CFS ENGINEERS

GEOTECHNICAL EXPLORATION AND SUBGRADE RECOMMENDATIONS

LEE'S SUMMIT WEST HIGH SCHOOL ROBOTICS BUIDLING

Lee's Summit, Missouri

CFS Project No. 22-5547

Prepared For

Lee's Summit R7 District
901 NE Douglas Street
Lee's Summit, Missouri 64086

July 28, 2022

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One Vision. One Team. One Call.

SYNOPSIS

A subsurface exploration and an evaluation were performed at the planned Lee's Summit West High School Robotics Building project site located in Lee's Summit, Missouri to provide geotechnical engineering related recommendations for design and construction of the proposed project.

Exploratory soil borings have been drilled and a laboratory testing program was conducted on selected soil samples. The data has been analyzed based upon the project information provided by the project team.

The results of the exploration and analysis indicate that conventional spread and continuous wall footings appear to be a suitable foundation system for support of the proposed structure. Please note, CFS anticipates some limestone bedrock excavation will be necessary in the southeast building corner to achieve a uniform bearing condition on shale bedrock. This may require the use of breakers which can increase the cost of excavation.

Detailed analysis of subsurface conditions, any alternate foundation types, and pertinent design recommendations are included, herein.

Groundwater conditions are not expected to cause any major difficulties. These conditions will be further discussed in the report. Please note, groundwater levels should be expected to fluctuate based on seasonal changes and precipitation events.

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LEE'S SUMMIT WEST HIGH SCHOOL ROBOTICS BUILDING
LEE'S SUMMIT, MISSOURI

Project Number: 22-5547
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1 INTRODUCTION

1.1 PURPOSE

The purpose of this geotechnical exploration was to evaluate the underlying materials at the proposed Lee's Summit West High School Robotics Building project site, and based upon this information, provide geotechnical engineering related recommendations for design and construction of the planned project. This exploration was performed in accordance with the requirements outlined by the project team and the Lee's Summit R-7 School district's request for proposal (RFP) number R19/20-04 titled "Geotechnical 7 Construction Testing Services" and dated March 17, 2020.

This report includes geotechnical recommendations and considerations pertaining to site development, foundation support, and concrete slab on grade construction. Also, included in this report are earthwork, construction and drainage considerations associated with the proposed project.

1.2 SCOPE OF SERVICES

This exploration and analysis included an engineering reconnaissance of the planned site, a subsurface exploration as outlined below, a field and laboratory testing program, and an engineering analysis and evaluation of the subsurface materials.

The scope of services did not include any environmental assessment for wetlands or hazardous materials in the soil, surface water, groundwater, air or surrounding area. Any statement in this report or on the boring logs regarding odors, colors or unusual or suspicious items is strictly for the information of the client.

1.3 GENERAL

The general subsurface conditions used in this analysis are based upon an interpolation of the subsurface data between the borings; varying conditions may be encountered between boring locations. If deviations from the noted subsurface conditions are encountered during construction, they should be brought to the attention of the Geotechnical Engineer.

The recommendations submitted for the proposed structure are based on the available soil information and the preliminary design details. Any revision in the plans for the proposed structure from those described in this report should be brought to the attention of the Geotechnical Engineer to determine if changes in the foundation recommendations are required.

The Geotechnical Engineer warrants that the findings, recommendations, specifications, and professional advice contained, herein, have been presented after being prepared in accordance with generally accepted professional engineering practice in the fields of foundation engineering, soil mechanics and engineering geology. No other warranties are implied or expressed.

After the plans and specifications are complete, it is recommended that the Geotechnical Engineer be provided the opportunity to review the final design and specifications, in order to verify that the earthwork and foundation recommendations are properly interpreted and implemented.

2 PROJECT DESCRIPTION

It is understood that the planned project comprises the new construction of a robotics and GiC facility on the southeast side of the existing Lee's Summit West High School. This facility will consist of three (3) individual structures, all independent of each other and the existing high school. CFS understands they will be single story buildings with concrete slab on grade construction. The proposed finish floor elevations were not available at the time of this report, however, CFS anticipates they will be similar to that of the existing grade. Foundation loads are expected to be on the order of 100 kips for column footings and two (2) to three (3) kips per linear foot for continuous wall footings.

CFS anticipates minimal cut and fill, less than three (3) feet plus or minus, will be necessary to achieve the desired construction grade. If any changes to the project occur, please notify CFS to allow for review of these changes and, if necessary, amend this report.

2.1 SITE LOCATION & SURFACE CONDITIONS

Lee's Summit West High School is located at 2800 SW Ward Road in Lee's Summit, Missouri. The project site is the southeast side of the existing school. It is bound by the existing school to the northwest and north, an open grass area to the east, and drive lanes to the south and west.

The area of the project site adjacent to the existing school is, relatively, level and grass covered. However, the existing grade does slope upward to the east and southeast starting at approximately 65 feet away from the school. Boring B8 encountered a limestone shelf in this slope that resides in the east-most corner of the largest structure. Previously, two (2) classroom trailers were at the project site, as well.

2.2 SITE GEOLOGY

Soils in the greater Kansas City area are generally residual soils, alluvial deposits, or till. Residual soils formed as a result of 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 SUBSURFACE EXPLORATION

Based on the project information as outlined above, CFS Engineers conducted a field exploration to determine the underlying materials at the proposed project site and to establish their engineering characteristics.

3.1 SCOPE OF WORK

This geotechnical exploration consisted of eight (8) borings with a planned depth of 20 feet beneath existing site grade within the footprint of the planned structure. The borings were drilled to their refusal on shale or limestone bedrock. The boring locations can be seen on the Boring Location Plan which is included in Appendix A.

The boring locations were determined in the field using measurements from existing landmarks and should be considered accurate only to the degree implied. The locations were established by Cook, Flatt & Strobel Engineers.

Boring logs representing the materials encountered in the borings are included in Appendix B. The boring logs represent CFS Engineers' interpretation of the field logs combined with laboratory observations and testing of the samples. The stratification boundaries indicated on the boring logs were based on field observations, an extrapolation of information obtained by examining samples from the borings, and comparisons of soils and/or bedrock types with similar engineering characteristic. As such, the boundaries between subsurface strata should be expected to vary from the logs to some extent.

The depth to groundwater, if encountered, was recorded in each test boring during drilling and can be seen in Section 3.5, Groundwater Conditions. After completion of drilling, sampling, and field testing, the excavations were backfilled with auger cuttings.

3.2 DRILLING AND SAMPLING PROCEDURES

The auger borings were drilled using a truck mounted Dietrich D50 drill rig with a rotary head. 3.25-inch solid-stem augers were used to drill the holes. During drilling, field logs were created and maintained by CFS personnel to catalog the materials encountered.

Representative samples were obtained during drilling using split-barrel sampling procedures in general accordance with the procedures for "Standard Test Methods for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils" (ASTM D 1586).

Upon completion of drilling, the samples were then sealed and returned to CFS's laboratory for further examination, classification, and testing. The samples recovered were identified, classified, and evaluated by a Geotechnical Engineer.

3.3 FIELD TESTS AND MEASUREMENTS

During the soil boring procedure, Standard Penetration Tests (SPT) were performed at pre-determined intervals to obtain the standard penetration value of the soil as outlined in the ASTM D1586 test method. The standard penetration value (N) is defined as the number of blows of a 140-pound hammer falling 30 inches, required to advance the split-barrel sampler one foot into the soil. The sampler is lowered to the bottom of the previously cleaned drill hole and advanced by blows from the hammer.

The number of blows is recorded for each of three successive increments of six inches penetration. The "N" value is then obtained by adding the second and third incremental numbers. The results of the standard penetration test are shown on the Boring Logs and indicate the relative density of cohesionless soils and comparative consistency of cohesive soils, and thereby provide a basis for estimating the relative strength and compressibility of the soil profile components.

The Standard Penetration Test (SPT) was also used to evaluate the consistency of the in-situ materials. The N-values for the site's materials were found to range from nine (9) to 50+ blows/foot.

3.4 Subsurface Conditions

The materials encountered in the test borings have been visually classified according to the Unified Soil Classification System (USCS). Specific subsurface conditions encountered—including field tests, lab tests, and water level observations—at the boring locations are also presented on the individual boring logs found in Appendix B of this report. The following table presents a general summary of the major strata encountered during this subsurface exploration.

T*able 1: General Subsurface Conditions*

STRATUM	MATERIAL	DEPTH TO TOP OF STRATUM (FT)	DEPTH TO BOTTOM OF STRATUM (FT)	MEASURED N-VALUES	COMMENTS
1	TOPSOIL	0.0	0.5	NA	Dark brown with roots. Grass at surface
2	LIMESTONE	2.0	4.5	50+	Encountered in boring B8 which was about 3 feet higher in elevation than the surrounding borings.
3	SHALE	0.5	BOTTOM	9 to 50+	Gray and moderately weathered to unweathered.
Note: the boundaries between subsurface strata should be expected to vary from this table and the logs to some extent.					

3.5 Groundwater Conditions

Groundwater was not encountered in the borings at the time of the investigation. Please note, the reported groundwater levels reflect the conditions observed at the time the borings were drilled. Groundwater levels should be expected to fluctuate with changes in grading, precipitation changes and seasonal changes. The water levels included in this report do not indicate a permanent groundwater condition. Additionally, the materials encountered during this exploration are, generally, low permeable soils.

4 LABORATORY TESTING

Upon completion of drilling, the samples were returned to CFS's laboratory located in Kansas City, Kansas for laboratory testing. A supplemental laboratory testing program was conducted to evaluate additional engineering characteristics of the in-situ soils necessary in analyzing the behavior of the support systems for the proposed building.

The laboratory testing program included the following tests:

- Supplementary visual classification (ASTM D2488) of all samples,
- Water content (ASTM D2216) of all samples, and
- Atterberg limit tests (ASTM D4318) on a selected sample.

The results of the laboratory testing program can be seen in on the boring logs in Appendix B. The Atterberg limits can be seen in the following table.

Table 2: Atterberg Limits Results

Boring ID	Sample #	Moisture Content (%)	Atterberg Limits			USCS Classification
			Liquid Limit	Plastic limit	Plasticity Index	
B6	SPT-1	14	43	23	20	SHALE

5 GEOTECHNICAL CONCERNS

The following geotechnical concerns are based upon the subsurface materials encountered during this exploration and CFS's understanding of the project as described in Section 2, "Project Description" of this report. If any changes to the planned structure's location, loading or elevations occur, CFS must be allowed to review these changes, and if necessary, issue amendments to this report and its recommendations.

1. *Bedrock Excavation*: Shallow shale bedrock was encountered at a depth of approximately one (1) foot beneath existing grade across the majority of the project site. CFS anticipates approximately three (3) to five (5) feet of shale excavation may be necessary for foundation and utility excavations. Additionally, please note that Boring B8 encountered a limestone shelf in the slope that resides in the east-most corner of the largest structure. CFS anticipates this slope will be cut down approximately three (3) feet to achieve the desired construction grade, thus some limestone excavation will be necessary in this area. Also, to achieve a uniform bearing condition, the planned foundations in this corner will need to penetrate the limestone and bear on the underlying shale bedrock encountered in the other borings. Shale and limestone excavation may require the use of hydraulic breakers which generally increases the cost of excavation.

2. *Possible Perched Water*: Although groundwater was not encountered during this exploration, it is common for perched water to travel along restrictive bedrock layers such as the limestone bedrock encountered in the slope at the eastmost corner of the project site. Additionally, please note that

this exploration occurred during the dry season. Depending on the time of construction, the contractor should plan for water seepage out of this slope once the limestone is excavated.

3. *Expansive Clay Soils*: Expansive shales were encountered during this exploration. The on-site materials are NOT suitable for direct support of concrete slabs and concrete/foundation wall backfill. It is recommended that all walls be backfilled with open graded stone (such as No. 57 as referenced in ASTM C33) extending two (2) feet behind the wall for the entire height of the wall to within 12-inches of the surface to allow for proper drainage and relief of any hydrostatic pressure build-ups that may occur in the native fat clay. All slabs on grade should be supported by a minimum 24-in-thick mat of low volume change material (LVC) constructed in accordance with Section 7.3, "Slab on Grade Recommendations" of this report.

6 EARTHWORK & SITE DEVELOPMENT

6.1 SITE PREPARATION

Prior to filling, the grass and topsoil should be stripped from all structural areas and be stockpiled for later use in landscape areas, or it should be wasted. Any trees and shrubs should be properly removed including the entirety of the root ball and root systems. The upper 12-inches of the subgrade should be moisture conditioned and recompacted, as necessary, to provide a stable subgrade upon which to begin placement of engineered fill.

Upon completion of stripping and prior to filling, the newly exposed subgrade should be evaluated by a qualified professional for stability by means of proof rolling. The proof roll should be conducted using a fully loaded, tandem axle dump truck weighing in excess of 25 tons. Any soft or unsuitable areas identified during the proof roll should be corrected by means of additional moisture conditioning and recompacting, or removal and replacement with an acceptable material.

Additionally, any undocumented fill encountered during construction should be completely removed from beneath the planned foundations. Please note, the fill encountered during this exploration was at the surface and CFS anticipates foundations will naturally penetrate this material. Undocumented fill is any foreign material that was placed or dumped in an uncontrolled manner (i.e. no records of testing exist from the time of placement). Undocumented fill is inconsistent and unpredictable in nature, and it should not be used in support of any foundation systems. Undocumented fill is permitted beneath non load bearing floor slabs given it is thoroughly evaluated by CFS during construction by means of a proof roll outlined above.

6.2 FILL MATERIALS

All general and structural fill should be free of debris and defined by ASTM 2487 as CH, CL, ML, GW, GP, SM, SW, SC, and SP. The onsite soils tend to meet this requirement; however, please note that CH (fat clay) classification materials should NOT be used as structural fill within two (2) feet of the finished grade supporting the building slab and within ten (10) feet laterally outside of the building footprint. Fat clays (CH) with Liquid Limits of greater than 55 should not be used in the upper one (1) foot beneath the pavement without being treated with cement as outlined later in this report.

The on-site topsoil contains organic material and is unsuitable for use as structural fill. Unsuitable materials are those defined by ASTM 2487 as MH, OL, OH, and PT.

6.3 Engineered Fill Placement

For the purpose of this report, engineered fill means fill placed in controlled layers and compacted and tested according to accepted geotechnical engineering practices to ensure that it meets the required specifications. Structural fill refers to any engineered fill placed within the footprint of the planned structures. Engineered fill materials should be free of organic matter. During placement, engineered fill materials should be within the specified moisture contents and compacted to the specified densities given below in Tables two (2) and three (3). Maximum dry density and optimum moisture content should be determined by the Standard Proctor test (ASTM D 698).

Fill should be placed in six (6) inch lifts (compacted thickness) in mass fill areas, and as needed to obtain the proper compaction in utility trenches and behind walls. Structural fill should extend a minimum of two (2) feet beyond any structure lines. *Additionally, where slopes exist, engineered fill must be properly benched into the existing materials.*

Table 3: Recommended Moisture Ranges

ENGINEERED FILL MATERIAL	MAXIMUM BELOW OPTIMUM	MAXIMUM ABOVE OPTIMUM
Lean Clay (CL)	-2%	+3%
Fat Clay (CH)	0%	+4%
Compacted Base Rock (i.e. MODOT Type 5, AB3 or equivalent)	NA	NA

Table 4: Compaction Requirements & Testing Frequency

LOCATION OR AREA	REQUIED COMPACTION (%) (ASTM D 698, DRY DENSITY)	TESTING FREQUENCY 3 PER LIFT PER …
Building Walkways	95%	20,000 sf
Retaining Walls	95%	1,000 sf
Trenches	95%	150 lf
Lawn or Unimproved Areas	92%	20,000 sf
Structural Fill (i.e., building and pavement subgrades)	95%	10,000 sf
Out-Parcels	95%	20,000 sf

A representative of the Geotechnical Engineer should monitor filling operations on a full-time basis. A sufficient number of density tests should be taken to verify that the specified compaction is obtained. See Table 3 above for required testing frequency.

6.4 Excavations & Trenches

All temporary slopes and excavations should conform to Occupational Safety and Health Administration (OSHA) Standards for the Construction Industry (29 CFR Part 1926, Subpart P). Excavations at this site are *expected* to be made in "Type B" clayey soil. Soil types should be verified in the field by a competent individual.

All excavations should be kept dry during subgrade preparation. Storm water runoff should be controlled and removed to prevent severe erosion of the subgrade and eliminate free standing water. Subgrade that has been rendered unsuitable from erosion or excessive wetting should be removed and replaced with controlled fill. Excavations through the very hard limestone and shale bedrocks will likely be necessary. The Boring Logs (Appendix B) and the Boring Location Plan (Figure 2, Appendix A) should be consulted in estimating the amount of rock to be excavated.

Trenches should be excavated so that pipes and culverts can be laid straight at uniform grade between the terminal elevations. Trench width should provide adequate working space and sidewall clearances. Trench subgrade should be removed and replaced with controlled fill if found to be wet, soft, loose, or frozen. Trench sub-grades should be compacted above 95% of the maximum dry density in accordance with ASTM D 698 at moisture contents between -3% to +3% of the optimum moisture content.

Granular bedding materials for pipes, such as well-graded sand or gravel, may be used provided that the bottom of the trench is graded so that water flows away from the structure.

Bedding material should be graded to provide a continuous support beneath all points of the pipe and joints. Embedment material should be deposited and compacted uniformly and simultaneous on each side of the pipe to prevent lateral displacement. Compacted control fill material will be required for the full depth of the trench above the embedment material except in area landscape area with the compaction may be reduced to 90% Standard Proctor ASTM D 698. No backfill should be deposited or compacted in standing water.

Permanent slopes greater than 3 horizontals to 1 vertical should not be used unless additional testing and slope analysis is performed.

6.5 Drainage and Dewatering

Normal seasonal weather conditions should be anticipated and planned for during earthwork. It is recommended that the Contractor determine the actual groundwater levels at the site at the time of the construction activities to assess the impact groundwater may have on construction. Water should not be allowed to collect in the foundation excavation, on floor slab areas, or on prepared subgrades of the construction area either during or after construction. Undercut or excavated areas should be sloped toward one corner to facilitate removal of collected rainwater, groundwater, or surface runoff. Positive site drainage should be provided to reduce infiltration of surface water around the perimeter of the building and beneath the floor slabs. The grades should be sloped away from the building and surface drainage should be collected and discharged such that water is not permitted to infiltrate the backfill and floor slab areas of the building.

The site should be graded such that positive drainage (normally 2% minimum) is provided away from any structures. Where sidewalks or paving do not immediately adjoin the building, protective slopes of at least 5% for a minimum of 10 feet from the perimeter walls are recommended. Roof drains and downpours should also be directed away from the building. Open-graded stone is not recommended for use under sidewalks unless the stone is adequately drained to prevent collection of water under the walks.

The site should also be graded to avoid water flows, concentrations, or pools behind retaining walls, curbs or similar structures. When swales are designed at the top of the walls, proper line and slope should be considered to avoid any flow down behind walls. Special attention is needed for sources of storm water from slopes, building roofs, gutter downspouts and paved areas draining to one point.

Perforated plastic pipes should be placed on the backfilled side of the walls near the bottom and day-lighted. Six inches of open graded crushed rock wrapped with geo-textile fabric should be placed behind the walls up to a depth of two feet below the finished grade. As an alternative to the open graded crushed rock, a manufactured geo-composite sheet drain such as Mirafi G100N, Contech C-Drain, or equivalent, may be used in conjunction with the perforated pipe.

6.6 LANDSCAPING

Landscaping and irrigation should be limited adjacent to buildings and pavements to reduce the potential for large moisture changes. Trees and large bushes can develop intricate root systems that can draw moisture from the subgrade, resulting in shrinkage of the bearing material during dry periods of the year. Desiccation of bearing material below foundations may result in foundation settlement.

Landscaped areas near pavements and sidewalks should include a drainage system that prevents over saturation of the subgrade beneath asphalt and concrete surfaces. Drainage systems in irrigation areas should be incorporated into the storm drain system.

7 GEOTECHNICAL ENGINEERING RECOMMENDATIONS

7.1 FOUNDATIONS RECOMMENDATIONS

Conventional spread and continuous wall footings are, generally, most economical when the existing soil conditions allow them to be founded at shallow depths on existing materials. Based on the materials encountered during this exploration, it is CFS Engineers' opinion that the planned structure can be supported by a shallow foundation system, such as spread and/or trench footings bearing in shale bedrock.

Please note, shale and limestone bedrock excavation is anticipated which may require the use of hydraulic breakers. Additionally, some over excavation of limestone bedrock may be necessary in the eastmost corner of the larger building to achieve a uniform bearing condition on shale bedrock. CFS does not anticipated over excavation to exceed three (3) feet. Please reference the following table for recommended design parameters.

Table 5: Shallow Foundation Design Parameters

DESIGN PARAMETER	RECOMMENDED VALUE	COMMENTS
Allowable Bearing Capacity (1) (shallow foundations)	3,000 psf	Evaluated based on field and laboratory testing results (1).
Recommended Bearing Material (2)	SHALE	Suitable bearing material required beneath entirety of foundation system (2).
Anticipated Total Settlement	< 1-inch	Maximum
Anticipated Differential Settlement	< ¾ -inch	Maximum per 100 feet of linear footing
Minimum Recommended width	24 and 16 inches	Spread and trench, respectively
Minimum Recommended Depth	36-inches	Based on seasonal freeze-thaw cycles

(1) If over excavation of any footing is required to reach design bearing capacity, backfill of the footing should be done with lean concrete.
(2) A uniform bearing condition should exist beneath the entirety of the foundation system for a given structure. A representative of the Geotechnical Engineer should test the materials in the footing excavations to verify the material and design bearing pressure.

If over excavation of footings becomes necessary to achieve the desired bearing pressure or a uniform bearing condition, backfill of the footing should be done with lean concrete. Footings should be suitably reinforced to reduce the effects of differential movement that may occur due to variations in the properties of the supporting soils. Top and bottom reinforcing steel is recommended for continuous wall footings to reduce differential settlement due to possible varying bearing capacities of the existing fill soils.

Every effort should be made to keep the footing excavations dry as the soils will tend to soften when exposed to free water. Footing bottoms should be free of loose soil and concrete should be placed as soon as possible to prevent drying of the foundation soils.

7.2 SEISMIC ANALYSIS

The determination of the seismic class is based on ASCE Standard 7: Minimum Design Loads for Building and Other Structures. Based upon this information, the seismic properties of the soil were interpolated from the standard penetration test values. A Seismic Site Class "D" was determined for this site. In addition, there is no significant risk of liquefaction or mass movement of the on-site soils due to a seismic event.

7.3 SLAB ON GRADE RECOMMENDATIONS

In its current state, the overburden materials (i.e., Shale) encountered during this exploration are unsuitable for direct support of the planned slab on grade. CFS recommends all concrete slabs on grade be supported by a minimum of 24-inches of Low Volume Change (LVC) material. LVC material should consist of lean clay (CL), KDOT AB3, crushed limestone screenings or equivalent. A low volume change material is defined as a material with a liquid limit less than 45 and a plasticity index less than 25. The subgrade can be constructed as outlined below.

1. Cut the subgrade to a minimum depth of 24-inches beneath the planned bottom of slab elevation. The exposed material at this depth should be moisture conditioned and re-compacted, as necessary, to pass a proof roll as specified in Section 6.1, “Site Preparation” of this report.
2. Twenty (20) inches of a compacted LVC material should be placed atop the exposed slab subgrade. The LVC should be placed in lifts no greater than 8-inches-thick (compacted thickness) and compacted to 95% of the maximum dry density as determined by ASTM 698. Limestone based LVC material should be compacted at a moisture content sufficient to achieve the desired compaction, and lean clay (CL) material should be compacted at a moisture content between 0 and +4% of optimum. Please note, if lean clay is utilized as LVC, CFS recommends it be capped with 6-inches of limestone based LVC to ease construction and protect the subgrade from excessive drying and wetting.
3. A 4-inch-thick layer of open graded stone (ASTM C33 or equivalent material) should be placed atop the 20-inches of compacted LVC material to return the subgrade to the original bottom of slab elevation. The open-graded stone will ease construction and provide a capillary break between the LVC and concrete slab.

Based on the materials encountered, 100 psi/in can be used as a modulus of subgrade reaction (k_s) for fat or lean clay soils. A subgrade reaction modulus value of 150 psi/in can be used for 20-inches of compacted granular fill such as KDOT AB3, MODOT Type 5 or equivalent.

Every floor slab should be evaluated to determine if a vapor retarder under the concrete floor is required. The slab designer should refer to ACI 302 and/or ACI 360 for procedures regarding the use and placement of a vapor retarder.

To reduce the effects of differential movement, slabs-on-grade should not be rigidly connected to columns, walls, or foundations unless it is designed to withstand the additional resultant forces. Floor slabs should not extend beneath exterior doors or over foundation grade beams, unless saw cut at the beam after construction. Expansion joints may be used to allow unrestrained vertical movement of the slabs. The floor slabs should be designed to have an adequate number of joints to reduce cracking resulting from differential movement and shrinkage. CFS suggests joints be provided on a minimum spacing of twelve (12) feet on center. For additional recommendations refer to the ACI Design Manual. The requirements for the slab reinforcement should be established by the designer based on experience and the intended slab use.

7.4 LATERAL EARTH PRESSURES

Lateral earth pressures are determined by multiplying the vertical applied pressure by the appropriate lateral earth pressure coefficient. If the foundation walls are rigidly attached to the building and not free to rotate or deflect at the top, CFS recommends designing the walls for the *at-rest* earth pressure coefficient. Walls that are permitted to rotate and deflect at the top can be designed for the *active* lateral earth pressure condition. Horizontal loads acting on shallow foundations are resisted by friction along the foundation base and by *passive* pressure against the footing face that is perpendicular to the line of applied force.

It is recommended that all walls be backfilled with open graded stone (such as No. 57 as referenced in ASTM C33) extending to two (2) feet behind the wall for the entire height of the wall to within 12-inches of the surface to allow for proper drainage and relief of any hydrostatic pressure build-ups that may occur in the native clay. The use of stone to backfill behind the walls will expedite construction, reduce potential settlement between the wall and the floor slab and lower the pressure induced on the wall from the backfill thus potentially reducing the thickness of the walls.

Table 6: Earth Pressure and Friction Coefficients

MATERIAL	ACTIVE (K_a)	PASSIVE (K_p)	AT-REST (K_o)	ALLOWABLE BASE FRICTION	UNIT WEIGHT (pcf)
Open-graded crushed limestone	0.27	3.69	0.43	0.47	130-140
In-situ lean clay soils	0.40	2.5	0.68	0.32	120-125
In-situ fat clay soils	0.49	2.04	0.66	0.24	120-125
Lean clay – conditioned and compacted	0.32	3.12	0.48	0.35	120-125
Fat clay/Weathered Shale – conditioned and compacted	0.45	2.2	0.63	0.27	120-130
Limestone Bedrock	-	-	-	0.55	140-150

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 six (6) inches in thickness and compacted to a minimum density of 95% of the Standard Proctor (ASTM D698) maximum dry density at a moisture content within +- 3% of the optimum moisture content. It is recommended that a representative of CFS should verify the compaction of any such materials relied upon to provide passive pressure.

The actual earth pressure on the walls will vary according to material types and backfill materials used and how the backfill is compacted. If the backfill conditions are different than the ones used above, CFS should be notified so the recommendations can be modified. The buildup of water behind a wall will increase the lateral pressure imposed on below-grade walls. Adequate drainage should be provided behind any below grade walls as described in this report. The walls should also be designed for appropriate surcharge pressures such as adjacent traffic, interior building floor slab loads, and construction equipment.

8 GENERAL COMMENTS

When the plans and specifications are complete, or if significant changes are made in the character or location of the proposed building, a consultation should be arranged to review the changes with respect to the prevailing soil conditions. At that time, it may be necessary to submit supplementary recommendations.

It is recommended that the services of Cook, Flatt & Strobel Engineers be engaged to test and evaluate the compaction of any additional fill materials and to test and evaluate the bearing value of the soils in the footing excavations.

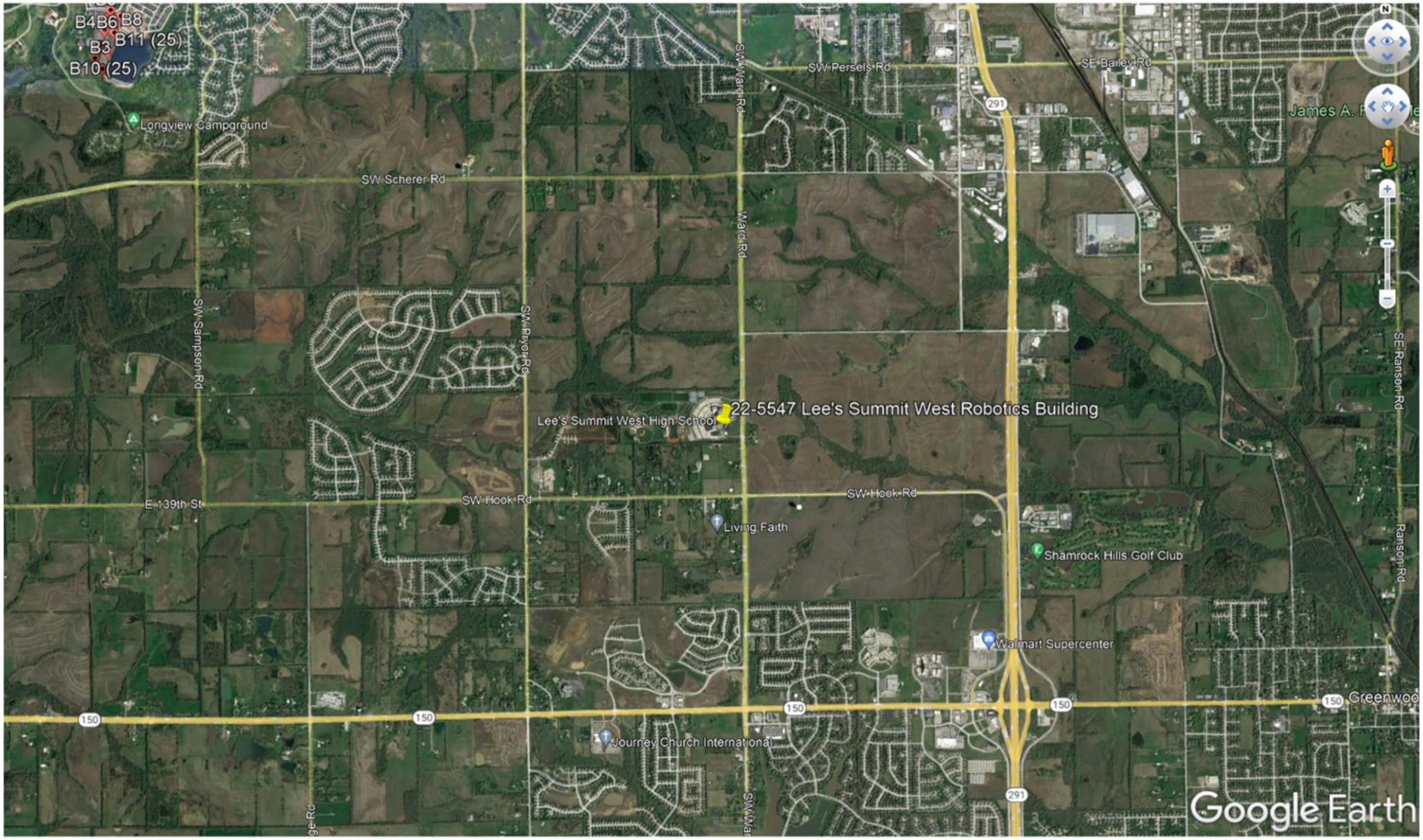
Respectfully submitted,

COOK, FLATT & STROBEL ENGINEERS, P.A.

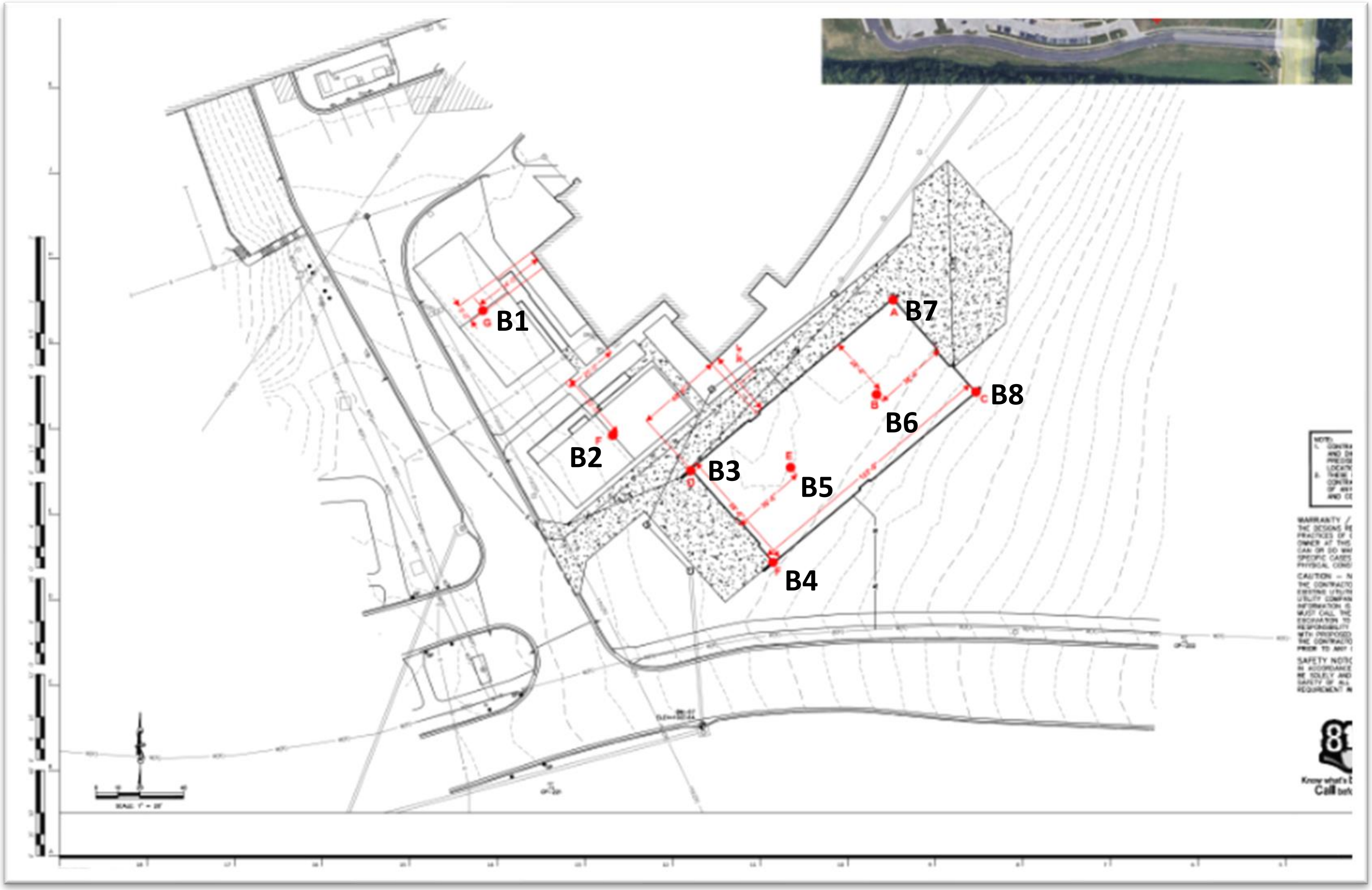
Jacob Engler, P.E.
Geotechnical Engineer

Reviewed by: Adam McEachron, P.E.
Senior Geotechnical Engineer

Appendix A: Figures



CFS ENGINEERS 1100 W. Cambridge Circle Dr, Ste 700 Kansas City, Kansas 66103	Project: **LEE'S SUMMIT WEST HIGH SCHOOL ROBOTICS BUILDING**	Project #: 22-5547	Figure 1: **SITE LOCATION PLAN**
	Project Location: Lee's Summit, MO	Comments:	
	Client: Lee's Summit R7 District		
	Date: 7/28/2022		



CFS ENGINEERS 1100 W. Cambridge Circle Dr, Ste 700 Kansas City, Kansas 66103	Project: **LEE'S SUMMIT WEST HIGH SCHOOL ROBOTICS**	Project #: 22-5547	Figure 2: **BORING LOCATION PLAN**
	Project Location: Lee's Summit, MO	Comments:	
	Client: Lee's Summit R7 District		
	Date: 7/28/2022		

Appendix B: Boring Logs

CFS ENGINEERS

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1100 W. Cambridge Circle Drive, Suite 700
Kansas City, Kansas 66103

BORING NUMBER B1

CLIENT Lee's Summit R-7 School District

PROJECT NAME LEE'S SUMMIT WEST HS ROBOTICS BUILDINGS

PROJECT NUMBER 22-5547

PROJECT LOCATION Lee's Summit, Missouri

DATE STARTED 07/07/22 **COMPLETED** 07/07/22

GROUND ELEVATION **HOLE SIZE** 3.25 inches

DRILLING CONTRACTOR CFS Engineers

GROUND WATER LEVELS:

DRILLING METHOD 3.25-inch Continuous Flight

AT TIME OF DRILLING --- No Free Water Encountered

LOGGED BY NG **CHECKED BY** JE

AT END OF DRILLING --- No Free Water Encountered

NOTES Split Spoon Refusal in Shale

AFTER DRILLING --- No Free Water Encountered

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	UNCONFINED COMP (PSF)
0.0		SHALE, moderately weathered, brown										
		Unweathered, and gray below 1.5'	SPT 1	100	6-17-22 (39)	4.5		15.4				
2.5												
			SPT 2	100	13-16-50/4"	3		9.7				
5.0												
			SPT 3	100	50/1"	2		9.6				

Refusal at 6.1 feet.
Bottom of borehole at 6.1 feet.

CFS Engineers, Inc
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Kansas City, Kansas 66103

BORING NUMBER B2

CLIENT Lee's Summit R-7 School District
PROJECT NAME LEE'S SUMMIT WEST HS ROBOTICS BUILDINGS
PROJECT NUMBER 22-5547
PROJECT LOCATION Lee's Summit, Missouri
DATE STARTED 07/07/22 **COMPLETED** 07/07/22
GROUND ELEVATION **HOLE SIZE** 3.25 inches
DRILLING CONTRACTOR CFS Engineers
GROUND WATER LEVELS:
DRILLING METHOD 3.25-inch Continuous Flight
AT TIME OF DRILLING --- No Free Water Encountered
LOGGED BY NG **CHECKED BY** JE
AT END OF DRILLING --- No Free Water Encountered
NOTES Split Spoon Refusal in Shale
AFTER DRILLING --- No Free Water Encountered

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	UNCONFINED COMP (PSF)
0.0		SHALE, moderately weathered, brown, with topsoil										
		Unweathered, and gray below 1'	SPT 1	100	12-50/5"	4.5		11.5	39	21	18	
2.5												
			SPT 2	100	50/5"	1.5		8.8				

Refusal at 3.9 feet.
Bottom of borehole at 3.9 feet.

GEOTECH BH COLUMNS - GINT STD US LAB.GDT - 07/28/22 12:30 - G:\SHARED DRIVES\225547\GEOTECH\EXPLORATION REPORTS\22-5547 LEES SUMMIT WEST GEO LOGS.GPJ

BORING NUMBER B3

CFS ENGINEERS

CFS Engineers, Inc
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Kansas City, Kansas 66103

CLIENT Lee's Summit R-7 School District

PROJECT NAME LEE'S SUMMIT WEST HS ROBOTICS BUILDINGS

PROJECT NUMBER 22-5547

PROJECT LOCATION Lee's Summit, Missouri

DATE STARTED 07/07/22 **COMPLETED** 07/07/22

GROUND ELEVATION **HOLE SIZE** 3.25 inches

DRILLING CONTRACTOR CFS Engineers

GROUND WATER LEVELS:

DRILLING METHOD 3.25-inch Continuous Flight

AT TIME OF DRILLING --- No Free Water Encountered

LOGGED BY NG **CHECKED BY** JE

AT END OF DRILLING --- No Free Water Encountered

NOTES Split Spoon Refusal in Shale

AFTER DRILLING --- No Free Water Encountered

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS			UNCONFINED COMP (PSF)
									LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
0.0		LEAN CLAY, (CL) brown and dark brown, with gravel, Shaley (FILL)										
		SHALE, moderately weathered to unweathered, gray	SPT 1	100	5-12-18 (30)	4		14.6				
2.5												
			SPT 2	100	22-32-50/4"	4.5		12.8				
5.0												
			SPT 3	100	50/5"	4.5		11.9				

Refusal at 6.4 feet.
Bottom of borehole at 6.4 feet.

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BORING NUMBER B4

CLIENT Lee's Summit R-7 School District
PROJECT NAME LEE'S SUMMIT WEST HS ROBOTICS BUILDINGS
PROJECT NUMBER 22-5547
PROJECT LOCATION Lee's Summit, Missouri
DATE STARTED 07/07/22 **COMPLETED** 07/07/22
GROUND ELEVATION **HOLE SIZE** 3.25 inches
DRILLING CONTRACTOR CFS Engineers
GROUND WATER LEVELS:
DRILLING METHOD 3.25-inch Continuous Flight
AT TIME OF DRILLING --- No Free Water Encountered
LOGGED BY NG **CHECKED BY** JE
AT END OF DRILLING --- No Free Water Encountered
NOTES Split Spoon Refusal in Shale
AFTER DRILLING --- No Free Water Encountered

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	UNCONFINED COMP (PSF)
0.0		LEAN CLAY, (CL) dark brown, with vegetation at surface (TOPSOIL)										
		LIMESTONE, highly weathered, fractured										
		SHALE, highly weathered, gray and tan, with highly weathered limestone fragments at interface	SPT 1	67	2-5-4 (9)	4.5		19.7				
2.5		Unweathered, and gray below 3'										
			SPT 2	100	13-24-40 (64)	4		16.8				
5.0												
			SPT 3	33	21-50/3"	0		10.2				
7.5												
			SPT 4	100	50/5"	0		9.2				
10.0												
12.5												
			5	100	50/1"	0		7.3				

Refusal at 14.0 feet.
Bottom of borehole at 14.0 feet.

BORING NUMBER B5

CFS Engineers, Inc
1100 W. Cambridge Circle Drive, Suite 700
Kansas City, Kansas 66103

CLIENT Lee's Summit R-7 School District
PROJECT NAME LEE'S SUMMIT WEST HS ROBOTICS BUILDINGS
PROJECT NUMBER 22-5547
PROJECT LOCATION Lee's Summit, Missouri
DATE STARTED 07/07/22 **COMPLETED** 07/07/22
GROUND ELEVATION **HOLE SIZE** 3.25 inches
DRILLING CONTRACTOR CFS Engineers
GROUND WATER LEVELS:
DRILLING METHOD 3.25-inch Continuous Flight
AT TIME OF DRILLING --- No Free Water Encountered
LOGGED BY NG **CHECKED BY** JE
AT END OF DRILLING --- No Free Water Encountered
NOTES Split Spoon Refusal in Shale
AFTER DRILLING --- No Free Water Encountered

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	UNCONFINED COMP (PSF)
0.0		LEAN CLAY, (CL) dark brown, with vegetation at surface (TOPSOIL)										
		SHALE, moderately weathered, gray and tan										
		Unweathered, and gray below 1.5'	SPT 1	78	4-12-19 (31)	4.5		26.3				
2.5												
			SPT 2	100	12-17-20 (37)	4.5		11.6				
5.0												
			SPT 3	100	50/5"	0		9.1				
7.5												
			SPT 4	100	50/2"	1.5		10.7				

Refusal at 8.7 feet.
Bottom of borehole at 8.7 feet.

BORING NUMBER B6

CFS ENGINEERS

CFS Engineers, Inc
1100 W. Cambridge Circle Drive, Suite 700
Kansas City, Kansas 66103

CLIENT Lee's Summit R-7 School District
PROJECT NAME LEE'S SUMMIT WEST HS ROBOTICS BUILDINGS
PROJECT NUMBER 22-5547
PROJECT LOCATION Lee's Summit, Missouri
DATE STARTED 07/07/22 **COMPLETED** 07/07/22
GROUND ELEVATION **HOLE SIZE** 3.25 inches
DRILLING CONTRACTOR CFS Engineers
GROUND WATER LEVELS:
DRILLING METHOD 3.25-inch Continuous Flight
AT TIME OF DRILLING --- No Free Water Encountered
LOGGED BY NG **CHECKED BY** JE
AT END OF DRILLING --- No Free Water Encountered
NOTES Split Spoon Refusal in Shale
AFTER DRILLING --- No Free Water Encountered

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	UNCONFINED COMP (PSF)
0.0		LEAN CLAY, (CL) dark brown, with vegetation at surface (TOPSOIL)										
		SHALE, unweathered, gray	SPT 1	100	7-29-46 (75)	4.5		20.3	43	23	20	
2.5			SPT 2	100	50/5"	2.5		11.0				
5.0			SPT 3	100	35-50/3"	0		10.9				

Refusal at 6.8 feet.
Bottom of borehole at 6.8 feet.

BORING NUMBER B7

CFS Engineers, Inc
1100 W. Cambridge Circle Drive, Suite 700
Kansas City, Kansas 66103

CLIENT Lee's Summit R-7 School District
PROJECT NAME LEE'S SUMMIT WEST HS ROBOTICS BUILDINGS
PROJECT NUMBER 22-5547
PROJECT LOCATION Lee's Summit, Missouri
DATE STARTED 07/07/22 **COMPLETED** 07/07/22
GROUND ELEVATION **HOLE SIZE** 3.25 inches
DRILLING CONTRACTOR CFS Engineers
GROUND WATER LEVELS:
DRILLING METHOD 3.25-inch Continuous Flight
AT TIME OF DRILLING --- No Free Water Encountered
LOGGED BY NG **CHECKED BY** JE
AT END OF DRILLING --- No Free Water Encountered
NOTES Split Spoon Refusal in Shale
AFTER DRILLING --- No Free Water Encountered

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	UNCONFINED COMP (PSF)
0.0		LEAN CLAY, (CL) dark brown, with vegetation at surface (TOPSOIL)										
		SHALE, unweathered, gray										
			SPT 1	100	17-33-35 (68)	3.5		10.2				
2.5												
			SPT 2	100	15-26-50/4"	4.5		12.7				
5.0												
			SPT 3	100	50/3"	2.5		10.0				

Refusal at 6.3 feet.
Bottom of borehole at 6.3 feet.

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CFS Engineers, Inc
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BORING NUMBER B8

CLIENT Lee's Summit R-7 School District
PROJECT NAME LEE'S SUMMIT WEST HS ROBOTICS BUILDINGS
PROJECT NUMBER 22-5547
PROJECT LOCATION Lee's Summit, Missouri
DATE STARTED 07/07/22 **COMPLETED** 07/07/22
GROUND ELEVATION **HOLE SIZE** 3.25 inches
DRILLING CONTRACTOR CFS Engineers
GROUND WATER LEVELS:
DRILLING METHOD 3.25-inch Continuous Flight
AT TIME OF DRILLING --- No Free Water Encountered
LOGGED BY NG **CHECKED BY** JE
AT END OF DRILLING --- No Free Water Encountered
NOTES Auger Refusal on Limestone
AFTER DRILLING --- No Free Water Encountered

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	UNCONFINED COMP (PSF)
0.0		LEAN CLAY, (CL) dark brown, with vegetation at surface (TOPSOIL)										
		FAT CLAY, (CH) brown and orangeish brown, dry	SPT 1	86	3-3-50/2"							
2.5		LIMESTONE, highly weathered to moderately weathered										
			SPT 2	100	50/1"							

Refusal at 4.5 feet.
Bottom of borehole at 4.5 feet.