GEOTECHNICAL INVESTIGATION
Proposed Residence
4719 Braesvalley Drive
Houston, Texas

Reported to:
Ms. Karen & Mr. Cary Robinson
Houston, Texas

Prepared by:
Geoscience Engineering and Testing, Inc.
Houston, Texas

PROJECT NO: 16G2857

May 2016

GEOSCIENCE
ENGINEERING & TESTING, INC.

405 E. 20th Street
Houston, Texas 77008
713.861.9700
713.861.4477 Fax

HOUSTON DALLAS SAN ANTONIO

May 27, 2016

Ms. Karen & Mr. Cary Robinson
4723 Braesvalley Drive
Houston, Texas 77008

Reference: Geotechnical Investigation
Proposed Residence
4719 Braesvalley Drive
Houston, Texas
GETI NO: 16G2857

Dear Ms. & Mr. Robinson:

GEOSCIENCE ENGINEERING & TESTING, INC. (GETI) is pleased to submit this report for the above referenced project. This study was authorized by Mr. Cary Robinson on April 28, 2016. This report briefly describes the procedures employed in our investigation and presents the conclusions and recommendations of our studies.

We appreciate the opportunity to work with you on this phase of the project. If you have any question concerning this report or require additional information, please contact us.

With Kindest Regards,

Somayyeh Sheikhi, M. Sc.
Staff Engineer

06 · 03 · 2016

STATE OF TEXAS
RONALD L. DILLY
111371
LICENSED
PROFESSIONAL ENGINEER

Ronald L. Dilly, Ph.D., P.E.
Principal Engineer

F-4802

Copies Submitted: (1)

I. INTRODUCTION

Geoscience Engineering and Testing, Inc. (GETI) hereby submits this report of geotechnical investigation of subsurface conditions at the site of the proposed Residence located at 4719 Braesvalley Drive in Houston, Texas. GETI's investigation was authorized by Mr. Cary Robinson on April 28, 2016.

The purpose of the geotechnical investigation was to determine the subsurface soil conditions at the site of the proposed Residence with particular reference to the recommendations for the design of the foundation for the structure.

NOTE: The project photos (Plate No.5) was taken during the drilling operations. Please review and verify this is your building site. Notify GETI immediately if this not your site. (There are a few sites that are difficult to locate for a variety reasons.) We have been as diligent as possible in locating your site to assure that the recommendations given in our report correspond to your needs.

II. SUBSURFACE EXPLORATION

1. General

This report presents the results of our soil exploration and foundation analysis for the proposed Residence located at 4719 Braesvalley Drive in Houston, Texas.

Scope of this investigation included a reconnaissance of the immediate site, the subsurface exploration, field and laboratory testing, an engineering analysis and evaluation of the subsurface materials. The purpose of this subsurface exploration and analysis was to determine soil profile components, the engineering characteristics of the subsurface materials and to provide criteria for use by design engineers and architects in preparing the foundation design.

The exploration and analysis of the subsurface conditions reported herein are considered in sufficient detail and scope to form a reasonable basis for the recommendations. The recommendations submitted are based on the available soil information and the preliminary design details furnished by Ms. Karen & Mr. Cary Robinson. Any revision in plans for the proposed Residence from those enumerated in this report should be brought to the attention of the soil engineer, so that he may determine, if changes in the recommendations are required. If deviations from the noted subsurface conditions are encountered during construction, they should also be brought to the attention of the soil engineer.

2. Description of the Site

The site of the proposed Residence, upon which this subsurface exploration has been made, is located at 4719 Braesvalley Drive in Houston, Texas. The site was developed with an existing shed and gardening area, the remaining area of the soil is relatively flat and partially covered with grass. The surface soils were possible fill material (sandy fat clay) and sandy fat clay at the time of drilling operation.

3. Field Investigation

The field investigation, which was completed on May 11, 2016, was to determine the engineering characteristics of the subsurface materials included a reconnaissance of the project site, drilling the exploratory borings and recovering the representative soil samples. Due to presence of an existing shed, soil test borings were drilled in the area accessible to drill rig.

The subsurface soil conditions were explored by advancing and sampling two (2) soil borings. The soil boring B-1 was drilled to a depth of twenty (20) feet, and boring B-2 was drilled to a depth of fifteen (15) feet, below the existing ground surface. The approximate soil boring locations are shown on the attached soil Boring Plan, Plate No. 1.

Sample depth and description of soil classification (based on the Unified Soil Classification System) are presented on the Soil Boring Logs, Plate Nos. 2 and 3. Keys to terms and symbols used on the soil boring logs are shown on Plate No. 4. Photographs appear on Plate No. 5.

The soil borings were of three-inch nominal diameter. Both relatively undisturbed and disturbed soil samples were obtained at two (2) feet intervals continuously to a depth of twelve (12) feet, between thirteen (13) and fifteen (15) feet and at five (5) feet intervals thereafter. The soil borings were performed with a drilling rig equipped with rotary head conventional solid-stem augers were used to advance the holes. Representative disturbed or undisturbed soil samples were obtained employing thin-walled sampling procedures in accordance with ASTMD-1587 Soil samples were identified according to the boring number and depth and wrapped in aluminum foil and polyethylene plastic wrapping bags to prevent moisture loss and disturbance. All of the samples were transported to our geotechnical laboratory for examination, testing and analysis. All borings were backfilled after final water readings were obtained with the soil cuttings accumulated during the drilling operation unless noted otherwise on the soil boring logs.

3.1 Field Strength Tests

During the field boring operation, samples of the cohesive soil from the thin-walled tube were frequently tested in compression by use of a calibrated soil penetrometer to provide a measure of shear strength to aid in characterizing the soil consistency.

3.2 Water Level Measurement

The information in this report summarizes conditions as found on the date the borings were drilled. Groundwater was not encountered during the drilling operation. Long-term monitoring of the groundwater level was beyond the scope of this study. It should be noted that the groundwater table may be expected to fluctuate with environmental variations such as frequency and magnitude of rainfall and the time of the year when construction begins.

4. Surface Fault

A surface fault investigation is beyond the scope of this investigation. It should be noted that the coastal plains in this region has a complex geology, which included active surface faulting.

5. Laboratory Testing

In addition to the field investigation, a supplemental laboratory investigation was conducted to ascertain additional pertinent engineering characteristics of the subsurface materials necessary in analyzing their behavior under the proposed loading conditions.

During the laboratory investigation all field soil samples from the boring were examined and classified by a soil engineer. Laboratory tests were then performed on selected soil samples in order to evaluate and determine the physical and engineering properties of the soils in accordance with the prescribed ASTM standards and methods. The following laboratory tests were performed:

LABORATORY TEST	TEST STANDARD
Moisture Content of Soils	ASTM D-2216
Moisture Content and In Situ Dry Density of Soils	ASTM D-2937
Unconfined Compressive Strength of Cohesive Soils	ASTM D-2166
Liquid Limit, Plastic Limit, and Plasticity Index of Soils	ASTM D-4318

Strength properties of the soils were determined by means of unconfined compression tests performed on undisturbed samples. The type and number of the laboratory tests performed for this investigation are:

DESCRIPTIONS	No. of Test	DESCRIPTIONS	No. of Test
Hand Penetrometer Test	15	Dry Density Test	2
Moisture Content Test	15	Unconfined Compressive Test	2
Atterberg Limits	4		

The tests noted above were performed to establish the index properties and to aid in the proper classification of the subsurface soils. The test results are shown on the soil boring logs and are presented on Plate Nos. 2 and 3.

III. GENERAL DESCRIPTION OF SUBSURFACE MATERIALS

The specific subsurface stratigraphy as determined by the field exploration is shown in detail on the soil boring logs herein. However, the stratigraphy can be generalized as follow:

STRATUM NUMBER	RANGE OF DEPTH, Ft.	BORING NUMBER	SOIL DESCRIPTION
I	0 – 2’	B-1	Possible Fill: Stiff, brown and light brown SANDY FAT CLAY
II	0 – 6’	B-2	Stiff to very stiff; dark brown and brown; Light brown, gray and light gray SANDY FAT CLAY (CH)*
	2’ – 8’	B-1	
	12’ – 15’	B-1	
III	6’ – 15’	B-2	Stiff to very stiff, light brown, gray and light gray LEAN CLAY (CL)*
	8’ – 12’	B-1	
IV	15’ – 20’	B-1	Firm to stiff, light brown, light gray and reddish brown CLAYEY SAND (SC)*

* Classification is in accordance with the Unified Soil Classification System

Laboratory tests results for the soils indicate that the Liquid Limits are ranging from 26 to 70 the Plasticity Indices (P.I.) are ranging from 13 to 43, and moistures contents from 19 to 25 percent.

Swell Potential

Based on plasticity index results, the clayey sand, lean clay, possible fill material (sandy fat clay) and sandy fat clay subsoil are characterized as low to very high shrink/swell potential.

When the moisture content of clay soil increases, the volume increases; conversely, when the moisture content of this type of soils decreases, the soil volume decreases. The volume changes can result in foundation movement and stresses.

IV. FOUNDATION RECOMMENDATION

1. Foundations and Risks

Many lightly loaded foundations are designed and constructed on the basis of economics, risks, soil type, foundation shape and structural loading. Many times, due to economic considerations, higher risks are accepted in foundation design. It should be noted that some levels of risk are associated with all types of foundations. All of these foundations must be stiffened in the areas where expansive soils are present and trees should be removed prior to construction.

2. Foundation Discussion

In general, the foundation for the structures must satisfy two independent criteria. First, the maximum design pressure exerted at foundation levels should not exceed the allowable net bearing pressure based on an adequate factor of safety with respect to soil shear strength. Second, the magnitude of total and differential settlements or heave under sustained foundation loads must be such that the structure movement is within tolerable limits.

Various types of foundation such as Slab-on-Grade, Spread Footings, Underreamed Drilled (Belled) Footings, Straight Shaft Footings etc. have been discussed for the support of the proposed structure. Based on the field investigation and laboratory test results, the clayey sand, lean clay, possible fill material (sandy fat clay) and sandy fat clay subsoil are characterized as low to very high shrink/swell potential. Details of soil strata are given in soil boring logs, Plate Nos. 2 and 3. In our opinion, for this type of soil strata both Underreamed Drilled Footings (Drilled Piers) and Post-tensioned slab are considered suitable foundation systems. Details are given in the following sections.

2.1 Underreamed Footings (Drilled Piers)

Based on the soil condition revealed by the field soil test borings and laboratory tests, it is our understanding that the structure at the site can be supported on a foundation system comprised of drilled underreamed footing bearing at a depth of twelve (12) feet below existing grade. The pier footings should bear at same elevation in the layer of the stiff to very stiff, light brown, gray and light gray lean clay. The footing on these sites may be sized for an estimate net allowable bearing pressure of 3,000 psf for dead load plus sustained live load. The bearing pressure contains a factor of safety of 2.5 and may be increased 25 percent for total load conditions, whichever is critical. Spacing between the centers of the two adjacent footings should be at least 3 times of the bell diameter.

The plinths of underreamed footing should be reinforced with sufficient reinforcing (tension) steel to resist the potential tension force caused by uplift loads due to expansive soils between the depth of seasonal moisture changes nine (9) feet and the final ground surface elevation. An adhesion value of

0.8 tsf should be applied to the straight shaft portion of the drilled footings for computation of uplift loads.

Caving of soils around the footings may occur during construction of the drilled piers due to the presence of sands. In case the bell on the drilled footings cannot be constructed due to the occurrence of caving, it is recommended that the construction contractor should use cased piers or convert this Underreamed footings to Straight shaft footings immediately. The bottom of the piers should be dry and clean.

If water is encountered during installation, it should be pumped out prior to concrete placement. A tremie should be used to displace water with concrete. Temporary casings or drilling slurry may be adopted to stabilize the excavation and counteract encountered groundwater. In such cases, shaft piers are installed by placing concrete using 'slurry displacement' method using a tremie. No pier excavation should be done at a distance less than 3 pier diameters in proximity to newly cast piers for a period of at least 24 hours. We recommend that the drilling be performed under the supervision of a qualified representative of the Geotechnical Engineer.

Experience indicates that underreams can be successfully installed and based on local practice for performing underreamed drill pier is to utilize 3.0 to 1.0 for underream to shaft ratio. Should caving occur during belling operation, the shaft diameter may have to be increased, thereby changing the bell to shaft ratio. If the soil conditions warrant the changing of the shaft diameter, the structural engineer of record should be informed about any changes, because they may require a change in reinforcing steel or bell diameter. Another alternative, would be to change the typical 45 degree angle of the underreamed to 60 degree. The concrete should be placed promptly after drilling to minimize the potential for caving of the foundation soils. By the end of the day, each drilled hole must be filled with concrete, i.e., no open holes at the end of the day.

No footing should be poured without the prior approval of the project engineer, architect or owner's representative. Since the exact locations of the footings are not known at this time, a detailed settlement analysis was not authorized, nor performed. It is anticipated that the footing designed using the recommended allowable bearing capacity will experience small settlement that will be within the tolerable limits for the proposed structure.

Inspection during Construction of Drilled Piers

The recommendations are based on the subsoil data in the field exploration and laboratory testing. Due to the geological deposition of the Pleistocene soils in the Gulf Coastal area, variances may occur between boring locations, therefore, the footing excavations should be inspected under the supervision of a qualified representative of the geotechnical engineer to confirm that the bearing soils are similar to those encountered in our field exploration and that the footing area have been properly prepared. The geotechnical engineer should be immediately notified if any subsoil condition be uncovered that will alter the conclusions and recommendations contained in this report. Further investigation and supplemental recommendations may be required, if such a condition is encountered.

Prior to placement of concrete, the footings should be inspected to monitor that:

1. The footing bears in the proper bearing strata at the depth recommended in this report.

2. The footing shafts are of the proper dimensions and reinforcing steel is placed as shown on the structural drawings.

3. The footings are concentric with the shaft and the shaft has been drilled plumb within specified tolerances.

4. Excessive cutting, build up of cutting, and any other soft compressible materials have been removed from the bottom of the excavations.

Pier Floor Slab Options
There may be two options for floor slab:

a) Slab supported by piers only: In this option slab is supported by only grade beams, which are supported by piers. In this case loads are applied on only piers. Slab should be raised from the ground surface by at least six (6) inches to avoid the vertical displacement of the slab. The slab should be tied and stiffened with grade beams. Details for void boxes are given below in the section "Void Boxes".

b) Slab supported by grade beams and sub-grade: Another option is that the slab may be supported by the grade beams and the sub-grade (soil beneath the slab). This option will require the removal of roots, organic and unsuitable materials and replacement with structural select fill as out lined in the "Structural Fill and Subgrade Preparation".

Due to the soil characteristics at this site, eighteen (18) inches of structural select fill materials having a liquid limit less than 35% and a plasticity index (PI) between 10% & 20% are required to minimize the possibility of vertical displacement. The structural select fill material can be used to elevate the grade, or the existing grade can be undercut for placing structural select fill material.

Void Boxes
A void/crawl space of six (6) inches may be provided beneath the grade beams. This void space allows for movement of the expansive soils below the grade beams without distressing the structural system. Structural cardboard void forms are often used to provide this void space.

Void Boxes are typically placed under the grade beams to provide this void space, and act as a barrier separating the grade beams from the expansive soils. The purpose for using the void boxes is when the underlying expansive soils swell, the void boxes will then collapse, thus minimizing the uplift loads caused from the expansive soils on the grade beams.

These voids may act as a channel for water to travel under a foundation system with poor area drainage, however, if this condition occurs, it may result in the subsequent swelling of the soils and an increase in subsoil moisture loads on the floor slabs. It is our opinion that the determination whether or not to provide voids under the grade beams be made by the owner, builder, engineer or architect after both the positive and negative aspects are evaluated. Geoscience Engineering & Testing, Inc. from our experience with these voids, as well as the experiences of other experts, brings us to the conclusion that even though they may be effective in reducing swell pressures on the grade beams, they may provide free water which would be available for absorption by slab support soils.

2.2 Post-Tension Slab Design Parameters

Based on the soil conditions revealed by the field soil test borings, recommended structural select fill and referring to the guide from "Design and Construction of Post-Tensioned Slabs on Ground", published by Post-Tensioning Institute (PTI), the structure can be supported on a foundation system comprised of post-tensioned slab. The "VOLFLO" computer program was used to estimate E_m and Y_m post-tensioned slab design parameters.

The following table(s) entitled "Post Tension Parameters" shows: the soil profile and respective plasticity index (PI) values; characteristic geotechnical PTI parameters for the "VOLFLO" program; computed estimates of edge moisture variation distance E_m and maximum unrestrained differential soil movement Y_m as a function of depth, and estimated bearing capacities as a function of depth.

Should any loose sand or soft clays be observed under the grade beam, the allowable bearing capacity will be lower than values shown below. Soft or loose soils should be replaced with compacted structural select fill materials as subsequently defined in this report, or a geotechnical engineer should be contacted and the allowable bearing capacity reduced.

The grade beam may be supported at a minimum depth of 12, 18, 24, or 30 inches below the finish grade elevation founded within the undisturbed soils or compacted select fill. With decreased beam depth, consideration should be given to increased potential for susceptibility to intrusion of roots, loss of support due to erosion, soil moisture variations and associated soil volume changes in underlying subsoil beneath the foundations, and weathering in regions subjected to freezing temperatures. The estimated capacities are provided for each respective beam depth. The beam width is to be defined by the structural engineer.

Parameters with Existing Soil Strata:

POST-TENSION PARAMETERS for Existing Soil Profile (Post-Tensioning Institute Third Edition with 2008 Supplement Design)		
SOIL PROFILE for PTI CALCULATION OF E_m and Y_m		
Stratum	**Thickness, ft.**	**Plasticity Index, PI**
Layer 1	7	37
Layer 2	3	29
PTI 3rd Edition POST-TENSION DESIGN PARAMETERS		
Slab subgrade coefficient		
Slab-on-sand bedding		1.00
Slab-on-polyethylene over sand bedding		0.75
Fabric Factor, F_f		1
Thornthwaite Index (I_M)		+18
Approximate Depth to Constant Soil Suction, ft.		9
Constant Soil Suction, pF		3.6
Estimated Moisture Velocity, inch/month		0.7
Principal Clay Mineral		Montmorillonite
E_m and Y_m values based on final moisture profile and depth of vertical moisture barrier		
Vertical Moisture Barrier see note (1,2)	**Center Lift**, -- drying of soil along foundation perimeter (wet to dry) **E_m = 7.5 ft.**	**Edge Lift**, wetting of soil along foundation perimeter (dry to wet) **E_m = 4.8 ft.**
Barrier Depth, inches	**Y_m, Inches**	**Y_m, Inches**
No barrier	2.08	2.40

POST-TENSION PARAMETERS for Existing Soil Profile (Post-Tensioning Institute Third Edition with 2008 Supplement Design)		
12	1.82	2.03
18	1.70	1.87
24	1.60	1.72
30	1.50	1.58

(1) Note: Vertical barrier depth defined as grade beam penetration depth into in-situ soil or compacted structural select soil (i.e. depth below finish grade of soil)
(2) Note: PTI states, "A vertical barrier should extend at least 2.5 ft. below the adjacent ground surface to be considered as having any significant effect".

Estimated Bearing Pressure based on shear strength, $c = 1165$ psf, $\phi = 0°$

Depth of grade beam, Inches see note (3)	Allowable Bearing Pressure, PSF	
	Dead Load Only (Factor of Safety = 3)	Total Load (Dead + Live) (Factor of Safety = 2):
12	2000	3000
18	2000	3000
24	2000	3000
30	2000	3000

(3) Note: Depth defined as grade beam penetration depth into in-situ soil or compacted structural select fill (i.e. depth below finish grade of soil)

The following post tension design parameters can be applied for proposed residence with two (2) feet of structural select fill below existing grade.

POST-TENSION PARAMETERS for Existing Soil Profile
(Post-Tensioning Institute Third Edition with 2008 Supplement Design)

SOIL PROFILE for PTI CALCULATION OF E_m and Y_m

Stratum	Thickness, ft.	Plasticity Index, PI
Layer 1	2	20
Layer 2	5	37
Layer 3	3	29

PTI 3rd Edition POST-TENSION DESIGN PARAMETERS

Slab subgrade coefficient
- Slab-on-sand bedding 1.00
- Slab-on-polyethylene over sand bedding 0.75

Fabric Factor, F_f 1
Thornthwaite Index (I_M) .... +18
Approximate Depth to Constant Soil Suction, ft. 9
Constant Soil Suction, pF 3.6
Estimated Moisture Velocity, inch/month 0.7
Principal Clay Mineral .... Montmorillonite

E_m and Y_m values based on final moisture profile and depth of vertical moisture barrier

POST-TENSION PARAMETERS for Existing Soil Profile (Post-Tensioning Institute Third Edition with 2008 Supplement Design)		
Vertical Moisture Barrier see note (1,2)	**Center Lift**, -- drying of soil along foundation perimeter (wet to dry) **E_m = 8.0 ft.**	**Edge Lift**, wetting of soil along foundation perimeter (dry to wet) **E_m = 4.8 ft.**
Barrier Depth, inches	**Y_m, Inches**	**Y_m, Inches**
No barrier	1.75	1.73
12	1.61	1.54
18	1.54	1.46
24	1.47	1.38
30	1.37	1.23

(1) Note: Vertical barrier depth defined as grade beam penetration depth into in-situ soil or compacted structural select soil (i.e. depth below finish grade of soil)
(2) Note: PTI states, "A vertical barrier should extend at least 2.5 ft. below the adjacent ground surface to be considered as having any significant effect".

Estimated Bearing Pressure based on shear strength, c = 700 psf, ϕ = 0°, 0 to 2'
c = 1165 psf, ϕ = 0°, below 2'

Depth of grade beam, Inches see note (3)	**Allowable Bearing Pressure, PSF**	
	Dead Load Only (Factor of Safety = 3)	**Total Load (Dead + Live) (Factor of Safety = 2):**
12	1200	1800
18	1200	1800
24	1200	1800
30	2000	3000

(3) Note: Depth defined as grade beam penetration depth into in-situ soil or compacted structural select fill (i.e. depth below finish grade of soil)

To assure firm surface soils, and to qualify the use of tabulated capacities, this site requires proof-rolling the building site with a 15-ton roller, or other equivalent suitable equipment as approved by the engineer. The proof-rolling serves to compact surficial soils and to detect any soft or loose zones. The proof-rolling operations should be observed by an experienced geotechnician.

In regions where soft soils are located, undercut at least four (4) feet of existing soil, process, and replace and compact to provide at least two (2) feet of stiff soil on the underside of grade beams; or place and compact structural select fill to provide at least two (2) feet of stiff soil on the underside of grade beams. The replaced soil or the placed Structural Select fill material should be placed in maximum of eight (8) inch loose lift and compacted to a minimum of 95 percent of the maximum dry density as per ASTM D-698. The moisture content should be with -1% to +3% of optimum moisture.

GETI recommends qualified personnel be present during the construction to observe and inspect the post-tensioning operation. The continuous inspection of the operation include tendon post-tensioning by the jacking systems, monitoring applied force and elongation in conformance with the structural requirements. The PTI design parameters, presented above, are based upon our interpretation of the on-site soil conditions found at the time of our field investigation and the empirical data presented in the design manual. Due to the presence of expansive soil at the site, we recommend the floating slabs can be stiffened such that minimum differential movements occur once a portion of the slab is lifted by expansive soils.

The PTI differential soil movements estimates do not account for site preparation and vegetative influences, such as prior trees and residential landscaping, which can greatly influence foundation performance. Actual performance of slab-on-grade foundations will largely depend on actual soil moisture conditions, construction techniques, site preparation and resulting surface drainage and landscaping.

The construction of post-tensioned slabs requires close attention to detail during construction. The surficial soil containing roots, organic and unsuitable materials should be removed and replaced with structural select fill and compacted as per recommendations for select fill. The excavations for the grade beams should be clean and free of any loose materials prior to concrete placement.

The GENERAL CONSTRUCTION CONSIDERATIONS section of the report describes Site Preparation, Structural Fill and Subgrade Preparation, Surface Drainage, and Vegetation Control. In general, site preparation should consist of removing any existing foundations, paved areas, and undesirable materials. All loose or organic material should be stripped and removed from the site. Existing fill without compaction records should be removed or processed. Subsequent to stripping operations, the exposed subgrade should be proof-rolled to detect local weak areas that should be excavated, processed, and re-compacted in loose lifts of approximately eight-inch thickness. The exposed subgrade should be scarified to a minimum depth of six (6) inches. The scarified soils should then be re-compacted and not allowed to dry out prior to placing structural fill.

Information was not available on whether fill will be used to raise site grade prior to foundation construction. In the event fill is placed on the site, specifications should require a uniform thickness throughout the slab area and placement in accordance with our recommendations given in the section "Structural Fill and Subgrade Preparation". Lack of proper consideration of these factors will result in additional stresses and inferior slab performance.

As mentioned earlier that the site was developed with an existing structure, the recommendations provided in this report are based on soil test borings drilled in areas accessible to drill rig and based on the assumption that same or similar subsurface condition are present at the area of existing structure. To confirm uniformity of the subsurface conditions, additional test boring can be drilled once the existing structure has been removed.

V. GENERAL CONSTRUCTION CONSIDERATIONS

1. Site Preparation

Our recommendations for site preparations are summarized below:

1.1 In general, remove all vegetation, tree roots, organic topsoil and any undesirable materials from the construction area. Tree trunks and roots under the floor slabs should be removed to a root size of less than 0.5-inch. We recommend that the stripping depth be evaluated at the time of construction by a soil technician.

1.2 Any on-site fill soils, encountered in the structure areas during construction, must have records of successful compaction tests signed by a registered professional engineer that confirms the use of the fill and record of construction and earthwork testing. These tests must have been performed on all the lifts for the entire thickness of the fill. In the event that no compaction test results are available, the fill soil must be removed, processed and re-compacted in accordance with our recommendations of "Structural Fill and Subgrade Preparation". Excavation should extend at least two (2) feet beyond the structure area and should the fill be used to elevate the existing grade, then the top of the fill area should extend to two (2) feet or to the distance equal to the height of fill above the existing grade, whichever is greater. Alternatively, the existing fill soils should be tested comprehensively to evaluate the degree of compaction in the fill soils.

1.3 The subgrade areas should then be proof-rolled with a 15-ton roller, or other equivalent suitable equipment as approved by the engineer. The proof-rolling serves to compact surficial soils and to detect any soft or loose zones. Any soils deflecting excessively under moving loads should be undercut to firm soils and re-compacted. The proof-rolling operations should be observed by an experienced geotechnician.

1.4 In the areas where expansive soils are present, rough grade the site with structural fill soils to insure positive drainage. Due to their high permeability of sands, sands should not be used for site grading where expansive soils are present.

1.5 We recommend that the site and soil conditions used in the structural design of the foundation be verified by the engineer's site visit after all of the earthwork and site preparation has been completed prior to the concrete placement.

2. Structural Fill and Subgrade Preparation

It is recommended that the subgrade and fill be prepared as follow:

2.1 The site should be stripped to suitable depth to remove any top soil and miscellaneous fill material. The exposed subgrade surface then should be proof-rolled. All soft or loose soils should be removed and replaced with select fill materials.

2.2 The natural subgrade should be scarified to a minimum depth of six (6) inches. The scarified soils should then be recompacted to a minimum of 95 percent of the maximum dry density as determined by the Standard Proctor Density Test (ASTM D-698). The moisture content should range -1% to +3% of optimum moisture.

2.3 The Structural Select fill should consist of a clean Sandy Clay with Liquid Limit less than 35 and a Plasticity Index (P.I.) between 10 and 20.

2.4 The Structural Select fill material should be placed in maximum of eight (8) inch loose lift and compacted to a minimum of 95 percent of the maximum dry density as per ASTM D-698. The moisture content should be with -1% to +3% of optimum moisture.

2.5 A bedding layer of leveling sand may be placed beneath the floor slab vapor barrier. The leveling sand depth should not exceed two (2) inches; and the leveling sand must be covered with plastic sheeting. A vapor barrier consisting of six (6) mil plastic sheeting should be placed over the sand cushion to prevent water migration through the concrete slab. The excavations for the grade beams should be clear and free of any loose materials prior to concrete placement.

2.6 In cut areas, the soils should be excavated to grade and the surface soils proofrolled and scarified to a minimum depth of six inches and recompacted to the previously mentioned density tests at the time of construction.

2.7 The select fill soil extending from the building towards the building line should be capped with on-site high plastic clay soils in order to retard any water seepage into subgrade soils.

3. Surface Drainage

It is recommended that the site drainage be well developed. Surface water should be directed away from the foundation soils (use a minimum of 2% with 10 feet away of foundation). No ponding of surface water should be allowed near the structure. The following drainage precaution should be observed during construction and at all times after the structure has been completed.

1) Backfill around the structure should be a cohesive soil material which should be moistened and compacted to at least ninety (90) percent of standard proctor density. Any cohesionless soil material accumulated around the perimeter of the structure during construction should be removed and not allowed to be mixed with or covered by the backfill material.

2) Where landscaping is to be installed next to the perimeter of grade beam, a moisture barrier or other suitable means should be installed to prevent moisture from entering the underlying clay soils.

3) Roof downspouts and drains should discharge well away from the limits of the foundation or grade beams.

4. Vegetation Control

We recommend trees not to be closer than half the canopy diameter of the mature tree from the grade beams, typically a minimum of 20 feet. This will minimize possible foundation settlement caused by the tree root systems.

VI. DISCLAIMER

The information and recommendation contained in the report summarized condition found at the site of the proposed Residence located at 4719 Braesvalley Drive in Houston, Texas specified and on the date the field exploration was completed. The attached soil boring logs are a true representation of the soils encountered at the stratigraphy as found during the field exploration and drilling of the subject site.

Reasonable variations from the subsurface information presented in this report are assumed. If conditions encountered during construction are significantly different than those presented in this report, GETI should be notified immediately.

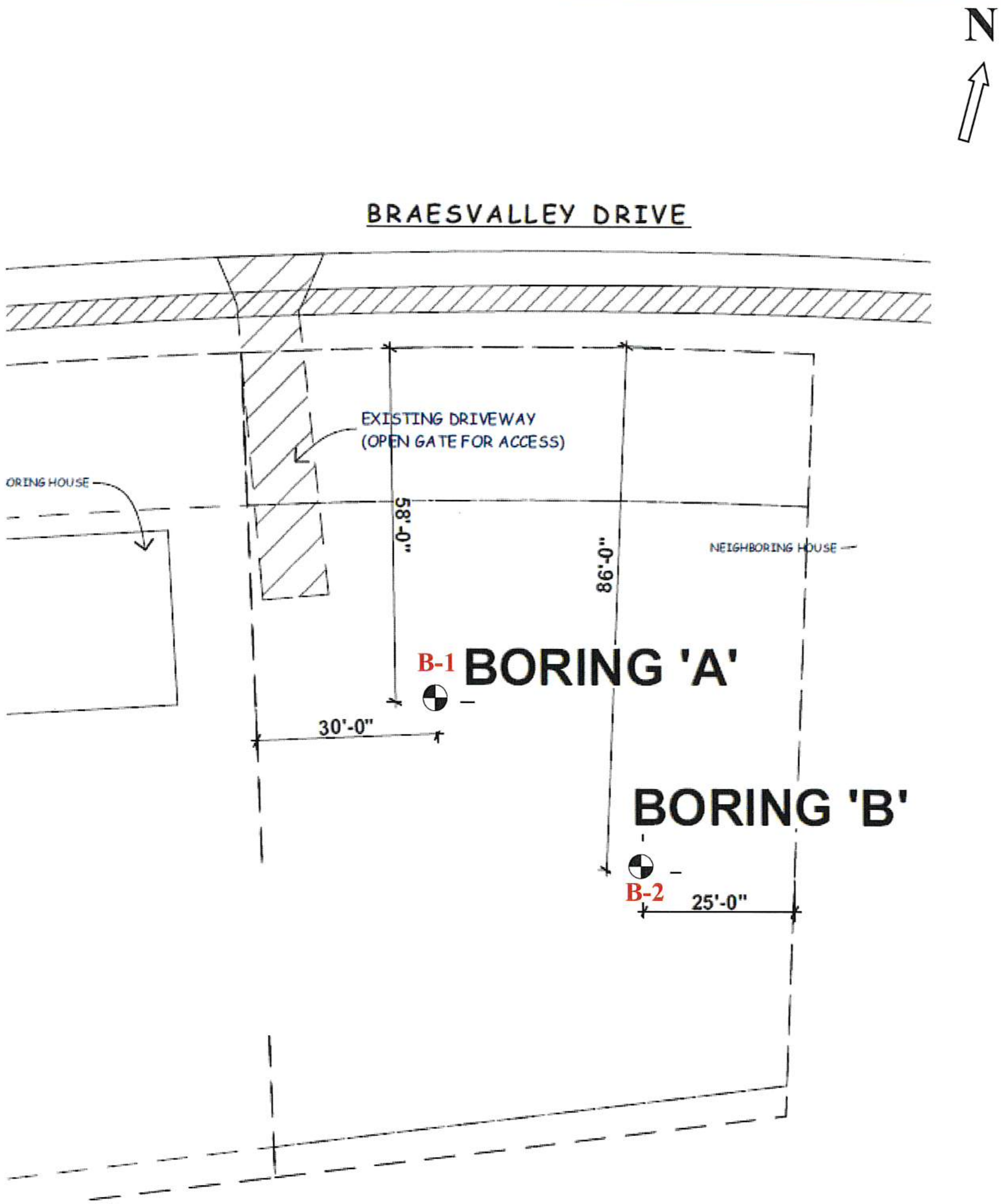
The report was prepared for the sole and exclusive use by our client, based on specific and limited objectives. All reports, boring logs, field data, laboratory test results, and other documents prepared by GETI as instruments of service shall remain the property of GETI. Reuse of these documents is not permitted without written approval by GETI. GETI assumes no responsibility or obligation for the unauthorized use of this report by other parties and for purposes beyond the stated project objectives and work limitations.

In addition, the construction process may itself alter site soil conditions. Therefore, experienced geotechnical personnel should observe and document the construction procedures and all conditions encountered. We recommend that the owner retain Geoscience Engineering and Testing, Inc. to provide this service as well as the construction material and testing and inspection required during the construction phase of the project.

The standard of care for all professional engineering and related services performed by Geoscience Engineering & Testing, Inc. (GETI) corresponds to other geotechnical firms under similar circumstances in the project locality. GETI makes no warranties, express or implied, under this agreement or in connection with any services performed or furnished by us.

We would welcome the opportunity to discuss our recommendation with you and hope we may have the opportunity to provide any additional studies or service to complete this project. The following illustrations are attached and complete this report:

ILLUSTRATIONS	PLATE NUMBERS
Boring Locations Plan	1
Boring Logs	2-3
Symbols and Terms used on Boring Logs	4
Site Pictures	5



Approximate Boring Locations

NOT TO SCALE

LOCATION
Proposed Residence
4719 Braesvalley Drive
Houston, Texas
GETI NO.: 16G2857

PLATE NO. 1

PROJECT: **Proposed Residence**
4719 Braesvalley Drive
Houston, Texas

CLIENT: **Ms. Karen & Mr. Cary Robinson**
Houston, Texas

BORING NO.: **B-1** DEPTH: **20'**

PROJECT NO. 16G2857 DATE: May 11, 2016

Water was not encountered during drilling operation

DRILLING METHOD (S)

Continuous Flight Auger & Intermittent Sampling

Legend

Fat Clay; Sandy Clay / Silty Clay; Silty Sand / Sandy Silt; Fill; Clayey Sand; Silty Clayey Sand

FIELD DATA							LABORATORY DATA							
DEPTH (FEET)	SOIL SYMBOL	SAMPLES	N: BLOWS/FT	T: INCHES/100 BLOWS	P: TONS/SQ FT	RQD: PERCENT	MOISTURE CONTENT (%)	DRY DENSITY POUNDS/CU. FT	ATTERBERG LIMITS (%) LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	MINUS NO. 200 SIEVE (%)	SHEAR STRENGTH (TSF)	DESCRIPTION OF STRATUM
0–2	Fill				P=1.75		25		62	25	37			Possible Fill: Stiff, brown and light brown SANDY FAT CLAY - with sandy lenses
2–8	Fat Clay				P=2.0		24							Stiff to very stiff, dark brown and brown SANDY FAT CLAY (CH)
5					P=3.5		20							- very stiff from 4' to 8'
					P=2.25		21							
8–12	Sandy Clay / Silty Clay				P=4.0		19							Light brown, gray and light gray LEAN CLAY (CL) - very stiff from 8' to 10' - with calcareous nodules from 8' to 10'
10					P=1.75		19	109					0.55	- stiff from 10' to 12'
12–15	Fat Clay				P=3.5		20		70	27	43			Very stiff, light brown, light gray and reddish brown SANDY FAT CLAY (CH)
15–20	Clayey Sand				P=1.0		19		26	13	13			Firm to stiff, light brown, light gray and reddish brown CLAYEY SAND (SC)

N- STANDARD PENETRATION TEST RESISTANCE
T- TXDOT CONE PENETRATION RESISTANCE
P- POCKET PENETROMETER RESISTANCE
R- PERCENTAGE OF ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

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PLATE NO. 2

PROJECT: Proposed Residence 4719 Braesvalley Drive Houston, Texas	BORING NO.: B-2	DEPTH: 15'
	PROJECT NO. 16G2857	DATE: May 11, 2016
CLIENT: Ms. Karen & Mr. Cary Robinson Houston, Texas	Water was not encountered during drilling operation	

DRILLING METHOD (S): **Continuous Flight Auger & Intermittent Sampling**

Legend: Fat Clay; Sandy Clay / Silty Clay; Silty Sand / Sandy Silt; Fill; Clayey Sand; Silty Clayey Sand

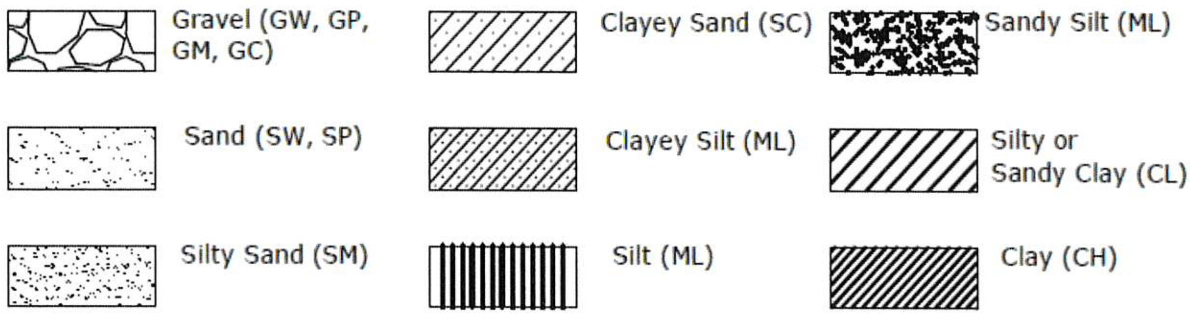
DEPTH (FEET)	SOIL SYMBOL	SAMPLES	N: BLOWS/FT	T: INCHES/100 BLOWS	P: TONS/SQ FT	RQD: PERCENT	MOISTURE CONTENT (%)	DRY DENSITY POUNDS/CU. FT	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	MINUS NO. 200 SIEVE (%)	SHEAR STRENGTH (TSF)	DESCRIPTION OF STRATUM
0–6	Fat Clay				P=2.5		24							Dark brown and brown SANDY FAT CLAY (CH) - very stiff from 0 to 4'
					P=2.75		20							
5					P=1.75		21							- stiff from 4' to 6'
6–15	Sandy Clay / Silty Clay				P=1.75		21							Stiff, light brown, gray and light gray LEAN CLAY (CL) - with calcareous pocket from 6' to 8' - very stiff from 8' to 12'
					P=3.0		19	113	48	19	29		1.50	
10					P=2.75		22							
					P=1.5		22							
15														
20														
25														
30														

N- STANDARD PENETRATION TEST RESISTANCE
T- TXDOT CONE PENETRATION RESISTANCE
P- POCKET PENETROMETER RESISTANCE
R- PERCENTAGE OF ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

GEOSCIENCE ENGINEERING & TESTING, INC

PLATE NO. 3

KEY TO SOIL CLASSIFICATION AND SYMBOLS



CONSISTENCY OF COHESIVE SOILS

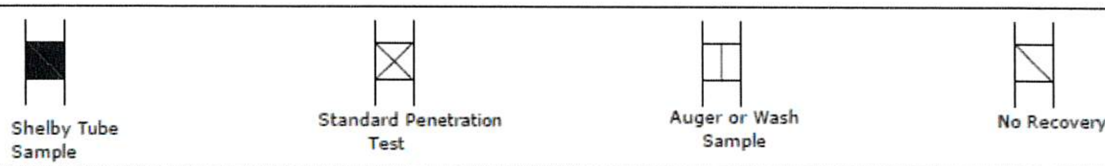
Description	Shear Strength KSF	Penetration Resistance Blows/ Ft
Very Soft	Less than 0.25	0 - 2
Soft	0.25 - 0.5	2 - 4
Firm	0.5 - 1.00	4 - 8
Stiff	1.00 - 2.00	8 - 15
VeryStiff	2.00 - 4.00	15 - 30
Hard	Greater than 4.00	>30

RELATIVE DENSITY OF COHESIONLESS SOILS

Description	Penetration Resistance Blows / Ft	Relative Density %
Very Loose	0 - 4	0 - 15
Loose	4 - 10	15 - 35
Medium dense	10 - 30	35 - 65
Dense	30 - 50	65 - 85
Very Dense	>50	85 - 100

Soil Structure

CALCAREOUS NODULES -- Nodules of Calcium Carbonate
FERROUS NODULES -- Nodules of Ferrous Material
SLICKENSIDED -- Having inclined planes of weakness that are slick and glossy
BLOCKY -- Having inclined planes of weakness that are frequent and rectangular in pattern
LAMINATED -- Composed of thin layers of varying soil type and texture
FISSURERD -- Containing shrinkage cracks frequently filled with fine sand
INTERBEDDED -- Composed of alternate layers of different soil types



GROUNDWATER

▽ (24 hOurs) - Water Level after drilling (time increment after drilling)

▼ - Free Water observed during drilling

FAILURE DESCRIPTION (COMPRESSION TEST)

B - Bulge
S - Shear
M/S - Multiple Shear

SLS - Failure surface occuring along slickensided plane
SAS - Failure surface occuring along or in sand seam
SS - Failure surface occuring in or along other secondary structure such as calcareous pockets

Project No.: 16G2857
Plate No.: 5