City of Conroe
PO Box 3066
Conroe, Texas 77305

ADDENDUM NO. 1

DATE ISSUED: July 7, 2020

PROJECT NAME: 0716-2020 Fire Department Metal Building

This revision shall be considered part of the contract documents for the above named project and shall be incorporated integrally with the previously issued documents. Wherein provisions of the revisions differ from the provisions of the original documents and/or the provisions of previously issued addendum, the provisions of this revision shall govern and take precedence.

The Geotechnical Soil report is attached.

By the signature affixed below, Addendum No. 1 is hereby incorporated into and made a part of the above referenced solicitation.

ACKNOWLEDGED

____

Authorized Signature

____

Printed Name

____

Respondent/Contractor

____

Date

Kristina Colville

Kristina Colville, Purchasing manager

Geotechnical Engineering Report

Conroe Fire Station No. 7 and Fire Training Facility

Conroe, Texas

July 13, 2016

Terracon Project No. 97165065

Prepared for:

PGAL

Houston, Texas

Prepared by:

Terracon Consultants, Inc.

Conroe, Texas

July 13, 2016

PGAL
3131 Briarpark, Suite 200
Houston, Texas 77042

Attn: Mr. Jeff Gerber, AIA
Chief Executive Officer
P: 713.622.1444
E: JPGerber@pgal.com

Re: Geotechnical Engineering Report
Conroe Fire Station No. 7 and Fire Training Facility
Conroe, Texas
Terracon Project No. 97165065

Dear Mr. Gerber:

Terracon Consultants, Inc. (Terracon) is pleased to submit our Geotechnical Engineering Report for the project referenced above in Conroe, Texas. We trust that this report is responsive to your project needs. Please contact us if you have any questions or if we can be of further assistance.

We appreciate the opportunity to work with you on this project and look forward to providing additional Geotechnical Engineering and Construction Materials Testing services in the future.

Sincerely,
Terracon Consultants, Inc.
(Texas Firm Registration No.: F-3272)

Sureel S. Saraf, Ph.D.
Staff Geotechnical Engineer

Bobbie Sue Hood, P.E.
Geotechnical Services Manager

Enclosures

Copies Submitted: (1) Electronic

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EXECUTIVE SUMMARY

This geotechnical engineering report has been prepared for the proposed construction of: (a) A single-story, steel or wood-frame building with brick veneer exterior walls for the Conroe Fire Station No. 7 at League Line Road and Longmire Road in Conroe, Texas; and (b) A six level cast-in-place concrete building for a Fire Training Facility at the intersection of F.M. 3083 and F.M. 1484 in Conroe, Texas.

Two test borings, designated B-1a and B-2a were drilled to depths of about 20 feet below existing grade (grade at the time of our field program) within the proposed building area; and two test borings, designated B-3a and B-4a were drilled to depths of about 6 feet below existing grade within the proposed paving area, at the Conroe Fire Station No. 7 location. Additionally, two test borings, designated B-1b and B-2b were drilled to depths of about 30 feet below existing grade at the proposed Conroe Fire Training Facility location.

Based on the information obtained from our subsurface exploration, the site can be developed for the proposed project. A summary of our findings and recommendations is listed below.

- Soils at the Fire Station No. 7 site generally included silty sand from the surface to depths that ranged from about 2 to 6 feet below existing grade. Underlying soil includes clayey sand to depths of about 10 feet, followed by silty sands with varying amounts of fine gravel.
- Soils at the Fire Training Facility site included silty sand from the surface to depths of about 2 feet below existing grade in Boring B-2b. Underlying soils and soils from the surface in Boring B-1b included sandy silty clay to depths of about 6 to 8 feet, followed by poorly graded sand with silt, gravel, and clay seams to the boring termination depth of 30 feet below existing grade.
- Groundwater was observed at the Fire Station No. 7 in Boring B-1a and B-2a, at depths of about 13 feet, during drilling, and was observed at a depth of about 12½ feet after a 5- to 15-minute observation period at both Boring B-1a and B-2a. Groundwater was not observed in Borings B-3a and B-4a, during or on completion of drilling.
- Groundwater was observed at the Fire Training Facility in Boring B-1b and B-2b, at depths of about 8 feet and 11 feet respectively, during drilling, and was observed at a depth of about 7½ to 7 feet after a 5- to 15-minute observation period at both Boring B-1b and B-2b. All groundwater level measurements are included in Section **3.3 Groundwater** and are shown on the boring logs.
- The surficial soils at this site will become weak with elevated moisture contents and present construction difficulties. In addition, at the time of our field activities, some of the upper soils were relatively weak. If the subgrade is wet and/or soft at the time of construction, remedial efforts may be necessary for preparation of the surficial soils to

create a working surface. Remedial efforts are discussed in Section **4.2.3 Wet Weather/Soft Subgrade Considerations**.

- A shallow spread/strip footing foundation system would be appropriate to support the structural loads of both the proposed buildings, provided the subgrade is prepared as discussed in this report. Spread footings should be founded at least 2 feet below final grade for the Fire Station No. 7 building and at least 6 feet below existing grade for the Fire Training Facility building. Recommendations for design and construction of spread/strip footings are provided in Section **4.3.2 Design Recommendations – Shallow Spread/Strip Footings**.

- A minimum 12-inch thick select fill building pad should be constructed below the grade supported floor slabs to provide a working surface and to provide uniform support to the floor slabs.

- Flexible pavement sections vary from 2.0 to 2.5 inches of asphaltic concrete over 8.0 to 10.0 inches of base material with chemically treated subgrade.

- Rigid pavement sections vary from 5.0 to 7.0 inches of reinforced concrete with chemically treated subgrade.

This summary should be used in conjunction with the entire report for design purposes. Details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. Section **5.0 GENERAL COMMENTS** should be read for an understanding of the report limitations.

GEOTECHNICAL ENGINEERING REPORT
CONROE FIRE STATION NO. 7 AND FIRE TRAINING FACILITY
CONROE, TEXAS

Project No. 97165065
July 13, 2016

1.0 INTRODUCTION

Terracon is pleased to submit our geotechnical engineering report for the proposed Conroe Fire Station No. 7 and Fire Training Facility in Conroe, Texas. This project was authorized by Mr. Jeff Gerber, AIA, Chief Executive Officer with PGAL, through City of Conroe Purchase Order No. 16-00985, dated June 3, 3016. The project scope was performed in general accordance with Terracon Proposal No. P97165065, dated June 1, 2016.

The purpose of this report is to describe the subsurface conditions observed at the six test borings drilled for the two project locations, analyze and evaluate the test data, and provide recommendations with respect to:

- Site and subgrade preparation;
- Foundation design and construction; and
- Pavement thickness and design guidelines.

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Project Location	■ Fire Station No. 7 - southwest quadrant of the intersection of League Line Road and Longmire Road in Conroe, Texas. ■ Fire Training Facility - southwest quadrant of the intersection of FM 3083 and FM 1484 in Conroe, Texas. See Appendix A, Exhibit A-1, Site Location Plan.
Site Layout	See Appendix A, Exhibit A-2a and Exhibit A-2b, Boring Location Plans.

Item	Description
Proposed Improvements[1]	■ Fire Station No. 7 – one to one and one-half-story, steel or wood-frame building with brick veneer exterior walls, with a footprint of approximately 11,000 square feet. ■ Fire Training Facility – six level cast-in-place concrete building, with a footprint of about 1,800 square feet.
Planned Foundation Systems	Shallow spread and strip footings with grade supported slabs.
Finished Floor Elevation (Assumed)	Within 3 feet of existing grade.
Maximum Loads[1,2]	■ Fire Station No. 7: Columns: Total Load - 75 kips Walls: Total Load - 5 klf ■ Fire Training Building: Columns: Dead Load - 240 kips Total Load - 300 kips Walls: Dead Load - 19 klf Total Load - 23 klf

1. Based on information provided by the client.
2. Loads for Fire Station were estimated. Loads for Fire Training Building provided by the client.

2.2 Site Description

Item	Description
Existing Improvements	None observed in the area of the proposed improvements.
Current Ground Cover	Both sites are heavily wooded.
Existing Topography	■ Fire Station No. 7 – ground surface appears to slope down toward the south and east with approximately 4 feet of fall across the site. ■ Fire Training Facility – ground surface appears to slope down toward the south with approximately 4 feet of fall across the site.

1. Based on a review of Google Earth images.

3.0 SUBSURFACE CONDITIONS

3.1 Geology

Based on the geologic maps published by the Bureau of Economics Geology, the Conroe Fire Station No. 7 and the Fire Training Facility sites are located on the Willis Formation. The Willis formation is the oldest formation of the Houston Group. The Willis Formation was deposited early in the Pleistocene epoch, during the Aftonian Interglacial Stage. It is fluviatile, consisting of sands, silts, and clays in approximately equal amounts.

The coastal plain in this region has a complex tectonic geology, several major features of which are: Gulf Coastal geosyncline, salt domes, major sea level fluctuations during the glacial stages, subsidence and faulting activities. Most of these faulting activities have ceased for millions of years, but some are still active. A detailed geologic fault investigation and study of the site geology were beyond the scope of this study.

3.2 Typical Profile

Fire Station No. 7 – Soils at this site generally included silty sand from the surface to depths that ranged from about 2 to 6 feet below existing grade. Underlying soil includes clayey sand to depths of about 10 feet, followed by silty sands with varying amounts of fine gravel.

Fire Training Facility – Soils at this site included silty sand from the surface to depths of about 2 feet below existing grade in Boring B-2b. Underlying soils and soils from the surface in Boring B-1b included sandy silty clay to depths of about 6 to 8 feet, followed by poorly graded sand with silt, gravel, and clay seams to the boring termination depth of 30 feet below existing grade.

Conditions observed at each boring location are indicated on the individual boring logs included in Appendix A. Stratification boundaries on the boring logs represent the approximate location of changes in soil types; in-situ, the transition between materials may be gradual.

Based on our field and laboratory programs, engineering values for the subsurface conditions can be summarized as follows:

Subsurface Soils						
Description	**Plasticity Index**	**Moisture Content (%)**	**Moisture content vs. Plastic limit**[1]	**Undrained Shear Strength**[2] **(psf)**	**SPT N-Value (bpf)**[3]	**Percentage of Fines**[4] **(%)**
Fire Station No. 7						
Silty Sand	NP[5]	5 to 8	---	---	2 to 19	16 to 27
Clayey Sand	8 to 12	11 to 13	-1 to 0	---	6 to 36	5 to 24
Fire Training Facility						
Silty Sand	NP[5]	---	---	---	8	---
Poorly Graded Sand with Silt	NP[5]	15 to 21	---	---	5 to 26	8 to 11
Sandy Silty Clay	4	12 to 15	0 to 3	2.5 to 3.0[6]	8 to 20	58 to 60

1. The difference between a soil sample's moisture content and its corresponding plastic limit.
2. Based on unconfined compressive strength tests.
3. bpf = blows per foot.
4. Percent passing the No. 200 sieve.
5. Non-plastic (NP). Based on visual classification.
6. Hand penetrometer test value in tons per square foot (tsf).

3.3 Groundwater

Borings B-1a, B-2a, B-3a and B-4a at the Conroe Fire Station No. 7 were drilled dry to their termination depths between 5 to 20 feet below existing grade. Dry drilling techniques were utilized to advance Borings B-1b and B-2b at the Fire Training Facility, to a depth of about 20 feet below existing grade. Borings B-1b and B-2b were then completed to their termination depths (about 30 feet below existing grade) using wet rotary techniques. Water was used as a drilling fluid for the wet rotary procedure. The observed groundwater measurements are summarized in the following table.

Summary of Short-Term Groundwater Information				
Boring Number	Approximate Boring Depth (feet)[1]	Approximate Groundwater Measurements (feet)[1,2]		
		During Dry Drilling	At 5 Minutes After First Observing Seepage	At 15 Minutes After First Observing Seepage
Fire Station No. 7				
B-1	20	13	12½	12½
B-2	20	13	12½	12½
B-3	5	Not Observed	--	--
B-4	5	Not Observed	--	--
Fire Training Facility				
B-1	30	8	7½	7
B-2	30	11	7½	7

1. Depths are with respect to existing grade.
2. Water levels were rounded to the nearest one-half foot.

These groundwater measurements are considered short-term, since the borings were open for a short time period. On a long-term basis, groundwater may be present at different depths. Additionally, groundwater will fluctuate seasonally with climatic changes and should be evaluated at the time of construction.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

The following recommendations are based upon the data obtained in our field and laboratory programs, project information provided to us, and on our experience with similar subsurface and site conditions.

4.1 Geotechnical Considerations

The surficial soils observed in portions of both the sites may be wet and soft at the time of construction, and remedial efforts may be necessary for preparation of those soils in the building and pavement areas to create a working surface. Remedial effort options are discussed in Section **4.2.3 Wet Weather/Soft Subgrade Considerations**.

4.2 Earthwork

Construction areas should be stripped of any trees, brush, vegetation, topsoil, and other debris/unsuitable surface material. Roots of trees to be removed within the construction areas should be grubbed to full depths. Care should be taken to replace or recompact all soil removed or loosened by removal of tree roots and stumps as described in subsequent paragraphs.

Once final subgrade elevations have been achieved, the exposed subgrade should be proofrolled with a 20-ton pneumatic roller or equivalent equipment, such as a fully loaded dump truck, to detect weak zones in the subgrade. Weak areas detected during proofrolling, as well as zones containing organic matter and debris, should be removed and replaced with select fill compacted as outlined in Section **4.2.2 Compaction Requirements.** Subsequent to proofrolling, and just prior to placement of fill, the exposed subgrade within the construction areas should be scarified to a minimum depth of 6 inches, moisture adjusted to within 2 percent of the optimum moisture content, and compacted to at least 95 percent of the Standard Effort (ASTM D 698) maximum dry density.

Proof rolling should be performed under the direct observation of the geotechnical engineer or his/her representative. Proper site drainage should be maintained during construction so that ponding of surface runoff does not occur and cause construction delays and/or inhibit site access.

4.2.1 Material Requirements

Select fill soils to be used at this site for grade adjustments should meet the following criteria.

Fill Type	USCS Classification	Acceptable Location for Placement
Select fill	CL and/or SC (10≤PI≤20)	Must be used to construct the building pads under the grade-supported floor slabs and any other at-grade slabs sensitive to movement, and for all grade adjustments within the building areas.
On-site soils	Varies	May be used for grading in pavement areas.

If blended or mixed soils are intended for use to construct the building pads, Terracon should be contacted to provide additional recommendations. Blended or mixed soils do not occur naturally. These soils are a blend of sand and clay and will require mechanical mixing with a pulvimixer at the site. If these soils are not mixed thoroughly to break down the clay clods and blend-in the sand to produce a uniform soil matrix, the fill material may be detrimental to the slab performance. If blended soils are used, we recommend that additional samples of the blended soils, as well as the clay clods, be obtained prior to and during earthwork operations to evaluate if the blended soils can be used in lieu of select fill. The actual type and amount of mechanical mixing at the site will depend on the amount of clay and sand, and properties of the clay.

4.2.2 Compaction Requirements

Item	Description
Fill Lift Thickness	Fill soils should be placed on prepared surfaces in lifts not to exceed 8 inches loose measure, with compacted thickness not to exceed 6 inches.
Compaction Requirements	n The select fill and on-site soils should be compacted to at least 95 percent of the material's Standard Effort (ASTM D 698) maximum dry density. n The select fill and on-site soils should be moisture adjusted to within 2 percent of the optimum moisture content.

Prior to any filling operations, samples of the proposed borrow and on-site materials should be obtained for laboratory moisture-density testing. The tests will provide a basis for evaluation of fill compaction by in-place density testing. A qualified soil technician should perform sufficient in-place density tests during the filling operations to evaluate that proper levels of compaction, including dry unit weight and moisture content, are being attained.

4.2.3 Wet Weather/Soft Subgrade Considerations

Construction operations may encounter difficulties due to the wet or soft surface soils becoming a general hindrance to equipment due to rutting and pumping of the soil surface, especially during and soon after periods of wet weather. If the subgrade cannot be adequately compacted to minimum densities as described above, one of the following measures will be required: 1) removal and replacement with select fill, 2) chemical treatment of the soil to dry and improve the condition of the subgrade, or 3) drying by natural means if the schedule allows.

Based on our experience with similar soils, chemical treatment is an efficient and effective method to increase the supporting value of wet and soft subgrade. Chemical treatment may be necessary to depths of approximately one to 2 feet or greater of the surficial sand soils, depending on the condition of the subgrade at the time of construction. We suggest that a cost be included in the construction budget for chemical treatment of the soils using a lime-flyash mixture to aid drying and improve the condition of the soil if the soil is wet and/or soft at the time of construction. We recommend that this cost be in the form of a contingency or allowance to be used if needed.

4.2.4 Grading and Drainage

All grades must provide effective drainage away from the structures during and after construction. Water permitted to pond next to the structures can result in distress in the structures. These greater movements can result in unacceptable differential floor slab movements, cracked slab and walls, and roof leaks. Slab and foundation performances described in this report are based on effective drainage for the life of the structures and cannot be relied upon if effective drainage is not maintained.

Exposed ground should be sloped away from the structures for at least 10 feet beyond the structure's perimeter. After building construction and landscaping, we recommend verifying final grades to document that effective drainage has been achieved. Grades around the structures should also be periodically inspected and adjusted as necessary, as part of the structure's maintenance program.

Planters located within 10 feet of the structures should be self-contained to prevent water from accessing the subgrade soils of the proposed buildings and athletic field structures. Locate sprinkler mains and spray heads a minimum of 5 feet away from the building lines. Low-volume, drip style landscaped irrigation should not be used near the structures. Collect roof runoff in drains or gutters. Discharge roof drains and downspouts onto pavements and/or flatworks which slope away from the structures or extend downspouts a minimum of 10 feet away from structures.

Flatworks and pavements will be subject to post-construction movement. Maximum grades practical should be used for paving and flatwork to prevent water from ponding. Allowances in final grades should also consider post-construction movement of flatwork, particularly if such movement would be critical. Where paving or flatwork abuts the structures, effectively seal and maintain joints to prevent surface water infiltration.

Utility trenches are a common source of water infiltration and migration. All utility trenches that penetrate beneath the structures should be effectively sealed to restrict water intrusion and flow through the trenches that could migrate below the structures. We recommend constructing an effective clay "trench plug" that extends at least 5 feet out from the face of the building's exterior. The plug material should consist of clay compacted at a water content at or above the soils optimum water content. The clay fill should be placed to completely surround the utility line and be compacted in accordance with recommendations in this report.

4.3 Foundation Systems

Based upon the subsurface conditions observed during our field and laboratory programs, a foundation system consisting of shallow spread/strip footing foundation systems would be appropriate for support of the planned structures. Recommendations for shallow spread/strip footing foundation systems are provided in the following sections, along with other geotechnical considerations for this project.

4.3.1 Design Recommendations – Shallow Spread/Strip Footings

Description	Design Parameters
Fire Station	
Minimum embedment below finished grade[1]	24 inches
Allowable bearing pressures	Net dead plus sustained live load – 1,600 psf Net total load – 2,400 psf
Approximate total settlement[2]	One inch or less
Estimated differential settlement[3]	Approximately ½ of total settlement
Allowable passive pressure[4]	500 psf
Allowable frictional resistance[4]	240 psf
Uplift resistance[5]	Foundation weight – 150 pcf Soil weight – 120 pcf
Fire Training Facility	
Minimum embedment below existing grade[1a]	6 feet
Allowable bearing pressures	Net dead plus sustained live load – 4,000 psf Net total load – 6,000 psf
Approximate total settlement[2]	One inch or less
Estimated differential settlement[3]	Approximately ½ of total settlement
Allowable passive pressure[4]	1,500 psf
Allowable frictional resistance[4]	300 psf
Uplift resistance[5]	Foundation weight – 150 pcf Soil weight – 120 pcf

1. The footings should bear upon properly compacted select fill or undisturbed native soils.

1a. The footings should bear upon undisturbed native soils.

2. Provided proper construction practices are followed. A clear distance between spread/strip footings of one footing size of the larger of the two footings should not produce overlapping stress distributions, and adjacent footings would essentially behave as independent foundations.

3. Differential settlements may result from variances in subsurface conditions, loading conditions and construction procedures. The settlement response of the footings will be more dependent upon the quality of construction than upon the response of the subgrade to the foundation loads.

4. Lateral loads transmitted to the shallow spread/strip footings will be resisted by a combination of soil-concrete friction on the base of the footing and passive pressure on the sides of the footing. The passive pressure along the exterior face of the footings should be neglected within the upper 3 feet due to surface effects unless pavement and/or flatwork is provided up to the edge of the building.

5. Structural uplift loads on the shallow footings may be resisted by the weight of the foundation plus the weight of any soil directly above the foundation. The ultimate uplift capacity of shallow footings should be reduced by an appropriate factor of safety to compute allowable uplift capacity.

4.3.2 Construction Considerations – Shallow Spread/Strip Footings

Excavations for shallow footings should be performed with equipment capable of providing a relatively clean bearing area. The bottom 6 inches of the foundation excavations should be completed with a smooth-mouthed bucket or by hand labor. The excavations should be neatly excavated and properly formed. Debris in the bottom of the excavation should be removed prior to steel placement. Based on the groundwater observations obtained during our field program (refer to the **"3.3 Groundwater"** section), significant groundwater seepage is not anticipated for shallow footings at the recommended bearing depth. However, water should not be allowed to accumulate at the bottom of the foundation excavations. To reduce the potential for groundwater seepage into the excavations and to minimize disturbance to the bearing area, we recommend that concrete and steel be placed as soon as possible after the excavations are completed. Excavations should not be left open overnight. The bearing surface of the shallow footings should be evaluated immediately prior to placing concrete or a seal slab.

A thin seal slab of lean concrete (approximately 2 to 4 inches thick) should be placed at the bottom of the footing excavation to protect the bearing surface of the footings from disturbance and/or infiltration of ground/surface water if the footing cannot be poured within the same day of its excavation.

4.3.3 Foundation Construction Monitoring

The performance of the foundation systems for the proposed structures will be highly dependent upon the quality of construction. Thus, we recommend that fill pad compaction and foundation installation be monitored full-time by an experienced Terracon soil technician under the direction of our geotechnical engineer. During foundation installation, the base should be monitored to evaluate the condition of the subgrade. We would be pleased to develop a plan for compaction and foundation installation monitoring to be incorporated in the overall quality control program.

4.4 Grade-Supported Floor Slabs

We have assumed that finished grades will be within about 3 feet of existing grade. If finished grades are different than assumed, Terracon should be notified to review and/or modify our recommendations given in this subsection.

The near-surface soils observed at this site generally exhibited a low expansion potential. Based on the information developed from our field and laboratory programs and on method TEX-124-E in the Texas Department of Transportation (TxDOT) Manual of Testing Procedures, we estimate that the subgrade soils at this site exhibit a Potential Vertical Rise (PVR) less than one inch.

Due to the presence of the moisture-sensitive silty sands, to provide a working surface and to provide uniform support under the floor slab, we recommend that a minimum of 12 inches of properly placed and compacted select fill soils be constructed beneath the floor slabs. The select fill pad should extend a minimum of 3 feet beyond the beyond the edge of the building. The final exterior grade adjacent to the building should be sloped to provide effective drainage away from the building.

Select fill should be utilized to construct the 12-inch-thick select fill pads and may also be used for grade adjustments within the building areas. The subgrade and select fill soils should be prepared as outlined in Section **4.2 Earthwork**, which contains material and placement requirements for select fill, as well as other subgrade preparation recommendations.

4.5 Pavements

Once the subgrade is properly prepared both flexible pavement systems (consisting of asphaltic-concrete and base material) and rigid pavement systems (consisting of reinforced concrete) may be considered for this project. Detailed traffic loads and frequencies were not available. However, we anticipate traffic will consist primarily of passenger vehicles in the parking areas and passenger vehicles combined with garbage and delivery trucks in the driveways.

Tabulated in the following table are the assumed traffic frequencies and loads used to design pavement sections for this project. When the actual traffic conditions have been determined, Terracon should be contacted to review the information to consider a need for revision of the pavement designs and related recommendations.

Pavement Area	Traffic Design Index[1]	Description
Automobile Parking Areas	DI-1	Light traffic (Few vehicles heavier than passenger cars, no regular use by heavily loaded two-axle trucks/buses.) (EAL[(2)] < 6)
Driveways (Light Duty)	DI-2	Medium to light traffic (Similar to DI-1 including not over 50 loaded two-axle trucks/buses or lightly loaded larger vehicles per day. No regular use by heavily loaded trucks/buses with three or more axles.) (EAL = 6-20)
Driveways and Truck Traffic Areas (Medium Duty)	DI-3	Medium traffic (Including not over 300 heavily loaded two-axle trucks/buses plus lightly loaded trucks/buses with three or more axles and no more than 30 heavily loaded trucks/buses with more than three axles per day.) (EAL = 21-75)

1 Based on NSSGA traffic design indices.
2 Equivalent daily 18-kip single-axle load applications.

The top 6 inches of the finished subgrade soils directly beneath the pavements should be chemically treated with a mixture of lime and flyash. Chemical treatment will increase the supporting value of the subgrade and decrease the effect of moisture on subgrade soils. These 6 inches of treatment is a required part of the pavement design and is not a part of site and subgrade preparation for wet/soft subgrade conditions.

Listed in the following tables are pavement component thicknesses, which may be used as a guide for pavement systems at the site for the traffic classifications stated herein. These systems were derived based on general characterization of the subgrade. Specific testing (such as CBRs, resilient modulus, etc.) was not performed for this project to evaluate the support characteristics of the subgrade.

Flexible Pavement System		
Component	**Material Thickness, Inches**	
	DI-1	**DI-2**
Asphaltic Concrete	2.0	2.5
Base Material	8.0	10.0
Treated Subgrade	6.0	6.0

Rigid Pavement System			
Component	**Material Thickness, Inches**		
	DI-1	**DI-2**	**DI-3**
Reinforced Concrete	5.0	6.0	7.0
Treated Subgrade	6.0	6.0	6.0

Waste dumpster areas should be constructed of at least 7 inches of reinforced concrete pavement. The concrete pad areas should be designed so that the vehicle wheels of the collection truck are supported on the concrete while the dumpster is being lifted to support the large wheel loading imposed during waste collection.

Presented in the following sections are our recommended material requirements for the various pavement sections.

Reinforced Concrete Pavement – The materials and properties of reinforced concrete pavement should meet applicable requirements in the ACI Manual of Concrete Practice. The portland cement concrete mix should have a minimum 28-day compressive strength of 3,500 psi.

Reinforcing Steel – ACI recommendations indicate that distributed steel reinforcement is not necessary when the pavement is properly jointed to form short panel lengths that will help reduce intermediate cracking. Provided the concrete pavement is designed and constructed as stated herein, the installation of reinforcing steel is optional and should be evaluated by the design team. Proper layout and installation of the joints within the pavement is critical to help control intermediate cracking.

If reinforcing steel is planned to be utilized in the concrete pavement by the design team, the following amount of reinforcing steel should be used as a guideline:

DI-1: #3 bars spaced at 18 inches or #4 bars spaced at 24 inches on-centers in both directions.
DI-2: #3 bars spaced at 12 inches or #4 bars spaced at 18 inches on-centers in both directions.
DI-3: #4 bars spaced at 18 inches on-centers in both directions.

Control Joint Spacing – ACI recommendations indicate that control joints should be spaced at a maximum spacing of 30 times the thickness of the pavement for unreinforced parking lot pavements. Furthermore, ACI recommends a maximum control joint spacing of 12.5 feet for 5-inch pavements and a maximum control joint spacing of 15 feet for 6-inch or thicker pavements. Sawcut control joints should be cut within 4 to 12 hours of concrete placement to help control the formation of plastic shrinkage cracks as the concrete cures. The depth of the joint should be at least one-quarter of the slab depth when using a conventional saw or one inch when using early entry saws. The width of the cut should be in accordance with the joint sealant manufacturer recommendations.

Expansion Joint Spacing – ACI recommendations indicate that regularly spaced expansion joints may be deleted from concrete pavements. Therefore, the installation of expansion joints is optional and should be evaluated by the design team.

Construction Joints – When concrete is planned to be placed at different times, we recommend the use of a construction joint between paving areas. The construction joint should consist of a butt joint (not a keyway joint).

Concrete Curing Compound – A concrete curing compound, such as a Type 2 membrane curing compound conforming to TxDOT DMS-4650, “Hydraulic Cement Concrete Curing Materials and Evaporation Retardants” or equivalent, should be applied to the concrete surface immediately after placement of the concrete in accordance with TxDOT 2004 Standard Specifications Item 360.

Dowels at Expansion/Construction Joints – The dowels at expansion/construction joints should be spaced at 12-inch centers and consist of the following:
DI-1: 5/8-inch diameter, 12 inches long with 5-inch embedment.
DI-2: 3/4-inch diameter, 14 inches long with 6-inch embedment.
DI-3: 7/8-inch diameter, 14 inches long with 6-inch embedment.

Hot Mix Asphaltic Concrete Surface Course – The asphaltic concrete surface course should be plant mixed, hot laid Type D (Fine Graded Surface Course) meeting the specifications requirements in TxDOT 2004 Standard Specifications Item 340. Specific criteria for the job specifications should include compaction to within an air void range of 5 to 9 percent calculated using the maximum theoretical specific gravity mix measured by TxDOT Tex-227-F. The asphalt cement content by percent of total mixture weight should be within ± 0.5 percent asphalt cement from the job mix design.

Base Material – Base material should be composed of crushed limestone or crushed concrete meeting the requirements of TxDOT 2004 Standard Specifications Item 247, Type A or D, Grade 1. The base material should be compacted to at least 95 percent of the Modified Effort (ASTM D 1557) maximum dry density at moisture content within 2 percent of the optimum moisture content.

Lime-Flyash Treated Subgrade – The on-site low to moderate plasticity soils (PI less than about 20) should be treated with lime-flyash in accordance with TxDOT 2004 Standard Specifications Item 265. Based on the classification test results, we recommend that 2 to 3 percent lime and 7 to 8 percent flyash by dry weight be used for estimating and planning. The percentages are given as application by dry weight and are typically equivalent to about 10 to 15 pounds of lime and 35 to 40 pounds of flyash per square yard per 6-inch depth. Lime-flyash is also available pre-mixed, typically in percentages of 20 to 30 percent lime and 70 to 80 percent flyash. These pre-mixed products may be used if preferred at a rate of 50 pounds per square yard per 6-inch depth. The actual quantity of the lime and flyash should be determined at the time of construction based on laboratory testing conducted using bulk samples of the subgrade soils. The subgrade soils should be compacted to a minimum of 95 percent of the Standard Effort (ASTM D 698) maximum dry density at a moisture content within 2 percent of the optimum moisture content.

Preferably, traffic should be kept off the treated subgrade for about 7 days to facilitate curing of the soil-chemical mixture; in addition, the subgrade is not suitable for heavy construction traffic prior to paving.

The pavement design methods described above are intended to provide structural sections with adequate thickness over a particular subgrade such that wheel loads are reduced to a level the subgrade can support. The support characteristics of the subgrade for pavement design do not account for shrink/swell movements of an expansive clay subgrade such as the soils encountered in some areas at this site. Thus the pavement may be adequate from a structural standpoint, yet still experience cracking and deformation due to shrink/swell related movement of the subgrade. Post-construction subgrade movements and some cracking of pavements are not uncommon for clay subgrade conditions such as those observed at this site. Reducing moisture changes in the subgrade is important to reduce shrink/swell movements. Although chemical treatment will help to reduce such movement/cracking, this movement/cracking cannot be economically eliminated.

Related civil design factors such as subgrade drainage, shoulder support, cross-sectional configurations, surface elevations and environmental factors which will significantly affect the service life must be included in the preparation of the construction drawings and specifications. Normal periodic maintenance will be required.

Long-term pavement performance will be dependent upon several factors, including maintaining subgrade moisture levels and providing for preventative maintenance.

The following recommendations should be implemented to help promote long-term pavement performance:

- The subgrade and the pavement surface should be designed to promote proper surface drainage, preferably at a minimum grade of 2 percent
- Install joint sealant and seal cracks immediately
- Extend curbs into the treated subgrade for a depth of at least 4 inches to help reduce moisture migration into the subgrade soils beneath the pavement section
- Place compacted, low permeability clayey backfill against the exterior side of the curb and gutter

Preventative maintenance should be planned and provided for the pavements at this site. Preventative maintenance activities are intended to slow the rate of pavement deterioration, and consist of both localized maintenance (e.g. crack and joint sealing and patching) and global maintenance (e.g. surface sealing). Prior to implementing any maintenance, additional engineering observations are recommended to determine the type and extent of preventative maintenance.

5.0 GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, foundation construction, and other earth-related construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

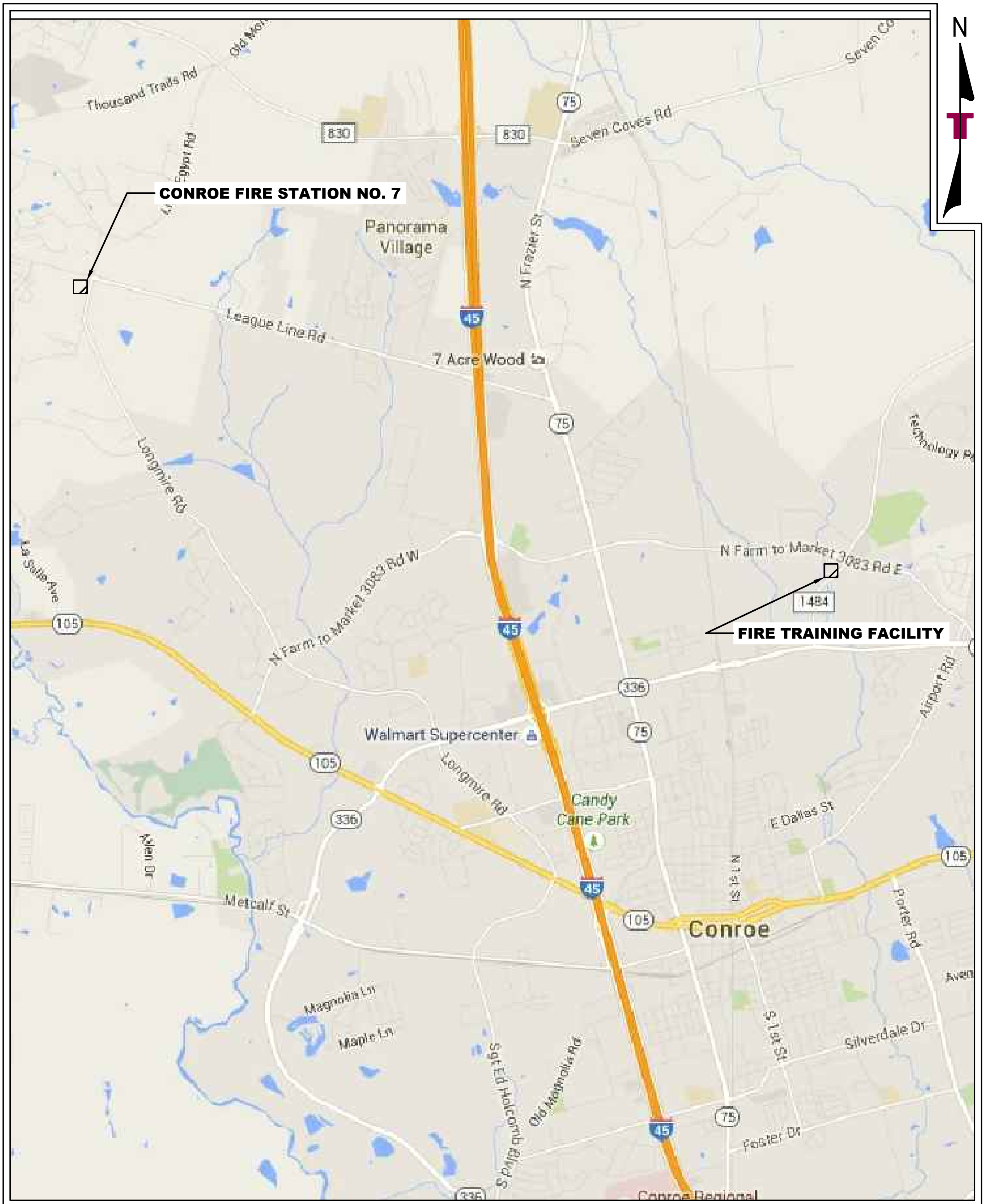
The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, and bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

For any excavation construction activities at this site, all Occupational Safety and Health Administration (OSHA) guidelines and directives should be followed by the Contractor during construction to insure a safe working environment. In regards to worker safety, OSHA Safety and Health Standards require the protection of workers from excavation instability in trench situations.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

APPENDIX A

FIELD EXPLORATION



2,000' 0 1,000' 2,000'

SCALE IN FEET

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Project Mng.: SSS	Project No.: 97165065	Terracon Consulting Engineers & Scientists	SITE LOCATION PLAN
Drawn By: SSS	Scale: AS SHOWN	11133 I-45 South, Building T Conroe, Texas 77302	Conroe Fire Station No. 7 and Fire Training Facility Conroe, Texas
Checked By: BSH	File No: 97165065	PH. (936) 539-1384 FAX. (936) 539-9622	Exhibit
Approved By: BSH	Date: 7/13/2016		A-1

100' 0 50' 100'

SCALE IN FEET

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

LEGEND

⊕ SOIL BORING LOCATIONS

Project Mng.	SSS	Project No.	97165065
Drawn By:	SSS	Scale:	AS SHOWN
Checked By:	BSH	File No:	97165065
Approved By:	BSH	Date:	7/13/2016

Terracon
Consulting Engineers & Scientists
11133 I-45 South, Building T Conroe, Texas 77302
PH. (936) 539-1384 FAX. (936) 539-9622

BORING LOCATION PLAN

Conroe Fire Station No. 7
League Line Road and Longmire Road
Conroe, Texas

Exhibit

A-2a

100' 0 50' 100'

SCALE IN FEET

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

LEGEND

SOIL BORING LOCATIONS

Project Mng.	SSS	Project No.	97165065
Drawn By:	SSS	Scale:	AS SHOWN
Checked By:	BSH	File No:	97165065
Approved By:	BSH	Date:	7/13/2016

Terracon
Consulting Engineers & Scientists
11133 I-45 South, Building T Conroe, Texas 77302
PH. (936) 539-1384 FAX. (936) 539-9622

BORING LOCATION PLAN

Fire Training Facility
F.M. 3083 and F.M. 1484
Conroe, Texas

Exhibit
A-2b

Field Exploration Description

Subsurface conditions at the Fire Station No. 7 site were evaluated by drilling two test borings, designated B-1a and B-2a to depths of about 20 feet below existing grade (grade at the time of our field program) within the proposed building area; and two test borings, designated B-3a and B-4a to a depth of about 5 feet below existing grade within the planned pavement areas. The borings were drilled on June 27, 2016, using all-terrain vehicle (ATV) mounted drilling equipment at the approximate boring locations shown on the Boring Location Plan, Exhibit A-2a.

Two test borings, designated B-1b and B-2b were drilled to a depth of about 30 feet below existing grade at the Fire Training Facility building area, to evaluate the subsurface conditions. Boring B-2b was drilled on June 27, 2016 to a depth of 20 feet and resumed on July 1, 2016 to a depth of 30 feet below existing grade. Boring B-1b was drilled on July 1, 2016. The borings were drilled using all-terrain vehicle (ATV) mounted drilling equipment at the approximate boring locations shown on the Boring Location Plan, Exhibit A-2b.

The boring locations were selected and staked on the ground using a handheld GPS unit with an accuracy of about ±20 feet. The boring depths were measured from the existing ground surface at the time of our field activities. Upon completion of our field program, the borings were backfilled with soil cuttings and plugged at the surface with soil cuttings.

The boring logs, presenting the subsurface soil descriptions, type of sampling used, and additional field data, are presented on Exhibits A-4 through A-9. The General Notes, which defines the terms used on the logs, are presented on Exhibit C-1. The Unified Soil Classification System is presented on Exhibit C-2.

Cohesive soil samples were generally recovered using open-tube samplers. Hand penetrometer tests were performed on samples of cohesive soils to serve as a general measure of consistency.

Granular soils and soils for which good quality open tubes samples could not be obtained were sampled by means of the Standard Penetration Test (SPT). This test consists of measuring the number of blows (N) required for a 140-pound hammer free falling 30 inches to drive a standard split-spoon sampler 12 inches into the subsurface material after being seated 6 inches. This blow count or SPT N-value is used to evaluate the stratum.

A CME automatic SPT hammer was used in advancing the split-spoon sampler in all the borings. A greater efficiency is typically achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. Published correlations between the SPT N-values and soil properties are based on the lower efficiency cathead and rope method. The higher efficiency of an automatic SPT hammer affects the SPT N-value by increasing the penetration per hammer blow over what would be obtained using the cathead and rope method. The effect of the automatic hammer efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

Samples were removed from samplers in the field, visually classified, and appropriately sealed in sample containers to preserve their in-situ moisture contents. Samples were then transported to our laboratory in Conroe, Texas.

BORING LOG NO. B-1a

PROJECT: Conroe Fire Station No. 7 and Fire Training Facility

CLIENT: PGAL
3131 Briarpark, Houston TX

SITE:
Conroe, TX

LOCATION See Exhibit A-2

Latitude: 30.3766° Longitude: -95.53037°

DEPTH	Material Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SILTY SAND (SM), reddish-brown and tan, very loose to loose			X	1-2-1 N=3				6			26
				X	3-2-3 N=5							
	- with gravel from 4 to 6 feet	5		X	3-3-3 N=6							
6.0	**CLAYEY SAND (SC)**, reddish-brown, medium dense, with gravel			X	5-7-6 N=13				11		20-12-8	28
				X	8-4-8 N=12							
10.0	**SILTY SAND (SM)**, reddish-brown and light gray, very loose to medium dense - with gravel from 10 to 15 feet	10		X	3-5-6 N=11							
			▼ ▽									
		15		X	2-1-1 N=2							
				X	1-1-1 N=2							
20.0	***Boring Terminated at 20 Feet***	20										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Dry Auger: 0' to 20'

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *13 ft While Drilling*

▽ *12.5 ft at 5 Minutes*

▼ *12.5 ft at 15 Minutes*

Terracon
11133 Interstate 45 S Ste T
Conroe, TX

Boring Started: 6/27/2016	Boring Completed: 6/27/2016
Drill Rig: Track Mounted	Driller: Roger B.
Project No.: 97165065	Exhibit: A-4

BORING LOG NO. B-2a

PROJECT: Conroe Fire Station No. 7 and Fire Training Facility

CLIENT: PGAL
3131 Briarpark, Houston TX

SITE:
Conroe, TX

LOCATION See Exhibit A-2

Latitude: 30.37633° Longitude: -95.5304°

GRAPHIC LOG / DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SILTY SAND (SM), tan, loose			X	1-2-2 N=4							
2.0	**CLAYEY SAND (SC)**, reddish-brown and tan, loose to medium dense			X	2-4-4 N=8				13		25-13-12	44
	- with gravel from 4 to 8 feet	5		X	5-9-15 N=24							
				X	6-10-12 N=22							
8.0	**SILTY SAND (SM)**, reddish-brown, medium dense - with gravel from 8 to 15 feet			X	5-8-9 N=17				8			16
		10		X	7-10-9 N=19							
			▼ ▽									
		15		X	7-8-9 N=17							
				X	2-4-7 N=11							
20.0	***Boring Terminated at 20 Feet***	20										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Dry Auger: 0' to 20'

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *13 ft While Drilling*

▽ *12.5 ft at 5 Minutes*

▼ *12.5 ft at 15 Minutes*

Terracon
11133 Interstate 45 S Ste T
Conroe, TX

Boring Started: 6/27/2016	Boring Completed: 6/27/2016
Drill Rig: Track Mounted	Driller: Roger B.
Project No.: 97165065	Exhibit: A-5

BORING LOG NO. B-3a

PROJECT: Conroe Fire Station No. 7 and Fire Training Facility

CLIENT: PGAL 3131 Briarpark, Houston TX

SITE: Conroe, TX

LOCATION See Exhibit A-2

Latitude: 30.37633° Longitude: -95.53036°

GRAPHIC LOG	DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		SILTY SAND (SM), tan, loose			X	2-2-3 N=5				7			27
	2.0	**CLAYEY SAND (SC)**, reddish-brown, loose			X	2-2-3 N=5							
			5		X	3-4-5 N=9							
	6.0	***Boring Terminated at 6 Feet***											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Dry Auger: 0' to 6'

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Not Observed During or On Completion of Drilling

Terracon
11133 Interstate 45 S Ste T
Conroe, TX

Boring Started: 6/27/2016 | Boring Completed: 6/27/2016

Drill Rig: Track Mounted | Driller: Roger B.

Project No.: 97165065 | Exhibit: A-6

BORING LOG NO. B-4a

PROJECT: Conroe Fire Station No. 7 and Fire Training Facility

CLIENT: PGAL
3131 Briarpark, Houston TX

SITE:
Conroe, TX

LOCATION See Exhibit A-2

Latitude: 30.37659° Longitude: -95.53053°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SILTY SAND (SM), tan, loose			X	2-3-4 N=7				5			24
	2.0											
	CLAYEY SAND (SC), dark gray and reddish-brown, loose to medium dense			X	3-3-4 N=7							
		5		X	4-5-6 N=11							
	6.0											
	Boring Terminated at 6 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Dry Auger: 0' to 6'

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Not Observed During or On Completion of Drilling

Terracon
11133 Interstate 45 S Ste T
Conroe, TX

Boring Started: 6/27/2016	Boring Completed: 6/27/2016
Drill Rig: Track Mounted	Driller: Roger B.
Project No.: 97165065	Exhibit: A-7

BORING LOG NO. B-1b

PROJECT: Conroe Fire Station No. 7 and Fire Training Facility

CLIENT: PGAL
3131 Briarpark, Houston TX

SITE:
Conroe, TX

LOCATION See Exhibit A-2

Latitude: 30.34761° Longitude: -95.44646°

DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SANDY SILTY CLAY (CL-ML), light gray and tan, medium-stiff to very stuff			Split spoon	2-4-4 N=8				15		16-12-4	60
	- with vertical sand fissures from 2 to 4 feet			Shelby tube	2.75 (HP)							
		5		Shelby tube	3.0 (HP)							
6.0	**POORLY GRADED SAND WITH SILT(SP-SM)**, light gray and tan, loose to medium dense, with clayey sand seams		▼ ▽	Split spoon	5-6-6 N=12				15		NP	
				Split spoon	3-9-13 N=22							
		10		Split spoon	6-7-8 N=15							
				Split spoon	3-5-6 N=11				21			11
		15										
	- with gravel from 18 to 30 feet			Split spoon	9-12-14 N=26							
		20										
				Split spoon	3-4-9 N=13							
		25										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Dry Auger: 0' to 20'
Wet Rotary: 20' to 30'

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

- ▽ *7.5 ft While Drilling*
- ▽ *7 ft at 5 Minutes*
- ▼ *7 ft at 15 Minutes*

Terracon
11133 Interstate 45 S Ste T
Conroe, TX

Boring Started: 7/1/2016	Boring Completed: 7/1/2016
Drill Rig: Track Mounted	Driller: Roger B./Van & Sons
Project No.: 97165065	Exhibit: A-8

BORING LOG NO. B-1b

PROJECT: Conroe Fire Station No. 7 and Fire Training Facility

CLIENT: PGAL
3131 Briarpark, Houston TX

SITE:
Conroe, TX

GRAPHIC LOG	LOCATION See Exhibit A-2 Latitude: 30.34761° Longitude: -95.44646° DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	POORLY GRADED SAND WITH SILT(SP-SM), light gray and tan, loose to medium dense, with clayey sand seams *(continued)*											
	30.0	30		X	2-3-3 N=6							
	Boring Terminated at 30 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Dry Auger: 0' to 20'
Wet Rotary: 20' to 30'

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS
- *7.5 ft While Drilling*
- *7 ft at 5 Minutes*
- *7 ft at 15 Minutes*

Terracon
11133 Interstate 45 S Ste T
Conroe, TX

Boring Started: 7/1/2016	Boring Completed: 7/1/2016
Drill Rig: Track Mounted	Driller: Roger B./Van & Sons
Project No.: 97165065	Exhibit: A-8

BORING LOG NO. B-2b

PROJECT: Conroe Fire Station No. 7 and Fire Training Facility

CLIENT: PGAL
3131 Briarpark, Houston TX

SITE:
Conroe, TX

LOCATION See Exhibit A-2

Latitude: 30.3476° Longitude: -95.44624°

GRAPHIC LOG	DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		SILTY SAND (SM), light gray, loose			X	2-5-3 N=8							
	2.0	**SANDY SILTY CLAY (CL-ML)**, light gray and tan, stiff to very stiff			X	1-4-7 N=11				12		16-12-4	58
			5		X	5-9-11 N=20							
				▼ ▽		2.5 (HP)							
	8.0	**POORLY GRADED SAND WITH SILT(SP-SM)**, light gray and tan, loose to medium dense			X	6-8-9 N=17				17			8
		- with clay pockets from 10 to 12 feet	10	▽	X	3-3-6 N=9							
			15		X	1-2-3 N=5							
		- with gravel from 18 to 20 feet	20		X	7-15-10 N=25							
		- with clayey sand seams from 23 to 25 feet	25		X	3-7-10 N=17							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Dry Auger: 0' to 20'
Wet Rotary: 20' to 30'

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *11 ft While Drilling*

▽ *7.5 ft at 5 Minutes*

▼ *7 ft at 15 Minutes*

Terracon
11133 Interstate 45 S Ste T
Conroe, TX

Boring Started: 6/27/2016	Boring Completed: 7/1/2016
Drill Rig: Track Mounted	Driller: Van & Sons
Project No.: 97165065	Exhibit: A-9

BORING LOG NO. B-2b

PROJECT: Conroe Fire Station No. 7 and Fire Training Facility

CLIENT: PGAL
3131 Briarpark, Houston TX

SITE:
Conroe, TX

GRAPHIC LOG	LOCATION See Exhibit A-2 Latitude: 30.3476° Longitude: -95.44624° DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	POORLY GRADED SAND WITH SILT(SP-SM), light gray and tan, loose to medium dense *(continued)* - with gravel from 28 to 30 feet											
	30.0	30		X	3-2-5 N=7							
	Boring Terminated at 30 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Dry Auger: 0' to 20'
Wet Rotary: 20' to 30'

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

- *11 ft While Drilling*
- *7.5 ft at 5 Minutes*
- *7 ft at 15 Minutes*

Terracon
11133 Interstate 45 S Ste T
Conroe, TX

Boring Started: 6/27/2016	Boring Completed: 7/1/2016
Drill Rig: Track Mounted	Driller: Van & Sons
Project No.: 97165065	Exhibit: A-9

APPENDIX B

LABORATORY TESTING

Laboratory Testing

Selected soil samples were tested in the laboratory to measure natural water content (ASTM D2216), Atterberg Limits (ASTM D4318), and percent passing the No. 200 sieve (ASTM D1140). The test results are provided on the Boring Logs included in Appendix A and in Section **3.2 Typical Profile**.

ASTM procedural standards noted above are for reference methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgement,

Descriptive classifications of the soils indicated on the boring log are in general accordance with the General Notes and the Unified Soil Classification System included in Appendix C. Also shown are estimated Unified Soil Classification Symbols. A brief description of this classification system is attached to this report. Classification of the soil samples was generally determined by visual manual procedures.

Samples not tested in the laboratory will be stored for a period of 30 days subsequent to submittal of this report and will be discarded after this period, unless we are notified otherwise.

APPENDIX C

SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

- Shelby Tube
- Standard Penetration Test

WATER LEVEL

- **Water Initially Encountered**
- **Water Level After a Specified Period of Time**
- **Water Level After a Specified Period of Time**

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

N	**Standard Penetration Test Resistance (Blows/Ft.)**
(HP)	**Hand Penetrometer**
(T)	**Torvane**
(DCP)	**Dynamic Cone Penetrometer**
(PID)	**Photo-Ionization Detector**
(OVA)	**Organic Vapor Analyzer**

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		**CONSISTENCY OF FINE-GRAINED SOILS** (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (tsf)**	**Standard Penetration or N-Value Blows/Ft.**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification: Group Symbol	Soil Classification: Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]		GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$ [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]		SW	Well-graded sand [I]
			$Cu < 6$ and/or $1 > Cc > 3$ [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines Classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	$PI > 7$ and plots on or above "A" line [J]		CL	Lean clay [K,L,M]
			$PI < 4$ or plots below "A" line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K,L,M]
			PI plots below "A" line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10} \qquad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] $PI \geq 4$ and plots on or above "A" line.

[O] $PI < 4$ or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.

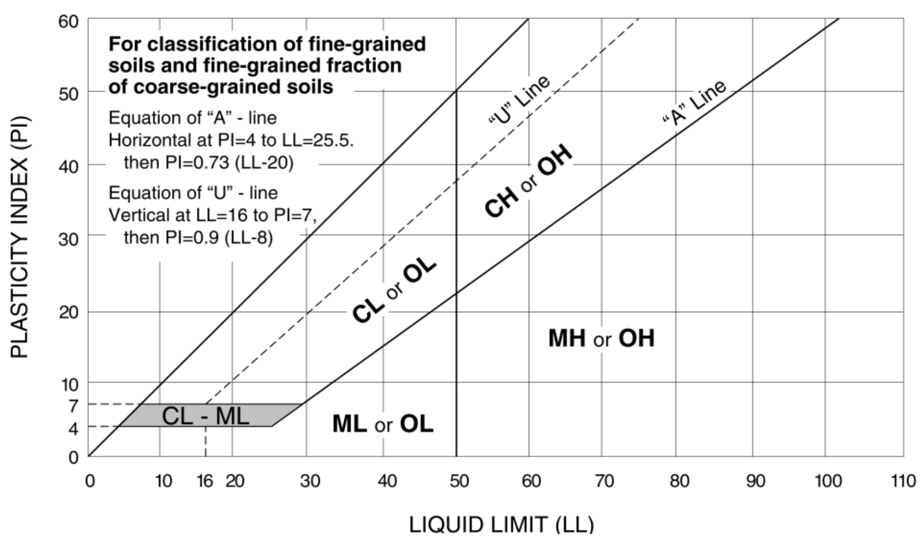


Exhibit C-2