THE COUNTY OF GALVESTON

RUFUS G. CROWDER, CPPO, CPPB
PURCHASING AGENT

COUNTY COURTHOUSE
722 Moody (21st Street)
Fifth (5th) Floor
GALVESTON, TEXAS 77550

October 6, 2023

PROJECT NAME: **Algoa/Alta Loma Culvert Replacement**

SOLICITATION NO: **ITB #B231027**

Re: **ADDENDUM #1**

To All Prospective Bidders:

The following information is being provided to aid in the preparation of your ITB submittal(s):

Question #1: ***Is there a Geotech available?***

Response: Attached you will find the requested information.

If you have any further questions regarding this bid, please address them to the representative listed below, via e-mail at purchasing.bids@co.galveston.tx.us, or contact the Purchasing Department at (409) 770-5371.

Rufus G. Crowder, CPPO CPPB
Galveston County Purchasing Agent
722 Moody, Fifth (5th) Floor
Galveston, Texas 77550
E-mail: purchasing.bids@co.galveston.tx.us

Please excuse us for any inconvenience that this may have caused.

Sincerely,

Rufus G. Crowder, CPPO CPPB
Purchasing Agent
Galveston County

Geotechnical Evaluation

Algoa/Alta Loma Culvert Replacements
Multiple Locations

Galveston County, Texas

Schaumburg & Polk, Inc.

11767 Katy Freeway, Suite 900 | Houston, Texas 77079

August 18, 2022 | Project No. 701307001

Environmental | Construction Inspection & Testing | Forensic Engineering & Expert Witness

Geophysics | Engineering Geology | Laboratory Testing | Industrial Hygiene | Occupational Safety | Air Quality | GIS

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CELEBRATING 35 YEARS

August 18, 2022
Project No. 701307001

Mr. Mark Dessens, PE
Schaumburg & Polk, Inc.
11767 Katy Freeway, Suite 900
Houston, Texas 77079

Subject: Geotechnical Evaluation
Algoa/Alta Loma Culvert Replacements
Multiple Locations
Galveston County, Texas

Dear Mr. Dessens:

The attached report presents our methodology, findings, geotechnical considerations, and recommendations for design and construction for the planned culvert replacements.

We appreciate the opportunity to be of service to you during this phase of the project.

Sincerely,
NINYO & MOORE
TBPE Firm No. F-9782

Jeffrey S. Rodgers

Jeffrey S. Rodgers, PE, PG
Principal Engineer

STATE OF TEXAS
JEFFREY S. RODGERS
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PROFESSIONAL ENGINEER
8/18/2022

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Jay T. Sunderwala, PE
Managing Principal Engineer

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1 INTRODUCTION

In accordance with our proposal dated January 18, 2022 and the Agreement Between Engineer and Consultant for Professional Services dated April 1, 2022, Ninyo & Moore has performed a geotechnical evaluation for the proposed culvert replacements in Galveston County, Texas (Figure 1). The purpose of our evaluation was to assess the subsurface conditions at the site to provide geotechnical recommendations for the design and construction of the project. This report presents the results of our evaluation, geotechnical considerations, and geotechnical design and construction recommendations for the planned culvert replacements.

2 SCOPE OF SERVICES

Our scope of services included the following:

- Reviewing readily available aerial photographs and published geologic literature, including maps and reports pertaining to the project site and vicinity.
- Performing a visual reconnaissance of the site, marking out boring locations, and notifying Texas811 of the boring locations prior to drilling.
- Drilling, logging, and sampling six exploratory soil borings to depths ranging from about 15 to 20 feet below the existing ground surface (bgs).
- Performing laboratory tests on selected samples obtained from our borings to evaluate the in-situ moisture content, percent passing the No. 200 sieve, Atterberg limits, and shear strength.
- Compiling the collected data and performing engineering analyses.
- Preparing this report presenting our findings, conclusions, and recommendations regarding the design and construction of the project.

Our scope of services did not include environmental consulting services such as hazardous waste sampling or analytical testing at the site. In addition, a fault study was beyond the scope of this study. If needed, a scope and fee for these services can be provided.

3 SITE DESCRIPTION

The project sites consist of existing culverts that are planned to be replaced. The site locations are shown on Figure 2 and summarized below in Table 1.

Table 1 – Culvert Replacement Locations	
Location	**Boring No.**
Rymal Road, North of McKay Road	B-1
Pearson Road, West of Cedar Road	B-2
Pearson Road, South of Cedar Road	B-3
Gamble Road, East of Pearson Road	B-4
Highland Road, South of Gamble Road	B-5
Highland Road, North of 28th Street	B-6

At the time of our evaluation, the areas of proposed construction at each site were occupied by existing asphaltic concrete pavements and culverts. Based on the *United States Geological Survey (USGS) Algoa and Mustang Bayou, Texas 7.5 Minute Topographic Quadrangle Map (2019),* the elevation of the sites ranges from approximately 20 to 25 feet relative to mean sea level (MSL). The regional topography in the vicinity of the sites is relatively flat.

4 PROPOSED CONSTRUCTION

The project consists of the design and construction of new culverts in Galveston County, Texas. We understand a total of nine culvert locations will be reconstructed, however, we have been requested to provide geotechnical recommendations only at six locations, where culverts are larger than 30 inches in diameter. The location and proposed improvements are summarized below in Table 2.

Table 2 – Proposed Culvert Replacements		
Site Location	**Existing Culverts**	**Proposed Culverts**
Rymal Road, North of McKay Road	3 - 80" Multiple Pipe (MP)	2 – 8' x 7' Reinforced Box Culvert (RCB)
Pearson Road, West of Cedar Road	3 - 36" Reinforced Concrete Pipe (RCP)	2 – 5' x 4' RCB
Pearson Road, South of Cedar Road	3 - 36" RCP	2 – 5' x 4' RCB 2 – 5' x 4' RCB
Gamble Road, East of Pearson Road	1 - 80" MP	1 – 8' x 6' RCB
Highland Road, South of Gamble Road	4 - 80" MP	3 – 8' x 6' RCB
Highland Road, North of 28th Street	2 - 42" RCP	2 – 60" Arch (45" x 73") RCP

5 FIELD EXPLORATION

On April 12, 2022, Ninyo & Moore performed a subsurface exploration at the sites to evaluate the subsurface conditions and collect soil samples for laboratory testing. Our evaluation consisted of drilling, logging, and sampling six exploratory soil borings, designated as B-1 through B-6 (Figure 2). The borings were drilled in the existing roadways adjacent to the culverts. The borings were drilled with an all-terrain vehicle (ATV)-mounted drill rig equipped with straight-flight augers. The location and planned drilling depth for each boring are summarized below in Table 3.

Table 3 – Boring Locations and Depth

Location	Boring No.	Depth per Boring (feet)
Rymal Road, North of McKay Road	B-1	20
Pearson Road, West of Cedar Road	B-2	15
Pearson Road, South of Cedar Road	B-3	15
Gamble Road, East of Pearson Road	B-4	20
Highland Road, South of Gamble Road	B-5	20
Highland Road, North of 28th Street	B-6	15

Soil samples were collected at selected intervals and were logged in general accordance with American Society of Testing Materials (ASTM) standard D 2488. Disturbed soil samples were collected during standard penetration testing using a split-spoon sampler. Relatively undisturbed soil samples were collected at regular intervals by hydraulically pushing Shelby tube samplers. A pocket penetrometer was used to approximate the unconfined compressive strength as an indicator of soil consistency for intact cohesive samples. The boring excavations were backfilled with soil cuttings and pavements patched with like materials (cold-patch asphalt) on conclusion of our fieldwork.

Brief descriptions of field sampling procedures used are presented on Figure A-1, Explanation of Field Sampling Procedures, in Appendix A. Descriptions of the soils encountered in our borings are presented on boring logs in Appendix A.

6 LABORATORY TESTING

The soil samples collected from our drilling activities were transported to our laboratory for geotechnical laboratory testing. Selected samples were visually classified and tested to evaluate their engineering properties as a basis for providing geotechnical design recommendations and construction considerations. Laboratory testing included natural moisture contents (ASTM D 2216), Atterberg limits (ASTM D 4318 Method B), percent of particles finer than the No. 200 sieve (ASTM D 1140), and unconfined compression tests (ASTM D 2166) were performed on selected samples.

Brief descriptions of laboratory test procedures used are presented on Figure B-1, Methods of Laboratory Testing, in Appendix B. Individual test results are presented on the boring logs and/or on summaries of test results on Figures B-2 through B-4 in Appendix B.

7 GEOLOGY AND SUBSURFACE CONDITIONS

The geology and subsurface conditions at the site are described in the following sections.

7.1 Geologic Setting

The site is located in the West Gulf Coastal Plain Province of the Atlantic Plain physiographic region. This province extends from the southern tip of Texas along the Gulf of Mexico Coast to the Mississippi Alluvial Plain to the east. This physiographic region is characterized as a gently sloping plain with gentle rolling hills.

The Geologic Atlas of Texas, Houston Sheet (1982) describes the geology of the sites as the Mid-Pleistocene-age (approximately 750,000 years old) Beaumont Formation. The Beaumont Formation is heterogeneous, containing interlayered deposits of clay, sand, and silt.

Based on the United States Department of Agriculture (USDA) Web Soil Survey, the surficial soils in the area of Boring B-1 primarily consist of Kemah silt loam. The surficial soils in the area of Borings B-2 and B-3 primarily consist of Morey silt loam. The surficial soils in the area of Boring B-4 primarily consist of Bernard clay loam. The surficial soils in the area of Boring B-5 primarily consist of Mocarey-Algoa loams complex and Mocarey-Leton complex. The surficial soils in the area of Boring B-6 primarily consist of Mocarey-Algoa loams complex. These soils generally consist of low to medium plasticity clay (CL-ML, CL) soils over medium to high plasticity clay (CL, CH) soils.

7.2 Subsurface Conditions

Our understanding of the subsurface conditions at the project site is based on our field exploration, laboratory testing, and our experience. Detailed stratigraphic information is presented on the boring logs in Appendix A. The boring logs contain our field and laboratory test results, as well as our interpretation of conditions believed to exist between actual samples retrieved. Therefore, these boring logs contain both factual and interpretive information. Lines delineating subsurface strata on the boring logs are intended to group soils having similar engineering properties and characteristics. They should be considered approximate as the actual transition between soil types (strata) may be gradual. A key to the soil symbols and terms used on the boring logs is provided in Appendix A.

7.2.1 Existing Pavement

Borings B-1 through B-6 were drilled within the existing roadways. The pavement section encountered in Borings B-1 through B-4 and B-6 consisted of about 2 to 5 inches of asphaltic concrete (HMAC) over about 1½ to 19 inches of crushed stone base material. The pavement section encountered in Boring B-5 consisted of about 4 inches of HMAC over about 2 inches of crushed stone base material over about 4 inches of HMAC over about 12 inches of crushed stone base material.

7.2.2 Fill Soils

Fill soils were observed underlying the pavement in our borings, except Borings B-3 and B-5, and extended to depths ranging from about 2 to 4 feet bgs. The fill soils generally consisted of fat clay (CH) and lean clay (CL) soils with varying sand fractions.

7.2.3 Beaumont Formation

Naturally-deposited soils from the Beaumont Formation were observed underlying the fill soils in our borings and extended to the termination depths of about 15 to 20 feet bgs. In general, these soils consisted of fat clay (CH) and lean clay (CL) soils with varying sand fractions. Clayey sand (SC) and silty sand (SM) soils were encountered at a depth of about 12 feet bgs underlying the clay soils in Boring B-4.

7.3 Depth-to-Water

The borings were drilled using dry-auger techniques in an attempt to measure depth-to-water in the open boreholes. Free water was observed during drilling in Borings B-4 and B-5 at a depth of about 17 feet bgs and rose to depths of about 7½ to 8½ feet bgs, respectively, after about 15 minutes. Free water was not encountered in Borings B-1 through B-3 and B-6 during drilling or on the conclusion of drilling operations.

Fluctuations in groundwater may occur at these sites as a function of seasonal moisture variation, precipitation, temperature, and groundwater withdrawal. Future construction activities may alter the surface and subsurface drainage characteristics of the sites. In addition, perched groundwater could be encountered at the sites, particularly after periods of heavy precipitation. The Contractor should be prepared for shallow groundwater conditions at the sites.

8 GEOLOGIC HAZARDS

A detailed fault study was not part of our scope of work for this project. Based on a review of published geologic data in our library, we did not find readily-available published literature on surface expressions of non-seismic growth faults in western Galveston County. The closest documented fault is mapped about 7½ miles northwest of the project sites (Holzer and Gabrysch, 1987). This fault does not trend in the direction of the site.

9 GEOTECHNICAL CONSIDERATIONS

Based on the results of our subsurface evaluation, laboratory testing, and data analysis, the proposed construction is feasible from a geotechnical standpoint, provided the recommendations in this report are incorporated into the design and construction of the project. Geotechnical considerations include the following:

- Due to the heterogeneous nature of the project area soils, and the relatively wide spacing between our borings, soils different than those encountered in our borings should be anticipated during construction.
- Free water was encountered during drilling in Borings B-4 and B-5 at a depth of about 17 feet bgs and rose to depths of about 7½ to 8½ feet bgs, respectively, after 15 minutes. Free water was not encountered in the remaining borings during drilling or on the conclusion of drilling operations. As such, relatively shallow groundwater and/or perched water may be encountered by the Contractor during construction, particularly after periods of heavy precipitation.
- Earthwork contractors should be made aware of the moisture sensitivity of near-surface clayey soils and potential compaction difficulties.
- Conventional earthmoving construction equipment may be used.
- Due to the presence of groundwater in our borings and the presence of cohesionless soils, care should be taken prior to excavation. The Contractor is responsible for evaluating the depth of groundwater at the time of construction, the need for shoring, and the need for dewatering prior to commencing any excavation.
- The onsite soils may generally be re-used as general fill for mass grading and utility trench backfill at the site, provided they are free of organics, debris, or other deleterious materials.

10 RECOMMENDATIONS

The following sections present our geotechnical recommendations and were developed based on our understanding of the proposed construction, the observed subsurface conditions, and our experience. If the proposed construction is changed from that discussed herein or subsurface conditions other than those shown on the boring logs are observed at the time of construction, Ninyo & Moore should be retained to conduct a review of the new information and to evaluate the need for additional recommendations.

10.1 Earthwork

The following sections present our earthwork recommendations for this project. In general, Galveston County standards and specifications are expected to apply, unless otherwise noted.

10.1.1 Existing Fill

As discussed in Section 7.2.2, fill soils were observed underlying the pavement in our borings, except Borings B-3 and B-5, and extended to depths ranging from about 2 to 4 feet bgs. Fill soils may also be present in other areas of the site. In practice, it is relatively difficult to accurately delineate fill soils that have similar visual characteristics to the native soils. Therefore, the recorded fill depths should be considered estimates that may vary somewhat from the actual fill depths.

We anticipate any weak or soft areas of fill soils will be identified and remediated during normal site preparation and proofrolling activities as discussed below.

10.1.2 Site Preparation

Prior to placing any new fill, pavement, or flatwork, the exposed subgrade should be evaluated by proofrolling. Proofrolling should be accomplished using a pneumatic-tired roller, dump truck, or similar equipment weighing approximately 20 tons and observed by the Geotechnical Engineer-of-Record or the Engineer's designated representative. Any soft or weak areas observed during the proofrolling process should be removed and replaced with compacted general fill as outlined in Section 10.1.11. Obstructions that extend below finish grade, if any, should be removed and the resulting holes filled with compacted soil.

Due to the nature of the surficial soils, traffic of heavy equipment (including heavy compaction equipment) may create pumping and general deterioration of shallow soils. Therefore, some construction difficulties should be anticipated, especially during periods when these soils are saturated.

10.1.3 Wet Weather Conditions

Earthwork contractors should be made aware of the moisture sensitivity of near-surface soils encountered at the site and potential compaction difficulties. If construction is undertaken during wet weather conditions, the surficial soils may become saturated, soft, and unworkable. Drainage trenches within the soils to be excavated, reworked, and/or recompacted may be needed. Additionally, subgrade treatment techniques, such as chemical (lime or lime-fly ash) treatment, may be needed to provide a more weather resistant working surface during pad construction.

We recommend that consideration be given to construction during drier months. Alternatively, the Contractor should protect exposed areas once topsoil has been stripped, as well as provide positive drainage during earthwork operations.

10.1.4 Excavation Considerations

Our evaluation of the excavation characteristics of the onsite materials is based on the results of our exploratory borings, site observations, and experience with similar materials. Due to the heterogeneous nature of the project area soils, and the relatively wide spacing between our borings, soils different than those encountered in our borings should be anticipated during construction.

In our opinion, excavations at this site may be performed using conventional heavy-duty earthmoving and/or excavation equipment. Equipment and procedures should be used that do not cause significant disturbance to excavation bottoms. The bottoms of excavations should expose competent soils and should be dry and free of loose, soft, or disturbed soil. Any soft, wet, weak, or deleterious materials should be overexcavated to expose strong competent soils.

Free water was encountered during drilling in Borings B-4 and B-5 at a depth of about 17 feet bgs and rose to depths of about 7½ to 8½ feet bgs, respectively, after about 15 minutes. Free water was not encountered in the remaining borings during drilling or on the conclusion of drilling operations. In addition, the Contractor may encounter relatively shallow groundwater and/or perched water during construction, particularly after periods of precipitation. This may result in difficulty achieving compaction of the soil, as well as subgrade pumping, etc., during earthwork activities. Wet or saturated soils at the excavation bases may soften under the action of light equipment and foot traffic. Drying or overexcavation of these materials may be appropriate prior to filling. If the subgrade becomes disturbed, it should be compacted before placing the backfill material.

Excavations should have stable side slopes in order to reduce vertical or lateral movements of the adjacent soil. The sides of the excavations should be sloped back and/or shored using bracing, such as trench boxes.

10.1.5 Stability of Temporary Excavations

Excavations that are 20 feet deep or less can be constructed using sloped sides designed based on the soil types encountered in accordance with current applicable state and federal trenching guidelines, including Occupational Safety and Health Administration (OSHA) requirements for excavations. Excavations over 20 feet deep should be designed by the Contractor's engineer based on alignment-specific geotechnical analyses and settlement-sensitive features.

Based on the soil conditions at the site, we recommend that an OSHA "Type B" soil classification be used for planning purposes for excavations in clays to 20 feet or less. In general, temporary slopes in "Type B" soil should be inclined no steeper than 1:1. However, if granular soils and/or groundwater seepage are encountered, an OSHA "Type C" soil classification should be used. This corresponds to temporary slopes of 1.5:1 (horizontal to vertical). Upon excavation, soil classifications should be evaluated in the field by the Contractor's geotechnical consultant in accordance with OSHA regulations.

Flatter slopes or bracing may be needed if excessive sloughing or raveling is observed. If material is stored or equipment is operated near an excavation, flatter slopes or shoring should be used to resist the extra pressure due to superimposed loads.

Temporary excavations that encounter groundwater seepage or surface runoff may need shoring or dewatering. Excavations encountering seepage should be evaluated on a case-by-case basis. Dewatering is discussed in Section 0 below.

10.1.6 Temporary Shoring

Based on the observed soils, it may be preferable to shore or brace trenches in lieu of sloping back the sides, particularly in areas in close proximity to adjacent roadways and existing underground utilities. Temporary earth retention systems may include braced systems, such as trench boxes or shields with internal supports, or cantilever systems (e.g., soldier piles and lagging).

The Contractor should retain a qualified and experienced structural engineer to design any shoring system. The Contractor's engineer should evaluate the adequacy of the shoring based on the soil parameters presented in this report and make appropriate modifications to their design.

Trench boxes may be used within relatively shallow excavations; however, trench boxes may not be a viable alternative for relatively deep excavations. In addition, excavations may not stand open long enough to install trench boxes in areas with granular soils or shallow groundwater. The Contractor should be prepared to deal with these soil conditions and plan accordingly.

Because the walls of trench boxes are generally not in intimate contact with the trench side walls, lateral movement along the trench excavation should be anticipated. Trench boxes with walls that hydraulically expand and come into intimate contact with excavation side walls should reduce lateral movement but may still result in some shifting of the adjacent soil. Once installed, some sloughing is possible at the ends of the trench box; therefore, any loose material should be removed prior to backfilling of the excavation.

10.1.7 Bottom Stability and Dewatering

As previously discussed, free water was encountered during drilling in Borings B-4 and B-5 at a depth of about 17 feet bgs and rose to depths of about 7½ to 8½ feet bgs, respectively, after about 15 minutes. Free water was not encountered in the remaining borings during drilling or on the conclusion of drilling operations. Based on the observed conditions, we anticipate some of the excavations for the planned culverts may extend below the free water depth. In addition, relatively shallow groundwater and/or perched water may be encountered by the Contractor during construction, particularly after periods of heavy precipitation.

The Contractor should be made aware of potential for encountering groundwater during construction and that a dewatering operation may need to be implemented. The depth of groundwater and the need for dewatering should be evaluated by the Contractor prior to beginning any excavation. Typically, the Contractor is responsible for designing, installing, and maintaining the dewatering system. Dewatering systems should be designed, installed, and monitored by qualified personnel familiar with dewatering soils in the Houston Area.

The stability of the bottom of excavations is dependent on the excavation geometry, soil strength parameters of the bearing soils, and the presence of groundwater. The bottom of an excavation in cohesionless soils is susceptible to "blow out" conditions when groundwater is present. Instability and quick conditions can occur when excavations approach charged granular layers without dewatering. In addition, if a saturated sand layer is situated beneath a clay layer, seepage pressures within the clay layer at the bottom of an excavation will result in unstable ground conditions. These conditions may endanger workers and equipment.

We recommend groundwater levels be kept 5 feet or more below the bottom of excavations. In addition, we recommend the use of an independent back-up system whenever workers are in or nearby excavations needing dewatering. Dewatering operations should be continued until backfilling operations are concluded, in order to reduce the potential for hydrostatic uplift ("floating") of the pipe.

10.1.8 Pipe Bedding and Trench Backfill

Pipe bedding and trench backfill materials should meet any requirements specified by Galveston County. Trench backfill as discussed herein refers to the material placed above the pipe zone/bedding backfill material. Based on the results of our study, many of the onsite soils will be suitable for use as trench backfill.

Trench backfill material should be compacted as discussed in Section 10.1.11. Lift thickness for backfill will be dependent upon the type of compaction equipment used, but should generally be placed in lifts not exceeding 8 inches in loose thickness. Special care should be exercised to avoid damaging the pipe or other structures during the compaction of the backfill.

Where the culvert crosses the roadway, the trench may generally be backfilled above the pipe zone with cement-stabilized sand (CSS) up to 12 inches below final grade. CSS should be compacted to a relative compaction a 95 percent or more as evaluated by ASTM D 558, at a moisture content within 2 percent below or above optimum moisture content. If CSS is used beneath a flexible (asphalt) pavement section, the CSS should be capped with 12 inches or more of flexible base material to reduce the potential for reflective cracking. Replacement pavement should generally match the existing pavement section.

10.1.9 Fill Materials

Onsite and imported fill soils should not include organic material, construction debris, or other non-soil fill materials. Clay lumps and rock particles should not be larger than 6 inches in dimension. Unsuitable material should be disposed of offsite or in non-structural areas.

Fill materials in contact with ferrous metals should also have low corrosion potential (minimum resistivity more than 2,000 ohm-cm, chloride content less than 25 parts per million [ppm]). Fill material in contact with concrete should have a soluble sulfate content of less than 0.1 percent. The Geotechnical Engineer-of-Record should evaluate such materials and details of their placement prior to importation.

10.1.10 Re-Use of Excavated Materials

Based on laboratory test results and our general observations, the onsite soils may generally be suitable for re-used as general fill for mass grading and trench backfill at the site, provided they are free of organics, debris, or other deleterious materials.

10.1.11 Fill Placement and Compaction

Fill soils should be moisture conditioned within the moisture range shown below in Table 4 and mechanically compacted to the percent compaction shown. Fill should generally be placed in 8-inch-thick loose lifts such that each lift is firm and non-yielding under the weight of construction equipment. Suitable fill soils should not contain organic material, construction debris, or other non-soil materials.

Table 4 – Summary of Compaction Recommendations

Description	Percent Compaction[1]	Moisture Content[2]
General Fill – Clay[3]	95 or more	-1% to +3%
General Fill – Sand	95 or more	-2% to +2%
Lime or Lime-Fly Ash Treated Subgrade	95 or more	-1% to +3%

Note:
[1]Percent compaction is the ratio of compacted dry density to the maximum dry density per ASTM D698.
[2]The range shown refers to the optimum moisture content per ASTM D698.
[3]Clayey soils used as fill should be processed so that particles or clods are no more than 6 inches in diameter prior to compaction.

10.1.12 Site Drainage

Surface drainage should be provided to divert water off of and away from paved surfaces. Surface water should not be permitted to drain toward pavement areas. Positive drainage is defined as a slope of 2 percent or more for a distance of 5 feet or more away from the pavements.

10.2 Headwall and Wingwall Design

Headwalls and wingwalls at the roadway culverts can be supported on shallow spread footings as described in Section 10.2.1. We recommend measures be taken so that moisture does not build up behind the headwalls or wingwalls. Drainage measures should include free-draining backfill material and perforated drainpipes or weep holes. Free draining granular fill material should consist of clean, non-plastic, ½- to ¾-inch drain rock with less than 10 percent finer than the No. 200 sieve size. The drain rock and pipe should be wrapped in a separation fabric, such as Mirafi 140N or equivalent. To reduce surface water seepage into the free draining granular backfill, the top 1-foot of the backfill should consist of onsite clay soil with a plasticity index 25 or more.

10.2.1 Foundations

Conventional concrete cantilever retaining walls, such as roadway culvert wingwalls, may be supported on shallow footings. Footings supporting headwalls and wingwalls at the culverts may be designed using an allowable bearing pressure of 2,000 pounds per square foot (psf). Such footings should bear on native soils at a depth of 2 feet or more below the scour elevation or lowest adjacent grade, whichever is deeper. In addition, we recommend the footings include a toe wall extending to a depth of 2 feet or more below the bottom of the footing. The allowable bearing pressure may be increased by a factor of 1/3 for transient loads, such as wind and seismic. Continuous (strip) footings should have a width of 18 inches or more.

Resistance to lateral loads on the headwall and wingwall footings may be analyzed using a combination of soil-concrete friction on the base of the footings and/or passive pressure on the face of the foundation. We recommend an allowable coefficient of friction along the base of the footings of 0.25. Passive resistance can be analyzed using an equivalent fluid pressure of 150 psf per foot of foundation embedment of the footing and the stem of the wall, up to 1,500 psf. The upper 2 feet of soil (or the depth of scour, whichever is deeper) should be neglected for passive resistance of the footings where the soils are not protected with concrete slope paving.

The footings should be reinforced in accordance with the Texas Department of Transportation (TxDOT)_Detail FW-S. Foundation excavations should be protected against any significant change in soil moisture content and disturbance by construction activity.

We recommend measures be taken so that moisture does not build up behind the walls. Drainage measures should include free-draining backfill material and perforated drainpipes or weep holes. Free draining material should consist of clean, non-plastic, ½- to ¾-inch drain rock with less than 10 percent finer than the No. 200 sieve size. The drain rock and pipe should be wrapped in a separation fabric, such as Mirafi 140N or equivalent.

Headwalls and wingwalls should be designed to withstand anticipated lateral earth pressures. The magnitude of lateral earth pressure against retaining walls is dependent on the method of backfill placement, type of backfill, drainage provisions, and type of wall (i.e. rigid or yielding) after placement of the backfill. Full hydrostatic pressure should be assumed to account for a potential rapid-drawdown condition if the walls are overtopped. We recommend an equivalent fluid pressure of 85 pounds per cubic foot (pcf) be used for walls at this site.

The walls should be also designed to resist additional horizontal surcharge loads due to vertical pressures induced by traffic loads. To calculate the design horizontal surcharge load, vertical surcharge loads should be multiplied by a factor of 0.50.

10.3 Concrete

Laboratory chemical tests were not performed to evaluate the sulfate content of the site soils for this project. We assume that the soluble sulfate content at the project site less than 0.2 percent by weight. If desired, laboratory chemical testing can be performed to estimate the sulfate content of the onsite soils.

Based on our experience with similar soil conditions and area practice, we recommend the use of Type II cement for construction of concrete structures at this site. Due to potential uncertainties as to the use of reclaimed irrigation water, or topsoil that may contain higher sulfate contents, pozzolan or admixtures designed to increase sulfate resistance may be considered.

The concrete design strength and the water-cement ratio should be in accordance with TxDOT Detail FW-S. Higher strength concrete may be selected for increased capacity, durability, and/or resistance to slab curling and shrinkage cracking. The concrete should have a ratio of water to cementitious materials no more than 0.50 by weight for normal weight aggregate concrete.

In order to reduce the potential for shrinkage cracks in the concrete during curing, we recommend that for slabs-on-grade, the concrete be placed with a slump in accordance with Table 6.2.1 of ACI 302.1R-96, "Guidelines for Floor and Slab Construction." If a higher slump is needed for screening and leveling, a super plasticizer is recommended to achieve the higher slump without changing the recommended water to cement ratio. The slump should be checked periodically at the site prior to concrete placement. We also recommend that crack control joints be provided in slabs in accordance with TxDOT requirements to reduce the potential for distress due to minor soil movement and concrete shrinkage. We further recommend that concrete cover over reinforcing steel for slabs-on-grade and foundations are in accordance with IBC 1907.7.1.

10.4 Pre-Construction Conference

We recommend a pre-construction conference be held. Representatives of the Owner, Civil Engineer, the Geotechnical Consultant, and the Contractor should be in attendance to discuss the project plans and schedule. Our office should be notified if the project description included herein is incorrect, or if the project characteristics are significantly changed.

10.5 Construction Observation and Testing

During construction operations, we recommend a qualified geotechnical consultant perform observation and testing services for the project. These services should be performed to evaluate exposed subgrade conditions, including the extent and depth of overexcavation, to evaluate the suitability of proposed borrow materials for use as fill and to observe placement and test compaction of fill soils. If another geotechnical consultant is selected to perform observation and testing services for the project, we request that the selected consultant provide a letter to the owner, with a copy to Ninyo & Moore, indicating that they fully understand our recommendations and they are in full agreement with the recommendations contained in this report. Qualified subcontractors utilizing appropriate techniques and construction materials should perform construction of the proposed improvements.

11 LIMITATIONS

The field evaluation, laboratory testing, and geotechnical analyses presented in this geotechnical report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be encountered during construction. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation will be performed upon request. Please also note that our evaluation was limited to assessment of the geotechnical aspects of the project, and did not include evaluation of structural issues, environmental concerns, or the presence of hazardous materials.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Ninyo & Moore should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

This report is intended for design purposes only. It does not provide sufficient data to prepare an accurate bid by contractors. It is suggested that the bidders and their geotechnical consultant perform an independent evaluation of the subsurface conditions in the project areas. The independent evaluations may include, but not be limited to, review of other geotechnical reports prepared for the adjacent areas, site reconnaissance, and additional exploration and laboratory testing.

Our conclusions, recommendations, and opinions are based on an analysis of the observed site conditions. If geotechnical conditions different from those described in this report are encountered, our office should be notified and additional recommendations, if warranted, will be provided upon request. It should be understood that the conditions of a site could change with time as a result of natural processes or the activities of mankind at the subject site or nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which Ninyo & Moore has no control.

This report is intended exclusively for use by the Client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the Client is undertaken at said parties' sole risk.

12 REFERENCES

American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards.

Galveston County Design Manual.

Geologic Atlas of Texas, Houston Sheet, 1982, Texas Bureau of Economic Geology.

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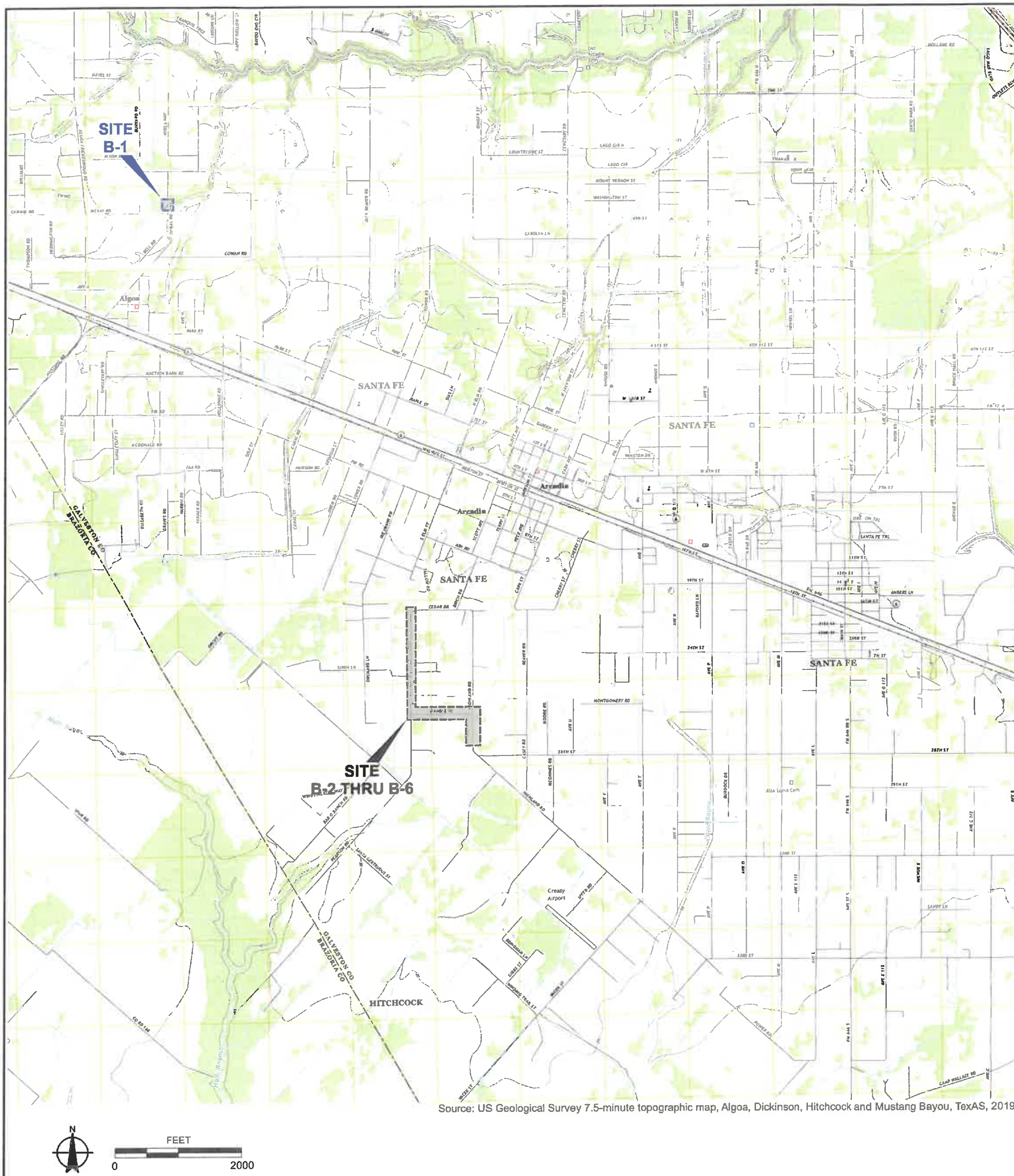
FIGURES



Source: US Geological Survey 7.5-minute topographic map, Algoa, Dickinson, Hitchcock and Mustang Bayou, TexAS, 2019.

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

FIGURE 1

SITE LOCATION

ALGOA/ALTA LOMA CULVERT REPLACEMENTS
MULTIPLE LOCATIONS
GALVESTON COUNTY, TEXAS

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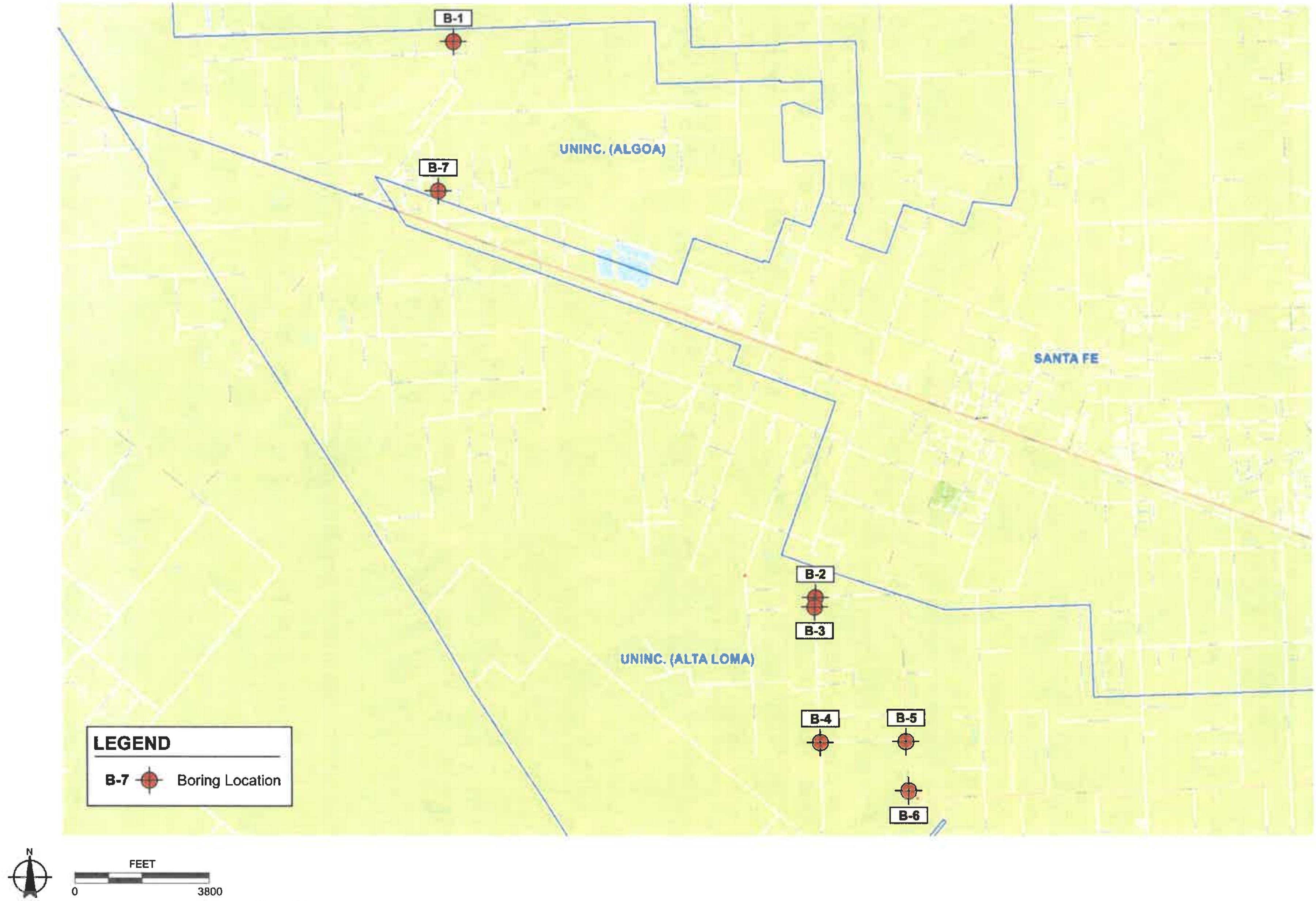
elt file no: 1307vmap0522



SOURCE: ESRI, HERE, GARMIN, USGS, INTERMAP, DATE UNKNOWN.
NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

elt file no: 1307blm0522

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FIGURE 2

BORING LOCATIONS

ALGOA/ALTA LOMA CULVERT REPLACEMENTS
MULTIPLE LOCATIONS
GALVESTON COUNTY, TEXAS

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APPENDIX A

Boring Logs

BORING LOG SAMPLING PROCEDURES

Field Procedure for the Collection of Relatively Undisturbed Samples

Relatively undisturbed soil samples were obtained in the field using the following methods.

Shelby Tube

The Shelby tube is a seamless, thin walled, steel tube having an external diameter of 3 inches and a length of 30 inches. The tube was connected to the drill rod or a hand tool and pushed into an undisturbed soil mass to obtain a relatively undisturbed sample of soft, cohesive soil in general accordance with ASTM D 1587. When the tube was almost full (to avoid over-penetration), it was withdrawn from the boring. The samples were removed from the sampling tubes in the field, assessed visually, and evaluated for consistency using a pocket penetrometer. A selected portion of each sample was then wrapped in aluminum foil and sealed in a plastic bag for use in future visual assessment and possible testing in our laboratory.

Field Procedure for the Collection of Relatively Disturbed Samples

Disturbed soil samples were obtained in the field using the following methods.

The Standard Penetration Test (SPT) Sampler

Disturbed samples of earth materials were obtained by means of a split spoon sampler during Standard Penetration Testing. The sampler is composed of a split barrel with an external diameter of 2 inches and an unlined internal diameter of 13/8 inches. The sampler was driven into the ground 12 to 18 inches with a 140-pound hammer free-falling from a height of 30 inches in general accordance with ASTM D 1586. The blow counts were recorded for every 6 inches of penetration; the blow counts reported on the logs are those for the last 12 inches of penetration. Soil samples were removed from the sampler, visually classified, bagged, sealed and transported to the laboratory for testing.

Bulk Samples

Bulk samples of representative soils were obtained from the exploratory borings. The samples were bagged and transported to the laboratory for testing.

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 ≥ 4 and 1 ≤ Cc ≤ 3[D]	GW	Well-graded gravel[E]
			Cu < 4 and/or [1 > Cc > 3][D]	GP	Poorly graded gravel[E]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[E,F,G]
			Fines classify as CL or CH	GC	Clayey gravel[E,F,G]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[H]	Cu ≥ 6 and 1 ≤ Cc ≤ 3[D]	SW	Well-graded sand[I]
			Cu < 6 and/or [1 > Cc > 3][D]	SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[H]	Fines classify as ML or MH	SM	Silty sand[F,G,H]
			Fines classify as CL or CH	SC	Clayey sand[F,G,H]
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 / Liquid limit - not dried < 0.75	OL	Organic clay[K,L,M,N]
					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 / Liquid limit - not dried < 0.75	OH	Organic clay[K,L,M,P]
					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]$Cu = D_{60}/D_{10}$ $Cc = (D_{30})^2 / (D_{10} \times D_{60})$

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

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

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

[H]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

[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 <30% 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.

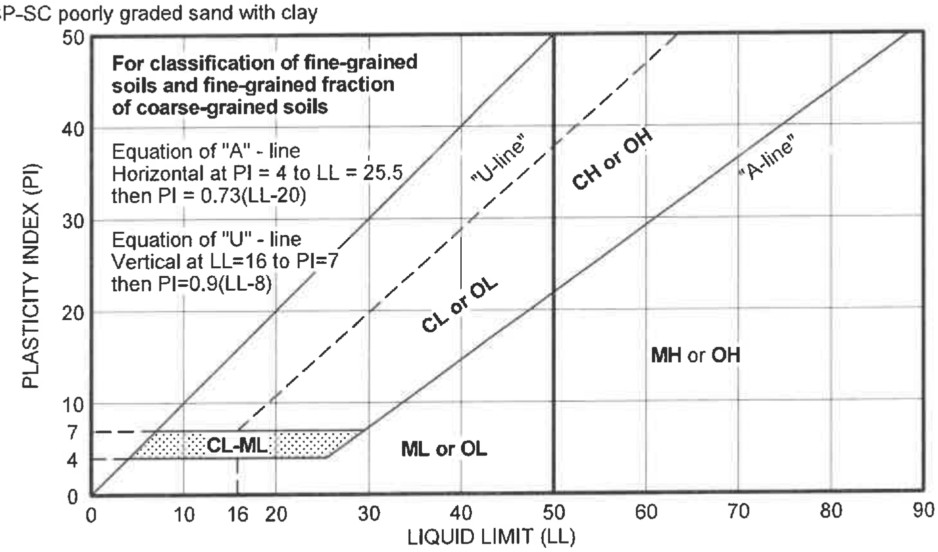
[M]If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N]PI ≥ 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.



BASED ON TABLE 1 "SOIL CLASSIFICATION CHART" ASTM D 2487-11

FIGURE A-2

SOIL CLASSIFICATION CHART

ALGOA/ALTA LOMA CULVERT REPLACEMENTS
MULTIPLE LOCATIONS
GALVESTON COUNTY, TEXAS

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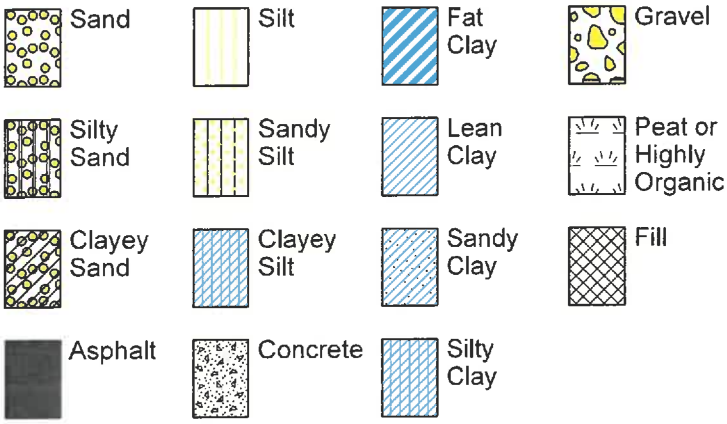
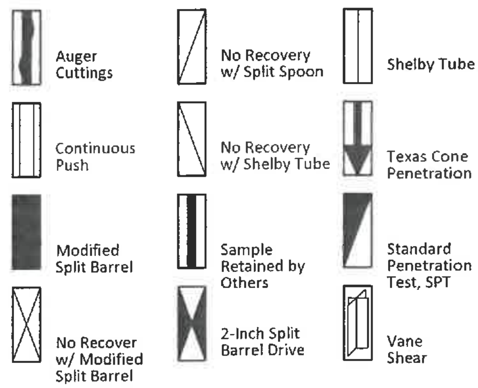
SYMBOLS

SOIL TYPES



SAMPLER TYPES



TERMINOLOGY

Terms used in this report to describe soils with regard to their consistency or conditions are in general accordance with the discussion presented in Article 45 of SOILS MECHANICS IN ENGINEERING PRACTICE, Terzaghi and Peck, John Wiley & Sons, Inc., 1967, using available information from the field and laboratory studies. Terms used for describing soils according to their texture or grain size distribution are in accordance with the UNIFIED SOIL CLASSIFICATION SYSTEM, as described in American Society for Testing and Materials D2487-11 and D2488-09a, Volume 04.08, Soil and Rock; Dimension Stone; Geosynthetics; 2015.

The depths shown on the boring logs are not exact, and have been estimated to the nearest half-foot. Lines delineating subsurface strata on the boring logs are intended to group soils having similar engineering properties and characteristics. They should be considered approximate as the actual transition between soil types (strata) may be gradual.

RELATIVE DENSITY

Cathead Hammer Penetration Resistance Blows per ft	Relative Density	Automatic Hammer Penetration Resistance Blows per ft
0 - 4	Very Loose	0 - 3
5 - 10	Loose	4 - 7
11 - 30	Medium Dense	8 - 20
31 - 50	Dense	21 - 33
> 50	Very Dense	> 33

COHESIVE STRENGTH

Cathead Resistance Blows per ft	Automatic Resistance Blows per ft	Consistency	Cohesion ksf
0 - 2	< 1	Very Soft	0 - 0.25
3 - 4	1 - 3	Soft	0.25 - 0.5
5 - 8	4 - 5	Firm	0.5 - 1.0
9 - 15	6 - 10	Stiff	1.0 - 2.0
16 - 30	11 - 20	Very Stiff	2.0 - 4.0
> 30	> 20	Hard	> 4.0

SOIL STRUCTURE

Slickensided	Having planes of weakness that appear slick and glossy.
Fissured	Containing shrinkage or relief cracks, often filled with fine sand or silt; usually more or less vertical.
Pocket	Inclusion of material of different texture that is smaller than the diameter of the sample.
Parting	Inclusion less than 1/8 inch thick extending through the sample.
Seam	Inclusion 1/8 inch to 3 inches thick extending through the sample.
Layer	Inclusion greater than 3 inches thick extending through the sample.
Laminated	Soil sample composed of alternating partings or seams of different soil type.
Interlayered	Soil sample composed of alternating layers of different soil type.
Intermixed	Soil sample composed of pockets of different soil type and layered or laminated structure is not evident.
Calcareous	Having appreciable quantities of carbonate.
Carbonate	Having more than 50% carbonate content.

DATE DRILLED	4/12/2022	BORING NO.	B-1
GROUND ELEVATION	~ 26 ft MSL	SHEET 1	OF 1
METHOD OF DRILLING	4¼" Straight Flight Auger (Patino - Truck)		
DRIVE WEIGHT	N/A	DROP HEIGHT	N/A
SAMPLED BY Patino	LOGGED BY ESL	REVIEWED BY RDS	

DEPTH, feet	WATER LEVEL	SYMBOL	SAMPLE TYPE	BLOWS PER FOOT	DRY UNIT WEIGHT, pcf	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)	PASSING NO. 200 SIEVE, %	UNCONFINED OR Q-TYPE COMPR, ksf	TORVANE, tsf	POCKET PEN, ksf	USCS GROUP SYMBOL	DESCRIPTION / INTERPRETATION
0															PAVEMENT SECTION: Approximately 2 inches of asphaltic concrete over about 8 inches of crushed stone base material.
						19	46	19	27	89.2			4.0	CL	FILL: Dark gray, gray, and light gray, moist, very stiff, lean CLAY; few to little sand; sand seams; ferrous and calcareous nodules; roots.
						16							4.5+	CL	BEAUMONT FORMATION: Dark gray, moist, hard, lean CLAY with sand; sand seams; ferrous and calcareous nodules.
						15	46	19	27				4.5+		Light brown and reddish yellow.
						18							4.25	CH	Reddish yellow and light brown, moist, hard, fat CLAY; few gravel; ferrous and calcareous nodules.
					105	23	57	22	35		1.7		1.5		Stiff.
10															
													3.5		Reddish brown and light gray; very stiff; slickensided.
													3.0		
20															Total Depth = 20 feet. Boring was backfilled with soil cuttings and patched with asphaltic concrete on 4/12/2022.

Note:
Groundwater, though not encountered in this boring at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors discussed in the report.

The ground elevation shown above is an estimation only. It is based on interpretation reviewed for the purpose of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

FIGURE A-4

BORING LOG

ALGOA/ALTA LOMA CULVERT REPLACEMENTS
MULTIPLE LOCATIONS
GALVESTON COUNTY, TEXAS

701307001 | 8/22

GROUND WATER OBSERVATIONS

- ∇ First Observed (ft): None
- ▼ After Drilling (ft): Dry
- ∇ After N/A Hours (ft): N/A

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DATE DRILLED 4/12/2022 BORING NO. B-2
GROUND ELEVATION ~ 23 ft MSL SHEET 1 OF 1
METHOD OF DRILLING 4¼" Straight Flight Auger (Patino - Truck)
DRIVE WEIGHT N/A DROP HEIGHT N/A
SAMPLED BY Patino LOGGED BY ESL REVIEWED BY RDS

DEPTH, feet	WATER LEVEL	SYMBOL	SAMPLE TYPE	BLOWS PER FOOT	DRY UNIT WEIGHT, pcf	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)	PASSING NO. 200 SIEVE, %	UNCONFINED OR Q-TYPE COMPR, ksf	TORVANE, tsf	POCKET PEN, ksf	USCS GROUP SYMBOL	DESCRIPTION / INTERPRETATION
0															PAVEMENT SECTION: Approximately 5 inches of asphaltic concrete over about 19 inches of sandy crushed stone base material.
						26								CH	FILL: Dark gray, moist, fat CLAY; crushed stone base material.
						27	64	26	38	94.3			1.5	CH	BEAUMONT FORMATION: Dark gray, moist, stiff, fat CLAY; few sand.
					97	29					1.2		2.0		Gray; stiff to very stiff; ferrous and calcareous nodules.
						29	76	26	50				2.0		Light gray and reddish yellow.
						26							2.0		
10															
													2.25		Reddish yellow, reddish brown, and light gray; very stiff; slickensided.
20															

Total Depth = 15 feet.
Boring was backfilled with soil cuttings and patched with asphaltic concrete on 4/12/2022.

Note:
Groundwater, though not encountered in this boring at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors discussed in the report.

The ground elevation shown above is an estimation only. It is based on interpretation reviewed for the purpose of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

FIGURE A-5

BORING LOG

ALGOA/ALTA LOMA CULVERT REPLACEMENTS
MULTIPLE LOCATIONS
GALVESTON COUNTY, TEXAS
701307001 | 8/22

GROUND WATER OBSERVATIONS
▽ First Observed (ft): None
▼ After Drilling (ft): Dry
▼ After N/A Hours (ft): N/A

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DATE DRILLED 4/12/2022 BORING NO. B-3

GROUND ELEVATION ~ 23 ft MSL SHEET 1 OF 1

METHOD OF DRILLING 4¼" Straight Flight Auger (Patino - Truck)

DRIVE WEIGHT N/A DROP HEIGHT N/A

SAMPLED BY Patino LOGGED BY ESL REVIEWED BY RDS

DEPTH, feet	FIELD: WATER LEVEL	FIELD: SYMBOL	FIELD: SAMPLE TYPE	FIELD: BLOWS PER FOOT	CLASSIFICATION: DRY UNIT WEIGHT, pcf	CLASSIFICATION: WATER CONTENT, %	CLASSIFICATION: LIQUID LIMIT	CLASSIFICATION: PLASTIC LIMIT	CLASSIFICATION: PLASTICITY INDEX (PI)	CLASSIFICATION: PASSING NO. 200 SIEVE, %	SHEAR STRENGTH: UNCONFINED OR Q-TYPE COMPR, ksf	SHEAR STRENGTH: TORVANE, tsf	SHEAR STRENGTH: POCKET PEN, ksf	USCS GROUP SYMBOL	DESCRIPTION / INTERPRETATION
0															PAVEMENT SECTION: Approximately 5 inches of asphaltic concrete over about 1½ inches of crushed stone base material.
						28	70	28	42				3.0	CH	BEAUMONT FORMATION: Dark gray, moist, very stiff, fat CLAY; trace sand; ferrous nodules.
						28							2.25		
						28	70	26	44	97.4			1.75		Stiff.
					97	28					1.5		1.75		Gray and light gray.
						29							2.5		Light gray and reddish yellow; very stiff; calcareous nodules.
10															
													2.5		Light gray, reddish yellow, and reddish brown; slickensided.
20															

Total Depth = 15 feet.
Boring was backfilled with soil cuttings and patched with asphaltic concrete on 4/12/2022.

Note:
Groundwater, though not encountered in this boring at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors discussed in the report.

The ground elevation shown above is an estimation only. It is based on interpretation reviewed for the purpose of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

GROUND WATER OBSERVATIONS

▽ First Observed (ft): None
▼ After Drilling (ft): Dry
▼ After N/A Hours (ft): N/A

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FIGURE A-6

BORING LOG

ALGOA/ALTA LOMA CULVERT REPLACEMENTS
MULTIPLE LOCATIONS
GALVESTON COUNTY, TEXAS

701307001 | 8/22

DATE DRILLED 4/12/2022 BORING NO. B-4
GROUND ELEVATION ~ 20 ft MSL SHEET 1 OF 1
METHOD OF DRILLING 4¼" Straight Flight Auger (Patino - Truck)
DRIVE WEIGHT 140 lbs (Cathead) DROP HEIGHT 30 inches
SAMPLED BY Patino LOGGED BY ESL REVIEWED BY RDS

DEPTH, feet	WATER LEVEL	SYMBOL	SAMPLE TYPE	BLOWS PER FOOT	DRY UNIT WEIGHT, pcf	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)	PASSING NO. 200 SIEVE, %	UNCONFINED OR Q-TYPE COMPR, ksf	TORVANE, tsf	POCKET PEN, ksf	USCS GROUP SYMBOL	DESCRIPTION / INTERPRETATION
0															PAVEMENT SECTION: Approximately 4 inches of asphaltic concrete over about 3 inches of crushed stone base material.
						26	62	26	36	82.9			1.5	CH	FILL: Gray, yellowish brown, and light brown, moist, stiff, fat CLAY with sand; ferrous nodules; crushed stone base material.
						25							1.5		Dark gray and gray; crushed stone base material not observed.
						27	68	24	44				1.5	CH	BEAUMONT FORMATION: Gray and reddish yellow, moist, stiff, fat CLAY; ferrous nodules.
	▼				98	28					1.2		1.25		Reddish gray, light brown, and reddish yellow.
						25	65	24	41				1.5		Light brown and reddish yellow; calcareous nodules.
10															
														SC	Light brown and reddish yellow, moist, clayey SAND.
						20				39.9					
														SM	Light brown and reddish brown, wet, medium dense, silty SAND.
	▽														
				25											
20															Total Depth = 20 feet. Boring was backfilled with soil cuttings and patched with asphaltic concrete on 4/12/2022.

Note:
Groundwater may rise to a higher level due to seasonal variations in precipitation and several other factors discussed in the report.

The ground elevation shown above is an estimation only. It is based on interpretation reviewed for the purpose of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

FIGURE A-7

BORING LOG

ALGOA/ALTA LOMA CULVERT REPLACEMENTS
MULTIPLE LOCATIONS
GALVESTON COUNTY, TEXAS
701307001 | 8/22

GROUND WATER OBSERVATIONS
▽ First Observed (ft): 17
▼ After Drilling (ft): N/A
▼ After 0.25 Hours (ft): 7.5

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

DATE DRILLED 4/12/2022 BORING NO. B-5

GROUND ELEVATION ~ 22 ft MSL SHEET 1 OF 1

METHOD OF DRILLING 4¼" Straight Flight Auger (Patino - Truck)

DRIVE WEIGHT N/A DROP HEIGHT N/A

SAMPLED BY Patino LOGGED BY ESL REVIEWED BY RDS

DEPTH, feet	BLOWS PER FOOT	DRY UNIT WEIGHT, pcf	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)	PASSING NO. 200 SIEVE, %	UNCONFINED OR Q-TYPE COMPR, ksf	TORVANE, tsf	POCKET PEN, ksf	USCS GROUP SYMBOL	DESCRIPTION / INTERPRETATION
0												PAVEMENT SECTION: Approximately 4 inches of asphaltic concrete over about 2 inches of crushed stone base material over about 4 inches of asphaltic concrete over about 12 inches of crushed stone base material.
											CL	BEAUMONT FORMATION: Reddish gray, moist, stiff, lean CLAY; sand seams.
			19	38	18	20				1.5		
											CH	Gray, moist, stiff to very stiff, fat CLAY; few sand.
			20							2.0		
			23	54	21	33	92.9			1.5		Gray and reddish yellow; stiff.
		100	24					1.4		2.25		Gray, light gray, and reddish yellow; very stiff.
10												
											CL	Reddish yellow, light brown, and dark gray, moist, stiff to very stiff, lean CLAY.
			21	47	21	26				2.0		
											CH	Reddish brown and light gray, moist, very stiff, fat CLAY; calcareous nodules; slickensided.
										3.5		
20												Total Depth = 20 feet. Boring was backfilled with soil cuttings and patched with asphaltic concrete on 4/12/2022.

Note:
Groundwater may rise to a higher level due to seasonal variations in precipitation and several other factors discussed in the report.

The ground elevation shown above is an estimation only. It is based on interpretation reviewed for the purpose of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

GROUND WATER OBSERVATIONS

∇ First Observed (ft): 17

▼ After Drilling (ft): N/A

▼ After 0.25 Hours (ft): 8.5

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FIGURE A-8

BORING LOG

ALGOA/ALTA LOMA CULVERT REPLACEMENTS
MULTIPLE LOCATIONS
GALVESTON COUNTY, TEXAS

701307001 | 8/22

DATE DRILLED 4/12/2022 BORING NO. B-6

GROUND ELEVATION ~ 22 ft MSL SHEET 1 OF 1

METHOD OF DRILLING 4¼" Straight Flight Auger (Patino - Truck)

DRIVE WEIGHT N/A DROP HEIGHT N/A

SAMPLED BY Patino LOGGED BY ESL REVIEWED BY RDS

DEPTH, feet	WATER LEVEL (FIELD)	SYMBOL (FIELD)	SAMPLE TYPE (FIELD)	BLOWS PER FOOT (FIELD)	DRY UNIT WEIGHT, pcf (CLASSIFICATION)	WATER CONTENT, % (CLASSIFICATION)	LIQUID LIMIT (CLASSIFICATION)	PLASTIC LIMIT (CLASSIFICATION)	PLASTICITY INDEX (PI) (CLASSIFICATION)	PASSING NO. 200 SIEVE, % (CLASSIFICATION)	UNCONFINED OR Q-TYPE COMPR, ksf (SHEAR STRENGTH)	TORVANE, tsf (SHEAR STRENGTH)	POCKET PEN, ksf (SHEAR STRENGTH)	USCS GROUP SYMBOL	DESCRIPTION / INTERPRETATION
0															PAVEMENT SECTION: Approximately 2 inches of asphaltic concrete over about 7 inches of crushed stone base material.
						15	32	20	12	63.6			3.25	CL	FILL: Dark brown and light gray, moist, very stiff, sandy lean CLAY.
						21							1.0	CH	BEAUMONT FORMATION: Dark gray, moist, firm to stiff, fat CLAY; sand pockets.
						22	58	25	33	84.9			2.0		Light brown and reddish yellow; stiff to very stiff; increase in sand content; sand seams; ferrous nodules.
					100	24					0.9		1.25		Stiff; decrease in sand content.
						23							1.5		Ferrous nodules.
10															
													2.0		Reddish yellow and light brown; stiff to very stiff; silt seams.
20															

Total Depth = 15 feet.
Boring was backfilled with soil cuttings and patched with asphaltic concrete on 4/12/2022.

Note:
Groundwater, though not encountered in this boring at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors discussed in the report.

The ground elevation shown above is an estimation only. It is based on interpretation reviewed for the purpose of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

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GROUND WATER OBSERVATIONS

▽ First Observed (ft): None
▼ After Drilling (ft): Dry
▼ After N/A Hours (ft): N/A

FIGURE A-9

BORING LOG

ALGOA/ALTA LOMA CULVERT REPLACEMENTS
MULTIPLE LOCATIONS
GALVESTON COUNTY, TEXAS

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DATE DRILLED	8/9/2022	BORING NO.	B-7
GROUND ELEVATION	~ 28 ft MSL	SHEET 1 OF 1	
METHOD OF DRILLING	4¼" Straight Flight Auger (Patino - Atlas)		
DRIVE WEIGHT	N/A	DROP HEIGHT	N/A
SAMPLED BY	Atlas	LOGGED BY RAG	REVIEWED BY JSR

DEPTH, feet	WATER LEVEL (FIELD)	SYMBOL (FIELD)	SAMPLE TYPE (FIELD)	BLOWS PER FOOT (FIELD)	DRY UNIT WEIGHT, pcf (CLASSIFICATION)	WATER CONTENT, % (CLASSIFICATION)	LIQUID LIMIT (CLASSIFICATION)	PLASTIC LIMIT (CLASSIFICATION)	PLASTICITY INDEX (PI) (CLASSIFICATION)	PASSING NO. 200 SIEVE, % (CLASSIFICATION)	UNCONFINED OR Q-TYPE COMPR, ksf (SHEAR STRENGTH)	TORVANE, tsf (SHEAR STRENGTH)	POCKET PEN, ksf (SHEAR STRENGTH)	USCS GROUP SYMBOL	DESCRIPTION / INTERPRETATION
0															PAVEMENT SECTION: Approximately 4 inches of asphaltic concrete over about 13 inches of stabilized treated base material.
													4.5+	CH	FILL: Dark gray and brown, moist, hard, fat CLAY; calcareous nodules.
						15	43	18	25				3.75	CL	BEAUMONT FORMATION: Light brown and dark brown, moist, very stiff, lean CLAY; ferrous nodules.
						16							1.75		Gray, yellowish brown, and dark gray; stiff.
						21	42	20	22				1.0		Reddish brown and light gray; firm to stiff; calcareous nodules; silt seams.
					92	31					0.9		1.25	CH	Reddish brown and light gray, moist, stiff, fat CLAY; calcareous and ferrous nodules; silt seams; slickensided.
10															
						36							1.75		Light gray and yellowish brown.
															Total Depth = 15 feet. Boring was backfilled with soil cuttings and patched with asphaltic concrete on 8/9/2022.
20															

Note:
Groundwater, though not encountered in this boring at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors discussed in the report.

The ground elevation shown above is an estimation only. It is based on interpretation reviewed for the purpose of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

GROUND WATER OBSERVATIONS

▽ First Observed (ft): None
▼ After Drilling (ft): Dry
▼ After N/A Hours (ft): N/A

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FIGURE A-10

BORING LOG

ALGOA/ALTA LOMA CULVERT REPLACEMENTS
MULTIPLE LOCATIONS
GALVESTON COUNTY, TEXAS

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APPENDIX B

Laboratory Testing

LABORATORY TESTING

Classification

Soils were visually and texturally classified using the Unified Soil Classification System (USCS) in general accordance with ASTM D 2488. Soil classifications are indicated on the boring logs in Appendix A and in the following summary tables in Appendix B.

Moisture Content

The moisture content of samples obtained from our exploratory borings were evaluated in general accordance with ASTM D 2216. The test results are presented on the boring logs in Appendix A and the Summary of Laboratory Results, Figure B-4.

No. 200 Wash

An evaluation of the percentage of particles finer than the No. 200 sieve in selected soil samples was performed in general accordance with ASTM D 1140. The results of the tests are presented on Figure B-2, on the boring logs in Appendix A, and in the Summary of Laboratory Results, Figure B-4.

Atterberg Limits

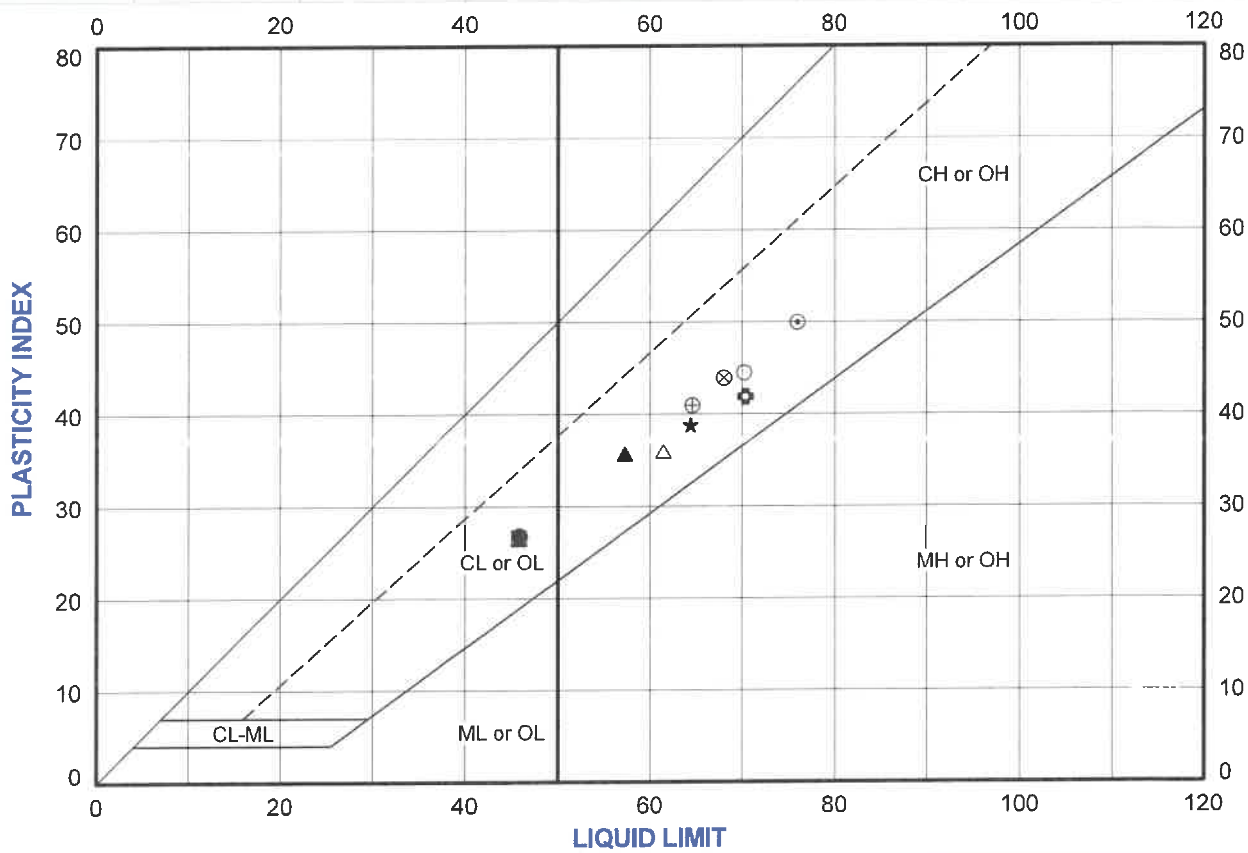
Tests were performed on selected representative fine-grained soil samples to evaluate the liquid limit, plastic limit, and plasticity index in general accordance with ASTM D 4318 (Method B). These test results were utilized to evaluate the soil classification in accordance with the Unified Soil Classification System (USCS). The results of these tests are presented on Figure B-3, on the boring logs in Appendix A, and in the Summary of Laboratory Results, Figure B-4.

Compression Tests

Unconfined compression tests were performed on relatively undisturbed samples in general accordance with ASTM D 2166. The test results are shown on the boring logs in Appendix A and in the Summary of Laboratory Results, Figure B-4.

SAMPLE LOCATION	DEPTH (feet)	DESCRIPTION	PERCENT PASSING NO. 4	PERCENT PASSING NO. 200	USCS
B-1	0.8 - 2	Lean CLAY	100.0	89.2	CL
B-2	3 - 4	Fat CLAY	100.0	94.3	CH
B-3	4 - 6	Fat CLAY	100.0	97.4	CH
B-4	0.6 - 2	Fat CLAY w/ Sand	100.0	82.9	CH
B-4	13 - 15	Clayey SAND	100.0	39.9	SC
B-5	6 - 8	Fat CLAY	100.0	92.9	CH
B-6	0.8 - 2	Sandy Lean CLAY	100.0	63.6	CL
B-6	4 - 6	Fat CLAY	100.0	84.9	CH

SYMBOL	LOCATION	DEPTH (FT)	LIQUID LIMIT, LL	PLASTIC LIMIT, PL	PLASTICITY INDEX, PI	USCS (Fraction Finer Than No. 40 Sieve)	USCS (Entire Sample)
●	B-1	0.8 - 2	46	19	27	CL	CL
⊠	B-1	4 - 6	46	19	27	CL	CL
▲	B-1	8 - 10	57	22	35	CH	CH
★	B-2	3 - 4	64	26	38	CH	CH
⊙	B-2	6 - 8	76	26	50	CH	CH
✿	B-3	0.5 - 2	70	28	42	CH	CH
○	B-3	4 - 6	70	26	44	CH	CH
△	B-4	0.6 - 2	62	26	36	CH	CH
⊗	B-4	4 - 6	68	24	44	CH	CH
⊕	B-4	8 - 10	65	24	41	CH	CH



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D4318.

FIGURE B-3a

ATTERBERG LIMIT TEST RESULTS

ALGOA/ALTA LOMA CULVERT REPLACEMENTS
MULTIPLE LOCATIONS
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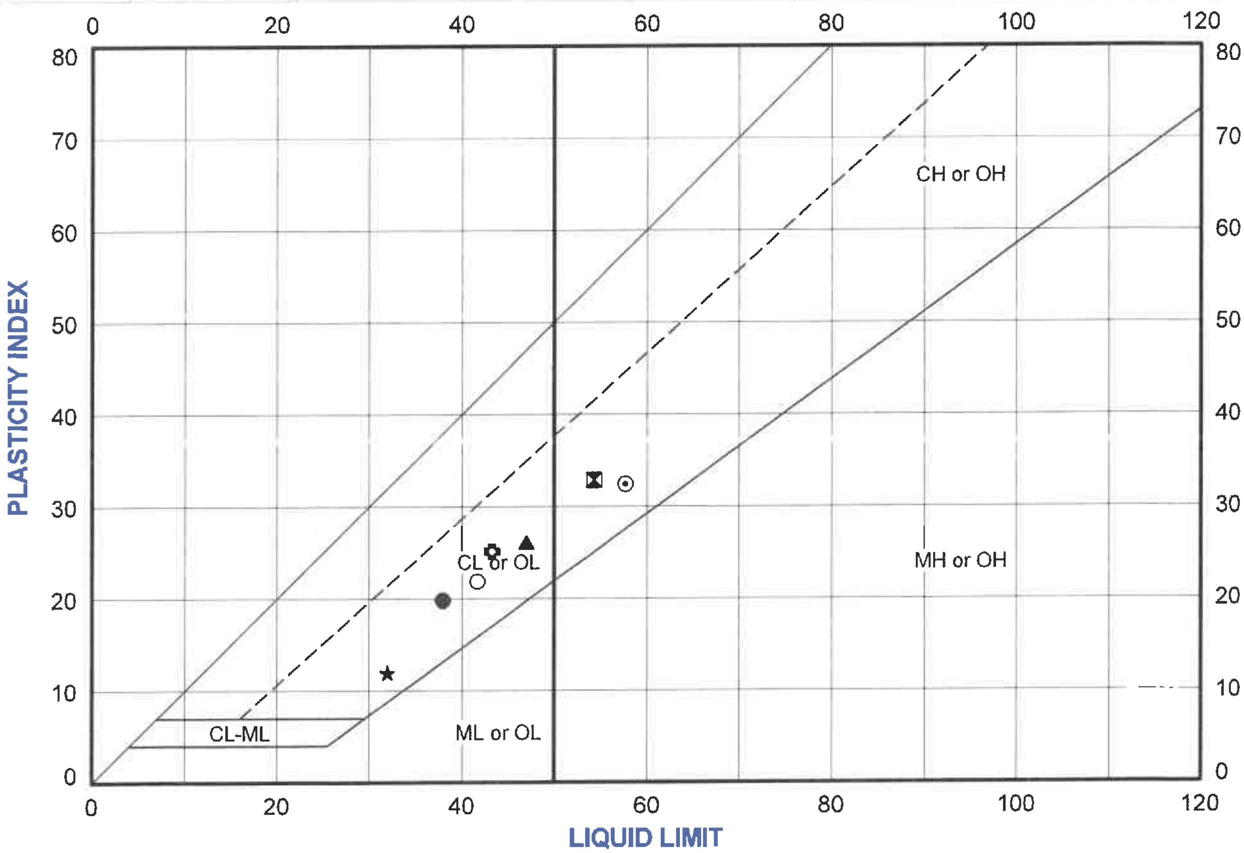
SYMBOL	LOCATION	DEPTH (FT)	LIQUID LIMIT, LL	PLASTIC LIMIT, PL	PLASTICITY INDEX, PI	USCS (Fraction Finer Than No. 40 Sieve)	USCS (Entire Sample)
●	B-5	2 - 4	38	18	20	CL	CL
⊠	B-5	6 - 8	54	21	33	CH	CH
▲	B-5	13 - 15	47	21	26	CL	CL
★	B-6	0.8 - 2	32	20	12	CL	CL
⊙	B-6	4 - 6	58	25	33	CH	CH
✿	B-7	2 - 4	43	18	25	CL	CL
○	B-7	6 - 8	42	20	22	CL	CL



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D4318.

FIGURE B-3b

ATTERBERG LIMIT TEST RESULTS

ALGOA/ALTA LOMA CULVERT REPLACEMENTS
MULTIPLE LOCATIONS
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Borehole	Depth (feet)	Liquid Limit	Plastic Limit	Plasticity Index	Shear Strength (ksf)	%<#200 Sieve	USCS Group Symbol	Water Content (%)	Dry Density (pcf)
B-1	0.8 - 2	46	19	27	4.0^{P}	89.2	CL	19.0	
B-1	2 - 4				$4.5+^{P}$		CL	16.0	
B-1	4 - 6	46	19	27	$4.5+^{P}$		CL	15.0	
B-1	6 - 8				4.25^{P}		CH	18.0	
B-1	8 - 10	57	22	35	1.7^{U}		CH	23.0	105.1
B-1	13 - 15				3.5^{P}		CH		
B-1	18 - 20				3.0^{P}		CH		
B-2	2 - 3						CH	26.0	
B-2	3 - 4	64	26	38	1.5^{P}	94.3	CH	27.0	
B-2	4 - 6				1.2^{U}		CH	29.0	96.6
B-2	6 - 8	76	26	50	2.0^{P}		CH	29.0	
B-2	8 - 10				2.0^{P}		CH	26.0	
B-2	13 - 15				2.25^{P}		CH		
B-3	0.5 - 2	70	28	42	3.0^{P}		CH	28.0	
B-3	2 - 4				2.25^{P}		CH	28.0	
B-3	4 - 6	70	26	44	1.75^{P}	97.4	CH	28.0	
B-3	6 - 8				1.5^{U}		CH	28.0	97.0
B-3	8 - 10				2.5^{P}		CH	29.0	
B-3	13 - 15				2.5^{P}		CH		
B-4	0.6 - 2	62	26	36	1.5^{P}	82.9	CH	26.0	
B-4	2 - 4				1.5^{P}		CH	25.0	
B-4	4 - 6	68	24	44	1.5^{P}		CH	27.0	
B-4	6 - 8				1.2^{U}		CH	28.0	98.4
B-4	8 - 10	65	24	41	1.5^{P}		CH	25.0	
B-4	13 - 15					39.9	SC	20.0	

U = Unconfined Compression; Q = Unconsolidated-Undrained Triaxial; T = Torvane; P = Pocket Penetrometer

FIGURE B-4a

SUMMARY OF LABORATORY RESULTS

ALGOA/ALTA LOMA CULVERT REPLACEMENTS
MULTIPLE LOCATIONS
GALVESTON COUNTY, TEXAS

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Borehole	Depth (feet)	Liquid Limit	Plastic Limit	Plasticity Index	Shear Strength (ksf)	%<#200 Sieve	USCS Group Symbol	Water Content (%)	Dry Density (pcf)
B-5	2 - 4	38	18	20	1.5^P		CL	19.0	
B-5	4 - 6				2.0^P		CH	20.0	
B-5	6 - 8	54	21	33	1.5^P	92.9	CH	23.0	
B-5	8 - 10				1.4^U		CH	24.0	100.2
B-5	13 - 15	47	21	26	2.0^P		CL	21.0	
B-5	18 - 20				3.5^P		CH		
B-6	0.8 - 2	32	20	12	3.25^P	63.6	CL	15.0	
B-6	2 - 4				1.0^P		CH	21.0	
B-6	4 - 6	58	25	33	2.0^P	84.9	CH	22.0	
B-6	6 - 8				0.9^U		CH	24.0	99.6
B-6	8 - 10				1.5^P		CH	23.0	
B-6	13 - 15				2.0^P		CH		
B-7	1.5 - 2				$4.5+^P$		CH		
B-7	2 - 4	43	18	25	3.75^P		CL	15.0	
B-7	4 - 6				1.75^P		CL	16.0	
B-7	6 - 8	42	20	22	1.0^P		CL	21.0	
B-7	8 - 10				0.9^U		CH	31.0	92.3
B-7	13 - 15				1.75^P		CH	36.0	

U = Unconfined Compression; Q = Unconsolidated-Undrained Triaxial; T = Torvane; P = Pocket Penetrometer

FIGURE B-4b

SUMMARY OF LABORATORY RESULTS

ALGOA/ALTA LOMA CULVERT REPLACEMENTS
MULTIPLE LOCATIONS
GALVESTON COUNTY, TEXAS

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