SUBSURFACE EXPLORATION PROPOSED DOUGLAS CORNERS 150 NE DOUGLAS ROAD LEE'S SUMMIT, MISSOURI

Prepared for:

HG CONSULT, INC.
LEE'S SUMMIT, MISSOURI

Prepared by:

GEOTECHNOLOGY, INC.
OVERLAND PARK, KANSAS

Date:

MAY 22, 2018

Geotechnology Project No.:

J032145.01

SAFETY
QUALITY
INTEGRITY
PARTNERSHIP
OPPORTUNITY
RESPONSIVENESS

GEOTECHNOLOGY INC
FROM THE GROUND UP

May 22, 2018

Mr. Kevin Sterrett, P.E.
Hg Consult, Inc.
1411 NE Todd George Road
Lee's Summit, Missouri 64086

Re: Subsurface Exploration
Proposed Douglas Corners
150 NE Douglas Road
Lee’s Summit, Missouri
Geotechnology Project No. J032145.01

Dear Mr. Sterrett:

Presented in this report are the results of the subsurface exploration conducted for the referenced project. This exploration was conducted in general accordance with our proposal P032145.01 dated April 20, 2018. This report includes our project understanding, observed site conditions, conclusions and/or recommendations, and support data as given in the Table of Contents.

It has been our pleasure to provide geotechnical services to you, and we would welcome the opportunity to provide other services during the course of the project. Please contact either of the undersigned if you need further information about this document.

Respectfully submitted,

GEOTECHNOLOGY, INC.

STATE OF MISSOURI
MATTHEW H.
McQUALITY
NUMBER
E-28930
REGISTERED PROFESSIONAL ENGINEER

May 22, 2018

Rob Jeronimus, E.I.T.
Engineer

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RFJ/MHM:rfj/ljd

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SUBSURFACE EXPLORATION
PROPOSED DOUGLAS CORNERS
150 NE DOUGLAS ROAD
LEE'S SUMMIT, MISSOURI
May 22, 2018 | Geotechnology Project No. J032145.01

1.0 EXECUTIVE SUMMARY

The executive summary is provided solely for the purposes of overview, and a number of details are omitted, any one of which could be crucial to the proper application of this report.

The project consists of the construction of a two-story, slab-on-grade retail/apartment building.

- The general stratigraphy of this site consists of approximately 2 feet of fill underlain by medium stiff to stiff, fat clay to a depth of approximately 12 feet. Below the fat clay in one boring slightly weathered shale was sampled to the depth explored of 20 feet. Auger refusal occurred in a second boring at a depth of approximately 12 feet.
- The concrete pavement core was measured to be 7 inches thick and was underlain by 5 inches of crushed rock base course.
- The fill should be considered uncontrolled and unsuitable for support of the structure. Overexcavation of the fill and replacement with compacted fill is recommended. Additional fill remediation criteria are given herein.
- Fat clay below floor slabs must be remediated as discussed herein. Fat clay occurring at pavement subgrade could also be remediated as a measure to improve pavement performance.
- The building may be supported on shallow foundations. Strip and spread footings bearing on firm, native soil and/or engineered fill may be proportioned for net allowable bearing pressures of 1,500 and 2,000 pounds per square feet (psf), respectively.
- Based on the results of the borings, and the general procedures of the 2012 Edition of the International Building Code (IBC), and provided the existing fill is remediated as discussed herein, the soil profile at the project site may be defined as Site Class C (Very Dense Soil and Soft Rock).

2.0 PROJECT DATA

2.1 Authorization

The services documented in this report were provided in general accordance with the scope of services described in Geotechnology's proposal P032145.01 dated April 20, 2018. The project was authorized by a representative of the Hg Consult, Inc.

2.2 Purpose and Scope of Services

The purpose of our services was to develop recommendations for geotechnical aspects of the design and construction of the project as defined in the scope of services of the referenced proposal. Briefly, geotechnical services consisted of site reconnaissance, drilling three borings, performing one pavement core, laboratory testing, engineering analyses and preparation of this report. Important information prepared by the Geotechnical Business Council for studies of the type is included in Appendix A for your review.

2.3 Project Description and Site Location

The project includes the construction of an 8,000-square-foot, two-story, slab-on-grade building. Structural loads were not provided. Based on our experience with similar structures, column and wall loads of up to 150 kips and 6 kips per lineal foot, respectively, are anticipated. Planned grades were not provided but have been assumed to be near existing grades. Consequently, site grading is anticipated to consist of cut and fill amounts of less than 3 feet. Additionally, we understand that the pavements will be subjected to light duty automobile traffic (i.e. passenger vehicles, pickup trucks and SUVs) and an occasional fire truck. We also understand underground utilities will be at a depth of less than 10 feet.

The rectangular project site is located at the northeast corner of NE Tudor Rd and NE Douglas Street. Based on historical aerial photographs, the west half of the site was previously occupied by a single-story, covered parking structure with pavement covering the remainder of the site. Currently, the east and north half of the site includes vegetation, and the southwest portion is a concrete pavement from the previous structure. Overall, the site is relatively flat; however, the northwest portion of the site is approximately 3 to 4 feet higher than the southeast portion of the site. The site location and general topography of the area as per the 2015 U.S.G.S. maps of the vicinity are shown on Plate 1.

3.0 FIELD EXPLORATION AND LABORATORY TESTING

3.1 Field Exploration

The field exploration included drilling three borings and performing one pavement core, designated as Borings B-1 through -3 and Core C-1 at approximately the locations shown on Plate 2. An engineer from Geotechnology located the borings in the field by measuring distances from site features. The elevations at the boring locations were approximated using Google Earth software. A registered land surveyor should establish the boring locations if more accurate measurements are required.

The borings were drilled using an all-terrain Diedrich D-50 rotary drill rig equipped with 4-inch diameter flight augers. Standard Penetration Tests (SPTs) were performed using an automatic hammer. Split spoon and Shelby tube samples were obtained at the depths indicated on the boring logs presented in Appendix B. An explanation of the terms and symbols used on the boring logs is also included in Appendix B.

An engineer from Geotechnology provided direction during field exploration, observed drilling and sampling, and prepared logs of the material encountered. The boring logs represent conditions observed at the time of exploration, and have been edited by a professional engineer to incorporate results of the laboratory tests.

Unless noted on the boring logs, the lines designating the changes between various strata represent approximate boundaries. The transition between materials might be gradual or might occur between recovered samples. The stratification given on the boring logs, or described herein, is for use by Geotechnology in its analyses and should not be used as the basis of design or construction cost estimates without realizing that there can be variation from that shown or described.

The boring logs and related information depict subsurface conditions only at the specific locations and time where sampling was conducted. The passage of time might result in changes in conditions, interpreted to exist, at or between the locations where sampling was conducted.

3.2 Laboratory Testing

Laboratory testing was performed on fine-grained soil and shale samples to estimate engineering and index properties. Moisture content tests were performed on each sample. Atterberg limits tests were performed on selected fine-grained soil samples. Dry unit weight determinations and unconfined compressive strength tests were performed on the Shelby tube samples. Results of the laboratory tests are presented on the boring logs.

4.0 SUBSURFACE CONDITIONS

4.1 Stratigraphy

Surface Cover. Boring B-1 was drilled in a crushed rock area; the crushed rock was measured to be approximately 6 inches thick. Borings B-2 and -3 were drilled a few feet to the east of the existing pavement area in an area surface with vegetation. Core C-1 was located in the existing pavement area; at this location the pavement section consisted of approximately 7 inches of concrete underlain by 5 inches of crushed rock.

Sewer Line (Boring B-1). Below the surficial materials, the stratigraphy at Boring B-1 consists of light brown fat clay fill to a depth of 2 feet underlain by medium stiff to soft, mottled gray brown to reddish tan, fat clay to the explored depth of 10 feet.

Building Footprint (Borings B-2 and -3). Below the surficial materials at Boring B-2, the stratigraphy consists of brown, fat clay fill to a depth of 2 feet underlain by native, medium stiff to stiff, brown to tannish red, fat clay, to a depth of 12 feet underlain, in turn, by slightly weathered shale to the depth explored of 20 feet. Below the surficial materials at Boring B-3, the stratigraphy consists of stiff to medium stiff, mottled tan and dark brown to rust brown, fat clay to the auger refusal depth of 11.5 feet.

4.2 Groundwater

Groundwater was observed at depths of 6 feet to 9 feet at Borings B-1 and -3. Water was encountered at a depth of 3 feet in Boring B-2. This boring is located near the edge of the existing pavement and the water could be due to seepage from the nearby pavement base course (the site had received rain the day before drilling).

Groundwater levels might not have stabilized, particularly in less permeable cohesive soil, prior to backfilling. Water might also be trapped in permeable pockets of fill, in pavement base course, or in utility trenches backfilled with clean rock. Consequently, the indicated groundwater levels might not represent present or future levels. Groundwater levels might vary over time due to the effects of seasonal variation in precipitation, or other factors not evident at the time of exploration. Excavations that remain open might collect water.

5.0 DESIGN CONSIDERATIONS AND RECOMMENDATIONS

Geotechnology should be allowed to review final grading and foundation plans to check that our recommendations have been properly implemented. If the structure loads, elevations or locations vary from those discussed, the recommendations herein might require modifications, and/or additional field exploration and related analysis might be required. Geotechnical features that will influence site development include the potential presence of previous structures; the presence of fill and fat clay, and the shallow depth to shale bedrock. A discussion of each of these features follows.

<u>Previous Structures</u>. Based on review of historical aerial photographs, the site was previously occupied by a covered parking structure. Details of the demolition of this structure are not known. Former footings, floor slabs and abandoned utilities, if present, should be removed and the overexcavations backfilled with engineered fill as discussed herein.

<u>Existing Fill</u>. Loose fill was encountered to a depth of approximately 2 feet in Borings B-1 and -2. Fill is likely in unexplored areas of the site. The extent of the existing fill might not be fully known until construction. The fill should be considered uncontrolled, unsuitable for support of the planned structure, and fully removed.

<u>Fat Clay</u>. Fat clay was encountered in the borings. These materials have the potential for volume change due to fluctuations in moisture content throughout the life of the structure. Swelling and consequent heaving of floors and pavements can occur when a fat clay subgrade absorbs moisture. Alternatively, shrinkage and consequent loss of subgrade support can occur when a fat clay subgrade desiccates. Remediation of fat clay occurring within the upper portion of floor slab subgrade is required, and criteria are given herein. As a measure to improve pavement performance, fat clay occurring at subgrade in new pavement areas could also be remediated.

5.1 Site Grading

<u>Site Preparation</u>. In general, the site should be stripped of existing fill, soft soil, remnants of previous structures, and other deleterious materials. Proofrolling with a tandem axle dump truck

loaded to approximately 20,000 pounds per axle (or equivalent proofrolling equipment) can be considered as a means of evaluating the subgrade. Soft areas that develop should be overexcavated and backfilled with engineered fill compacted to the density outlined in the Compaction Summary.

Remediation of Fat Clay. Fat clay should be remediated to a depth of at least 2 feet below floor slab subgrade. As a measure to improve performance, fat clay could also be remediated to a depth of 12 inches below new pavement sections. The overexcavations may be backfilled with low plasticity soil (liquid limit less than 45 percent) or well-graded crushed limestone with a 2-inch maximum particle size. Chemical remediation of fat clay using lime or fly ash is not advised due to the urban nature of the project and the potential for these caustic materials to become airborne.

The method of treatment previously suggested is based on generally accepted standards in the local engineering community. Clay properties, including plasticity, moisture content, density, swell pressure, and mineralogy are extremely variable and could, in some instances, be conducive to more severe swell pressures and volume change potential than can be mitigated by nominal treatment. Consequently, when building in an area where fat clay is present, the owner should recognize that there is an inherent risk that damage associated with shrink or swell of the soil could occur, even with remedial treatment of subgrade soil.

Suitable Fill Materials. On-site materials generated from excavations are expected to include fat clay. Fat clay may be used for fill provided the material is moisture conditioned and free of deleterious materials; however, fat clay should be restricted to pavement areas only and used below a depth of 2 feet due to its expansive nature.

Imported fill should consist of lean clay (liquid limit value of 45 percent or less) and well-graded crushed limestone with a 2-inch maximum particle size.

Fill and Backfill Placement. Fill or backfill should be placed in uniform lifts and compacted. The loose lift thickness should not exceed 8 inches. The fill should be systematically compacted to the level given in the Compaction Summary. The soil should be placed at moisture contents compatible with the required unit weight. Depending on the soil moisture at the time of construction, drying or wetting might be required to achieve compaction. Deleterious material should not be included in fill, and the fill should not be placed on soft materials or frozen ground.

Table 1. Compaction Summary

Category	Minimum Compaction[a]
Fine-Grained Soil	95%[b]
Pavement Subgrade	
Crushed Limestone	100%

[a] Measured as a percent of the maximum unit weight as determined by the modified Proctor test (ASTM D 1557).

[b] Moisture content within minus 1 to plus 3 percent of the optimum moisture content.

Trench Backfill. Settlement of trench backfill can result in unsightly depressions and localized slab and pavement failures. The magnitude of settlement can be substantially reduced by mechanical compaction of the trench backfill. In floor slab and pavement areas, well-graded crushed rock compacted to the minimum level specified in the Compaction Summary should be used as trench backfill. Poorly-graded (clean) rock must not be used for trench backfill. Clean rock can collect water which can soften the underlying cohesive soils, or lead to the migration of fines and loss of subgrade support, or in the presence of fat clay, could lead to heaving.

Subgrade Protection. Drainage of the construction areas should be provided to protect foundation, floor slab and pavement subgrades from the detrimental effects of weather during construction. Finished subgrades and foundation excavations should be kept free of standing water. Concrete should be placed in foundation excavations the same day they are completed.

Subgrades will be exposed to weather and disturbances from the installation of utilities and normal construction traffic. Disturbance is relatively easy to repair in drier months by reworking of the upper soils. During wetter periods of the year, such as spring and winter, considerable difficulty can be experienced. Construction traffic should be routed away from prepared subgrades.

Collection and Disposal of Site Water. Managing site water is important in the successful performance of foundation and pavement systems. Water from surface runoff, downspouts and subsurface drains should be collected and discharged through a site drainage system. Water should not be allowed to pond next to pavements.

Control of surface runoff should be maintained in compliance with the rules and regulations set forth in the Federal Water Pollution Control Act. Additionally, permits related to site grading activities and control of stormwater during construction activities should be obtained from the applicable governmental jurisdiction(s).

5.2 Temporary Excavations

If site geometry permits, it might be possible to lay slopes back to a stable configuration. The soil type encountered during excavations is anticipated to consist of medium stiff to stiff clay, which classifies as OSHA Type B soil. Temporary slopes per OSHA regulations for this OSHA soil type are 1V:1H or flatter. Per OSHA regulations, slopes below groundwater should be constructed at 1V:1.5H or flatter

The provided soil classification is the professional opinion of Geotechnology. Soil classification relative to temporary slope configuration and worker safety is the responsibility of the contractor. The contractor should be aware that excavation depths and inclinations must comply with local, state or federal safety regulations (e.g., OSHA Health and Safety Standards for Excavations, 29 CFR Part 1926, or successor regulations). Such regulations are strictly enforced and, if not followed, the contractor, or earthwork or utility subcontractors, could be subjected to substantial penalties. Construction site safety is the responsibility of the contractor, who shall also be solely responsible for the means, methods and sequencing of construction operations.

Materials can vary across the excavation, and even if the OSHA criteria are used, there is a potential for slope failure. Temporary slopes left open could undergo sloughing and result in an unstable situation. The contractor should evaluate stability and failure consequences before open cut slopes are made. Minor sloughing of open face slopes can occur. If the slope is expected to remain open for an extended time an impermeable membrane covering the slopes could be considered as a means to reduce the potential for slope degradation and instability.

5.3 Shallow Foundations

Allowable Bearing Pressure. Strip and spread footings may be proportioned for net allowable bearing pressures of 1,500 and 2,000 psf provided the footings are bearing on firm, native soil or compacted fill as discussed herein. The minimum lateral dimensions for strip and spread footings should be 18 and 24 inches, respectively. As a measure to provide protection from seasonal moisture variations and frost penetration, exterior footings and footings in unheated interior areas should bear at least 36 inches below grade.

Construction Considerations. If soft soil is encountered at footing bearing elevations, footing excavations should be extended through these materials to firm, native soil and the overexcavation backfilled with concrete or lean concrete.

Settlement. Footings, proportioned and constructed as recommended herein, could settle approximately 1 inch. Differential settlement between footings could be approximately ¾ inch. Estimated values of settlement contained in this report are based on our experience with projects of a similar nature.

Lateral Resistance. Lateral loads may be resisted by available frictional resistance between the base of the footing and the bearing material. Resistance to sliding can be computed assuming an ultimate coefficient of friction of 0.35; however, the maximum resistance should be limited to 500 psf. Ultimate passive resistance, if required, can be computed assuming an equivalent fluid pressure of 300 pounds per cubic foot. Safety factors should be applied to determine the allowable sliding and passive resistances. Passive resistance in the top 36 inches of soil should be neglected due to seasonal variations in moisture and frost penetration.

Uplift Resistance. Uplift loads can be resisted with the dead weight of the footings and the structure, and frictional resistance between the sides of the footings and the soil. An allowable resistance of 350 psf can be used for frictional resistance between the sides of the footings and the soil provided the footings are earth-formed or engineered backfill is placed around them. Frictional resistance in the top 36 inches of soil should be neglected due to seasonal variations in moisture and frost penetration.

5.4 Floor Slabs

Existing fill and fat clay should be remediated as previously discussed. Floor slabs can be designed using a vertical subgrade modulus of 100 pounds per cubic inch (pci). Floor slabs should be underlain by a minimum 4-inch layer of compacted well-graded crushed rock. A 15-mil or thicker plastic vapor barrier can be placed below the floor in interior finished areas to reduce the potential for moisture permeation through the slab and for mold growth within the building. Notwithstanding other structural considerations, slab-on-grade floors should be designed to allow for differential movements that normally occur between the floor slab, columns, and foundation walls.

5.5 Pavement Considerations

A pavement design and analysis was beyond the scope of our services. Standard pavement design for a given service life requires evaluation of the soil by CBR tests or other methods, estimates of daily traffic volumes and axle weights, drainage requirements, and the desired level of maintenance.

At the location of Core C-1, the pavement section consisted of 7 inches of concrete underlain by 5 inches of crushed rock. A photograph of the concrete core is below. Such a pavement section is expected to support the anticipated traffic.

In accordance with the City of Lee's Summit Unified Development Ordinance Section 12.120 Parking Lot Design Item F, new pavements should consist of 6 inches of Portland cement concrete underlain by 4 inches of MoDOT Type 5 compacted aggregate base course. The soil subgrade should be stable and compacted as specified in Table 1. In addition, fat clay in new pavement areas could be remediated as previously discussed. Pavement service life can decrease if the pavement is constructed on a poor subgrade, if it has poor surface or subsurface drainage, and/or if the pavement is not maintained. Periodic maintenance, such as filling cracks and sealing, is required for a pavement section to achieve its design life.

If pavements are not constructed immediately after grading, the subgrade should be shaped to prevent ponding. Minor ponding, of even short duration, can cause softening of a soil subgrade to a substantial depth. If there is substantial lapse of time between grading and paving, or if the subgrade is disturbed by construction activities, the subgrade should be proofrolled. Soft spots observed during initial construction or proofrolling should be removed and replaced with compacted soil of the same type present in the subgrade, possibly combined with a geotextile or geogrid. The rock base course and soil subgrade should be compacted as specified in Table 1.

Depending on when the pavement is constructed, the subgrade might not support construction equipment such as rock trucks or concrete trucks, which have substantially heavier axle loads than those vehicles that the pavement section is expected to support. Such conditions will be more apparent during wetter periods of the year. Overexcavation of soft subgrade and placement of additional base course and/or geogrid could be required to construct pavements during these periods.

5.6 Seismicity

Per the general procedures of Section 1613.1 of the 2012 edition of the IBC, the soil profile at the project site can be defined as Class C (Very Dense Soil and Soft Rock) provided the existing fill/soft soil is remediated as discussed herein. Based on the computer program *U.S. Seismic Design Maps Web Application* prepared by the United States Geological Survey (USGS), the mapped maximum considered earthquake spectral response acceleration is approximately 11.4 percent gravity (0.114 g) at short periods (S_S) and 6.7 percent gravity (0.067 g) at 1-second periods (S_1).

6.0 RECOMMENDED ADDITIONAL SERVICES

The conclusions and recommendations given in this report are based on: Geotechnology's understanding of the proposed design and construction, as outlined in this report; site observations; interpretation of the exploration data; and our experience. Since the intent of the design recommendations is best understood by Geotechnology, we recommend that Geotechnology be included in the final design and construction process, and be retained to review the project plans and specifications to confirm that the recommendations given in this report have been correctly implemented. We recommend that Geotechnology be retained to participate in prebid and preconstruction conferences to reduce the risk of misinterpretation of the conclusions and recommendations in this report relative to the proposed construction of the subject project.

Since actual subsurface conditions between boring locations may vary from those encountered in the borings, our design recommendations are subject to adjustment in the field based on the subsurface conditions encountered during construction. Therefore, we recommend that Geotechnology be retained to provide construction observation services as a continuation of the design process to confirm the recommendations in this report and to revise them accordingly to accommodate differing subsurface conditions. Construction observation is intended to enhance compliance with project plans and specifications. It is not insurance, nor does it constitute a warranty or guarantee of any type. Regardless of construction observation, contractors, suppliers, and others are solely responsible for the quality of their work and for adhering to plans and specifications.

7.0 LIMITATIONS OF REPORT

This report has been prepared on behalf of, and for the exclusive use of the client for specific application to the named project as described herein. If this report is provided to other parties, it should be provided in its entirety with all supplementary information. In addition, the client should make it clear that the information is provided for factual data only, and not as a warranty of subsurface conditions presented in this report.

Geotechnology has attempted to conduct the services reported herein in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality and under similar conditions. The recommendations and conclusions contained in this report are professional opinions. The report is not a bidding document and should not be used for that purpose.

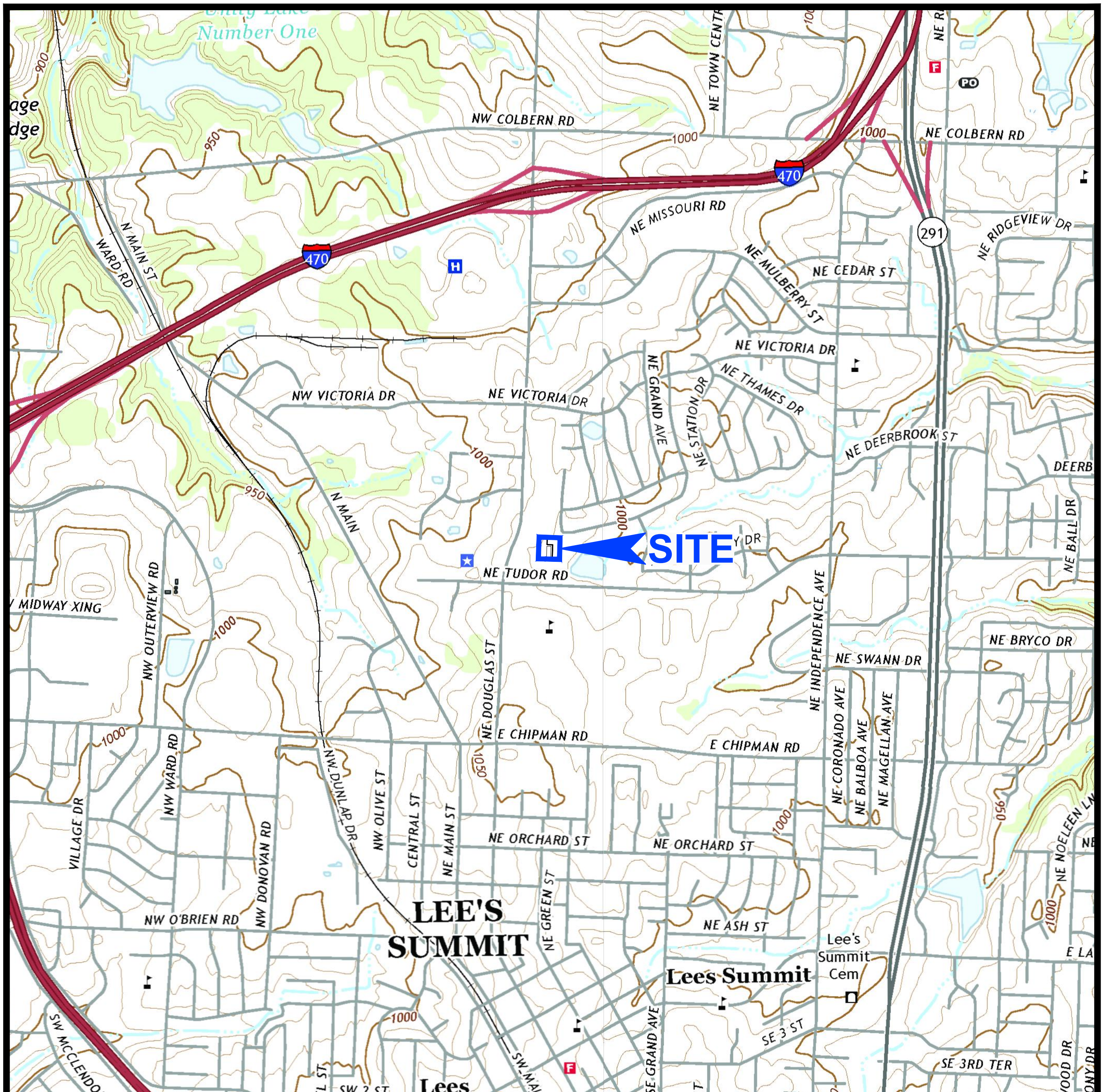
Our scope of service for this phase of the project did not include any environmental assessment or investigation for the presence or absence of wetlands or hazardous or toxic materials in the soil, surface water, groundwater, or air, on or below or around this site. Any statements in this report or on the boring logs regarding odors noted or unusual or suspicious items or conditions observed are strictly for the information of our client. Our scope of service did not include an assessment of the effects of flooding and erosion of creeks or rivers adjacent to or on the project site.

The analyses, conclusions, and recommendations contained in this report are based on the data obtained from the subsurface exploration. The field exploration methods used indicate subsurface conditions only at the specific locations where samples were obtained, only at the time they were obtained, and only to the depths penetrated. Consequently, subsurface conditions may vary gradually, abruptly, and/or nonlinearly between sample locations and/or intervals.

The conclusions or recommendations presented in this report should not be used without Geotechnology's review and assessment if the nature, design, or location of the facilities is changed, if there is a substantial lapse in time between the submittal of this report and the start of work at the site, or if there is a substantial interruption or delay during work at the site. If changes are contemplated or delays occur, Geotechnology must be allowed to review them to assess their impact on the findings, conclusions, and/or design recommendations given in this report. Geotechnology will not be responsible for any claims, damages, or liability associated with any other party's interpretations of the subsurface data or with reuse of the subsurface data or engineering analyses in this report.

The recommendations included in this report have been based in part on assumptions about variations in site stratigraphy that may be evaluated further during earthwork and foundation construction. Geotechnology should be retained to perform construction observation and continue its geotechnical engineering service using observational methods. Geotechnology cannot assume liability for the adequacy of its recommendations when they are used in the field without Geotechnology being retained to observe construction.

A copy of "Important Information about This Geotechnical-Engineering Report" that is published by the Geotechnical Business Council (GBC) of the Geoprofessional Business Association (GBA) is included in Appendix A for your review. The publication discusses some other limitations, as well as ways to manage risk associated with subsurface conditions.



NOTES

1. Plan adapted from 7.5 minute U.S.G.S. maps for Lees Summit and Lake Jacomo, Missouri quadrangles, last revised in 2017.

0 2,000 4,000

SCALE IN FEET

N

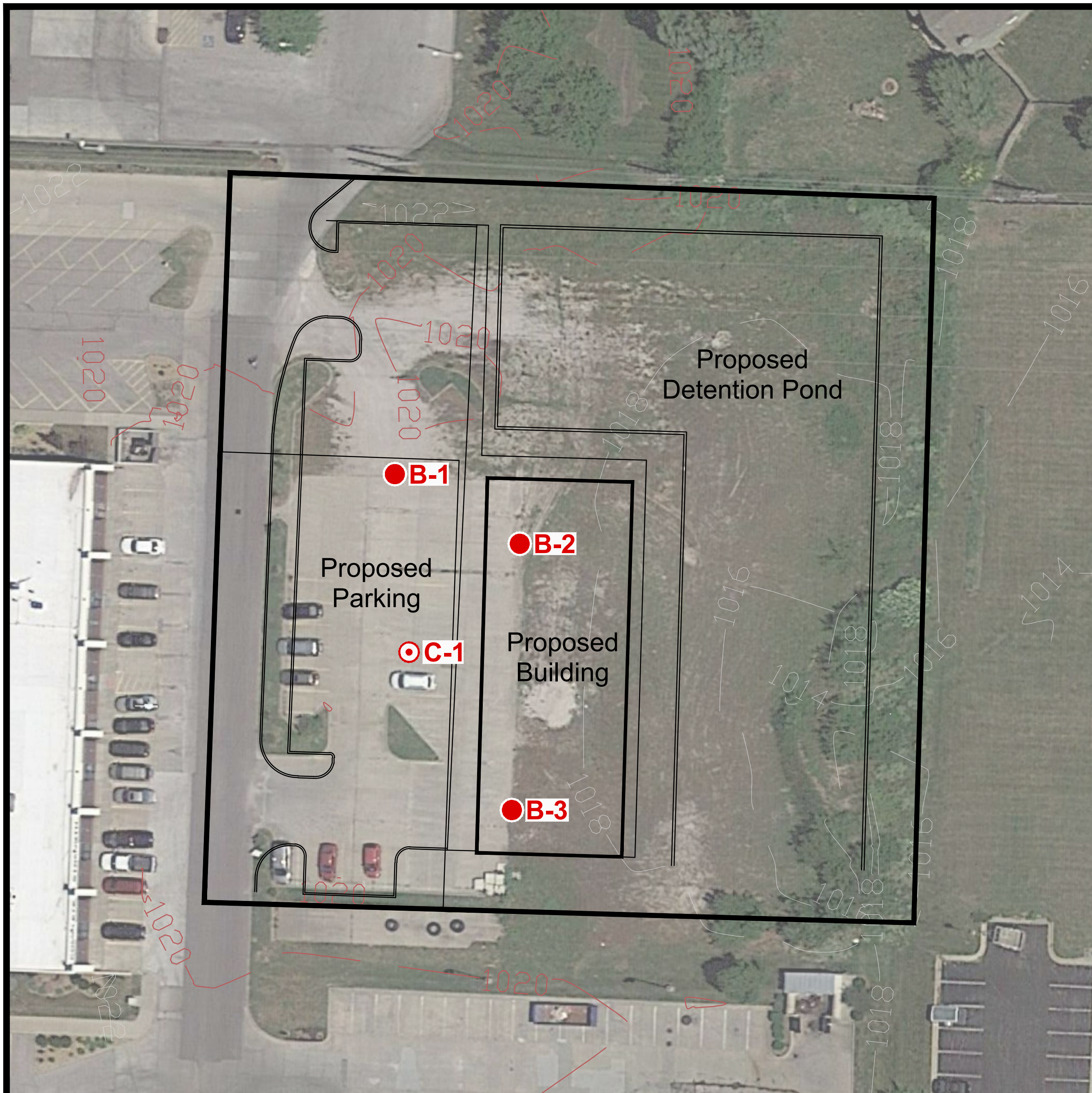
Drawn By: WAH	Ck'd By: RFJ	App'vd By: MHM
Date: 5-2-18	Date: 5-16-18	Date: 5-17-18

GEOTECHNOLOGY INC
FROM THE GROUND UP

Proposed Douglas Corners
150 NE Douglas Road
Lee's Summit, Missouri

SITE LOCATION AND TOPOGRAPHY

Project Number J032145.02	PLATE 1



NOTES

1. Plan adapted from a June 10, 2017 aerial photograph courtesy of Google Earth and a drawing dated April 13, 2018 titled "Concept Plan D" prepared by Hg Consult, Inc.

2. Borings were located in the field with reference to site features and are shown approximate only.

LEGEND

- Boring Location
- Pavement Core Location

0 60 120

SCALE IN FEET

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Drawn By: WAH	Ck'd By: RFJ	App'vd By: MHM
Date: 5-2-18	Date: 5-16-18	Date: 5-17-18

GEOTECHNOLOGY INC
FROM THE GROUND UP

Proposed Douglas Corners
150 NE Douglas Road
Lee's Summit, Missouri

AERIAL PHOTOGRAPH OF SITE AND BORING LOCATIONS

Project Number
J032145.02

PLATE 2

APPENDIX A

Important Information about This Geotechnical-Engineering Report

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a civil engineer may not fulfill the needs of a constructor — a construction contractor — or even another civil engineer. Because each geotechnical- engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. No one except you should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply this report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical-engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

Geotechnical Engineers Base Each Report on a Unique Set of Project-Specific Factors

Geotechnical engineers consider many unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk-management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical-engineering report that was:

- not prepared for you;
- not prepared for your project;
- not prepared for the specific site explored; or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical-engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical-engineering report is based on conditions that existed at the time the geotechnical engineer performed the study. *Do not rely on a geotechnical-engineering report whose adequacy may have been affected by*: the passage of time; man-made events, such as construction on or adjacent to the site; or natural events, such as floods, droughts, earthquakes, or groundwater fluctuations. *Contact the geotechnical engineer before applying this report to determine if it is still reliable.* A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ — sometimes significantly — from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide geotechnical-construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are Not Final

Do not overrely on the confirmation-dependent recommendations included in your report. *Confirmation-dependent recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations *only* by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's confirmation-dependent recommendations if that engineer does not perform the geotechnical-construction observation required to confirm the recommendations' applicability.*

A Geotechnical-Engineering Report Is Subject to Misinterpretation

Other design-team members' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Constructors can also misinterpret a geotechnical-engineering report. Confront that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing geotechnical construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical-engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make constructors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give constructors the complete geotechnical-engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise constructors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure constructors have sufficient time* to perform additional study. Only then might you be in a position to give constructors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and constructors fail to recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Environmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform an *environmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold-prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, many mold- prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical- engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; *none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.*

Rely, on Your GBC-Member Geotechnical Engineer for Additional Assistance

Membership in the Geotechnical Business Council of the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you GBC-Member geotechnical engineer for more information.

GEOTECHNICAL BUSINESS COUNCIL
of the Geoprofessional Business Association

8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 Facsimile: 301/589-2017
e-mail: info@geoprofessional.org www.geoprofessional.org

APPENDIX B

Logs of borings B-1 through -3
Boring Log: Terms and Symbols
Rock: Terms and Symbols

Surface Elevation 1020

Datum WGS84

Completion Date: 4/26/18

SHEAR STRENGTH, tsf

△ - UU/2 ○ - QU/2 □ - PP/2

0.5 1.0 1.5 2.0 2.5

STANDARD PENETRATION RESISTANCE

(ASTM D 1586)

▲ N-VALUE (BLOWS PER FOOT)

WATER CONTENT, %

PL ⊢ ● ⊣ LL

10 20 30 40 50

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD	SAMPLES
	FILL - crushed limestone base			
	FILL - light brown, fat		5-7-7	SS1
	CLAY - mottled gray brown to reddish tan, fat, medium stiff to soft - CH		2-4-5	SS2
5	∇		2-3-4	SS3
			2-2-2	SS4
10	Boring terminated at 10 feet.			
15				
20				

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

GROUNDWATER DATA

ENCOUNTERED AT 6 FEET

DRILLING DATA

4" AUGER ___ HOLLOW STEM

WASHBORING FROM ___ FEET

ALL DRILLER RFJ LOGGER

Diedrich D-50 DRILL RIG

HAMMER TYPE Auto

REMARKS:

Drawn by: RFJ	Ck'd. by: RFJ	App'vd. by: MHM
Date: 5/2/18	Date: 5/16/18	Date: 5/16/18

GEOTECHNOLOGY INC FROM THE GROUND UP

Proposed Douglas Corners
150 NE Douglas Road
Lee's Summit, Missouri

LOG OF BORING: B-1

Project No. J032145.01

Surface Elevation 1019

Datum WGS84

Completion Date: 4/26/18

DEPTH IN FEET	DESCRIPTION OF MATERIAL	DRY UNIT WEIGHT (pcf) / SPT BLOW COUNTS / CORE RECOVERY/RQD	SAMPLES
	TOPSOIL - 6 inches		
	FILL - brown, some limestone fragments, fat clay	4-3-2	SS1
	CLAY - dark brown to tannish red, fat, soft to medium stiff - (CH)	2-4-5	SS2
5		94	ST3
		2-2-3	SS4
10			
	SHALE - gray, slightly weathered, soft		
	pocket of black	38-50/4"	SS5
15			
		17-30-43	SS6
20	Boring terminated at 20 feet.		

SHEAR STRENGTH, tsf: △ - UU/2 ○ - QU/2 □ - PP/2 (0.5, 1.0, 1.5, 2.0, 2.5)

STANDARD PENETRATION RESISTANCE (ASTM D 1586) ▲ N-VALUE (BLOWS PER FOOT)

WATER CONTENT, %: PL — LL (10, 20, 30, 40, 50)

66 >>

73

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

GROUNDWATER DATA

ENCOUNTERED AT 3 FEET

DRILLING DATA

4" AUGER ___ HOLLOW STEM

WASHBORING FROM ___ FEET

ALL DRILLER RFJ LOGGER

Diedrich D-50 DRILL RIG

HAMMER TYPE Auto

REMARKS: Groundwater observed could be trapped in nearby pavement base course.

Drawn by: RFJ	Ck'd. by: RFJ	App'vd. by: MHM
Date: 5/2/18	Date: 5/16/18	Date: 5/16/18

GEOTECHNOLOGY INC FROM THE GROUND UP

Proposed Douglas Corners
150 NE Douglas Road
Lee's Summit, Missouri

LOG OF BORING: B-2

Project No. J032145.01

Surface Elevation 1019	Completion Date: 4/26/18
Datum WGS84	

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

SHEAR STRENGTH, tsf: Δ - UU/2 ○ - QU/2 □ - PP/2 (0.5, 1.0, 1.5, 2.0, 2.5)

STANDARD PENETRATION RESISTANCE (ASTM D 1586) ▲ N-VALUE (BLOWS PER FOOT)

WATER CONTENT, % PL ● LL (10, 20, 30, 40, 50)

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GRAPHIC LOG	DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD	SAMPLES
	TOPSOIL - 6 inches			
	CLAY - mottled tan and dark brown to rust brown, fat, stiff to medium stiff - (CH)			
			3-4-6	SS1
			3-4-5	SS2
5				
			95	ST3
		▽	2-3-3	SS4
10				
	Auger refusal at 11.5 feet.			
15				
20				

GROUNDWATER DATA

ENCOUNTERED AT 9 FEET

DRILLING DATA

4" AUGER ___ HOLLOW STEM

WASHBORING FROM ___ FEET

ALL DRILLER RFJ LOGGER

Diedrich D-50 DRILL RIG

HAMMER TYPE Auto

REMARKS:

Drawn by: RFJ	Ck'd. by: RFJ	App'vd. by: MHM
Date: 5/2/18	Date: 5/16/18	Date: 5/16/18

GEOTECHNOLOGY INC
FROM THE GROUND UP

Proposed Douglas Corners
150 NE Douglas Road
Lee's Summit, Missouri

LOG OF BORING: B-3

Project No. J032145.01

BORING LOG: TERMS AND SYMBOLS

GENERAL NOTES

1. *Information on each boring log is a compilation of subsurface conditions based on soil or rock classifications obtained from the field as well as from laboratory testing of samples. The strata lines on the logs may be approximate or the transition between the strata may be gradual rather than distinct. Water level measurements refer only to those observed at the times and places indicated, and may vary with time, geologic condition or construction activity.*
2. *Relative composition and Unified Soil Classification designations are based on visual estimates and are approximate only. If laboratory tests were performed to classify the soil, the unified designation is show in parenthesis.*
3. *Value given in Unit Dry Weight/SPT Column is either a unit dry weight in pounds per cubic foot, if adjacent to a ST sample designation, or blows per 6-inch increment if adjacent to a SS sample designation.*

ABBREVIATIONS

UU/2	*Shear Strength from Unconsolidated – Undrained Triaxial Test (ASTM D2850)*
QU/2	*Shear Strength from Unconfined Compression Test (ASTM D2166)*
SV	*Shear Strength from Field Vane (ASTM D2573)*
PL	*Plastic Limit (ASTM D4318)*
LL	*Liquid Limit (ASTM D4318)*

LEGEND

CS	Continuous Sampler
GB	Grab Sample Taken From Auger Cuttings or Wash Water Return
NX 100/42	NX Rock Core with Percent Recovery/R.Q.D. Given In Adjacent Column
PST	Three Inch Diameter Piston Tube Sample
SS	Split Spoon Sample (Standard Penetration Test)
ST	Three Inch Diameter Shelby Tube Sample
*	Sample Not Recovered
SV	Field Vane Test

SPLIT – BARREL SAMPLER DRIVING RECORD

Blow per Foot (N-Value)	*Description*
25	*25 blows drove sampler 12 inches after initial 6 inches of seating.*
75/10”	*75 blows drove sampler 10 inches after initial 6 inches of seating.*
50/S3”	*50 blows drove sampler 3 inches during initial 6 inch seating interval.*

NOTES:
1. *To avoid damage to sampling tools, driving is limited to 50 blows during any six inch interval.*
2. *N-Value (Blow Count) is the standard penetration resistance based on the total number of blows, using a 140-lb hammer with 30-inch free fall, required to drive a split spoon the last two of three, 6-inch drive increments. (Example: 4/7/9, N = 7 + 9 = 16). Values are shown as a summation on grid plot and may be shown as 4/7/9 in Unit Dry Weight – SPT column.*

RELATIVE COMPOSITION

Trace……………………...0-10 %
With/Some…………...11-35 %
Soil modifier such…..... > 35 %
As silty, clayey, sandy, etc.

DENSITY OF GRANULAR SOILS

Descriptive Term:	***N—Value***
Very Loose	*0 - 4*
Loose	*5 - 10*
Medium Dense	*11 - 30*
Dense	*31 - 50*
Very Dense	*> 50*

STRENGTH OF COHESIVE SOILS

Consistency	***Undrained Shear Strength Tons Per Sq. Ft.***	***Field Test***	***Approximate N-Value Range***
Very Soft	*less than 0.12*	*Thumb will penetrate soil more than 1”*	*0 - 1*
Soft	*0.13 to 0.25*	*Thumb will penetrate soil about 1”*	*2 - 4*
Medium Stiff	*0.26 to 0.50*	*Thumb will penetrate soil about ¼”*	*5 – 8*
Stiff	*0.51 to 1.00*	*Thumb hardly indents soil*	*9 – 15*
Very Stiff	*1.01 to 2.00*	*Thumb will not indent soil, but readily indented with thumbnail*	*16 – 30*
Hard	*greater than 2.00*	*Thumbnail will not indent soil*	*> 30*

SOIL GRAIN SIZE

U.S. STANDARD SIEVE

	12”		3”		¾“		4		10		40		200		
BOULDERS		COBBLES		GRAVEL COARSE		GRAVEL FINE		SAND COARSE		SAND MEDIUM		SAND FINE		SILT	CLAY
	300		76.2		19.1		4.76		2.00		0.42		0.074		0.002

SOIL GRAIN SIZE IN MILLIMETERS

SOIL STRUCTURE

Calcareous *– Having appreciable quantities of carbonate.*

Fissured *– Containing shrinkage or relief cracks, often filled with sand or silt; usually more or less vertical.*

Slickensided *– Having planes of weakness that appear slick and glossy. The degree of slickensidedness depends upon the spacing of slickensides and the ease of breaking along those planes.*

Layer *-- Inclusion greater than 3 inches thick.*

Seam *– Inclusion 1/8 inch to 3 inches thick extending through the sample*

Parting *– Inclusion less than 1/8 inch thick.*

Pocket *– Inclusion of material of different texture that is smaller than the diameter of the sample.*

Interlayered *– Soil samples composed of alternating layers of different soil types.*

Intermixed *– Soil samples composed of pockets of different soil types and a layered or laminated structure is not evident.*

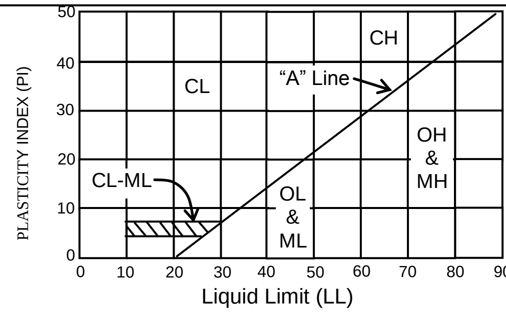
Laminated *– Soil sample composed of alternating partings or seams of different soil type.*

GEOTECHNOLOGY INC
FROM THE GROUND UP

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			SYMBOL	DESCRIPTION
Coarse-Grained Soils (More than 50% Larger than No 200 Sieve Size)	Gravel and Gravelly Soils	Clean Gravels Little or no Fines	GW	Well-Graded Gravel, Gravel-Sand Mixture
			GP	Poorly –Graded Gravel, Gravel-Sand Mixture
		Gravels with Appreciable Fines	GM	Silty Gravel, Gravel-Sand-Silt Mixture
			GC	Clayey-Gravel, Gravel-Sand-Clay Mixture
	Sand and Sandy Soils	Clean Sands Little or no Fines	SW	Well-Graded Sand, Gravelly Sand
			SP	Poorly Graded Sand, Gravelly Sand
		Sands with Appreciable Fines	SM	Silty Sand, Sand-Silt Mixture
			SC	Clayey Sand, Sand-Clay Mixture
Fine-Grained Soils (More than 50% Smaller than No 200 Sieve Size)	Silts and Clays	Liquid Limit Less Than 50	ML	Silt, Clayey Silt, Silty or Clayey Very Fine Sand, Slight Plasticity
			CL	Clay, Sandy Clay, Silty Clay, Low to Medium Plasticity
			OL	Organic Silts, or Silty Clays of Low Plasticity
	Silts and Clays	Liquid Limit More Than 50	MH	Silt, Fine Sandy or Silt Soil with High Plasticity
			CH	Clay, High Plasticity
			OH	Organic Clay of Medium to High Plasticity
	Highly Organic Soils		PT	Peat, Humus, Swamp Soil

PLASTICITY CHART



RELATIVE PLASTICITY

Nonplastic	Cannot Roll Into Ball
Trace Plasticity	Barely Roll Into Ball
Medium Plastic	Can be Rolled Into Ball
Highly Plastic	No Rupture by Kneading

VISUAL DESCRIPTION CRITERIA*

TABLE 1: CRITERIA FOR DESCRIBING ANGULARITY OF COARSE-GRAINED PARTICLES

Description	***Criteria***
Angular	*Particles have sharp edges and relatively plane sides with unpolished surfaces*
Subangular	*Particles are similar to angular description but have rounded edges*
Subrounded	*Particles have nearly plane sides but have well-rounded corners and edges*
Rounded	*Particles have smoothly curved sides and no edges*

TABLE 2: CRITERIA FOR DESCRIBING PARTICLE SHAPE

Description	***Criteria***
Flat	*Particles with width/thickness X3*
Elongated	*Particles with length/width X3*
Flat and Elongated	*Particles meet criteria for both flat and elongated*

TABLE 3: CRITERIA FOR DESCRIBING MOISTURE CONDITION

Description	***Criteria***
Dry	*Absence of moisture, dusty, dry to the touch*
Moist	*Damp, but no visible water*
Wet	*Visible free water, usually soil is below the water table*

TABLE 4: CRITERIA FOR DESCRIBING REACTION WITH HCL

Description	***Criteria***
None	*No visible reaction*
Weak	*Some reaction, with bubbles forming slowly*
Strong	*Violent reaction, with bubbles forming rapidly*

TABLE 6: CRITERIA FOR DESCRIBING CEMENTATION

Description	***Criteria***
Weak	*Crumbles or breaks with handling or little finger pressure*
Moderate	*Crumbles or breaks with considerable finger pressure*
Strong	*Will not crumble or break with finger pressure*

**NOTES: 1. Tables adapted from ASTM D2488 "Description and identification of Soils" (Visual-Manual Procedure)*
2. Tables 5, 7 and 11 incorporated into other information on this plate.

TABLE 8: CRITERIA FOR DESCRIBING DRY STRENGTH

Description	***Criteria***
None	*The dry specimen crumbles into powder with mere pressure of handling*
Low	*The dry specimen crumbles into powder with some finger pressure*
Medium	*The dry specimen breaks into pieces or crumbles with considerable finger pressure*
High	*The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface.*
Very High	*The dry specimen cannot be broken between the thumb and a hard surface*

TABLE 9: CRITERIA FOR DESCRIBING DILATANCY

Description	***Criteria***
None	*No visible change in the specimen*
Slow	*Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.*
Rapid	*Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.*

TABLE 10: CRITERIA FOR DESCRIBING TOUGHNESS

Description	***Criteria***
Low	*Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft.*
Medium	*Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness*
High	*Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness*

TABLE 12: IDENTIFICATION OF INORGANIC FINE-GRAINED SOILS FROM MANUAL TESTS

Soil Symbol	***Dry Strength***	***Dilatancy***	***Toughness***
ML	*None to low*	*Slow to rapid*	*Low or thread cannot be formed*
CL	*Medium to high*	*None to slow*	*Medium*
MH	*Low to medium*	*None to slow*	*Low to medium*
CH	*High to very high*	*none*	*High*

ROCK: TERMS AND SYMBOLS

Field descriptions can include the following:

TERM	REFERENCE
Hardness	Table 1
Color	(1)
Crystallinity	Table 2
Bedding	Table 3
Weathering	Table 4
Fabric (if applicable)	Table 5
Jointing (including filling)	Table 6
Voids	Table 7
RQD	Table 8
Sorting Criteria	Figure 1
Angularity Criteria	Figure 2

TABLE 1: ROCK HARDNESS

DESCRIPTION	CRITERIA
Very Soft	- Easily indented with the thumb
Soft	- Able to be scratched with a fingernail
Moderately Hard	- Easily scratched with a knife; Cannot be scratched with the fingernail
Hard	- Difficult to scratch with a knife
Very Hard	- Cannot be scratched with a knife

TABLE 2: ROCK CRYSTALLINITY

DESCRIPTION	CRITERIA
Aphanitic (Micritic)	- Crystals cannot be distinguished with the naked eye
Very Finely Crystalline	- Crystals are barely discernable with the naked eye
Finely Crystalline	- Crystals are easily discernable with the naked eye
Medium Crystalline	- Crystals are medium size; up to 1/8" in diameter
Coarsely Crystalline	- Crystals are 1/8" to 1/4" in Diameter
Very Coarsely Crystalline	- Crystals are larger than 1/4" In diameter

TABLE3: ROCK MASS BEDDING

DESCRIPTION	CRITERIA
Parting	- Less than 0.02 foot (<0.60 cm)
Band	- 0.02 to 0.2 foot (0.60 to 6.1 cm)
Thin Bed	- 0.2 to 0.5 foot (6.1 to 15.2 cm)
Medium Bed	- 0.5 to 1.0 foot (15.2 to 30.5 cm)
Thick Bed	- 1.0 to 2.0 feet (30.5 to 61.0 cm)
Massive	- Greater than 2.0 feet (>61.0 cm)

TABLE 4: ROCK WEATHERING

DESCRIPTION	CRITERIA
Fresh	- No visible signs of decomposition or discoloration
Slightly Weathered	- Slight discoloration inward from open fractures
Moderately Weathered	- Discoloration throughout, slight loss of strength, texture intact
Highly Weathered	- Specimens can be broken by hand, texture indistinct, fabric intact
Completely Weathered	- Specimens easily crumbled, minerals decomposed to soil
Residual Soil	- Advanced state of decomposition resulting in plastic soil

TABLE 5: ROCK FABRIC

DESCRIPTION	CRITERIA
Equigranular	- Grains essentially of equal size
Porphyritic	- Mixed coarse and fine grains
Amorphous	- No definite crystal form (Glass)
Platy	- Schistose or foliated, planar

TABLE 6: ROCK JOINTING

DESCRIPTION	CRITERIA	
Very Wide	>3.25 ft.	(>3 m)
Wide	1.1 – 3.25 ft.	(1-3 m)
Moderately Wide	0.3 – 1.1 ft.	(0.3 – 1 m)
Close	0.05 – 0.3 ft.	(0.05 – 0.3 m)
Very Close	<0.05 ft.	(<0.05 m)

TABLE 7: ROCK VOIDS

DESCRIPTION	CRITERIA
Dense	- Usually not discernable with the naked eye
Pit (Pitted)	- Discernable to 1/4"
Vug (Vuggy)	- 1/4" to diameter of the core
Cavity	- Larger than 6" in diameter

ROCK 8: ROCK QUALITY

PERCENT RQD	QUALITY
90 to 100	Excellent
75 to 90	Good
50 to 75	Fair
25 to 50	Poor
0 to 25	Very Poor

FIGURE 1: Sorting Criteria

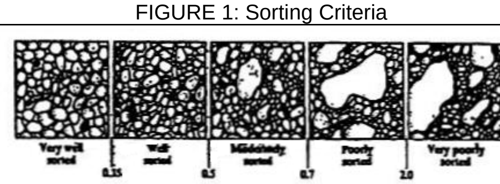
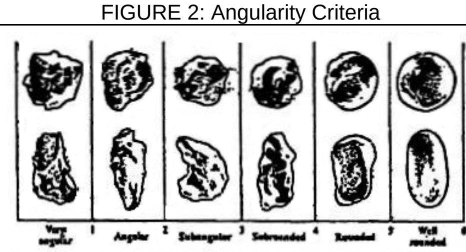


FIGURE 2: Angularity Criteria



GEOTECHNOLOGY INC
FROM THE GROUND UP

TYPE SPECIFIC CHARACTERISTICS

CHARACTERISTICS OF DETRITAL SEDIMENTARY ROCKS

ROCK TYPE	CHARACTERISTICS
	COARSE-GRAINED
Conglomerates	- Rounded fragments of any type rock; cementing agent chiefly silica, but iron, clay, and calcareous material also common/
Breccia	- Angular fragments of any type rock; resulting from glaciation, rock falls, cave collapse, and/or fault movements.
	MEDIUM-GRAINED
Sandstones	- Predominantly quartz grains cemented by silica, iron,clay or carbonate material. Color depends on cementing agent; porous and pervious; hard and generally thickly bedded.
Arkose	- Similar to sandstone but at least 25% feldspar.
Graywacke	- Angular particles of a variety of minerals in a clay matrix; indurated, impure sandstone.
	FINE-GRAINED
Siltstone	- Composition similar to sandstone but at least 50% of grains 0.002 – 0.02mm in size. Rarely forms thick beds, but often hard.
Shale	- Predominant particles, <0.002mm; a wall defined fissile fabric. Commonly interbedded with sandstone and relatively soft.
Argillites	- Hard, indurated shales devoid of fissility.
Clay Shale	- Moderately indurated shales.
Claystone	- Clay-size particles compacted into rock without a fissle structure (stiff to hard consistency).

CHARACTERISTICS OF NON-DETRITAL SEDIMENTARY ROCKS

ROCK TYPE	CHARACTERISTICS
	CALCAREOUS PRECIPITATES
Limestone	- Contains more than 50% calcium carbonate. The calcite can be precipitated chemically, organically, or it may be detrital in origin. Reacts violently with dilute HCL.
Coquina	- Weak porous rock consisting of lightly cemented shells and shell fragments.
Chalk	- Soft, porous, and fine-textured; composed of shells of microscopic organisms; usually white.
Dolomite	- Harder and heavier than limeston. Forms by alteration of limestone or by direct precipitation from sea water. Reacts with dilute HCL only when powered; hardness >5.
Gypsum	- An evaporate, commonly massive, white and soft.
Anhydrite	- An evaporate, harder than gypsum; normally white with a pearly luster and splintery fracture.
Halite	- An evaporate; a crystalline aggregate of salt.
	ORGANIC ORIGIN
Coal	- Composed of highly altered plant remains and varying amounts of clay, generally black.
	BIOGENIC AND CHEMICAL ORIGIN
Chert	- Formed by silica deposted from solution in water. May occur as nodules or relatively thick beds; hardness of 7.
Diatomite	- Soft, white, very light, porous rock.

CHARACTERISTICS OF IGNEOUS ROCKS

ROCK TYPE	CHARACTERISTICS
	COARSE TO MEDIUM GRAINED
Pegmatite	- Chiefly quartz and feldspar, occuring separately as large grains; abundant as dikes in granite.
Granite	- Most common igneous rock; normally equigranular and light in color; chiefly quartz and feldspar.
Syenite	- Light colored rock similar to granite but contains no quartz; almost entirely feldspar.
Diorite	- Equlgranular and gray to dark gray; composed of plagioclase feldspar and at least one ferromagnesian mineral.
Gabbro	- Dark colored rock composed of ferromagnesian minerals and plagiociase feldspar.
Peridotite	- Dark colored rock composed almost entirely of ferromagnesian minerals, readily altertered.
Dunite	- Very dark green; major constituent is olivine. Readily alters to serpentine.
Dolerite	- Dark colored rock, intermediate in grain size.
	FINE-GRAINED
Andesite	- Generally dark gray, green or red, fine-grained rock; occasionally porphyritic.
Basalt	- Most abundant extrusive rock; variable colors; fine-grained with a dense structure.
Rhyolite	- Microcrystalline equivalent of granite; usually white, gray or pink with a few phenocrysts.
Felsite	- A finely-crystalline variety of quartz-porphyry.
	GLASSY ROCKS
Obsidian	- Solid natural glass devoid of all crystal form.
Pumice	- Extremely vesicular glass; sponge structure.
Scoria	- Rock which has equal void space and solid mass.

CHARACTERISTICS OF METAMORPHIC ROCKS

ROCK TYPE	CHARACTERISTICS
	FOLIATED FABRIC
Gneiss	- Coarse-grained rock with imperfect follation resulting in slabbing. Chief minerals are quartz and feldspar.
Schist	- Fine-grained rock with a well-developed foliation. Mainly consists of platy minerals and commonly garnet.
Amphibolite	- Consists largely of amphibole with a schist-like foliation. Commonly hard and very dense.
Phyllite	- Soft, with a satin luster and extremely fine schistosity; very unstable cut slopes.
Slate	- Extremely fine-grained (micritic) with a very well-defined cleavage; generally hard.
	MASSIVE FABRIC
Meta-conglomerate	- Similar to conglomerate in appearance but has been fused and deformed by heat and pressure.
Quartzite	- Extensively altered sandstone; individual sand grains have been fused together.
Serpentine	- A green, soft, compact rock with a waxy luster and splintery fracture.
Soapstone	- Derived from talc; generally green in color and easily cut with a sharp knife; resists the action of heat and acids.
Hornfels	- Rocks baked by contact metamorphism into a hard aphanitic material, with concoldal fracture and generally dark gray to black in color.
Migmatite	- A complex intermixture of metamorphic and granular igneous rocks formed by injection of granite magma into foliated rocks.
Mylonites	- Produced by intense metamorphism; variable fabric due to deformation of original minerals. Common along the base of overthrust sheets.

GEOLOGIC DEFINITIONS

ARENACEOUS – A term applied to rocks that have been derived from sand or contain abundant, >30% , sand in composition.
ARGILLACEOUS – A term applied to all rock or substances composed of clay minerals or having a notable portion, >30%, clay in composition.
BRECCIATED – A rock texture with is composed of angular fragments which corresponds in size to gravel and/or pebbles.
CONGLOMERITIC – A rock texture which is composed of rounded fragments which correspond in size to gravel and/or pebbles.
FABRIC – That factor of the texture of a crystalline rock which depends on the relative sizes, shapes, and arrangements of the component crystals.
FISSILITY – A property of splitting along closely spaced parallel planes.
OOLITIC – A spherical or ellipsoidal texture, 0.25 – 2.0mm in diameter, with a concentric or radial structure.
PHANERITIC – A textural term applied to those igneous rocks in which all the grains are essentially the same size.
PORPHYRITIC- A textural term applied to those igneous rocks which have larger crystals set in a fine matrix.
SLICKENSIDE – A polished or striated surface on or within a rock or compact soil.
STYLOLITE – A term applied to parts of certain limestones which have a columnlike development that is grooved, sutured, or striated and irregular

Note: Tables, Figures and data adapted from: *"Geotechnical Engineering Investigation Manual"*, Roy E. Hunt, McGraw-Hill Book Co., New york, NY, 1984., *"Petrology Igneous, Sedimentary, and Metamorphic"*, Harvey Blatt & Ernest G. Ehlers, W. H. Freman & co., San Francisco, CA, 1982., and the U.S. Army Corps of Engineers.