REPORT OF
GEOTECHNICAL INVESTIGATION
FOR THE
PROPOSED FIRESTATION BUILDING ADDITION
6902 NAVIGATION BOULEVARD
HOUSTON, TEXAS

FOR

LAY-SU & ASSOCIATES GROUP, INC.
10700 SAM HOUSTON PARKWAY, SUITE 20
HOUSTON, TEXAS 77031

PREPARED BY

ASSOCIATED TESTING LABORATORIES, INC.
HOUSTON, TEXAS

DATE: September 16, 2009
REPORT NO: G09-186

Lay-Su & Associates, Inc.
10700 Sam Houston Parkway, Suite 20
Houston, Texas 77031

Attention: Mr. Robert Lay-Su

Reference: Proposed Firestation Building Addition
6902 Navigation Boulevard
Houston, Texas

Dear Mr. Lay-Su:

We have completed the above referenced geotechnical investigation report. Our findings, analyses and recommendations are submitted herein. If you have any questions please call at your convenience.

Once you are ready for construction, we will be pleased to assist you in field/laboratory testing of materials and construction inspection.

It has been a pleasure working with you on this project and we look forward to serving you in the future.

Respectfully submitted,

ASSOCIATED TESTING LABORATORIES, INC.

Jay Vaghela, P.E
Project Manager

Jasbir Singh, P.E.
President

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Area Geology

The site is underlain by the Beaumont Formation of Pleistocene age. This formation consists of over consolidated clays, silts and sands with some shell calcium carbonate and iron oxides. These formations are quite strong and extend to an approximate depth of 100 feet. The surface materials are often weakened by the weathering process.

There are numerous faults and fault systems in the greater Houston area. The movement of many of these faults has been affected in recent history by area subsidence. The subsidence is caused by removal of oil and ground water. As much as nine feet of subsidence has taken place in the area east of Houston in the last seventy years, and more than five feet of that has taken place in the last decade as demand for oil and water has increased. Conversion to surface water usage and the limiting of oil production has greatly reduced the subsidence rate in the area east of Houston. However, continued ground water withdrawal in the southwest Houston area makes subsidence and associated faulting a continuing problem in that area.

Area Geology (Cont'd)

A complete investigative fault study is beyond the scope of this report. Due to presence of faulting within the greater Houston area, a fault study is recommended. For additional information on area faulting, we recommend you contact a professional geologist.

Surface and Shallow Formations

The surface and shallow formations at this site generally consists of firm to very stiff Clay (CH) soils extending to the depth of 18 feet underlained by very stiff to hard Clay (CH) soils to a depth of 8 feet. These soils are underlained by stiff to very stiff Clay (CH) soils extending to the maximum depth of the borings at twenty (20) feet below the existing ground level. At boring B-1, possible fill clay (CH) soils were encountered to a depth of 4 feet. The clays are over consolidated caused by desiccation. These types of clay have a considerable shrink/swell potential due to seasonal moisture variation.

A more detailed stratigraphy may be found on the boring logs in Appendix A.

As shown on the logs of test borings contained in the report, free water was encountered during the drilling operations at depths of about 1 6 feet. However, it should be noted that ground water levels are subject to seasonal variations as well as other factors and should be checked prior to initiating any construction which could be affected.

Design Criteria

Information on this project was supplied by Mr. Robert Lay-Su of Lay-Su & Associates Group, Inc. The project consists of firestation building addition. Column and wall loads are not known at this time.

Variations

The recommendations contained in this report are based on data gained from test borings at the locations shown on Figure 1, a reasonable volume of laboratory tests, and professional interpretation and evaluation of such data in view of the project information furnished. Should it become apparent during construction that soil conditions differing significantly from those discussed in this report are being encountered, this office should be notified immediately so that an evaluation, and any necessary adjustments can be made. Also, should the nature of the project change significantly, this office should be notified. Analyses of slope stability, bulkhead or any other features at the site is not within the scope of this investigation and, therefore, ATL is not responsible for any problems caused by these features. Also the recommendations given in this report may not be valid if conditions such as leaking pipes, leaking pools, ponding of water occurs at the site. ATL is not responsible for any problems caused by these features.

General Site Conditions

The site is relatively flat with topographic variation of less than 3- feet. An existing fire station and concrete paving were observed at the site. A property fence was also observed around the property.

Site Preparation

The upper stratum of soil at this site consists of relatively very high plasticity clays. These clay soils within the active zone have a very high potential for expansion and shrinkage with increases and decreases in moisture content. Based on Test Method TEX-124-E by the Texas State Department of Highways and Public Transportation, Materials and Tests Division, the worst soil at this site has a potential vertical rise (PVR) of about 2.1 to 3.2 inches. Foundations should be designed accordingly.

Site Preparation (Cont'd)

The following system of construction procedures is recommended:

1. Strip and remove all surface organics, topsoil and unsuitable materials from all building and paving areas.
2. Establish positive site drainage. Install storm drainage structures is required. All trees and root system within the building and pavement areas should be removed and the soils compacted as specified in the report. Evaluations of any existing structure are beyond the scope of this investigation. However, subsurface foundation and septic tanks, if any, should be removed and site be prepared for new construction
3. Proof roll the sub grade to detect any wet, soft, or pumping areas. Treat these areas with drying or stabilizing agents as necessary or remove and replace them with a suitable fill material.
4. Compact the subgrade to a minimum of ninety-five (95) percent of its maximum dry density as determined by the Standard Proctor compaction Test (ASTM D 698).
5. Additional fill material within the building area should be a silty or sandy clay having a plasticity index (P.I.) of ten (10) to twenty (20) and a liquid limit of 28 or more. Fill materials should be placed in six (6) to eight (8) inch loose lifts and compacted at optimum moisture content to ninety-five (95) percent of their maximum dry density as determined by the Standard Proctor Compaction Test.

Foundation Considerations

The soils at the foundation bearing depths should easily support the anticipated loads. The surface soils, however, possess a considerable shrink/swell potential. Based on the Test Method TEX-124-E by Texas State Department of Highways and Public Transportation, Materials and Tests Division, the worst soils at this site have a potential vertical rise (PVR) of about 2.1 to 3.2 inches. Foundation should be designed accordingly.

In order to reduce the soil movement, a select fill thickness may be developed under the building slab. Select fill thickness may be developed by replacing the topsoils, adding to the topsoils or by a combination of cut and fill. The select fill thickness should extend at least 2-feet beyond the building perimeter. Use of select fill will reduce the shrink/swell potential of clay subgrade in proportion to the depth of fill. Developing a three (3)-feet thickness of select fill will reduce the PVR to about 1.2 to 2.0 inches. Developing a five (5)-feet thickness of select fill will reduce the PVR to about 1.0 to 1.5 inches. It should be noted that the above PVR values are based on worst soil and Moisture conditions. It should also be noted that soil movements will occur only if there is changes in soil moisture. The actual thickness of select fill to be used should be determined by the structural engineer based on the site topography and PVR requirements of the structural design and other client/project requirements. However, for floor slabs used incojunction with drilled piers, it is our opinion that a minimum select fill thickness of 4-feet should be developed under the floor slabs.

Foundation Considerations (Cont'd)

Positive drainage must be developed and maintained all around the building at all times.

As an alternative to the above:

1. The structures may be supported on post-tensioned or ribbed and reinforced concrete slabs. These structures provide rigidity to the foundations, allowing it to move as a unit and resist bending, which causes cracking.

2. The slabs may be structurally designed and suspended to isolate from the underlying soils.

Presented below are design data for both shallow foundations and bell bottom footings to allow you or your designers to select the most suitable system for your project.

Shallow Foundations

As an alternative to the above, a shallow foundation system at this site may be an engineered post-tensioned foundation or ribbed & reinforced slab with a perimeter footing and interior thickened sections (designed according to P.T.I. –3rd edition) founded at minimum depth of 12-inches below final grade and designed for an allowable soil bearing capacity of 1500 PSF and a weighted average plasticity index (P.I.) of 43. The fill soils (wherever and whatever depth encountered) must be excavated, reprocessed and recompacted (or replaced with select fill) inaccordance with our "site preparation" section. Alternatively, these soils may be left in place if records of passing densities are available for all lifts.

Atterberg Limits:	LL=64;		PL=21;	PI=43
Thornwaite Moisture Index: Im	= 18			
Constant Suction Value:	PF =	3.45		
Edge Moisture Variation:	em =	9.0	ft. (Center lift)	
	em =	5.8	ft. (Edge lift)	
Estimated Differential Swell:	Ym =	1.0	inch (Center lift)	
	Ym =	0.9	inch (Edge lift)	

Bell Bottomed Footings

Drilled shafts with bell-bottoms should be founded at the twelve (12) feet depth below the existing ground elevation. If sand is encountered at this depth then bell-bottom footings may not be feasible, in this case straight-sided shafts (without bell bottoms) may be an alternative to consider. Bell-bottom foundations should be designed for an allowable bearing capacity of 4500 PSF total loads. This bearing capacity is based on a minimum safety factor of 2.0. Using a safety factor of 3.0, the allowable bearing capacity for dead load plus sustained live load is 3000 PSF.

Casing did not appear to be necessary for installation of footings at this site. Should conditions change (such as rise in ground water levels) casing may become necessary. For best results, any standing water should be pumped out and footings poured immediately after the excavation has been made.

Bell Bottomed Footings (Cont'd)

The calcareous nodules or slickensided clays at the belling depth could cause some sloughing of the under reamed portion of the footings. This problem can usually be alleviated by increasing the belling angle or by increasing the diameter of the shaft portion of the footing. Should sloughing persist, it may become necessary to use straight-sided shafts. A shaft to bell ratio of 3.0 is recommended initially.

The ultimate capacity of under reamed footings to resist uplift loads can be determined from the following equation provided the ratio of footing depth to bell diameter is greater than 1.5:

$$Q_u = 5.8\ c\ (D^2 - d^2)$$

where: Q_u= ultimate uplift capacity, pounds

c= Average shear strength above the footing grade, pounds per square foot. (use c = 800 PSF)

D= underream diameter, feet.

d= shaft diameter, feet.

A minimum factor of safety of 2.0 is recommended for final design.

Foundation Settlements

Although detailed settlement analysis was not within the scope of this study, foundation designed based on the allowable bearing pressures will experience settlement which should be within the tolerable limit of the structure. However, it is recommended that a detailed settlement analysis be performed after the footings are sized.

Trench Safety System

Utility trenches or any earth excavations deeper than 5 feet should be retained using a suitably designed temporary earth retaining system. We assume that in a project of this nature the deepest excavation should be no more that 8 feet. For OSHA Trench safety system, the soils at this site to a depth of 8 feet are classified as Type 'B'.

Design Review

It is recommended that Associated Testing Laboratories be allowed to review the design and construction plans and specifications prior to release to make certain that the geotechnical recommendations and design criteria presented herein have been properly interpreted.

Foundation Construction

Placement of concrete should be accomplished as soon as possible to prevent changes in state of stress and caving of the foundation soils. Excavation/drilling of foundations should be inspected by an Associated Testing Laboratories representative to help assure the integrity of foundations.

Concrete Paving

The pavement designs presented below are based on the use of a compacted subgrade. (See the paragraph entitled "Site Preparation" for subgrade compaction requirements). The designs are also based on the use of 3000 PSI concrete with a Modules of Rupture of about 525 PSI. Stabilization of the top 8-inches of subgrade with approximately 7 percent lime is recommended.

Light Vehicles	*Medium Vehicles*	*Heavy Vehicles*
6" High traffic volume	7" High traffic volume	8" High traffic volume
4" Low traffic volume	5" Low traffic volume	6" Low traffic volume

Asphalt Paving

Pavement designs presented below are for asphalt pavement. It is recommended that the top 8 inches of natural subgrade be stabilized with approximately 7 percent lime by dry weight and compacted to 95% of its maximum dry density as determined by Standard Proctor Compaction test (ASTM D 698). Close field supervision is recommended during subgrade preparation.

Light Vehicles	*Medium Vehicles*	*Heavy Vehicles*
1-1/2" Asphalt	2" Asphalt	3" Asphaltic Concrete
6" Compacted base	7" Compacted base	8" Compacted Base
Compacted subgrade	Compacted subgrade	Compacted subgrade

Base materials options include sand-shell, limestone or recycled concrete. The required base thickness can be reduced by about 30% for black base. Asphalt concrete should be a hot mixed asphaltic concrete conforming to appropriate Texas Highway specifications.

Asphalt Paving (Cont'd)

In the areas subjected to excessive loading from refuse trucks, impact loads, trash receptacles, and other unusual conditions, a reinforced concrete slab is suggested to prevent excessive pavement defections. Such concrete apron would be approximately six (6) inches thick with reinforcing of 4 x 4 - 4/4 w.w.m. or equal.

The pavement designs presented in this report are based on the following load classifications:

Light	Gross Vehicle Weight	6,000 pounds
Medium	Gross Vehicle Weight	10,000 pounds
Heavy	Gross Vehicle Weight	20,000 pounds

Expansive Soils

The high plasticity clays at this site may experience significant volume changes with changes in moisture content. During hot, dry periods the soil loses moisture and shrinks. Conversely, during extended wet weather cycles, the soil gains moisture and swells. This seasonal movement can exert considerable stresses on structures supported by these soils.

Under normal conditions, water evaporates from the surface of the soil and it replaced by water drawn upward by capillary action from below. When a floor slab and vapor barrier are placed on the surface, this evaporation is effectively cut off. Moisture continues to be drawn upward until a balanced condition is developed. During wet season, the soils near the edge of the slab receive more moisture than the soils at the center of the slab. During dry season, the soils near the edge of the slab dries out more than the soils at the center of the slab. These conditions may cause differential movement and cracking of the slab.

Expansive Soils (Cont'd)

Several preventive measures are available to reduce the effects of volume changes in these soils. One is to use deep grade beams to provide a barrier to evaporation of water from below the slab. Another is to place a paved strip around the perimeter of the building. This strip acts as a buffer zone, with most of the differential movement taking place in this area. A minimum width of 5 feet is normally recommended. Residences or other structures may use a mulch bed around the perimeter to help keep moisture from evaporating. Lime stabilization of a 5 foot wide strip outside the building line will also help prevent moisture loss.

Trees can also contribute to the soil shrink/swell movement in highly plastic soils. During extended periods of dry weather, trees remove water from the soil and cause shrinkage. This shrinkage causes movement of the soils downward and toward the tree and can seriously damage nearby structures. This condition can normally be neutralized by removing the trees or by placing the structure on foundations bearing below the affected soil. Existing trees absorb water from the soil through the roots. This leads to the formation of isolated pockets of dry soils near the tree roots. When the trees are removed and the building constructed on top of it, the isolated pockets of dry soil when exposed to moisture will swell more than the surrounding soils. This will lead to differential swelling. Although, the tree roots are generally found in the top few feet, there may be cases where tree roots may be present at deeper depths. In this event, the foundation is designed based on the potential vertical rise (PVR) of deeper soils, permeability of soils and probability of moisture changes in soils at deeper depths.

APPENDIX A

FIELD AND LABORATORY PROCEDURES

Field Procedures

All borings were drilled with rotary type drilling rigs on the dates and to the depths shown on the boring logs. The boring locations are shown on the Plan of Borings, Figure 1. Samples were taken continuously for the first ten (10) feet of depth and at five (5) feet intervals thereafter to the bottom of the borings. Where possible, the borings were dry augured until water was encountered in each boring in order to secure reliable data on ground water levels.

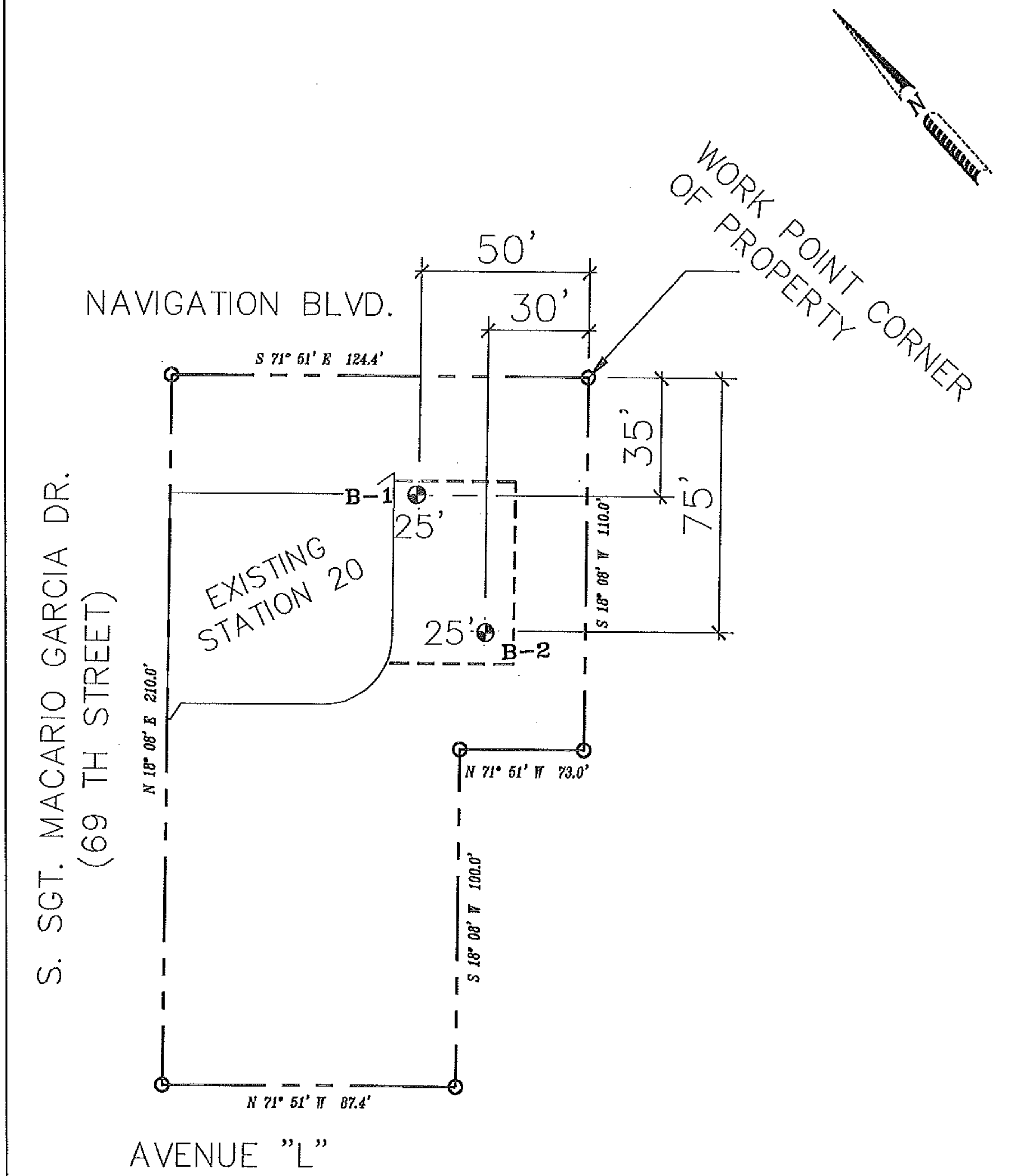
Cohesive soils were sampled by pushing 3 inch diameter thin-wall steel core barrels (Shelby Tubes) into the undisturbed soil at the bottom of each boring as the drilling progressed. The penetration resistance of each undisturbed core sample was determined in the field using a pocket penetrometer. The samples were then extruded, visually classified, marked and prepared for transport to the laboratory.

Field Procedures (Cont'd)

Cohesion less soils was sampled by a 2 inch OD, 1.375 inch ID Split Spoon Sampler. The sampler is driven into the soil by a 140 pound hammer dropped 30 inches free fall. The blows are recorded in three 6-inch increments; the first 6 inches is driven to seat the sampler; the last 12 inches is driven and the number of blows required is recorded. The sample is then prepared for transport to the laboratory.

Laboratory Procedures

Laboratory testing consists primarily of Moisture Contents, Atterberg Limits and Unconfined Compression Tests. All tests are assigned by a soils engineer to provide a testing program consistent with the project requirements and soil conditions. The test results are presented in the appropriate columns of the boring logs.



SITE PLAN

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd. Houston, Texas
Tel: (713) 748-3717 Fax: (713) 748-3748

PROPOSED FIRE STATION ON
NAVIGATION BLVD. AT WAYSIDE
HOUSTON, TEXAS

SCALE: N.T.S.

PROJECT NO. G09-186

FIGURE. 1

B-1

PROJECT NO.G09-186	PROJECT NAME: 6902 NNAVIGATION BLVD, FIRE STATION NO # 20
DATE: 09-11-09	CLIENT NAME: LAY-SU & ASSOCOATES

Legend	Boring Method:
Shelby Type	Auger: X
Augar Cutting	Wash:
Standard Penetration Test	Ground Elev: Existing
No Recovery	

DEPTH, FT.	SAMPLE TYPE	SPT	POCKET PENETROMETER (tsf)	UNCONFINED COMP. (tsf)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX	#200 SIEVE (%)	MATERIAL DESCRIPTION
			1.50		27		59	39		Firm, dark gray **Clay (CH)** **(4' possible fill)**
2.0			1.00	0.50	33	90				
4.0			2.00		23		62	41		Stiff, dark gray **Clay (CH)**
6.0			2.00		28					..light gray and tan with calcareous nodules below 6'
8.0			2.50	1.30	26	106	71	49		..with ferrous nodules below 8'
10.0										
			2.50	1.30	21	100				..reddish brown below 13' (light odor of oil)
15.0										
			2.00	1.10	20	112	36	19		Stiff, light gray and tan **Sandy Clay (CL) (light odor of oil)**
20.0										
			4.00	2.60	18	117	48	30		..very stiff below 23'
25.0										Boring Terminated at 25'
30.0										
35.0										
40.0										

Initial Water Reading: 18.5'	**Drilled by: Brian**
Final Water Reading: 15.11'	
Hole Caved at: 24.1'	**Prepared by: Jitu** **Approved by: Jay**

ASSOCIATED TESTING LABORATORIES, INC.

B-2

PROJECT NO.G09-186	PROJECT NAME: 6902 NNAVIGATION BLVD, FIRE STATION NO # 20
DATE: 09-11-09	CLIENT NAME: LAY-SU & ASSOCOATES

Legend: Shelby Type; Augar Cutting; Standard Penetration Test; No Recovery

Boring Method:
Auger: X
Wash:
Ground Elev: Existing

DEPTH, FT.	SAMPLE TYPE	SPT	POCKET PENETROMETER (tsf)	UNCONFINED COMP. (tsf)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX	#200 SIEVE (%)	MATERIAL DESCRIPTION
			1.00		30					Firm, dark gray **Clay (CH)**
2.0			3.00	1.50	28	97	49	20		..stiff below 2'
4.0			2.50		27					..light gray and tan below 4'
6.0			2.00		27		66	45		..with ferrous and calcareous nodules below 6'
8.0			3.00	1.40	28	99				..tan and light gray below 8'
10.0										
			4.00	2.40	23	106	56	36		..very stiff, reddish brown below 13' **(light odor of oil)**
15.0										
			2.00	1.00	18	114				Stiff, light gray and tan **Sandy Clay (CL) (light odor of oil)**
20.0										
			3.00	1.80	15	122	31	15		..with ferrous nodules below 23'
25.0										
										Boring Terminated at 25'
30.0										
35.0										
40.0										

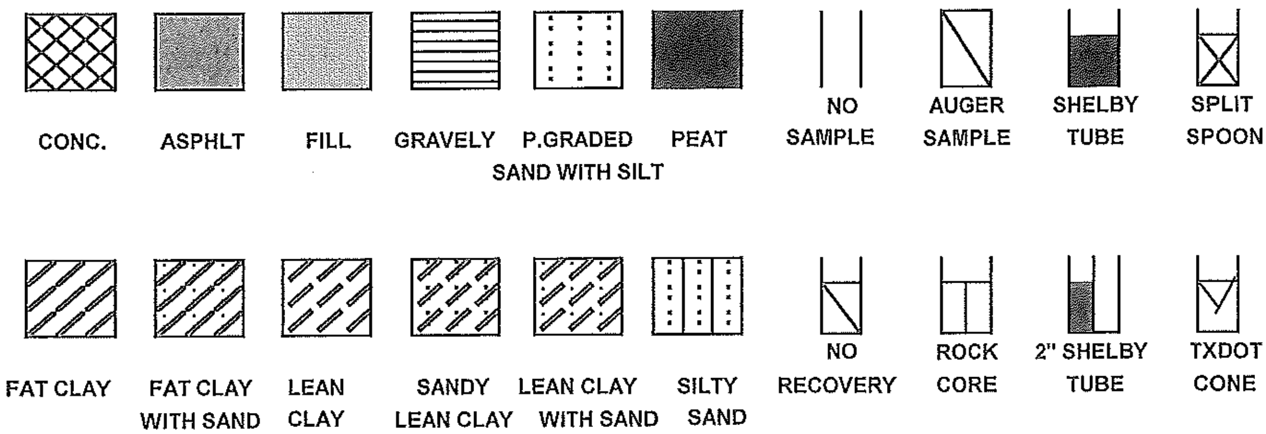
Initial Water Reading: 19'
Final Water Reading: 16.2'
Hole Caved at: 24.2'

Drilled by: Brian
Prepared by: Jitu
Approved by: Jay

ASSOCIATED TESTING LABORATORIES, INC.

KEY TO LOG TERMS AND SYMBOLS

SOIL TYPE / SAMPLER TYPE



UNIFIED SOIL CLASSIFICATION SYSTEM - ASTM D 2487

MAJOR DIVISIONS			LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS LESS THAN 50% PASSING No. 200 SIEVE	GRAVEL & GRAVELY SOILS LESS THAN 50% PASSING No.4 SIEVE	CLEAN GRAVELS LITTLE OR NO FINES	GW	WELL GRADEED GRAVELS,GRAVELSAND MIXTURES WITH LITTLE OR NO FINES
			GP	POORLY GRADED GRAVELS,GRAVEL SAND MIXTURES WITH LITTLE OR NO FINES
		W/ APPRECIATEBLE FINES	GM	SILTY GRAVELS,GRAVEL SAND-SILT MIXTURES
			GC	CLAYEY GRAVELS,GRAVEL SAND-CLAY MIXTURES
	SANDS MORE THAN 50% PASSING No.4 SIEVE	CLEAN SANDS LITTLE FINES	SW	WELL GRADED SAND,GRAVELY SAND (LITTLE FINES)
			SP	POORLY GRADED SANDS,GRAVELY SAND(L. FINES)
		SANDS WITH APPREA. FINES	SM	SILTY SANDS,SAND-SILT MIXTURES
			SC	CLAYEY SANDS,SAND-CLAY MIXTURES
FINE GRAINED SOILS LESS THAN 50% PASSING NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS & VERY FINE SANDS,ROCK FLOUR SILTY OR CLAYEY FINE SANDS OR CLAYEY SILT W/PI
			CL	INORGANIC CLAY OF LOW TO MEDIUM PI LEAN CLAY, GRAVELY LEAN CLAYS,SANDY LEAN CLAYS,LEAN CLAYS WITH SAND
			OL	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PI
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS,MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY FAT CLAYS, FAT CLAYS WITH SAND, SANDY FAT CLAYS, FAT CLAYS WITH GRAVEL
			OH	ORGANIC CLAYS OF MED TO HIGH PI, ORGANIC SILT
HIGHLY ORGANIC SOIL			FT	PEAT AND OTHER HIGHLY ORGANIC SOILS
UNCLASSIFIED FILL MATERIALS			ARTIFICIALLY DEPOSITED AND OTHER UNCLASSIFIED SOILS FILL MATERIALS	

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNCONFINED COMP. STRENGTH IN TSF
VERY SOFT	LESS THAN 0.25
SOFT	0.25 TO 0.5
FIRM	0.5 TO 1.0
STIFF	1.0 TO 2.0
VERY STIFF	2.0 TO 4.0
HARD	GREATER THAN 4.0

RELATIVE DENSITY - GRANULAR SOILS

CONSISTENCY	N-VALUE (BLOWS PER FT)
VERY LOOSE	0-4
LOOSE	5-10
MEDIUM DENSE	11-30
DENSE	31-50
VERY DENSE	>50 OR 50+

CONSISTENCY	THD-VALUE (BLOWS PER FT)
VERY LOOSE	0-8
LOOSE	8-20
SLIGHTLY COMPACT	20-40
COMPACT	40-80
DENSE	80-5"/100
VERY DENSE	5"/100 - 0"/100

CLASSIFICATION OF GRANULAR SOILS

U.S.STANDARD SIEVE SIZE(S)

6"	3"	3/4"	4	10		40	200		
BOULDERS	COBBLES	GRAVEL		SAND				SILT OR CLAY	CLAY
		COARSE	FINE	COARSE	MEDIUM		FINE		
152	76.2	19.1	4.76	2.0		0.42	0.074	0.002	

GRAIN SIZE IN MM