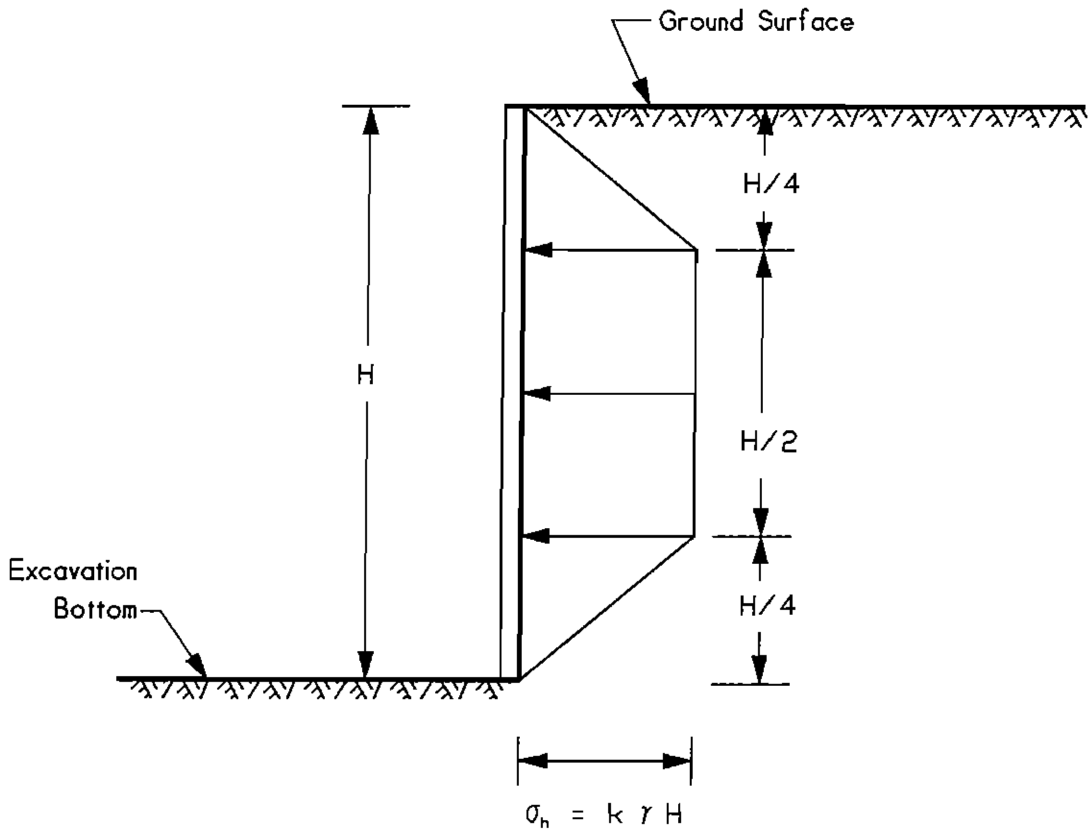
NOTE: Recommended slope ratios may be subject to reduced stability under the influence of groundwater or saturation by rain.

RECOMMENDED SLOPE RATIOS

TERRA-MAR, INC.

DE94-040

FIGURE 23



WHERE:

σ_h = Lateral Earth Pressure, psf.
γ = Saturated Unit Weight of Soil,
Use 130 pcf for clay,
Use 140 pcf for fractured or weathered rock.
H = Height of Excavation (ft.)
k = Earth Pressure Coefficient,
Use 0.3 for clay,
Use 0.2 for fractured or weathered rock.

NOTES:

1) If water is not allowed to drain from behind, full hydrostatic pressure must be considered.

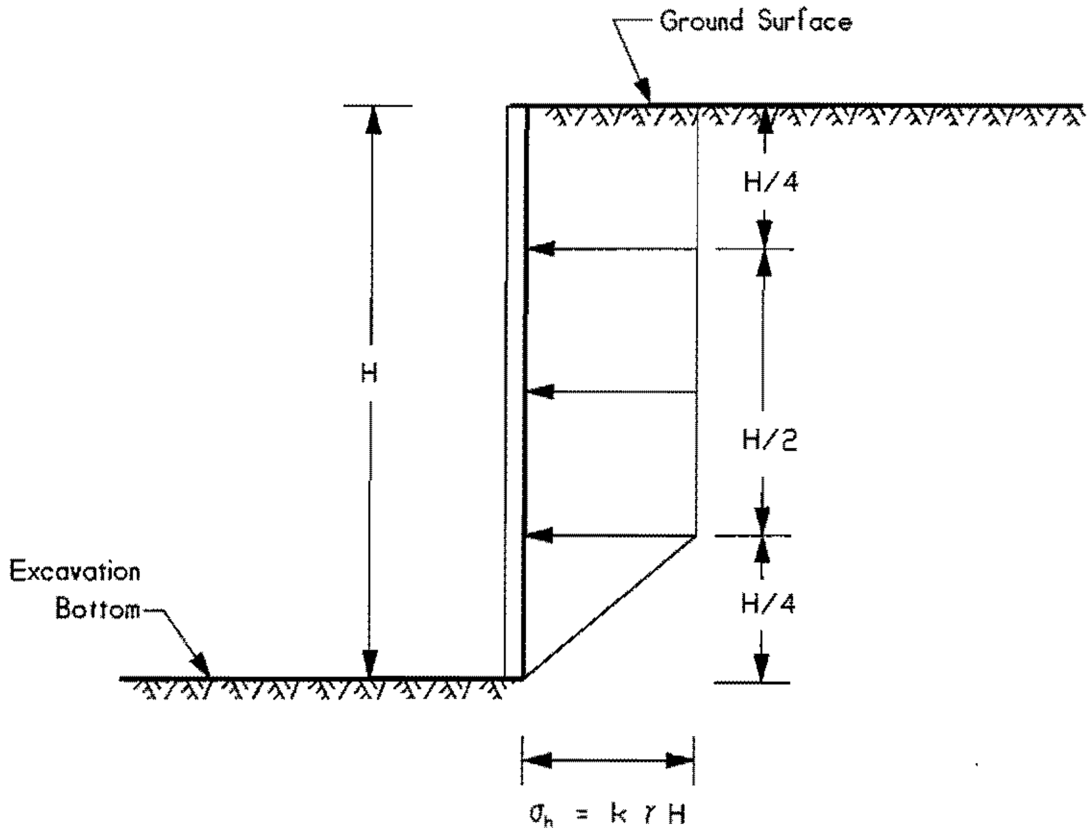
2) Surcharge loads and traffic live loads, if present, must also be considered.

LATERAL EARTH PRESSURE FOR INTERNALLY BRACED EXCAVATION IN CLAY SOIL UNDERLAIN BY FRACTURED ROCK

TERRA-MAR, INC.

DE94-040

FIGURE 24



WHERE:

σ_h = Lateral Earth Pressure, psf.
γ = Saturated Unit Weight of Soil,
Use 130 pcf for clay,
Use 140 pcf for fractured or weathered rock.
H = Height of Excavation (ft.)
k = Earth Pressure Coefficient,
Use 0.3 for clay,
Use 0.2 for fractured or weathered rock.

NOTES:

1) If water is not allowed to drain from behind, full hydrostatic pressure must be considered.

2) Surcharge loads and traffic live loads, if present, must also be considered.

LATERAL EARTH PRESSURE FOR INTERNALLY BRACED EXCAVATION IN GRANULAR SOIL UNDERLAIN BY CLAY OR FRACTURED ROCK

TERRA-MAR, INC.

DE94-040

FIGURE 25

APPENDIX A

SPECIFICATIONS FOR

WATER INJECTION STABILIZATION

Site Preparation

Prior to the start of injection stabilization, the building area should be staked out to accurately mark the area to be injected. The area to be injected should extend at least five feet beyond the limits of the building areas and adjacent sidewalks. Allowance should be made for 2" to 6" of swelling that may occur as a result of the injection process depending on soil properties and in-situ moistures.

Equipment and Materials

1. The injection vehicle shall be capable of forcing injection pipes into the soil with minimal lateral movement to prevent excessive blowback and loss of liquid around the injection pipes. The vehicle may be rubber tire or track mounted suitable for the purpose intended.

2 Slurry pumps shall be capable of pumping at least 3000 GPH at 50-200 psi.

3. A nonionic surfactant (wetting agent) shall be used according to manufacturer's recommendations, but in no case shall proportions be less than one part (undiluted) per 3,500 gallons water.

Application

1. Injection stabilization work shall be accomplished prior to installation of any plumbing, utilities, ditches or foundations.

2. The injection pressures shall be adjusted as directed by a Terra-Mar technician within the range of 50 to 100 psi to inject the greatest quantity of fluid into the soil mass. . In order to assure that the pressure is within this specified range, each injection vehicle shall be equipped with an accurate pressure gauge attached to the manifold (the pipe fitting on which the probe valves are attached).

3. Space injections so as not to exceed five feet on center each way, and inject a minimum of five feet outside building areas.

4. Injection shall either proceed from the ground surface downward or in an upward manner beginning at the specified injection depth and proceeding upward, as directed by a Terra-Mar technician. Inject fluid to the required depth, or to impenetrable material, whichever occurs first. Impenetrable material is the maximum depth to which two injection rods can be mechanically pushed into the soil using an injection machine having a minimum gross weight of five tons. Injections are to be made in 12" to 16" intervals, with a minimum of six stops for seven feet and eight stops for ten feet. The probes shall be forced into the soil, not washed down by scouring action of the fluids. The lower portion of the injection pipes shall contain a hole pattern that will uniformly disperse fluid in a 360 radial pattern. Inject at each interval to "refusal" (i.e., until the maximum quantity of fluid has been

injection into the soil and fluid is running freely at the surface, either out of previous injection holes or from areas where the surface soils have fractured around each injection probe). Back-pressure flow out of previous injection holes shall not constitute "refusal". Fluid coming up around or in the vicinity of one injection probe shall also not be considered as refusal. If this occurs around any probe, this probe shall be cut off so that water can be properly injected through the remaining probes until refusal occurs for all probes. However, no probe shall be cut off within 20 seconds after verifying that each probe is clear and water is flowing freely through each probe at each 12 inch injection depth interval. The injection vehicle shall be fitted with individual cut off valves for each probe. At each twelve inch interval, each valve will be cut off and on to assure that each probe is not blocked and that water is flowing. If one or two probes are blocked, the others shall be cut off so that the added pressure will clear out the blockage.

5. After a minimum curing time of 48 hours, the injected pad may be tested to determine if additional injections with water and surfactant are necessary. The water injections will be five feet on center each way and spaced 2-1/2 feet offset in two orthogonal directions from the initial injection.

6. A minimum of 48 hours shall elapse between each injection application in any one area to allow for moisture absorption, if required.

7. After four injection applications, the surface soils shall be scarified and recompacted to form a surface seal prior to additional injections.

8. The required final moisture content shall be controlled by penetrometer readings as outlined below.

9. Upon completion and approval of the final injection, remove ponding water. Re-excavate to final subgrade and proofroll subgrade per specification requirements. Excavate, rework and compact any soft areas detected. A tight non-yielding subgrade should be achieved prior to beginning lime stabilization operations.

Observation and Testing

1. A full-time engineering technician from Terra-Mar should be present throughout the entire injection operation. After completion, undisturbed samples will be taken at one foot intervals to the total depth injected from test borings located as specified by the Geotechnical Engineer.

2. Inspection, test drilling and verification of moisture contents will be performed under the direction of the Geotechnical Engineer.

3. Injection shall be repeated until pocket penetrometer readings on undisturbed samples have been reduced to less than 2.5 tsf in the upper five feet and less than 3.0 tsf in the lower depth of treatment.

APPENDIX B

SPECIFICATIONS FOR CONSTRUCTION

Pavement Subgrade Preparation

Recommended earthwork construction and subgrade preparation procedures are as follows:

1. Remove the existing pavement, all vegetation, organic topsoil and any soft or otherwise undesirable material from the construction area.

2. The pavement subgrade should be cut to rough grade. Excavation should extend to an elevation below the bottom of the concrete pavement section if lime stabilization is to be performed.

3. Pavement area should be proofrolled to detect any areas of weakness. Proofrolling should be performed in accordance with Texas Highway Department Standard Specifications, Item 216, Proofrolling. The proofrolling operation should be observed by an experienced geotechnician.. Areas of weakness should be undercut to firm soil. Low areas produced by undercutting should be filled in maximum six (6) inch lifts in accordance with Item 4, below.

4 Remove fill debris east of Quorum Drive and replace with on-site soils per Item No. 6 below (see Geotechnical Report text, "Removal of Fill Debris").

5. In fill areas, scarify the subgrade, add moisture if necessary and recompact to a minimum of 95 percent of the maximum dry density as determined by the Standard Proctor Test (ASTM D 698). The moisture content of clay subgrade soils at the time of compaction should be from optimum to four percentage points above the optimum Proctor value.

6. Fill required to bring the site to grade may consist of on-site soils or their equal. Fill should be placed in lifts not exceeding eight inches in thickness and compacted as outlined above in Item No. 4. The use of rock fragments larger than six (6) inches should be prohibited. Rock should not be used as fill in the upper eight (8) inches of final subgrade to prevent difficulties during lime stabilization operations.

7. If injection stabilization is required, it should be performed prior to final grading and prior to lime stabilization of the subgrade. Upon completion and approval of the final injection, remove ponding water. Re-excavate to final subgrade and proofroll subgrade per specification requirements. Excavate, rework and compact any soft areas detected. A tight non-yielding subgrade should be achieved prior to beginning lime stabilization operations.

8. Excavate and shape subgrade to pavement subgrade using on-site soils prior to subgrade stabilization.

The subgrade moisture content and density must be maintained until paving is completed.

Lime Stabilization of Subgrade Soils

Lime Treatment of the clay soils should be accomplished in accordance with the applicable provisions of Item 260 of the Texas Highway Department Standard Specifications for Construction of Highways, Streets and Bridges, 1972 Edition.

Lime should be added to the subgrade after removal of all surface vegetation and debris. A minimum of six (6) percent hydrated lime should be used in all pavement areas to stabilize the moderately active surficial clay soils. The required application rate of lime for a depth of six (6) inches is outlined below:

Percent Lime (%)	Depth of Treatment (inches)	Lime Required (pounds per square yard)
6	6	30

Approval of final mixing operations should be based on gradation tests with 100% passing the 1-3/4 inch sieve and at least 60 percent on a dry weight basis of the stabilized soil passing the No. 4 sieve at a moisture content near optimum.

The lime stabilized soil should be compacted to a minimum of 95% of the maximum dry density defined by the Standard Proctor Test (ASTM D698), at a moisture content within plus to minus three percentage points of optimum.

Sand should be specifically prohibited beneath pavement areas, since these more porous soils can allow water inflow, resulting in heave and strength loss of subgrade clay soils. It should be specified that only lime stabilized soil will be allowed for fine grading. After fine grading each area in preparation for paving, the subgrade surface should be lightly moistened, as needed, and recompacted to obtain a tight non-yielding subgrade.

The subgrade moisture content and density must be maintained until paving is completed by daily watering or by the application of an asphalt seal coat.

Reinforced Concrete Pavement

Reinforced Portland Cement Concrete Pavement should consist of Portland cement concrete having compressive strengths of at least 3,000 psi or flexural strengths of at least 650 psi, depending on the selected section criteria and should be designed in accordance with the ACI Building Code 318 using 3% to 6% air entrainment. This concrete should be saw-cut at least one-eighth inch wide and 1.5 inches deep or one-fourth the pavement thickness, whichever is deeper. All saw cuts should be made on maximum 15 foot centers (12 foot centers are preferable) in both directions as soon as possible after placement but before shrinkage cracks occur. The pavement should be adequately reinforced with steel and all construction joints should be provided with load transfer dowels. It is recommended that, as a minimum, the reinforcement steel should be No. 3 bars placed on chairs on a maximum spacing of 24 inches each way.

APPENDIX C

ENVIRONMENTAL INVESTIGATION RESULTS

Environmental Investigation Results

Due to suspect conditions, i.e. underground storage tanks (UST's) and historical railroad activity, soil samples from Borings B-1 and B-2 (drilled near the Seven-Eleven Store containing petroleum UST's) were screened by an environmental specialist using an organic vapor analyzer (OVA). Soil samples were collected on August 9 & 11, 1994, from seven geotechnical soil borings and submitted to Star Analytical, Forth Worth, Texas for laboratory analysis of Total Petroleum Hydrocarbons (TPH), Benzene, Toluene, Eythal Benzene, and Xylene (BTEX), Volatile Organic Compounds (VOC's), PCB's, and Chlorinated Herbicides and Pesticides. Samples selected for testing contained the highest vapor levels detected during field monitoring using an organic volatile analyzer (OVA). A summary of OVA readings taken at Borings B-1 and B-2 is presented in Table I.

Soil sample results indicate small quantities of TPH from Borings B-1 and TPH & BTEX from Boring B-2. All other results were below the detection limits as shown in Table II. Sampled TPH and BTEX values were below the 100 ppm TPH and 30 ppm total BTEX corrective action standards as outlined in the Texas Natural Resource Conservation Commission (TNRCC) remediation guidance program in response to releases of petroleum products from UST's. TPH and BTEX values are also below the Texas Department of Health (TDH) concentrations requiring permits for disposal into a TDH Type I Landfill.

Sample results from these borings indicate that soil removed from trenching through these areas contain only traces of hydrocarbon contamination and should therefore not expose construction personnel to hazardous materials. Therefore, Level D personal protective equipment should be adequate. However, due to the close proximity of UST's at the 7-11 Convenience Store, a potential for petroleum hydrocarbons emanating from this source during construction is possible. Precautions should be taken during trenching operations as indicated in the Geotech Report text, "Environmental Concerns".

TABLE I
ENVIRONMENTAL DRILLING
SUMMARY OF OVA* SCREENING

Boring No.	Depth (ft)	Material	OVA Reading (ppm)
B-1**	0 - 6'	Clay Soil	10 - 150
	6' - 13'	Fracture tan weathered Limestone	40
	13' - 15'	Fractured gray Limestone	50
B-2**	0 - 5'	Clay Soil	5 - 110
	5' - 11'	Fractured tan weathered Limestone	35
	11' - 15'	Fractured gray Limestone	50

* Screening performed using Organic Vapor Analyzer.
** Borings B-1 and B-2 drilled near Seven-Eleven Store (See Figure 1).

TABLE II
ENVIRONMENTAL DRILLING
SUMMARY OF SOIL ANALYTICAL RESULTS

SAMPLE NO. DEPTH	TPH 418.1 (ppm)	TOTAL BTEX 8020 (ppm)	VOLATILE ORGANIC 8240 (ppb)	PESTICIDES PCB's 8080 (ppb)	CHLORINATED HERBICIDES 8150 (ppm)
B1-3'	27	ND	NA	NA	NA
B2-3'	ND	ND	NA	NA	NA
B2-13'	10	0.154	NA	NA	NA
B4-1'	NA	NA	ND	ND	ND
B5-1'	NA	NA	ND	ND	ND
B6-2'	NA	NA	ND	ND	ND
B7-5'	NA	NA	ND	ND	ND
B8-3'	NA	NA	ND	ND	ND

NA = Not Analyzed ND = Non-Detect