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GEOTECHNICAL EXPLORATION REPORT
Proposed Dutch Brothers Coffee
NEC NW Ward Rd. and NW Chipman Rd.
Lee's Summit, Missouri

GSI Project No. 2173104
July 28, 2021

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I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Missouri.

K. Erik Troy, P.E. Date

My license renewal date is December 31, 2023
Sections covered by this seal: Sections 1 through 6 and all pages included as appendices within this bound document.

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1. INTRODUCTION

1.1 General

This report summarizes the findings of our geotechnical exploration for the proposed Dutch Brothers Coffee located west of the Lion's Choice at the northeast corner of NW Ward Road and NW Chipman Road in Lee's Summit, Missouri. The scope of work was outlined in our proposal dated June 14, 2021. Ms. Shannon Netherton of TM Crowley & Associates authorized this exploration on June 30, 2021.

The purpose of this geotechnical study is to explore the subsurface conditions at the proposed site with exploratory borings, evaluate the engineering properties of the subsurface materials with appropriate field and laboratory tests, and perform engineering analyses for developing design and construction recommendations for the proposed project.

1.2 Project Description

The proposed project will be located at NW Chipman Road and NW Ward Parkway in Lee's Summit, Missouri. We understand the development will consist of a new Dutch Brothers coffee shop drive-through facility. The one-story structure will be of steel or wood frame construction with a concrete slab-on-grade floor. We estimate the structure will have maximum column and continuous wall loads on the order of 50 kips and 2 kips per linear foot, respectively.

We anticipate that the pavement will support predominately light passenger cars with less frequent panel delivery vans, passenger vans, and trash trucks.

Site grades very approximately 1 foot across the building area and 2 feet or less across the site. We assume site grading required to bring the building pad to the desired elevation will be minimal, with cuts or fills less than 2 feet. Please contact us if site grading will be more significant so we may evaluate and adjust our scope of service if necessary.

A site plan is included in Appendix A for reference.

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2. FIELD EXPLORATION

We drilled 4 borings for this geotechnical exploration on drilling date with a CME-75 truck mounted drilling rig using 6-inch diameter continuous flight augers. We drilled 2 borings within the building footprint and 2 borings in the parking/drive areas. All borings were drilled to a depth of approximately 15 feet below the site grade at the time of our exploration.

We selected boring locations based on a preliminary site plan/boring location plan provided by TM Crowley & Associates. GSI personnel established field locations using a Garmin handheld GPS.

We interpolated ground surface elevations at the boring locations using elevations obtained from site survey plan provided by the client on July 21, 2021. The ground surface elevations at the borings are shown on the boring logs included in Appendix B. The locations and elevations of the borings should be considered accurate only to the degree implied by the methods used in their determination.

Our drill crew obtained soil samples at the intervals shown on the boring logs in Appendix B. Recovered samples were sealed in plastic containers, labeled, and protected for transportation to the laboratory for further examination, testing, and classification.

We obtained split-barrel samples (designated "Split Spoon" or "S" samples) while performing Standard Penetration Tests (SPT) with a 1-3/8-inch I.D. thick-walled sampler, driven using an automatic hammer in general accordance with ASTM D1586, "*Penetration Test and Split-Barrel Sampling of Soils*." The "N" value, reported in blows per foot (bpf), equals the number of blows required to drive the sampler through the last 12 inches of the 18-inch sample interval using a 140-pound hammer falling 30 inches.

We obtained undisturbed samples (designated "Shelby Tube" or "U" samples) with 3-inch O.D. thin-walled tube samplers, hydraulically pushed in general accordance with ASTM D1587, "*Thin-Walled Tube Sampling of Soils for Geotechnical Purposes*."

Our drilling personnel prepared field boring logs during drilling operations. These field logs report drilling and sampling methods, sampling intervals, groundwater measurements and the subsurface conditions we encountered. At the conclusion of drilling, our drill crew made groundwater measurements and backfilled the borings in accordance with Kansas state regulations.

3. SITE CONDITIONS

3.1 Regional Geology

Soils in the greater Kansas City area are generally residual soils, alluvial deposits, or till. Residual soils formed from weathering of bedrock, or by weathering of sediments that were transported by water, ice, wind, or a combination of these. Regional soils derived from shale, limestone, and loess have high shrink-swell potentials. Major alluvial deposits occur along the Missouri and Kansas rivers and their tributaries. These consist of clay, sand, and gravel sized sediments. Northern parts of the city were glaciated during the early Pleistocene time resulting in till deposits. Surface bedrock in northeastern Kansas and northwestern Missouri generally consist of limestone and shale (with sandstone found in prehistoric channels) arranged in nearly horizontal beds or layers that can be followed continuously over long distances. These bedrocks are part of the Pennsylvanian bedrock system.

3.2 Surface Conditions

The project site comprises a grass covered field in the process of commercial development. The site is bounded to the east by a Lion's Choice restaurant, to the south by NW Chipman Road, and to the north by and an unnamed drive to access the shopping center.

3.3 Subsurface Conditions

Although we observed some variability, the subsurface materials we encountered within the depths of exploration generally consisted of residual or glacial lean clay soils underlain by shale bedrock. General descriptions of the strata we encountered are presented below, while more detailed subsurface information is presented on the boring logs located in Appendix B. Please note that the indicated depths are relative to the site grade at the time of our exploration.

Stratum 1

We encountered lean clay in Borings B-1 and B-4 to depths of 5.5 feet. Fills comprise of lean clay was encountered in Borings B-2 and B-3 to depths of 2.5 feet and was underlain by native lean clay in Boring B-3 and by shale in Boring B-2. The native lean clay was generally light gray and yellow brown and moist. The lean clay fill was generally dark brown and moist. We measured Standard Penetration Test (SPT) N-values between 6 and 9 blows per foot (bpf)and unconfined compressive strengths between 1.21 and 5.29 kips per square foot (ksf), indicating the lean clay is in a soft to stiff condition.

Stratum 2

We encountered weathered shale bedrock below the lean clay in all borings. The shale was generally yellow brown and varied from decomposed to highly weathered. We measured SPT N-values between 10 bpf and 86 for 11 inches (86/11") indicating the shale was very soft to moderately hard rock.

3.4 Groundwater Conditions

Our drill crew made water level observations during drilling and after completion of the borings to evaluate groundwater conditions. We did not encounter groundwater in any of our soil borings. However, the slow percolation rate of the on-site fat clay and shale (or glacial till, etc.) can cause water to pond or become perched for extended time periods. In addition, the clay and shale in this vicinity can contain thin sand lenses or desiccation cracks that can transport water laterally. Excavations that encounter the sand seams or desiccation cracks may flood and require dewatering.

The groundwater conditions we observed during our exploration program should not be construed to represent an absolute or permanent condition. Uncertainty is involved with short-term water level observations in boreholes.

3.5 Seismic Site Classification

We have reviewed the boring logs and laboratory test data for this project. We have also reviewed other geologic data from the general area available to us for further information on the soils extending to a depth of 100 feet below the existing grade.

Based on the above resources, we estimate that the weighted average N-value for soil and rock across this depth is approximately 50 blows per foot (bpf). As defined in Chapter 20 of ASCE 7-10 as well as the 2012 version of the International Building Code, this building site is assigned a Site Class of C.

4. LABORATORY TESTING

Our engineering staff reviewed the field boring logs to outline the depth, thickness and extent of the soil strata. The samples taken from the borings were examined in our laboratory and visually classified in general accordance with ASTM D2488, "*Description and Identification of Soils (Visual-Manual Procedure)*." We established a testing program to evaluate the engineering properties of the recovered samples. A GSI technician performed laboratory testing in general accordance with the following current ASTM test methods:

- Moisture Content (ASTM D2216, "*Laboratory Determination of Water (Moisture) Content of Soil and Rock*")
- Unit Weight (ASTM D7263, "*Laboratory Determination of Density (Unit Weight) of Soil Specimens*")
- Atterberg Limits (ASTM D4318, "*Liquid Limit, Plastic Limit, and Plasticity Index of Soils*")
- Unconfined Compressive Strength (ASTM D2166, *"Unconfined Compressive Strength of Cohesive Soil")*

Laboratory test results are presented on the boring logs in Appendix B and tabulated in Appendix C.

Moisture content and unit weight tests were used to evaluate the existing moisture condition of the soils. The Atterberg limits were used to help classify the soils under the Unified Soils Classification System. The Atterberg limits were also used to evaluate the plasticity characteristics of the soils. Unconfined compression tests were used to define the stress-strain characteristics and related shear strength of the soils.

The following data summarize our laboratory test results. We used these data to develop the allowable bearing values, anticipated settlements, and other geotechnical design criteria for the project.

- Natural Moisture Content (clay)..22.0 to 29.1%
- Natural Moisture Content (shale)...13.5 to 25.4%
- Wet Density ....124.4 to 129.2 lb./ft^3
- Dry Density ....99.5 to 101.2 lb./ft^3
- Unconfined Compressive Strength .... 1.21 to 5.29 kips/ft^2
- Liquid Limit ....48 to 49

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- Plastic Limit 26
- Plasticity Index..22 to 23
- Standard Penetration Test (SPT 'N' blows per foot) (clay).......................6 to 9
- Standard Penetration Test (SPT 'N' blows per foot) (shale).............8 to 86/11"

Based on the results of this testing program, we reviewed and supplemented the field logs to arrive at the final logs as presented in Appendix B. The final logs represent our interpretation of the field logs and reflect the additional information obtained from the laboratory testing. Stratification boundaries indicated on the boring logs were based on observations made during drilling, an extrapolation of information obtained by evaluating samples from the borings, and comparisons of similar engineering characteristics. Locations of these boundaries are approximate and the transitions between soil types may be gradual rather than clearly defined.

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5. CONCLUSIONS AND RECOMMENDATIONS

5.1 General Geotechnical Considerations

The soils we encountered in the test borings are generally capable of supporting the anticipated loads on shallow foundations.

The near-surface clay soils we encountered at the site are classified as moderately to highly plastic and may be susceptible to changes in strength and volume (shrink/swell) with changes in moisture content. These soils are not recommended for direct support of floor slabs or pavements, unless chemically stabilized as outlined later in this report.

5.2 Earthwork

5.2.1 Site Preparation

In preparing the site for construction, surface vegetation and topsoil containing a significant percentage of organic matter should be removed from the areas beneath structures and any other areas that are to be paved, cut or receive fill. The removal depth for this site is expected to be approximately 6 inches. However, the removal depth should be monitored during stripping and adjusted as required. This material should either be removed from the site or stockpiled for later use in landscaping of unpaved or non-structural areas.

Prior to fill placement, the top 9 inches of the ground surface in fill areas should be scarified, moisture conditioned and recompacted in accordance with Section 5.2.5 to eliminate a plane of weakness along the contact surface.

The subgrade should be proof rolled with a loaded tandem axle dump truck or equivalent (loaded water truck, loaded concrete mixer or motor grader with a minimum weight of 20 tons). A proof-roll is considered acceptable if no ruts greater than one inch deep appear behind the loaded vehicle, and no pumping or weaving is observed as the wheels pass over the area. Any soft or unsuitable areas should be compacted or removed and replaced with stable fill material similar in composition to the surrounding soils. If necessary, clean materials such as crushed concrete or crushed stone may be used to stabilize areas where wet soil or water is present. Geogrid or structural geotextile may be used in conjunction with crushed concrete or stone to provide additional stabilization.

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Whether in cut or fill, the final subgrade surface must be maintained in a stable condition at the moisture content and level of compaction identified in Section 5.2.5. Verification and maintenance of the completed subgrade may require scarification, moisture conditioning, recompaction, and proof rolling.

5.2.2 General Structural Fill

General structural fill may be used for mass site grading, landscaping applications or as utility trench backfill outside of building areas. General structural fill may also be used to within 18 inches of the base of any granular cushion beneath floor slabs and to within 9 inches of the base of any vehicular pavements. In the former applications, low volume change materials are required immediately below the floor slabs or pavements (low volume change material is discussed in the following section).

General structural fill may comprise cohesive or granular material but should be free from organic matter or debris. Granular materials used as general structural fill should be well graded, have a maximum particle size of 1.5 inches, and meet KDOT freeze/thaw durability and sulfate soundness requirements. Off-site material used as general structural fill should have a liquid limit (LL) of less than 50 and a plastic index (PI) of less than 30.

If free of organic matter or debris, the on-site soils may be reused as general structural fill within the areas outlined above.

5.2.3 Low Volume Change Material (LVC)

Low volume change (LVC) material as specified for use below floor slabs and pavements must consist of granular material or cohesive soil with a liquid limit (LL) less than 40 and a plasticity index (PI) between 10 and 20. Granular material used as LVC must have sufficient cohesion to form a compactable, uniform and stable subgrade. This typically translates to a material with greater than 15 percent fines (percent passing the No. 200 sieve) and a maximum particle size of 1.5 inches. Silty gravel (such as MoDOT Type 5), crushed concrete with a maximum particle size of 1.5 inches, or limestone screenings are also acceptable LVC materials. Granular materials with less than 15 percent fines may be used within confined areas such as within foundation stem walls. LVC materials should be free of organic matter or debris.

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The on-site lean clay soils are not considered LVC material as defined in this section, unless chemically stabilized as outlined below.

5.2.4 Chemical Stabilization of Soil

The moderately to highly plastic clay soils we encountered in this exploration are considered moisture sensitive and may lose strength and undergo volume changes with fluctuations in moisture content. The on-site lean clay soils are not suitable for use as LVC material without chemical stabilization. Chemical stabilization may be achieved by amending the soil with 14 to 16 percent class "C" fly ash, 6 to 8 percent cement kiln dust (CKD), or 3 to 5 percent Portland cement.

We recommend a laboratory standard Proctor Moisture-Density Relationship (ASTM D698, *"Laboratory Compaction Characteristics of Soil Using Standard Effort"*) be performed prior to field mixing using a sample of the soil to be stabilized and the proposed amendment (fly ash, CKD or Portland cement). The sample should be prepared in advance to match the intended field mix proportions, using the same amendment source as will be utilized in the field.

Fly Ash Stabilization

Prior to the introduction of fly ash, the soil material should be thoroughly pulverized to reduce clods to ½ inch or less. During the pulverization process, we recommend that water be added to reach a moisture content at or above the optimum moisture content as determined by ASTM D698 for the proposed fly ash-soil mixture. The fly ash should remain dry and be protected from external sources of moisture during transportation and storage. Fly ash material that is introduced to moisture prior to incorporation with the soil must be discarded.

The fly ash and soil should be thoroughly mixed within ½ hour after introduction. The moisture content should be field tested immediately following mixing and adjusted as needed to maintain a range between optimum and 4 percent above optimum. The fly ash-soil mixture should not be allowed to air dry. If the moisture content is determined to be in excess of 4 percent of optimum, additional fly ash should be applied to achieve the specified moisture content. Compaction of the fly ash supplemented soil should be completed within 2 hours after incorporation. Additional compaction after 2 hours may cause degradation of the soil strength. The fly ash-soil mixture should be compacted as noted in Section 5.2.5.

Fly ash mixing should not be performed at ambient air temperatures below 50 degrees Fahrenheit.

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Cement Kiln Dust

Cement kiln dust can also be used as a soil stabilization agent and should be incorporated into the soils using the procedures outlined for fly ash stabilization. Cement kiln dust may be used at temperatures below 50 degrees Fahrenheit, provided the soil to be amended is frost-free.

Portland Cement

Type I/II Portland cement can be used as a soil stabilization agent using dry application methods as outlined above, or by injection of a liquefied cementitious mixture (A.K.A. Super Slurry) into the soil to be treated. Cement treatment and mixing can be performed at temperatures below 50 degrees Fahrenheit, provided the soil to be amended is frost-free.

Stabilized Subgrade Maintenance

Stabilized soil that will be utilized as floor slab subgrade should not be allowed to freeze prior to floor slab placement. OR Stabilized soil that will be utilized as pavement subgrade should be covered with a minimum of 3.5 inches of asphalt or the full Portland cement concrete pavement section prior to being subjected to freezing conditions. If paving/slab placement does not immediately follow soil stabilization, the supplemented soil should be protected from extreme weather, kept moist, and minimally trafficked until slab placement occurs. In areas that are to be paved, an asphalt prime coat could be applied over the stabilized material surface as an alternative to periodic moisture additions to maintain acceptable moisture throughout curing.

If the stabilized subgrade deteriorates prior to paving or slab placement, we recommend any unstable areas be scarified and recompacted. We recommend an additional 3 percent class "C" fly ash be incorporated in areas that are to be scarified and recompacted. Expansive soils stabilized with cement kiln dust or Portland cement may be reworked without additional amendment. Other soil types may require the incorporation of additional cement kiln dust or Portland cement to restore the desired strength characteristics.

5.2.5 Compaction of Engineered Structural Fills

Unless otherwise noted, fill materials should be placed in loose lifts not to exceed 9 inches and be compacted to a minimum of 95 percent of the maximum dry unit weight obtained from ASTM D698 (Standard Proctor). Moisture content at the time of compaction should be controlled to between optimum and 4 percent above optimum moisture content.

Granular fill materials which produce a definable moisture-density curve when tested according to ASTM D698 should be compacted to a minimum of 95 percent of the maximum dry unit weight obtained from ASTM D698. Granular fill materials which do not produce a definable moisture-density curve should be compacted to a minimum of 75 percent relative density (ASTM D4253, *"Maximum Index Density and Unit Weight of Soils Using a Vibratory Table"* and ASTM D4254, "*Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density"*). Granular materials should be placed at a moisture content that will achieve the desired densities. Please note that relative density and standard Proctor tests measure different parameters and are not interchangeable.

In general, proper compaction of cohesive soils can be achieved with sheepsfoot or pneumatic-type compactors, while compaction of granular soils can be achieved with smooth-drum or smooth-plate vibratory compactors. Water flooding is not an acceptable compaction method for any soil type.

5.2.6 Utility Trench Backfill

As a minimum, utility trench backfill material should meet the requirements of general structural fill as defined in Section 5.2.2. Where utility trenches pass beneath the structure, pavements or flatwork, the upper foot of utility backfill should meet the requirements of LVC material as defined in Section 5.2.3. Backfill soils in utility trenches must be placed in lifts of 6 inches or less in loose thickness and be compacted in accordance with Section 5.2.5.

Controlled low strength material (CLSM) or flowable fill may also be used for utility backfills. We recommend designing flowable fill with a compressive strength between 50 and 300 pounds per square inch (psi). CLSM with a maximum compressive strength less than 300 psi can be readily excavated with a backhoe. The intent for the CLSM is to provide a backfill that can be placed in a single lift, without personnel entering the excavation and without the need for compaction equipment.

Where used beneath pavements, flatwork or the structure, CLSM should be terminated a minimum of one foot below the structure, floor slab or pavement subgrade elevation. To provide uniform support beneath pavements, flatwork, and the structure, the fill placed over the CLSM should be of similar composition as the surrounding bearing materials and be constructed as moisture-conditioned and compacted engineered structural fill in accordance with Section 5.2.5.

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5.2.7 Foundation Backfill

As a minimum, backfill soils for formed foundations should meet the requirements of general structural fill as defined in Section 5.2.2. However, we recommend fill around foundations meet the requirements of LVC material as defined in Section 5.2.3. The use of LVC material to backfill foundations is intended to help reduce lateral swell pressures on the foundation wall and reduce desiccation cracking adjacent to the structure, which can provide a pathway for water to infiltrate the foundation subgrade. If other cohesive materials are used to backfill foundations, the risk of differential movements caused by water infiltration into the foundation subgrade may be increased.

We also recommend the upper 18 inches of exterior foundation backfill have sufficient cohesion to direct surface water away from the structure. Granular materials such as sand and gravel are not suitable for use as exterior foundation backfill in the surficial 18 inches.

Backfill soils around formed foundations must be placed in lifts of 6 inches or less in loose thickness and be moisture conditioned and compacted in accordance with Section 5.2.5. Care should be exercised during compaction to avoid applying excessive stress to the foundation surfaces. Where both sides of a foundation wall are backfilled, the fill should be placed simultaneously in uniform lifts on both sides of the wall to reduce unbalanced lateral loads.

5.2.8 Correction of Unsuitable Foundation Soils

If soft, loose, or otherwise unsuitable soils are encountered at the base of any foundations, an over-excavation and replacement/recompaction procedure will be required, unless the unsuitable materials can be removed and suitable materials and the foundation constructed at the lower level. If adjusting bearing level is not possible, the unsuitable soils beneath the foundations should be removed to the required depth, with the excavation extending laterally 9 inches in all directions for each vertical foot of over-excavation. Structural fill for the over-excavated areas should be of similar composition as the surrounding materials or meet the requirements of LVC material as defined in Section 5.2.3. Backfill material should be compacted in accordance with Section 5.2.5. CLSM, as defined in Section 5.2.6 may also be used to backfill over-excavated areas.

5.2.9 Excavation Slopes

Vertical cuts and excavations may stand for short periods of time, but should not be considered stable in any case. All excavations should be sloped back, shored, or shielded for the protection of

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workers. As a minimum, trenching and excavation activities should conform to federal and local regulations.

The clay soils we encountered in the test borings generally classify as a type B soil according to OSHA's Construction Standards for Excavations. In general, the maximum allowable slope for shallow excavations of less than 20 feet in a type B soil is 1H:1V, although other provisions and restrictions may apply. If different soil types are encountered, the maximum allowable slope may be different.

The Contractor is responsible for designing any excavation slopes or temporary shoring. The Contractor must also be aware that slope height, slope inclination, and excavation depths (including utility trench excavations) should in no case exceed those specified in federal, state, or local safety regulations, such as OSHA Health and Safety Standards for Excavations, 29 CFR Part 1926, or successor regulations.

The information presented in this section is solely for our client's reference. **GSI assumes no responsibility for site safety or the implementation of proper excavation techniques.**

5.2.10 Rock Excavation

We anticipate the shale bedrock in the building area can be excavated with standard excavation equipment. However, lenses of harder shale or limestone may be present, requiring the use of rock excavation equipment such as rock rippers or hydraulic breakers.

5.3 Shallow Foundations

Based on the subsurface conditions revealed by the boring and testing program, this site appears suitable for use of a shallow foundation system The selection of an allowable soil bearing pressure for shallow foundation elements must fulfill two requirements. First, the foundation load must be sufficiently less than the ultimate soil bearing capacity to ensure stability. Second, the total and differential settlements must not exceed amounts which will produce adverse behavior of the superstructure.

To meet the previous criteria, we have explored both the bearing capacity and the load settlement characteristics of the subsurface materials using maximum column and continuous wall loads on the

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order of 50 kips and 2 kips per linear foot, respectively. The allowable soil bearing pressure is based on a factor of safety of three against the ultimate bearing capacity of the soil, with additional consideration given to limiting settlement to acceptable levels. In our analysis, we used a maximum allowable total settlement of 1 inch and a maximum allowable differential settlement of ¾ of an inch across the width of the foundation. These limits are generally considered acceptable for most structures.

A net allowable soil bearing pressure of 2,500 pounds per square foot (psf) may be used to size shallow foundation elements bearing on the existing lean clay soils or shale bedrock. The allowable bearing pressure is expressed in terms of the net pressure transferred to the soil. The net allowable bearing pressure is defined as the total structural dead load including the weight of the foundation elements, less the weight of the soil excavated for the foundation elements. This value may be increased by one-third for transient loading conditions such as wind or seismic

This site appears to be suitable for the use of trenched "grade beam" type footings. Trenched footings utilize the excavation side walls as a form. Because separate forms do not need to be installed, this type of footing can be constructed more quickly and eliminate the need to backfill the foundation. Stresses applied to the soil by the foundation are also distributed more evenly.

All exterior and any interior foundation elements exposed to freezing conditions should be constructed at least 3 feet below the surrounding exterior grade to help reduce the effects of frost and seasonal moisture changes. Interior footings, which will be protected from the effects of frost, may be founded 1.5 feet below finished floor elevation.

We recommend that concrete be placed as soon as practical after footing excavation, with as little disturbance to the bearing soil as possible. Footing excavations should be free of loose soil or debris. Loose or disturbed soil must be removed or compacted prior to foundation construction. Water that collects in the excavations should be promptly removed to prevent softening of the foundation supporting soils prior to concrete placement. In addition, we recommend all excavations be observed by our geotechnical personnel prior to placement of concrete for the possible presence of unsuitable bearing soils. If unsuitable bearing soils are encountered during construction, these areas should be corrected in accordance with Section 5.2.8.

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If shallow foundations are designed and constructed in accordance with the recommendations presented, total settlements are not expected to exceed 1 inch with differential settlements less than ¾ of an inch across the width of the foundation.

5.4 Floor Slabs

The clay soils we encountered near the surface in our borings are moderately plastic and susceptible to changes in strength and volume (shrink/swell) with changes in moisture content. Such changes present a risk of causing slab movement. Most slabs-on-grade will experience some amount of vertical movement, which the Owner must be willing to accept. Recommendations to help reduce the risk of movement of a slab supported on plastic clay soils are presented below.

To provide uniform support for floor slabs and reduce the potential for subgrade volume change, we recommend all floor slabs bear on a minimum of 18 inches of LVC material as defined in Section 5.2.3 (or chemically stabilized on-site soils as outlined in Section 5.2.4). The placement and compaction of the LVC material should conform to the recommendations in Section 5.2.5 of this report. Depending on final grades, some over-excavation of the plastic lean clay soils may be required to develop the 18-inch layer of LVC material.

By constructing an 18-inch layer of low plasticity, low volume change material immediately beneath the floor slab and closely controlling the moisture and density of the scarified soil and new fill materials, it is our opinion that the potential for detrimental floor slab movement will be sufficiently reduced. However, because of the remaining thickness of the moderately plastic shale, the potential for future movement will still exist. A greater thickness of low volume change material beneath the floor slab may further reduce potential slab movement. If even slight slab movements are not acceptable, please contact GSI for further floor slab recommendations.

We recommend a 2- to 4-inch thick granular cushion be placed beneath the floor slab in addition to the low plasticity, low volume change material. This layer should be free-draining, well-graded and compacted by vibration prior to placing the floor slab.

We also recommend the moisture content of upper 9 inches of the subgrade be checked prior to placement of a sand base, reinforcing steel or concrete floor slab. If the moisture content of the

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subgrade is below optimum, we recommend the subgrade be scarified, moisture conditioned and recompacted according to Section 5.2.5.

In many construction projects, the moisture content of the floor slab subgrade is tested during grading of the site. The subgrade then remains exposed until floor slab placement occurs several weeks later. In this situation, even LVC material is subject to some swell movement if not properly moisture conditioned prior to slab placement. Periodic applications of water will help maintain the proper moisture content of subgrade soils. The risk of differential movements can be reduced by creating and properly preparing a LVC zone beneath the slab as well as ensuring proper drainage is maintained around the structure at all times.

In finished areas, the floor covering manufacturer should be consulted regarding the use of a vapor retarder beneath floor slabs. If a vapor retarder is recommended by the floor covering manufacturer, it should conform to the manufacturer's specifications to maintain the product warranty. In other areas, vapor retarder should be placed in accordance with recommendations outlined in ACI 302.1R-15, "Guide to Concrete Floor and Slab Construction."

5.5 Pavement Recommendations

The asphalt and Portland cement concrete pavement recommendations provided below are separated into a regular duty and a heavy duty section. To perform properly, the pavement sections require that the subgrade be prepared in accordance with the recommendations in Section 5.6.1.

5.5.1 Pavement Subgrade Preparation

Pavement performance is directly affected by the degree of compaction, uniformity, and stability of the subgrade. The stability and quality of the pavement subgrade is particularly important where high traffic volume and heavy axle loads are anticipated. Based on the subsurface conditions encountered at the boring locations, the pavement subgrade will comprise lean clay. The on-site clay soils exceed the liquid limit and plasticity index criteria for use as LVC material.

We recommend that as a minimum, the top 9 inches of the pavement subgrade in vehicular and pedestrian areas be constructed of LVC material (as defined in Section 5.2.3) or chemically-stabilized on-site soils. Additional LVC material below vehicular and pedestrian pavements will

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enhance pavement performance, but is an economic consideration between initial construction cost and future potential pavement maintenance costs.

The top 9 inches of pavement subgrade should be compacted to a minimum of 95 percent of the maximum dry unit weight determined by ASTM D698. The moisture content should also be controlled to between optimum and 4 percent above the optimum moisture content.

To detect any localized areas of instability, the final subgrade should be proof rolled with a loaded tandem axle dump truck or equivalent (loaded water truck, loaded concrete mixer or motor grader with a minimum weight of 20 tons) immediately prior to placement of the concrete or asphalt. Unstable areas should be removed and replaced or reworked to provide a more uniform subgrade. If necessary, clean materials such as crushed concrete or crushed stone may be used to stabilize areas where wet soil or water is present. Geogrid or structural geotextile may be used in conjunction with crushed concrete or stone to provide additional stabilization.

We also recommend the moisture content of the subgrade be checked prior to paving. If the moisture content is below optimum, we recommend the subgrade be scarified, moisture conditioned and recompacted according to Section 5.2.5.

5.5.2 Recommended Design Sections

The pavement sections for this project are based on our experience with similar pavements and a design life of 15 to 20 years. The regular duty pavement sections are intended for passenger car and light truck traffic and parking areas. The heavy duty pavement sections are intended for areas that will experience high traffic volumes or heavy axle loads such as main access drives or delivery truck routes. Portland cement concrete pavements are recommended for areas with frequent start-stop or turning traffic such as entrance and exit aprons or the parking stalls closest to buildings, as well as areas that support stationary loads such as dumpsters.

Our recommendations for full-depth asphalt and Portland cement concrete pavement sections are presented in the following tables.

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Table 5.5.2-1: Full-Depth ACC Pavement Design Recommendations

	Regular Duty Section	Heavy Duty Section	Heavy Duty Section--Truck Area
APWA Type 3 Surface Course (in)	2.0	2.0	2.0
APWA Type 2 Surface Course (in)	3.5	5.5	7.0
LVC Subgrade	9.0 (minimum)	9.0 (minimum)	9.0 (minimum)

LVC subgrade placed and compacted in accordance with Section 5.5.1.

Table 5.5.2-2: PCC Pavement Design Recommendations

	Sidewalks & Pedestrian Areas	Regular Duty Section	Heavy Duty Section	Heavy Duty Section--Truck Area
APWA Section 2208 Air Entrained Portland Cement Concrete (in.)	4.0	5.0	6.0	8.0
LVC Subgrade	9.0 (minimum)	9.0 (minimum)	9.0 (minimum)	9.0 (minimum)

LVC subgrade placed and compacted in accordance with Section 5.5.1.

5.5.3 Asphaltic Cement Concrete Pavement Construction

We recommend that both the asphalt surface and base coarse aggregate gradations meet APWA Type 5 with a performance graded asphalt binder meeting KDOT PG 64-22. We recommend that a maximum of 15% RAP be used in the surface course and that a maximum of 20% RAP be used in the base courses.

Asphalt should be placed at an ambient temperature above 40 degrees Fahrenheit. Asphalt temperature at the time of compaction should be between 265 and 330 degrees Fahrenheit. We recommend the initial asphalt lift placed directly on the subgrade should be compacted to a minimum of 94 percent of the Marshall density with subsequent asphalt lifts compacted to a minimum of 96 percent of the Marshall density. Please note that recommendations regarding compaction temperature and percentage for a specific pavement design should supersede these recommendations.

All asphaltic concrete mix designs should be submitted to GSI and reviewed to determine if the designs are consistent with the recommendations given in this report. We also recommend a GSI

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representative be present during paving operations to help ensure adherence to project pavement specifications.

5.5.4 General Pavement Considerations

Pavement service life can be significantly reduced if the pavement is constructed on a poor subgrade, if poor surface or subsurface drainage is present, or if the pavement is not maintained properly. We emphasize the importance of preparing the pavement subgrade in accordance with the procedures listed in the previous sections of this report.

Drainage of surface and subsurface water is also a critical component of pavement performance. Wetting of the subgrade soils or base course will cause loss of support strength resulting in premature pavement distress. Surface drainage should be designed to remove all water from paved areas. All curbs, including those surrounding pavement islands, should be backfilled as soon as possible after construction of the pavement. Backfill should be compacted and sloped to prevent water from ponding and infiltrating under the pavement. Regular active maintenance of pavements, which includes filling of cracks and joints, is required to minimize water infiltration and lengthen pavement life.

5.6 Lateral Earth Pressures

If utilized, earth-retaining structures should be designed to withstand lateral earth pressures caused by adjacent soil and applied surcharge loads. The magnitude of the lateral earth pressure will depend on the height of the walls, stiffness of the walls, magnitude of the surcharge loads behind the walls, and the backfill and existing soil conditions behind the walls. Free standing site walls should be designed for an active earth pressure condition. If walls are fixed at the top and cannot move sufficiently to mobilize the shear strength of the soil, we recommend designing for an at-rest earth pressure condition.

Table 5.6-1: Lateral Earth Pressure Coefficients

Soil Type (USCS Symbol)	Wet Unit Weight (pcf)	Drained Friction Angle (Φ')	At Rest (K_o)	Active (K_a)	Passive (K_p)
Lean to Fat Clay (CL, CH)	125	22	0.63	0.45	2.20
Granular Backfill * (SP, SW)	115	32	0.47	0.31	3.25
Granular Backfill* (GP, GW)	125	35	0.43	0.27	3.69

****Values for material compacted in accordance with Section 5.2.5***

The values provided above are empirical and are based on basic testing as well as our experience with similar materials. These values also assume a vertical wall with a horizontal retained surface behind the wall. Lateral earth pressure parameters for granular backfill may be used only if the granular backfill extends upward from the heel of the wall at a slope shallower than 1H:1V. Please contact us if different backfill materials or wall geometries are a consideration for this project.

Alternatively, a geosynthetic wall drain sheet, such as Contech Strip Drain 75 or equivalent and LVC material could be substituted for the granular backfill.

5.7 Surface Drainage and Landscaping

The success of the shallow foundation system and slab-on-grade floor system, and pavement section is contingent upon keeping the moisture content of subgrade soils as constant as possible and not allowing surface drainage to have a path to the subsurface soils. Positive surface drainage away from structures must be maintained throughout the life of the structures. Landscaped areas should be designed and constructed such that irrigation and other surface water will be collected and carried away from foundation elements. Pavements should be sloped or crowned to direct surface water to storm sewer systems or detention/retention ponds.

During construction, temporary grades should be established to prevent runoff from entering excavations or footing trenches. Backfill should be placed as soon as concrete structural strength requirements are met and should be graded to drain away from the building.

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The final grade of the foundation backfill and any overlying pavements should have a positive slope away from foundation walls on all sides. We typically recommend a minimum slope of one inch per foot for the first 5 to 10 feet for uncovered surfaces. However, the slope may be decreased if the ground surface adjacent to foundations is covered with concrete slabs or asphalt pavements. For other areas of the site, we recommend a minimum slope of two percent. Pavements and exterior slabs that abut structures should be carefully sealed against moisture intrusion at the joint. All downspouts and faucets should discharge onto splash blocks that extend at least five feet from the building line or be tied into the storm drain system. Splash blocks should slope away from the foundation walls.

The placement of vegetation and plantings next to the foundation should be minimized. Where landscaping is required, we recommend considering plants and vegetation that require minimal irrigation. Irrigation within ten feet of the foundation should be carefully controlled and minimized.

5.8 Construction Considerations

If construction of the project is to be performed during periods of freezing temperatures, steps should be taken to prevent the soils under floor slabs, footings, or pavements from freezing. In no case should the fill materials, floor slabs, foundations, pavements, or other exterior flat work be placed on frozen or partially frozen materials. Frozen materials should be removed and replaced with a suitable material as described in earlier sections of this report.

Construction performed during periods of high precipitation may result in saturated unstable soils, and caving or sloughing of excavations. Control of soil moisture will be necessary for successful soil compaction, and to maintain soil bearing capacity.

5.9 Construction Observation and Quality Assurance

We recommend that GSI review those portions of the plans and specifications that pertain to foundations and earthwork to evaluate consistency with our findings and recommendations. GSI will provide up to 2 hours of engineering support services at no charge to review project documents for adherence to our recommendations.

Site grading, including proof-rolling, replacement or recompaction of material, and placement of fill and backfill, should be observed by a quality assurance technician from GSI under the direction of a

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registered professional engineer. The technician should perform density tests and make any other observations necessary to assure that the requirements of the specifications are being achieved.

It is the opinion of GSI that construction observation by the geotechnical engineer of record or his designated representative is necessary to complete the design process. Field observation services are viewed as essential and a continuation of the design process. Unless these services are provided by GSI, the geotechnical engineer will not be responsible for improper use of our recommendations or failure by others to recognize conditions which may be detrimental to the successful completion of the project.

GSI will be available to make field observations and provide consultation services as may be necessary. A written proposal outlining the cost of construction testing services such as soil, concrete, steel and pavement quality assurance can be provided upon request.

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6. CLOSING REMARKS AND LIMITATIONS

This report is presented in broad terms to provide an assessment of the subsurface conditions and their potential effect on the adequate design and economical construction of the proposed structure and pavement. The analyses, conclusions, and recommendations contained in this report are based on the site conditions existing at the time of the exploration, the project layout described herein, and the assumption that the information obtained from our 4 borings is representative of subsurface conditions throughout the site.

Any changes in the design or location of the proposed structure should be assumed to invalidate the conclusions and recommendations given in this report until we have had the opportunity to review the changes and, if necessary, modify our conclusions and recommendations accordingly. If subsurface conditions different from those encountered in the explorations are observed during construction or appear to be present beneath excavations, GSI should be advised at once so that the conditions can be reviewed and recommendations reconsidered where necessary.

If there is a substantial lapse in time between the submission of this report and the start of construction, or if site conditions or the project layout have significantly changed (due to further development of grading plans, natural causes, or construction operations at or adjacent to the site), we recommend that this report be reviewed to determine the applicability of our previous conclusions and recommendations.

Our geotechnical exploration and subsequent recommendations address only the design and construction considerations contained in this report. We make no warranty for the contents of this report, neither expressed nor implied, except that our professional services were performed in accordance with engineering principles and practices generally accepted at this time and location.

The scope of services for this exploration did not include a wetlands evaluation, an environmental assessment, or an investigation for the presence of hazardous or toxic materials in the soil, surface water, groundwater, or air within or adjacent to this site. If contamination is suspected or is a concern, we recommend the scope of this study be expanded to include an environmental assessment.

This report was prepared by the firm of GSI Engineering, LLC (GSI) under the supervision of a professional engineer registered in the State of Missouri. Report preparation was in accordance with

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generally accepted geotechnical engineering practices for the exclusive use of our client for evaluating the design of the project as it relates to the geotechnical aspects discussed herein. Recommendations are based on the applicable standards of the profession at the time of this report within this geographic area. GSI Engineering, LLC will not be responsible for misrepresentation of this report resulting from partial reproduction or paraphrasing of its contents.

We appreciate the opportunity to be of service on this project. Please contact us if we can provide further information regarding the contents of this report or the scope and cost of additional services.

Respectfully submitted,
GSI Engineering, LLC

K. Erik Troy, P.E.
Senior Geotechnical Engineer

Matthew N. Tye, P.E.
Senior Geotechnical Engineer

KET/MNT

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APPENDIX A

General Vicinity Map
Boring Location Plan

FIG. #: 1	PROJ. #: 2073104
DATE: 07/19/2021	SCALE: NOT TO SCALE
DRAWN BY: KET	PROJECT MANAGER: KET

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GENERAL VICINITY MAP
DUTCH BROTHERS COFFEE
LEE'S SUMMIT, MISSOURI

FIG. #: 2	PROJ. #: 2073104	GSI Engineering	GSI Engineering, LLC 6208 Richards Drive Shawnee, Kansas 66216 (913) 496-2360 www.gsinetwork.com
DATE: 07/22/21	SCALE: NTS		
DRAWN BY: KET	PROJECT MANAGER: KET		

BORING LOCATION PLAN
DUTCH BROTHERS COFFEE
LEE'S SUMMIT, MISSOURI

APPENDIX B

Boring Logs
Key to Symbols
Legend & Nomenclature
Unified Soil Classification System (USCS)
Rock Descriptors

BORING LOG No. B-1

BORING NO.	LOCATION OF BORING	ELEVATION	DATUM	DRILLER	LOGGER
B-1	See Attached Boring Location Plan	1006.3	USGS Datum	P. Pulkrabek	C. Parker

WATER LEVEL OBSERVATIONS				TYPE OF SURFACE	DRILL RIG
WHILE DRILLING	END OF DRILLING	24 HOURS AFTER DRILLING	AFTER DRILLING	Grass field	CME-75
				DRILLING METHOD	TOTAL DEPTH
N.E.	N.E.	Boring backfilled After Drilling		6-inch Diameter Continuous Flight Auger	15.0 ft.

DEP. FT.	SAMPLE DATA: SAMPLE NO. & TYPE	"N" BLOWS (FT)	% REC.	SOIL DESCRIPTION: COLOR, CONSISTENCY, MOISTURE / GEOLOGIC DESCRIPTION & OTHER REMARKS	USCS CLASS.	LABORATORY DATA: MC %	Dry Dens. pcf	q_u ksf	ELEV. FT.
				0.5'					
	S-1	6		LEAN CLAY, red brown and light gray, moist, medium stiff LL=49, PL=26, PI=23	CL	27.7			
	U-2	N.A.		-stiff, else as above		27.7	101.2	3.63	
5									1001.3
				5.5'					
	S-3	17		SHALE, yellow brown and light gray, decomposed, very soft rock, moist		21.1			
10	S-4	37		-very highly weathered, else as above		17.8			996.3
15	S-5	55		-olive gray, highly weathered, soft rock		14.9			991.3
				15.0' Bottom of Boring @ 15'					
20									986.3
25									981.3
30									976.3
35									971.3
40									966.3

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LOCATION: Lee's Summit, Missouri
JOB NO.: 2173104
DATE: July 19, 2021

BORING LOG No. B-2

BORING NO.	LOCATION OF BORING	ELEVATION	DATUM	DRILLER	LOGGER
B-2	See Attached Boring Location Plan	1005.2	USGS Datum	P. Pulkrabek	C. Parker

WATER LEVEL OBSERVATIONS				TYPE OF SURFACE	DRILL RIG
WHILE DRILLING	END OF DRILLING	24 HOURS AFTER DRILLING	AFTER DRILLING	Grass field	CME-75
				DRILLING METHOD	TOTAL DEPTH
N.E.	N.E.	Boring Backfilled After Drilling		6-inch Diameter Continuous Flight Auger	15.0 ft.

DEP. FT.	SAMPLE DATA: SAMPLE NO. & TYPE	"N" BLOWS (FT)	% REC.	SOIL DESCRIPTION: COLOR, CONSISTENCY, MOISTURE / GEOLOGIC DESCRIPTION & OTHER REMARKS	USCS CLASS.	LABORATORY DATA: MC %	Dry Dens. pcf	q_u ksf	ELEV. FT.
0.5'	S-1	7		FILL, dark brown lean clay with gravel and roots, moist LL=48, PL=26, PI=22	FILL	29.1			
2.5'	U-2	N.A.		SHALE, yellow brown and light gray, very highly weathered, moist, very soft rock		18.8			
5	S-3	10		-reddish brown and light gray, else as above		25.7			1000.2
10	S-4	16		-as above		21.6			995.2
15	S-5	56		-highly weathered, soft rock,else as above		15.9			990.2
15.0'				Bottom of Boring @ 15'					
20									985.2
25									980.2
30									975.2
35									970.2
40									965.2

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BORING LOG No. B-3

BORING NO.	LOCATION OF BORING	ELEVATION	DATUM	DRILLER	LOGGER
B-3	See Attached Boring Location Plan	1007.2	USGS Datum	P. Pulkrabek	C. Parker

WATER LEVEL OBSERVATIONS				TYPE OF SURFACE	DRILL RIG
WHILE DRILLING	END OF DRILLING	24 HOURS AFTER DRILLING	AFTER DRILLING	Grass field	CME-75
				DRILLING METHOD	TOTAL DEPTH
N.E.	N.E.	Boring Backfilled After Drilling		6-inch Diameter Continuous Flight Auger	15.0 ft.

DEP. FT.	SAMPLE DATA: SAMPLE NO. & TYPE	"N" BLOWS (FT)	% REC.	SOIL DESCRIPTION: COLOR, CONSISTENCY, MOISTURE / GEOLOGIC DESCRIPTION & OTHER REMARKS	USCS CLASS.	LABORATORY DATA: MC %	Dry Dens. pcf	q_u ksf	ELEV. FT.
				0.5'					
	S-1	9		FILL, dark brown lean clay with gravel and roots, moist, stiff	FILL	22.9			
				2.5'					
	U-2	N.A.		LEAN CLAY, yellow brown and light gray, stiff	CL	25.0	99.5	5.29	
5				5.0'					1002.2
	S-3	23		SHALE, yellow brown and light gray, decomposed, very soft rock, moist		19.9			
				-very highly weathered, soft rock, else as above					
10	S-4	55				15.4			997.2
				-gray, highly weathered, moderately hard rock, moist					
15	S-5	86/11"		15.0'		13.5			992.2
				Bottom of Boring @ 15'					
20									987.2
25									982.2
30									977.2
35									972.2
40									967.2

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DATE: July 19, 2021

BORING LOG No. B-4

BORING NO.	LOCATION OF BORING	ELEVATION	DATUM	DRILLER	LOGGER
B-4	See Attached Boring Location Plan	1005.5		P. Pulkrabek	C. Parker

WATER LEVEL OBSERVATIONS				TYPE OF SURFACE	DRILL RIG
WHILE DRILLING	END OF DRILLING	24 HOURS AFTER DRILLING	AFTER DRILLING	Grass field	CME-75
				DRILLING METHOD	TOTAL DEPTH
N.E.	N.E.	Boring Backfilled After Drilling		6-inch Diameter Continuous Flight Auger	15.0 ft.

DEP. FT.	SAMPLE DATA: SAMPLE NO. & TYPE	"N" BLOWS (FT)	% REC.	SOIL DESCRIPTION: COLOR, CONSISTENCY, MOISTURE / GEOLOGIC DESCRIPTION & OTHER REMARKS	USCS CLASS.	LABORATORY DATA: MC %	Dry Dens. pcf	q_u ksf	ELEV. FT.
				0.5'					
	S-1	9		LEAN CLAY, red brown and light gray, moist, stiff	CL	22.0			
	U-2	N.A.		-as above		25.0	101.0	1.21	
5				5.5'					1000.5
	S-3	17		SHALE, yellow brown and light gray, decomposed, very soft rock, moist		21.1			
10	S-4	37		-very highly weathered, else as above		17.8			995.5
15	S-5	55		-olive gray, highly weathered, soft rock, moist		14.9			990.5
				15.0' Bottom of Boring @ 15'					
20									985.5
25									980.5
30									975.5
35									970.5
40									965.5

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PROJECT: Dutch Brothers Coffee
LOCATION: Lee's Summit, Missouri
JOB NO.: 2173104
DATE: July 19, 2021

KEY TO SYMBOLS

Symbol Description

Strata symbols

Symbol	Description
	Low plasticity clay
	Shale
	Fill

Notes:

1. Exploratory borings were drilled on July 19, 2021 using a CME-75 drill rig equipped with 6.0-inch diameter continuous flight augers.
2. Free water was not encountered enduring drilling or sampling.
3. Boring locations were located with a handheld GPS unit and elevations interpolated from the site grading plan
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.

Boring Log
Legend and Nomenclature

Items shown on boring logs refer to the following:

1. **Depth** - Depth below ground surface or drilling platform

2. **Sample** -Types designated by letter:

   A - Disturbed sample, obtained from auger cuttings or wash water.

   S - Split barrel sample, obtained by driving a 2-inch split-barrel sampler unless otherwise noted.

   C - California liner sample, obtained using a thick-walled liner sampler containing 2-inch-diameter liner tubes.

   U - Undisturbed sample, obtained using a thin-walled tube, 3-inch-diameter, or as noted, and open sampling head.

   Recovery - Recovery is expressed as a percentage of the length recovered to the total length pushed, driven or cored.

   Resistance - Resistance is designated as follows:

   P - Sample pushed in one continuous movement by hydraulic rig action.

   12 - The Standard Penetration Resistance is the number of blows for the last 12 inches of penetration of split spoon sampler, driven by a 140-pound hammer falling 30 inches.

   50/4" - Number of blows to drive sampler distance shown.

3. **Soil Description** - Description of material according to the Unified Soil Classification: word description giving soil constituents, consistency or density, and other appropriate classification characteristics. Geologic name or type of deposit and other pertinent information, where appropriate, is shown under Geologic Description or other Remarks. A solid line indicates the approximate location of stratigraphic change.

4. **Lab Data** – Laboratory test data.

5. **Legend**

A.D.	—	After drilling	N.A.	—	Not Applicable
A.T.D.	—	At time of drilling	N.D.	—	Not detectable due to drilling method
C.F.A.	—	Continuous flight auger			
D.W.L.	—	Drill water loss	N.E.	—	None encountered
D.W.R.	—	Drill water return	N.R.	—	Not recorded
E.D.	—	End of drilling	R.Q.D.	—	Rock quality designation
H.B.	—	Hole backfilled	R.W.B.	—	Rotary wash boring

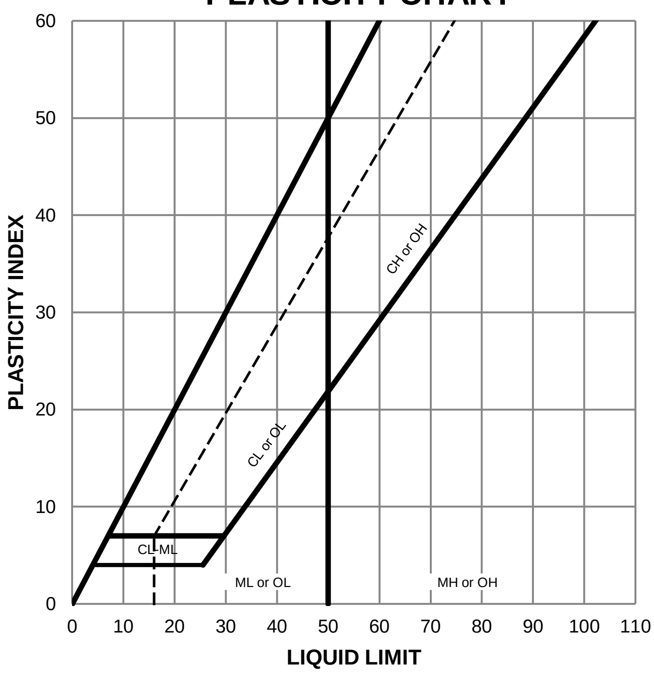
6. **Limitations** - The lines between materials shown on the boring logs represent approximate boundaries between material types and the changes may be gradual. Water level readings shown on the logs were made at the time and under the conditions indicated. Fluctuations in the water levels may occur with time. The boring logs in this report are subject to the limitations, explanations and conclusions of this report.

UNIFIED SOIL CLASSIFICATION SYSTEM

GROUP NAME	GROUP SYMBOL	SOIL DESCRIPTION	COMMENTS
Peat	Pt	Highly Organic Soils	50% or More Is Smaller than No. 200 Sieve
Fat Clay	CH	Clay - Liquid Limit => 50*	
Elastic Silt	MH	Silt - Liquid Limit => 50*	
Lean Clay	CL	Clay - Liquid Limit < 50*	
Silt	ML	Silt - Liquid Limit < 50*	
Silty Clay	CL-ML	Silty Clay*	
Clayey Sand	SC	Sands with 12 to 50% Smaller than No. 200 Sieve	More than 50% Is Larger than No. 200 Sieve and % Sand > % Gravel
Silty Sand	SM		
Poorly-Graded Sand with Clay	SP-SC	Sands with 5 to 12% Smaller than No. 200 Sieve	
Poorly-Graded Sand with Silt	SP-SM		
Well-Graded Sand with Clay**	SW-SC		
Well-Graded Sand with Silt**	SW-SM		
Poorly-Graded Sand	SP	Sands with Less than 5% Smaller than No. 200 Sieve	
Well-Graded Sand**	SW		
Clayey Gravel	GC	Gravels with 12 to 50% Smaller than No. 200 Sieve	More than 50% Is Larger than No. 200 Sieve and % Gravel > % Sand
Silty Gravel	GM		
Poorly-Graded Gravel with Clay	GP-GC	Gravels with 5 to 12% Smaller than No. 200 Sieve	
Poorly-Graded Gravel with Silt	GP-GM		
Well-Graded Gravel with Clay**	GW-GC		
Well-Graded Gravel with Silt**	GW-GP		
Poorly-Graded Gravel	GP	Gravels with Less than 5% Smaller than No. 200 Sieve	
Well-Graded Gravel**	GW		

*See Plasticity Chart for definition of silts and clays. If organic, use OL or OH.
**See definition of well-graded

PLASTICITY CHART



LEGEND OF TERMS

MOISTURE CONDITIONS
Dry, Slightly Moist, Moist, Very Moist, Wet (Saturated)

SOIL CONSISTENCY

Fine-Grained Soils

Description	SPT (N)	UCS (q_u, tsf)
Very Soft	0-2	0-0.25
Soft	2-4	0.25-0.50
Medium Stiff	4-8	0.50-1.0
Stiff	8-16	1.0-2.0
Very Stiff	16-32	2.0-4.0
Hard	>32	>4.0

Coarse-Grained Soils

Description	SPT (N)
Very Loose	0-4
Loose	4-10
Medium Dense	10-30
Dense	30-50
Very Dense	>50

CLASSIFICATION OF SANDS & GRAVELS

Boulders	Cobbles	Coarse Gravel	Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Fines (Silt or Clay)
10"	3"	3/4"	#4	#10	#40	#200	

Well-Graded Sands (SW): $C_u \geq 6$ and $1 \leq C_c \leq 3$

Well-Graded Gravels (GW): $C_u \geq 4$ and $1 \leq C_c \leq 3$

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ROCK DESCRIPTORS

DEGREE OF WEATHERING

Descriptor	Definition
Unweathered	No evidence of any chemical or mechanical alteration
Slightly Weathered	Slight discoloration on surface, slight alteration along discontinuities, less than 10% of the rock volume atlered
Moderately Weathered	Discoloring evident, surface pitted and altered with alteration penetrating well below rock surfaces, weathering "halos" evident, 10% to 50% of the rock altered
Highly Weathered	Entire mass discolored, alteration pervading nearly all of the rock with some pockets of slightly weathered rock noticeable, some minerals leached away
Decomposed	Rock reduced to a soil with relict rock texture, generally molded and crumbled by hand

HARDNESS

Descriptor	Definition
Very Soft	Can be deformed by hand
Soft	Can be scratched with a fingernail
Moderately Hard	Can be scratched easily with a knife
Hard	Can be scratched with difficulty with a knife
Very Hard	Cannot be scratched with a knife

TEXTURE*

Texture	Grain Diameter	Particle Name	Rock Name
*	80 mm	Cobble	Conglomerate
*	5 - 80 mm	Gravel	
Coarse Grained	2 - 5 mm		
Medium Grained	0.4 - 2 mm	Sand	Sandstone
Fine Grained	0.1 - 0.4 mm		
Very Fine Grained	0.1 mm	Clay, silt	Shale, Claystone, Siltstone

* Sedimentary Rocks

ROCK STRUCTURE

Descriptor	Definition
Massive	3 feet thick or greater
Thick Bedded	Beds from 1 foot to 3 feet thick
Medium Bedded	Beds from 4 in. to 1 foot thick
Thin Bedded	4 inches thick or less

DISCONTINUITIES

Joints

1.) Type: Type of joint if it can be readily determined (i.e., bedding, cleavage, foliation, schistosity, or extension.)

2.) Degree of joint wall weathering:

(i) Unweathered: No visible signs are noted of weathering; joint wall rock is fresh, crystal bright.

(ii) Slightly weathered joints: Discontinuities are stained or discolored and may contain a thin coating of altered material. Discoloration may extend into the rock from the discontinuity surfaces to a distance of up to 20% of the discontinuity spacing.

(iii) Moderately weathered joints: Slight discoloration extends from discontinuity planes for greater than 20% of the discontinuity spacing. Discontinuities may contain filling of altered material. Partial opening of grain bounderies may be observed.

(iv) Highly weathered joints: Entire mass discolored, alteration pervading nearly all of the rock with some pockets of slightly weathered rock noticeable, some minerals leached away.

(v) Completely weathered joints: Rock reduced to a soil with relicit rock texture, generally molded and crumbled by hand.

From EM 1110-1-2908

APPENDIX C

Field & Laboratory Test Results

SUMMARY OF FIELD AND LABORATORY TESTS

BORING NO.	SAMPLE NO.	SAMPLE DEPTH (ft.)	DIA. (in.)	MOISTURE CONTENT (%)	UNIT WEIGHT WET (pcf)	UNIT WEIGHT DRY (pcf)	VOID RATIO (e)	SAT. (%)	UNCONF. COMPR. STR. (ksf)	ATTERBERG LIMITS LL	ATTERBERG LIMITS PL	ATTERBERG LIMITS PI	PASS NO. 200 (%)	SPT "N" (blows /ft)	USCS SOIL CLASS.
B-1	S-1	0.5-2.0		27.7						49	26	23		6	CL
	U-2	2.5-4.5	2.83	27.7	129.2	101.2	0.634	100	3.63					NA	CL
	S-3	5.0-6.5		21.1										17	SHALE
	S-4	8.5-10.0		17.8										37	SHALE
	S-5	13.5-15.0		14.9										55	SHALE
B-2	S-1	0.5-2.0		29.1						48	26	22		7	FILL
	U-2	2.5-4.5		18.8										NA	SHALE
	S-3	5.0-6.5		25.7										10	SHALE
	S-4	8.5-10.0		21.6										16	SHALE
	S-5	13.5-15.0		15.9										56	SHALE
B-3	S-1	0.5-2.0		22.9										9	FILL
	U-2	2.5-4.5	2.86	25.0	124.4	99.5	0.662	100	5.29					NA	CL
	S-3	5.0-6.5		19.9										23	SHALE
	S-4	8.5-10.0		15.4										55	SHALE
	S-5	13.5-15.0		13.5										86/11"	SHALE
B-4	S-1	0.5-2.0		22.0										9	CL
	U-2	2.5-4.5	2.85	25.0	126.3	101.0	0.637	100	1.21					NA	CL
	S-3	5.0-6.5		25.4										8	SHALE
	S-4	8.5-10.0		19.3										13	SHALE
	S-5	13.5-15.0		18.3										39	SHALE

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PROJECT
Dutch Brothers Coffee

LOCATION
Lee's Summit, Missouri

PROJECT NUMBER 2173104

DATE July 22,2021