Geotechnical Engineering Report

Field Services Facility
Lee's Summit, Missouri
May 1, 2015
Terracon Project No. 02145038

Prepared for:
City of Lee's Summit
Lee's Summit, Missouri

Prepared by:
Terracon Consultants, Inc.
Lenexa, Kansas

May 1, 2015

City of Lee's Summit
220 SE Green Street
Lee's Summit, Missouri - 64063

Attn: Mr. Jeff Thorn, P.E.
jeff.thorn@cityofls.net

Re: Geotechnical Engineering Report
Field Services Facility
SE Hamblen Road
Lee's Summit, Missouri
Terracon Project Number: 02145038

Dear Mr. Thorn:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the referenced project. This study was performed in general accordance with our task order dated April 7, 2015 and City of Lee's Summit purchase order number 106167-R1. This report presents the findings of the subsurface exploration and provides geotechnical recommendations regarding the design and construction of foundations and the floor slab for the project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

R. Sonawane

Richa A. Sonawane, E.I.
Senior Geotechnical Engineer

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EXECUTIVE SUMMARY

Ten (10) borings were performed at the site of the proposed Field Services Facility. Samples recovered from the borings have been tested. Logs of borings with test data are appended to this geotechnical engineering report. Professional opinions and recommendations presented in this report are summarized below.

- The proposed building and structures can be supported by a shallow spread footing foundation system bearing on stiff, native soil or on properly compacted engineered fill that extends to suitable native soils.

- The majority of the on-site material encountered at this site has the potential to shrink and swell with seasonal moisture fluctuations. Therefore, a 24-inch thick low volume change (LVC) layer should be constructed beneath the grade-supported floor slabs.

- The 2012 International Building Code seismic site classification for this site is C.

The professional opinions and recommendations presented in this report are based on evaluation of data developed by testing discrete samples obtained from widely spaced borings. Site subsurface conditions have been inferred from available data, but actual subsurface conditions will only be revealed by excavation. We recommend a qualified geotechnical engineer be retained to observe excavation and perform tests during the site preparation, earthwork and foundation construction phases of the project.

This executive summary should not be separated from or used apart from this report. This report presents recommendations and opinions based on our understanding of the project at the time the report was prepared. The report limitations are described in section **5.0 GENERAL COMMENTS**.

GEOTECHNICAL ENGINEERING REPORT
PROPOSED FIELD SERVICES FACILITY
SE HAMBLEN ROAD
LEE'S SUMMIT, MISSOURI

Terracon Project No. 02145038

May 1, 2015

1.0 INTRODUCTION

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the proposed Field Services Facility planned in Lee's Summit, Missouri. Ten (10) borings were performed to depths ranging from approximately 14 to 15 feet. An exploration plan and logs of borings with test data are included in Appendix A of this report. The purpose of these services is to provide information and geotechnical engineering recommendations and professional opinions relative to:

- subsurface conditions
- groundwater conditions
- earthwork
- seismic site class
- floor slab design and construction
- foundation design and construction

At the time of the subsurface exploration, the project was in a preliminary design phase. Terracon issued a preliminary geotechnical report, dated March 4, 2014. Subsequent to issuing the preliminary geotechnical report, 60 percent complete construction plans were provided. This report supersedes our preliminary report.

2.0 PROJECT INFORMATION

2.1 Site Location and Description

Item	Description
Location	The site is located along SE Hamblen Road in Lee's Summit, Missouri.
Existing improvements	The site is mostly grass-covered. A small portion of the site along the western most boundary, is asphalt paved. There are a few trees along the perimeter of the site.
Existing topography	Based on the 60% drawings provided to us, the site generally slopes downward from southwest to northeast with as much as 20 feet of elevation change.

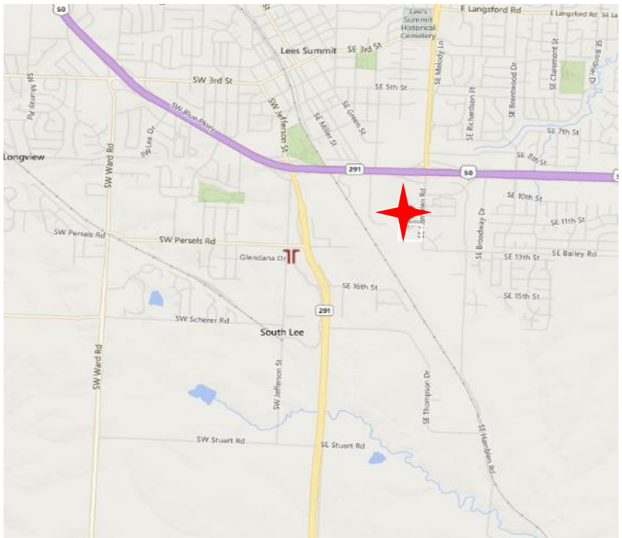


Figure 1. Site location

Figure 2. Aerial photograph of site

2.2 Project Description

Item	Description
Building and structure information	■ Facilities service building: - pre-engineered metal building with grade-supported floor slabs - building size = 41,813 square ft - finished floor elevation = 1024.5 ft ■ Canopies will be constructed over the fuel tanks and the covered parking and laydown areas islands located on the north and west sides of the proposed facilities building, respectively. ■ Storage bins will be constructed on the west end of the site. ■ A retention pond will be constructed northeast of the building. ■ Retaining wall: - A dry stack quarry block wall will be constructed in the southwestern portion of the site - Maximum wall height =6.5 ft
Maximum loads (estimated by Terracon)	Information regarding structural loads was not provided. We have considered the following maximum loads: Columns: 100 kips Walls: 3 kips per linear foot Slabs: 100 psf
Site grading	Based on the 60 percent plans provided to us, we understand grade changes on the order of 2 feet (cut/fill) will be required to develop design grades across the majority of the site. Cut depths of up to 6 feet are anticipated in the western portion of the site.

3.0 SUBSURFACE CONDITIONS

3.1 Typical Profile

The subsurface conditions encountered at the boring locations can be generalized as follows:

Stratum	Approximate Depth to Bottom of Stratum	Material Description	Borings Encountered	Comments
1A	4 inches	Topsoil	All borings	---
1B	6 inches	Asphalt	BH-9 and BH-10	---
2	8 feet	Existing fill	BH-9 and BH-10	Fat clay, dark brown
3	10 to 15 feet	Fat clay	BH-1 through BH-8	Stiff to hard, dark brown, gray-brown, brown, gray
	Not determined[1]		BH-9 and BH-10	
4	Not determined[2]	Shale	BH-1 through BH-8	Sandy, light brown, severely to moderately weathered

1. Borings BH-9 and BH-10 were terminated at depths of 15 feet in fat clay.
2. Borings BH-1 through BH-8 were terminated at depths of 15 feet in shale bedrock.

Conditions encountered at each boring location are indicated on the individual boring logs. Stratification boundaries on the boring logs represent the approximate location of changes in soil and rock types; in situ, the transition between materials may be gradual.

3.2 Water Level Observations

The borings were observed while drilling and immediately after completion for the presence and level of groundwater. Water was not observed at any of the borings. Due to the low permeability of the cohesive soils encountered in the borings, a relatively long period of time may be necessary for a groundwater level to develop and stabilize in a borehole. Long term observations in piezometers or observation wells sealed from the influence of surface water are often required to define groundwater levels in soils of this type.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times may be higher or lower than the levels indicated on the boring logs. Water can perch within existing fills and may be encountered at the soil and bedrock interface. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

The subsurface exploration completed at the site revealed the presence of highly plastic fat clay overlying shale bedrock. Borings BH-9 and BH-10, within the asphalt paved area along western property boundary, encountered as much as 8 feet of existing fat clay fill over native clay soils. Severely weathered shale bedrock was encountered at borings BH-1 through BH-8 at depths ranging from 10 to 14.5 feet. Moderately weathered shale bedrock was encountered at borings BH-4, BH-5, and BH-6 to the termination of the borings at approximate depths of 15 feet.

Existing fill was encountered at borings BH-9 and BH-10 to depths of about 8 feet, but could extend to greater depths in other areas of the site. The depth, composition and lateral extent of existing fill may not be fully known even during construction. The site should be evaluated by experienced Terracon personnel following site stripping to help identify the extent of existing fills. Floor slabs or foundations for proposed improvements should not be supported on uncontrolled fill. Support of structures on or above existing fill of variable composition and quality involves risks, which include, but are not limited to, unpredictable total and differential settlement of supported slabs, walls, foundations, and pavements. The existing fill may contain soft zones, debris, or significantly greater amounts of unsuitable materials than could be reasonably inferred from the boring information. These risks cannot be eliminated without completely removing the existing fill and replacing with engineered fill capable of supporting footing foundations.

Highly plastic fat clay soils are present on this site. Fat clay soils in particular are commonly referred to as "expansive" or "swelling" soils because they expand or swell as their moisture contents increase. Footings, floor slabs, and pavements supported on expansive soils can move upward and downward significantly and such movements can result in distortion of, cracking in and cosmetic as well as structural damage to the structure. Based on our knowledge of the site soil conditions and our experience with similar sites and structures concrete grade-supported floors should be supported on low volume change (LVC) materials. LVC materials can consist of clay soils, which are not desiccated (dry) and which exhibit a maximum liquid limit of 45 and a maximum plastic limit of 23. Granular soils and crushed limestone aggregates are also considered acceptable LVC materials. Shale would not be considered suitable within the LVC layer.

We recommend a 24-inch thick low volume change (LVC) zone be constructed beneath grade-supported floor slabs. The use of a LVC zone, as recommended in this report, will not eliminate all future subgrade volume change and resultant grade-supported floor slab movements. However, use of an LVC zone should reduce the potential for subgrade volume change. Details regarding the LVC zone for grade-supported floor slabs are provided in this report in sections **4.2.2 Engineered Fill Material Requirements** and **4.5 Floor Slab.**

This report provides recommendations to help mitigate the effects of soil shrinkage and expansion. However, even if these procedures are followed, some movement and at least minor cracking in the structure could still occur. The severity of cracking and other cosmetic damage such as floor slab movement will probably increase if any modification of the site results in excessive wetting or drying of the expansive soils. Eliminating the risk of movement and cosmetic distress may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction. We would be pleased to discuss other construction alternatives with you upon request.

4.2 Earthwork

Earthwork on this project should be observed and evaluated by Terracon. Recommendations for site preparation, excavation, subgrade preparation, and placement of engineered fill for the project are provided in the following sections.

4.2.1 Site Preparation

Vegetation, topsoil, and loose, soft, or otherwise unsuitable material should be removed from proposed construction areas. The soils within the proposed building areas should be further undercut as necessary to accommodate placement of the recommended 24-inch thick LVC layer below floor slabs. The undercut areas should extend a minimum of 5 feet laterally outside of the building wall lines. After initial stripping and any necessary undercutting, a representative of Terracon should further evaluate exposed subgrades. Test pits, field density tests, and/or obtaining additional samples for laboratory tests may be recommended. If unsuitable materials are encountered at this time, these materials should be removed and replaced with controlled engineered fill.

Following these operations, the exposed soils should be proofrolled. A Terracon representative should observe the proofrolling. Proofrolling can be accomplished using a loaded tandem-axle dump truck with a gross weight of at least 20 tons, or similarly loaded equipment. Areas that display excessive deflection (pumping) or rutting during proofroll operations should be improved by scarification/compaction or by removal and replacement with engineered fill.

4.2.2 Engineered Fill Material Requirements

Engineered fill should meet the following material property requirements:

Fill Type [1]	USCS Classification	Acceptable Location for Placement
Low Volume Change (LVC) Material [2]	CL (LL<45 & PI<23) GM [3]	All locations and elevations, except where free-draining [4] backfill is required.
Clay soils	CH, CL	Outside of building areas. Material could be used below LVC layer if approved in advance by Terracon and if placed with strict moisture and density control.

Fill Type [1]	USCS Classification	Acceptable Location for Placement
Well-graded granular (not present on site)	GM [3]	All locations and elevations, except where free-draining [4] backfill is required

1. Materials used to construct engineered fills should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade.
2. Low plasticity cohesive soil or granular soil having at least 18% low plasticity fines.
3. Similar to MoDOT Type 5 crushed limestone aggregate.
4. Free-draining backfill should be comprised of granular soils with less than 5% fines (material passing No. 200 sieve).

4.2.3 Fill Placement and Compaction Requirements

Item		Description
Lift Thickness (maximum)		9 inches in loose thickness when large, self-propelled compaction equipment is used. 4 inches when small, hand-guided equipment (plate or "jumping jack" compactor) is used.
Minimum Compaction Requirements [1]		95% of the material's maximum dry density [2]
Moisture Content of Clay Soil	LL<45	-2% to +2% of optimum moisture content value [2]
	LL>45	0 to 4% above the optimum moisture content value [2]
Moisture Content of Granular Material		Sufficient to achieve compaction without pumping when proofrolled.

1. We recommend that engineered fill be tested for moisture content and compaction during placement. Should the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.
2. As determined by the standard Proctor test (ASTM D 698).

4.2.4 Utility Trench Backfill

Utility trench backfill should be placed and compacted as recommended above. All trench excavations should be made with sufficient working space to permit construction including backfill placement and compaction. If utility trenches are backfilled with relatively clean granular material, they should be capped with at least 18 inches of cohesive fill in landscape areas to reduce the infiltration and conveyance of surface water through the trench backfill.

Utility trenches are a common source of water infiltration and migration. Utility trenches that penetrate beneath the building should be effectively sealed to restrict water intrusion and flow through the trenches that could migrate below the building. In these areas, we recommend constructing an effective clay "trench plug" that extends at least 5 feet out from the face of the building exterior. The plug material should consist of clay compacted at water contents at or above the soil's optimum moisture content. The clay fill should be placed to completely surround the utility line and be compacted in accordance with recommendations in this report.

4.2.5 Grading and Surface Water Drainage

During construction, grades should be developed to direct surface water flow away from or around the site. Exposed subgrades should be sloped to provide positive drainage so that saturation of subgrades is avoided. Surface water should not be permitted to accumulate on the site. Final surrounding grades should promote rapid surface drainage away from structures and pavements. Accumulation of water adjacent to the building could contribute to significant moisture increases in the subgrade soils and subsequent softening/settlement or expansion/heave. Roof drains should discharge into a storm sewer or at least 10 feet away from the building.

After building construction and landscaping, we recommend verifying final grades to document that effective drainage has been achieved.

4.2.6 Earthwork Construction Considerations

Although the exposed clay subgrade is anticipated to be relatively stable upon initial exposure, unstable subgrade conditions could develop during general construction operations, particularly if the soils are wetted and/or subjected to repetitive construction traffic.

Upon completion of filling and grading, care should be taken to maintain the subgrade moisture content prior to construction of the floor slab and pavements. Construction traffic over the completed subgrade should be avoided to the extent practical. The site should also be graded to prevent ponding of surface water on prepared subgrades. If the subgrade should become frozen, desiccated, saturated, or disturbed, the affected material should be scarified and compacted or be removed and replaced. Subgrades should be observed and tested by Terracon prior to construction of the slabs and pavements.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, "Excavations" and its appendices, and in accordance with any applicable local, state, and federal safety regulations. The contractor should be aware that slope height, slope inclination, and excavation depth should in no instance exceed those specified by these safety regulations. Flatter slopes than those dictated by these regulations may be required depending upon the soil conditions encountered and other external factors. These regulations are strictly enforced and if they are not followed, the Owner, Contractor, and/or earthwork and utility subcontractor could be liable and subject to substantial penalties. Under no circumstances should the information provided in this report be interpreted to mean that Terracon is responsible for construction site safety or the contractor's activities. Construction site safety is the sole responsibility of the contractor who shall also be solely responsible for the means, methods, and sequencing of the construction operations.

4.3 Foundations

The proposed building and structures can be supported on shallow footing foundations. Footings should bear on stiff to very stiff native clay soils or engineered fill placed with strict moisture and density control. Footings should not bear on existing fill or other unsuitable soil. Existing fill or other on-site soils located within the building area that are found to be unsuitable should be removed and replaced with an engineered fill placed according to the recommended requirements in section **4.2 Earthwork**. Recommendations for design of shallow foundations for the proposed structure are presented in the following sections.

4.3.1 Shallow Foundation Design Recommendations

Description	Value
Maximum net allowable bearing pressure [1]	2,500 psf
Minimum embedment below finished grade [2]	3 feet
Minimum footing widths	Isolated footings: 30 inches Continuous footings: 16 inches
Approximate total settlement [3]	<1 inch
Approximate differential settlement [3]	<3/4 inch over 40 feet

1. The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. This pressure assumes that any undocumented existing fill or soft soils, if encountered, will be undercut and replaced with engineered fill.
2. This embedment depth is recommended for perimeter footings and footings beneath unheated areas to provide frost protection and to reduce the effects of seasonal moisture variations in the foundation bearing soils. Interior footings in heated areas may be supported at shallower depths, provided they are not exposed to freezing conditions during construction.
3. The foundation settlement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth of the footings, the thickness of engineered fill, and the quality of the earthwork operations and footing construction.

4.3.2 Uplift Considerations

Uplift resistance for canopy footing foundations may be computed as the sum of the weight of the foundation element and the weight of the soil overlying the foundation. We recommend using a soil unit weight of 120 pcf for compacted engineered fill overlying the footings. We recommend a minimum factor of safety of 1.5 be utilized for uplift calculations.

4.3.3 Shallow Foundation Construction Considerations

The base of each foundation excavation should be free of water and any loose, soft or disturbed soil prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. If the soils at bearing level become excessively dry, disturbed, saturated, or frozen, the affected soil should be removed prior to placing concrete. Placement of a lean concrete mud-mat over the bearing soils should be considered if the excavations must remain open overnight or for an extended period of time.

Although groundwater was not encountered at or above the anticipated foundation bearing elevation in our exploratory borings, it may be encountered during foundation or utility trench excavation. In addition, some surface and/or perched groundwater may enter foundation excavations during construction. It is anticipated any water entering foundation excavations from these sources can be removed using sump pumps or gravity drainage.

All footing bearing surfaces should be observed and tested by Terracon. If unsuitable conditions are encountered, footing excavations should be extended deeper to suitable bearing materials. Footings can bear directly on suitable soils at the lower level or on lean concrete backfill placed in the excavations as shown in Figure 4. The footings could also bear on properly compacted backfill extending down to the suitable soils as shown in Figure 5. Overexcavation for compacted backfill placement below footings should extend laterally beyond all edges of the footings at least 8 inches per foot of overexcavation depth below footing base elevation. The overexcavation should then be backfilled up to the footing base elevation with well graded granular material placed and compacted as recommended in **Section 4.2.3**.

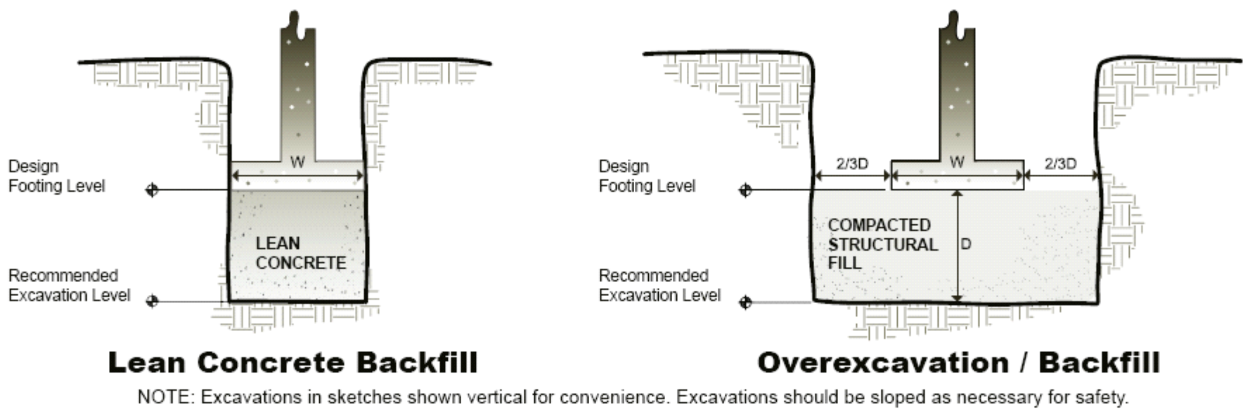


Figure 4 **Figure 5**

4.4 Seismic Considerations

Code	Site Classification
2012 International Building Code (IBC)	C [1]

1. IBC Site Class determination is based on average properties of the subsurface profile within 100 feet of the ground surface. Exploratory borings extended to a maximum depth of 15 feet. Terracon's opinion of Site Class is based on boring data and our knowledge of geotechnical and geologic conditions in this locale.

4.5 Floor Slab

4.5.1 Design Recommendations

Item	Description
Floor Slab Support [1, 2]	24 inches (minimum) of low volume change (LVC) materials on top of native soils or engineered fill
Modulus of Subgrade Reaction	100 pounds per square inch per inch (psi/in) for point loading conditions
Granular Leveling Course Layer Thickness	Minimum of 4 inches [4]
Capillary Break Layer Thickness [3]	Minimum of 6 inches [4]

1. Loads on footings which support structural walls and column loads are typically greater than floor slab loads. Consequently, footings should be expected to settle more than the adjacent floor slab. Differential movement between foundations and the grade-supported floor should be considered by the structural engineer.
2. Clay subgrades should be scarified at least 9 inches, moisture conditioned, and re-compacted prior to placement of LVC materials. We recommend LVC subgrades be maintained in a relatively moist condition until the floor slabs are constructed. If the subgrade should become desiccated prior to construction of the floor slabs, the affected material should be removed or the materials scarified, moistened, and re-compacted. Upon completion of grading operations, care should be taken to maintain the recommended LVC layer moisture content and density prior to construction of the floor slab.
3. If penetration of moisture vapor through the slab is a concern, in our opinion the floor slab design should include a capillary break layer instead of the granular leveling course layer described above. In our opinion, capillary break layers should be comprised of granular materials that have less than 5 percent fines (material passing the #200 sieve). Other design considerations such as cold temperatures and condensation development could warrant addition design considerations.
4. These granular materials may be considered part of the total LVC layer thickness.

Joints should be constructed at regular intervals as recommended by the American Concrete Institute (ACI) to help control the location of cracking. The use of a vapor retarder should be considered beneath concrete slabs on grade that will be covered with wood, tile, carpet or other moisture sensitive or impervious coverings. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

4.5.2 Construction Considerations

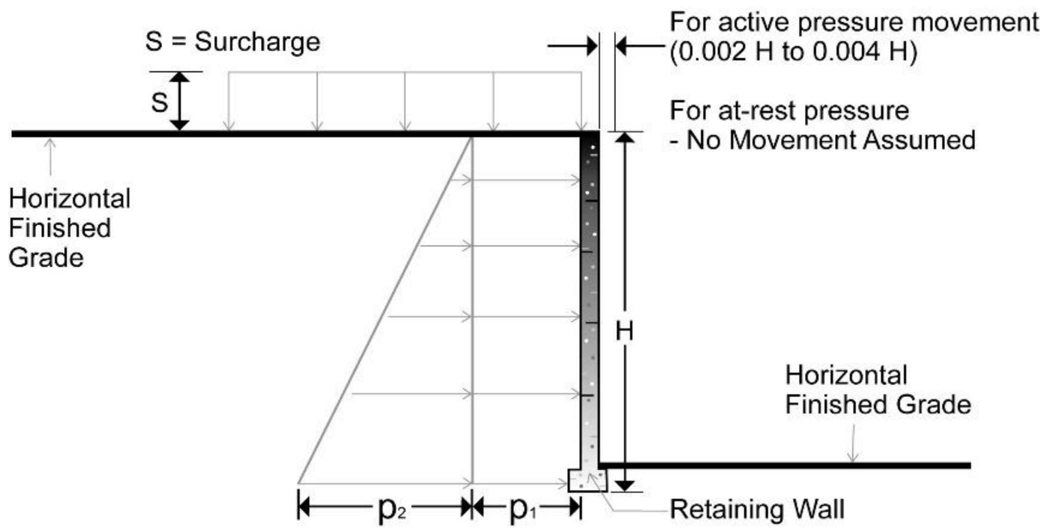
On most project sites, the site grading is generally accomplished early in the construction phase. However as construction proceeds, subgrades may be disturbed due to utility excavations, construction traffic, desiccation, rainfall, etc. As a result, floor slab subgrades may not be suitable for placement of granular material and/or concrete at the time of building construction and corrective action would be required.

Terracon should review the condition of the floor slab subgrades immediately prior to placement of the granular leveling course and construction of the floor slabs. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas containing backfilled trenches. Areas where unsuitable conditions are located should be repaired by removing and replacing the affected material with properly compacted fill.

4.6 Below Grade Walls

4.6.1 Lateral Earth Pressures

Reinforced concrete walls with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to those indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the mateFrials being restrained. Two wall restraint conditions are shown. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The at-rest condition assumes no wall movement. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls.



Lateral Earth Pressure Parameters

Earth Pressure Conditions	Coefficient for Backfill Type	Equivalent Fluid Unit Weight (pcf)	Surcharge Pressure, p_1 (psf)	Earth Pressure, p_2 (psf)
Active (K_a)	Granular - 0.33	40	(0.33)S	(40)H
	Clay - 0.42	50	(0.42)S	(50)H
At-Rest (K_o)	Granular - 0.5	60	(0.5)S	(60)H
	Clay - 0.6	70	(0.6)S	(70)H
Passive (K_p)	Granular - 3.0	360	---	---
	Clay - 2.4	290	---	---

Applicable conditions to the above include:

- For active earth pressure, wall must rotate about base, with top lateral movements of about 0.002 H to 0.004 H, where H is wall height
- For passive earth pressure to develop, wall must move horizontally to mobilize resistance
- Uniform surcharge, where S is surcharge pressure
- In-situ soil backfill weight a maximum of 120 pcf
- Horizontal backfill, compacted as recommended in the report
- Loading from heavy compaction equipment not included
- No hydrostatic pressures acting on wall
- No loading from nearby footing or slabs
- No dynamic loading
- No safety factor included in soil parameters
- Ignore passive pressure in frost zone

Backfill placed against structures should consist of granular soils or low plasticity cohesive soils. For the granular values to be valid, the granular backfill must extend out from the base of the wall at an angle of at least 45 degrees from vertical for the active and at-rest cases, and at an angle of 60 degrees from vertical for the passive case. To calculate the resistance to sliding, a value of 0.30 should be used as the ultimate coefficient of friction where the footing bears on native clay soil or engineered fill.

4.6.2 Subsurface Drainage

To reduce the potential for hydrostatic loading on walls with unbalanced backfill, we recommend that drain lines be installed along the base of the walls. Each drain line should be surrounded by free-draining granular material encapsulated with an approved geotextile filter fabric. The granular material should extend from the drainage pipes to within 2 feet of final grade and should be capped with a cohesive (clay) fill material that is placed and compacted as recommended in **Section 4.2** of this report. The drain lines should be sloped to provide positive gravity drainage to a down gradient storm sewer or to another suitable frost-free outlet that will allow gravity drainage. Periodic maintenance of drainage systems is necessary so that they do not become plugged and inoperative.

4.7 Pavements

4.7.1 Pavement Subgrades

Following site stripping, the pavement subgrades should be carefully evaluated by proofrolling as recommended in section **4.2 Earthwork**. If soft or otherwise unsuitable areas are observed, additional stripping and/or overexcavation and replacement will be needed.

Prior to placement of pavements, particular attention should be paid to high traffic areas where the subgrades have rutted or were disturbed during construction. In these areas, the subgrades should be repaired by removing and replacing the materials with properly compacted fills as recommended in this report.

4.7.2 Opinions of Minimum Pavement Thickness

Pavement thickness depends upon:

- applied wheel/axle loads and number of repetitions
- subgrade and pavement material characteristics
- climate conditions
- site and pavement drainage

Specific information regarding anticipated vehicle types, axle loads and traffic volumes was not provided. However, the following pavement sections were included in the 60 percent complete plans (Civil Details – Sheet 00C501) provided to Terracon.

Full Depth Asphalt Pavement on Compacted Soil Subgrade

Material	Light Duty	Heavy Duty
Asphalt Surface Course	2 inches (minimum)	2 inches (minimum)
Asphalt Base Course	5 inches (minimum)	6 inches (minimum)
Crushed stone (MoDOT Type 5)	8 inches (minimum)	8 inches (minimum)

Portland Cement Concrete [1] with Crushed Rock Base on Compacted Soil Subgrade

Material	Light Duty	Heavy Duty [1]
Portland Cement Concrete [1]	7 inches (minimum)	6 inches (minimum)
Crushed stone (MoDOT Type 5)	8 inches (minimum)	8 inches (minimum)

1. We recommend Portland cement concrete (PCC) pavements be used for the trash container pad and in any other areas subjected to heavy wheel loads and/or turning traffic.

Paved areas should be sloped to provide rapid drainage of surface water and to drain water away from the pavement edges. Pavements should be designed so water does not accumulate on or adjacent to the pavement, since this could saturate and soften the subgrade soils and subsequently accelerate pavement deterioration. Periodic maintenance of the pavements will be required. Cracks should be sealed, and areas exhibiting distress should be repaired promptly to help prevent further deterioration. Even with periodic maintenance, some movement and related cracking may still occur and repairs may be required.

Proper drainage below the pavement section helps minimize the potential for softening of the subgrade and has a significant impact on pavement performance and pavement life. Therefore, the granular section should be graded to adjacent storm sewer inlets or drainage ditches and provisions should be made to provide drainage from the granular section into the storm sewer. Drainage of the granular base is particularly important where two different sections of pavements (such as full-depth asphaltic concrete and Portland cement concrete with aggregate base) abut, so that water does not pond beneath the pavements and saturate the subgrade soils.

We also recommend that a granular blanket drain be constructed at all storm sewer inlets within the pavement areas. The blanket drain should consist of clean, crushed stone aggregate extending a minimum of 6 inches below pavement subgrade level. The blanket drains should extend a minimum of 15 feet away from the curb at all storm sewer inlets, and should be a minimum of 15 feet wide. The grade within the blanket drain should be sloped toward the storm sewer inlet, and weep holes should be drilled through the inlet to provide drainage of the granular section into the inlet. Placement of geotextile filter fabric across the weep holes could be considered to prevent loss of aggregate through the weep holes.

4.7.3 Pavement Construction Considerations

Grading and paving are commonly performed by separate contractors and there is often a time lapse between the end of grading operations and the commencement of paving. Subgrades prepared early in the construction process may become disturbed by construction traffic. Non-uniform subgrades often result in poor pavement performance and local failures relatively soon after pavements are constructed. Depending on the paving equipment used by the contractor, measures may be required to improve subgrade strength to greater depths for support of heavily loaded concrete/asphalt trucks.

We recommend the moisture content and density of the top 9 inches of the subgrade be evaluated and the pavement subgrades be proofrolled (minimum gross weight of 20 tons) within two days prior to commencement of actual paving operations. Areas not in compliance with the required ranges of moisture or density should be scarified 9 inches, moisture conditioned and recompacted. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the materials with properly compacted fills. Some areas may be affected to depths greater than 9 inches. The subgrade should be in its finished form at the time of the final review.

5.0 GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, foundation construction, and other earth-related construction phases of the project.

The analysis, recommendations, and professional opinions presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of geotechnical services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

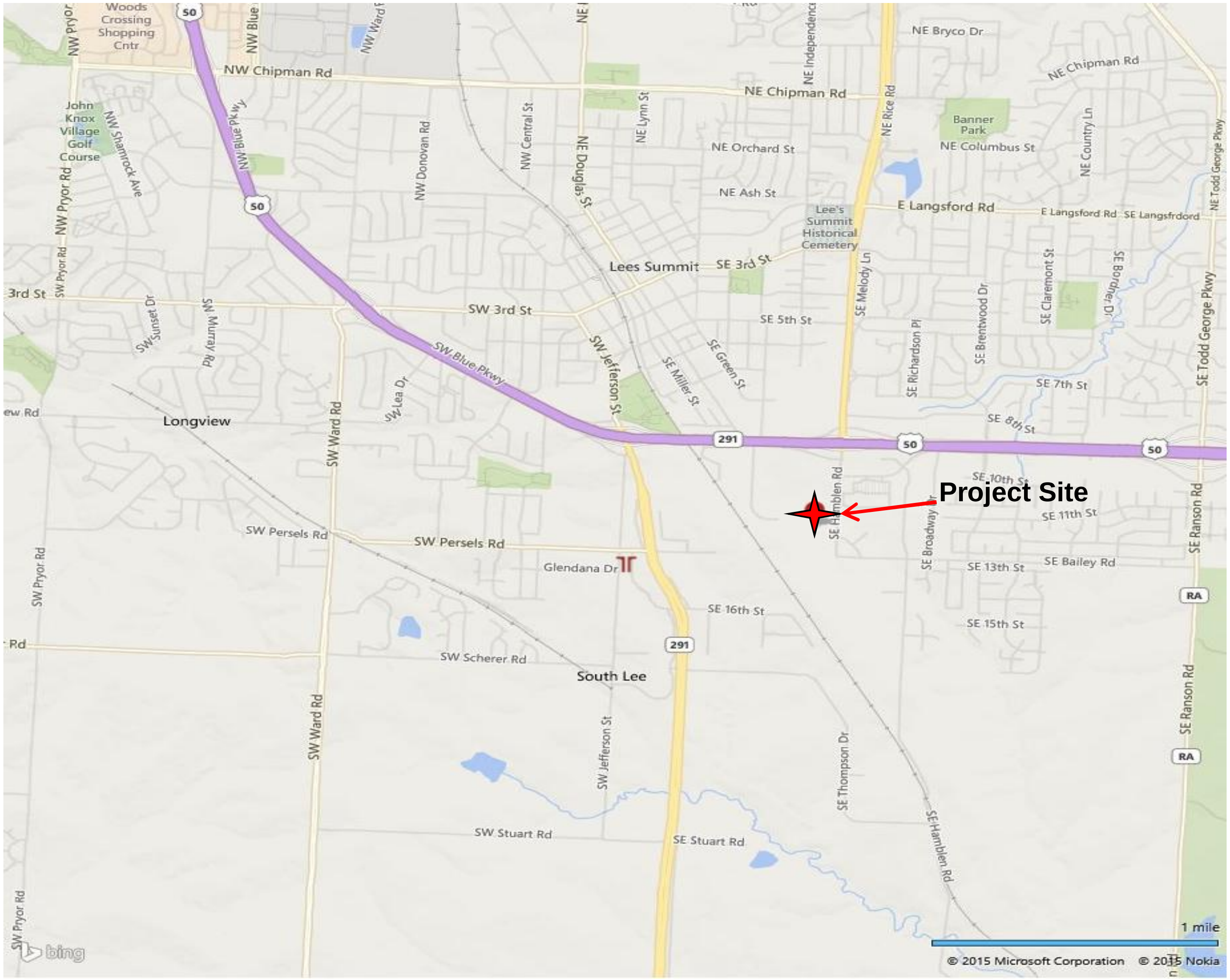
APPENDIX A
FIELD EXPLORATION

Field Exploration Description

The proposed boring locations were drilled at locations staked by HDR. Ground surface elevations noted on the boring logs were provided by HDR.

The borings were drilled with an ATV-mounted rotary drill rig using continuous flight solid-stem augers to advance the boreholes. Samples of the soils encountered at the borings were obtained using thin-walled tube and split-barrel sampling procedures. In the thin-walled tube sampling procedure, a thin-walled, seamless steel tube with a sharp cutting edge is pushed hydraulically into the soil to obtain a relatively undisturbed sample. In the split-barrel sampling procedure, the number of blows required to advance a standard 2-inch outer diameter split-barrel sampler the last 12 inches of the typical total 18-inch penetration by means of a 140-pound automatic hammer with a free fall of 30 inches is the standard penetration resistance value (SPT-N). The samples were sealed and transported to the laboratory for testing and classification.

A field log of each boring was prepared by the drill crew. These logs included visual classifications of the materials encountered during drilling as well as the driller's interpretation of the subsurface conditions between samples. Final boring logs included with this report represent the engineer's interpretation of the field logs and include modifications based on laboratory observation and tests of the samples.



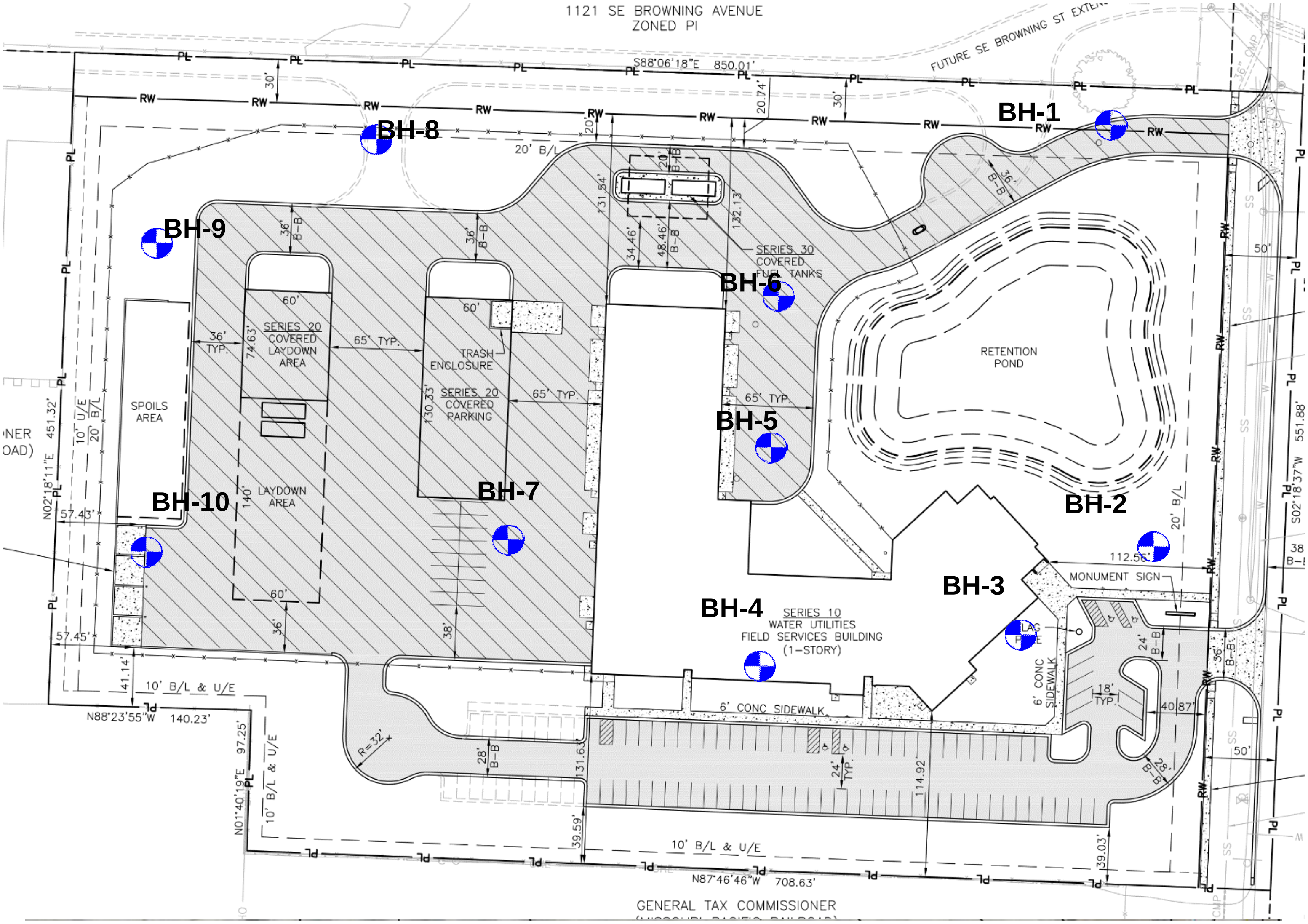
N

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Project Manager: RAS	Project No. 02145038	Terracon Consulting Engineers & Scientists	SITE LOCATION DIAGRAM
Drawn by: RAS	Scale: N.T.S.		FIELD SERVICES FACILITY
Checked by: SJS	File Name:	13910 West 96th Terrace Lenexa, Kansas 66215	SE Hamblen Road
Approved by: SJS	Date: 05/01/2015	PH. (913) 492-7777 FAX. (913) 492-7443	LEE'S SUMMIT, MO

Exhibit

A-2



N

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Project Manager: RAS	Project No. 02145038	Terracon Consulting Engineers & Scientists	BORING LOCATION DIAGRAM
Drawn by: RAS	Scale: N.T.S.		FIELD SERVICES FACILITY SE Hamblen Road LEE'S SUMMIT, MO
Checked by: SJS	File Name:	13910 West 96th Terrace Lenexa, Kansas 66215	
Approved by: SJS	Date: 05/012015	PH. (913) 492-7777 FAX. (913) 492-7443	Exhibit A-3

BORING LOG NO. BH-1

PROJECT: Field Services Facility

CLIENT: City of Lee's Summit
220 Southeast Green Street

SITE: SE Hamblen Road
Lee's Summit, MO

LOCATION See Exhibit A-2

Surface Elev.: 1016.44 (Ft.)

DEPTH	DESCRIPTION	ELEVATION (Ft.)
0.3	**4" TOPSOIL**	1016
10.0	**FAT CLAY (CH)**, dark brown, gray-brown, stiff to very stiff	1006.5
13.5	**FAT CLAY (CH)**, brown-gray	1003
15.0	**SHALE**, sandy, light brown, weathered	1001.5
	Boring Terminated at 15 Feet	

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
1–3			8		3500 (HP)		22	101	
3–5			24		2500 (HP)		30	95	
8–10			16		5500 (HP)		27	102	
13.5–15			16	17-18-15 N=33			24		

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic SPT Hammer

Advancement Method:
0-15': Power auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-13 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS
No free water observed

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 2/24/2014
Boring Completed: 2/24/2014
Drill Rig: CME 45 ATV
Driller: SSS
Project No.: 02145038
Exhibit: A-4

BORING LOG NO. BH-2

PROJECT: Field Services Facility

CLIENT: City of Lee's Summit
220 Southeast Green Street

SITE: SE Hamblen Road
Lee's Summit, MO

LOCATION See Exhibit A-2

Surface Elev.: 1019.60 (Ft.)

DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.3	**4" TOPSOIL**	1019.5										
	FAT CLAY (CH), dark brown, gray-brown, very stiff					8		5500 (HP)		26	97	
						14		4000 (HP)		30	93	
			5									
8.0		1011.5										
	FAT CLAY (CH), brown-gray, very stiff					15		4000 (HP)		25	100	
			10									
14.5		1005				16	8-9-32 N=41			29		
15.0	**SHALE**, sandy, light brown, weathered	1004.5	15									
	Boring Terminated at 15 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic SPT Hammer

Advancement Method:
0-15': Power auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-13 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS
No free water observed

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 2/24/2014	Boring Completed: 2/24/2014
Drill Rig: CME 45 ATV	Driller: SSS
Project No.: 02145038	Exhibit: A-5

BORING LOG NO. BH-3

PROJECT: Field Services Facility

CLIENT: City of Lee's Summit
220 Southeast Green Street

SITE: SE Hamblen Road
Lee's Summit, MO

LOCATION See Exhibit A-2

Surface Elev.: 1021.31 (Ft.)

DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.3	**4" TOPSOIL**	1021										
	FAT CLAY (CH), bark brown, gray-brown, medium stiff to stiff					10		2000 (HP)		27	97	
						16			1832	31	90	
			5									
						24		3500 (HP)		34	91	
			10									
14.5		1007				8	24-50/3"			25		
15.0	**SHALE**, sandy, light brown, weathered	1006.5	15									
	Boring Terminated at 15 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic SPT Hammer

Advancement Method:
0-15': Power auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-13 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 2/24/2014

Boring Completed: 2/24/2014

Drill Rig: CME 45 ATV

Driller: SSS

Project No.: 02145038

Exhibit: A-6

BORING LOG NO. BH-4

PROJECT: Field Services Facility

CLIENT: City of Lee's Summit
220 Southeast Green Street

SITE: SE Hamblen Road
Lee's Summit, MO

LOCATION See Exhibit A-2

Surface Elev.: 1023.91 (Ft.)

DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.3	**4" TOPSOIL**	1023.5										
	FAT CLAY (CH), gray-brown, very stiff to hard					15		5000 (HP)		25	98	65-21-44
						11		+9000 (HP)		20	108	
			5									
8.0		1016										
	FAT CLAY (CH), brown-gray, very stiff					23			4600	27	98	
10.0		1014	10									
	SHALE, light brown, weathered					8	20-50/4"			19		
14.3		1009.5										
	Boring Terminated at 14.3 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic SPT Hammer

Advancement Method:
0-15': Power auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-13 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS
No free water observed

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 2/24/2014	Boring Completed: 2/24/2014
Drill Rig: CME 45 ATV	Driller: SSS
Project No.: 02145038	Exhibit: A-7

BORING LOG NO. BH-5

PROJECT: Field Services Facility

CLIENT: City of Lee's Summit
220 Southeast Green Street

SITE: SE Hamblen Road
Lee's Summit, MO

LOCATION See Exhibit A-2

Surface Elev.: 1023.50 (Ft.)

DEPTH	Material Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.3	**4" TOPSOIL**	1023										
	FAT CLAY (CH), gray-brown, stiff to very stiff					12		3000 (HP)		28	95	
			5			12		5500 (HP)		26	98	
8.0		1015.5										
	FAT CLAY (CH), brown-gray, stiff					15		3500 (HP)		32	93	
10.0		1013.5	10									
	SHALE, light brown, weathered					8	20-50/4"			22		
14.4		1009										

Boring Terminated at 14.4 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic SPT Hammer

Advancement Method:
0-15': Power auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-13 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS
No free water observed

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 2/24/2014	Boring Completed: 2/24/2014
Drill Rig: CME 45 ATV	Driller: SSS
Project No.: 02145038	Exhibit: A-8

BORING LOG NO. BH-6

PROJECT: Field Services Facility

CLIENT: City of Lee's Summit
220 Southeast Green Street

SITE: SE Hamblen Road
Lee's Summit, MO

LOCATION See Exhibit A-2

Surface Elev.: 1021.02 (Ft.)

DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.3	**4" TOPSOIL**	1020.5										
	FAT CLAY (CH), gray-brown, hard					19		+9000 (HP)		32	93	
						12		9000 (HP)		18	108	
5.0		1016	5									
	FAT CLAY (CH), brown-gray, stiff					17		3500 (HP)		29	96	
10.0		1011	10									
	SHALE, sandy, light brown, weathered					16	20-35-50 N=85			19		
15.0		1006	15									
	Boring Terminated at 15 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic SPT Hammer

Advancement Method:
0-15': Power auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-13 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS
No free water observed

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 2/24/2014	Boring Completed: 2/24/2014
Drill Rig: CME 45 ATV	Driller: SSS
Project No.: 02145038	Exhibit: A-9

BORING LOG NO. BH-7

PROJECT: Field Services Facility

CLIENT: City of Lee's Summit
220 Southeast Green Street

SITE: SE Hamblen Road
Lee's Summit, MO

LOCATION See Exhibit A-2

Surface Elev.: 1027.03 (Ft.)

GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	0.7	**8" TOPSOIL**	1026.5										
		FAT CLAY (CH), dark brown, gray-brown, stiff to very stiff					15		2500 (HP)		32	92	
							16			3700	25	98	
				5									
							18		5500 (HP)		27	99	
				10									
	14.0		1013				14		4000 (HP)		29	94	

Boring terminated at 14' upon SH refusal on apparent shale at 14 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic SPT Hammer

Advancement Method:
0-15': Power auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-13 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS
No free water observed

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 2/24/2014	Boring Completed: 2/24/2014
Drill Rig: CME 45 ATV	Driller: SSS
Project No.: 02145038	Exhibit: A-10

BORING LOG NO. BH-8

PROJECT: Field Services Facility

CLIENT: City of Lee's Summit
220 Southeast Green Street

SITE: SE Hamblen Road
Lee's Summit, MO

LOCATION See Exhibit A-2

Surface Elev.: 1029.91 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.3	**8" TOPSOIL**	1029.5										
	FAT CLAY (CH), dark brown, gray-brown, very stiff					8		6500 (HP)		25	95	
						10			4000	28	95	
5.0		1025	5									
	FAT CLAY (CH), brown-gray, very stiff					18		5500 (HP)		24	106	
			10									
13.0		1017										
	FAT CLAY (CH), sandy, light brown, medium stiff					18	3-3-4 N=7			29		
15.0		1015	15									
	Boring Terminated at 15 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic SPT Hammer

Advancement Method:
0-15': Power auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-13 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 2/24/2014 | Boring Completed: 2/24/2014
Drill Rig: CME 45 ATV | Driller: SSS
Project No.: 02145038 | Exhibit: A-11

BORING LOG NO. BH-9

PROJECT: Field Services Facility

CLIENT: City of Lee's Summit
220 Southeast Green Street

SITE: SE Hamblen Road
Lee's Summit, MO

LOCATION See Exhibit A-2

Surface Elev.: 1036.09 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" ASPHALT**	1035.5										
	FAT CLAY, dark brown					10		7000 (HP)		28	93	
						12		2000 (HP)		29	96	
			5									
8.0		1028										
	FAT CLAY (CH), gray-brown, stiff to very stiff					15		2500 (HP)		25	103	
			10									
						17		4500 (HP)		28	95	
15.0		1021	15									
	Boring Terminated at 15 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic SPT Hammer

Advancement Method:
0-15': Power auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-13 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS
No free water observed

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 2/24/2014	Boring Completed: 2/24/2014
Drill Rig: CME 45 ATV	Driller: SSS
Project No.: 02145038	Exhibit: A-12

BORING LOG NO. BH-10

PROJECT: Field Services Facility

CLIENT: City of Lee's Summit
220 Southeast Green Street

SITE: SE Hamblen Road
Lee's Summit, MO

LOCATION See Exhibit A-2

Surface Elev.: 1037.10 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" ASPHALT**	1036.5										
	FAT CLAY (CH), dark brown, with gray					12		4500 (HP)		26	94	62-22-40
						16			4160	30	93	
			5									
8.0		1029										
	FAT CLAY (CH), gray-brown, stiff to very stiff					19		5500 (HP)		23	100	
			10									
						15		2500 (HP)		30	92	
15.0		1022	15									
	Boring Terminated at 15 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic SPT Hammer

Advancement Method:
0-15': Power auger

Abandonment Method:
Boring backfilled with soil cuttings upon completion.

See Exhibit A-13 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS
No free water observed

Terracon
13910 West 96th Terrace
Lenexa, Kansas

Boring Started: 2/24/2014	Boring Completed: 2/24/2014
Drill Rig: CME 45 ATV	Driller: SSS
Project No.: 02145038	Exhibit: A-13

APPENDIX B
LABORATORY TESTS

Laboratory Test Description

Representative soil samples were tested in the laboratory to measure their natural water content, dry unit weight, unconfined compression, and Atterberg limits, as applicable. A pocket penetrometer was used to help estimate the approximate unconfined compressive strength of selected cohesive samples. The test results are provided on the boring logs included in Appendix A.

Descriptive classifications of the soils indicated on the boring logs are in accordance with the enclosed General Notes and the Unified Soil Classification System. Also shown are estimated Unified Soil Classification Symbols. A brief description of this classification system is attached to this report. Classification was by visual manual procedures. Bedrock was classified in general accordance with the enclosed Description of Rock Properties.

APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING		WATER LEVEL	FIELD TESTS	
Auger	Split Spoon	Water Initially Encountered	(HP)	Hand Penetrometer
Shelby Tube	Macro Core	Water Level After a Specified Period of Time	(T)	Torvane
Ring Sampler	Rock Core	Water Level After a Specified Period of Time	(b/f)	Standard Penetration Test (blows per foot)
Grab Sample	No Recovery		(PID)	Photo-Ionization Detector
			(OVA)	Organic Vapor Analyzer

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength, Qu, psf**	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**
Very Loose	0 - 3	0 - 6	Very Soft	less than 500	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	500 to 1,000	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	1,000 to 2,000	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	2,000 to 4,000	8 - 15	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	4,000 to 8,000	15 - 30	19 - 42
			Hard	> 8,000	> 30	> 42

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

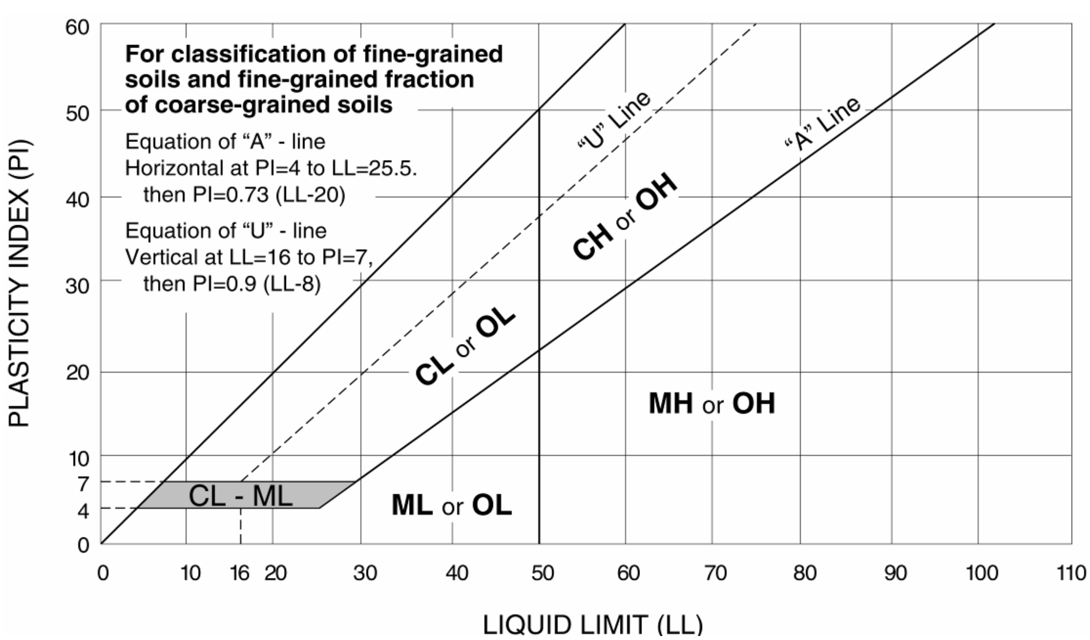
UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification	
				Group Symbol	**Group Name** [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3 [E]	GW	Well-graded gravel [F]
			Cu < 4 and/or 1 > Cc > 3 [E]	GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3 [E]	SW	Well-graded sand [I]
			Cu < 6 and/or 1 > Cc > 3 [E]	SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G,H,I]
			Fines classify as CL or CH	SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line [J]	CL	Lean clay [K,L,M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OL	Organic clay [K,L,M,N]
					Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line	CH	Fat clay [K,L,M]
			PI plots below "A" line	MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OH	Organic clay [K,L,M,P]
					Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.



DESCRIPTION OF ROCK PROPERTIES

WEATHERING

Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" not discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.

HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)

Very hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Joint, Bedding, and Foliation Spacing in Rock [a]		
Spacing	**Joints**	**Bedding/Foliation**
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

a. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

Rock Quality Designator (RQD) a	
RQD, as a percentage	**Diagnostic description**
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

a. RQD (given as a percentage) = length of core in pieces 4 in. and longer/length of run.

Joint Openness Descriptors	
Openness	**Descriptor**
No Visible Separation	Tight
Less than 1/32 in.	Slightly Open
1/32 to 1/8 in.	Moderately Open
1/8 to 3/8 in.	Open
3/8 in. to 0.1 ft.	Moderately Wide
Greater than 0.1 ft.	Wide

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976. U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.