GEOTECHNICAL EXPLORATION

THE RESERVES AT MAGNOLIA
1020 Willowwood Street
Denton, Texas
ALPHA Report No. W222913
December 21, 2022

Prepared for:

JONES GILLAM RENZ ARCHITECTS, INC.
730 N. Ninth Street
Salina, Kansas 6702
Attention: Ms. Maggie Gillam

Prepared By:

ALPHA TESTING

A Universal Engineering Sciences Company

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Geotechnical
Construction Materials
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December 21, 2022

Jones Gillam Renz Architects, Inc.
730 N. Ninth Street
Salina, Kansas 6702

Attention: Ms. Maggie Gillam

Re: Geotechnical Exploration
The Reserves at Magnolia
1020 Willowwood Street
Denton, Texas
ALPHA Report No. W222913

Attached is the report of the geotechnical exploration performed for the project referenced above. This study was authorized by Ms. Maggie Gillam on October 6, 2022 and performed in accordance with ALPHA Proposal No. 93682-rev1, dated October 6, 2022.

This report contains results of field explorations and laboratory testing and an engineering interpretation of these with respect to available project characteristics. The results and analyses were used to develop recommendations to aid design and construction of foundations and private pavement.

ALPHA TESTING, LLC appreciates the opportunity to be of service on this project. If we can be of further assistance, such as providing materials testing services during construction, please contact our office.

Sincerely,

ALPHA TESTING, LLC

STATE OF TEXAS
GREGORY S. FAGAN
116518
LICENSED
PROFESSIONAL ENGINEER
December 21, 2022

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Geotechnical Project Manager

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ALPHA REPORT NO. W222913

1.0 PURPOSE AND SCOPE

The purpose of this geotechnical exploration is for ALPHA TESTING, LLC (ALPHA) to evaluate for Jones Gillam Renz Architects, Inc. (Client) some of the physical and engineering properties of subsurface materials at selected locations on the subject site with respect to formulation of appropriate geotechnical design parameters for the proposed construction. The field exploration was accomplished by securing subsurface samples from widely spaced test borings performed across the expanse of the site. Engineering analyses were performed from results of the field exploration and results of laboratory tests performed on representative samples.

Also included are general comments pertaining to reasonably anticipated construction problems and recommendations concerning earthwork and quality control testing during construction. This information can be used to evaluate subsurface conditions and to aid in ascertaining construction meets project specifications.

Recommendations provided in this report were developed from information obtained in test borings depicting subsurface conditions only at the specific boring locations and at the particular time designated on the logs. Subsurface conditions at other locations may differ from those observed at the boring locations, and subsurface conditions at boring locations may vary at different times of the year. The scope of work may not fully define the variability of subsurface materials and conditions that are present on the site.

The nature and extent of variations between borings may not become evident until construction. If significant variations then appear evident, our office should be contacted to re-evaluate our recommendations after performing on-site observations and possibly other tests.

2.0 PROJECT CHARACTERISTICS

It is proposed to construct a four-story apartment building with associated parking and drives generally located at 1020 Willowwood Street in Denton, Texas. In addition, a detention pond is planned at the southwest corner of the site. A site plan illustrating the general outline of the property is provided as Figure 1, the Boring Location Plan, in the Appendix.

At the time the field exploration was performed, the site generally consisted of a vacant tract of land with dense trees. No information regarding previous development on the site was provided to us. Grading plans were not available at the time of this study. Topographical maps available at www.dfwmaps.com indicates the site generally slopes to the west about 18 ft (Approximate Elevation: 700 ft to Approximate Elevation: 682 ft). For the purpose of our analysis, we have assumed maximum cuts and fills of 2 ft will be required to achieve final grades.

The new structure is expected to create light loads to be carried by the foundation. We understand it is intended to support the structures with post-tensioned slab-on-grade foundations designed for post-construction seasonal movements of about 1 inch or 2 inches. Pavement for the project will consist of portland cement concrete (PCC). No below grade slabs are planned.

3.0 FIELD EXPLORATION

Subsurface conditions on the site were explored by drilling a total of seven (7) test borings. Three (3) test borings were drilled to a depth of 20 ft for the building, one (1) test boring was drilled to a depth of 10 ft for the detention ponds, and three (3) test borings were drilled to a depth of 5 ft for the pavement. The test borings were drilled in general accordance with ASTM Standard D 420 using standard rotary drilling equipment. The approximate location of each test boring is shown on the Boring Location Plan, Figure 1, enclosed in the Appendix. Details of drilling and sampling operations are briefly summarized in Methods of Field Exploration, Section A-1 of the Appendix.

Subsurface types encountered during the field exploration are presented on Log of Boring sheets (boring logs) included in the Appendix. The boring logs contain our Field Technician's and Engineer's 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 approximate and the actual transition between strata may be gradual.

4.0 LABORATORY TESTS

Selected samples of the subsurface materials were tested in the laboratory to evaluate their engineering properties as a basis in providing information for foundation design and earthwork construction. A brief description of testing procedures used in the laboratory can be found in Methods of Laboratory Testing, Section B-1 of the Appendix. Individual test results are presented on the Log of Boring sheets or summary data sheets in the Appendix.

5.0 GENERAL SUBSURFACE CONDITIONS

Based on geological maps available from the Bureau of Economic Geology, published by The University of Texas at Austin, the site lies within the Woodbine formation. The Woodbine formation generally consists of shale, sandstone and limestone. The residual overburden soils associated with the Woodbine formation generally consist of high to low plasticity clay and sand. Hard and discontinuous sandstone lenses, layers, ledges and boulders are commonly encountered at various depths within the formation. The Woodbine formation was deposited in a near shore marine environment, which can account for extreme lateral variability of this formation.

Subsurface conditions encountered in Borings 1, 2, and 3 generally consisted of sandy clay to depths of about 6 ft to 8 ft below the ground surface, underlain by cemented sand extending to the 20 ft termination depth. Subsurface conditions encountered in Borings 4, 5, 6, and 7 generally consisted of sandy clay extending to the termination depth of the borings (5 ft to 10 ft). The upper 4 ft and 2 ft of of sandy clay encountered in Borings 1 and 4, respectively, were visually classified as fill material. More detailed stratigraphic information is presented on the Log of Borings sheets attached to this report.

The granular materials (cemented sand) encountered in the borings are relatively permeable and are anticipated to have a relatively rapid response to groundwater movement. However, the sandy clay encountered in the borings are considered relatively impermeable and is expected to have a relatively slow response to water movement. Therefore, several days of observation would be required to evaluate actual groundwater levels within the depths explored. Also, the groundwater level at the site is anticipated to fluctuate seasonally depending on the amount of rainfall, prevailing weather conditions and subsurface drainage characteristics.

Free groundwater was not encountered in the borings. However, it is common to encounter seasonal groundwater in fill material, granular soils, and from natural fractures within the clayey matrix, particularly during or after periods of precipitation. If more detailed groundwater information is required, monitoring wells or piezometers can be installed.

Additional information concerning subsurface materials and conditions encountered can be obtained from the Log of Boring sheets in the Appendix.

6.0 DESIGN RECOMMENDATIONS

The following design recommendations were developed on the basis of the previously described Project Characteristics (Section 2.0) and General Subsurface Conditions (Section 5.0). If project criteria should change, our office should conduct a review to determine if modifications to the recommendations are required. Further, it is recommended our office be provided with a copy of the final plans and specifications for review prior to construction.

The following design criteria were developed based on our assumption that maximum cuts and fills of 2 ft will be required to achieve final grade in the building pad area. Cutting or filling on the site more than 2 ft can alter the recommended foundation design parameters. Therefore, it is recommended our office be contacted before performing other cutting and filling on site to verify appropriate design parameters are utilized for final foundation design.

6.1 Existing Fill

As discussed in Section 5.0, possible fill material was encountered in the upper 4 ft and 2 ft of Borings 1 and 4, respectively. Additional fill material may be present in areas not explored. It is not known if the fill was placed under engineering supervision with compaction records. If compaction records for the fill cannot be obtained, the fill should be considered as uncontrolled fill. Uncontrolled fill is generally not considered suitable for support of slabs or foundations due to the risk of under-compacted zones resulting in failures of weak soil and/or indeterminate levels of settlement. Any existing uncontrolled fill should be removed from the building pad areas and replaced with engineered fill as recommended in Section 6.2 or Section 7.3 as applicable. The excavated materials may be suitable for reuse as engineered fill provided they are free of organics, boulders, rubble, and other debris.

The lateral extent and depth and nature of the fill are not known. Test pits could be performed prior to construction to verify the lateral extent, depth, and nature of the fill materials. ALPHA would be pleased to provide this service if desired.

6.2 Potential Seasonal Movements and Subgrade Improvement

Our findings indicate the floor slabs constructed within 2 ft of the existing ground surface could experience post construction seasonal movements of up to about 3 inches due to shrinking and swelling of active clay soils. Floor slabs and at-grade structures supported on uncontrolled fill are also subject to indeterminate levels of settlement.

This estimate of potential movement is based on the assumption that any fill used to raise the grade or backfill excavations of uncontrolled fill consists of onsite or similar soils with a plasticity index of 20 or less. Use of fill material with a higher plasticity index could result in potential movements exceeding our estimates.

Potential seasonal movements discussed above was estimated in general accordance with methods outlined by Texas Department of Transportation (TxDOT) Test Method Tex-124-E, from results of absorption swell tests and engineering judgment and experience. Estimated movements were calculated assuming the moisture content of the in-situ soil within the normal zone of seasonal moisture content change varies between a "dry" condition and a "wet" condition as defined by Tex-124-E. Also, it was assumed a 1 psi surcharge load from the floor slab acts on the subgrade soils. Movements exceeding our estimates could occur if positive drainage of surface water is not maintained or if soils are subject to an outside water source, such as leakage from a utility line or subsurface moisture migration from off-site locations.

We understand it is desired to reduce potential movements of the slab foundations to about 1 or 2 inches. Potential movements could be reduced to about 2 inches by raising the grades using non-expansive fill or reduced to about 1 inch by using moisture conditioning and/or non-expansive fill to depths as summarized in Table A. Moisture conditioning is described in Section 6.2.1. Non-expansive fill could consist of select fill or flexible base material as described in Section 7.3.

Table A
Desired Potential Seasonal Movement and Corresponding Subgrade Improvement

Target Post Construction Movement (inches)	Required Subgrade Improvement below Floor Slab
2	1 ft of Non-Expansive Fill in Conjunction with 4 ft of Moisture Conditioning or Top of Cemented Sand
1	1 ft of Non-Expansive Fill in Conjunction with 10 ft of Moisture Conditioning or Top of Cemented Sand

In choosing moisture conditioning as a method of potential soil movement reduction, the Client is accepting some post construction movement of grade supported structures (about 1 inch or 2 inches depending on the chosen improvement).

Due to the presence of granular soil layers, water pressure injection is not considered practical for this project. Our office should be contacted if recommendations for water pressure injection are desired.

6.2.1 Subgrade Improvement Using Moisture-Conditioning

Estimated potential seasonal movement of the slab-on-grade foundations could be reduced to about 2 inches or 1 inch by placing at least 1 ft of non-expansive material between the bottom of the floor slab and the top surface of moisture conditioned soil extending to respective depths of at least 4 ft and 10 ft below the bottom of non-expansive fill, as recommended in Table A. Non-expansive material could consist of select fill or flexible base material as discussed in Section 7.3.

Based on conditions encountered in the borings, we expect relatively sandy soils will be encountered in the moisture conditioning excavation. However, these soils were very dry and have the potential for higher swelling than typically expected. The purpose of reworking the upper 4 ft or 10 ft of soil in the building pad is partially to pre-swell existing clayey soils in the building pad. It is also intended to break up the tight clayey matrix which causes sandy soils in the Woodbine formation to exhibit higher swell potential relative to their index properties than normally expected in other geological formations.

Moisture-conditioning consists of processing and compacting the specified minimum thickness of on-site soils at a “target” moisture content approximated to at least 4 percentage points above the material’s optimum moisture content as determined by the standard Proctor method (ASTM D 698). Some of the sandier onsite soils with a lower plasticity index may require compaction at a moisture content closer to optimum. Any deviation from the 4 percentage points above optimum should be verified by ALPHA during construction. The moisture-conditioned soil, free of debris and any rock fragment greater than 4 inches, should be placed in about 8-inch thick loose lifts and compacted to a dry density of 93 to 97 percent of standard Proctor maximum dry density. Moisture conditioning of the on-site soil should extend throughout the entire building pad area, at least 5 ft beyond the perimeter of the building and below any adjacent flatwork for which it is desired to reduce movements. At entrance areas and outward swinging doors, the moisture conditioning process should extend at least 10 ft beyond the perimeter of the building. However, non-expansive material should not extend beyond the building limits. If flatwork or paving is not planned adjacent to the structure (i.e. above the moisture-conditioned soils), a moisture barrier consisting of a minimum of 10 mil plastic sheeting with 8 to 12 inches of soil cover should be provided above the moisture conditioned soils. Moisture-conditioned soils should be maintained in a moist condition prior to placement of the required thickness of non-expansive material or flatwork.

The resulting estimated potential seasonal movements of about 1 inch (depending on the depth of improvement) were calculated assuming the moisture content of the moisture-conditioned soil varies between the “target” moisture content and the “wet” condition while the deeper undisturbed in-situ soil within the normal zone of seasonal moisture content change varies between the "dry" condition and the "wet" condition as defined by methods outlined in TxDOT Test Method Tex-124-E.

The purpose of moisture-conditioning is to reduce the free swell potential of the moisture-conditioned soil to 1 percent or less. Additional laboratory tests (i.e., standard Proctors, absorption swell tests, etc.) should be conducted during construction to verify the “target” moisture content for moisture-conditioning (estimated at 5 percentage points above the material’s optimum moisture content as defined by ASTM D 698) is sufficient to reduce the free swell potential of the processed soil to 1 percent or less. In addition, it is recommended samples of the moisture-conditioned material be routinely obtained during construction to verify the free swell of the improved material is 1 percent or less.

Moisture conditioning should be monitored and tested on a full-time basis by ALPHA to verify materials tested are placed with the proper degree of moisture and compaction as presented in this report. Field density tests should be performed for each lift of fill placed in each building pad area.

6.3 Slab-on-Grade Foundations

Slab-on-grade foundations should be designed with exterior and interior grade beams adequate to provide sufficient rigidity to the foundation system. A net allowable soil bearing pressure of 1.5 kips per sq ft may be used for design of all grade beams bearing on a moisture improved subgrade placed in accordance with Section 6.2. Grade beams should bear a minimum depth of 18 inches below final grade and should have a minimum width of 10 inches considering the recommended bearing capacity.

To reduce cracking as normal movements occur in foundation soils, all grade beams and slab foundations should be adequately reinforced with steel (conventional reinforcing steel and/or post-tensioned reinforcement). It is common to experience some minor cosmetic distress to structures with slab-on-grade foundation systems due to normal ground movements. A properly designed and constructed moisture barrier should be placed between the slabs and subgrade soils to retard moisture migration through the slabs.

6.3.1 Post-Tensioning Institute, Design of Post-Tensioned Slab-on-Grade

Tables B and C contain information for design of the post-tensioned, slab-on-grade foundation. Design parameters were evaluated based on the conditions encountered in the borings and using information and correlations published by PTI Third Edition and VOLFLO 1.5 computer program provided by Geostructural Tool Kit, Inc. (GTI).

TABLE B
PTI Design Parameters
Potential Seasonal Movement = 1 inch
(After Subgrade Improvement as Described in Section 6.2)

	EDGE LIFT	CENTER LIFT
Edge Moisture Distance, ft (em)	3.9	7.5
Differential Soil Movement, inches (y_m)	1.2 (swell)	1.0 (shrink)

TABLE C
PTI Design Parameters
Potential Seasonal Movement = 2 inches
(After Subgrade Improvement as Described in Section 6.2)

	EDGE LIFT	CENTER LIFT
Edge Moisture Distance, ft (em)	3.9	7.5
Differential Soil Movement, inches (y_m)	1.6 (swell)	1.2 (shrink)

6.4 Seismic Considerations

The Site Class for seismic design is based on several factors that include soil profile (soil or rock), shear wave velocity, and strength, averaged over a depth of 100 ft. Since our borings did not extend to 100-foot depths, we based our determinations on the assumption that the subsurface materials below the bottom of the borings were similar to those encountered at the termination depth of the borings. Based on Section 1613.3.2 of the 2012 International Building Code and

Table 20.3-1 in the 2010 ASCE-7, we recommend using Site Class C (very dense soil) for seismic design at this site.

6.5 Exterior Flatwork

Exterior flatwork supported within 2 ft of existing grade are subject to potential seasonal movements of up to about 3 inches described in Section 6.2. In areas where flatwork movement is critical (such as, but not limited to, main entrances), subgrade improvement as discussed in Section 6.2 can be considered to reduce the potential soil movement.

6.6 Pavement

To permit correlation between information from test borings and actual subgrade conditions exposed during construction, a qualified Geotechnical Engineer should be retained to provide subgrade monitoring and testing during construction. If there is any change in project criteria, the recommendations contained in this report should be reviewed by our office.

Calculations used to determine the required pavement thickness are based only on the physical and engineering properties of the materials used and conventional thickness determination procedures. Pavement joining buildings should be constructed with a curb and the joint between the building and curb should be sealed. Related civil design factors such as subgrade drainage, shoulder support, cross-sectional configurations, surface elevations, reinforcing steel, joint design and environmental factors will significantly affect the service life and must be included in preparation of the construction drawings and specifications, but all were not included in the scope of this study. Normal periodic maintenance will be required for all pavement to achieve the design life of the pavement system.

Please note, the recommended pavement sections are considered the minimum necessary to provide satisfactory performance based on the expected traffic loading. In some cases, City minimum standards for pavement section construction may exceed those recommended.

6.6.1 Pavement Subgrade Preparation

Based on the soil profile encountered in the borings, we would expect the pavement subgrade could consist of sandy material or clayey material depending on where the pavement is located. In general, clayey soils with a plasticity index of 15 or greater should be lime stabilized. Sandy soils with a plasticity index less than 15 should be cement modified. As an alternative, Cem-Lime™ could be used to improve either clayey or sandy soils. Provided below are subgrade improvement recommendations for lime, cement and Cem-Lime™

In areas where moderate to high plasticity sandy clay (plasticity index of about 15 or greater) is exposed after final subgrade elevation is achieved, the exposed surface of the pavement subgrade soil should be scarified to a depth of 6 inches and mixed with a minimum 6 percent hydrated lime (by dry soil weight) in conformance with TxDOT Standard Specification Item 260. Assuming an in-place unit weight of 100 pcf for the pavement subgrade soils, this percentage of lime equates to about 27 lbs of lime per sq yard of treated subgrade. The actual amount of lime required should be confirmed by additional laboratory tests (ASTM C 977 Appendix XI) prior to construction. The soil-lime mixture should be compacted to at least 95 percent of standard Proctor maximum dry density (ASTM D 698) and within the range of 0 to 4 percentage points above the mixture's optimum moisture content. In all areas where hydrated lime is used to stabilize subgrade soil, routine Atterberg-limit tests should be performed to verify the resulting plasticity index of the soil-lime mixture is at/or below 15.

Cement modification should be used in pavement areas where clayey sand and low PI (less than 15) sandy clay is exposed after final subgrade elevation is achieved. The exposed surface of the pavement subgrade soils should be scarified to a depth of 6 inches and mixed with at least 5 percent Portland cement (by dry unit weight) in conformance with TxDOT Item 275. Assuming an in-place unit weight of 105 pcf for the pavement subgrade soils, this percentage of cement equates to about 24 lbs of cement per sq yard of subgrade treated. The soil-cement mixture should be compacted to at least 95 percent of standard Proctor maximum dry density (ASTM D 698) and within the range of -1 to +3 percentage points of the mixture's optimum moisture content. Cement stabilization could also be utilized where subgrade consists of sandy clay with a plasticity index of 15 or higher, although processing cement into these soils could be more difficult.

Cem-Lime™ is designed to serve the same purpose as both lime and cement for soil stabilization or modification in highly variable subgrade conditions similar to those encountered at the referenced project site. Cem-Lime™ is a proprietary product manufactured by Martin Marietta. Cem-Lime™ should be placed according to the manufacturer’s specifications. After final subgrade elevation is achieved, the exposed surface of the pavement subgrade soils should be scarified to a depth of at least 6 inches and mixed with Cem-Lime™. For preliminary purposes, a minimum 5 percent (by dry soil unit weight) of Cem-Lime™ should be used. Unconfined compressive strength tests should be performed on laboratory molded specimens of representative onsite material mixed with Cem-Lime™ to evaluate the actual percent of required Cem-Lime™.

Subgrade improvement could also consist of a minimum 6 inch layer of flexible base material. Flexible base used for pavement subgrade should consist of material meeting the requirements of TxDOT Standard Specifications Item 247, Type A, Grade 1-2. The flexible base should be compacted to at least 95 percent of standard Proctor maximum dry density (ASTM D 698) and within the range of 2 percentage points below to 2 percentage points above the material's optimum moisture content.

We recommend subgrade improvement procedures extend at least 1 ft beyond the edge of the pavement to reduce effects of seasonal shrinking and swelling upon the extreme edges of pavement.

Improvement of the pavement subgrade soil will not prevent normal seasonal movement of the underlying untreated materials. Pavement and other flatwork will have the same potential for movement as slabs constructed directly on the existing undisturbed soils. Good perimeter surface drainage with a minimum slope of 2 percent away from the pavement is recommended. Normal maintenance of pavement should be expected over the life of the structures.

6.6.2 Portland Cement Concrete (PCC) Pavement

Following subgrade improvement as recommended in Section 6.6.1, PCC (reinforced) pavement sections are recommended in Table D.

TABLE D Recommended PCC Pavement Sections		
Paving Areas and/or Type	**Subgrade Thickness, Inches**	**PCC Thickness, Inches**
Parking Areas Subjected Exclusively to Passenger Vehicle Traffic,	Scarified and Compacted (native), 6	5
Drive Lanes, Fire Lanes, Areas Subject to Light Volume Truck Traffic,	Modified Subgrade, 6	6
Dumpster Traffic Areas, Areas subject to Moderate Volume Truck Traffic,	Modified Subgrade, 6	7

PCC should have a minimum compressive strength of 3,000 psi at 28 days in parking areas subjected exclusively to passenger vehicle traffic. We recommend a minimum compressive strength of 3,500 psi at 28 days for the drive lanes, fire lanes, and truck areas. Concrete should be designed with 4.5 ± 1.5 percent entrained air. Joints in concrete paving should not exceed 15 ft. Reinforcing steel should consist of No. 3 bars placed at 18 inches on-center in two directions.

Alternatively, mechanical treatment of the pavement subgrade could be eliminated by increasing the PCC thickness in the pavement sections presented in Table D by 1 inch. Prior to construction of pavement on untreated subgrade soil, the exposed subgrade should be scarified to a depth of at least 6 inches and compacted to at least 95 percent of standard Proctor maximum dry density (ASTM D 698) and within the range of -1 to +3 percentage points of the material's optimum moisture content.

6.7 Drainage and Other Considerations

Adequate drainage should be provided to reduce seasonal variations in the moisture content of foundation soils. All pavement and sidewalks within 5 ft of the building should be sloped away from the structure to prevent ponding of water around the foundation. Final grades within 5 ft of the structure should be adjusted to slope away from the structure at a minimum slope of 2 percent. **Maintaining positive surface drainage throughout the life of the structures is essential.**

In areas with pavement or sidewalks adjacent to the new structure, a positive seal must be maintained between the structures and the pavement or sidewalk to minimize seepage of water into the underlying supporting soils. Post-construction movement of pavement and flat-work is common. Normal maintenance should include examination of all joints in paving and sidewalks, etc. as well as resealing where necessary.

Several factors relate to civil and architectural design and/or maintenance, which can significantly affect future movements of the foundation and floor slab systems:

- Preferably, a complete system of gutters and downspouts should carry runoff water a minimum of 5 feet from the completed structure.

- Large trees and shrubs should not be allowed closer to the foundation than a horizontal distance equal to roughly one-half of their mature height due to their significant moisture demand upon maturing.

- Moisture conditions should be maintained "constant" around the edge of the slab. Ponding of water in planters, in unpaved areas, and around joints in paving and sidewalks can cause slab movements beyond those predicted in this report.

- Planter box structures placed adjacent to the buildings should be provided with a means to assure concentrations of water are not available to the subsoil stratigraphy.

- *The root systems from existing trees at this site will have dried and desiccated the surrounding clay soils, resulting in soil with near-maximum swell potential. Clay soils surrounding tree root mats in areas to be covered with grade slabs (including but not limited to the foundation, flatwork, pavement or equipment pads.) should be removed to a minimum depth of 1 ft below the root ball and compacted in-place with moisture and density control as described in Section 7.3.*

Trench backfill for utilities should be properly placed and compacted as outlined in Section 7.4 and in accordance with requirements of local City standards. Since granular bedding backfill is used for most utility lines, the backfilled trench should not become a conduit and allow access for surface or subsurface water to travel toward the new structures. Concrete cut-off collars or clay plugs should be provided where utility lines cross building lines to prevent water from traveling in the trench backfill and entering beneath the structures.

7.0 GENERAL CONSTRUCTION PROCEDURES AND GUIDELINES

Variations in subsurface conditions could be encountered during construction. To permit correlation between test boring data and actual subsurface conditions encountered during construction, it is recommended a registered Professional Engineering firm be retained to observe construction procedures and materials.

Some construction problems, particularly degree or magnitude, cannot be anticipated until the course of construction. The recommendations offered in the following paragraphs are intended not to limit or preclude other conceivable solutions, but rather to provide our observations based on our experience and understanding of the project characteristics and subsurface conditions encountered in the borings.

7.1 Site Preparation and Grading

Existing fill was encountered to depths of up 4 ft and 2 ft below the ground surface in Borings 1 and 4, respectively. Although not encountered in the borings, the existing fill materials can also contain organics, boulders, rubble, and other debris which could be encountered during site grading and general excavation. The earthwork and excavation contracts should contain provision for removal of unsuitable materials in the existing fill. Test pit excavations performed prior to construction can be used to evaluate the depth, extent and composition of existing fill at this site. ALPHA would be pleased to provide this service if desired.

Although not encountered in the borings, the residual sandy and clayey soils of the Woodbine formation can contain very hard and discontinuous sandstone seams, layers and boulders. These rock materials could be encountered during foundation excavation, other general excavation, and earthwork operations at this site. Rock excavation methods (including, but not limited to rock teeth, rippers, jack hammers, or sawcutting) may be required to remove this sandstone. The contractor selected should have experience with excavation and earthwork in sandstone in the Woodbine formation.

All areas supporting the slab foundation, pavement, flatwork, or areas to receive new fill should be properly prepared.

- After completion of the necessary stripping, clearing, and excavating and prior to placing any required fill, the exposed soil subgrade should be carefully evaluated by probing and testing. Any undesirable material (organic material, wet, soft, or loose soil) still in place should be removed.

- The exposed soil subgrade should be further evaluated by proof-rolling with a heavy pneumatic tired roller, loaded dump truck or similar equipment weighing approximately 20 tons to check for pockets of soft or loose material hidden beneath a thin crust of possibly better soil.

- Proof-rolling procedures should be observed routinely by a Professional Engineer, or his designated representative. Any undesirable material (organic material, wet, soft, or loose soil) exposed during the proof-roll should be removed and replaced with well-compacted material as outlined in Section 7.3.

- Prior to placement of any fill, the exposed soil subgrade should then be scarified to a minimum depth of 6 inches and recompacted as outlined in Section 7.3.

If fill is to be placed on existing slopes (natural or constructed) steeper than six horizontal to one vertical (6:1), the fill materials should be benched into the existing slopes in such a manner as to provide a minimum bench-key width of five (5) ft. This should provide a good contact between the existing soils and new fill materials, reduce potential sliding planes, and allow relatively horizontal lift placements.

Even if fill is properly compacted as recommended in Section 7.3, fills in excess of about 10 ft are still subject to settlements over time of up to about 1 to 2 percent of the total fill thickness. This should be considered when planning or placing deep fills.

Slope stability analysis of embankments (natural or constructed) and global stability analysis for retaining walls was not within the scope of this study.

The contractor is responsible for designing any excavation slopes, temporary sheeting or shoring. Design of these structures should include any imposed surface surcharges. Construction site safety is the sole responsibility of the contractor, who shall also be solely responsible for the means, methods and sequencing of construction operations. The contractor should also be aware that slope height, slope inclination or excavation depths (including utility trench excavations) should in no case exceed those specified in local, state and/or federal safety regulations, such as OSHA

Health and Safety Standard for Excavations, 29 CFR Part 1926, or successor regulations. Stockpiles should be placed well away from the edge of the excavation and their heights should be controlled so they do not surcharge the sides of the excavation. Surface drainage should be carefully controlled to prevent flow of water over the slopes and/or into the excavations. Construction slopes should be closely observed for signs of mass movement, including tension cracks near the crest or bulging at the toe. If potential stability problems are observed, a geotechnical engineer should be contacted immediately. Shoring, bracing or underpinning required for the project (if any) should be designed by a professional engineer registered in the State of Texas.

Due to the nature of the clayey and sandy soils found near the surface at the borings, traffic of heavy equipment (including heavy compaction equipment) may create pumping and general deterioration of shallow soils. Therefore, some construction difficulties should be anticipated during periods when these soils are saturated.

7.2 Foundation Excavations

All foundation excavations should be properly monitored to verify loose, soft, or otherwise undesirable materials are removed and foundations will bear on satisfactory material. Surface runoff should be drained away from excavations and not allowed to pond in the bottom of the excavation. The exposed foundation soils should not be allowed to become excessively dry or wet before placement of concrete. All concrete for foundations should be placed as soon as practical after the excavation is made.

Prolonged exposure of the bearing surface to air or water will result in changes in strength and compressibility of the bearing stratum. Therefore, if delays occur, excavations should be slightly deepened and cleaned, in order to provide a fresh bearing surface.

7.3 Fill Compaction

Select Fill (Non-Expansive Fill): Select fill used as non-expansive fill should have a liquid limit less than 35, a plasticity index (PI) not less than 4 nor greater than 15. Select fill should not contain deleterious material and debris. Select fill should be compacted to a dry density of at least 95 percent of standard Proctor maximum dry density (ASTM D 698) and within the range of -1 to +3 percentage points of the material's optimum moisture content. The plasticity index and liquid limit of material used as select, non-expansive fill should be verified during fill placement using laboratory tests. Atterberg limits tests to verify the select, non-expansive fill shall be performed at a frequency of at least one test per 2 feet of thickness per 5,000 square feet. Atterberg limits shall be staggered between various lifts within each 5,000 square feet.

Flexible Base Material (Non-Expansive Fill): Flexible base material used as non-expansive fill for the building pad area should meet the requirements of TxDOT Item 247, Type A, B, C or D, Grade 1-2 or 3. The material should be compacted to a minimum 95 percent of standard Proctor maximum dry density (ASTM D 698) and within -2 to +3 percentage points of the material's optimum moisture content.

Sandy clay used for general fill with a plasticity index equal to or greater than 25 should be compacted to a dry density between 93 and 98 percent of standard Proctor maximum dry density (ASTM D 698). The compacted moisture content of the clays during placement should be within the range of +2 to +6 percentage points of the material’s optimum moisture.

Sandy clay with a plasticity index below 25 should be compacted to a dry density of at least 95 percent of standard Proctor maximum dry density (ASTM D 698) and within the range of 1 percentage point below to 3 percentage points above the material's optimum moisture content.

Clayey fill should be process and the largest particle or clod should be less than 6 inches prior to compaction.

Where mass fills are deeper than 10 ft, the fill/backfill below 10 ft should be compacted to at least 100 percent of standard Proctor maximum dry density (ASTM D-698) and within 2 percentage points of the material's optimum moisture content. The portion of the fill/backfill shallower than 10 ft should be compacted as outlined herein.

Compaction should be accomplished by placing fill in about 8-inch thick loose lifts and compacting each lift to at least the specified minimum dry density. Field density and moisture content tests should be performed on each lift.

In general site grading areas where final fill slopes will be four horizontal to one vertical (4:1) or steeper and greater than 5 ft in height, field density and moisture content tests should be performed on each lift.

7.4 Utilities

Where utility lines are deeper than 10 ft, the fill/backfill below 10 ft should be compacted to at least 100 percent of standard Proctor maximum dry density (ASTM D 698) and within –2 to +2 percentage points of the material's optimum moisture content. The portion of the fill/backfill shallower than 10 ft should be compacted as previously outlined. Density tests should be performed on each lift (maximum 12-inch thick) and should be performed as the trench is being backfilled.

Even if fill is properly compacted, fills in excess of about 10 ft are still subject to settlements over time of up to about 1 to 2 percent of the total fill thickness. This should be considered when designing pavement over utility lines and/or other areas with deep fill.

If utility trenches or other excavations extend to or beyond a depth of 5 ft below construction grade, the contractor or others shall be required to develop an excavation safety plan to protect personnel entering the excavation or excavation vicinity. The collection of specific geotechnical data and the development of such a plan, which could include designs for sloping and benching or various types of temporary shoring, is beyond the scope of this study. Any such designs and safety plans shall be developed in accordance with current OSHA guidelines and other applicable industry standards.

7.5 Groundwater

Groundwater was not encountered in the borings. However, from our experience, shallow groundwater could be encountered during general excavation at this site. The risk of encountering seepage is increased during or after periods of precipitation. Standard sump pit and pumping procedures should be adequate to control seepage on a local basis for relatively shallow excavations.

Where groundwater is encountered in granular soils, sump pits may not be adequate to control seepage and supplemental dewatering measures may be necessary to control groundwater seepage. Supplemental dewatering measures include (but are not limited to) submersible pumps in slotted casings and well points.

In any areas where cuts are made, attention should be given to possible seasonal water seepage that could occur through natural cracks and fissures in the newly exposed stratigraphy. The risk of seepage is increased were sandstone is exposed in slopes and excavations or is near final grade. In these areas, subsurface drains may be required to intercept seasonal groundwater seepage. The need for these or other de-watering devices should be carefully addressed during construction. Our office could be contacted to visually observe the final grades to evaluate the need for such drains.

8.0 LIMITATIONS

Professional services provided in this geotechnical exploration were performed, findings obtained, and recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. The scope of services provided herein does not include an environmental assessment of the site or investigation for the presence or absence of hazardous materials in the soil, surface water or groundwater. ALPHA, upon written request, can be retained to provide these services.

ALPHA is not responsible for conclusions, opinions or recommendations made by others based on this data. Information contained in this report is intended for the exclusive use of the Client (and their designated design representatives), and is related solely to design of the specific structures outlined in Section 2.0. No party other than the Client (and their designated design representatives) shall use or rely upon this report in any manner whatsoever unless such party shall have obtained ALPHA’s written acceptance of such intended use. Any such third party using this report after obtaining ALPHA’s written acceptance shall be bound by the limitations and limitations of liability contained herein, including ALPHA’s liability being limited to the fee paid to it for this report. Recommendations presented in this report should not be used for design of any other structures except those specifically described in this report. In all areas of this report in which ALPHA may provide additional services if requested to do so in writing, it is presumed that such requests have not been made if not evidenced by a written document accepted by ALPHA. Further, subsurface conditions can change with passage of time. Recommendations contained herein are not considered applicable for an extended period of time after the completion date of this report. It is recommended our office be contacted for a review of the contents of this report for construction commencing more than one (1) year after completion of this report. Non-compliance with any of these requirements by the Client or anyone else shall release ALPHA from any liability resulting from the use of, or reliance upon, this report.

Recommendations provided in this report are based on our understanding of information provided by the Client about characteristics of the project. If the Client notes any deviation from the facts about project characteristics, our office should be contacted immediately since this may materially alter the recommendations. Further, ALPHA is not responsible for damages resulting from workmanship of designers or contractors. It is recommended the Owner retain qualified personnel, such as a Geotechnical Engineering firm, to verify construction is performed in accordance with plans and specifications.

APPENDIX

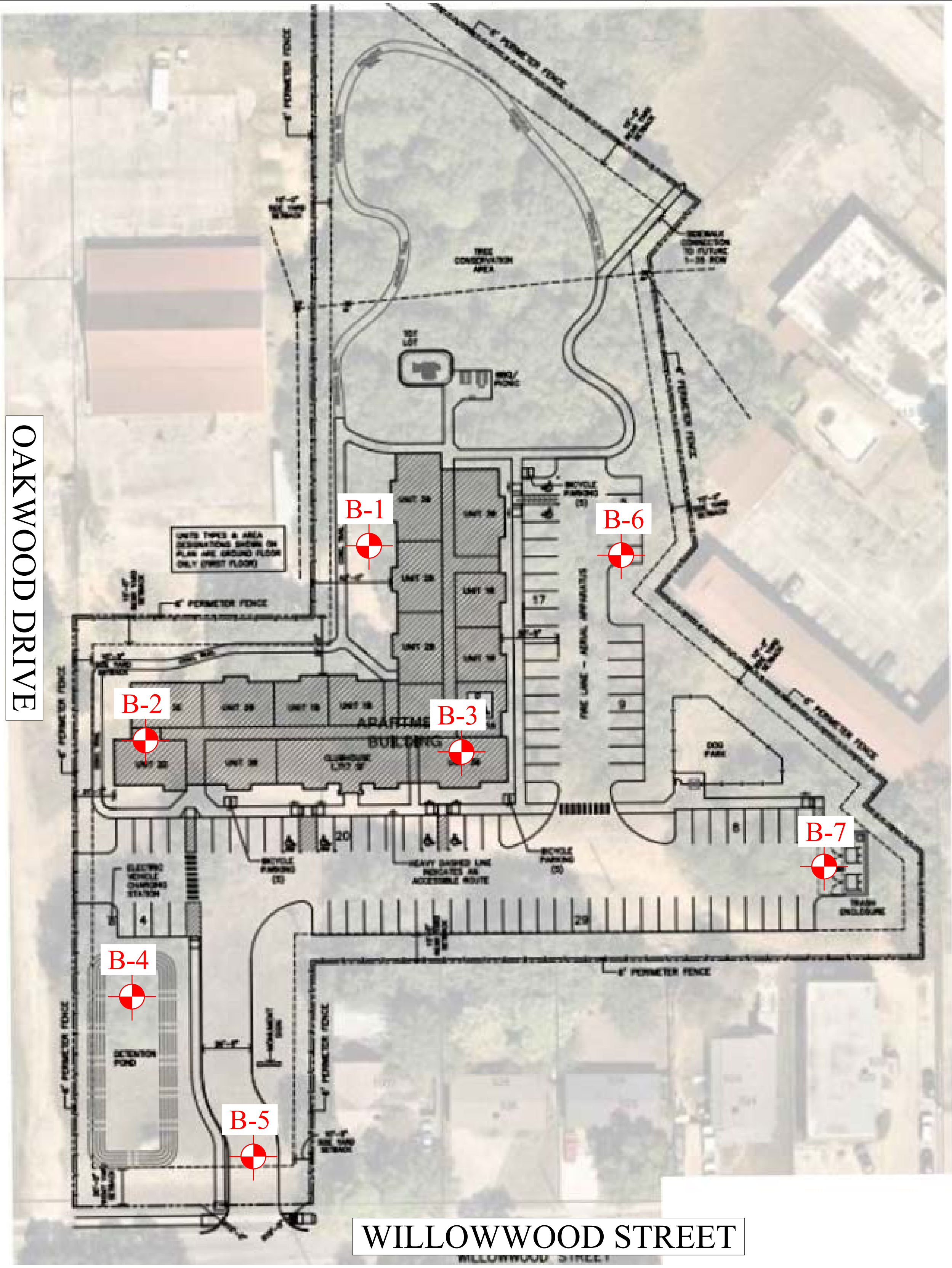
A-1 METHODS OF FIELD EXPLORATION

Using standard rotary drilling equipment, seven (7) test borings were performed for this geotechnical exploration at the approximate locations shown on the Boring Location Plan, Figure 1. The boring locations were staked by using a handheld GPS device or by pacing/taping and estimating right angles from landmarks which could be identified in the field and as shown on the site plan provided during this study. The locations of the test borings shown on the Boring Location Plan are considered accurate only to the degree implied by the methods used to define them.

Relatively undisturbed soil samples were obtained by hydraulically pressing 3-inch O.D. thin-wall sampling tubes into the underlying soils at selected depths (ASTM D 1587). These samples were removed from the sampling tubes in the field and evaluate visually. One representative portion of each sample was sealed in a plastic bag for use in future visual evaluation and possible testing in the laboratory.

Disturbed samples were obtained using split-spoon sampling procedures in general accordance with ASTM Standard D 1586. Disturbed samples were obtained at selected depths in the borings by driving a standard 2-inch O.D. split-spoon sampler 18 inches into the subsurface material using a 140-pound hammer falling 30 inches. The number of blows required to drive the split-spoon sampler the final 12 inches of penetration (N-value) is recorded in the appropriate column on the boring logs. However, if the sampler was not driven the initial 6-inch seating increment with 50 hammer blows, refusal (i.e. “ref”) is recorded along with the inches driven on the boring logs.

The boring logs are included in this Appendix. The logs show visual descriptions of subsurface strata encountered in the borings using the Unified Soil Classification System. Sampling information, pertinent field data, and field observations are also included. Samples not consumed by testing will be retained in our laboratory for at least 14 days and then discarded unless the Client requests otherwise.



GEOTECHNICAL EXPLORATION
THE RESERVES AT MAGNOLIA
1020 WILLOWWOOD STREET
DENTON, TEXAS
ALPHA PROJECT NO. W222913

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FIGURE 1

BORING LOCATION PLAN

APPROXIMATE BORING LOCATION

B-1 METHODS OF LABORATORY TESTING

Representative samples were evaluated and classified by a qualified member of the Geotechnical Division and the boring logs were edited as necessary. To aid in classifying the subsurface materials and to determine the general engineering characteristics, natural moisture content tests (ASTM D 2216), Atterberg-limit tests (ASTM D 4318), percent material passing the No. 200 sieve tests (ASTM D 1140), and dry unit weight determinations were performed on selected samples. In addition, unconfined compressive strength tests (ASTM D 2166) and pocket-penetrometer tests were conducted on selected soil samples to evaluate the soil shear strength. Results of these laboratory tests are provided on the Log of Boring sheets.

In addition to the Atterberg-limit tests, the expansive properties of the clayey soils were further analyzed by absorption swell tests. The swell test is performed by placing a selected sample in a consolidation machine and applying either the approximate current or expected overburden pressure and then allowing the sample to absorb water. When the sample exhibits very little tendency for further expansion, the height increase is recorded and the percent free swell and total moisture gain calculated. Results of the absorption swell tests are provided on the attached Log of Boring sheets.

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BORING NO.: 1
Sheet 1 of 1

PROJECT NO.: W222913

Client: Jones Gilliam Panz Architects, Inc.
Project: The Reserves at Magnolia
Start Date: 10/21/2022 **End Date:** 10/21/2022
Drilling Method: CONTINUOUS FLIGHT AUGER

Location: Denton, Texas
Surface Elevation:
West:
North:
Hammer Drop (lbs / in): 140 / 30

GROUND WATER OBSERVATIONS
On Rods (ft): NONE
After Drilling (ft): DRY
After ____ Hours (ft):

Depth, feet	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Recovery % RQD	TX Cone or Std. Pen. (blows/ft, in)	Pocket Penetrometer (tsf)	Unconfined Comp. Strength (tsf)	% Passing No. 200 Sieve	Unit Dry Weight (pcf)	Water Content, %	Liquid Limit	Plastic Limit	Plasticity Index	Swell, %
0–4.0		Brown SANDY CLAY with asphalt - FILL (4.0)				1.5		17		6	26	12	14	
4.0–6.0 (5)		Reddish Brown SANDY CLAY with clayey sand seams and layers (6.0)				0.5	0.4		90	5	25	12	13	
6.0–20.0 (10)		Tan CEMENTED SAND			50/ 2.25"									
(15)					50/ 2"									
(20)		(20.0)			50/ 1.5"									
		TEST BORING TERMINATED AT 20 FT												

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PROJECT NO.: W222913

Client: Jones Gilliam Panz Architects, Inc.
Project: The Reserves at Magnolia
Start Date: 10/21/2022 **End Date:** 10/21/2022
Drilling Method: CONTINUOUS FLIGHT AUGER

Location: Denton, Texas
Surface Elevation:
West:
North:
Hammer Drop (lbs / in): 140 / 30

GROUND WATER OBSERVATIONS
▽ On Rods (ft): NONE
▼ After Drilling (ft): DRY
▼ After ____ Hours (ft):

Depth, feet	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Recovery % RQD	TX Cone or Std. Pen. (blows/ft, in)	Pocket Penetrometer (tsf)	Unconfined Comp. Strength (tsf)	% Passing No. 200 Sieve	Unit Dry Weight (pcf)	Water Content, %	Liquid Limit	Plastic Limit	Plasticity Index	Swell, %
		Reddish Brown and Brown SANDY CLAY with clayey sand seams and layers												
1						1.5				9				
3						4.5	6.2		109	9	40	15	25	
5						2.0				10				
7						4.5+				9	48	18	30	0.0
8.0		Tan CEMENTED SAND												
10					50/ 3.5"									
15					50/ 2"									
20.0					50/ 1.75"									
		TEST BORING TERMINATED AT 20 FT												

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BORING NO.: 3
Sheet 1 of 1

PROJECT NO.: W222913

Client: Jones Gilliam Panz Architects, Inc.
Project: The Reserves at Magnolia
Start Date: 10/21/2022 **End Date:** 10/21/2022
Drilling Method: CONTINUOUS FLIGHT AUGER

Location: Denton, Texas
Surface Elevation:
West:
North:
Hammer Drop (lbs / in): 140 / 30

GROUND WATER OBSERVATIONS
On Rods (ft): NONE
After Drilling (ft): DRY
After ____ Hours (ft):

Depth, feet	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Recovery % RQD	TX Cone or Std. Pen. (blows/ft, in)	Pocket Penetrometer (tsf)	Unconfined Comp. Strength (tsf)	% Passing No. 200 Sieve	Unit Dry Weight (pcf)	Water Content, %	Liquid Limit	Plastic Limit	Plasticity Index	Swell, %
		Reddish Brown and Brown SANDY CLAY with clayey sand seams and layers				0.25				4				
						0.5				9				
5						3.0				9	42	17	25	1.1
						3.0	7.3		116	7	47	18	29	
		8.0												
		Tan CEMENTED SAND with sandstone seams												
10					50/ 2.5"									
15					50/ 2.5"									
20		20.0			50/ 1.75"									
		TEST BORING TERMINATED AT 20 FT												

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BORING NO.: 4

Sheet 1 of 1

PROJECT NO.: W222913

Client: Jones Gilliam Panz Architects, Inc.

Project: The Reserves at Magnolia

Start Date: 10/21/2022 **End Date:** 10/21/2022

Drilling Method: CONTINUOUS FLIGHT AUGER

Location: Denton, Texas

Surface Elevation:

West:

North:

Hammer Drop (lbs / in): 140 / 30

GROUND WATER OBSERVATIONS

▽ On Rods (ft): NONE

▼ After Drilling (ft): DRY

▽ After ____ Hours (ft):

Depth, feet	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Recovery % RQD	TX Cone or Std. Pen. (blows/ft, in)	Pocket Penetrometer (tsf)	Unconfined Comp. Strength (tsf)	% Passing No. 200 Sieve	Unit Dry Weight (pcf)	Water Content, %	Liquid Limit	Plastic Limit	Plasticity Index	Swell, %
		Brown SANDY CLAY - FILL				2.0				13	33	15	18	
2.0		Reddish Brown, Tan, and Gray SANDY CLAY with clayey sand seams and layers				2.0				6				
5						4.5				7	36	17	19	0.0
						4.5+				6				
						4.0				6				
10.0		TEST BORING TERMINATED AT 10 FT												
15														
20														

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BORING NO.: 5
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PROJECT NO.: W222913

Client: Jones Gilliam Panz Architects, Inc.
Project: The Reserves at Magnolia
Start Date: 10/21/2022 **End Date:** 10/21/2022
Drilling Method: CONTINUOUS FLIGHT AUGER

Location: Denton, Texas
Surface Elevation:
West:
North:
Hammer Drop (lbs / in):

GROUND WATER OBSERVATIONS
▽ On Rods (ft): NONE
▼ After Drilling (ft): DRY
▼ After ____ Hours (ft):

Depth, feet	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Recovery % RQD	TX Cone or Std. Pen. (blows/ft, in)	Pocket Penetrometer (tsf)	Unconfined Comp. Strength (tsf)	% Passing No. 200 Sieve	Unit Dry Weight (pcf)	Water Content, %	Liquid Limit	Plastic Limit	Plasticity Index	Swell, %
		Reddish Brown and Brown SANDY CLAY with clayey sand seams and layers				4.5+				8				
						1.5				8				
5		5.0				4.5+				4				
		TEST BORING TERMINATED AT 5 FT												
10														
15														
20														

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BORING NO.: 6
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PROJECT NO.: W222913

Client: Jones Gilliam Panz Architects, Inc.
Project: The Reserves at Magnolia
Start Date: 10/21/2022 **End Date:** 10/21/2022
Drilling Method: CONTINUOUS FLIGHT AUGER

Location: Denton, Texas
Surface Elevation:
West:
North:
Hammer Drop (lbs / in):

GROUND WATER OBSERVATIONS
On Rods (ft): NONE
After Drilling (ft): DRY
After ____ Hours (ft):

Depth, feet	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Recovery % RQD	TX Cone or Std. Pen. (blows/ft, in)	Pocket Penetrometer (tsf)	Unconfined Comp. Strength (tsf)	% Passing No. 200 Sieve	Unit Dry Weight (pcf)	Water Content, %	Liquid Limit	Plastic Limit	Plasticity Index	Swell, %
		Reddish Brown and Brown SANDY CLAY with clayey sand seams and layers				2.5		13		3	17	9	8	
						2.0				4				
5		5.0				4.5+				13				
		TEST BORING TERMINATED AT 5 FT												
10														
15														
20														

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PROJECT NO.: W222913

Client: Jones Gilliam Panz Architects, Inc.
Project: The Reserves at Magnolia
Start Date: 10/21/2022 **End Date:** 10/21/2022
Drilling Method: CONTINUOUS FLIGHT AUGER

Location: Denton, Texas
Surface Elevation:
West:
North:
Hammer Drop (lbs / in):

GROUND WATER OBSERVATIONS
▽ On Rods (ft): NONE
▼ After Drilling (ft): DRY
▼ After ____ Hours (ft):

Depth, feet	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Recovery % RQD	TX Cone or Std. Pen. (blows/ft, in)	Pocket Penetrometer (tsf)	Unconfined Comp. Strength (tsf)	% Passing No. 200 Sieve	Unit Dry Weight (pcf)	Water Content, %	Liquid Limit	Plastic Limit	Plasticity Index	Swell, %
		Reddish Brown and Brown SANDY CLAY with clayey sand seams and layers				1.5				5				
						3.5	6.5		113	6	27	12	15	
5		5.0				4.5+				9				
		TEST BORING TERMINATED AT 5 FT												
10														
15														
20														

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KEY TO SOIL SYMBOLS AND CLASSIFICATIONS

SOIL & ROCK SYMBOLS

- (CH), High Plasticity CLAY
- (CL), Low Plasticity CLAY
- (SC), CLAYEY SAND
- (SP), Poorly Graded SAND
- (SW), Well Graded SAND
- (SM), SILTY SAND
- (ML), SILT
- (MH), Elastic SILT
- LIMESTONE
- SHALE / MARL
- SANDSTONE
- (GP), Poorly Graded GRAVEL
- (GW), Well Graded GRAVEL
- (GC), CLAYEY GRAVEL
- (GM), SILTY GRAVEL
- (OL), ORGANIC SILT
- (OH), ORGANIC CLAY
- FILL

SAMPLING SYMBOLS

- SHELBY TUBE (3" OD except where noted otherwise)
- SPLIT SPOON (2" OD except where noted otherwise)
- AUGER SAMPLE
- TEXAS CONE PENETRATION
- ROCK CORE (2" ID except where noted otherwise)

RELATIVE DENSITY OF COHESIONLESS SOILS (blows/ft)

VERY LOOSE	0 TO 4
LOOSE	5 TO 10
MEDIUM	11 TO 30
DENSE	31 TO 50
VERY DENSE	OVER 50

SHEAR STRENGTH OF COHESIVE SOILS (tsf)

VERY SOFT	LESS THAN 0.25
SOFT	0.25 TO 0.50
FIRM	0.50 TO 1.00
STIFF	1.00 TO 2.00
VERY STIFF	2.00 TO 4.00
HARD	OVER 4.00

RELATIVE DEGREE OF PLASTICITY (PI)

LOW	4 TO 15
MEDIUM	16 TO 25
HIGH	26 TO 35
VERY HIGH	OVER 35

RELATIVE PROPORTIONS (%)

TRACE	1 TO 10
LITTLE	11 TO 20
SOME	21 TO 35
AND	36 TO 50

PARTICLE SIZE IDENTIFICATION (DIAMETER)

BOULDERS	8.0" OR LARGER
COBBLES	3.0" TO 8.0"
COARSE GRAVEL	0.75" TO 3.0"
FINE GRAVEL	5.0 mm TO 3.0"
COURSE SAND	2.0 mm TO 5.0 mm
MEDIUM SAND	0.4 mm TO 5.0 mm
FINE SAND	0.07 mm TO 0.4 mm
SILT	0.002 mm TO 0.07 mm
CLAY	LESS THAN 0.002 mm