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GEOTECHNICAL ENGINEERING REPORT

**LOT 10 LAKEWOOD BUSINESS PARK**

SEC OF NE INDEPENDENCE AVENUE & MCBAIN DRIVE  
LEE'S SUMMIT, MISSOURI  
(AOG 21-419E)

Date: December 3, 2021

Submitted to: Ward Development  
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Kent,

Alpha Omega Geotech, Inc. (AOG) has completed its geotechnical engineering investigation for the above-referenced project.

Attached are the following items that were utilized in the analysis and evaluation of the subsurface conditions at this site: a sketch giving the approximate location of the five (5) auger borings completed during this investigation with reference to the existing site features; detailed laboratory results of five (5) moisture contents (ASTM D2216), five (5) dry densities (ASTM D7263); four (4) sets of Atterberg limits (ASTM D4318), and five (5) unconfined compression (ASTM D2166) tests; ten (10) calibrated pocket penetrometer readings; and five (5) auger boring (ASTM D1452) logs that describe the materials encountered, their approximate thicknesses, and the sampling depths where Shelby tube, thin-walled steel, samplers (ASTM D1587) and Standard Penetration (ASTM D1586) tests were performed.

Representatives of AOG located each of the selected borings by measuring from the existing site features, and these measurements should be considered accurate only to the extent implied by the method of measurement. Elevations were not determined in the field at the time of drilling. Each of the borings was completed by AOG using a CME 55 high-torque drill rig.

## 1.0 PROJECT DESCRIPTION

Alpha Omega Geotech (AOG) understands the proposed project will consist of constructing a new warehouse with associated paved areas.

The current site covers an area of approximately 2.0 Acres. It is an open grass lot relatively flat with a no real elevation change across the site.

It is understood this project consists of a new single-story building with a footprint of approximately 24,000 sqft. It is assumed to be a slab on grade structure with shallow foundations and light steel construction. The building will be lightly loaded with finished floor at elevation 994.6.

Based on the provided grading plan, AOG assumes that cuts and fills will be in the range three (3) to four (4) feet to meet desired construction grade.

## 2.0 SUBSURFACE INVESTIGATION

Based on the information provided as well as discussions with the design team, AOG drilled five (5) auger borings at the proposed site. The borings were advanced to their planned depths or auger refusal, whichever occurred first. Refusal depths are shown on the following table:

Table 1: Auger Refusal Depths

ROCK REFUSAL TABLE (FT)			
Boring #	Boring Location	Depth to Top of Weathered Rock	Practical Refusal Depth
B1	NWC	~ 8.5	~ 17.9*
B2	SWC	~ 7.1	~ 8.2*
B3	MID BUILDING	~ 7.5	~ 7.9*
B4	NEC	~ 9.0	~ 10.5*
B5	SEC	~ 9.0	~ 10.5*

(\* ) Very hard, weathered limestone and shale that was penetrable using our high-torque drilling equipment was encountered above the auger refusal depths shown above (see the boring logs enclosed in Appendix Section 1 of this report).

It should be understood that the depth of boring, split-spoon refusal or auger refusal reported herein applies to the type of drilling equipment that was used. As such, it might be possible to extend some of these borings deeper using different drilling equipment and/or techniques. Conversely, residual sandstone, shale and limestone materials through which AOG's drill rig penetrated, without achieving refusal, may be difficult to excavate depending upon the equipment being used. As such, Alpha-Omega Geotech, Inc. shall not be responsible, for the determination of Others, regarding the rippability, or ease of excavation, of the in-situ subgrade, bedrock and/or geo-intermediate materials.



Above the depth, at which, boring termination occurred, predominantly silty sands were encountered in the borings. Thin-walled, steel, Shelby tube samplers (ASTM D1587) were used to collect relatively undisturbed samples from these borings for laboratory analysis. Standard Penetration tests (SPT) (ASTM D1586) were also used to sample and evaluate the consistency of the in-situ subgrade materials encountered in these test borings. Standard Penetration Tests are conducted by advancing a hollow, split spoon sampler into the base of the auger hole by means of dropping a 140-pound hammer a distance of 30 inches onto the drill rods. Each drop of the hammer is one blow, and these blow counts are recorded for each of three, 6-inch advances of the sampler. The first 6-inch advance is the seating drive, and the summation of the blow counts of the final two, 6-inch advances is taken as the standard penetration resistance. The standard penetration resistance, or N-value, as it is known, along with the soil classification, can be used to estimate the density, shear strength and other engineering properties of the materials encountered.

The N-values obtained from each of the SPT's completed in these borings using a CME automatic hammer are included on the boring logs and summarized in the Summary of Laboratory Testing sheet found in Appendix B. Samples retrieved during drilling efforts were returned to AOG's laboratory for testing and evaluation.

### **3.0 LABORATORY TESTING PROGRAM**

Laboratory testing on materials collected during drilling was performed on samples selected by AOG. Results from these tests can be found in Appendix B and on the boring logs in Appendix C. The following laboratory tests were performed by qualified AOG personnel in accordance with ASTM specifications to determine pertinent engineering properties of the soils:

- Visual classification (ASTM D2488)
- Moisture content tests (ASTM D2216)
- Atterberg limits tests (ASTM D4318)
- Dry Unit Weight (ASTM D7263)
- Unconfined compression tests on soil (ASTM D2166)

The dry unit weights of specimens cut from the Shelby tube samples were found to be moderate, ranging from 85.7 pounds per cubic foot (pcf) to 104.5 pcf. Depending upon the material composition and depth below existing grade, the moisture content of the specimens cut from these tube samples ranged from 19.8 to 33.8 percent. The unconfined compressive strength of the specimen cut from the Shelby tube sample ranged from 4,239 to 8,350 pounds per square foot (psf). Calibrated pocket penetrometer readings ranging from 1.5 tons per square foot (tsf) (3,000 psf) to 4.25 tsf (8,500 psf) were obtained on the recovered Shelby tube samples. However, it should be noted that the pocket penetrometer values tend to over-estimate the strength of in-situ subgrade materials relative to the actual unconfined compressive strength test.

The Atterberg consistency limits were determined for four (4), generally, representative sample taken at relatively shallow depth from within the proposed structures' footprints. Based on the Atterberg limits, the samples were classified in accordance with the Unified Soil Classification System (USCS) as Fat Clay (CH) and Lean Clay (CL) classification materials. The results of these laboratory analyses are presented in the following table:



Table #2: Atterberg Limits Results

ATTERBERG LIMITS TESTS					
Sample	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	USCS Classification
B1, ST-2	3.0-5.0	84	25	59	FAT CLAY (CH)
B2, ST-2	3.0-5.0	67	23	44	FAT CLAY (CH)
B4, ST-2	3.0-5.0	44	21	23	LEAN CLAY (CL)
B5, ST-2	3.0-5.0	36	20	16	LEAN CLAY (CL)

Based on the Atterberg limits, it is anticipated the majority of the onsite soil materials generally possess a moderate to very high swelling potential. The swelling potential of a clay soil is an indication of the volume changes that may take place with variations in the soil moisture content.

Except for the samples for which the Atterberg limits were determined, all of the other soil classifications given throughout the laboratory test data, as well as, the boring logs, were made using the visual and tactile techniques described in ASTM D2488. As a result, additional analyses could reveal other soil types of different classification and potentially higher plasticity and swelling potential both onsite and within the nearby vicinity.

#### 4.0 GROUNDWATER

Free water was not encountered in any of the borings at the time of drilling. However, a twenty-four-hour water level was not established in these borings due to time restrictions, as well as, potential safety hazards associated with open bore holes.

Although the ground water levels given on the boring logs reflect the conditions observed at the time the borings were made, they should not be construed to represent an accurate or permanent condition. There is uncertainty involved with short-term water level observations in bore holes especially in clay soils of relatively low permeability. The groundwater level should be expected to fluctuate with variations in precipitation, site grading and drainage conditions. In addition, it is also possible that seasonal perched ground water may be encountered within these soil deposits and bedrock formations at different depths during other times of the year based on drainage conditions, seasonal snowmelt and rainwater infiltration.



## 5.0 GEOTECHNICAL CONSIDERATIONS

The following considerations are given based on observations made by AOG at the time of drilling, during reconnaissance trips, and based on the project requirements and description as stated above:

- 1) Expansive Materials: Moderately expansive clays were encountered during this exploration. Expansive clays are known to experience significant volume changes with changes in moisture. Expansive clays located beneath any slabs on grade should be removed in accordance with Section 8.0, SLABS ON GRADE of this report.
- 2) Shallow Bedrock: Shallow bedrock may impact the deeper utilities depending on the final design elevations.

## 6.0 SITE DEVELOPMENT

### 6.1 Site Preparation

Based on the information provided, AOG anticipates amounts of cut and fill, three (3) to six (6) feet +/-, from the current elevation within the proposed structure footprint will be required to achieve finish floor elevations. It is possible that additional cuts and fills may be required to obtain improved surface drainage.

Appropriate erosion control measures, such as proper site contouring during grading activities, as well as silt fences, should be maintained to help keep any eroded materials onsite.

Within the footprint of the proposed new structure and associated paving, it is recommended that any topsoil, vegetation, utility backfill, and other deleterious material (i.e. concrete slabs, relic foundations, utilities, etc.) or pavements should be stripped and removed prior to the placement of any fill required to achieve the finished floor elevation.

Transitions between cuts and fills should be on slopes of 5:1 (H:V), or flatter, and will require proper benching. Additionally, any placement of engineered fill on existing slopes will require proper benching with the native clay soils during placement.

*In accordance with the local building code, the exposed subgrade and any benching required during fill placement must be verified by a representative of Alpha-Omega Geotech, Inc. prior to the placement of fill.*

Once initial site stripping operations have been completed and prior to the placement of any engineered fill in this area, it is recommended that the exposed subgrade be moisture conditioned and recompact, as needed, and be thoroughly evaluated by means of a proof-roll with a fully loaded, tandem-axle dump truck to locate any soft, compressible areas within the proposed project site. Any soft, compressible areas identified on the proposed project site must be corrected by over-excavation to a suitable subgrade and replaced with an acceptable material. Although it is not typically anticipated that any extensive removal and replacement would be necessary, it is possible that some effort may be required to develop a stable platform on which to place the necessary fill material and address any other existing site conditions that become known during construction. It is generally anticipated that the extent of these efforts would strongly depend upon the ground moisture conditions at the time the site work begins. In the event that the ground is generally dry, it is possible that only a minimal amount of stabilization would



be required, which may be possible to accomplish by simple moisture conditioning and recompaction efforts. Nevertheless, it is recommended that a representative of Alpha-Omega Geotech, Inc. should be onsite to witness this proof-rolling and offer recommendations, as needed, to correct any problem areas identified.

## 6.2 Undocumented Fill

Undocumented fill is a foreign material, of which no records of testing or evaluation by a qualified professional during the time of placement exist. The risks associated with supporting foundations and floor slabs on undocumented fill include total and differential settlements in excess of tolerable limits. Undocumented fill was not encountered during this exploration. If undocumented fill is encountered during construction, it should be addressed in accordance with this report.

Undocumented fill is, generally, unsuitable beneath structures and pavements, and, if encountered during development, should be completely removed and replaced with engineered fill.

## 6.3 Engineered Fill Placement

It is assumed that any fill material needed will come from cut areas and, if necessary, on-site or nearby borrow sources of similar material. It is recommended that silts and any unweathered shales should NOT be used to construct any of the necessary fill within either the new building or paved portions of the site. Assuming they are properly moisture conditioned and compacted, it generally appears that the clean clay soils encountered in the borings that are free of rubble, trash, concrete, asphalt, and other debris would be acceptable for use as controlled fill. However, due to their very high swelling potential, detailed recommendations for the placement of a non-expansive subbase are provided in Section 8.0, SLABS ON GRADE of this report.

Any imported fill materials for use as structural fill should be tested by Alpha-Omega Geotech, Inc. to determine if they are acceptable for the intended use. Any groundwater seeps that are encountered must be diverted prior to placing fill.

In addition, no compaction of soil fill material should be performed during freezing weather. Nevertheless, as weather conditions dictate, it may be possible to substitute crusher-run limestone in lieu of soil fill to allow placement of engineered controlled fill material to continue during the cold fall and winter months. However, any frozen fill material must be stripped prior to placing subsequent lifts.

All general fill within the area of the new structure (except for the upper 24-inches, as discussed in Section 8.0, SLABS ON GRADE of this report) should be placed in lifts not exceeding 6 inches in thickness, and compacted to a minimum density of 95 percent of the Standard Proctor (ASTM D698) maximum dry density at a moisture content within  $\pm 3$  percent of the optimum moisture content.

As required by the local building code, the compaction of any structural fill beneath the new buildings, pavements, and any other areas where settlement control is necessary, as well as any slopes that are steeper than 4:1 (H:V), should be tested lift-by-lift by a representative of Alpha-Omega Geotech, Inc.





## 6.4 Drainage Considerations

Fluctuations of the groundwater level can occur due to seasonal variations in the amount of rainfall and other climatic factors that were not evident at the time the borings were made. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project. In spring and late fall, soil moisture contents may be abnormally high and drying of the soils that are exposed and/or undercutting may be required to develop a suitable base for the placement and compaction of engineered fill. Disking and aeration of the exposed soils may be sufficient to develop a stable base. However, if site grading begins during the summer or early fall, moisture contents may be abnormally low and the plastic clay soils encountered during this exploration may undergo significant volume changes with subsequent increases in their moisture content. Therefore, when these conditions exist, disking and moisture conditioning of the exposed subgrade soils may be required.

It is important to consider drainage and construction elements that will help to inhibit future slab on grade problems, foundation cracks, as well as intolerable settlements due to volume changes of the onsite soils. The surface drainage must be designed to prevent ponding and effectively move water away from both the new and existing buildings, pavements and other structures. It is also very important to place all materials under carefully controlled conditions of moisture and density to inhibit significant soil volume changes. Shrubs and trees with deep root systems and requiring large quantities of water should not be planted within 20 feet of the building lines. Any planters located near the building should have impermeable bases with weep holes to discharge water away from the wall lines. Down spouts should be connected to subsurface drains to carry the water to safe exits beyond the building lines, retaining walls, pavements, slopes and other site features or structures that could be adversely affected by water seepage.

In addition to controlling surface drainage, it is recommended that a gravity drainage system, such as a French drain or similar, designed to intercept free water prior to contact with foundations be installed in areas where the topography will direct water toward the proposed structure. foundation drainage systems should, also, be considered to prevent any free water accumulation and/or ingress at the foundations where shallow groundwater was encountered. Any basement or below grade slabs should have a permanent dewatering system, such as a sump pump or similar type system, installed to alleviate and water accumulation.

## 6.5 General

Permanent slopes should not be steeper than 3:1 (H:V) to help ensure their future stability and accommodate normal mowing equipment. The responsibility for excavation safety and stability of temporary construction slopes should lie solely with the contractor and should follow the OSHA regulations given in 29 CFR Part 1926.650 - .652, Subpart P. The stability of open excavations is dependent upon a number of factors including but not limited to the presence of gravel, sand and/or silt seams, groundwater seepage, strength characteristics of the soil layers, slickensides and other unique geological features, the slope and height of the cut, surcharge loading and vibrations during construction, weather conditions, as well as the length of time the excavation is left open. Alpha-Omega Geotech, Inc. does not assume any responsibility for construction site safety or the contractor's or other parties' compliance with all local, state and federal safety or other regulations including imprudent excavating practices that results in any damage to nearby structures, roadways, utilities, as well as onsite or offsite improvements.



## 7.0 FOUNDATIONS

### 7.1 Foundation Recommendations

Based on the finding during this geotechnical exploration and AOG's understanding the proposed project, it is AOG's opinion that a shallow foundation system consisting of either earth-formed trench or spread footings may be used as economical foundation elements.

Based on the subsurface conditions that have been identified, Site Class C conditions (IBC 2015) may be assumed for seismic consideration.

Perimeter footings, and any footings in unheated areas, should be placed at least 3 feet below final exterior grade to provide adequate frost protection and place them in a more stable moisture environment. Under heated areas, the interior footings can be founded at shallower depths of at least 18 inches below the finished floor elevation. The footing excavations should be carried to undisturbed, inorganic soil or engineered fill.

### 7.2 Allowable Bearing Pressure

Provided all design and inspection recommendations as given in this report are closely followed and good construction practices are exercised, it is recommended an allowable bearing value of 2,500 psf may be used for design purposes to proportion the spread/wall footings. A twenty-percent increase, i.e. 3,000 psf, may be used for individual column footings. These allowable bearing capacity values, which are based on shear strength alone and not on settlement, incorporate a factor of safety of 3.0. The actual bearing capacity of all subgrade supporting the foundation elements must be confirmed by a representative of Alpha-Omega Geotech, Inc. as the excavations for the load-bearing wall and column footings are completed and prior to placement of reinforcing steel and concrete. For transient loading conditions, such as unsustained wind and earthquake, a 33 percent increase may be applied to the above-referenced allowable bearing capacity values.

### 7.3 Anticipated Settlement

Uniform bearing conditions should be provided beneath the footings to minimize differential settlements. If any soft or otherwise unsuitable material is encountered in the footing excavations, it will have to be removed and replaced with engineered controlled fill. Recommendations for the over-excavation and replacement with engineered controlled fill can be made when the footing excavations are inspected during construction, if needed. A representative of Alpha-Omega Geotech, Inc. should inspect all of the footing excavations to verify that uniform and competent bearing material is present beneath all of the foundation elements prior to the placement of any reinforcing steel and concrete.

For spread footings designed and constructed in accordance with this report, it is anticipated that settlements will be limited to 0.75 inches of differential and 1.0 inches in total.



## 7.5 General

If possible, the over-dug footing excavations should not be left open for more than 24 hours to help reduce excessive sloughing, softening or drying of the exposed subgrade material. The base of the footing excavations should be free of water and loose soil prior to placing reinforcing steel and concrete. No groundwater is expected in the footing excavations since groundwater was not encountered in any of the borings that were made at the time of drilling. However, if groundwater is encountered within the expected depth of excavation for the footings, it is anticipated that it can be removed by the use of sumps and pumps. Based on the subsurface conditions that have been identified, it is anticipated that earth-formed trench footing excavations may be used effectively on this project. A minimum width of 12 inches should be used for trenched wall footings to allow for steel placement and inspection. Minimum widths of 16 and 24 inches should be used for formed wall and column footings, respectively.

## 8.0 SLABS ON GRADE

### 8.1 Slab Thicknesses

Slabs on grade that will be subjected to repeated wheel loads, such as passenger vehicles, should be at least 6 inches in thickness. Slabs that are **not** exposed to repeated wheel loads, should be at least 4 inches in thickness. Slabs in storage areas may need to be thicker due to shelving post and other concentrated floor loads. The final slab design thickness should be determined by the project structural engineer.

### 8.2 Low Volume Change (LVC)

The following recommendations are provided to help protect the slabs from damage caused by volume changes within the underlying subgrade, and should be implemented in conjunction with Section 7.0, FOUNDATIONS of this report:

- 1) Cut the subgrade a minimum of 24-inches beneath the base of slab elevation to allow placement of a 20-inch subbase and a 4-inch base course beneath the slab-on-grade.
- 2) Scarify and recompact the upper 9 inches of exposed subgrade to within 95 to 100 percent of the Standard Proctor (ASTM D698) maximum dry density at a moisture content wet of the optimum moisture content 0 to 3 percent.
- 3) For the 20-inch granular subbase, place crusher-run limestone or rock dust in three (3) equal lifts and compact to a minimum density of 95 percent of the Standard Proctor (ASTM D698) maximum dry density. The moisture content of this material at the time of placement must be sufficient to achieve the specified level of compaction.
- 4) Place a 4-inch base course of clean, open-graded crushed limestone. This granular base course should be compacted with a suitable vibratory steel wheel roller.

Alternatively, it would be possible to consider constructing the 20-inch subbase (in addition to the above recommended 4-inch base course) by chemically stabilizing the onsite expansive clay soil material with Type C flyash or Portland cement blended at 15 percent or 5 percent, respectively, by weight using a large Bomag Tiller. However, due to the amount of dust that is generated, the use of these materials may not be a viable alternative for this project site. In addition, it should also be noted that chemical stabilization is, generally, only effective when the



ground temperature is a minimum of 50° to 60°F. Nevertheless, if this alternative is utilized, the stabilized subbase should be placed in three (3) equal lifts and compacted to a minimum density of 95 percent of the Standard Proctor (ASTM D698) maximum dry density at a moisture content within  $\pm 3$  percent of the optimum moisture content. Compaction of the supplemented soil should be completed within one hour after incorporation. Additional compaction after two hours could cause degradation of the soil strength.

Please note, when constructing in areas where fat clays are present, the owner should recognize there is an inherent risk of distress associated with volume changes of the soil, even with subgrade removal and/or treatment.

### 8.3 General

It is recommended that under-slab utility trenches should be backfilled with impermeable clay soil (\*), flowable fill or lean concrete to help reduce the potential of these trenches acting as aqueducts transmitting groundwater beneath the new building, pavements, retaining walls and other structures.

- (\*) If impermeable clay soil is used as backfill, it should be placed in lifts not exceeding 6 inches in thickness and compacted to a minimum density of 95 percent of the Standard Proctor (ASTM D698) maximum dry density at a moisture content within  $\pm 3$  percent of the optimum moisture content, which should be verified lift-by-lift during placement by a representative of Alpha-Omega Geotech, Inc. Although clay soil may be less costly than flowable fill or lean concrete, the OSHA excavation safety regulations given in 29 CFR Part 1926.650 - .652, Subpart P must be followed in the event that clay soil is used to backfill any utility trenches.

Finally, it should be noted that the recommendations given, herein, regarding placement of low-volume change fill to help protect the slabs on grade from volume changes associated with fluctuations within the moisture content of the underlying subgrade materials, would still apply.

Plumbing lines and other water leaks occurring beneath the structure's slab-on-grade floor can induce volume changes within the underlying subgrade materials. Therefore, it is recommended that all water supply and waste water lines should be tested for leaks prior to backfilling the utility trenches. In addition, it is also recommended that every effort should be made to maintain the plumbing in good working order and prevent or minimize water leaks and discharges.

It is assumed the concrete will be reinforced with properly placed steel reinforcement, such as #4 bars, and control joints will be cut during or shortly after finishing (to be designed by the project structural engineer). Properly placed wire mesh may be used as secondary reinforcement. Fiber reinforcement may also be considered to help control shrinkage cracking and the use of other admixtures may be considered to enhance the workability and performance of the concrete. Suitable construction and sawed joints should be used to control cracking of the slab. In addition, it is recommended that the slump and temperature of the concrete at the time of placement should be limited to standard American Concrete Institute (ACI) guidelines. Furthermore, it is also recommended that proper concrete curing techniques should be utilized and the addition of jobsite water to the concrete be avoided or very closely controlled to within acceptable parameters. Nevertheless, it should be noted that cracking of concrete used for slabs on grade is a normal occurrence and should be expected.



If a 20-inch thick subbase layer of crusher-run limestone (AB-3) or rock dust is used, as recommended, a modulus of subgrade reaction of 150 pci may be assumed for reinforcement and thickness design to support surface loads. If a higher modulus of subgrade reaction were desired, we would be pleased to work with the project's structural engineer to develop recommendations for alternate bases and/or subbases to achieve a higher modulus of subgrade reaction.

## 9.0 EARTH PRESSURE COEFFICIENTS

A coefficient of sliding friction over the in-situ clay soils at this site may be taken as 0.32. A minimum factor of safety of 1.5 should be used when considering sliding resistance.

Active, passive and at-rest earth pressure coefficients of 0.25, 4.2 and 0.4 may be assumed for backfills of clean, open-graded crushed limestone.

Active, passive and at-rest earth pressure coefficients of 0.5, 1.9 and 1.0 may be assumed for the in-situ clay soils at this site.

However, some of the in-situ soils encountered during this exploration are classified as a Fat Clay and possess a high swelling potential, and, as such, should not be used as backfill since considerable lateral loads may develop with the addition of water.

If deflection of extended foundation walls or retaining walls is not tolerable, as rest earth pressures should be assumed.

These earth pressure coefficients do not include the effect of surcharge loads, hydrostatic loading or a sloping backfill nor do they incorporate a factor of safety. Also, these earth pressure coefficients do not account for high lateral pressures that may result from volume changes when expansive clay soils are used as backfill behind walls with unbalanced fill depths. In addition, any disturbed soils that are relied upon to provide some level of passive resistance should be placed in lifts not exceeding 6 inches in thickness and compacted to a minimum density of 95 percent of the Standard Proctor (ASTM D698) maximum dry density at a moisture content within  $\pm 3$  percent of the optimum moisture content. It is recommended that a representative of Alpha-Omega Geotech, Inc. should verify the compaction of any such materials relied upon to provide passive pressure lift-by-lift during placement.

## 10.0 DOCK WALLS

In order to protect the dock walls from possible high lateral earth pressures exerted by the native expansive soils, it is recommended the area behind the dock should be over-excavated by a minimum of 18 inches. To provide drainage, and thus prevent hydrostatic loading, a clean, open-graded crushed limestone aggregate should be placed behind the dock walls. This clean crushed limestone aggregate should be placed in lifts not exceeding about 8 inches in thickness and compacted with a suitable vibratory plate compactor.

*It should be noted that placement of this granular fill within the over-dig area will also provide stable support beneath the adjacent slab-on-grade along the docks.*



A non-woven geotextile fabric, such as Amoco 4545, Trevira Spunbond 011/140 or Synthetic Industries 401, or an acceptable equivalent, may be considered to encapsulate the granular fill and thus prevent the infiltration of clays and silts. The geotextile fabric should be placed and overlapped in accordance with the manufacturer's recommendations, which should be verified by a representative of Alpha-Omega Geotech, Inc. The vertical walls of the docks must be considered to act as a retaining wall. If there is a possible source of water, weep holes should be provided in order to avoid hydrostatic forces from forming behind the wall. These weep holes should be positioned high enough along the face of the dock walls to prevent debris from blocking them. These weep holes should be at least 2 inches in diameter and spaced no further than 6 feet apart. A slotted drainpipe should also be installed behind the dock walls.

If these recommendations are not followed, an at-rest equivalent fluid pressure of at least 75 pcf may be assumed for the structural design of the dock walls. However, if these dock walls are constructed as recommended, an at-rest equivalent fluid pressure of 50 pcf can be used assuming that no lateral movement at the top of the wall can be tolerated. These equivalent fluid pressures do not include the effect of surcharge loads, hydrostatic loading or a sloping backfill nor do they incorporate a factor of safety.

## 11.0 PAVEMENTS

### 11.1 Subgrade Preparation

Please note, a formal pavement design is beyond AOG's scope of service. Standard asphaltic concrete and Portland concrete pavement designs for a given service life requires evaluation of the soil by means of a California Bearing Ratio (CBR) test and/or other methods, estimates of traffic volumes and axle weights, drainage requirements and the desired level of maintenance. As such, some standard pavement design options based on assumptions made for materials of this nature are included in this section.

The subgrade soils at this site are considered to be poor subgrade materials for the support of pavements. California Bearing Ratio (CBR) values we have obtained rarely exceed 5, soaked, for these materials. Pavements, either total strength flexible or rigid, do not usually perform well when they are placed directly on highly expansive, poor soil subgrades. Soft areas can develop during wet periods and differential shrinkage can occur during dry periods. As a result, no pavement can avoid damage from wheel loads under these circumstances.

Unless the subgrade is stabilized, the subgrade for all pavements should consist of at least 12 inches of properly moisture conditioned and compacted soil, which will require tilling and recompacting in cut sections. The subgrade should be compacted to a minimum density of 95 percent of the Standard Proctor (ASTM D698) maximum dry density at a moisture content within  $\pm 3$  percent of the optimum moisture content. Any additional fill that is required to develop the paved areas should also be placed in loose lifts not exceeding 8 inches in thickness and compacted in accordance with these recommendations. It is recommended that any and all subgrade operations including recompacted subgrades, compacted aggregate bases or chemically stabilized subgrade layers should extend at least 2 feet beyond the pavement and curb lines.

Prior to the placement of any pavement section, the exposed subgrade should be proof-rolled with a fully loaded, tandem-axle dump truck after the final subgrade elevation has been established throughout the paved area. A representative of Alpha-Omega Geotech, Inc. should witness this proof-rolling.



Please note, if asphaltic pavements are used, annual maintenance including but not limited to crack sealing, fog sealing, and possible patch with overlay should be anticipated. In addition, the quality of the aggregates and overall composition of the asphalt or concrete mix, as well as drainage conditions, can have a profound effect upon the durability of the pavement section.

### 11.2 Pavement Sections

Table 2: Recompacted Subgrade Section

<b>RECOMPACTED SUBGRADE SECTIONS (INCHES)</b>			
<b>PAVEMENT MATERIALS</b>	<b>PASSENGER VEHICLE PARKING</b>	<b>PASSENGER VEHICLE DRIVE LANES</b>	<b>HEAVY DUTY AREAS (i.e. Dumpster pads, approach lanes, etc.)</b>
Asphaltic Surface Course	2	2	NA
Asphaltic Base Course	3	5.5	NA
Moisture Conditions/Recompacted Subgrade	12	12	NA
Portland Cement Concrete	5	7	8
Crushed Stone Base (3/4-inch minus)	4	4	4
Moisture Conditions/Recompacted Subgrade	12	12	12

\*Reference Section 11.3, "Recompacted Subgrade Sections"

Table 3: Recommended Thicknesses with Chemically Stabilized Subgrade

<b>CHEMICALLY STABILIZED SUBGRADE SECTIONS (INCHES)</b>			
<b>PAVEMENT MATERIALS</b>	<b>PASSENGER VEHICLE PARKING</b>	<b>PASSENGER VEHICLE DRIVE LANES</b>	<b>HEAVY DUTY AREAS (i.e. Dumpster pads, approach lanes, etc.)</b>
Asphaltic Surface Course	2	2	NA
Asphaltic Base Course	2	4	NA
Chemical Stabilization	12	12	NA
Portland Cement Concrete	4	6	7
Crushed Stone Base (3/4-inch minus)	4	4	4
Chemical Stabilization	12	12	12

\*Reference Section 11.4.1, "Chemically Stabilized Subgrade"



Table 4: Recommended Thicknesses with Geogrid Reinforcement & Baserock

<b>GEOGRID REINFORCEMENT AND BASEROCK SUBGRADE STABILIZATION SECTIONS (INCHES)</b>			
<b>PAVEMENT MATERIALS</b>	<b>PASSENGER VEHICLE PARKING</b>	<b>PASSENGER VEHICLE DRIVE LANES</b>	<b>HEAVY DUTY AREAS (i.e. Dumpster pads, approach lanes, etc.)</b>
Asphaltic Surface Course	2	2	NA
Asphaltic Base Course	2	4	NA
Geogrid & Crushed Stone (3/4-inch minus)	6	6	NA
Portland Cement Concrete	4	6	7
Geogrid & Crushed Stone (3/4-inch minus)	6	6	6

\*Reference Section 11.4, "Subgrade Stabilization Sections"

### 11.3 Moisture conditioned & Recompacted Subgrade Sections

#### 11.3.1 Flexible Pavements Sections

From an initial cost perspective, flexible asphaltic concrete pavement is the most economical pavement section. However, treating the subgrade with Class C flyash, Portland cement or using a geogrid reinforced base course can provide a higher quality pavement section, having a much longer service life. Nevertheless, if the subgrade is untreated and asphaltic pavement is used, areas used exclusively for automobile parking should consist of at least 5.0 inches of asphaltic concrete (2.0 inches of surface mix and 3.0 inches of base mix). Drives should be constructed of at least 7.5 inches of asphaltic concrete (2.0 inches of surface and 5.5 inches of base mix).

The above-referenced pavement section represents minimum design thicknesses and, as such, periodic maintenance should be anticipated. If an increased pavement performance is desired, as described in Section 10.4, "Subgrade Stabilization," flyash stabilization, Portland cement or the use of a layer of base rock and geogrid reinforcement should be considered. Asphaltic cement concrete should NOT be used in areas where heavy truck loads/concentrations are expected.

It is also recommended that an asphalt binder grade of PG 64-28 should be considered to help reduce the potential of thermal cracking based on the climatic conditions of this region. However, for base mix asphalt placed at least 4 inches below the surface, an asphalt binder grade of PG 64-22 should be sufficient.

#### 11.3.2 Rigid Pavement Sections

As an alternative, rigid Portland Cement concrete with a 4-inch thick base course of crushed limestone may also be used with minimum thicknesses of 5.0 and 7.0 inches for automobile parking areas and drive lanes, respectively. The above-referenced pavement section represents minimum design thicknesses, and as such periodic maintenance should be anticipated. If a better pavement is desired, recommendations as described in Section 10.4, "Subgrade Stabilization Sections," should be considered.





The crusher-run limestone base course should be compacted to a minimum density of 95 percent of the Standard Proctor (ASTM D698) maximum dry density at a moisture content sufficient to achieve the specified level of compaction.

For areas where heavy truck loads/concentrations are anticipated, Portland Cement concrete is recommended. Portland cement concrete slabs having a thickness of 8 inches over a 4-inch, minimum, compacted, crusher-run limestone base should be used for dumpster stations, parking lot entrances, areas where a high concentration of heavily loaded trucks are anticipated, as well as any areas where trucks accelerate/decelerate and execute sharp turning maneuvers.

#### **11.4 Subgrade Stabilization Sections**

Alternate pavement sections utilizing flyash or Portland cement stabilization, geogrids and granular base and/or subbase courses should be considered. Treating the subgrade with Class C flyash, Portland cement or using a geogrid reinforced base course can provide a pavement section having a much longer service life.

If specific pavement performance standards are to be met, AOG would be pleased to be of further assistance once the actual design loading conditions, service-life and maintenance expectations have been defined.

##### ***11.4.1 Chemically Stabilized Subgrade – Flyash or Portland Cement***

The use of flyash is usually not effective during cold winter months. Notwithstanding this weather limitation, assuming the flyash is thoroughly and uniformly mixed with the subgrade, flyash stabilization can greatly reduce the swelling potential and improve the strength of the subgrade soil.

Additionally, Portland cement stabilization, assuming it is thoroughly and uniformly mixed with the subgrade, can greatly reduce the swelling potential and improve the strength of the subgrade soil.

Chemically treated subbases, Class C flyash or Portland cement stabilization, should be extended to a depth of 12 inches.

For a chemically treated subbase, full depth asphalt pavements with thicknesses of 4.0 and 6.0 inches for parking and drive lanes, respectively, can be used. Likewise, if the subgrade is chemically stabilized, the Portland cement concrete pavement sections over a 4-inch thick base course of crushed limestone may also be reduced to 4.0 and 6.0 inches, respectively.

The crusher-run limestone base course should be compacted to a minimum density of 95 percent of the Standard Proctor (ASTM D698) maximum dry density at a moisture content sufficient to achieve the specified level of compaction.



Based on experience with similar projects, adding more flyash or Portland cement does not always increase the stiffness of the subgrade. In fact, too much flyash or cement in the subgrade may cause excessive brittleness, which may result in reflective cracking problems to develop. It is usually cost effective to determine the optimum amount of flyash or Portland cement necessary by laboratory testing; however, it usually ranges from about 12 to 15 percent by weight for flyash and about 4 to 6 percent by weight for Portland cement. The Class C flyash or Portland cement should be thoroughly mixed with the subgrade soil by means of a Bomag tiller or other similar equipment specifically designed for such procedures and compacted to a minimum density of 95 percent of the Standard Proctor (ASTM D698) maximum dry density at a moisture content within  $\pm 3$  percent of the optimum moisture content.

#### **11.4.2 Geogrid Reinforcement & Base Rock**

Soft areas can develop even when the subgrade is chemically stabilized. An even better pavement section can be developed by the use of a tri-axial geogrid over a properly compacted subgrade, as discussed in this report, and a layer of untreated crushed limestone base rock under either flexible or rigid pavements. The purpose of the geogrid is to help span soft spots that will inevitably develop in the subgrade. The geogrid helps to confine the base rock and acts as a "snowshoe," distributing the loads over the subgrade in a tri-axial direction. The layer of base rock, which is placed over the geogrid, must be thick enough to support construction traffic and paving equipment so the geogrid does not become exposed. In general, the crushed limestone base rock should not be less than approximately 6 inches in thickness. If this option is chosen, it is recommended that Tensar TX-140, which is a tri-axial polypropylene geogrid, be used. The geogrid reinforcement should be placed and overlapped as needed in accordance with the manufacturer's recommendations, which should be verified by a representative of Alpha-Omega Geotech, Inc.

Asphaltic concrete thicknesses of 4.0 and 6.0 inches for parking areas and drive lanes, respectively, can be used if geogrid and base rock stabilization are used. Similarly, the Portland cement concrete sections can be reduced to 4.0 and 6.0 inches for the respective areas. Although these thicknesses are the same as given if the subgrade is treated with Class C flyash, the use of a tri-axial geogrid and base rock usually represents the most effective, reasonable pavement section.

#### **11.5 General**

If asphaltic pavements are used, periodic maintenance including, but not limited to, crack sealing, fog sealing, and possible patch with overlay should be anticipated. In addition, the quality of the aggregates and overall composition of the asphalt or concrete mix, as well as drainage conditions, can have a profound effect upon the durability of the pavement section.

Where engineered controlled fill is placed beneath paved areas, it is recommended the compacted fill should extend a minimum distance of two (2) feet beyond the pavement edge or curb line, or a distance equal to the depth of the fill, whichever is greater.

Asphalt mixes meeting APWA KC Metro Specifications may be used for surface and base mixes, respectively. Compaction testing of each pavement layer is recommended to help ensure compliance with the mix design specifications.



For areas where heavy truck loads/concentrations are anticipated, Portland Cement concrete is should be used. It is recommended that load-transfer devices should be installed where construction joints are required. For dumpster stations, the concrete slabs should be large enough to accommodate the dumpster and at least the rear wheels of the disposal vehicle. Rigid pavements should have No. 4 bars on at least 2-foot centers and positioned in the upper third of the slab. Joints should be tooled or cut within 4 hours of hardening to a depth of at least one third of the thickness.

The subgrade should be moistened prior to placement of concrete. Fresh concrete should be properly cured as recommended by the American Concrete Institute (ACI). To help provide resistance to damage caused by alternating cycles of freezing and thawing, it is recommended that any exposed concrete should be properly air entrained; typically at 5 to 7 percent. In addition, it is also recommended the outer edges of pavement slabs should be thickened to help resist cracking associated with heavy wheel loads near these unrestrained areas.

If full-depth pavement is used, it is important the moisture content of the subgrade should be kept as constant as possible from the time of recompacting until the pavement is laid. However, if the subgrade becomes dry, it should be moistened for at least 72 hours prior to paving, but it should not be saturated. In all cases, pavements should be sloped to inhibit ponding and provide rapid surface drainage. If water is allowed to pond on or adjacent to the pavement, the subgrade could become saturated and lose its bearing capacity which would contribute to premature pavement deterioration under a single cycle of heavy wheel loads or a number of cycles of lighter wheel loads.

## **12.0 TESTING AND INSPECTION RECOMMENDATIONS**

Unless Alpha-Omega Geotech, Inc. is retained to provide the construction observation, monitoring and testing services for this project, we cannot accept any responsibility for any conditions that deviate from those identified in this subsurface investigation nor for the performance of the foundations, pavements and other structures including any retaining walls that are a part of this project. Alpha-Omega Geotech, Inc. is accredited by AASHTO and we are experienced in construction quality control and have a fully-equipped soil, concrete, aggregate, rock and asphalt testing laboratory, as well as qualified field technicians to provide these field services.

It is not economically practical to perform enough exploratory borings on any site to identify all subsurface conditions. Some conditions affecting the design and/or construction may not become known until the project is underway. The boring logs, field SPT and laboratory test results depict subsurface conditions only at the specified locations and depths at the site. The boundaries between soil and rock layers indicated on the boring logs are based on observations made during drilling and an interpretation of the laboratory testing results. The exact depths of these boundaries are approximate and the transitions between soil and rock types may be gradual rather than being clearly defined. Also, due to the prior development at this site, as well as the natural conditions of the formation of soils and rock, it is possible that unanticipated subsurface conditions may be encountered during construction. Monitoring of the subsurface conditions that are revealed during construction is needed to verify that subsurface conditions are consistent with those conditions identified in this preliminary geotechnical investigation. If variations in subsurface conditions are encountered, it will be necessary for Alpha-Omega Geotech, Inc. to re-evaluate the recommendations that have been made in this report.



*Special Inspections should be performed in accordance with the local building code under which the project is designed, as adopted by Lee's Summit, MO.*

Prior to filling, it is recommended that a representative of Alpha-Omega Geotech, Inc. should verify that the site has been properly stripped of all topsoil and other deleterious material, benched as needed and prepared for the placement of fill. The compaction of any structural fill beneath the new building, pavements, and any other areas where settlement control is necessary should be tested lift-by-lift by a representative of Alpha-Omega Geotech, Inc. as it is being placed. This should include the prepared subgrade layers beneath the building's slab-on-grade, as well as any other fill material relied upon to provide passive resistance. Also, in accordance with the local building code, any fill that is used to construct slopes steeper than 4:1 (H:V) must be placed as engineered controlled fill and the compaction tested lift-by-lift during placement.

Assuming that uniform fill material is used, nuclear density gauges (ASTM D2922/D3017) should be used to test compaction wherever necessary. However, if fill material of non-uniform consistency is used, other evaluation methods may be required. Such methods may include, but not be limited to, the use of a GeoGauge Stiffness meter, Dynamic Cone Penetrometer (DCP), proof-rolling or other visual inspection techniques.

Any geotextile fabric and geogrid reinforcement that is utilized should be placed and overlapped as needed in accordance with the manufacturer's recommendations, which should be verified by a representative of Alpha-Omega Geotech, Inc. Proper placement of the reinforcing steel for drilled piers, grade beams, pier caps, foundation walls and other structural elements including any necessary wing walls and retaining walls should be verified prior to the placement of concrete. The subgrade under the slabs on grade and pavements should be checked to verify they are in compliance with the density and moisture requirements. Wherever possible, in addition to compaction testing, cut and fill areas should be proof-rolled with a loaded tandem-axle dump truck to identify soft areas that will need to be corrected. A representative of Alpha-Omega Geotech, Inc. should observe this proof-rolling. Checks should also be made of the subbases, concrete and any pavement materials.

Finally, the inspection and testing services listed herein are given as a minimum and it should be understood that additional inspection and testing services might also be required or otherwise beneficial.

### **13.0 LIMITATIONS**

This report is presented in broad terms to provide a comprehensive assessment of the interpreted subsurface conditions and their potential effect on the adequate design and economical construction of the proposed new Warehouse Building – Lot 10 Lakewood Business Park project located in Lee's Summit, MO, as discussed herein. This report has been prepared for the exclusive use of our client for specific application to the project discussed herein and has been prepared within our client's directive and budgetary constraints and in accordance with generally accepted geotechnical engineering practices. No other warranty, expressed or implied, is made.

It should be noted that the concept of risk is an important aspect of the geotechnical engineering evaluation and report since the recommendations given in this report are not based on exact science but rather analytical tools and empirical methods in conjunction with engineering judgment and experience. Therefore, the recommendations given herein should not be considered risk-free and, more importantly, are not a guarantee that the interaction between the soil materials and the proposed structures will perform as planned. Nevertheless, the geotechnical



engineering recommendations presented herein are Alpha-Omega Geotech, Inc.'s professional opinion of those measures that are necessary for the proposed structures to perform according to the proposed design based on the information provided to Alpha-Omega Geotech, Inc., the referenced information gathered during the course of this investigation and our experience with these conditions.

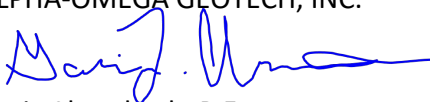
Any significant structural changes to the proposed new structure or its location on this site relative to where these test borings were completed shall be assumed to invalidate the conclusions and recommendations given in this report until we have had the opportunity to review these changes and, if necessary, modify our conclusions and recommendations accordingly. It is also strongly suggested that Alpha-Omega Geotech, Inc. should review your plans and specifications dealing with the earthwork, foundations, as well as any pavements prior to construction to confirm compliance with the recommendations given herein. Particular details of foundation design, construction specifications or quality control may develop, and we would be pleased to respond to any questions regarding these details.

*If Alpha-Omega Geotech, Inc. is not retained to review the project plans and specifications, address to the proposed building and parking structure or their location on the site relative to where these test borings were completed, provide the recommended construction phase observation, monitoring and testing services and respond to any subsurface conditions that are identified during construction to evaluate whether or not changes in the recommendations given in this report are needed, we cannot be held responsible for the impact of those conditions on the project or the future performance of the buildings, pavements and/or structures that may be involved.*

The scope of our services did not include any environmental assessment or investigation for the presence of hazardous or toxic materials in the soil, surface water, groundwater or air, either on, below or adjacent to this site. In addition, no determination regarding the presence or absence of wetlands was made. Furthermore, it should be understood that the scope of geotechnical services for this project does not include either specifically or by implication any biological (i.e. mold, fungi or bacteria) assessment of the site or the proposed construction. Any statements in this report or included on the boring logs regarding odors, colors and unusual or suspicious items or conditions are strictly for informational purposes only.

We appreciate the opportunity to be of service to Ward Development, as well as the project developers, and look forward to working with you throughout the construction process. We are prepared to provide the Special Inspection services that will be required by the local building code under which this project is designed, as adopted by the City of Lee's Summit, Missouri, as well as the other necessary construction observation, monitoring and testing services discussed in this report. If you have any questions concerning this report, or if we may be of further assistance, please call us at (913) 371-0000.

Sincerely,  
ALPHA-OMEGA GEOTECH, INC.



Garic Abendroth, P.E.  
Director of Engineering

Enclosures



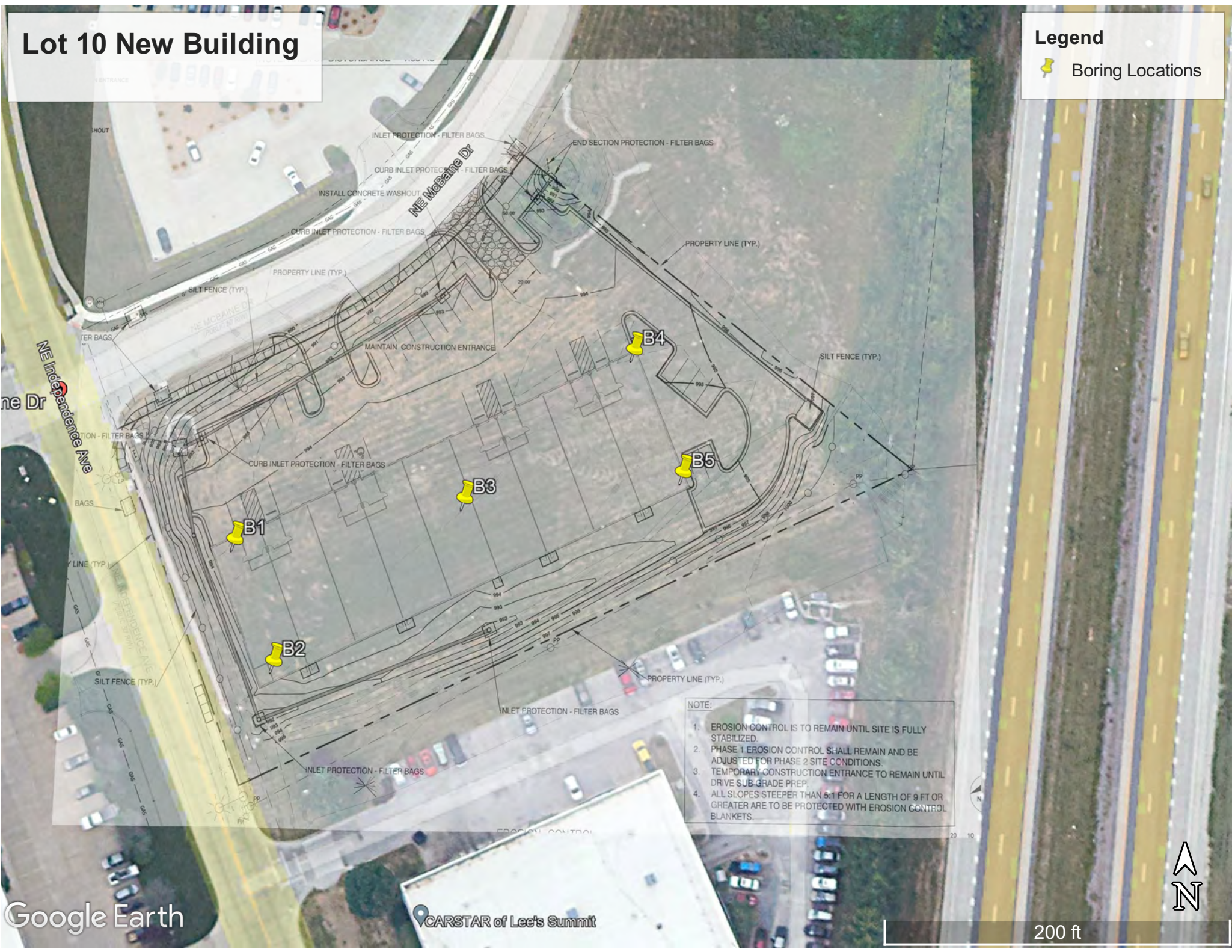
**Appendix Section A**

**SITE SKETCH**

**Site and Boring Location Plans**

# Lot 10 New Building

**Legend**  
📌 Boring Locations



**Appendix Section B**

**LABORATORY TEST RESULTS**



# Summary of Laboratory Testing

SLT 22205

Alpha-Omega Geotech, Inc.  
 1701 State Avenue  
 Kansas City, KS 66102  
 Office: (913) 371-0000 Fax: (913) 371-6710  
 Website: www.aogeotech.com



PROJECT NAME: LOT 10 LAKEWOOD BUSINESS PARK  
 PROJECT LOCATION: INDEP. AVE. & MCBAIN DR., LEE'S SUMMIT, MO.

PROJECT NUMBER: 21-419E  
 DATE: 12/1/2021

Boring Number	Sample Number	Depth or Elevation	Description	Natural Moisture (%)	Dry Unit Weight (pcf)	Atterberg Limits			USCS/ Visual Class.	% Passing No. 200	Unconfined Compression (psf)	%e	% Swell	Remarks
						LL	PL	PI						
B1	SS-1	1.0-2.5	Brown, spotted dark brown LEAN/FAT CLAY						CL-CH					N=9
B1	ST-2	3.0-5.0	Brown, spotted reddish brown and dark brown FAT CLAY	33.8	85.7	84	25	59	CH		4239	4.8		PP=2.0
B1	SS-3	6.5-8.0	Brown LEAN/FAT CLAY (weathered SHALE)(Very Hard, Very Slow Drilling)						CL-CH					N=41
B1	SS-4	13.5-15.0	Gray SHALE (Very Hard, Very Slow Drilling)						SH					N=32
B2	SS-1	1.0-2.5	Brown, spotted dark brown LEAN/FAT CLAY						CL-CH					N=10
B2	ST-2	3.0-5.0	Brown, spotted reddish brown and dark brown FAT CLAY	24.0	102.2	67	23	44	CH		8350	6.5		PP=4.25
B2	ST-3	6.0-6.5	Brown, mottled reddish brown, spotted dark brown FAT CLAY						CH					PP=1.50
B2	SS-4	6.5-7.1	Light reddish brown, spotted dark brown FAT CLAY with trace of gravel (Very Hard, Very Slow Drilling)						CH					N=50/1
B3	SS-1	1.0-2.5	Brown LEAN CLAY (Very Hard, Very Slow Drilling)						CL					N=69
B3	ST-2	3.0-5.0	Brown, spotted dark brown FAT CLAY	28.6	92.5				CH		6030	1.8		PP= +4.50

# Summary of Laboratory Testing

SLT 22205

Alpha-Omega Geotech, Inc.  
 1701 State Avenue  
 Kansas City, KS 66102  
 Office: (913) 371-0000 Fax: (913) 371-6710  
 Website: www.aogeotech.com

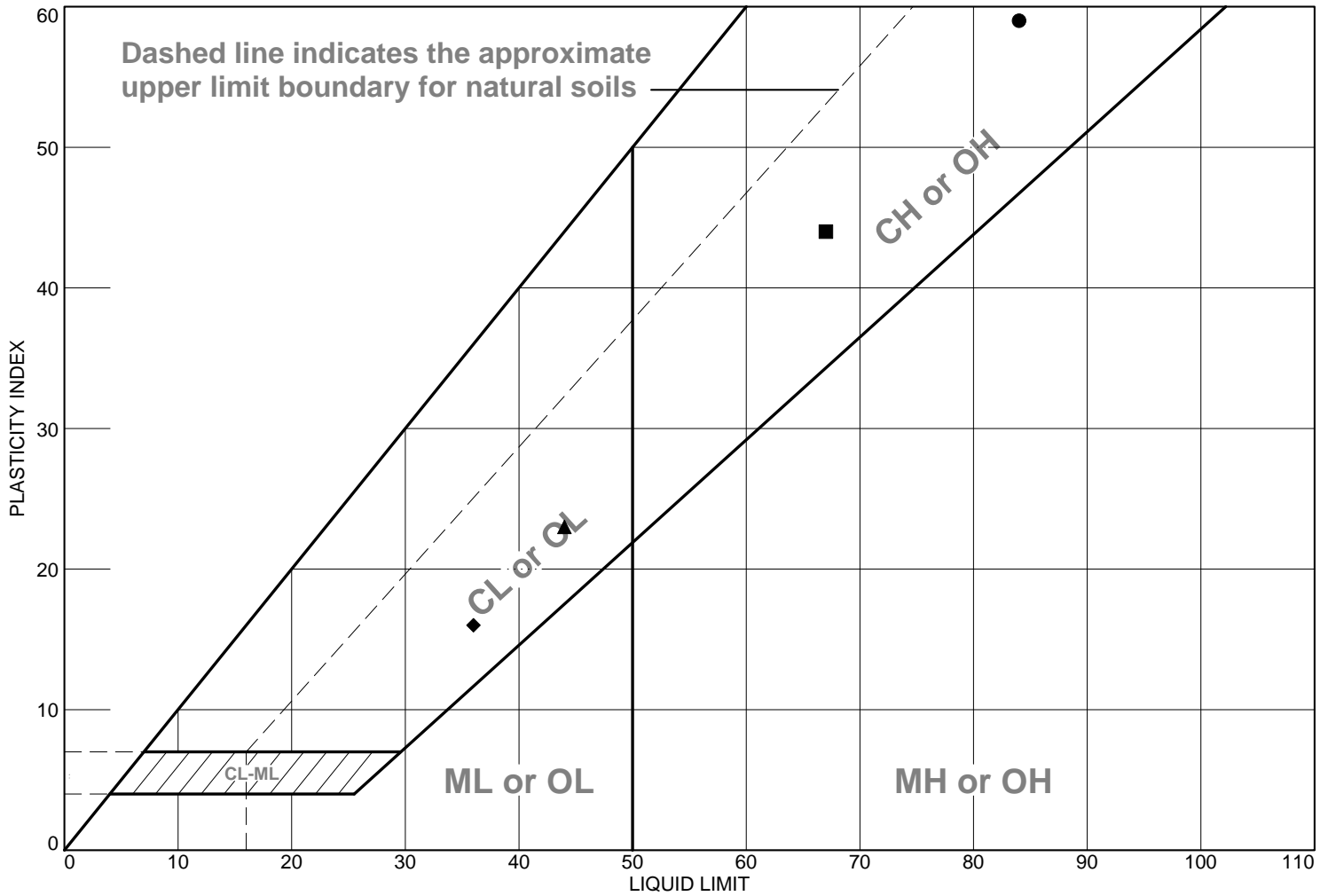


PROJECT NAME: LOT 10 LAKEWOOD BUSINESS PARK  
 PROJECT LOCATION: INDEP. AVE. & MCBAINE DR., LEE'S SUMMIT, MO.

PROJECT NUMBER: 21-419E  
 DATE: 12/1/2021

Boring Number	Sample Number	Depth or Elevation	Description	Natural Moisture (%)	Dry Unit Weight (pcf)	Atterberg Limits			USCS/ Visual Class.	% Passing No. 200	Unconfined Compression (psf)	%e	% Swell	Remarks
						LL	PL	PI						
B3	ST-3	6.0-7.0	Brown, spotted dark brown and reddish brown FAT CLAY						CH					PP=1.75
B4	SS-1	1.0-2.5	Brown LEAN/FAT CLAY						CL-CH					N=10
B4	ST-2	3.0-5.0	Brown, spotted dark brown LEAN CLAY	21.6	103.3	44	21	23	CL	5288	6.6			PP=3.75
B4	ST-3	6.0-8.0	Brown LEAN/FAT CLAY						CL-CH					PP=2.25
B4	SS-4	8.5-9.4	Reddish brown, spotted gray FAT CLAY with trace of gravel (weathered LIMESTONE) (Very Hard, Very Slow Drilling)						CH					N=50/5
B5	SS-1	1.0-2.5	Brown, spotted gray and dark brown LEAN/FAT CLAY						CL-CH					N=10
B5	ST-2	3.0-5.0	Brown, spotted dark brown LEAN CLAY	19.8	104.5	36	20	16	CL	5059	2.9			PP=3.75
B5	ST-3	6.0-7.5	Brown, spotted dark brown FAT CLAY						CH					PP=1.75
B5	SS-4	8.5-9.5	Brown, spotted dark brown LEAN/FAT CLAY with trace of gravel (weathered LIMESTONE) (Very Hard, Very Slow Drilling)						CL-CH					N=50/6

# LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Brown, spotted reddish brown and dark brown FAT CLAY	84	25	59			CH
■	Brown, spotted reddish brown and dark brown FAT CLAY	67	23	44			CH
▲	Brown, spotted dark brown LEAN CLAY	44	21	23			CL
◆	Brown, spotted dark brown LEAN CLAY	36	20	16			CL

**Project No.** 21-419E      **Client:** WARD DEVELOPEMENT  
**Project:** LOT 10 LAKEWOOD BUSINESS PARK

● **Source of Sample:** B1      **Depth:** 3.0      **Sample Number:** ST-2  
 ■ **Source of Sample:** B2      **Depth:** 3.0      **Sample Number:** ST-2  
 ▲ **Source of Sample:** B4      **Depth:** 3.0      **Sample Number:** ST-2  
 ◆ **Source of Sample:** B5      **Depth:** 3.0      **Sample Number:** ST-2

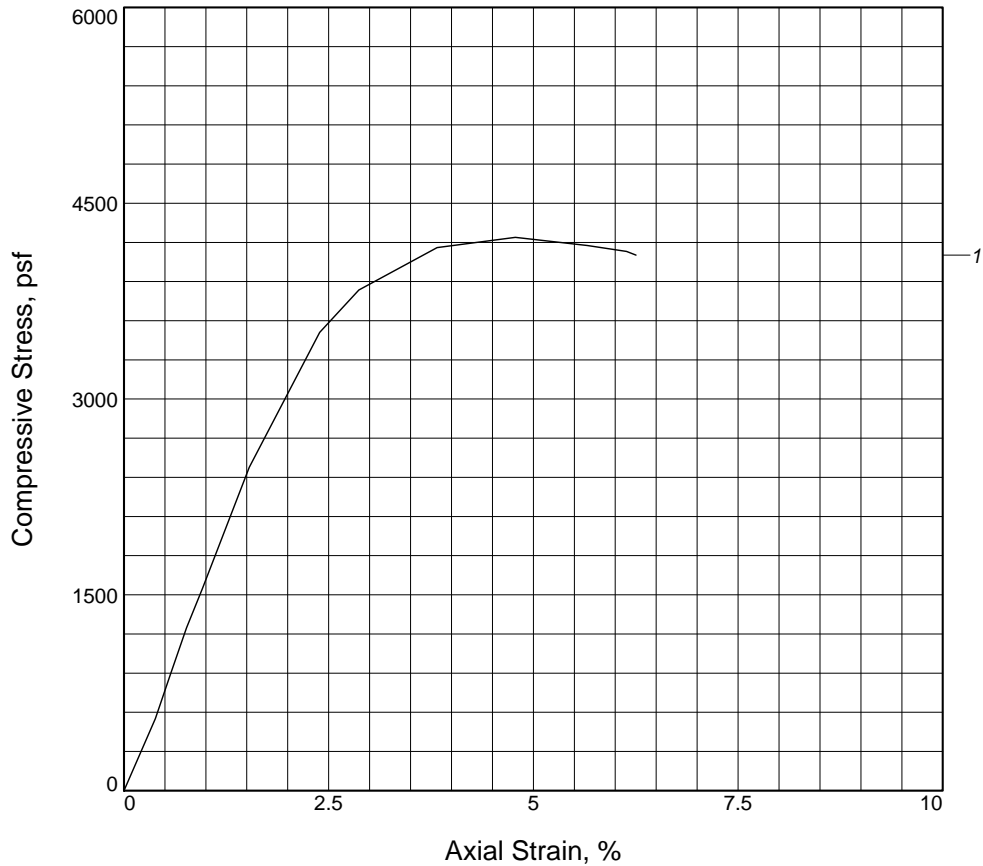
**Remarks:**



Figure

**Tested By:** ○ M.S.   □ M.S.   △ D.B.   ◆ M.S.   **Checked By:** T.B.

# UNCONFINED COMPRESSION TEST



Sample No.	1		
Unconfined strength, psf	4239		
Undrained shear strength, psf	2119		
Failure strain, %	4.8		
Strain rate, in./min.	0.080		
Water content, %	33.8		
Wet density, pcf	114.7		
Dry density, pcf	85.7		
Saturation, %	94.4		
Void ratio	0.9673		
Specimen diameter, in.	2.700		
Specimen height, in.	5.230		
Height/diameter ratio	1.94		

**Description:** Brown, spotted reddish brown and dark brown FAT CLAY

LL = 84	PL = 25	PI = 59	Assumed GS= 2.70	Type: Undisturbed
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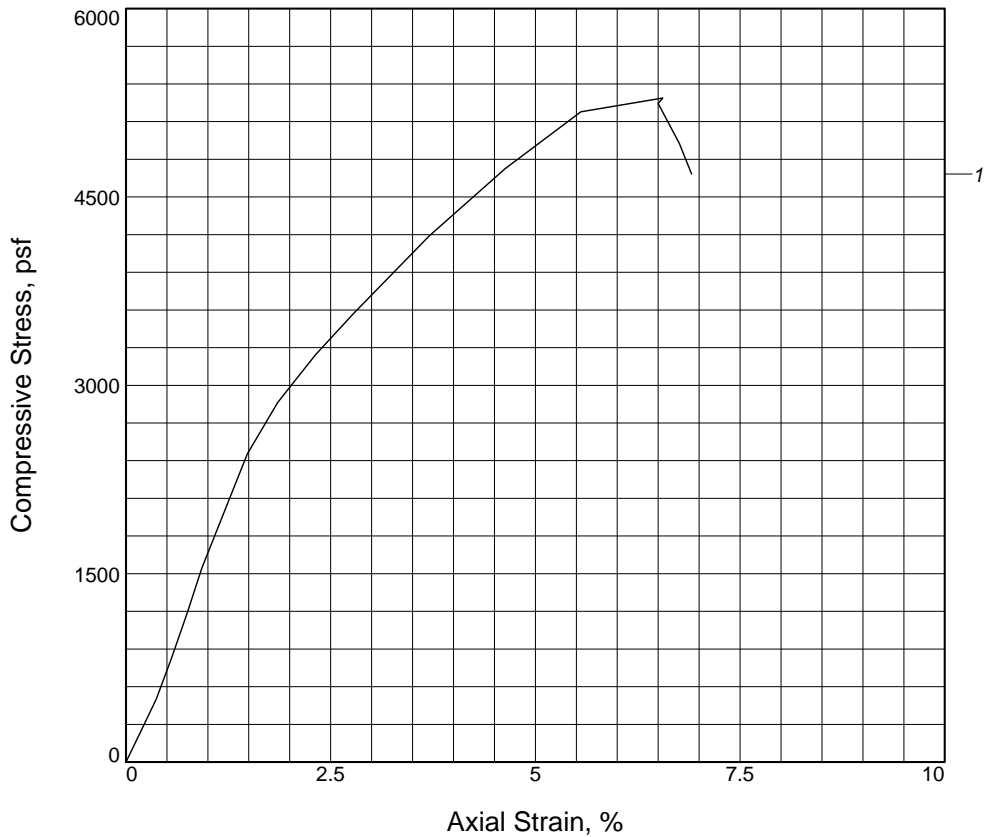
<p><b>Project No.:</b> 21-419E  <b>Date Sampled:</b> 11/28/2021  <b>Remarks:</b></p>	<p><b>Client:</b> WARD DEVELOPEMENT  <b>Project:</b> LOT 10 LAKEWOOD BUSINESS PARK  <b>Source of Sample:</b> B1      <b>Depth:</b> 3.0  <b>Sample Number:</b> ST-2</p>
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# UNCONFINED COMPRESSION TEST



Sample No.	1		
Unconfined strength, psf	5288		
Undrained shear strength, psf	2644		
Failure strain, %	6.6		
Strain rate, in./min.	0.080		
Water content, %	21.6		
Wet density, pcf	125.7		
Dry density, pcf	103.3		
Saturation, %	92.5		
Void ratio	0.6313		
Specimen diameter, in.	2.700		
Specimen height, in.	5.400		
Height/diameter ratio	2.00		

**Description:** Brown, spotted dark brown LEAN CLAY

**LL = 44**     **PL = 21**     **PI = 23**     **Assumed GS= 2.70**     **Type: Undisturbed**

**Project No.:** 21-419E  
**Date Sampled:** 11/30/2021  
**Remarks:**

**Client:** WARD DEVELOPEMENT  
**Project:** LOT 10 LAKEWOOD BUSINESS PARK  
**Source of Sample:** B4     **Depth:** 3.0  
**Sample Number:** ST-2

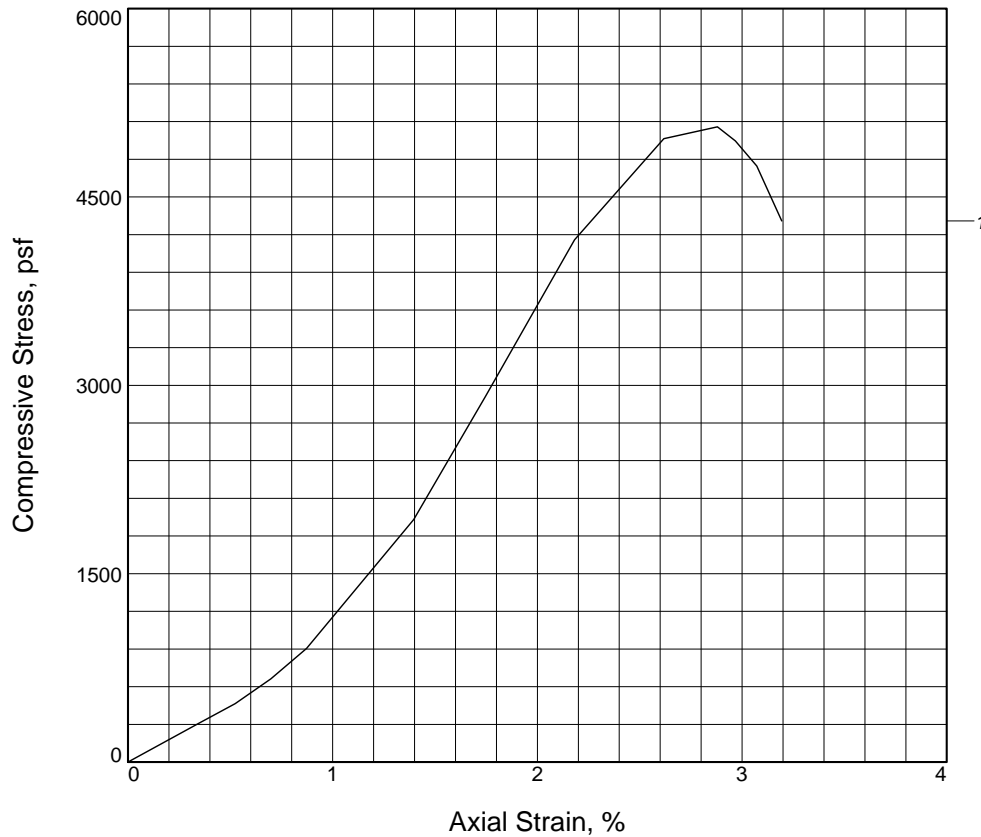
Figure 1 of 1



Tested By: D.B.

Checked By: T.B.

## UNCONFINED COMPRESSION TEST



Sample No.	1		
Unconfined strength, psf	5059		
Undrained shear strength, psf	2529		
Failure strain, %	2.9		
Strain rate, in./min.	0.080		
Water content, %	19.8		
Wet density, pcf	125.2		
Dry density, pcf	104.5		
Saturation, %	87.3		
Void ratio	0.6122		
Specimen diameter, in.	2.870		
Specimen height, in.	5.730		
Height/diameter ratio	2.00		

**Description:** Brown, spotted dark brown LEAN CLAY

**LL** = 36    **PL** = 20    **PI** = 16    **Assumed GS**= 2.70    **Type:** Undisturbed

**Project No.:** 21-419E

**Date Sampled:** 11/30/2021

**Remarks:**

**Client:** WARD DEVELOPEMENT

**Project:** LOT 10 LAKEWOOD BUSINESS PARK

**Source of Sample:** B5        **Depth:** 3.0

**Sample Number:** ST-2

Figure 1 of 1



Tested By: D.B.

Checked By: T.B.



## **Appendix Section C**

### **BORING LOGS**

Note: The logs of subsurface conditions shown in this section apply only at the specific boring location and depths at the date indicated and might not be indicative of all subsurface conditions that may be encountered. This information is not warranted to be representative of subsurface conditions at other locations, depths and times. The passage of time or construction operations at or adjacent to this site may result in changes to the soil conditions at these boring locations and depths. As a result, the character of subsurface materials shall be each bidder's responsibility.



**LOG OF BORING  
No. B1**

**PROJECT:** LOT 10 LAKEWOOD BUSINESS PARK **PROJECT NO.:** 21-419E  
**CLIENT:** WARD DEVELOPEMENT  
**PROJECT LOCATION:** INDEPENDENCE AVE. & MCBAIN DR., LEE'S SUMMIT, MO.  
**LOCATION:** NWC **ELEVATION:** N/D  
**DRILLER:** K. KEMPTON **LOGGED BY:** E. GAUT  
**DRILLING METHOD:** POWER AUGER **DATE:** 11-18-21  
**DEPTH TO - WATER> INITIAL:** NONE **AFTER 24 HOURS:** NONE **CAVING> C:** NONE

Elevation	Soil Symbols Sampler Symbols and Field Test Data	Description	w%	DDen pcf	LL	PI	200 %	Uncomp. psf	PPen. tsf	USCS/ Visual Class.
Depth (ft.)										
0		Brown, spotted dark brown LEAN/FAT CLAY (3" root zone)								CL-CH
3										CL-CH
4		Brown, spotted dark brown LEAN/FAT CLAY								CL-CH
5		Brown, spotted dark brown LEAN/FAT CLAY	33.8	85.7	84	59		4239	2.0	CL-CH
12		Brown, spotted reddish brown and dark brown FAT CLAY								CH
17		Brown, spotted reddish brown and dark brown FAT CLAY								CL-CH
24		Brown LEAN/FAT CLAY (weathered SHALE)(Very Hard, Very Slow drilling)								SH
10		Gray SHALE (Very Hard, Very Slow drilling)								SH
15		Gray SHALE (Very Hard, Very Slow drilling)								SH
16		Gray SHALE (Very Hard, Very Slow drilling)								SH
17.4		Weathered LIMESTONE (Very Hard, Very Slow drilling)								LS
17.9		Auger Refusal on Limestone at about 17.9'. End of Boring at about 17.9'.								
20										
25										
30										
35										



**LOG OF BORING  
No. B2**

**PROJECT:** LOT 10 LAKEWOOD BUSINESS PARK **PROJECT NO.:** 21-419E  
**CLIENT:** WARD DEVELOPEMENT  
**PROJECT LOCATION:** INDEPENDENCE AVE. & MCBAIN DR., LEE'S SUMMIT, MO.  
**LOCATION:** SWC **ELEVATION:** N/D  
**DRILLER:** K. KEMPTON **LOGGED BY:** E. GAUT  
**DRILLING METHOD:** POWER AUGER **DATE:** 11-18-21  
**DEPTH TO - WATER> INITIAL:** NONE **AFTER 24 HOURS:** NONE **CAVING>** C. NONE

Elevation	Soil Symbols Sampler Symbols and Field Test Data	Description	w%	DDen pcf	LL	PI	200 %	Uncomp. psf	PPen. tsf	USCS/ Visual Class.	
0		Brown, spotted dark brown LEAN/FAT CLAY (3" root zone)								CL-CH	
		Brown, spotted dark brown LEAN/FAT CLAY									CL-CH
		Brown, spotted dark brown LEAN/FAT CLAY									CL-CH
		Brown, spotted reddish brown and dark brown FAT CLAY									CH
		Brown, spotted reddish brown and dark brown FAT CLAY								1.50	CH
		Brown, mottled reddish brown, spotted dark brown FAT CLAY									CH
		Light reddish brown, spotted dark brown FAT CLAY with trace of gravel (Very Hard, Very Slow drilling)									LS
		Weathered LIMESTONE (Very Hard, Very Slow drilling)									
		Auger Refusal on Limestone at about 8.2'. End of Boring at about 8.2'.									
10											
15											
20											
25											
30											
35											



**LOG OF BORING  
No. B3**

**PROJECT:** LOT 10 LAKEWOOD BUSINESS PARK **PROJECT NO.:** 21-419E  
**CLIENT:** WARD DEVELOPEMENT  
**PROJECT LOCATION:** INDEPENDENCE AVE. & MCBAIN DR., LEE'S SUMMIT, MO.  
**LOCATION:** MID BLDG **ELEVATION:** N/D  
**DRILLER:** K. KEMPTON **LOGGED BY:** E. GAUT  
**DRILLING METHOD:** POWER AUGER **DATE:** 11-18-21  
**DEPTH TO - WATER> INITIAL:** NONE **AFTER 24 HOURS:** NONE **CAVING>** C. NONE

Elevation	Soil Symbols Sampler Symbols and Field Test Data	Description	w%	DDen pcf	LL	PI	200 %	Uncomp. psf	PPen. tsf	USCS/ Visual Class.
0		Brown LEAN CLAY (3" root zone)								CL
		Brown LEAN CLAY (Very Hard, Very Slow drilling)								CL
		Brown LEAN CLAY (Very Hard, Very Slow drilling)	28.6	92.5				6030	+4.50	CL CH
5		Brown, spotted dark brown FAT CLAY								CH
		Brown, spotted dark brown FAT CLAY							1.75	CH
		Brown, spotted dark brown and reddish brown FAT CLAY								CH
		Brown, spotted dark brown and reddish brown FAT CLAY								LS
10		Weathered LIMESTONE (Very Hard, Very Slow drilling)								
15		Auger Refusal on Limestone at about 7.9'. End of Boring at about 7.9'.								
20										
25										
30										
35										



**LOG OF BORING  
No. B4**

**PROJECT:** LOT 10 LAKEWOOD BUSINESS PARK **PROJECT NO.:** 21-419E  
**CLIENT:** WARD DEVELOPEMENT  
**PROJECT LOCATION:** INDEPENDENCE AVE. & MCBAIN DR., LEE'S SUMMIT, MO.  
**LOCATION:** NEC **ELEVATION:** N/D  
**DRILLER:** K. KEMPTON **LOGGED BY:** E. GAUT  
**DRILLING METHOD:** POWER AUGER **DATE:** 11-18-21  
**DEPTH TO - WATER> INITIAL:** NONE **AFTER 24 HOURS:** NONE **CAVING>** C. NONE

Elevation	Soil Symbols Sampler Symbols and Field Test Data	Description	w%	DDen pcf	LL	PI	200 %	Uncomp. psf	PPen. tsf	USCS/ Visual Class.	
0		Brown LEAN/FAT CLAY (3" root zone)	1.0							CL-CH	
		Brown LEAN/FAT CLAY	2.5								CL-CH
		Brown LEAN/FAT CLAY	3.0								CL-CH
		Brown, spotted dark brown LEAN CLAY	3.0	21.6	103.3	44	23	5288	3.75		CL
5		Brown, spotted dark brown LEAN CLAY	5.0								CL
		Brown LEAN/FAT CLAY	6.0						2.25		CL-CH
		Brown LEAN/FAT CLAY	8.0								CL-CH
		Brown LEAN/FAT CLAY	8.5								CH
10		Reddish brown, spotted gray FAT CLAY with trace of gravel (weathered LIMESTONE)(Very Hard, Very Slow drilling)	9.4								CH
		Reddish brown, spotted gray FAT CLAY with trace of gravel (weathered LIMESTONE)(Very Hard, Very Slow drilling)	10.0								LS
15		Weathered LIMESTONE (Very Hard, Very Slow drilling)	10.5								
		Auger Refusal on Limestone at about 10.5'. End of Boring at about 10.5'.									
20											
25											
30											
35											



**LOG OF BORING  
No. B5**

**PROJECT:** LOT 10 LAKEWOOD BUSINESS PARK **PROJECT NO.:** 21-419E  
**CLIENT:** WARD DEVELOPEMENT  
**PROJECT LOCATION:** INDEPENDENCE AVE. & MCBAIN DR., LEE'S SUMMIT, MO.  
**LOCATION:** SEC **ELEVATION:** N/D  
**DRILLER:** K. KEMPTON **LOGGED BY:** E. GAUT  
**DRILLING METHOD:** POWER AUGER **DATE:** 11-18-21  
**DEPTH TO - WATER> INITIAL:** NONE **AFTER 24 HOURS:** NONE **CAVING>** C NONE


Elevation	Soil Symbols Sampler Symbols and Field Test Data	Description	w%	DDen pcf	LL	PI	200 %	Uncomp. psf	PPen. tsf	USCS/ Visual Class.	
0		Brown, spotted gray and dark brown LEAN/FAT CLAY (3" root zone)								CL-CH	
1.0		Brown, spotted gray and dark brown LEAN/FAT CLAY								CL-CH	
2.5		Brown, spotted gray and dark brown LEAN/FAT CLAY	19.8	104.5	36	16		5059	3.75	CL-CH	
3.0		Brown, spotted dark brown LEAN CLAY								CL	
5.0		Brown, spotted dark brown LEAN CLAY								CH	
6.0		Brown, spotted dark brown FAT CLAY								1.75	CH
7.5		Brown, spotted dark brown FAT CLAY									CL-CH
8.5		Brown, spotted dark brown FAT CLAY									LS
9.5		Brown, spotted dark brown LEAN/FAT CLAY with trace of gravel (weathered LIMESTONE)(Very Hard, Very Slow drilling)									
10.5		Weathered LIMESTONE (Very Hard, Very Slow drilling)									
10.5		Auger Refusal on Limestone at about 10.5'. End of Boring at about 10.5'.									


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
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
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
Strata symbols


 Undisturbed thin wall Shelby tube

 FAT/LEAN CLAY


 FAT CLAY

 Weathered SHALE


 Weathered LIMESTONE

 LEAN CLAY

Misc. Symbols

 Drill rejection

Soil Samplers

 Standard penetration test

Notes:

1. Borings were drilled on November 18, 2021 using solid auger, split spoon sampler and shelly tube sampler techniques.
  2. Ground water was not encountered while drilling at the reported depths.
  3. Borings were staked by Alpha-Omega, Inc.
  4. These logs are subject to the limitations, conclusions, and recommendations in this report.
  5. Results of tests conducted on samples recovered are reported on the logs.
- Abbreviations are:

DDen =	natural dry density (pcf)	LL =	Liquid
limit			
w% =	natural moisture content (%)	PI =	Plasticity
index			
UComp =	Unconfined compression (psf)	PPen =	Pocket
Penetrometer			
-200 =	percent passing #200 sieve (%)	RQD =	Rock
Quality			
DCP =	Dynamic Cone Penetrometer		