Computing★Design★Forensic★Testing

Quartet Engineers, PLLC
2313 W Sam Houston Pkwy N, Suite 121
Houston, TX 77043
Toll Free/Fax: 1-844-MAT-CHECK (628-2432)
Email: services@quartet-eng.com
Web: www.quartet-eng.com
TBPE Reg. No.: F-17380

September 20th, 2020

Shree Homes
16107 Kensington Drive, Suite 247
Sugar Land, Texas 77479

Kind Attn.: Mr. Visham Odhrani

Ref: Project # PGH-20-0172
Report # PGH-20-0172, Rev. 0
Geotechnical Study
Proposed Single-Family House
311 Electra Drive
Houston, TX 77024

Dear Mr. Odhrani,

Quartet Engineers, PLLC is pleased to submit this report on geotechnical engineering study performed for the subject project. This report contains details of the soil boring logs and the laboratory tests carried out on the samples obtained through drilling. Detailed analysis of the laboratory results was done, and geotechnical design and engineering recommendations developed based on data obtained. These recommendations are included in the attached report.

Quartet Engineers, PLLC appreciates this opportunity to work with you on this project and we look forward to further opportunities during subsequent phases of this project to provide our additional services including construction material testing.

If you need any clarification regarding this report, or if we can be of further assistance, please do not hesitate to contact us.

Thanking you,

With Kindest Regards,

09/20/2020

Vijay K Jha, PhD, PE, PMP
Principal Engineer

09/20/2020

VIJAY K JHA
114340

Geotechnical Engineering Report, Rev. 0

Proposed Single-Family House at 311 Electra Drive, Houston, TX 77024

Project No.: PGH-20-0172, Report No.: PGH-20-0172

Prepared by:
Quartet Engineers, PLLC
2313 W Sam Houston Pkwy N, Suite 121
Houston, TX 77043

Prepared for:
Shree Homes
16107 Kensington Drive, Suite 247, Sugar Land, TX 77479

Shree Homes
Homes@shreehomes.com

Shreehome2013@gmail.com

9/20/2020

Table of Contents

1.0 Introduction

1.1 General

Quartet Engineers, PLLC has completed an initial geotechnical investigation for the construction of the proposed Single-Family House to be located at 311 Electra Drive, Houston, TX 77024. This study was authorized by Mr. Visham Odhrani with Shree Homes. This report presents field as well as laboratory data and recommendations for the geotechnical design and construction of the foundation of the proposed structures.

1.2 Scope of Services

The main purpose of this study was to investigate subsurface soil conditions, to determine the index and other engineering properties of the subsurface soil and to recommend suitable foundation system for the proposed Single-Family House. As stated in our proposal authorized on September 2nd, 2020, the scope of services includes the following:

- Reconnaissance of the drilling site to examine the general site conditions and to mark the proposed boring locations.

- Drilling and sampling of soil samples to evaluate subsurface soil and groundwater conditions.

- Perform laboratory tests on selected recovered soil samples to establish physical and engineering properties of subsurface soil.

- Compilation of field and laboratory test data for subsequent engineering analysis to estimate load bearing capacity and swell potential of the underlying soils.

- Preparation of a geotechnical engineering report presenting recommendations on (1) suitable foundation system required to adequately support anticipated structural load; (2) proper construction methodology; (3) ground modification; and (4) design parameters to facilitate structural design of foundation.

1.3 Limitations

Our site exploration is based on only two (2) exploratory borings at selected locations. It is customarily assumed that the soil properties between consecutive borings do not change significantly in any subsurface exploration program. Sub-surface conditions including fluctuation in the groundwater elevation between test borings can vary; the extent of variations will become known only when actual construction begins. If significant variations in the subsurface conditions is encountered during the excavation, Quartet Engineers should be notified immediately to review the findings and recommendations presented in this report.

The Quartet Engineers warrants that the information contained in this report are solely based on generally accepted engineering practices in the field of soil mechanics and foundation engineering. Quartet Engineers makes no warranties, express or implied, under this agreement or in connection with any services performed or furnished by us.

This report is prepared for the sole and exclusive use by our client and for specific project, based on specific and limited objectives. All reports, boring logs, field data, laboratory test results, and other documents prepared by us shall remain the property of Quartet Engineers. Reuse of these documents is not permitted without written approval by Quartet Engineers. We assume 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.

2.0 Field Exploration

2.1 Description of the Site

The project site, where subsurface explorations were carried out at location, mentioned in Section 1.1 of this report, as shown in plate 1D. The site was relatively level and covered with grass and some trees. The site geology for the geographic area corresponds to Beaumont Formation, Quaternary Period, and Pleistocene, Holocene Epoch or Series[1].

2.2 Field Investigation and Soil Stratigraphy

The objective of the field investigation, completed on September 11th, 2020, was to determine the engineering characteristics of the subsurface materials included a reconnaissance of the project site,

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[1] Note: USGS, GEOLOGIC ATLAS OF TEXAS

drilling the exploratory borings and recovering the representative soil samples. Sample depth and description of soil (based on the Unified Soil Classification System) are presented on the Soil Boring Logs, Plates No. 2 and 3.

Subsurface conditions at the proposed site were examined with the help of two (2) exploratory borings B-1 and B-2 indicated on the plan shown in Plate 1D. Boring locations and depths were approved by the Client. Borings B-1 and B-2 were drilled to a depth of 20 feet and 15 feet respectively, below the existing grade. Continuous samples were obtained to a depth of ten (10) feet and at five (5) feet intervals thereafter. Several undisturbed samples for clayey soils were recovered using thin walled Shelby tube samplers following the procedure outlined in ASTM D-1587. Split-barrel sampling is utilized to recover the undisturbed sandy samples in accordance with the procedure described in the ASTM D1586. The obtained soil samples were extruded from the tube and visually classified in the field.

The stratification shown in the boring logs represents the soil conditions at the actual boring locations. Subsurface exploration revealed that the extent of boring may be divided into four general strata with their thickness and general characteristics as shown in the Table 2.1. Please refer Boring Logs for detail of Soil strata in Illustration Section.

Table 2.1: General soil strata at the project site.

Stratum	Boring No.	Thickness (ft.)	Soil Description*
I	B-1 & B-2	0 – 4	Top Soils: Light brown medium dense to dense **Sandy Silt (MS)** with root fibers.
II	B-1 & B-2	4 – 10	Gray and light brown very stiff to hard **Sandy Fat Clay (CH)** with calcareous nodules.
III	B-1 & B-2	10 – 15	Tan and light brown very stiff to hard **Sandy Clay (CL)** with calcareous nodules.
IV	B-1	15 – 20	Tan and brown medium dense **Clayey Sand (SC)**.

* Classification is in accordance with the Unified Soil Classification System

2.3 Water-Table Location

Observation on groundwater elevation during drilling and 30 min. after drilling for each boring is summarized in Table 2.2.

Table 2.2: Groundwater elevation during and 30min after drilling.

Boring No.	Boring Depth (ft.)	Groundwater Elevation During Drilling (ft.)	Groundwater Elevation After 30 min. of Drilling (ft.)	Caving Condition
B-1	20	DRY	DRY	
B-2	15	DRY	DRY	

It should be noted that groundwater fluctuations may occur due to change in environmental conditions such as frequency and magnitude of rainfall, presence of wells near the site, and the proximity of the site to any bayous or streams. Accurate groundwater measurements can be measured only using piezometers or monitor wells. Piezometer installation is beyond the scope of this project.

3.0 Laboratory Tests

3.1 General

Upon completion of drilling operations, all the recovered samples were properly sealed and transported to the laboratory to perform routine geotechnical tests to obtain various engineering properties of the foundation soil. More specifically, liquid limit and plasticity index determination, percentage finer than no. 200 sieve, soil classification, and unconfined compression tests on soil samples were carried out. Table 3.1 shows the type and frequency of tests performed as well as procedures followed in running these tests.

Table 3.1: Laboratory testing program

Test	Procedure	Frequency
Moisture Content	ASTM D2216	13
Plasticity Index	ASTM D4318	6
Unit Weight	-	3
Particle Finer Than No. 200	ASTM D1140	6
Unconfined Compressive Strength	ASTM 2166	3

3.2 Percentage of Soil Finer than No. 200 Sieve

This test is usually conducted to determine the amount of soils finer than no. 200 sieve by washing. The loss of soil mass, after washing, is expressed as a percentage of original soil mass. This quantity is a measure of clay and silt fraction present in soil mass and is a useful parameter in the classification of soil. Following standard ASTM procedure, percentage finer than no. 200 sieve were determined on selected samples.

3.3 Liquid Limit and Plasticity Index

Determination of liquid limit, plastic limit and plasticity index are used to classify a given soil mass. Plasticity index is also used to determine the swell-shrink (volume change) potential of a soil. A very high value of plasticity index indicates that the soil is susceptible to a volume change. This parameter is particularly very important in the design of slab-on-grade type of foundation. On some samples, this test was carried out employing standard ASTM procedures.

3.4 Soil Classification

Once the values of Liquid limit, plasticity index and percentage finer than no. 200 sieve, a given sample of soil can be classified in accordance with the unified soil classification system (USCS) based on which suitability of a natural soil as a subgrade material can be ascertained. The visual classification performed in the field were verified in the laboratory using this classification system.

3.5 Moisture Content and Dry Unit Weight

Moisture content and dry unit weight tests were run on almost all samples recovered from the test borings to establish moisture variation and compactness of soil throughout the profile. These parameters are essential to eventually calculate the load carrying capacity of the soil.

3.6 Unconfined Compression Test

Shear strength of selected clayey samples was evaluated in the laboratory by performing unconfined compression test. In the field, this parameter was evaluated by making use of a pocket penetrometer. The shear strength so obtained was used to compute the load bearing capacity of the soil.

3.7 Potential Vertical Rise

Potential vertical rise (PVR) is a measure of swell potential of certain type of soil mass at a given density, moisture and loading condition when exposed to capillary or surface water [1]. Swelling of the underlying soil is generally manifested in the form of rise in the elevation of ground surface. Any structure resisting on this surface would experience distress unless it is within the permissible limit of one (1) inch.

Evaluation of PVR becomes essential if one encounter expansive soils at the proposed construction site. Field observation and laboratory tests confirm the presence of expansive soils at the site under consideration. Several methods exist to evaluate swell poetical of expansive soils in the literature. However, a method proposed by the Texas Department of Transportation method, designated as Tex 124-E, is normally utilized to compute the swell potential of the soil encountered. Tex 124-E method provides an estimate of PVR from the known values of liquid limits, plasticity indices, and existing water contents for the soils.

Based on the aforementioned method, the potential vertical rise (PVR) at the locations of the test borings drilled is estimated to be **1.30 inch**. More movement will occur in areas where the soil dries, and water subsequently ponds during or after construction. Site grading may also influence the potential for movement.

Table 3.2: Estimated PVR

Existing Soil Removal Depth and Replacement with Structural Select Fill Materials (Ft.)	0	2
Estimated Expected PVR (Inch)	1.3	1.0

Existing materials need to be replaced with structural select fill materials as per design criteria of the structural engineer of the record and compacted to minimum 95% of the maximum dry density as per ASTM D698. The following PTI design parameters are based on the above-mentioned information.

To reduce the differential movement of the foundation slab following measures should be taken:

a) Foundation slab should consist of a good quality select fill materials and should be clean sandy lean clay (CL) with liquid limit of less than 40 and a plasticity index between 10 and 20. Select Fill materials should be from natural occurring soils and should not be made of a mixture of sand and high plasticity soils. The select fill should be extended at 5ft beyond the building footprint in all directions. Preparation and compaction of structural select fill materials should be done as given in Section 5.2 of this report.

b) If high plasticity soils such as Fat Clays are present, then chemical injection in foundation slab area will reduce the PVR.

c) Keep soils around the foundation moist by regular watering the plants and soils, which will help to reduce the drastic change in moisture and hence help to reduce the foundation tilt caused due to PVR. . Also, keep 1 ft of space between grade beam and the detached garage driveway (if that exists), which should be planted and kept uniformly moist. This will help to reduce the moisture change possible PVR.

d) Extension of Exterior Grade Beam depth to 36 inches, which will help to reduce the change of moisture under the foundation slab.

e) A slope of 5% within 10 ft of exterior grade beam all around the foundation will help surface water to run off from the foundation slab. Limit the use of sand for site grading to 2 inches for grass growth. On-site expansive soils or select fill materials should be used for site grading around the foundation structure.

3.8 Foundation Settlements

Foundation Settlement Analysis is out of the scope of our work and it is anticipated that foundation will experience small settlements if foundation will be designed based on the recommended allowable bearing capacities.

3.9 Sample Storage

Unused samples will be stored for 14 days after the submission of this report. Thereafter, all the samples will be discarded if a request to store for the extended period is not received within this time frame.

4.0 Foundation Recommendations

Construction of lightly loaded structures is challenging, and it is our experience that economic considerations usually govern the associated risks with foundation design. However, there are some level of associated risks with all types of foundation. In general, risk decreases as the cost of the foundation increases.

The choice of foundation system very much depends on the subsurface soil and on the magnitude of load transmitted by the superstructure. The size and extent of the foundation are generally decided based on two factors: the pressure exerted on the underlying soil should be less than the allowable bearing capacity of the soil and the settlement within the soil mass should always stay within the permissible limit. After careful examination of field conditions and laboratory test results, we find that post tensioned or conventional reinforced concrete slab-on-grade are suitable foundation systems for the proposed structures.

4.1 Underreamed Footings (Drilled Piers)

Underreamed footings are used most advantageously when relatively soft or expansive strata overlie the firm to stiff foundation. Based on the subsurface condition at boring locations, it is our understanding that the structure at the site can be supported on a foundation system comprised of drilled underreamed footing placed at a depth of **fourteen (14)** feet below the existing grade. The field and laboratory data were utilized to determine the allowable soil loading as a function of foundation shape and depth. The footing may be sized for an estimated net allowable bearing pressure of **3,200psf and 4,800psf** for dead load plus sustained live load and for total load, respectively. The bearing pressure contains a factor of safety of 3.0 and 2.0 for these two load conditions. It is recommended to limit the bell to shaft ratio to 3:1. In the event that bell caving occurs during construction, a bell to shaft ratio of 2.5:1 should be constructed. The maximum bell diameter should not be greater than half of the depth of the foundation and the spacing between the drilled footings should not be less than one bell diameter.

Drilled piers should be designed to resist both axial and uplift loads. Uplift forces are applied at the perimeter of the pier. We recommend designing the drilled piers to resist adhesion stresses of 1.0 TSF along the upper ten (10) feet of the shaft length. The shaft should contain sufficient full-length reinforcing steel to resist uplift forces.

4.1.2 Uplift Capacity

The ultimate uplift capacity of a singled drilled shaft is generally estimated using the following formula:

For $L/Ds > 1.5$ $\quad Q_u = 5.2S_u (D_b^2 – D_s^2) + W$

For $L/Ds \leq 1.5$ $\quad Q_u = 2.98\, S_u^{0.5} \frac{L}{D_s} (D_b^2 - D_s^2) + W$

Where, Q_u = Ultimate uplift capacity, kip
S_u = Undrained shear strength of the soil, (0.75ksf)
D_s = Diameter of shaft, ft.
D_b = Diameter of bell, ft.
L = Depth of the footing, ft.
W = Submerged weight of the drilled shaft, kip

For the estimation of unit weight of the drilled, the groundwater may be assumed to be at the ground surface. To estimate the allowable uplift capacity of the shaft, a factor of safety of 2 and 3 can be assumed for dead plus sustained live load and total load, respectively.

4.1.3 Uplift Capacity due to Expansive Soil

The allowable uplift capacity of the drilled piers due to the presence of expansive soil within active zone may be calculated using the following equation.

$$Q_u = 0.79 D_s Z_a \sigma_s$$

Where,

$Q_u =$ Ultimate uplift capacity, Ton
$D_s =$ Diameter of Shaft, ft.
$Z_a =$ Depth of Active Zone, (10 ft.)

$\sigma_s =$ Swelling Pressure of the soil, (1.2 TSF)

4.2 Floor Slab Associated with Underreamed Drilled Footings

4.2.1 Structural Slab

Structural slab is supported only by grade beams which are supported by piers. The structural slab entails the least risk because it is isolated from the onsite soils. The slab should be raised from the ground surface by **six (6) inches** using void boxes to avoid the vertical displacement of the slab.

4.2.2 Slab on Fill (Supported by Grade Beams & Sub-grade)

Slab can also be supported by grade beams and subgrade which is economically maybe feasible and can be effective if used with positive drainage and vegetation control. This option will require the removal of roots and unsuitable material and replacement of existing soils with the structural select fill materials or put on top of the existing surface based on Table 3.2 (PVR) above and as per Design Criteria of the Engineer of Record.

Based on the soil conditions where soils consist of silts minimum **two (2) feet** of existing materials need to be replaced with structural select fill materials and compacted 95% of the maximum dry density as per ASTM D698.

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 floor slab should be installed as soon the structure pad is prepared. The slab should be protected from inclement weather always by providing proper drainage and placing plastic sheeting on top of the slab. If the structure pad is left exposed to rainfall, perched groundwater conditions may develop which will undermine the integrity of the floor slab. Therefore, the floor pad should be covered with a plastic sheet, if the floor slab is not placed immediately.

In general, perched water tends to be trapped within the fill. The trapped groundwater tends to soften the subgrade. The excess moisture promotes clay expansion (heave) which may be detrimental to the integrity of the slab foundation and structure. Positive drainage should be maintained across the entire structure pad. In addition, the select fill extending from the building towards the building line should be **capped with high plastic clay soils** in order to retard any water seepage into subgrade soils.

4.2 Floating Slab (Post-Tension Slab/Slab-on-grade) Foundation

We understand that the structural loads could be supported either on a post-tensioned slab foundation or a conventionally reinforced slab. Our recommendations for the design of conventionally reinforced slab or post-tensioned slabs are in general accordance with the PTI DC10.1-08, Third Edition with 2008 supplement. Our recommendations for conventionally reinforced slab as well as the post-tensioned slab are presented below:

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 **18 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 floor slab should be installed as soon the structure pad is prepared. The slab should be protected from inclement weather always by providing proper drainage and placing plastic sheeting on top of the slab. If the structure pad is left exposed to rainfall, perched groundwater conditions may develop which will undermine the integrity of the floor slab. Therefore, the floor pad should be covered with a plastic sheet, if the floor slab is not placed immediately.

In general, perched water tends to be trapped within the fill. The trapped groundwater tends to soften the subgrade. The excess moisture promotes clay expansion (heave) which may be detrimental to the integrity of the slab foundation and structure. Positive drainage should be maintained across the entire structure pad. In addition, the select fill extending from the building towards the building line should be **capped with high plastic clay soils** in order to retard any water seepage into subgrade soils.

Minimum **two (2) feet** of existing materials need to be replaced with structural select fill materials and compacted 95% of the maximum dry density as per ASTM D698. The following PTI design parameters are based on the above-mentioned information.

Post-Tension Slab Design Parameters

Minimum Grade Beam Depth Below the Final Grade:	1.5 ft.
Allowable Net Bearing Capacity:	
Total (Dead + Live) Loading:	1,000psf
Dead + Sustained Live Loads:	1,500psf
Slab Subgrade Coefficient	
Slab-on-Vapor Sheeting over Sand:	0.75
Edge Moisture Variation, e_m, feet:	
Edge Lift:	4.8
Center Lift:	8.0
Differential Swell, y_m, inches:	
Edge Lift:	1.1
Center Lift:	1.2
Effective Plasticity Index (PI):	18
The Required Minimum Fill Undrained	
Shear Strength:	1,000psf
Support Index:	0.70
Climatic Rating:	26
Thornthwaite Moisture Index:	18
Design Suction Profile:	Post-Equilibrium
Potential Vertical Rise (PVR) at existing soil conditions:	1.30 inch

It should be noted here that the slab designed based on the value recommended has a factor of safety of 3 and 2 with respect to shear failure for dead load plus sustained live load and total load, respectively.

5.0 Construction Considerations

5.1 Subgrade Preparation

For new constructions, the area should be stripped of all surface vegetation, loose topsoil, and other debris. On the new exposed subgrade, proof rolling with at least 15-ton pneumatic roller should be carried out. Soil in any weak area should be removed, refilled and compacted properly. In accordance with ASTM D698, the exposed subgrade should achieve compaction to at least 95% of the maximum dry density with optimum moisture content of -2 to +2%.

In interest of an orderly construction, proper drainage from the area should be maintained at all times. In the event the natural subgrade becomes wet and soft, removal and replacement with suitable structural fill, or in-place stabilization over time should be considered.

5.2 Placement of Fill Material

A good quality select fill material would be clean sandy lean clay (CL) with liquid limit of less than 40 and a plasticity index between 10 and 20. The select fill should be extended at 5ft beyond the building footprint in all directions. Selected fill material should be placed in layers not more than 8” of loose soil (with moisture content between -2% to 2% of optimum value) and compacted to specification as indicated above. The depth of each layer of fill will also depend upon the limits set on account of use of specific compaction equipment. In this regard, proper depth for use of a mechanical hand tamper is 4”, and that for a pneumatic tire roller is 6”.

Samples of proposed fill material should be collected for laboratory testing to develop moisture-density relationship. Using laboratory results as the basis, verification of proper levels of compaction during construction should be done through in-place density tests.

5.3 Foundation Construction

The performance of the building foundation will depend upon the quality of its construction. To ensure proper quality of construction for the foundation, certain special care need be exercised:

- Excavations should be sloped and should have internal sumps for runoff collection and removal. In the event, water accumulation more than 1 inch occurs at the bottom of foundation excavations, it should be collected and removed.

- Grade beams should be excavated with a smooth mouthed bucket. Any loose soil should be removed after excavation.

- Excavations for the construction of grade beams and floor slabs should not remain open for extended durations. In case it becomes necessary, concrete mud mats should be used to reduce moisture changes and other damage to the natural subgrade.

- If soft or loose soils are encountered at the design excavation level, the excavations should be further extended to firm or dense soil, and the extra excavations should be backfilled with lean concrete.

- 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 **ten (10) 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

It is recommended that the construction of the foundation be monitored by a qualified Geotechnical Engineer for due care and diligence. Quartet Engineers would be pleased to develop and submit a plan and offer its services in this regard.

5.4 Site Drainage

The site should be graded in such a manner as to channel all rainwater away from the structure(s). Water should not be allowed to pond around the structure(s). Positive site drainage should be maintained throughout the lifespan of the structure(s). The exposed, unpaved ground should be sloped away from the structure(s) at a minimum grade of 5% and should extend at least 10 feet beyond the perimeter of structure upon completion of construction and landscaping.

Positive site drainage will reduce the exposure of the on-site clays to moisture, thus eliminating potential swelling of the on-site clays. The grading around the structure(s) should be periodically inspected and adjusted as necessary, as part of the maintenance program.

5.5 Groundwater Control

A groundwater dewatering system will need to be employed. One way to monitor the fluctuation in the groundwater table is to install piezometers near the excavation area, especially where the underground storage tanks will be located, prior to the construction. These piezometers would also be helpful during the construction to evaluate the effectiveness of dewatering system. Note that the groundwater level should be at least 3ft below the bottom of the excavation to have dry and firm bedding. Design of an effective dewatering system requires prior knowledge of the amount of groundwater to be lowered and the permeability of the soil near the excavation. The task of designing a dewatering system is beyond the scope the present study.

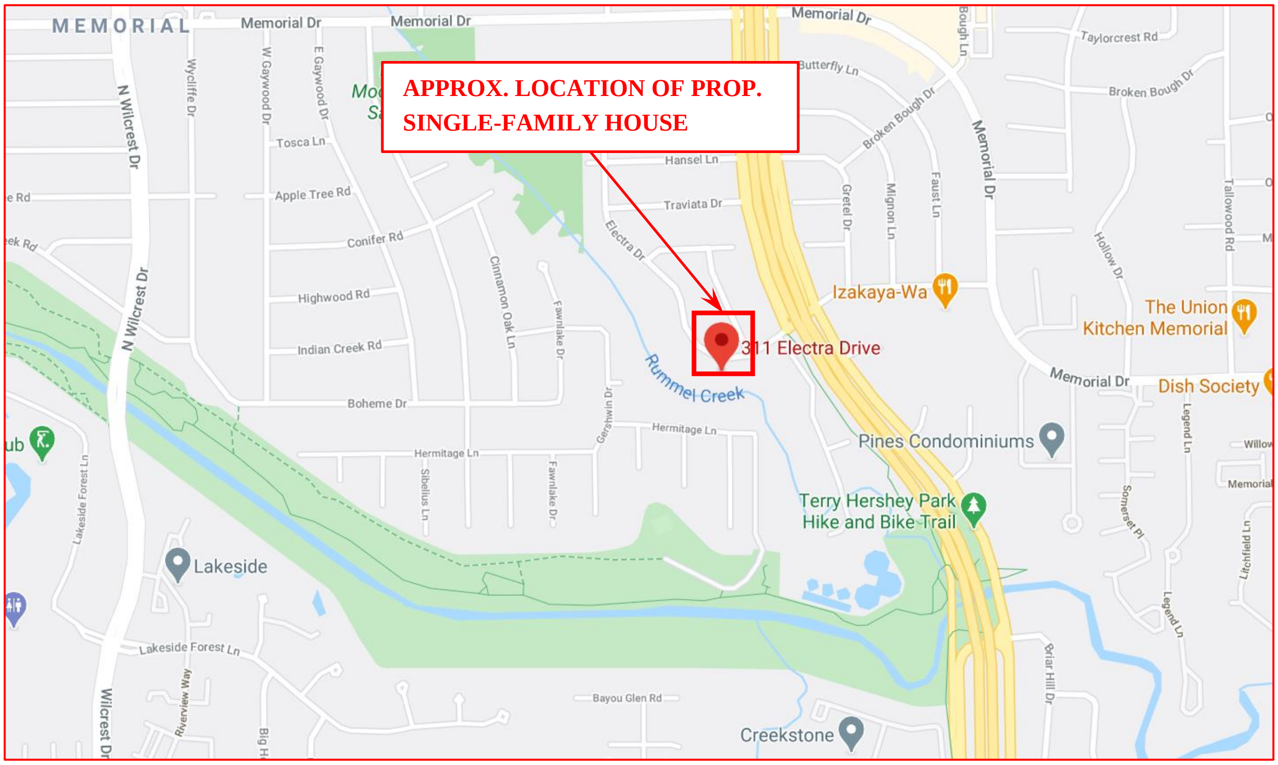
5.6 Vegetation Control

Trees should be planted a distance away from the structure(s) equivalent to the anticipated height of the mature tree. Trees can withdraw large quantities of water from the soil, which causes a net volume reduction in the soil matrix. The decrease in water volume within the soil matric can result in excessive settlement. Additionally, if existing trees are removed from an area, heave may occur due to the reallocation of moisture within the soil matrix.

6.0 References

1. "Method for Determining the Potential Vertical Rise, PVR," State Department of Highways and Public Transportation, Test Method Tex 124-E, Austin, Texas.
2. Committee Papers from Foundation Performance Association (FPA), see FPA Website: http://www.foundationperformance.org/committee_papers.cfm.
3. “Design of Post-Tensioned Slab-on-Ground”, Post-Tensioning Institute, Phoenix, Arizona, Third Edition, with 2008 Supplement, 2008.
4. “Construction and Maintenance Procedures Manual for Post-Tensioned Slabs-on-Ground”, 2nd Edition, Post-Tensioning Institute, Phoenix, Arizona, September 1998.
5. “Expansive Soils”, John D. Nelson and Debora J. Miller, John Wiley & Sons, Inc., 1992.

Illustrations



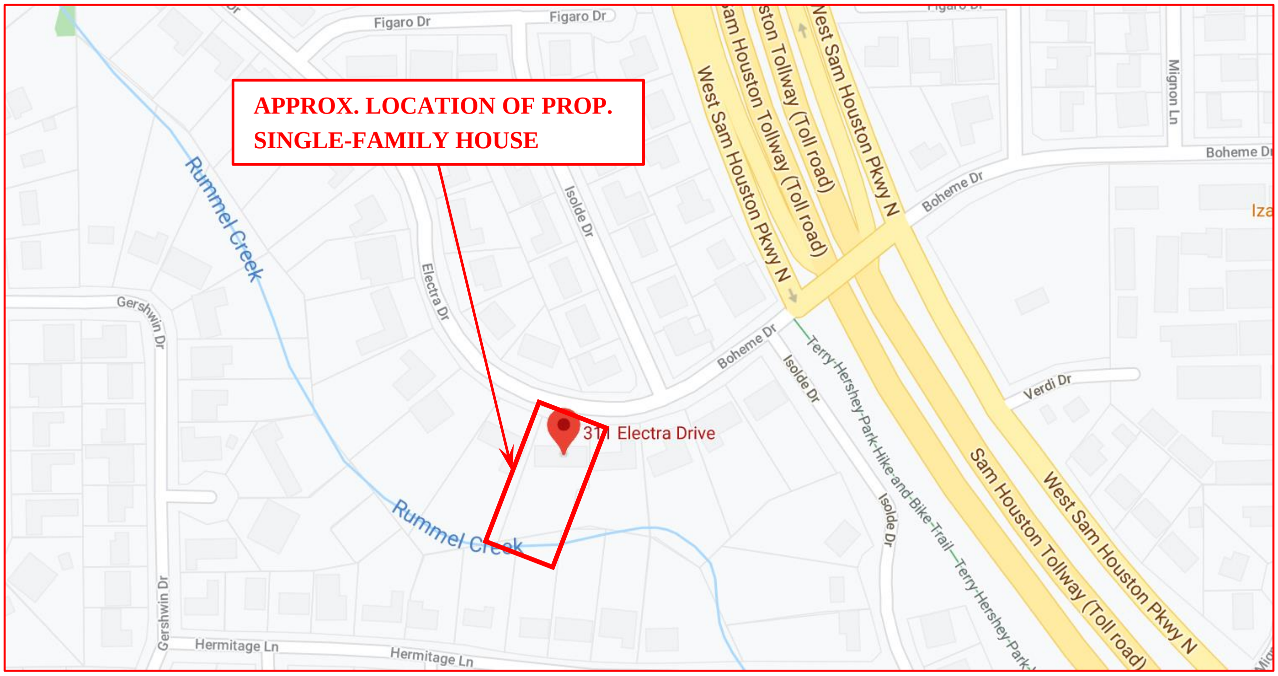


PLATE 1A: VICINITY MAP

PLATE 1B: ARIAL MAPS

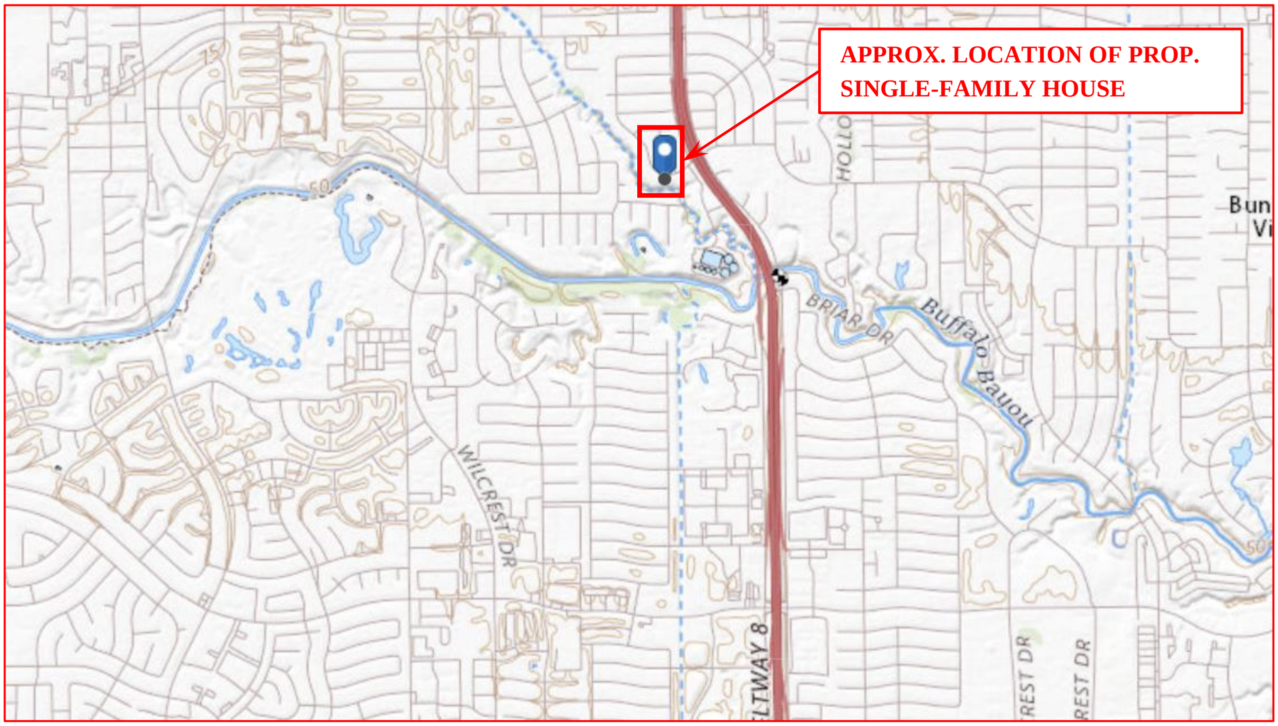
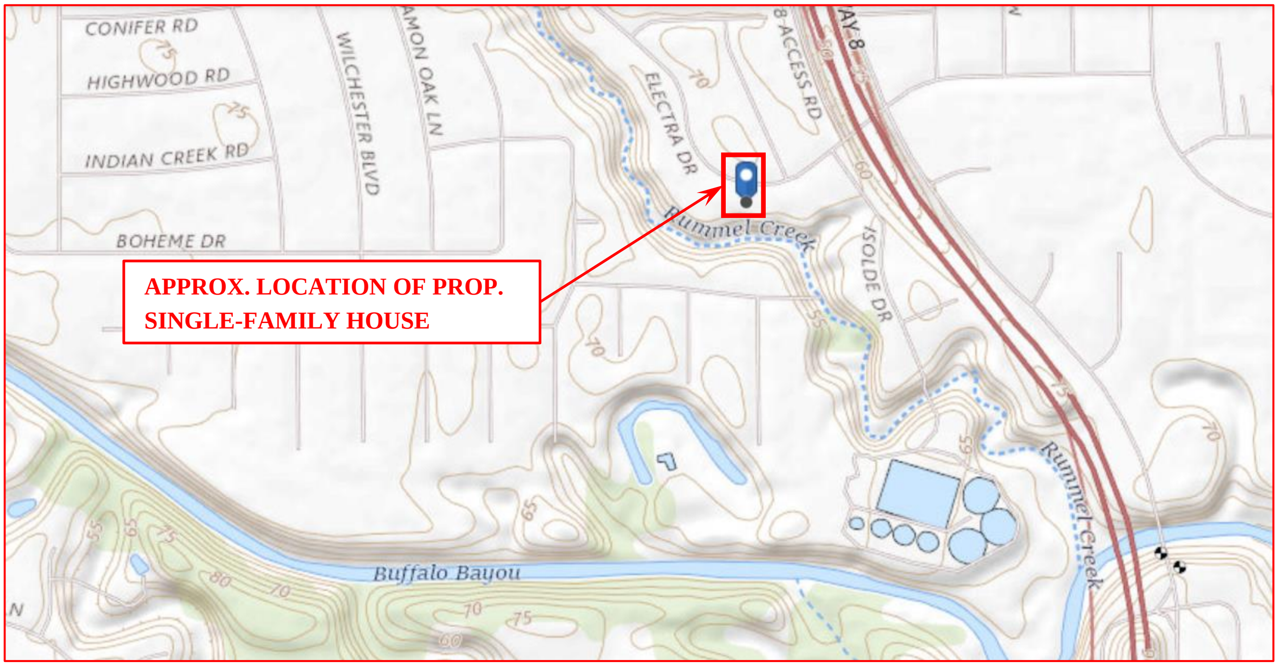


PLATE 1C.1: TOPOGRAPHIC MAP OF THE AREA IN GENERAL

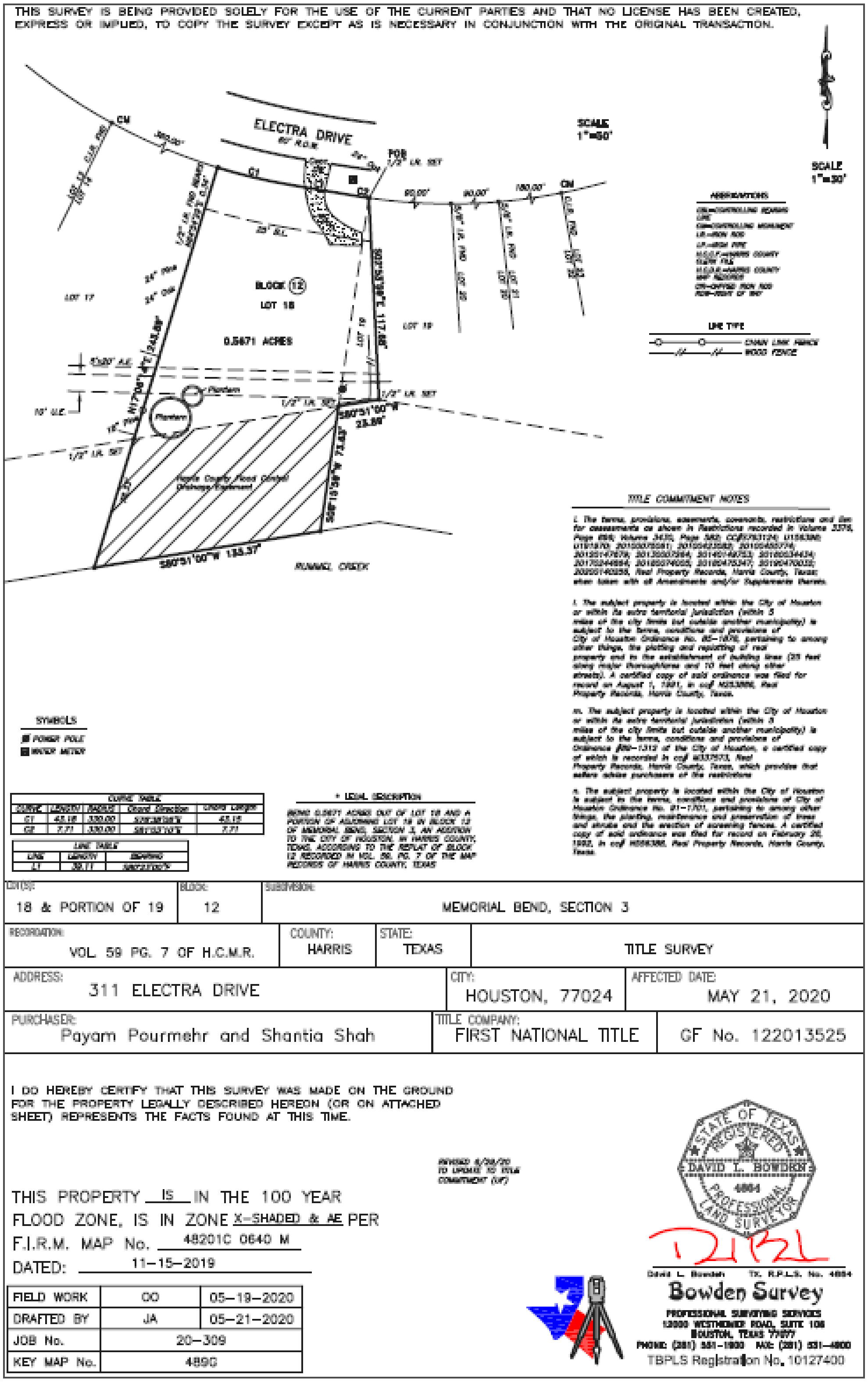
(SOURCE: USGS)



APPROX. LOCATION OF PROP. SINGLE-FAMILY HOUSE

<u>**PLATE 1C.2: TOPOGRAPHIC MAP OF THE SITE AND VICINITY**</u>

(SOURCE: USGS)



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LOT(S): 18 & PORTION OF 19

BLOCK: 12

SUBDIVISION: MEMORIAL BEND, SECTION 3

RECORDATION: VOL. 59 PG. 7 OF H.C.M.R.

COUNTY: HARRIS

STATE: TEXAS

TITLE SURVEY

ADDRESS: 311 ELECTRA DRIVE

CITY: HOUSTON, 77024

AFFECTED DATE: MAY 21, 2020

PURCHASER: Payam Pourmehr and Shantia Shah

TITLE COMPANY: FIRST NATIONAL TITLE

GF No. 122013525

I DO HEREBY CERTIFY THAT THIS SURVEY WAS MADE ON THE GROUND FOR THE PROPERTY LEGALLY DESCRIBED HEREON (OR ON ATTACHED SHEET) REPRESENTS THE FACTS FOUND AT THIS TIME.

REVISED 6/26/20 TO UPDATE TO TITLE COMMITMENT (UF)

THIS PROPERTY IS IN THE 100 YEAR FLOOD ZONE, IS IN ZONE X-SHADED & AE PER F.I.R.M. MAP No. 48201C 0640 M

DATED: 11-15-2019

FIELD WORK	OO	05-19-2020
DRAFTED BY	JA	05-21-2020
JOB No.	20-309	
KEY MAP No.	489G	

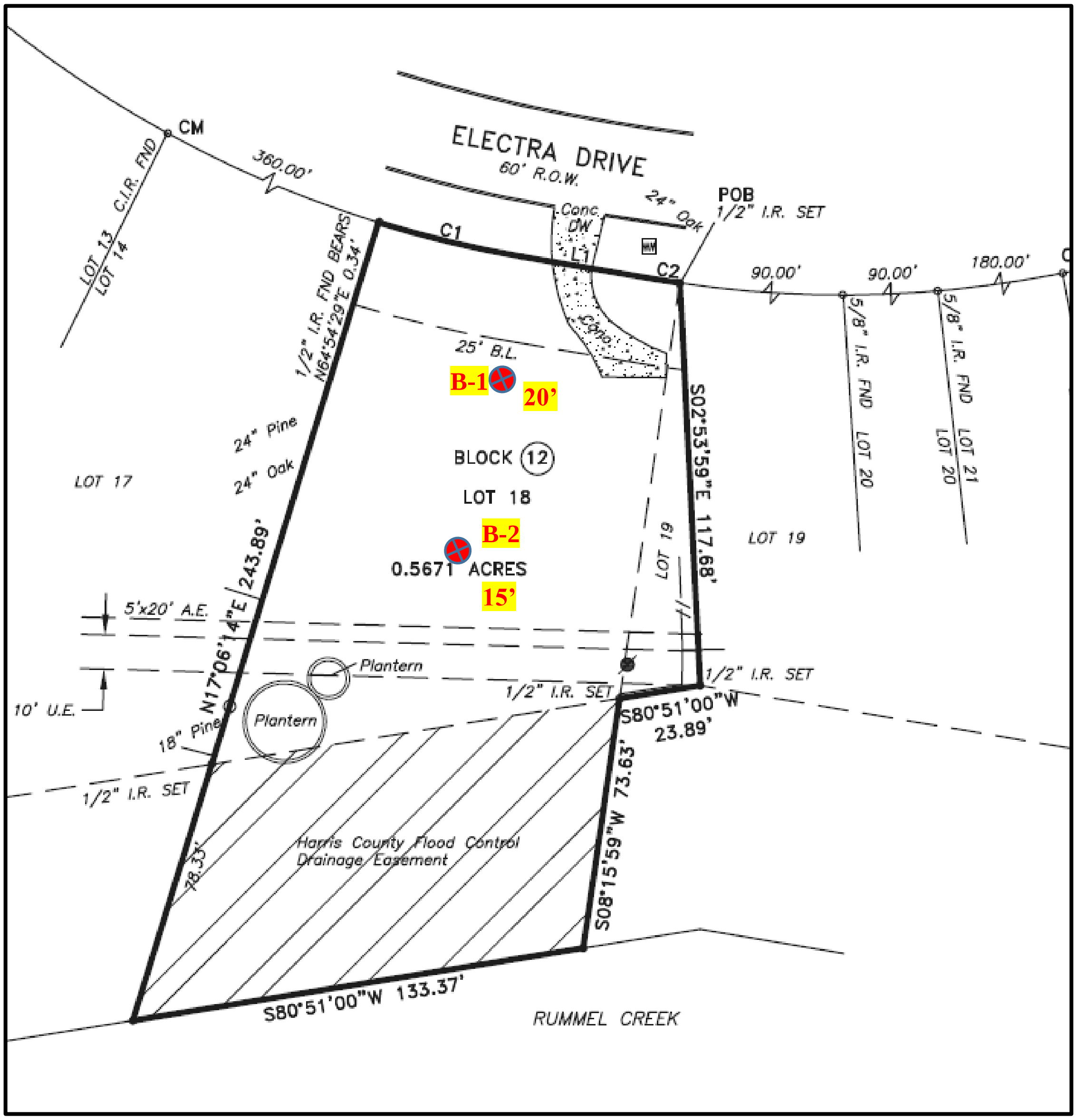
DAVID L. BOWDEN 4884

David L. Bowden TX. R.P.L.S. No. 4884

Bowden Survey

PROFESSIONAL SURVEYING SERVICES
12000 WESTHEIMER ROAD, SUITE 108
HOUSTON, TEXAS 77077
PHONE: (281) 531-1900 FAX: (281) 531-4800
TBPLS Registration No. 10127400

PLATE 1D.1: GENERAL SITE PLAN



⊗ **APPROXIMATE BORING LOCATIONS**

PLATE 1D.2: APPROXIMATE BORING LOCATIONS

Geotechnical Engineering Field Exploration & Boring Logs

Project: **Single-Family House**	Project Number: **PGH-20-0172**		Client: **Shree Homes**	Boring No. **B-1**
Address, City, State: **311 Electra Drive, Houston, TX 77024**			Drilling Contractor: **Ace GeoDrilling, Inc.**	Drill Rig Type: **Truck mounted Rig**
Logged By: **AGD**	Date	Started: **11-Sep-20**	Bit Type:	SPT Tube Diameter: **1.5"**
Drilling Crew: **AGD**		Completed: **11-Sep-20**	Hammer Type:	
Boring Method: **Auger**		Backfilled: **11-Sep-20**	Hammer Weight: **140 Lbs**	Hammer Drop: **30"**
Groundwater Depth: At time Drilling: **DRY**		At the end of Drilling: **DRY**	Ground Elevation: **Existing**	Total Depth of Boring: **20 Ft.**

Depth (feet)	Sample Type	Ground Water Table	Blow Counts (blows/foot), N	Graphic Log	**Lithology** **Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors **Rock Description:** modifierm color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.	Moisture Content (%)	Liquid Limit (LL)	Plasticity Index (PI)	Bulk Density (pcf)	Dry Density (pcf)	Pocket Penetrometer (TSF)	Unconfined Comp. (TSF)	Shear Strength (TSF)	#200 Sieve (%)
2	■		Auger	▩	Fill Materials: Light brown medium dense to dense Sandy Silt (MS) with root fibers.	9.7	NP	NP						
4	☒		32	▩		10.5								64.9
6	■			▨	Gray and light brown very stiff to hard Sandy Fat Clay (CH) with calcareous nodules.	11.5	50	31	129.5	116.2	4.50	4.55	2.28	
8	■			▨		13.8					4.50			77.8
10	■			▨		15.0	51	32	135.6	117.9	4.00	2.96	1.48	
12 14	■			▨	Tan and light brown very stiff Sandy Clay (CL) with calcareous nodules.	11.4					4.00			
16 18 20	☐ ☒		23	▨	Tan and brown medium dense Clayey Sand (SC).	9.9								46.6
22 24														

Notes: **Boring terminated at 20 feet**

Geotechnical Engineering - Field Exploration **Boring Log: Sheet 1 of 2**

- ☒ Standard Penetration Split Spoon Sampler (SPT)
- ☐ No Recovery
- ■ Shelby Tube
- ▼ Stablized Ground water
- ▽ Groundwater At time of Drilling
- ▨ Fat Clay
- ▨ Sandy (Lean) Clay
- ▨ Sandy Fat Clay
- ▥ Sandy Silt
- ▩ Top Soil & Fill materials
- ▩ Silty Sands
- ▨ Clayey Sands
- ▥ Clayey Sandy Silt

PLATE 2: BORING LOG B-1

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Geotechnical Engineering Field Exploration & Boring Logs

Project: **Single-Family House**	Project Number: **PGH-20-0172**	Client: **Shree Homes**	Boring No. **B-2**
Address, City, State: **311 Electra Drive, Houston, TX 77024**		Drilling Contractor: **Ace GeoDrilling, Inc.**	Drill Rig Type: **Truck mounted Rig**
Logged By: **AGD**	Date — Started: **11-Sep-20**	Bit Type:	SPT Tube Diameter: **1.5"**
Drilling Crew: **AGD**	Date — Completed: **11-Sep-20**	Hammer Type:	
Boring Method: **Auger**	Date — Backfilled: **11-Sep-20**	Hammer Weight: **140 Lbs**	Hammer Drop: **30"**
Groundwater Depth: At time Drilling: **DRY**	At the end of Drilling: **DRY**	Ground Elevation: **Existing**	Total Depth of Boring: **15 Ft.**

Depth (feet)	**Sample Type**	**Ground Water Table**	**Blow Counts (blows/foot), N**	**Graphic Log**	**Lithology** **Soil Group Name:** modifier, color, moisture, density/consistency, grain size, other descriptors **Rock Description:** modifierm color, hardness/degree of concentration, bedding and joint characteristics, solutions, void conditions.	**Moisture Content (%)**	**Liquid Limit (LL)**	**Plasticity Index (PI)**	**Bulk Density (pcf)**	**Dry Density (pcf)**	**Pocket Penetrometer (TSF)**	**Unconfined Comp. (TSF)**	**Shear Strength (TSF)**	**#200 Sieve (%)**
2	■		Auger	▩	Fill Materials: Light brown medium dense to dense Sandy Silt (MS) with root fibers.	10.1								66.8
4	☒		32	▩		10.4	NP	NP						
6	■			▨	Gray and light brown hard Sandy Fat Clay (CH) with calcareous nodules.	12.3					4.50			80.8
8	■			▨		14.6	51	32	137	119.5	4.50	4.94	2.47	
10	■			▨	Tan and light brown very stiff to hard Sandy Clay (CL) with calcareous nodules.	12.7					4.25			57.9
12 14	■			▨		13.8	42	24			4.50			
16 18 20														
22 24														

Notes: | **Boring terminated at 15 feet**

Geotechnical Engineering - Field Exploration

Boring Log: Sheet 2 of 2

- ☒ Standard Penetration Split Spoon Sampler (SPT)
- ☐ No Recovery
- ■ Shelby Tube
- ▼ Stabllized Ground water
- ▽ Groundwater At time of Drilling
- ▨ Fat Clay
- ▨ Sandy (Lean) Clay
- ▨ Sandy Fat Clay
- ▥ Sandy Silt
- ▩ Top Soil & Fill materials
- ▦ Silty Sands
- ▨ Clayey Sands
- ▥ Clayey Sandy Silt

PLATE 3: BORING LOG B-2

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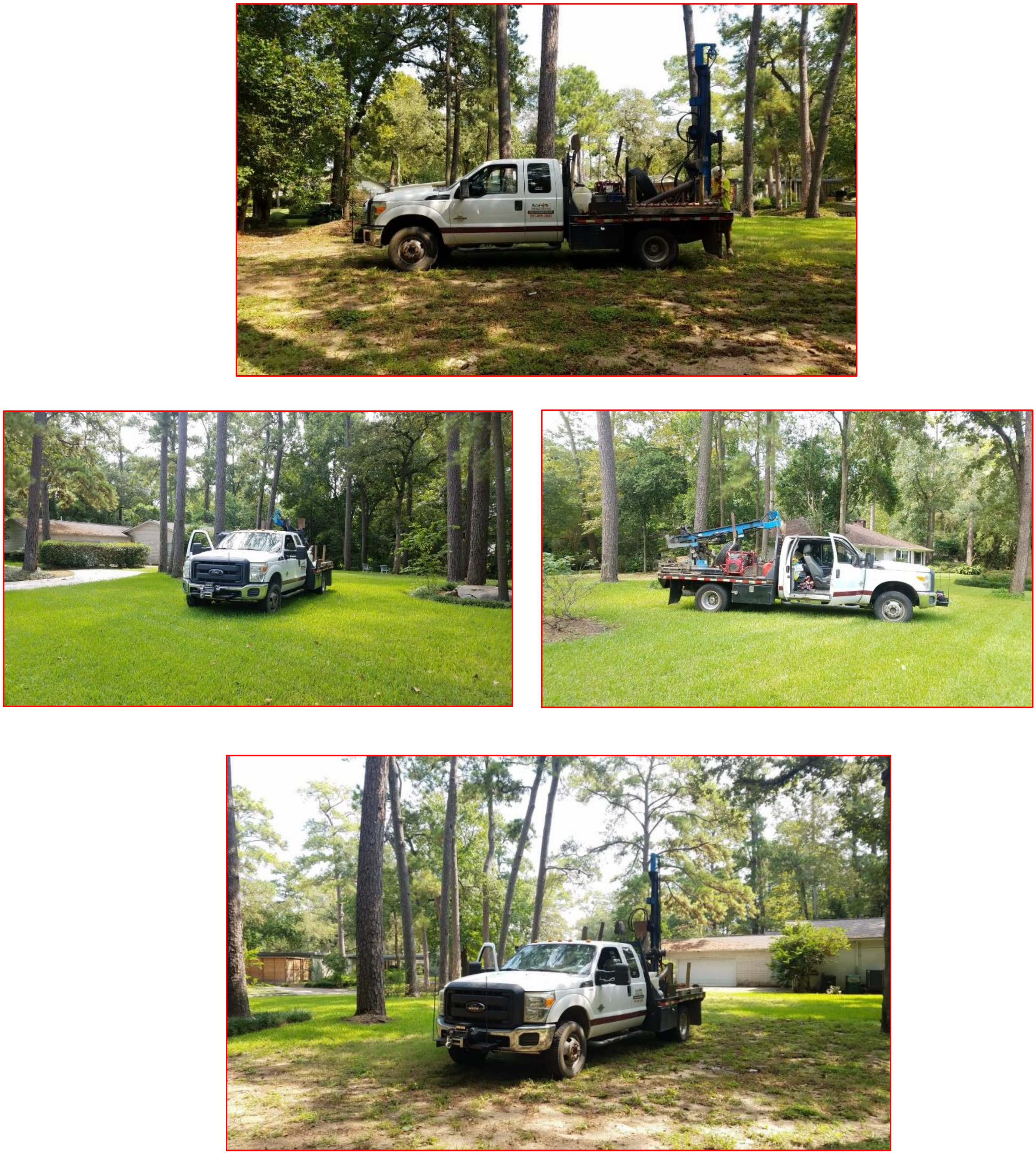

PLATE 4: SITE PICTURES