LANGERMAN FOSTER
ENGINEERING COMPANY

July 10, 2015

Chasco Constructors
P.O. 1057
Round Rock, Texas 78680

Attention: Mr. Scott Badgett
Vice President- Building Estimating

Reference: Geotechnical Investigation (Revision No. 1)
Hewlett Volkswagen
Waco, Texas
LFE Project No. W14-024R1

Dear Mr. Badgett:

This letter transmits our geotechnical report, which has been electronically produced. We appreciate the opportunity to provide engineering services for you.

Once the project plans and specifications are completed, we would be pleased to review those portions that pertain to this report. We would also appreciate the opportunity to provide construction phase services such as materials testing as a part of the success of the project.

If you have any questions regarding our report, please call me at (254) 235-1048.

Best Regards,

LANGERMAN FOSTER ENGINEERING COMPANY
Texas Registered Engineering Firm No. F-13144

Scott Langerman

Scott M. Langerman, P.E.
Principal / Geotechnical Engineer

Distribution List:

- Chasco- Mr. Scott Badgett (Scott@Chasco.com)

GEOTECHNICAL INVESTIGATION

HEWLETT VOLKSWAGEN
Waco, Texas

LFE Project No. W14-024R1

Report Prepared For:

Chasco Constructors
Round Rock, Texas

Report Prepared By:

Scott M. Langerman, P.E.
Principal / Geotechnical Engineer

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July 10, 2015

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GEOTECHNICAL INVESTIGATION
HEWLETT VOLKSWAGEN
WACO, TEXAS

1.0 INTRODUCTION

Purpose: The purpose of this geotechnical investigation is to provide geotechnical design and construction criteria for a new Hewlett Volkswagen Dealership. Geotechnical data and recommendations are provided in a brief, and hopefully user friendly manner.

Authorization: Services were performed in general accordance with LFE Proposal No. GEO14-100R, dated July 30, 2013. Authorization to proceed was provided by Mr. Scott Badgett with Chasco on May 6, 2014.

2.0 SUBSURFACE EXPLORATION

Drilling Date: May 7, 2014

Boring Layout: The borings were marked at accessible locations in the field by LFE using a site plan provided by Chasco (Goree Architects, dated 5/1/2014), and a topographic profile (Walker Partners, dated 2/26/2014). Boring elevations were estimated from the topographic profile, and the accuracy is probably within about 2 feet. Plates 1 and 2 show the approximate boring locations.

If more precise locations and surface elevations are needed, then a licensed professional land surveyor should be retained to locate the borings.

Sampling Methods: Push-tubes were used in clay soils, and standard penetration tests were used in granular soils. NX-size core drilling was performed in limestone bedrock, and compressed air was used to cool the cutting bit and discharge cuttings.

3.0 LABORATORY TESTS

Test Procedures: The following tests were conducted in general conformance with the standards noted in Table 3.1.

TABLE 3.1: LABORATORY TESTS	
Test Name	***Test Method***
Atterberg Limits	ASTM D 4318
-#200 Mesh Sieve	ASTM D 1140
Moisture Content	ASTM D 2216
Soil Classification	ASTM D 2487
Unconfined Compression (soil)	ASTM D 2166
Unconfined Compression (rock)	ASTM D 2938

Test Results: Laboratory test results are shown on Plate 3 in the Appendix, and selected test results on the boring logs. Results are also discussed subsequently.

4.0 SUBSURFACE MATERIALS AND SITE OBSERVATIONS

Stratigraphy: Major strata types for the foundation borings (Borings B-1, B-2, B-3, F-1, and F-2) are listed in Table 4.1. Individual boring logs are contained in the Appendix. Material descriptions are general and range of depths approximate because boundaries between different strata are seldom clear and abrupt in the field.

TABLE 4.1: MAJOR STRATA TYPES			
Strata	***Depth to Top of Strata (ft)***	***Depth to Base of Strata (ft)***	***General Description***
I	0	2 to 8.5	FAT CLAY and LEAN CLAY; dark brown, gray-tan, tan, and brown, with limestone fragments
II	2 to 8.5	17 to 21	SEVERELY WEATHERED LIMESTONE; tan, consists of a mixture of broken rock and silty clay
III	17 to 21	25+	LIMESTONE; gray, fractured, with marly clay layers
Strata changes are approximate, and in-situ transitions are usually gradual.			

Geology: Based on the available geologic map[1] of the area, and the contents of the borings, the site is located within the *Austin Chalk Formation*. The Austin Chalk is considered a relatively soft limestone based on universal rock classification systems, but is considered relatively hard rock in the Central Texas area. Although the Austin Chalk is usually described as limestone, it is comprised of chalk, limestone, and marl (marl is calcareous clay). The unweathered Austin Chalk is gray in color. Weathering produces a tan to white color.

Groundwater: Borings P-1 through P-3 were each drilled to a depth of 5 feet using dry drilling methods, meaning that water was not used in the drilling process. Groundwater was not encountered.

Borings B-1, B-2, B-3, F-1, and F-2 were each drilled to a depth of 25 feet using dry drilling methods. Compressed air was used in the limestone core drilling process to cool the bit and discharge cuttings.

Groundwater was only encountered in Boring F-1. Initially, groundwater was observed at a depth of 19 feet. After a 10 minute observation period, the water level rose to 17.5 feet.

Groundwater is seasonal in this area, and may be present during construction. The water tends to percolate down through the surficial soil cracks, and then either flow down gradient or become trapped. Water also tends to travel through fractures in the limestone bedrock.

The water observations conducted for this investigation are short-term and should not be interpreted as a groundwater study. However, the presence of groundwater may affect construction and long-term performance of the proposed foundations and pavements.

5.0 GEOTECHNICAL FOUNDATION RECOMMENDATIONS

Project Summary: The project consists of a new Hewlett Volkswagen that will include a new building with a foundation area of roughly 18,500 square feet. Interior elements will include a showroom, parts department, service department, and sales offices. Site retaining walls and new pavements will also be constructed. Sections 5, 6, and 7 of this report include recommendations for the building foundations and retaining walls. Pavement thickness design information is included in Section 8.

Structural Loads: At the time of this report, structural loads were not provided to us. We assume that the column loads will be similar to other one-story structures, perhaps on the order of 75 to 150 kips.

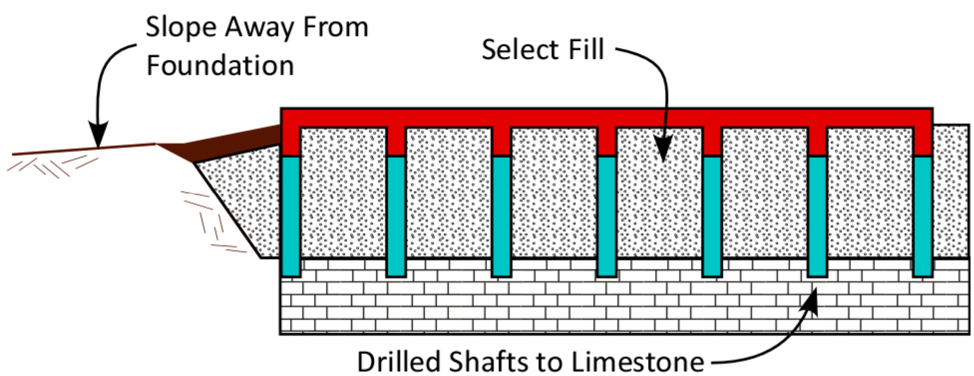
Expansive Soil: Clay soils in the Central Texas area are subject to expansive soil movements, which include swelling under moist conditions and shrinking under dry conditions. Moisture fluctuations occur due to seasonal wet and dry cycles, but are also influenced after construction by site grading, drainage, landscaping, and groundwater. Actual soil movement is difficult to determine due to the many unpredictable variables involved.

TxDOT uses the Potential Vertical Rise (PVR) procedure to estimate soil movements. For purposes of this project, the results of the laboratory tests, engineering judgment, and experience have also been considered. ***The approximate PVR for a typical ground supported slab will be about 1 to 2 inches, which is considered low to moderate for the Central Texas area.***

Actual soil movements will depend on the subsurface moisture fluctuations over the life of the structure. Soil movements may be less than those calculated if moisture variations are minimized after construction. However, significantly larger soil movements than estimated could occur due to inadequate site grading, poor drainage, ponding of rainfall, extraction of water by vegetation and trees, and/or leaking utilities.

Foundation Type: Based on the type of structure, as well as the anticipated loads, we believe that a slab on grade foundation in conjunction with drilled shafts will offer a reasonable foundation system.

DRILLED STRAIGHT SHAFT PIERS WITH A SLAB ON GRADE



Risk:	A properly designed and constructed foundation using drilled shafts in conjunction with a slab on grade will offer a low risk of future foundation movements. Drilled shafts will offer a relatively high structural load capacity as compared to footings.
Bearing Stratum:	Stratum III Gray Limestone
End Bearing:	An allowable end-bearing of 30,000 psf may be used with a minimum penetration of at least 3 feet into the bearing stratum. Piers should be specified to terminate on a hard layer, and not a softer marly layer, after the required penetration is achieved.
Side Friction:	An allowable side friction value of 2,500 psf (either tensile or compressive) may be used after an initial 3-ft penetration into limestone.
Settlement:	Properly designed and constructed drilled shafts are expected to have a settlement of ½ inch or less.
Casing:	Groundwater was measured at a depth of 17.5 feet below the ground surface at Boring No. F-1, but was not observed in the other borings. Temporary steel casing may be necessary to seal out groundwater and prevent caving of the piers. We recommend that the contractor verify the drilling and groundwater conditions prior to commencing drilled shaft installation.

Pier Spacing: The ***side friction*** for piers spaced horizontally less than 6 diameters (center to center) should be multiplied by a reduction factor as listed in Table 5.1.

TABLE 5.1: CLOSELY SPACED PIERS	
Pier Spacing	**Side Friction Reduction Factor (percent)**
<2 diameters	50
3 diameters	67
4 diameters	78
5 diameters	89
≥6 diameters	100
This table only applies to the reduction in side friction. For end-bearing, the capacity is not reduced if the pier bases are at roughly the same elevation.	

Interior Slab: We understand that a net PVR of 1 inch or less is desired to reduce the potential for future expansive clay movements. In order to achieve this goal, we have calculated cut/fill requirements relative to the proposed finished floor elevations of 579.5 feet for the showroom and 580 for the future building. Table 5.2 shows the cut/fill depths and resulting thicknesses of select fill.

TABLE 5.2: CUT AND FILL DEPTHS FOR PVR OF ABOUT 1 INCH				
Boring No.	**Surface Elevation (ft)**	**Top of Pad Elevation (ft)**	**Cut Elevation (ft)**	**Total Select Fill Thickness (ft)**
B-1	574	579	573.5	5.5
B-2	579	579	577	2
B-3	580	579	577	2
F-1	576	579.5	575	4.5
F-2	581	579.5	577.5	2
Assumes a minimum of 2 feet of select fill. We must be contacted to revise our recommendations in the event that the finished floor elevations are changed.				

Groundwater, at the time of drilling, was not present within the proposed excavation levels. However, depending on the actual depth of excavation, as well as the antecedent rainfall, groundwater may be encountered above the excavation depth. If this occurs, then clean crushed stone should be placed at the base of the excavation to above the water surface.

The crushed stone must be clean, and should generally range in size from 3 to 6 inches. Compaction specifications do not apply; however, the rock should be placed in such a manner that will stabilize the bottom of the excavation. This type of clean rock is normally used to stabilize construction entrances, and should be readily available.

Once the excavation is stabilized, select fill can be placed directly over the stone. It is normally desirable to use a filter fabric between the stone and select fill. However, filter fabric would interfere with drilled shaft construction, and therefore should not be used in this instance.

MISCELLANEOUS DESIGN ITEMS:

Flatwork: This site is on expansive soils. The recommendations provided herein address the foundation. Be aware that concrete flatwork, such as sidewalks, drainage features, plazas, and utilities will be subject to adverse soil movements. The owner should be prepared to repair and even replace these items over time, depending on the magnitude of movement that actually occurs. Where the ground is intentionally sloped and graded to provide positive drainage, the ground may swell and shrink sufficiently over time to reverse the intended drainage, and must be remediated when necessary.

Seismic: For structural designs based upon the 2006 IBC, the following criteria will apply. The Site Class is B. The Mapped Spectral Response Acceleration at short periods (SS) is about 0.10g, and the Mapped Spectral Response Acceleration at a 1 second period (S1) is about 0.04g. Site Coefficients are as follows: Fa= 1.0 and Fv= 1.0.

Hazards associated with slope stability, soil liquefaction, surface rupture, and lateral spreading are not considered an issue with this site due to the study area being in a seismically inactive area and the site being underlain at a shallow depth by bedrock.

Vapor Barriers: The need for vapor barriers, and where to place them, must be determined by the architect or structural engineer based on the proposed floor treatment, building function, concrete properties, placement techniques, and the construction schedule. When moisture barriers are used, precautions should be taken during the initial floor slab concrete curing period to reduce differential curing and possible curling of the slabs.

Impervious Seal: We recommend that an impervious seal consisting of at least 12 inches of clay soil or a synthetic membrane be constructed on top of the backfill material around the building perimeter. The intent of this impervious seal is to reduce surface runoff water from infiltrating the select backfill. The seal must be sloped away from the foundation.

Utility Connections: Utilities resting on or within expansive soils are subject to soil movements. Utility connections should account for such movement potential, such as by using flexible connections.

Based on our previous experience, clay soils are corrosive to buried metals. Corrosion protection should be provided for such metals. If granular backfill materials are used for the utility lines, then a clay plug must be placed at the exterior foundation penetrations to avoid water intrusion and collection within the utility trenches.

6.0 SITE RETAINING WALLS

Project Information: Retaining walls may be used to accommodate changes in grade, and are expected to be less than 10 feet in height.

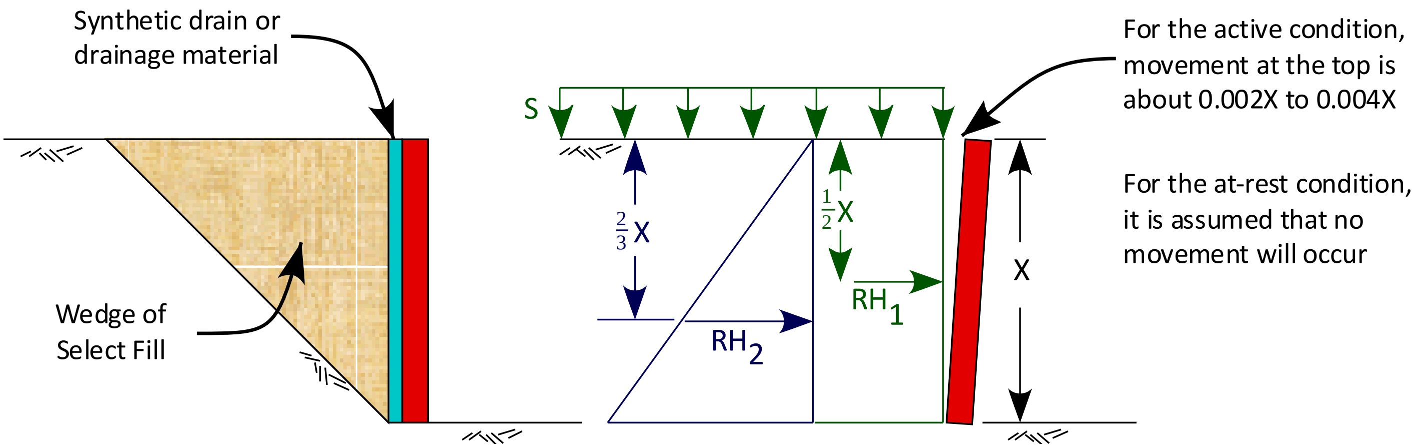


Figure 6.1: Sketch of Retaining Wall (not to scale, for illustrative purposes only)

TABLE 6.1: EARTH PRESSURE PARAMETERS

Earth Pressure	Coefficient	Equivalent Fluid Pressure (pcf)	Surcharge Pressure, P_1 (psf)	Earth Pressure, P_2 (psf)
At-Rest (K_0)	0.50	60	(0.50)S	60X
Active (K_A)	0.33	40	(0.33)S	40X
Passive (K_P)	3.0	360	--	--

- Values assume a 1H:1V wedge of select fill behind the wall with a unit weight of 120 pcf.
- Values assume that the wall is drained. Hydrostatic pressures must be added for an undrained condition
- Earth pressure parameters do not include a factor of safety
- Drainage material: ASTM C-33, Size 67 gravel aggregate, uniformly compacted
- Base sliding resistance: 500 psf
- Footing bearing pressure: 3,000 psf
- Resultant Horizontal Forces per linear foot:
  - R_{H1}= (P_1)(X), where R_{H1} is acting at ½X from the top of the wall
  - R_{H2}= (0.5)(P_2)(X), where R_{H2} is acting at ⅔X from the top of the wall

7.0 GEOTECHNICAL CONSTRUCTION RECOMMENDATIONS

Site Preparation: Surficial vegetation, root systems, existing pavements and utilities, and any underground structures must be removed. Existing clay soils must be removed below the building as discussed in Section 5 of this report. The stripping depth must be based on field observations with attention given to old drainage areas, uneven topography, and wet soils. Proof-rolling should be used to detect soft spots or pumping subgrade areas. Proof-rolling should be performed using a heavy pneumatic tired roller, loaded dump truck, or similar piece of equipment weighing at least 25 tons.

Grading: Grading, landscaping, and drainage pose a significant risk factor for future performance of the foundation systems. Prevention of water ponding around the foundation is critical. We suggest the following general guidelines for perimeter drainage:

1. The building pad or the finished floor elevation must be elevated from the exterior finished grade to assist in draining the surface water away from the structure.

2. Where possible, extend paved surfaces up to the building line to serve as a barrier to soil moisture evaporation and infiltration. These surfaces must slope away from the building.

3. Outlets for gutter systems must rapidly discharge water away from the foundation.

4. Roots from trees and decorative vegetation remove moisture from soils, which causes soil shrinkage (settlement). Trees should have root blockers near the foundation or be located as far away from the foundation as practical.

5. Sprinkler systems must be properly maintained and over-watering of the soils should be avoided.

Subgrade: The subgrade soils should be scarified to a depth of 6 inches and then compacted to at least 95 percent of ASTM D698 (or TEX-113-E) maximum dry density at 0 to +3% of the optimum moisture content. A maximum compacted lift thickness of six inches must be specified, with each lift tested for compliance prior to the addition of subsequent lifts. The placement and compaction of fill material must be observed, monitored, and tested by LFE on a full-time basis.

Select Fill: Select Fill should meet the requirements of 2004 TxDOT Item 247, Type A, Grade 3 or better. If another local source of select fill is desired, the following specification may be used as a guide:

Maximum Aggregate:	3 inches
Percent Retained on #4 Sieve:	25 - 50
Percent Retained on #40 Sieve:	50 - 75
Plasticity Index:	5 - 15
Non-Organic	

Please note that locally available "red fill" is generally acceptable for use as select fill below the building, provided that these materials are confined by grade beams. However, red fill is highly variable and will require evaluation by LFE on a case-by-case basis. Some contractor's use a layer of crushed limestone base on the top of the pad to provide a better surface during wet weather.

The select fill material should be compacted to at least 95 percent of ASTM D698 (or TEX-113-E) maximum dry density at ±3% of the optimum moisture content. A maximum compacted lift thickness of six inches must be specified, with each lift tested for compliance prior to the addition of subsequent lifts. The placement and compaction of fill material must be observed, monitored, and tested by LFE on a full-time basis.

Foundation: Foundation and drilled shaft construction recommendations are listed below.

1. A minimum pier shaft diameter of 24 inches is normally specified to allow for cleaning, minimum construction tolerances, and conventional concrete mix designs. Smaller diameters may be used at the discretion of the structural engineer.

2. The foundation construction must be observed by LFE to determine that the proper bearing material has been reached in accordance with the recommendations given herein.

3. Prior to the placement of concrete, water must be removed from the foundation excavations. Prolonged exposure or inundation of the bearing surface with water may result in changes in bearing strength and compressibility characteristics. If delays occur, the footing and/or drilled shaft excavations should be deepened and cleaned, in order to provide a fresh bearing surface.

4. Concrete must be placed promptly after the excavations are completed, cleaned, and observed. Drilled piers must be concreted before the end of the work day.

5. The reinforcement steel cage placed in the shaft must be designed from the standpoint of meeting at least the following two requirements: (1) the structural requirements for the imposed loads including uplift; and (2) stability requirements during the placement of concrete.

6. Groundwater was measured at a depth of 17.5 feet below the ground surface at Boring No. F-1, but was not observed in the other borings. Temporary steel casing may be required to seal out groundwater or prevent the pier holes from caving. Special concrete design and construction procedures as described in ACI 336.1 and ACI 336.3R should be specified in order to properly extract the casing during concrete placement. The pier concrete should be placed at a minimum slump of 6 inches when temporary steel casing is used. We advise that the bid schedule include installation of temporary casing as a separate unit-price bid item.

8.0 PAVEMENT RECOMMENDATIONS

Pavement: New pavement will be constructed, and will consist primarily of parking areas and drive lanes for light vehicles. However, heavy-duty pavement will be needed in some areas for delivery trucks and trash trucks.

Risk: Pavement design methods are intended to provide an adequate thickness of structural materials over the subgrade to support the wheel loads. Design methods do not account for shrink and swell movements of expansive clays, nor do design methods account for settlement of randomly placed fill materials. *The pavement may be adequate from a structural standpoint, yet still experience cracking due to movement of the subgrade.* It is critical to minimize moisture changes in the subgrade to reduce shrink/swell movements.

The pavement and adjacent areas must be well drained. Proper maintenance must be performed on cracks in the pavement surface to prevent water passing through to the base or subbase material. Extending the base material out about 2 feet from the edge of the pavement curb will also aid in reducing edge related cracking. Even with these precautions, some movements and related cracking may still occur. Routine maintenance is essential.

Using lime stabilization or geogrids will help reduce damage from expansive clay soils, but will usually increase the cost of the initial pavement installation. In the long-term, it has been our experience that using either lime or geogrids reduces maintenance costs and extends the pavement life.

Pavement "islands" often provide a means of water infiltration into the base and subgrade materials below the pavement. If islands are used, then we recommend that a synthetic lining or clay soils be used to limit infiltration of water into the base and subgrade. Water entry into the base and subgrade will cause softening of the materials, and will cause potholes and/or ruts to form.

The presence of trees and vegetation adjacent to paved areas will exacerbate the formation of cracks in pavements due to moisture loss in the subgrade from transpiration to the root systems of the vegetation. Soil moisture loss from vegetation can extend a distance from the vegetation about equal to its height. ***In general, concrete pavements perform better than asphalt pavements on expansive clay sites.***

Traffic Types: We anticipate that traffic will consist of light vehicles throughout the site, but trucks will be restricted to designated areas. Because traffic data was not available for this project, we have made assumptions based on past experience and traffic criteria used for other projects. These estimates should be reviewed by the owner because the traffic information has an impact on the pavement thickness and future performance.

Traffic Loads: For pavement design purposes, traffic volumes are expressed as the number of Equivalent 18-kip single axle load applications (ESAL) over a 20 year theoretical pavement design life. We have summarized values for three primary traffic conditions in Table 8.1.

We have computed the approximate types and volumes of different vehicles to aid in the owner's evaluation of the intended uses of the pavements.

TABLE 8.1: TRAFFIC ESTIMATES

Traffic Area	Typical Traffic	ESAL's	Reference Table
Light Parking	Light cars and trucks, no heavy vehicles, similar to a low volume residential street.	20,000	Table 8.2A
Drive Lanes	Light cars and trucks, no heavy vehicles, similar to a moderate volume residential street.	60,000	Table 8.2B
Trucks	Semi-Trailer and/or Trash Trucks	100,000	Table 8.2C

TABLE 8.2A: ESTIMATED TRAFFIC CHARACTERISTICS (20,000 ESAL'S – LIGHT VEHICLE PARKING)		
Vehicle Type	***Gross Vehicle Weight (lbs)***	***Vehicles per Day***
Cars	4,000	2,000
Pickup Trucks	7,000	300
Semi-Trailer Trucks	80,000	0

TABLE 8.2B: ESTIMATED TRAFFIC CHARACTERISTICS (60,000 ESAL'S – DRIVE LANES)		
Vehicle Type	***Gross Vehicle Weight (lbs)***	***Vehicles per Day (per lane)***
Cars	4,000	5,000
Pickup Trucks	7,000	1,000
Semi-Trailer Trucks	80,000	0

TABLE 8.2C: ESTIMATED TRAFFIC CHARACTERISTICS (100,000 ESAL'S – TRUCK AREAS)		
Vehicle Type	***Gross Vehicle Weight (lbs)***	***Vehicles per Day (per lane)***
Cars	4,000	2,000
Pickup Trucks	7,000	1,000
Trash Trucks	46,000	1
Semi-Trailer Trucks	80,000	1

Subgrade:	Based on the subsurface materials observed at the boring locations, the primary subgrade at this site will consist primarily of either fat clay or lean clay. However, it is possible that severely weathered limestone may be exposed at the subgrade level in some areas. A resilient modulus value of 3,200 psi has been assigned to the clay subgrade based correlations between soil index properties and resilient modulus values. Severely weathered limestone has a higher resilient modulus, but the clay value was used to simplify the design and construction process.
Design Method:	AASHTO and American Concrete Association guidelines.
Thickness:	Pavement thickness designs are provided in Tables 8.3A, 8.3B, and 8.3C. A reliability value of 80 percent was assigned to the pavement that corresponds to occasional interruption of traffic for pavement repairs. These designs reflect a theoretical "Design Life" of 20 years and are subject to the previously described assumptions. The "design life" of a pavement is defined as the expected life at the end of which reconstruction of the pavement will need to occur. Normal maintenance, including crack sealing, slurry sealing, and/or chip sealing, should be performed during the life of the pavement.

TABLE 8.3A: PAVEMENT THICKNESS RECOMMENDATIONS LIGHT PARKING AREAS- 20,000 ESAL'S			
Traffic Area	**Pavement Type**	**Surface Course**	**Base Course**
Light Parking Areas	Asphalt	1.5" Type C or D	6" CTB and 6" LSS*
	Asphalt	1.5" Type C or D	8" CLB and GRID
	Reinforced Concrete	5" RCP	6" CTB or 6" CLB

Type C or D- Hot Mix Asphalt, TxDOT

CTB… Cement Treated Base

LSS… Lime Stabilized Subgrade

CLB… Crushed Limestone Base

GRID… Tensar TX130S Geogrid

RCP… Reinforced Concrete Pavement

*Lime stabilization for asphalt pavement is not critical for structural support of the pavement, but is recommended due to the presence of fat clay soils. Lime stabilization will help reduce heave and cracking in the pavement, which will promote a longer service life.

TABLE 8.3B: PAVEMENT THICKNESS RECOMMENDATIONS DRIVE LANES- 60,000 ESAL'S			
Traffic Area	**Pavement Type**	**Surface Course**	**Base Course**
Medium Duty Drive Lanes	Asphalt	2.5" Type C or D	6" CTB and 6" LSS*
	Asphalt	2.5" Type C or D	8" CLB and GRID
	Reinforced Concrete	5" RCP	6" CTB or 6" CLB

Type C or D- Hot Mix Asphalt, TxDOT

CTB… Cement Treated Base

LSS… Lime Stabilized Subgrade

CLB… Crushed Limestone Base

GRID… Tensar TX130S Geogrid

RCP… Reinforced Concrete Pavement

*Lime stabilization for asphalt pavement is not critical for structural support of the pavement, but is recommended due to the presence of fat clay soils. Lime stabilization will help reduce heave and cracking in the pavement, which will promote a longer service life.

TABLE 8.3C: PAVEMENT THICKNESS RECOMMENDATIONS TRUCK ACCESS- 100,000 ESAL'S			
Traffic Area	**Pavement Type**	**Surface Course**	**Base Course**
Heavy Duty Trucks	Asphalt	3" Type C or D	6" CTB and 6" LSS*
	Asphalt	3" Type C or D	8" CLB and GRID
	Reinforced Concrete	6" RCP	6" CTB or 6" CLB

Type C or D- Hot Mix Asphalt, TxDOT

CTB… Cement Treated Base

LSS… Lime Stabilized Subgrade

CLB… Crushed Limestone Base

GRID… Tensar TX130S Geogrid

RCP… Reinforced Concrete Pavement

*Lime stabilization for asphalt pavement is not critical for structural support of the pavement, but is recommended due to the presence of fat clay soils. Lime stabilization will help reduce heave and cracking in the pavement, which will promote a longer service life.

Subgrade Delineation: Depending on the cuts/fills in the pavement areas, the subgrade will vary from fat clay to lean clay to severely weathered limestone. The areas that consist of fat clay or lean clay will benefit from using lime to stabilize the subgrade.

Lime stabilization for asphalt pavements is not critical for structural support of the pavements, but is recommended. Lime stabilization will help reduce heave and cracking in the pavement, and will promote a longer service life. Once rough cutting is completed, we can delineate those areas that will benefit from lime.

CTB: Cement Treated Base (CTB) is essentially weak concrete. It offers relatively high strength, and generally performs better than other base materials such as crushed limestone when exposed to water. Although the use of cement in the base material produces a material of superior structural performance as compared to untreated base material, the addition of cement also produces a material subject to shrinkage and cracking as the base matures. These cracks will propagate to the surface of asphalt pavements and will require crack sealing, possibly soon after completion of the pavement installation.

One method to reduce reflective cracking is a procedure termed "pre-cracking". The concept of pre-cracking is to induce multiple microcracks instead of occasional transverse cracks. After placement and compaction, the CTB must be kept continuously moist for 24 to 48 hours. The pre-cracks are created either one or two days after construction using a 10 to 12 ton vibratory roller with the vibrator set on the maximum amplitude and traveling at a speed of about 2 mph. Usually, two vibratory rolling passes are sufficient to generate the microcracks.

Specifications: Pavement specifications. TxDOT citations below reference the 2004 Edition unless stated otherwise.

1. Hot Mix Asphaltic Concrete (HMAC): TxDOT Item 340, Type C or D.
2. Reinforced Concrete Pavement (RCP): TxDOT Item 360, Concrete Pavement. The concrete class should be specified as Class P in accordance with TxDOT Item 421, Portland Cement Concrete with the exception that the strength criterion may be modified to 3,600 psi at 28 days. Usually, sawcut joints are placed at 10-ft to 15-ft intervals, with expansions joints at 50-ft to 100-ft spacings. Reinforcement often consists of #4 or #5 bars placed at 12-in to 16-in intervals in each direction. The project Civil Engineer should use their discretion to decide on the joint and reinforcement details, and should follow ACI recommended practices. When sawcut joints are used, the cuts must be made within a few hours of concrete placement. Sawcuts must not be delayed to the following day.
3. Cement Treated Base (CTB): City of Waco Specifications.
4. Crushed Limestone Base (CLB): TxDOT Item 247, Type A, Grade 1 or 2. Compact to at least 95% of ASTM D1557 (or 100% of TEX-113) at a moisture content range of -3% to +3% of optimum moisture content in 6-inch compacted lifts.
5. Lime Stabilized Subgrade (LSS)- TxDOT Item 260, with a lime solids application rate of at least 6 percent by dry soil unit weight. This will result in an application rate of approximately 28 pounds of lime per square yard for a 6 inch lift. The LSS should be compacted in a 6-inch compacted thickness to at least 95% of ASTM D698 (or TEX-113-E) maximum dry density within 0% to +3% of optimum moisture content. Only liquid lime should be used to avoid harmful dust generation.

6. Subgrade: The subgrade should be scarified to a depth of 6 inches and then compacted to at least 95% of ASTM D698 (or TEX-113-E) maximum dry density at a moisture content range of 0% to +3% of optimum moisture content. Fill material should be placed in 6-inch compacted lifts.

7. Transitions from an asphalt pavement to a rigid pavement are often problematic in that over time a depression usually forms in the asphalt at the joint. This is caused when vehicle tires pass from the rigid concrete pavement to the flexible asphalt pavement. One method to reduce this effect is to continue a “lip” of concrete under the asphalt.

8. The pavement must have positive drainage, and water must not pond in areas directly adjoining paved sections.

9.0 DESIGN REVIEW AND LIMITATIONS

Design Review: The recommendations contained in this report were based on preliminary site plans and design information provided by the Client. Our recommendations may not be applicable if changes have been made to the original information that formed the basis for this report, and we must be retained to make such a determination if such changes have been made. We also must be given the opportunity to review construction documents to affirm that our recommendations have been interpreted correctly. We cannot be responsible for misinterpretations if not given the opportunity to review aspects of the project that are based on the contents of this report. Such a review is considered an additional service.

Limitations: This report has been prepared for the exclusive use of our client and their designated project design team. Preparation of the report has been performed using that degree of care and skill ordinarily exercised under similar conditions by reputable geotechnical engineers practicing in the same locality. No warranties, express or implied, are intended or made.

As stated in the attachment "Important Information About Your Geotechnical Engineering Report", the subsurface conditions are interpreted from samples taken only at the boring locations. During construction, variations will be encountered, and will require interpretation by LFE to verify the adequacy of the geotechnical recommendations. Other concerns and limitations are discussed in the attachment.

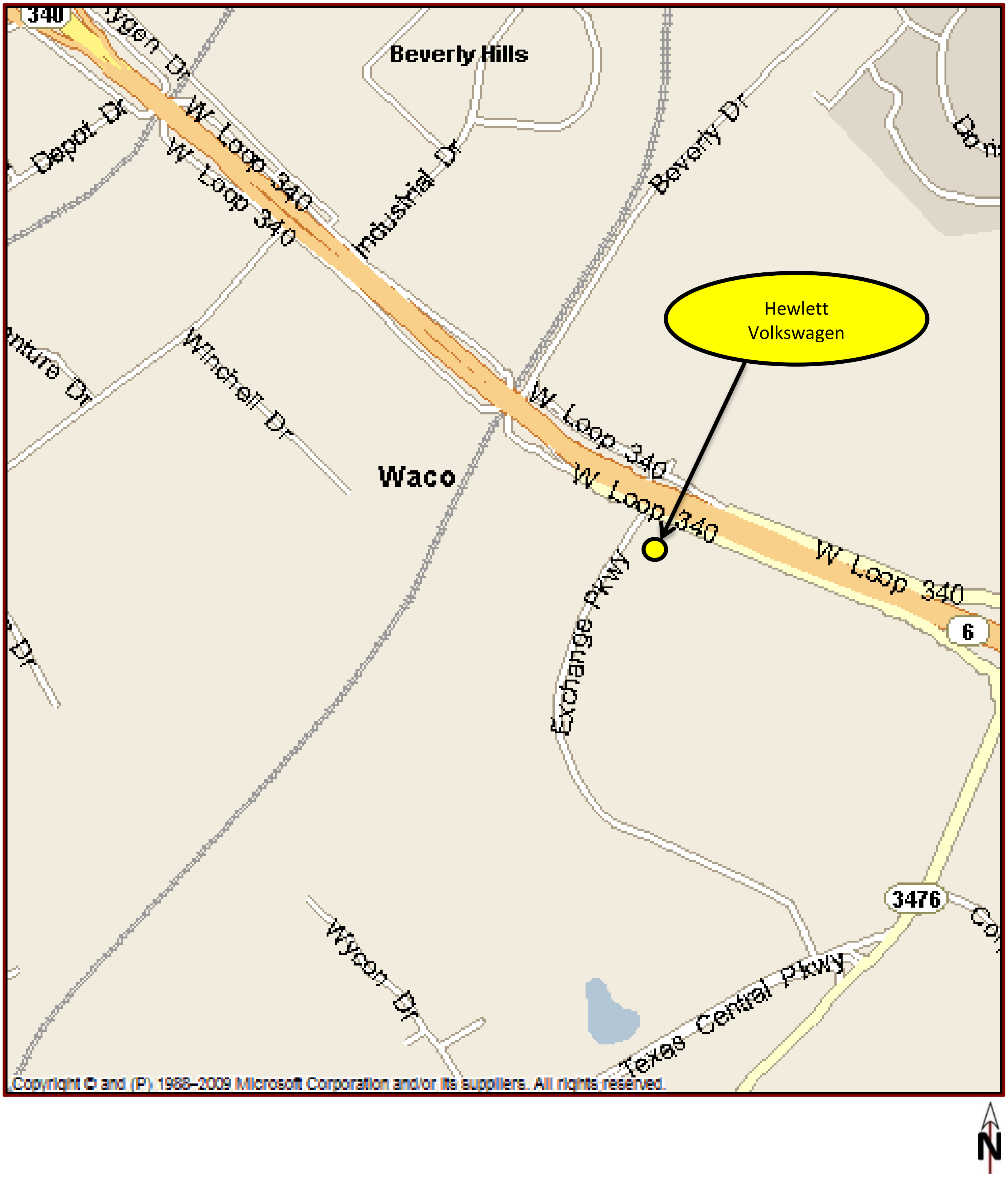
This investigation did not include environmental testing or evaluations, and does not address whether landfilling operations, as defined by the State of Texas, have occurred on the property. An environmental professional should be retained to address environmental issues.

10.0 REFERENCES:

1. Geologic Atlas of Texas, Waco Sheet, Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas 1970.

APPENDIX

Site Location Map
Boring Location Sketch
Laboratory Test Results
Boring Logs
Important Information about Your Geotechnical Engineering Report



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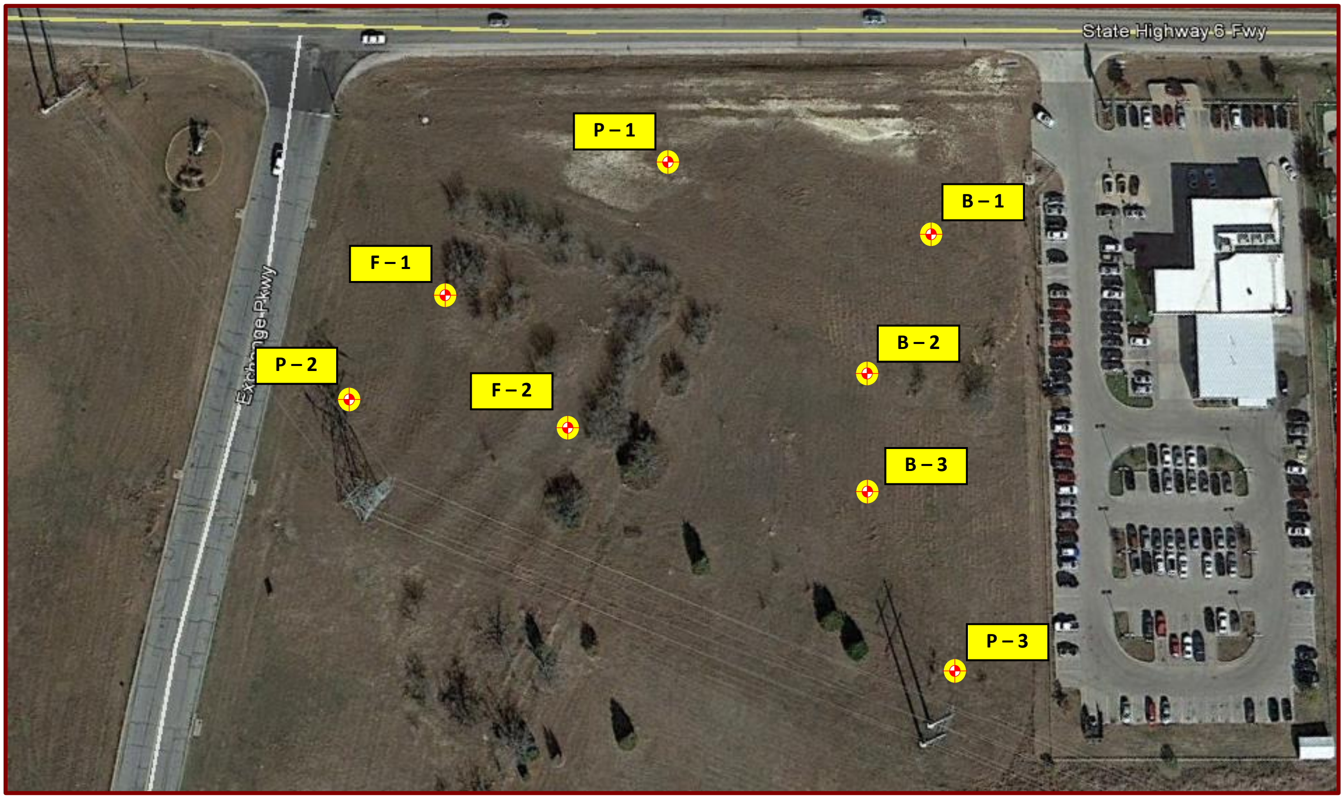
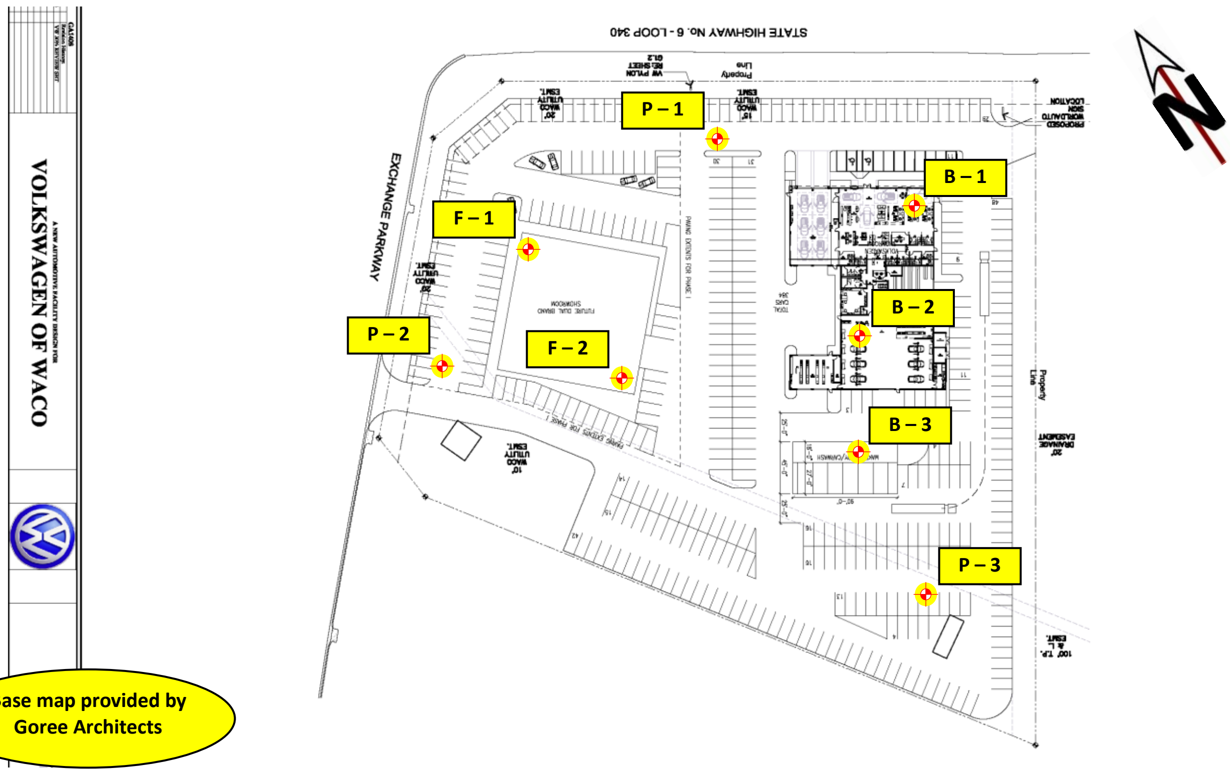
SITE LOCATION MAP	PLATE
HEWLETT VOLKSWAGEN WACO, TEXAS LFE PROJECT NO. W14-024	1





Base map provided by Goree Architects

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BORING LOCATION SKETCH

HEWLETT VOLKSWAGEN
WACO, TEXAS
LFE PROJECT NO. W14-024

PLATE

2

Boring No.	Sample Depth (ft.)	Liquid Limit	Plastic Limit	Plasticity Index	Percent Passing No. 200 Sieve	Moisture Content (%)	Unit Dry Weight (pcf)	Unconfined Compressive Strength (tsf)	Strain at Failure (%)
B-1	2.0 - 4.0	52	20	32	86	18			
B-1	4.0 - 6.0				75	18			
B-1	6.5 - 8.0				91	34			
B-1	21.5 -							26.3	1.6
B-1	24.0 -							28.6	1.6
B-2	0.0 - 2.0	43	19	24	85	13			
B-2	4.5 - 5.4				92	20			
B-2	21.5 -							21.8	1.5
B-2	23.5 -							32.5	1.9
B-3	0.0 - 2.0	52	21	31	93	16			
B-3	4.5 - 5.8				86	17			
B-3	23.0 -							27.8	2.2
B-3	24.5 -							30.5	1.9
F-1	0.0 - 2.0	43	17	26	89	14			
F-1	2.0 - 4.0	44	20	24	94	16			
F-1	4.0 - 6.0				96	18			
F-1	21.0 -							22.5	2.2
F-1	24.7 -							14.4	2.1
F-2	0.0 - 2.0	53	20	33	92	16			
F-2	2.5 - 3.5				50	11			
F-2	21.5 -							26.8	2.0
F-2	24.0 -							34.4	2.7
P-1	0.0 - 2.0	47	20	27	77	9			
P-1	2.0 - 4.0				73	13			
P-2	0.0 - 2.0					10	110.6	2.4	3.0
P-2	2.0 - 4.0	60	22	38	96	24			
P-3	0.0 - 2.0	57	22	35	87	16			
P-3	2.0 - 4.0					22	101.6	2.2	2.5

LANGERMAN FOSTER ENGINEERING COMPANY

Summary of Laboratory Results

Project: Hewlett Volkswagen

Project Number: W14-024

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2000 South 15th Street
Waco, Texas 76706
Telephone: 254-235-1048

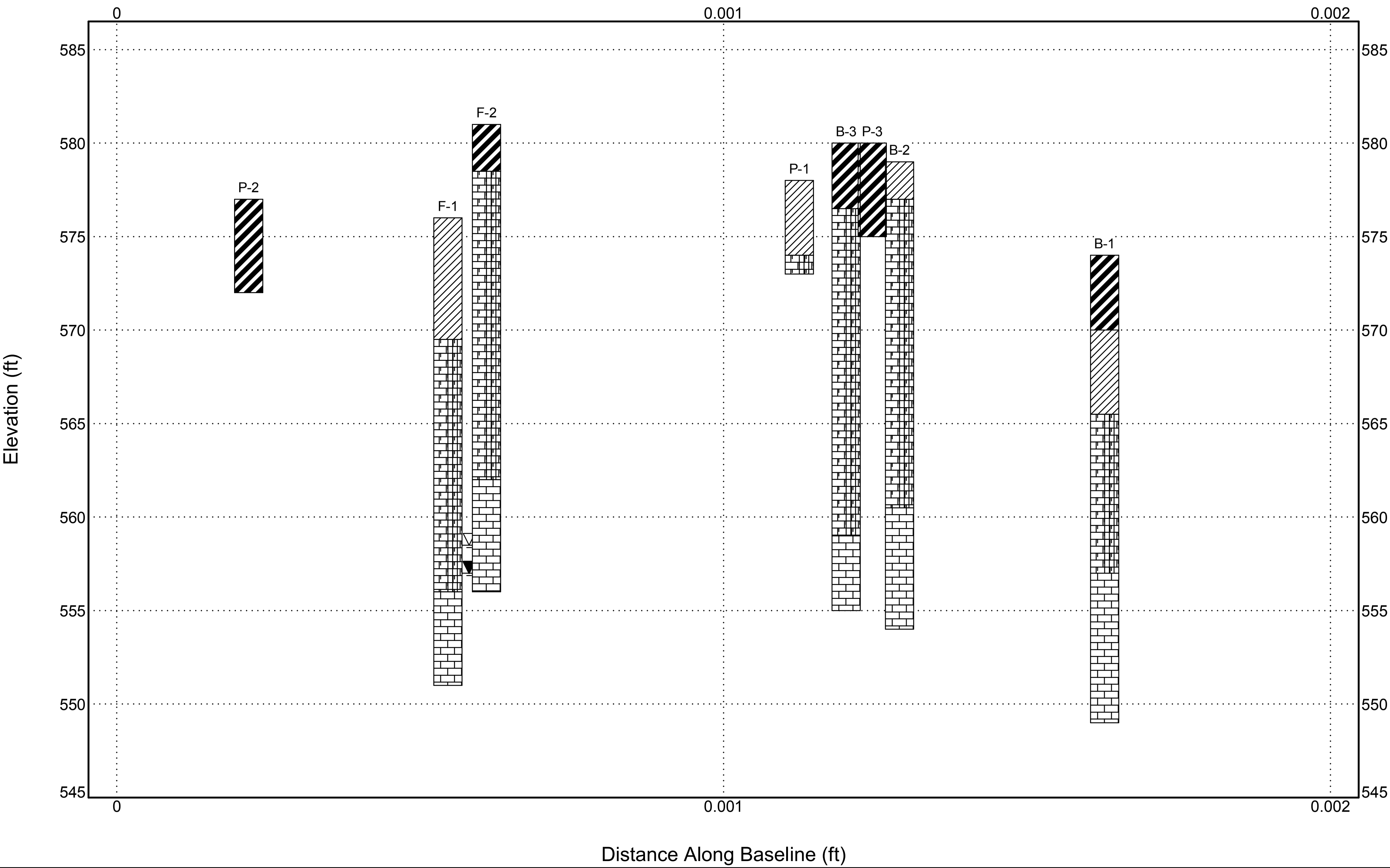
SUBSURFACE DIAGRAM

CLIENT Chasco Constructors

PROJECT NUMBER W14-024

PROJECT NAME Hewlett Volkswagen

PROJECT LOCATION Waco, Texas



SUBSURFACE DIAGRAM

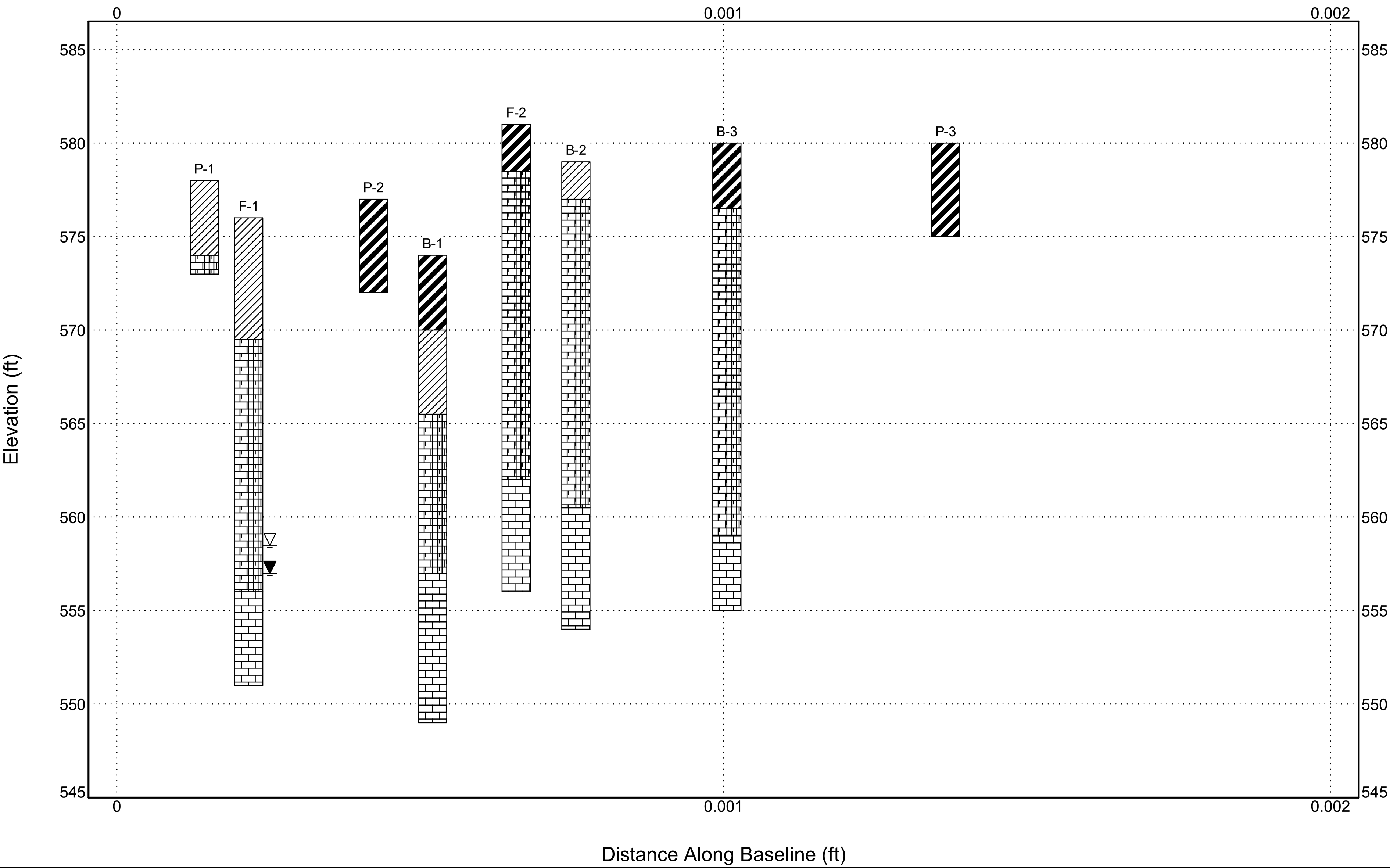
Langerman Foster Engineering Company
2000 South 15th Street
Waco, Texas 76706
Telephone: 254-235-1048

CLIENT Chasco Constructors

PROJECT NUMBER W14-024

PROJECT NAME Hewlett Volkswagen

PROJECT LOCATION Waco, Texas



Langerman Foster Engineering Company
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BORING NO. B-1

CLIENT Chasco Constructors
PROJECT NAME Hewlett Volkswagen
PROJECT NUMBER W14-024
PROJECT LOCATION Waco, Texas

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	STRAIN AT FAILURE (%)
0		Approximate Surface Elevation 574 feet												
		FAT CLAY; dark brown, with limestone fragments	ST			4.5+								
		570.0	ST			4.5+	52	20	32	86	18			
5		LEAN CLAY; gray-tan to tan, with limestone fragments	ST			4.5				75	18			
			A											
			SS		17-20-31 (51)					91	34			
		565.5	A											
		SEVERELY WEATHERED LIMESTONE; tan, consists of a mixture of broken rock and silty clay	SS		50/6"									
10			A											
			SS		50/2"									
			A											
			SS		50/3"									
15		557.0	A											
		LIMESTONE; gray, fractured, with marly clay layers	SS		50/1"									
20			A											
			RC	82 (80)									26.3	1.6
													28.6	1.6
25		549.0												

Completion Depth: 25 ft.
Date Started: 5/7/14
Completed: 5/7/14
Logged by: HW drilling

Remarks: Boring was advanced to a depth of 20 feet before using compressed air in the rock core drilling process. Groundwater was not observed above that depth.

Langerman Foster Engineering Company
2000 South 15th Street
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Telephone: 254-235-1048

BORING NO. B-2

CLIENT Chasco Constructors | **PROJECT NAME** Hewlett Volkswagen

PROJECT NUMBER W14-024 | **PROJECT LOCATION** Waco, Texas

DEPTH (ft)	MATERIAL DESCRIPTION	Elev.	SAMPLE TYPE	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (%)	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	STRAIN AT FAILURE (%)
0	Approximate Surface Elevation 579 feet													
	LEAN CLAY; dark brown, with limestone fragments	577.0	ST			4.5+	43	19	24	85	13			
	SEVERELY WEATHERED LIMESTONE; tan, consists of a mixture of broken rock and silty clay		ST											
			SS		50/6"									
			A											
5			SS		21-50/5"					92	20			
			A											
			SS		50/5"									
			A											
			SS		50/1"									
10			A											
			SS		17-21-22 (43)									
			A											
			SS		50/2"									
15			A											
		560.5												
	LIMESTONE; gray, fractured, with marly clay layers		SS		50/2"									
			A											
20														
													21.8	1.5
			RC	84 (58)										
													32.5	1.9
25		554.0												

Completion Depth: 25 ft.
Date Started: 5/7/14
Completed: 5/7/14
Logged by: HW drilling

Remarks: Boring was advanced to a depth of 20 feet before using compressed air in the rock core drilling process. Groundwater was not observed above that depth.

Langerman Foster Engineering Company
2000 South 15th Street
Waco, Texas 76706
Telephone: 254-235-1048

BORING NO. B-3

CLIENT Chasco Constructors **PROJECT NAME** Hewlett Volkswagen

PROJECT NUMBER W14-024 **PROJECT LOCATION** Waco, Texas

Approximate Surface Elevation 580 feet

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	STRAIN AT FAILURE (%)
0	FAT CLAY; dark brown, with limestone fragments	ST			4.5+	52	21	31	93	16			
	576.5	ST			4.5								
	SEVERELY WEATHERED LIMESTONE; tan, consists of a mixture of broken rock and silty clay	A											
5		SS		19-32-50/3"					86	17			
		A											
		SS		39-50/6"									
		A											
		SS		50/2"									
10		A											
		SS		50/5"									
		A											
		SS		50/3"									
15		A											
		SS		50/3"									
20		A											
	559.0												
	LIMESTONE; gray, fractured, with marly clay layers	RC	74 (60)									27.8	2.2
25	555.0											30.5	1.9

Completion Depth: 25 ft.
Date Started: 5/7/14
Completed: 5/7/14
Logged by: HW drilling

Remarks: Boring was advanced to a depth of 20 feet before using compressed air in the rock core drilling process. Groundwater was not observed above that depth.

Langerman Foster Engineering Company
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BORING NO. F-1

CLIENT Chasco Constructors

PROJECT NAME Hewlett Volkswagen

PROJECT NUMBER W14-024

PROJECT LOCATION Waco, Texas

Approximate Surface Elevation 576 feet

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	ATTERBERG LIMITS LIQUID LIMIT	ATTERBERG LIMITS PLASTIC LIMIT	ATTERBERG LIMITS PLASTICITY INDEX	FINES CONTENT (%)	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	STRAIN AT FAILURE (%)
0	LEAN CLAY; brown, with limestone fragments	ST			4.5+	43	17	26	89	14			
	--- tan below 2 feet	ST			4.5+	44	20	24	94	16			
5		ST			4.5+				96	18			
	569.5	A											
	SEVERELY WEATHERED LIMESTONE; tan, consists of a mixture of broken rock and silty clay	SS		50/4"									
		A											
		SS		20-50/6"									
10		A											
		SS		50/2"									
		A											
15		SS		50/6"									
		A											
		SS		50/2"									
20	556.0	A											
	LIMESTONE; gray, fractured, with marly clay layers	RC	86 (78)									22.5	2.2
25	551.0											14.4	2.1

Completion Depth: 25 ft.
Date Started: 5/7/14
Completed: 5/7/14
Logged by: HW drilling

Remarks: Boring was advanced to a depth of 20 feet before using compressed air in the rock core drilling process. Groundwater was observed at a depth of 19 feet. After a 10 minute observation period, the groundwater level rose to 17.5 feet.

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Waco, Texas 76706
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BORING NO. F-2

CLIENT Chasco Constructors **PROJECT NAME** Hewlett Volkswagen

PROJECT NUMBER W14-024 **PROJECT LOCATION** Waco, Texas

DEPTH (ft)	MATERIAL DESCRIPTION	ELEV.	SAMPLE TYPE	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	STRAIN AT FAILURE (%)
0	Approximate Surface Elevation 581 feet													
	FAT CLAY; dark brown, with limestone fragments		ST			4.5	53	20	33	92	16			
		578.5	ST											
	SEVERELY WEATHERED LIMESTONE; tan, consists of a mixture of broken rock and silty clay		SS		31-50/5"					50	11			
			A											
5			SS		50/3"									
			A											
			SS		50/3"									
			A											
			SS		50/6"									
10			A											
			SS		50/3"									
			A											
15			SS		30-50/3"									
			A											
		562.0	SS		50/3"									
20	LIMESTONE; gray, fractured, with marly clay layers		A											
			RC	98 (74)									26.8	2.0
													34.4	2.7
25		556.0												

Completion Depth: 25 ft.
Date Started: 5/7/14
Completed: 5/7/14
Logged by: HW drilling

Remarks: Boring was advanced to a depth of 20 feet before using compressed air in the rock core drilling process. Groundwater was not observed above that depth.

Langerman Foster Engineering Company
2000 South 15th Street
Waco, Texas 76706
Telephone: 254-235-1048

BORING NO. P-1

CLIENT Chasco Constructors | **PROJECT NAME** Hewlett Volkswagen

PROJECT NUMBER W14-024 | **PROJECT LOCATION** Waco, Texas

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	STRAIN AT FAILURE (%)
0		Approximate Surface Elevation 578 feet												
		LEAN CLAY; tan, with limestone fragments	ST			4.5+	47	20	27	77	9			
			ST			4.5				73	13			
		574.0												
5		SEVERELY WEATHERED LIMESTONE; tan, consists of a mixture of broken rock and silty clay 573.0	SS		13-50/6"									

Completion Depth: 5 ft.
Date Started: 5/7/14
Completed: 5/7/14
Logged by: HW drilling

Remarks: Boring was advanced to a depth of 5 feet using dry drilling techniques. Groundwater was not observed above that depth.

Langerman Foster Engineering Company
2000 South 15th Street
Waco, Texas 76706
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BORING NO. P-2

CLIENT Chasco Constructors
PROJECT NAME Hewlett Volkswagen
PROJECT NUMBER W14-024
PROJECT LOCATION Waco, Texas

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	STRAIN AT FAILURE (%)
0		Approximate Surface Elevation 577 feet												
		FAT CLAY; dark brown, with limestone fragments	ST			4.5+					10	111	2.4	3.0
			ST			4.5+	60	22	38	96	24			
5		572.0	ST			4.5								

Completion Depth: 5 ft.
Date Started: 5/7/14
Completed: 5/7/14
Logged by: HW drilling

Remarks: Boring was advanced to a depth of 5 feet using dry drilling techniques. Groundwater was not observed above that depth.

Langerman Foster Engineering Company
2000 South 15th Street
Waco, Texas 76706
Telephone: 254-235-1048

BORING NO. P-3

CLIENT Chasco Constructors

PROJECT NAME Hewlett Volkswagen

PROJECT NUMBER W14-024

PROJECT LOCATION Waco, Texas

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	STRAIN AT FAILURE (%)
0		Approximate Surface Elevation 580 feet												
		FAT CLAY; dark brown, with limestone fragments	ST			4.5+	57	22	35	87	16			
			ST			4.5+					22	102	2.2	2.5
5		575.0	ST			4.5								

Completion Depth: 5 ft.
Date Started: 5/7/14
Completed: 5/7/14
Logged by: HW drilling

Remarks: Boring was advanced to a depth of 5 feet using dry drilling techniques. Groundwater was not observed above that depth.

Important Information about Your

Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely on Your ASFE-Member Geotechnical Engineer for Additional Assistance

Membership in ASFE/The Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with your ASFE-member geotechnical engineer for more information.

ASFE THE GEOPROFESSIONAL BUSINESS ASSOCIATION

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