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April 9th, 2018

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Attn.: Mr. Barket Ali

Ref: Project # PGH-18-0117
Geotechnical Study
Proposed New Lawrence Grocery Store with Gas Station
902 East Bayshore Drive
San Leon, TX 77539

Dear Mr. Ali,

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,

Samuel Niyongabo
Graduate Engineer

STATE OF TEXAS
VIJAY K JHA
114340
LICENSED
PROFESSIONAL ENGINEER

April 9th, 2018

Vijay K Jha, PhD, PE, PMP
Principal Engineer

Geotechnical Engineering Report

Proposed New Lawrence Grocery Gas Station at 902 E. Bayshore Dr., San Leon, TX 77539.

Project No.: PGH-18-0117

Prepared by:
Quartet Engineers
1839 Harland Dr., Houston, TX 77055

Prepared for:
Lawrence Grocery

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4/9/2018

Table of Contents

1.0 Introduction

1.1 General

Quartet Engineers, PLLC has completed an initial geotechnical investigation for the construction of the proposed New Lawrence Grocery Gas Station to be located at 902 East Bayshore Dr., San Leon, Texas 77539. This study was authorized by Mr. Barket Ali with Lawrence Grocery. 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 building, canopy and parking pavement. As stated in our proposal authorized on March 8th, 2018, 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 and pavement.

1.3 Limitations

Our site exploration is based on 4 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, is located at 902 East Bayshore Dr., San Leon, TX 77539, as shown in plate 1D. The site is relatively level and covered with grass. The site geology for the geographic area corresponds to Beaumont Formation, Quaternary Period, and Holocene, Pleistocene Epoch or Series[1].

2.2 Field Investigation and Soil Stratigraphy

The objective of the field investigation, completed on March 16, 2018, was to determine the engineering characteristics of the subsurface materials included a reconnaissance of the project site,

[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 through 6.

Subsurface conditions at the proposed site were examined with the help of four (4) exploratory borings B-1 through B-4 indicated on the plan shown in Plate 1D. Boring locations and depths were approved by the Client. Boring B-1 and B-2 were drilled to a depth of 20 feet, B-3 drilled to a depth of 15 feet, and B-4 was drilled to a depth of 5 feet below the existing grade. 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 D-1586. The recovered 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 three general strata with their thickness and general characteristics as shown in the Table 2.1.

Table 2.1: General soil strata at the project site.

Stratum	Boring No.	Thickness (ft.)	Soil Description
I	B-1 through B-4	0 – 2	Top Soils: Light gray and brown Clayey Sand with root fibers.
II	B-1	2 – 10	Light gray and brown stiff to very stiff **Clay (CH)*** with sand, calcareous and ferrous nodules.
	B-2 through B-4	2 – 20	Light gray, tan and brown stiff to very stiff **Sandy Clay (CL)*** with sand, calcareous and ferrous nodules. B-3: 2’ to 15’ and B-4: 2’ to 5’.
III	B-1	10 – 20	Tan **Sandy Clay (CL)*.**

* Classification is in accordance with the Unified Soil Classification System

2.3 Water-Table Location

Groundwater was not encountered during drilling operation. 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	12	11	
B-2	20	14	12	
B-3	15	12	11	
B-4	5	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	23
Plasticity Index	ASTM D4318	4
Unit Weight	-	1
Particle Finer Than No. 200	ASTM D1140	4
Unconfined Compressive Strength	ASTM 2166	1

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 **1.90in**.

3.8 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 either underreamed drilled Pier or shallow footing is considered suitable foundation systems.

4.1 Underreamed Footings (Drilled Piers)

4.1.1 Bearing Capacity:

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 **eleven (11)** 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 where buildings are located may be sized for an estimated net allowable bearing pressure of **3000psf and 4500psf** 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. If 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 1.0tsf 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 ≤ 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.

4.2 Continuous/ Spread Footing

A continuous or spread footing type of foundation may be selected if a relatively lighter load is anticipated from the super structure. The net allowable bearing capacity of the footing are evaluated to be 2100psf & 3150psf for dead plus sustained live and total loads, respectively. The minimum depth at which the footing base is located should at least 3ft below the existing grade.

The values of factor of safety (FS) should be equal to 3.0 and 2.0 with respect to shearing failure for dead and total load respectively. The above-mentioned equation can also be used to evaluate the bearing capacity of the soil where the canopy and car wash structures are located. The ground floor slab should be supported partly on ground and partly on the grid beams connecting the isolated footings.

The resistance to lateral load acting on the footing may be resisted by the soil friction acting on the base of the foundation and passive earth pressure. With a factor of safety of 2, the frictional resistance of 300psf may be used. Similarly, a value of 500psf per feet of foundation depth should be considered for the passive resistance of the natural soil or compacted fill material. This value may be increased by one third for wind loading.

The ultimate uplift capacity of an isolated footing may be evaluated by adding the weight of the concrete footing to the weight of the soil wedge. For estimating the weight of the soil wedge, a value of 60pcf may be used for the submerged unit weight of the soil. Similarly, we recommend that a buoyant unit weight of 90pcf be used for concrete to calculate the weight of the footing. The ultimate uplift capacity so obtained should be reduced by a factor of safety of 1.5.

5.0 Pavement Recommendation

5.1 Pavement Design Parameters

The design of pavement largely depends on the subgrade material, anticipated traffic measured in terms of magnitude of axle load and number of repetitions, and type of pavement. As stated earlier, the upper surface of the project site predominantly consists of clayey sands with fiber roots. Based on stratigraphic information as described earlier, a general subgrade can be assumed to exist and extends to a depth of about 3 ft. throughout the project site.

Traffic data required for the design of the pavements at this site was not available to us. However, based on the location of the project site, we can suitably assume the pertinent design data. A gas station like Lawrence Grocery Gas Station normally receives lightly-loaded automobiles and trucks. Occasionally, the pavement at a gas station receives, especially at entrance/exit and dumpster areas, heavily-loaded trucks and fuel tankers, albeit the frequency of such vehicles are much lower as compared to the lightly loaded vehicles. Based on this notion, an equivalent single axle load (EASL) of 18000 Lbs. and 60,000 Lbs. for designing the pavement under consideration subject to light and heavy-duty traffic, respectively, can be assumed. Similarly, California Bearing Ratio (CBR) of 4 can be assigned to evaluate the base and subgrade components of the pavement.

The surface soil encountered at the project site is predominately clayey sand with root fibers, which may not be suitable subgrade material to withstand the anticipated traffic loading due to the presence of roots. A lime stabilization is recommended to increase the mechanical strength of this type of soil.

Since sandy clay were encountered in surface, we recommend that the subgrade be stabilized with lime. The upper six- (6) inches of the subgrade in the light traffic area and eight (8) inches in the medium and heavy traffic area should be stabilized with in accordance with TxDOT 2004 Specification Item 260.

The upper six- (6) inches of the subgrade in the light traffic area and eight (8) inches in the medium and heavy traffic area should be stabilized with **4% lime** by dry weight in accordance with TxDOT 2004 Specification Item 260. By this application rate, approximately **24 pounds** of lime per square yard would be required for 6” depth of pavement subgrade. For 8” thick subgrade, the corresponding quantity for lime would be **32 pounds** per square yard. However, it is recommended that more

accurate percentage of lime should be determined by running a lime series test at the time of construction.

The mixing procedure should be in accordance with TxDOT 2004 Standard Specifications Item 265. However, the actual amount of lime to treat the subgrade should be decided based on the lime series test during construction. It should be noted that a more accurate quantity estimation is a subject of running laboratory tests on samples from the job sites.

On a finished subgrade, either a flexible (Asphaltic concrete) or rigid (Reinforced Cement Concrete) pavement can be constructed. The choice between these two types of pavement depends on the initial and maintenance costs. For concrete pavement, the initial cost of construction is high as compared to its flexible one but requires less maintenance cost throughout its design life. Based on the anticipated design life and traffic data presented above, we recommend thickness of the flexible and rigid pavement as shown in Tables 5.1 and 5.2, respectively.

Table 5.1: Recommended Thickness (in.) for Flexible Pavement

Layer	Parking lots	Light to Medium Duty Areas
Asphaltic concrete	1.5	2
Base material	8	8
Subgrade	8	8

Table 5.2: Recommended Thickness (in.) for Rigid Pavement

Layer	Parking lots	Light to Medium Duty Areas
Reinforced Concrete	5	6
Subgrade	6	8

Reinforced cement concrete pavement will be subject to a concentrated load at the dumpster wheel which may result in the rutting of the pavement. To avoid such distress, a minimum thickness of 7 in. is recommended in the area where dumpster is planned to be located.

5.2 Pavement Materials

Base Material: The base material for flexible pavement should be crushed limestone of Type "A" or "D" and Grade "1" or "2" and should confirm to Item 247, TX DOT Standard Specification. Crushed limestone should be placed in loose lifts of 8in. and compacted to a minimum of 95% of the maximum dry density with optimum moisture content varying in the rage of ± 2% in accordance with the procedure described in ASTM D1557.

Hot Mix Asphaltic Concrete (HMAC) Surface Course: A type "D" HMAC should be used as a surface course material and should be in compliance with Item 340 of TX DOT Standard Specifications. The asphaltic concrete should be compacted to a minimum of 92% of the maximum theoretical rice specific gravity of the mixture obtained according to the test method Tex-227-F.

Subgrade: In this project, it is recommended that the subgrade of the pavement area should be treated with lime in accordance with the procedure of Item 265 of the TXDOT standard specifications to improve its mechanical strength. For this purpose, we recommend 7% hydrated lime by dry weight. The lime treated subgrade should be compacted to a minimum of 95% of the maximum dry density as determined by ASTM D698 and it should have moisture content in the range 0-3% of the optimum value. Such subgrade should be moist cured a minimum of 3-day before the laying of the pavement.

Cement Concrete: The cement concrete used for pavement should have a minimum compressive strength of 3000 psi at 28 days, which corresponds to a flexural strength of 570 psi at 28 days. Similarly, it should have percentage of entrained air in the range of 3-5% with a maximum slump value of 5in. Use of liquid membrane-forming compound is recommended to help reduce the shrinkage cracking of the concrete. The minimum thickness of concrete for different locations is shown in Table 5.2.

Table 5.3: Bar Size and Spacing for Reinforcing Steel

Thickness (in.)	Size	Spacing (in.) in both direction and on-center
5	#3	18
6	#3	12
7	#4	18

Table 5.4: Control joint spacing

Thickness (in.)	Maximum Spacing (in.)
5	12
6	15
7	15

Structural Steel: The steel used for reinforcement should be minimum of grade 60. Depending upon the thickness of the pavement, it should be reinforced with either #3 or #4 bars with minimum on-center spacing given in Table 5.3. In any case, the longitudinal and transverse joint spacing for concrete pavement should not be less than 12 in, Table 5.3. Dowel bars should be used to transfer loads at the transverse joints; size and embedment length of dowel are presented in Table 5.5.

Table 5.5: Dowels at Expansion Joints

Pavement Thickness (in.)	Diameter (in.)	Length (in.)	Embedment (in.)
5	5/8	12	5
6	3/4	14	6
7	7/8	14	6

6.0 Construction Considerations

6.1 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.

6.2 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.

6.3 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 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

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.

6.4 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.

6.5 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.

6.6 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.

7.0 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

Descriptions	**Plate No.**
Vicinity Map	Plate 1A
Aerial Map	Plate 1B
Topographic Map	Plate 1C
Approximate Boring Locations	Plate 1D
Boring Logs	Plate 2-4
Project Site Pictures	Plate 5

PLATE 1A: VICINITY MAP

PLATE 1B: ARIAL MAPS

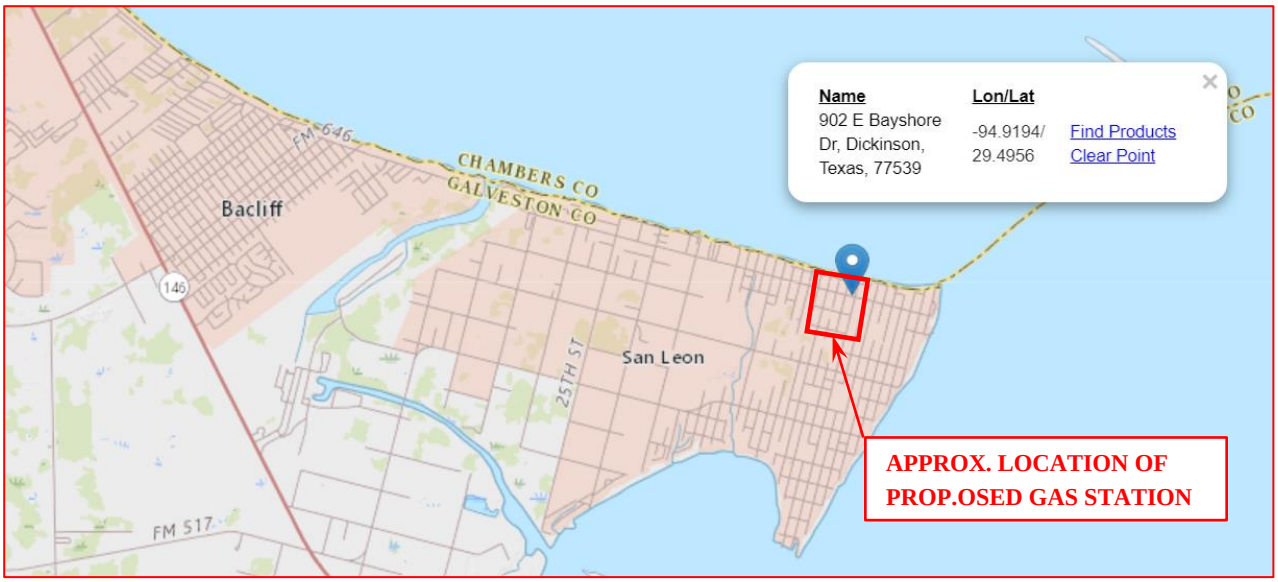


PLATE 1C.1: TOPOGRAPHIC MAP OF THE AREA IN GENERAL

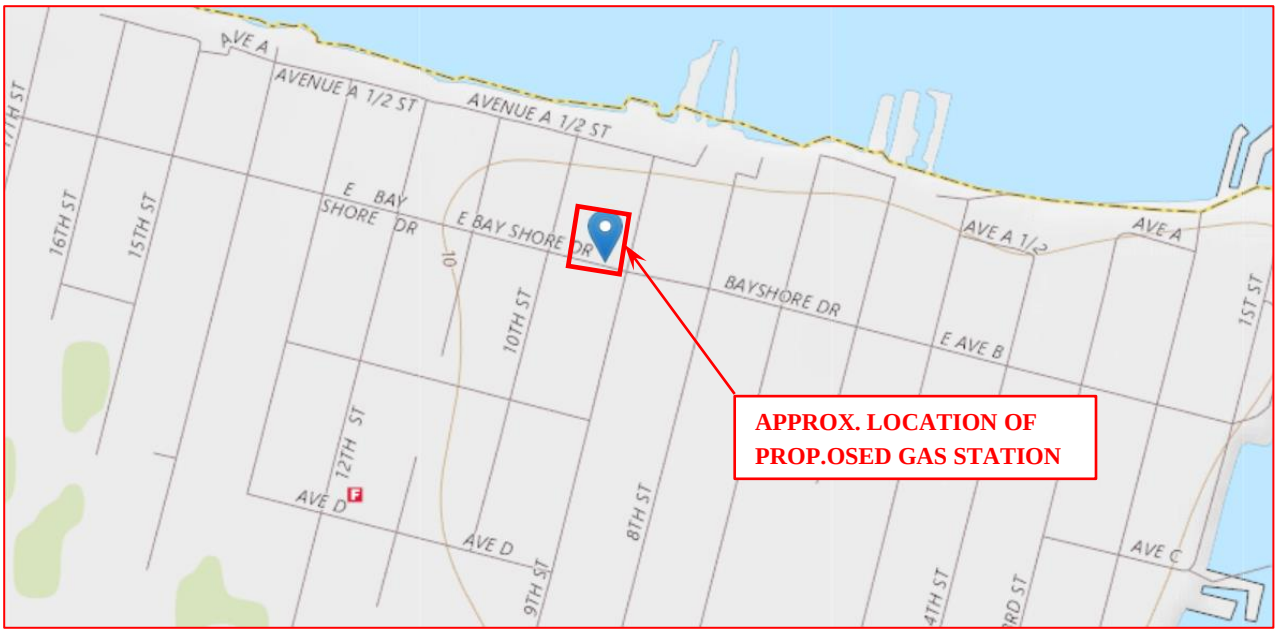
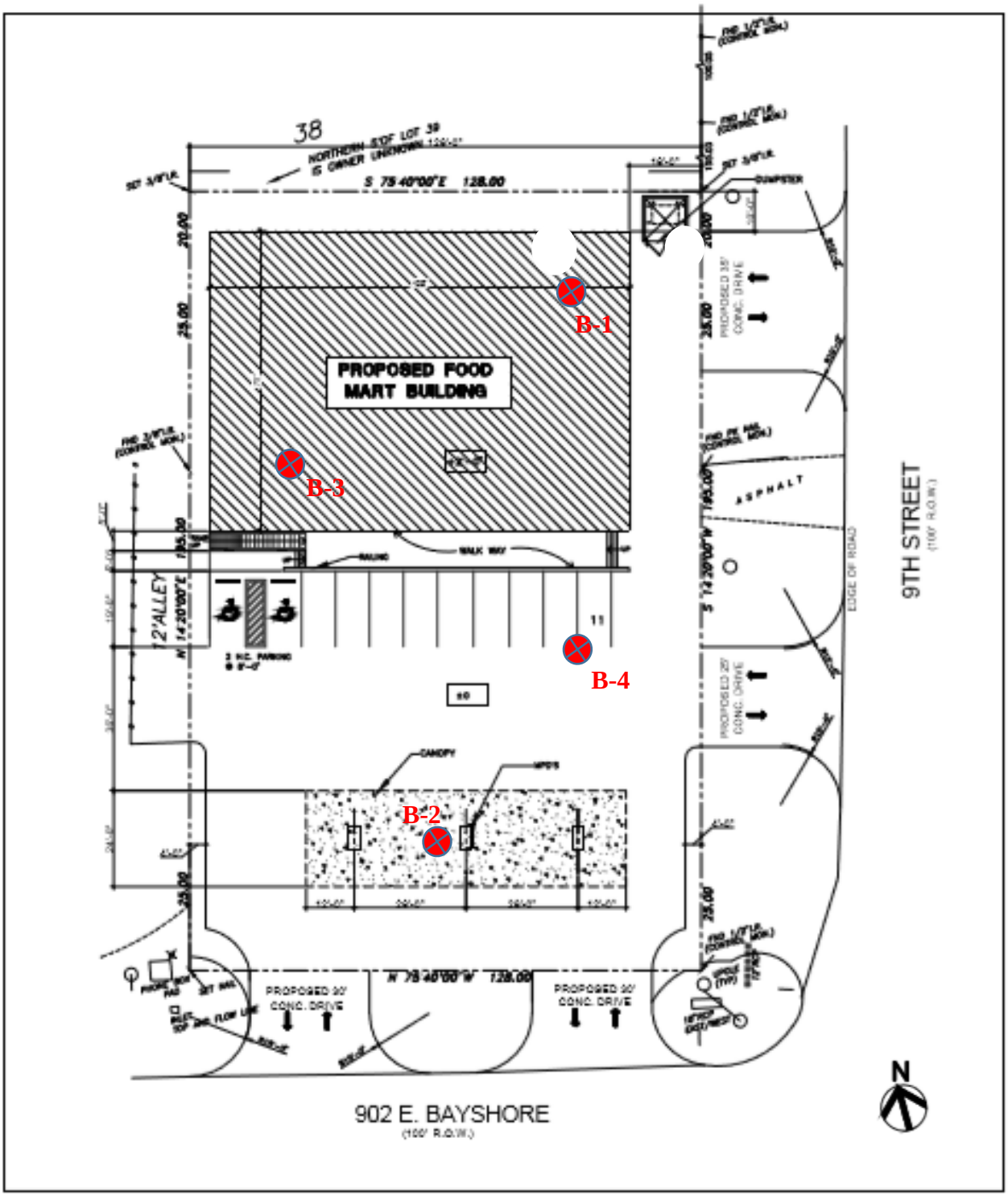


PLATE 1C.2: TOPOGRAPHIC MAP OF THE SITE AND VICINITY



APPROXIMATE BORING LOCATIONS

PLATE 1D: APPROXIMATE BORING LOCATIONS

Geotechnical Engineering Field Exploration & Boring Log

Project: **Lawrence Grocery Gas Station**	Project Number: **PGH-18-0117**	Client: **Lawrence Grocery**	Boring No. **B-1**
Address, City, State: **902 East Bayshore Dr., San Leon, TX 77539**		Drilling Contractor: **SJ Knight Drilling**	Drill Rig Type: **Truck mounted Rig**
Logged By: **SJ Knight Drilling**	Date — Started: **16-Mar-18**	Bit Type:	SPT Tube Diameter: **1.5"**
Drilling Crew: **SJ Knight Drilling**	Date — Completed: **16-Mar-18**	Hammer Type:	
Boring Method: **Auger**	Date — Backfilled: **16-Mar-18**	Hammer Weight: **140 Lbs**	Hammer Drop: **30"**
Groundwater Depth: At time Drilling: **12 ft.**	At the end of Drilling: **11 ft.**	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 (%)
					Top Soils: Light gray and brown Clayey Sand with root fibers.	13.6								
2														
						23.8					2.50			
4														
					Light gary and brown, stiff to very stiif Clay (CH) with sand, calcareous and ferrous nodules.	21.5	52	33			3.00			87.7
6														
						20.6					4.00			
8														
						22.7					4.00			
10														
12						26.7								
14														
16					Tan Sandy Clay.									
18						32.5								
20														
22														
24														

Notes: **Boring terminated at 20 feet**

Geotechnical Engineering - Field Exploration

Boring Log: Sheet 1 of 4

Standard Penetration Split Spoon Sampler (SPT)
No Recovery
Shelby Tube
Stabllized Ground water
Groundwater At time of Drilling
Fat Clay
Sandy (Lean) Clay
Sands
Silt
Top Soil & Fill materials
Silty Sands
Clayey Sands

PLATE 2: BORING LOG B-1

Form GT-16-001, Rev. 0, Sep 01, 2016

Geotechnical Engineering Field Exploration & Boring Log

Project: **Lawrence Grocery Gas Station**	Project Number: **PGH-18-0117**	Client: **Lawrence Grocery**	Boring No. **B-2**
Address, City, State: **902 East Bayshore Dr., San Leon, TX 77539**		Drilling Contractor: **SJ Knight Drilling**	Drill Rig Type: **Truck mounted Rig**
Logged By: **SJ Knight Drilling**	Date — Started: **16-Mar-18**	Bit Type:	SPT Tube Diameter: **1.5"**
Drilling Crew: **SJ Knight Drilling**	Date — Completed: **16-Mar-18**	Hammer Type:	
Boring Method: **Auger**	Date — Backfilled: **16-Mar-18**	Hammer Weight: **140 Lbs**	Hammer Drop: **30"**
Groundwater Depth: At time Drilling: **14 ft.**	At the end of Drilling: **12 ft.**	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 (%)
					Top Soils: Light gray and brown Clayey Sand with root fibers	18.9								
2														
						21.3					2.50			
4														
						21.1					3.00			
6					Light gary and brown, stiff to very stiif Sandy Clay (CL) with sand, calcareous and ferrous nodules.									
						20.7	41	24			3.50			79.8
8														
						23.0			128.6	104.6	4.00	2.00	1.00	
10														
12						27.0								
14														
16					Tan Sandy Clay.									
18						29.7								
20														
22														
24														

Notes: **Boring terminated at 20 feet**

Geotechnical Engineering - Field Exploration

Boring Log: Sheet 2 of 4

Standard Penetration Split Spoon Sampler (SPT)
No Recovery
Shelby Tube
Stabllized Ground water
Groundwater At time of Drilling
Fat Clay
Sandy (Lean) Clay
Sands
Silt
Top Soil & Fill materials
Silty Sands
Clayey Sands

PLATE 3: BORING LOG B-2

Geotechnical Engineering Field Exploration & Boring Log

Project: **Lawrence Grocery Gas Station**	Project Number: **PGH-18-0117**	Client: **Lawrence Grocery**	Boring No. **B-2**
Address, City, State: **902 East Bayshore Dr., San Leon, TX 77539**		Drilling Contractor: **SJ Knight Drilling**	Drill Rig Type: **Truck mounted Rig**
Logged By: **SJ Knight Drilling**	Date — Started: **16-Mar-18**	Bit Type:	SPT Tube Diameter: **1.5"**
Drilling Crew: **SJ Knight Drilling**	Date — Completed: **16-Mar-18**	Hammer Type:	
Boring Method: **Auger**	Date — Backfilled: **16-Mar-18**	Hammer Weight: **140 Lbs**	Hammer Drop: **30"**
Groundwater Depth: At time Drilling: **12 ft.**	At the end of Drilling: **11 ft.**	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 (%)
					Top Soils: Light gray and brown Clayey Sand with root fibers	20.1								
2														
						28.0					2.50			
4														
					Light gary and brown stiff to very stiif Sandy Clay (CL) with sand, calcareous and ferrous nodules.	21.4					3.00			
6														
						16.6					3.00			
8														
						22.3	35	19			3.50			80.2
10														
					Tan Sandy Clay.	28.3								
12														
14														
16														
18														
20														
22														
24														

Notes: **Boring terminated at 15 feet**

Geotechnical Engineering - Field Exploration

Boring Log: Sheet 3 of 4

Standard Penetration Split Spoon Sampler (SPT)
No Recovery
Shelby Tube
Stabllized Ground water
Groundwater At time of Drilling
Fat Clay
Sandy (Lean) Clay
Sands
Silt
Top Soil & Fill materials
Silty Sands
Clayey Sands

PLATE 4: BORING LOG B-3

Geotechnical Engineering Field Exploration & Boring Log

Project: **Lawrence Grocery Gas Station**	Project Number: **PGH-18-0117**	Client: **Lawrence Grocery**	Boring No. **B-4**
Address, City, State: **902 East Bayshore Dr., San Leon, TX 77539**		Drilling Contractor: **SJ Knight Drilling**	Drill Rig Type: **Truck mounted Rig**
Logged By: **SJ Knight Drilling**	Date — Started: **16-Mar-18**	Bit Type:	SPT Tube Diameter: **1.5"**
Drill Crew: **SJ Knight Drilling**	Date — Completed: **16-Mar-18**	Hammer Type:	
Boring Method: **Auger**	Date — Backfilled: **16-Mar-18**	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: **5 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 (%)
					Top Soils: Light gray and brown Clayey Sand with root fibers.	16.5								
2					Light gary and brown very stiif Sandy Clay (CL) with sand, calcareous and ferrous nodules.	21.3								
4						25.5	38	21			4.00			81.4
														Boring terminated at 5 feet
6														
8														
10														
12														
14														
16														
18														
20														
22														
24														

Note:

Geotechnical Engineering - Field Exploration

Boring Log: Sheet 4 of 4

Standard Penetration Split Spoon Sampler (SPT)
No Recovery
Shelby Tube
Stabllized Ground water
Groundwater At time of Drilling
Fat Clay
Sandy (Lean) Clay
Sands
Silt
Top Soil & Fill materials
Silty Sands
Clayey Sands

PLATE 5: BORING LOG B-4

PLATE 5: SITE PICTURES