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October 2, 2020

Mr. Robert Balderston
Lee's Summit Subaru
2101 NE Independence Avenue
Lee's Summit, Missouri 64064

Re: **Geotechnical Engineering Services Report**
Proposed Detail Center
2150 NE Independence Avenue
Lee's Summit, Missouri
PSI Project Number: 03382128

Dear Mr. Balderston:

Thank you for choosing Professional Service Industries, Inc. (PSI), an Intertek company, as your consultant for the proposed detail center in Lee's Summit, Missouri. Per your authorization, PSI has completed a geotechnical engineering study for the referenced project. The results of the study are discussed in the accompanying report, two copies of which are enclosed.

Should there be questions pertaining to this report, please contact our office at (913) 310-1600. PSI would be pleased to continue providing geotechnical services throughout the implementation of the project, and we look forward to working with you and your organization on this and future projects.

Respectfully submitted,
Professional Service Industries, Inc.

Ian Sutherland, PE
Project Manager
Geotechnical Services

Kelly E. Rotert, PE, DBIA
Vice President

Distribution: (2 hard copies, 1 copy via email)

Geotechnical Services Report
Lee's Summit Subaru
2150 NE Independence Avenue
Lee's Summit, Missouri
PSI Report No. 03382128
October 1, 2020

intertek
psi

Geotechnical Engineering Services Report

for the
Proposed Detail Center
2150 NE Independence Avenue
Lee's Summit, Missouri

Prepared for

Lee's Summit Subaru
2101 NE Independence Avenue
Lee's Summit, Missouri 64063

Prepared by

Professional Service Industries, Inc.
1211 West Cambridge Circle Drive
Kansas City, Kansas 66103

October 1, 2020

PSI Project 03382128

IAN SUTHERLAND
NUMBER
PE-2018013641

Ian M. Sutherland, P.E.
Staff Engineer
Geotechnical Services
Missouri License
No. PE-2018013641
Expires: 12/31/2020

Reviewed by:
Kelly Rotert, P.E., DBIA
Vice President

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PROJECT INFORMATION

Project Authorization

The following table summarizes, in chronological order, the Project Authorization History for the services performed and represented in this report by Professional Service Industries, Inc. (PSI).

PROJECT TITLE: PROPOSED DETAIL CENTER		
Document and Reference Number	**Date**	**Requested/Provided By**
Request for Proposal	8/10/2020	Mr. Powell Minnis with Davidson A+E
PSI Proposal Number: 0338318660	8/12/2020	Mr. Kelly Rotert of PSI
Notice to Proceed	9/3/2020	Mr. Robert Balderston with Lee's Summit Subaru

Project Description

PSI understands that the project includes the construction of a new approximately 12,862 square foot car detail center at the northwest corner of Town Center Drive and Independence Avenue in Lee's Summit, Missouri. PSI understands that the building will be a single-story building with a mezzanine.

The following table lists the material and information provided for this project:

DESCRIPTION OF MATERIAL	PROVIDER/SOURCE	DATED
Floor Plan A2.2	Davidson A+E	1/8/2020
Floor Plan A 2.1		1/8/2020
Elevation Plan A3.1		2/21/2020
Site Plan (with boring locations) A1.1		3/25/2020
Grading Plan		6/19/2020

The following table lists the structural loads and site features that are required for or are the design basis for the conclusions of this report:

STRUCTURAL LOAD/PROPERTY	REQUIREMENT/REPORT BASIS		
BUILDING		**R***	**B***
Maximum Column Loads	150 kips		X
Maximum Wall Loads	5 kips per foot		X
Finish Floor Elevation and Type	995 feet, slab on grade		X
Maximum Floor Loads	150 psf		X
Settlement Tolerances	1 inch total, ¾ inch Differential		X
PAVEMENTS			
Pavement 18-kip ESAL (cycle & duration)	Light Duty- 30,000 ESAL Heavy Duty – 60,000 ESAL; with a life expectancy of 20 years		X
GRADING			
Planned Grade Variations at Site	Building: Up to 10 feet of fill		X

*"R" = Requirement indicates specific design information was supplied.
*"B" = Report Basis indicates specific design information was not supplied; therefore, this report is based on this parameter.

The following image of the site plan was provided to PSI for the preparation of this project:

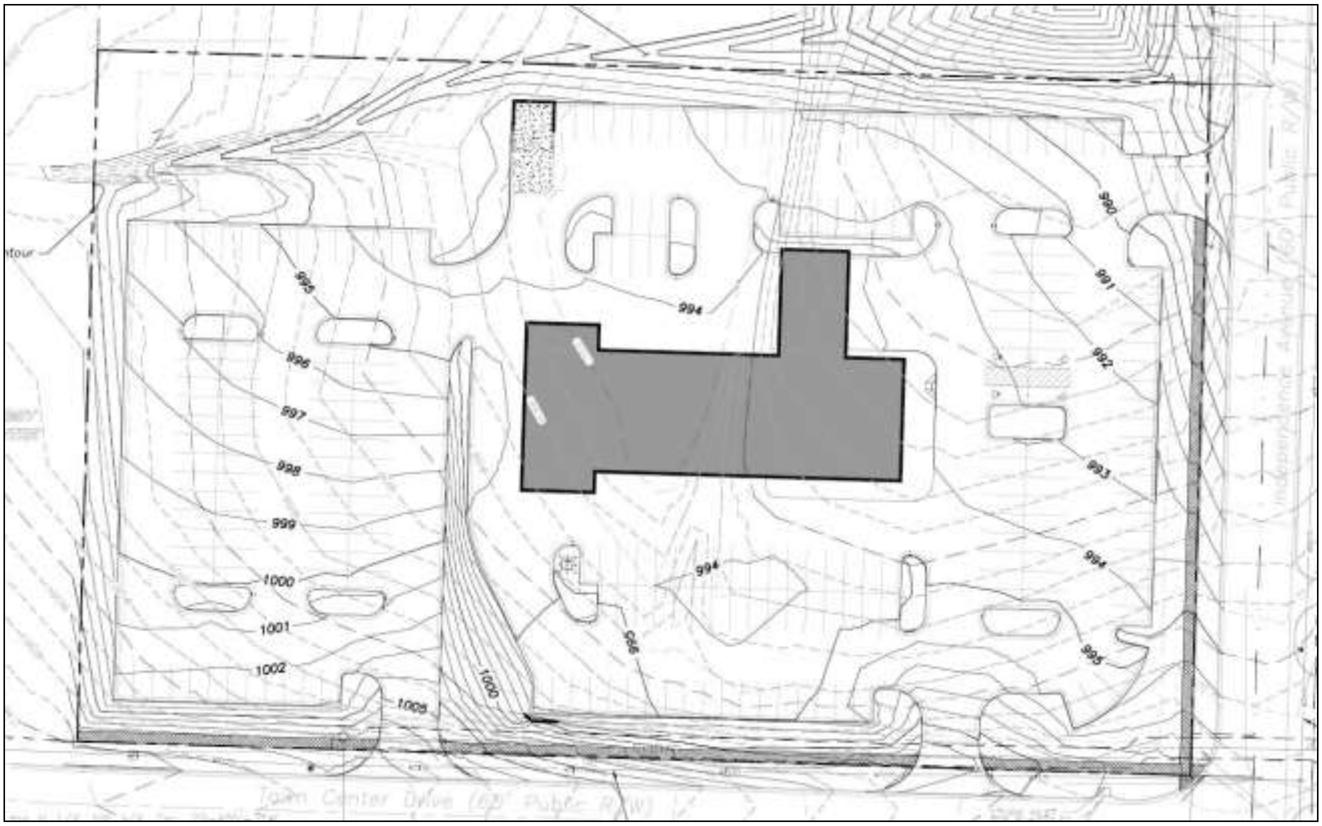


Figure 1. Client Provided Site Plan

The geotechnical recommendations presented in this report are based on the available project information, building location, and the subsurface materials described in this report. If the noted information is incorrect, please inform PSI in writing so that we may amend the recommendations presented in this report if appropriate and if desired by the client. PSI will not be responsible for the implementation of its recommendations when it is not notified of changes in the project.

Purpose and Scope of Services

The purpose of this study was to explore the subsurface conditions within the site to evaluate and provide recommendations for site preparation and grading and for design of foundation and pavement section systems for the proposed construction. PSI's contracted scope of services included drilling nine (9) soil test borings at the site to depths of about 10 to 20 feet below the ground surface, select laboratory testing, and preparation of this geotechnical report. This report briefly outlines the testing procedures, presents available project information, describes the site and subsurface conditions, and presents recommendations regarding the following:

- General site development and subgrade preparation recommendations;
- Estimated potential soil movements associated with, shrinking and swelling soils and methods to reduce these movements to acceptable levels;
- Recommendations for site excavation, fill compaction, and the use of on-site and imported fill material under pavements and the structures;
- Recommendations for building pad preparation for ground supported slabs having a maximum movement potential, due to heave or settlement, of 1-inch;
- Recommendations for the design of foundations for supporting the proposed structure;
- Seismic design site classification per the International Building Code; (2015)
- Recommendations for the design of flexible asphaltic and rigid concrete pavement systems for the proposed parking and drive areas.

The scope of services did not include an environmental assessment for determining the presence or absence of wetlands, or hazardous or toxic materials in the soil, bedrock, surface water, groundwater, or air on, below, or around this site. Any statements in this report or on the boring logs regarding odors, colors, and unusual or suspicious items or conditions are strictly for informational purposes. PSI's scope also did not provide any service to investigate or detect the presence of moisture, mold or other biological contaminants in or around any structure, or any service that was designed or intended to prevent or lower the risk of the occurrence or the amplification of the same. Client should be aware that mold is ubiquitous to the environment with mold amplification occurring when building materials are impacted by moisture.

SITE AND SUBSURFACE CONDITIONS

Site Location and Description

The approximate four (4) acre site for the proposed detail center is located at 2150 Northeast Independence Avenue in Lee's Summit, Missouri. The property is bordered by an undeveloped grass field to the north and west, Town Center Drive to the south, and Northeast Independence Avenue to the east. At the time of drilling, the site was covered with grass. An existing pond is located near the north end of the site. Based on the client-provided grading plan, the site generally slopes downward from west to east. The site latitude and longitude are approximately 38.9504° and -94.3649°, respectively. The following is an aerial image from 2019 and generally illustrates the site conditions at the time of drilling:

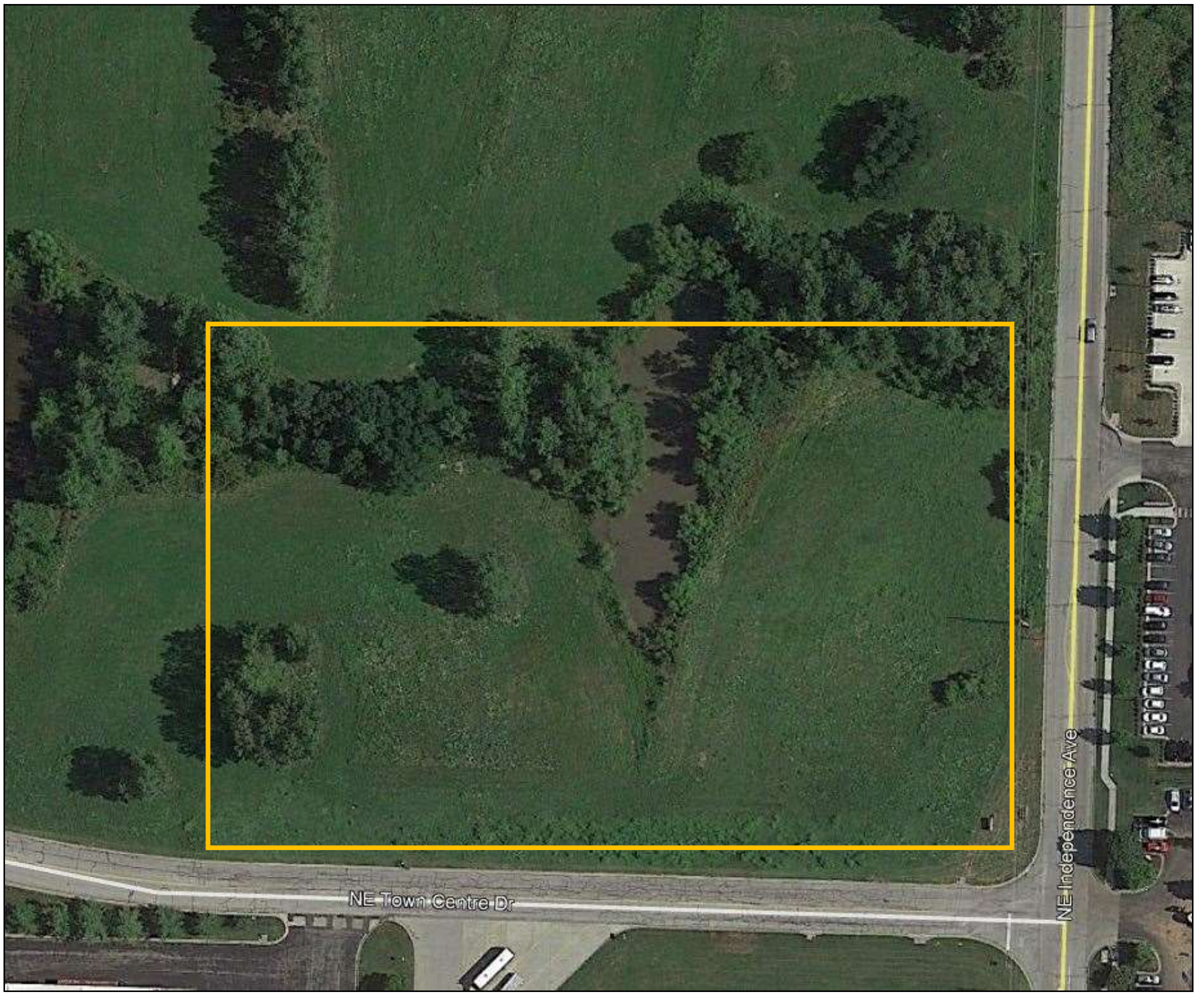


Figure 2. Aerial Image of Proposed Detail Site

<u>Site History (Timeline)</u>

Based on historical images obtained from Google Earth^{TM} , the site appears to have been primarily undeveloped farm pasture since at least February of 1990. It appears that the existing pond in it's current configuration may have been constructed between 1996 and 2002. It appears that the trees that were present at the site in 1996 were also removed. It appears that the site has remained relatively unchanged since 1992.

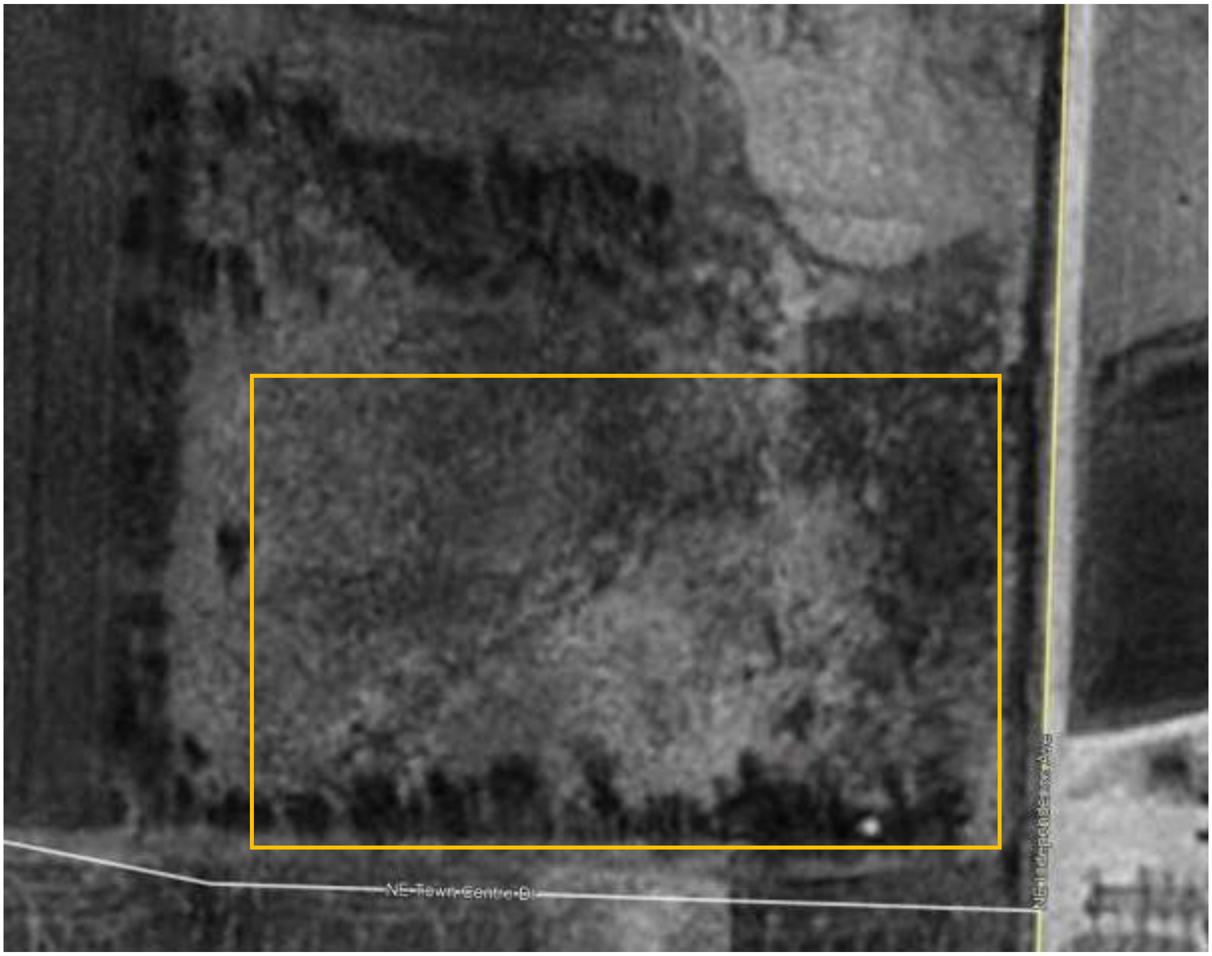


Figure 3. Aerial Image Dated February 1990

Geology

According to the Geologic Map of Missouri, 2003, Sesquicentennial Edition, the surficial bedrock within the project area belongs to the Kansas City Group. This group includes the Argentine Limestone Member and the Raytown Limestone Member, which consist primarily of limestone and shale.

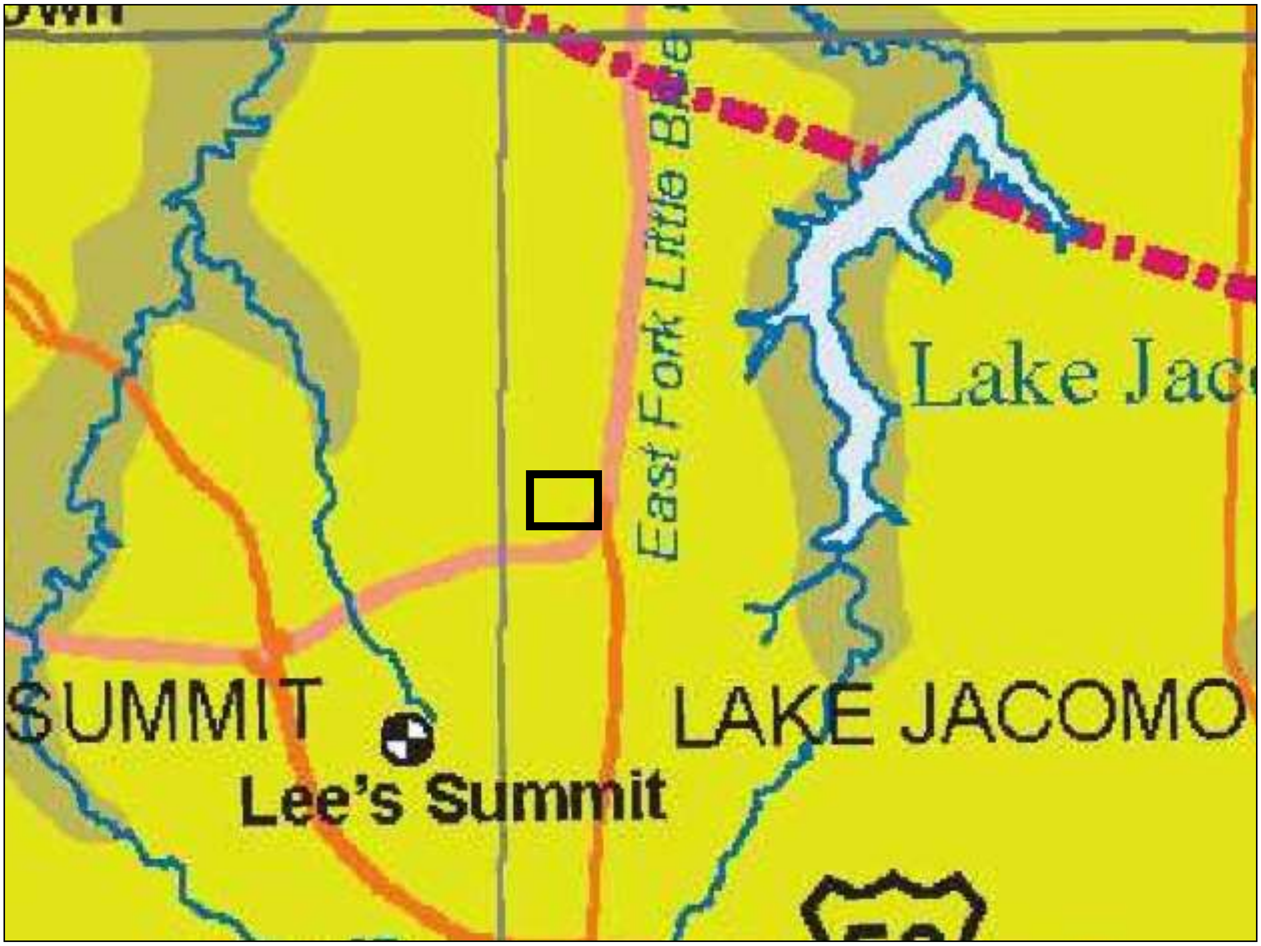


Figure 4. Excerpt from the Geologic Map of Missouri, 2003, Sesquicentennial Edition

Exploration Procedures and Subsurface Conditions

The soil borings were performed with an ATV-mounted drill rig and were advanced using 3¼-inch inside diameter hollow-stem augers. Representative samples were obtained employing split-spoon and thin-wall tube sampling procedures in general accordance with ASTM procedures. The laboratory testing program was conducted in general accordance with applicable ASTM specifications. The results of these tests are to be found on the accompanying boring logs located in the Appendix.

Subsurface Conditions

The site subsurface conditions were explored with nine (9) soil test borings. Six (6) of these borings were drilled within the proposed building area to depths of approximately 19 ½ to 20 feet. Three (3) of the borings were drilled within the parking and drive areas to a depth of approximately 10 feet.

The boring locations were selected by the client and the depths were suggested by PSI and reviewed by the client. PSI personnel located the borings in the field using a hand-held GPS device and coordinates estimated using Google Earth. PSI estimated the elevations of the borings using the client provided grading plan.

An organic layer was encountered at the surface of borings B-1 through B-5 and B-7 through B-9. In general, the thickness of the organic layer ranged from 2 inches to 7 inches. PSI encountered fine-grained soils beneath the organic layer in borings B-1 through B-5, B-7 and B-8 and at the surface of boring B-6, extending to depths between approximately 4 to 8 ½ feet below site grade at the time of our exploration. Based on visual classification and Atterberg limits tests, these soils were generally classified as high plasticity clay.

PSI encountered weathered weathered shale and shale beneath the organic layer in boring B-9 and beneath the high plasticity clay soils in borings B-1 through B-8, extending to the termination depth of the borings at depths between 10 and 20 feet. PSI also encountered a relatively thin weathered limestone layer in borings B-1 at a depth between 9 to 9 ½ feet below existing grade and in boring B-7 at depths between approximatey 5 ½ and 6 ½ feet below site grade.

Split spoon refusal materials were encountered with the borings. Split spoon refusal materials are defined as materials that cannot be penetrated with a standard split spoon using ordinary effort (greater than 50 blows per 6 inches). These materials were encountered in borings B-1. B-3, B-4 and B-6 at depths between 14 and 20 feet.

The following table briefly summarizes the range of results from the field and laboratory testing programs. Please refer to the attached boring logs and laboratory data sheets for more specific information:

PROPOSED DETAIL CENTER- LEE'S SUMMIT, MISSOURI	Approximate Depths Encountered (ft.)	RANGE OF PROPERTY VALUES					
SOIL STRATA TYPE		Standard Penetration, N_{60}	Moisture Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, Qu (tsf)	Liquid Limit, %	Plastic Limit, %
High Plasticity Clay	0 – 8 ½	6 to 14	21 - 32	98 - 102	1.2 – 1.4	61 -68	22- 25
Weathered Limestone	5 ½ - 9 ½	17	--	--	--	--	--
Weathered Shale	½ - 18 ½	7 – 63	16 - 25	111	2.7-3.4		
Shale	6 ½ - 20	64 - 50/3"	9 – 12	--	--	--	--

The above subsurface description is of a generalized nature to highlight the major subsurface stratification features and material characteristics. The boring logs included in the Appendix should be reviewed for specific information at individual boring locations. These records include soil/rock descriptions, stratifications, penetration resistances, and locations of the samples and laboratory test data. The stratifications shown on the boring logs represent the conditions only at the actual boring locations. Variations may occur and should be expected between boring locations. The stratifications represent the approximate boundary between subsurface materials and the actual transition may be gradual. Water level information obtained during field operations is also shown on these boring logs. The samples that were not altered by laboratory testing will be retained for sixty (60) days from the date of this report and then will be discarded.

Water Level Measurements

Free groundwater was not observed in the borings upon completion, indicating that groundwater at the site at the time of the exploration was either below the terminated depths of the borings, or that the soils encountered are relatively impermeable. Although free water was not encountered at this time, water can be present within the depths explored during other times of the year depending upon climatic and rainfall conditions. It should be noted that saturated soils were identified during laboratory analysis at depths as shallow as 1 foot below the ground surface. Additionally, discontinuous zones of perched water may exist within the overburden materials and/or at the contact with bedrock. The water level measurements presented in this report are the levels that were measured at the time of PSI's field activities.

GEOTECHNICAL EVALUATION

Geotechnical Discussion

There are six (6) primary geotechnical characteristics at this site, which will affect the selection and performance of the foundations for this structure and the development of the site. The following summarizes those concerns:

1. The shear strength and compressibility of the upper soils will control the behavior of the proposed structure.
2. Compressible material was encountered that could cause significant settlement under placement of 10 feet of fill.
3. High plasticity "fat" clays were encountered in the exploration that could require remediation.
4. Shallow rock was encountered in the building area that could be difficult to excavate for general grading, footings and utility trenches.
5. Relatively wet and moisture sensitive soils were encountered in the upper parts of the borings and equipment mobility difficulty may be anticipated.
6. Existing trees on the site will impact grading and site preparation.

Shear Strength and Compressibility of Soil

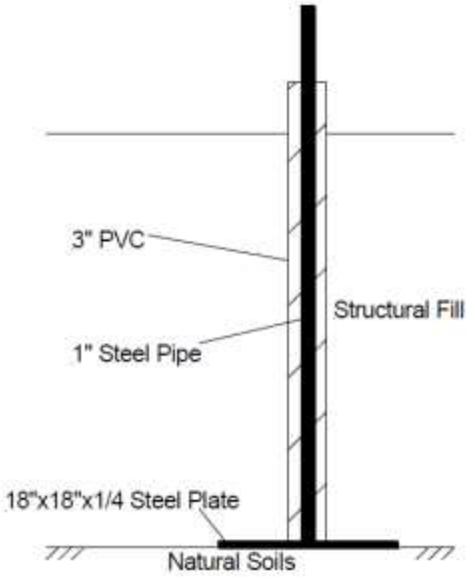
The primary geotechnical property controlling the bearing capacity and compressibility of the soils bearing the applied loads is the shear strength of the clay soil. Based on the finished floor elevation of 995 feet and a shallow foundation bearing at a depth of 3 feet below exterior or adjacent grades, the applied foundation load on a shallow foundation up to 4 feet wide will be distributed through the 8 to 12 feet of soil generally beneath the footing. PSI believes the shear strength of the soils in this zone ranges from 900 psf to 1,700 psf, with shear strength exceeding 2,500 psf in the weathered shale and shale zones. PSI anticipates that an engineered fill placed as recommend in this report would have a minimum shear strength of 1,800 psf. This shear strength is considered "undrained" or a "total stress" parameter and will be used in conjunction with other physical and geometric parameters to calculate an allowable bearing capacity.

Settlement Due to Fill

Based on applying up to 10 feet of fill to the site, PSI anticipates settlements up to 1 to 1 ½ inches. Some of this settlement will occur during the placement of the fill material and the rest will occur afterwards. Differential settlement of the fill may occur across the site due to the different quantities of fill. PSI recommends that construction of the building not begin until the remaining settlement is within a tolerable limit. To determine when to start the building construction, PSI recommends the installation of settlement monitoring instruments prior to the placement of fill. The settlement can either be monitored using multiple settlement plates or surface mounted settlement monuments.

If it is desired to shorten the expected delay period, then settlement plates should be installed prior to placing the fill. The typical method is to place a metallic plate (approximately 2 feet to 3 feet square) with a metal rod (approximately ½-inch to 1-inch in diameter) welded to the plate inside an oversized casing (approximately 3 inches in diameter) the covers the rod and extends to the surface of the fill. Placing this system on the fill prior to the placement of fill will allow for the measurement of the settlement of the original soil/fill interface. The initial elevation should be plotted verses subsequent elevation of the original ground/fill interface with respect to time. From this plotted information, it can be estimated when the monitored interface has reached secondary consolidation. At this point in time, it is typically acceptable to continue with construction.

Below is a general an illustration of the settlement plate. In general, PSI recommends constructing a 6- to 12-inch thick leveling pad at the selected locations on the existing soils. This is typically performed using a fine-grained aggregate, similar to a concrete sand, to reduce horizontal displacement that could “hang” the plate up and not record accurate settlement. Fill placed within 5 feet of the settlement should be placed and compacted with hand operated equipment to minimize damage to the pipes.



The delay time may be shorted further if additional fill is placed in addition to what is required to establish grade. This is typically referred to as preloading or surcharging the site. With preloading it is recommended that monitoring of the fill settlement be the actual gage of time delay. Estimates of the preload requirements were outside the scope of the original project, but can be estimated upon request.

PSI recommends placing approximately twelve (12) inches of a granular material along the existing grade prior to placement of additional fill. This crushed stone will reduce the drainage path to relieve the water pressure in the underlying soils, thus reducing the time of settlement.

High Plasticity Clay

High plasticity "fat" clays are present in the project area that may expand and shrink thereby impacting the proposed construction. Where these soils are within about two feet of lightly loaded structural features or slabs, remediation is recommended or class “C” fly ash, portland cement or lime-treatment of the high plastic clays can be performed. Class “C” fly ash, portland cement or lime-treatment of the high plastic clay would reduce the plasticity index, improve workability, promote drying, and reduce shrink/swell potential. Lightly loaded structures are defined as having normal operating loads of less than 2 kips per linear foot for walls and 50 kips for columns. Fat clays have the potential for volume change with changes in the soil moisture content. In severe cases, movement and distress to footings and foundation walls can occur, although a severe case is not obviously apparent at this site. Remedial measures are recommended in select areas of the site to reduce the shrink/swell potential. Grading the subgrade to drain and not trap water below the slabs and pavements is recommended to further reduce the potential of distress from these soils.

Shallow Rock

Weathered rock consisting of weathered limestone, weathered shale and shale was encountered below depths of approximately ½ to 5 ½ feet in borings B-7, B-8 and B-9. Some of the weathered limestone, weathered shale and shale may be difficult to excavate, especially in utility trenches. These rock materials were also encountered at depths between approximately 4 to 8 ½ feet within borings B-1 through B-6; however, based on the provided grading plan, PSI anticipates that footing excavations will not likely extend to the weathered rock materials. Excavation machinery equipped with rock chippers may be required in some locations. In addition, intact ledges or boulders of sound and hard rock may be encountered within the weathered limestone and shale that could increase the excavation difficulty.

Moisture Sensitive Soils

The presence of potentially moisture sensitive shallow soils and the presence of the existing pond will increase the difficulty of site grading. PSI has been involved with projects in this region where these soils can undergo a loss of stability during wetter portions of the year. PSI anticipates that the soils at their current moisture levels and the soils within the existing pond after the water is drained will become easily disturbed if subjected to conventional rubber tire or narrow track-type equipment resulting in a loss of strength and characteristic "pumping". Soils that become disturbed would need to be excavated and replaced; however, this remedial excavation may expose progressively wetter soils with depth, thus compounding the condition. In the event these conditions are observed, PSI recommends that the following remediation procedures be considered to further stabilize wet/soft areas if typical surface moisture conditioning/disking/recompacting methods are not affective..

1. Scarify, dry, and recompact the soils to a moisture content that will facilitate compaction in accordance with the structural fill requirements of this report.

2. If scarifying, drying and recompacting of the soils does not stabilize the soils, removing and replacement with new structural fill or treating the soils with class “C” fly ash, portland cement or lime-treatment of the clay soils may need to be performed. The amount of these materials will likely range between 10 to 15 percent by weight for fly ash, 5 to 8 percent by weight for portland cement, and 4 to 8 percent by weight for lime.

3. Track in 3 to 5-inch minus well-graded crushed limestone or similar material into the failing areas to attempt to bridge the soft zones. These materials should be placed in loose lifts of no more than 10 inches and tracked in with a loaded rubber tire truck or beat in with a backhoe bucket. Once the areas are stabilized onsite soils then be placed to the recommended low volume change material subgrade elevation for pavements. If for some reason areas do not stabilize with 1 to 2 lifts of stone, a layer of grid or fabric may need to be incorporated into those areas at that time, followed by additional lifts of stone consisting of ¾ inch minus materials (AB-3).

4. A fourth option would be to place geo grid similar to Tensar BX1100 and then place new granular fill similar to ¾-inch minus material in compacted lifts. The grid should extend at least 10 feet past the perimeter of the failing areas and should be overlapped according to the manufactures requirements. If the area does not stabilize by the second lift of ¾ inch minus material an additional layer of grid should then be placed and the process should be repeated until it is stabilized.

PSI recommends a test section be performed to verify the selected remediation method.

Existing Trees

Due to the existing trees, additional remediation will likely be required during site grading. The trees on site are mature and could have an extensive root system that will be required to be removed during the stripping of the site. Any roots greater than ¼ inch in thickness or pockets of rootlets great than 5 percent by volume should be planned to be removed from the site.

GEOTECHNICAL RECOMMENDATIONS

The following geotechnical related recommendations have been developed on the basis of the subsurface conditions encountered and PSI's understanding of the proposed development. Should changes in the project criteria occur, a review must be made by PSI to determine if modifications to our recommendations will be required.

Site Preparation

PSI recommends that topsoil, vegetation, roots, soft, organic, frozen, or unsuitable soils in the construction areas be stripped from the site and either wasted or stockpiled for later use in non-structural areas. In the event that roots/rootlets are observed within the existing soils, it would be acceptable for the soils to consist of 5 percent by volume of root/rootlets to be left in place of roots that are ¼ inch or less in diameter. Larger roots or tree root bulbs should be removed and replaced with new structural fill as recommended below. Depth of the organic layer in our borings ranged from approximately 2 to 7 inches. It is typical for the organic layer thickness to vary from these values. A representative of the geotechnical engineer should evaluate and document the required depth of removal at the time of construction.

After stripping to the proposed subgrade level, as required, the building area and parking area should be proof-rolled with a loaded tandem axle dump truck or similar heavy rubber tired vehicle (typically with an axial load greater than nine (9) tons). Soils that are observed to rut or deflect excessively (typically greater than one (1) inch) under the moving load should be undercut and replaced with properly compacted low plasticity fill material. The proof-rolling and undercutting activities should be witnessed by a representative of the geotechnical engineer and should be performed during a period of dry weather. Care should be taken during construction activities not to allow excessive drying or wetting of exposed soils. The subgrade soils should be scarified and compacted to at least 95% of the materials' standard Proctor maximum dry density, in general accordance with ASTM procedures, to a depth of at least twelve (12) inches below the surface. The proof-rolling may be eliminated due to high groundwater upon consultation with the geotechnical engineer. New fill for building structures, asphalt, and concrete should not be placed on frozen ground.

High plasticity fat clays should be removed where they are present within a depth of two (2) feet beneath proposed slabs or lightly loaded structural features. This material should be replaced with a low plasticity compacted soil, a dense positively-drained graded crushed stone or class "C" fly ash, portland cement or lime-treatment of the high plastic clays can be performed. Class "C" fly ash or lime-treatment of the high plastic clay would reduce the plasticity index, improve workability, promote drying, and reduce shrink/swell potential. A representative of PSI's geotechnical engineer should observe the subgrade soils, perform plasticity index tests, and estimate the approximate extent of the exposed fat clays. If it is desirable to modify the fat clays with a commercially available class "C" fly ash, portland cement or lime product, PSI recommends that actual application amounts be set by conducting a laboratory class "C" fly ash, portland cement or lime series test. However, for preliminary purposes, the amount of class "C" fly ash will likely range from 10 to 15 percent by weight. There are many variables including water and soils chemistry and the variable nature of class "C" fly ash. Therefore, a laboratory test is recommended. The geotechnical engineer's representative should observe the remediation procedures for compliance with the project plans and specifications.

After subgrade preparation and observation have been completed, fill placement required to establish grade may begin. Low-plasticity structural fill materials placed beneath the lightly loaded structural features or slabs should be free of organic or other deleterious materials and have a maximum particle size of less than three (3) inches. Low-plasticity soils are defined as having a liquid limit less than forty-five (45) and plasticity index less than twenty-five (25). The on-site high plasticity fat clay soils may be utilized as fill material to within 2 feet below the final subgrade for lightly loaded structures and building slabs. If high plasticity fat clays are utilized as fill, they should have a liquid limit no greater than seventy-five (75) and a plasticity index no greater than forty-five (45). A representative of PSI should be on-site to observe, test, and document the placement of the fill. If the fill is too dry, water should be uniformly applied and thoroughly mixed into the soil by disking or scarifying. Close moisture content control will be required to achieve the recommended degree of compaction. It should be noted that high plasticity clays are typically more difficult to compact and achieve the optimum moisture content during the placement of fill.

Highly permeable fill such as sand or clean stone used on this site should be given careful consideration. These highly permeable materials should not be placed within three (3) feet of fat clays. Even though the excavation may be dry, and no groundwater is anticipated, these highly permeable pockets will eventually collect water through condensation and therefore promote soil swelling and heaving. If permeable fill is used, it is strongly recommended that the surface where the permeable fill is placed be graded in a manner to drain without pocketing water and be drained through the use of draintile or other appropriate means.

Fill should be placed in maximum loose lifts of eight (8) inches and compacted to at least 95% of the materials' standard Proctor maximum dry density, and within a range of the optimum moisture content as designated in the table below, as determined in general accordance with ASTM procedures. Each lift of compacted-engineered fill should be tested and documented by a representative of the geotechnical engineer prior to placement of subsequent lifts. The edges of compacted fill should extend a minimum of five (5) feet beyond the building footprint, or a distance equal to the depth of fill beneath the footings, whichever is greater. The measurement should be taken from the outside edge of the footing to the toe of the excavation prior to sloping.

Clean or screened rock could be used as select fill, but a fabric separator would be needed where it is placed adjacent to fine grained soils. This type of fill and backfill should be tracked or tamped to achieve densification.

The fill placed should be tested and documented by a geotechnical technician and directed by a geotechnical engineer to evaluate the placement of fill material. It should be noted that the geotechnical engineer of record can only certify the testing that is performed and the work observed by that engineer or staff in direct report to that engineer. The fill should be evaluated in accordance with the following table:

MATERIAL TESTED	PROCTOR TYPE	MIN % DRY DENSITY	PLACEMENT MOISTURE CONTENT RANGE	FREQUENCY OF TESTING *¹
Structural Lean Clay Fill* (Cohesive)	Standard	95%	-1 to +3 %	1 per 2,500 ft^2 of fill placed / lift
Structural Fat Clay Fill* (Cohesive)	Standard	95%	0 to +3%	1 per 2,500 ft^2 of fill placed / lift
Structural Fill (Granular)*	Standard	95%	-2 to +2 %	1 per 2,500 ft^2 of fill placed / lift
Random Fill (non load bearing)	Standard	90%	-3 to +3 %	1 per 6,000 ft^2 of fill placed / lift
Utility Trench Backfill	Standard	95%	-1 to +2 %	1 per 150 lineal foot / lift

*Structural Fill is defined as fill beneath or supporting any improvements on site such as foundation, slabs, pavements, etc.
*¹ Minimum 3 per lift.

The test frequency for the laboratory reference should be one laboratory Proctor or Relative Density test for each material used on the site. If the borrow or source of fill material changes, a new reference moisture/density test should be performed.

Tested fill materials that do not achieve either the required dry density or moisture content range shall be recorded, the location noted, and reported to the Contractor and Owner. A re-test of that area should be performed after the Contractor performs remedial measures.

High Plasticity Clay Considerations

Due to the presence of high plasticity clays, consideration should be given to measures that can reduce the long term shrink/swell potential of the clay soils. High plasticity clays expand or shrink by absorbing or losing moisture; therefore, reducing the moisture content variation of a soil will reduce its volume change. Although it is not possible to prevent soil moisture changes, a number of steps may be taken to aid in the reduction of subsoil moisture content variations. These steps are intended to help reduce the shrink/swell potential, not eliminate it. Some of these measures are:

1. During construction, a positive drainage scheme should be implemented and maintained to prevent ponding of water on subgrades.

2. The building subgrade should not be allowed to dry out; backfill should proceed as soon as possible to minimize changes in the natural moisture regime.

3. Permanent positive drainage should be maintained around the building through a roof/gutter system connected to drainage piping or discharging upon paved surfaces, thereby transmitting water away from the foundation perimeter. In addition, site grading should provide rapid drainage of surface water away from foundation areas.

4. Utility trenches should be backfilled with low plasticity clays or lean concrete to reduce the potential of the trenches to act as aqueducts transmitting water beneath the structures due to excess surface water infiltration.

5. Shrubbery, flower beds and sprinkler systems surrounding the structures should be eliminated or at least limited, and should be designed so that the bedding soils drain away from the building areas. The planters should have impermeable bases with weep holes discharging into drainage pipes or onto paved surfaces.

6. Trees and/or large bushes should not be planted adjacent to the structures.

7. Since plumbing and other water leaks can cause excessive heaving of high plasticity soils, every effort should be made to maintain the plumbing in good working order and prevent or minimize water leaks and discharges. It is recommended that all water supply lines and waste water lines be tested for leaks prior to backfilling the utility trenches.
8.

Foundation Recommendations

The planned construction can be supported on conventional spread-type footing foundations bearing on either competent naturally deposited soils or compacted-engineered fill. Spread footings for building columns and continuous footings for bearing walls can be designed for allowable soil bearing pressures of 2,500 psf and 2,000 psf, respectively, based on dead load plus design live load. PSI recommends a minimum dimension of 24 inches for square footings and 18 inches for continuous footings to reduce the possibility of a local bearing capacity failure.

Footing Excavations and Backfilling

It is recommended that PSI personnel evaluate the soils conditions at and below footing grade at the time the excavations are performed. If unsuitable materials (such as, soft to medium stiff cohesive soils, loose granular soils that cannot be densified, or debris/organic laden fill materials) are encountered below the design bottom of footing elevation, the footing excavations should be extended deeper to reach adequate bearing soils or an overexcavation and backfill procedure could be performed with lean clay, lean concrete or compacted granular fill to the design bearing elevation. If lean concrete (minimum f'_c = 1,500 psi) is used, the excavation should be widened at least 6 inches from all edges of the design footing width. For the overexcavation and either lean clay or granular backfill options, we recommend the excavation extend laterally at least 8 inches beyond all edges of the footing for each 12 inches of additional excavation required below foundation design elevation. The overexcavation should then be backfilled up to design elevation. A coarse crushed stone could be used, placed in lifts of 9 inches or less in loose thickness and compacted to at least 95 percent of the material’s maximum dry density per ASTM D698.

Exterior footings and footings in unheated areas should be located at a depth of thirty-six (36) inches or deeper below the final exterior grade to provide adequate frost protection. If the building is to be constructed during the winter months or if footings will likely be subjected to freezing temperatures after foundation construction, then the footings should be protected from freezing. PSI recommends that interior footings be a minimum depth of eighteen (18) inches below the finished floor elevation.

The foundation excavations should be observed and documented by a representative of PSI prior to steel or concrete placement to assess that the foundation materials are consistent with the materials discussed in this report, and therefore are capable of supporting the design loads. Soft or loose soil zones encountered at the bottom of the footing excavations should be removed to the level of competent naturally deposited soils or properly compacted structural fill as directed by the geotechnical engineer. Cavities formed as a result of excavation of soft or loose soil zones should be backfilled with lean concrete or dense graded compacted crushed stone.

After opening, footing excavations should be observed and concrete placed as quickly as possible to avoid exposure of the footing bottoms to wetting and drying. Surface run-off water should be drained away from the excavations and not be allowed to pond. If possible, the foundation concrete should be placed during the same day the excavation is made. If it is required that footing excavations be left open for more than one day, they should be protected to reduce evaporation or entry of moisture.

Based on the known subsurface conditions and site geology, laboratory testing and past experience, PSI anticipates that properly designed and constructed footings supported on the recommended materials should experience total and differential settlement between adjacent columns of less than one (1) inch and ¾ inch, respectively.

Earthquake and Seismic Design Consideration

The 2012 International Building Code (IBC) requires that a site class be determined for the calculation of earthquake design forces in structures. The site class designation is a function of soil type (i.e., depth of soil and strata types). Based on PSI's borings and experience in this area, Site Class "D" is recommended. The USGS-NEHRP probabilistic ground motion values interpolated between the nearest four grid points from latitude 38.9504° and longitude -94.3649°° are as follows:

Period (Seconds)	**2% Probability of Event in 50 Years (%g)**	**Site Coefficients**	**Max. Spectral Acceleration Parameters**	**Design Spectral Acceleration Parameters**	
0.2 (S_s)	11.3	$F_a = 1.6$	$S_{ms} = 0.181$	$S_{Ds}= 0.121$	$T_0= 0.177$
1.0 (S_1)	6.7	$F_v = 2.4$	$S_{m1} = 0.160$	$S_{D1}= 0.107$	$T_s= 0.884$

$S_{ms} = F_aS_s$ $S_{Ds} = ⅔*S_{ms}$ $T_0= 0.2*S_{D1}/S_{Ds}$
$S_{m1} = F_vS_1$ $S_{D1} = ⅔*S_{m1}$ $T_s= S_{D1}/S_{Ds}$

The Site Coefficients, F_a and F_v were interpolated for IBC 2012 Tables 1613.3.3(1) and 1613.3.3(2) as a function of the site classifications and the mapped spectral response acceleration at the short (S_s) and 1-second (S_1) periods.

Based on the Spectral Acceleration values for this site, structures with a Risk Category of I, II, and III (Table 1604.5) should be designed as a Seismic Design Category B as defined in Tables 1613.3.5(1) and 1613.3.5(2). Structures with a Risk Category IV should be designed as a Seismic Design Category C. The Risk Category is based on the nature of the occupancy of the structure and is typically determined by the design team (Architect/Structural Engineer) or building official. The determination of the Risk Category is beyond PSI's scope of service.

Floor Slab Recommendations

The floor slab can be grade supported on a minimum of twenty-four (24) inches of properly compacted low plasticity structural fill. Alternatively, class "C" fly ash, portland cement or lime-treatment of the high plastic clay can be accomplished to reduce the plasticity index, improve workability, promote drying, and reduce shrink/swell potential. Proof-rolling, as discussed earlier in this report, should be accomplished to identify soft or unstable soils that should be removed from the floor slab area prior to fill placement and/or floor slab construction. These soils should be replaced with properly compacted structural fill as described earlier in this report. Fat clays below floor slabs should be remediated, as discussed earlier.

PSI recommends that a minimum four (4) inch thick free-draining granular mat be placed beneath the floor slab to enhance drainage. This 4-inch mat can be included in the 24 inches of remediation recommended in the areas of undocumented fill and fat clay. The soil surface shall be graded to drain away from the building without low spots that can trap water prior to placing the granular drainage layer. Polyethylene sheeting should be placed to act as a vapor retarder where the floor will be in contact with moisture sensitive equipment or products such as tile, wood, carpet, etc., as directed by the design professional. The decision to locate the vapor retarder in direct contact with the slab or beneath the layer of granular fill should be made by the design professional after considering the moisture sensitivity of subsequent floor finishes, anticipated project conditions, and the potential effects of slab curling and cracking. The floor slabs should have an adequate number of joints to reduce cracking resulting from differential movement and shrinkage.

For subgrade prepared as recommended and properly compacted fill, a modulus of subgrade reaction, *k* value, of 140 pounds per cubic inch (pci) may be used in the grade slab design based on correlation to values typically resulting from a 1 ft. x 1 ft. plate load test. However, depending on how the slab load is applied, the value will have to be geometrically modified. Where slab loading is distributed over more than a 1 foot by 1 foot area, the value k should be adjusted for larger areas using the following expression for cohesive and cohesionless soil:

Modulus of Subgrade Reaction, $k_s = (\frac{k}{B})$ for cohesive soil and

$k_s = k\,(\frac{B+1}{2B})^2$ for cohesionless soil

Where: k_s = coefficient of vertical subgrade reaction for loaded area,
k = coefficient of vertical subgrade reaction for 1 square foot area, and
B = effective width of area loaded, in feet

The precautions listed below should be followed for construction of slab-on-grade pads. These details will not reduce the amount of movement, but are intended to reduce potential damage should some settlement of the supporting subgrade take place. Some increase in moisture content is inevitable as a result of development and associated landscaping. However, extreme moisture content increases can be largely controlled by proper and responsible site drainage, building maintenance and irrigation practices.

- Cracking of slab-on-grade concrete is normal and should be expected. Cracking can occur not only as a result of heaving or compression of the supporting soil and/or bedrock material, but also as a result of concrete curing stresses. The occurrence of concrete shrinkage crack , and problems associated with concrete curing may be reduced and/or controlled by limiting the slump of the concrete, proper concrete placement, finishing, and curing, and by the placement of crack control joints at frequent intervals, particularly where re-entrant slab corners occur. The American Concrete Institute (ACI) recommends a maximum panel size (in feet) equal to approximately three times the thickness of the slab (in inches) in both directions. For example, joints are recommended at a maximum spacing of twelve (12) feet based on having a four-inch slab. PSI also recommends that the slab be independent of the foundation walls. Using fiber reinforcement in the concrete can also control shrinkage cracking.

- Areas supporting slabs should be properly moisture conditioned and compacted. Backfill in all interior and exterior water and sewer line trenches should be carefully compacted to reduce the shear stress in the concrete extending over these areas.

Exterior slabs should be isolated from the building. These slabs should be reinforced to function as independent units. Movement of these slabs should not be transmitted to the building foundation or superstructure.

Utilities Trenching

Excavation for utility trenches shall be performed in accordance with OSHA regulations as stated in 29 CFR Part 1926. It should be noted that utility trench excavations have the potential to degrade the properties of the adjacent fill materials. Utility trench walls that are allowed to move laterally can lead to reduced bearing capacity and increased settlement of adjacent structural elements and overlying slabs.

Backfill for utility trenches is as important as the original subgrade preparation or structural fill placed to support either a foundation or slab. Therefore, it is imperative that the backfill for utility trenches be placed to meet the project specifications for the structural fill of this project. PSI recommends that flowable fill or lean mix concrete be utilized for utility trench backfill. If on-site soils are placed as trench backfill, the backfill for the utility trenches should be placed in four (4) to six (6) inch loose lifts and compacted to a minimum of 95% of the maximum dry density achieved by the standard Proctor test. The backfill soil should be moisture conditioned to be within 2% of the optimum moisture content as determined by the standard Proctor test. Up to four (4) inches of bedding material placed directly under the pipes or conduits placed in the utility trench can be compacted to the 90% compaction criteria with respect to the standard Proctor. Compaction testing should be performed for every 200 cubic yards of backfill place or each lift within 200 linear feet of trench, which ever is less. Backfill of utility trenches should not be performed with water standing in the trench. If granular material is used for the backfill of the utility trench, the granular material should have a gradation that will filter protect the backfill material from the adjacent soils. If this gradation is not available, a geosynthetic non-woven filter fabric should be used to reduce the potential for the migration of fines into the backfill material. Granular backfill material shall be compacted to meet the above compaction criteria. The clean granular backfill material should be compacted to achieve a relative density greater than 75% or as specified by the geotechnical engineer for the specific material used.

Pavement Recommendations

PSI's scope of services did not include extensive sampling and CBR testing of existing subgrade or potential sources of imported fill for the specific purpose of detailed pavement analysis. Instead, this report is based on pavement-related design parameters that are considered to be typical for the area soils types.

Pavement sections can be grade supported on a minimum of twelve (12) inches of properly compacted structural fill. Proof-rolling, as discussed earlier in this report, should be accomplished to identify soft or unstable soils that should be removed from the pavement area prior to fill placement and/or pavement construction. These soils should be replaced with properly compacted structural fill as described earlier in this report.

Pavement sections were evaluated using Pavement Assessment Software (PAS), which is based on the 1993 AASHTO Design equations, a reliability of 80%, an annual growth rate of 2%, and a 20 year equivalent 18-kip single axle load (ESAL) of 30,000 for light duty pavements and 60,000 for heavy duty pavements. Flexible Pavements were evaluated based on an initial serviceability of 4.2 and a terminal service of 2.0. Rigid Pavements were evaluated based on an initial serviceability of 4.5, a terminal service of 2.0, an unreinforced concrete mix with a 28-day modulus of rupture of 650 pounds per square inch (psi) (approximately 4,000 psi compressive strength), are to be edge supported, and dowel and mesh reinforced.

In large areas of pavement, or where pavements are subject to significant traffic, a more detailed analysis of the subgrade and traffic conditions should be made. The results of such a study will provide information necessary to design an economical and serviceable pavement.

The recommended thicknesses presented below are considered typical and minimum for the calculated parameters. The client, the owner, and the project principals should be aware that thinner pavement sections might result in increased maintenance costs and lower than anticipated pavement life. The pavement subgrade should be prepared as discussed below.

The PSI recommendation is based on the subgrade soils being prepared to achieve a minimum CBR of three (3). On this basis, it is possible to use a locally typical "standard" pavement section consisting of the following:

RECOMMENDED THICKNESSES (INCHES)		
PAVEMENT MATERIALS *	**CAR PARKING**	**DRIVEWAYS**
Asphaltic Surface Course	1½	1½
Asphaltic Binder Course	2	3½
Crushed stone (3/4-inch minus)	6	6
Or		
Portland Cement Concrete	5	6
Crushed stone (3/4-inch minus)	4	4

*Pavement materials should conform to local and state guidelines, if applicable.

Asphalt Pavement

The granular base course should be built at least two (2) feet wider than the pavement on each side to support the tracks of the slipform paver. This extra width is structurally beneficial for wheel loads applied at the pavement edge. The asphalt base course should be compacted to a minimum of 95% Marshall density according to ASTM D1559.

Asphaltic surface mixture should have a minimum stability of 1,800 pounds and the surface course should be compacted to a minimum of 97% Marshall density according to ASTM D1559. Asphalt mixes should comply with APWA or MODOT specifications.

Asphaltic concrete mix designs and Marshall characteristics should be reviewed to determine if they are consistent with the recommendations given in this report.

Portland Cement Concrete Pavement

Because the pavement at this site will be subjected to freeze-thaw cycles, PSI recommends that an air entrainment admixture be added to the concrete mix to achieve air content in the range of 5% to 7% to provide freeze-thaw durability in the concrete. PSI recommends that a portland cement concrete with a 28-day specified compressive strength of 4,000 psi should be used. A mixture with a maximum slump of four (4) inches is acceptable. If a water reducing admixture is specified, the slump can be higher. It is recommended that admixtures be submitted to the owner in advance of use in the concrete.

Pavement for any dumpster areas or areas subject to consistent heavy loads should be constructed of Portland cement concrete with load transfer devices installed where construction joints are required. A thickened edge is recommended on the outside of slabs subjected to wheel loads. This thickened edge usually takes the form of an integral curb. Fill material should be compacted behind the curb or the edge of the outside slabs should be thickened. The following are recommended to enhance the quality of the pavement.

- Moisten subgrade just prior to placement of concrete.
- Cure fresh concrete with a liquid membrane-forming curing compound.
- Keep automobile traffic off the slab for three (3) days and truck traffic off the slab for seven (7) days, unless tests are made to determine that the concrete has gained adequate strength (i.e., usually 70% of design strength).

Pavement Subgrade Preparation

Prior to paving, the prepared subgrade should be proof-rolled using a loaded tandem axle dump truck or similar type of pneumatic tired equipment with a minimum gross weight of nine (9) tons per single axle. Localized soft areas identified should be repaired prior to paving. Moisture content of the subgrade should be maintained between –2% and +3% of the optimum at the time of paving. It may require rework when the subgrade is either desiccated or wet. PSI highly recommends that parking and drive subgrade be sloped in a manner to drain water from under the pavement without pocketing or trapping water beneath the pavement. This grading should be accomplished prior to placing the base aggregate.

Construction traffic should be minimized to prevent unnecessary disturbance of the pavement subgrade. Disturbed areas, as verified by PSI, should be removed and replaced with properly compacted material.

The edges of compacted fill should extend a minimum two (2) feet beyond the edges of the pavement, or a distance equal to the depth of fill beneath the pavement, whichever is greater. The measurement should be taken from the outside edge of the pavement to the toe of the excavation prior to sloping.

Pavement Drainage & Maintenance

PSI recommends pavements be sloped to provide rapid surface drainage. Water allowed to pond on or adjacent to the pavement could saturate the subgrade, cause premature deterioration of the pavements, and may require removal and replacement. PSI recommends the subgrade be sloped to drain prior to placing the crushed stone base. Consideration should be given to the use of interceptor drains to collect and remove water collecting in the crushed stone base. The interceptor drains could be incorporated with the storm drains of other utilities located in the pavement areas.

Periodic maintenance of the pavement should be anticipated. This should include sealing of cracks and joints and by maintaining proper surface drainage to avoid ponding of water on or near the pavement areas. Underdrains, sub-drains and underslab drains presented in this report will not prevent moisture vapor that can cause mold growth.

Slopes

The benched placement of engineered structural fill on natural slopes steeper than five (5) horizontal to one (1) vertical where the final area will be uncontained is recommended. The placement of fill should begin at the base of the natural slope with benches or terraces. The benches or terraces should be a minimum of eight (8) feet wide laterally, and should be cut into the slope every five (5) feet of vertical rise. The naturally occurring existing soils should be prepared and fill placed in accordance with the previously described structural fill guidelines. A representative of the geotechnical engineer should monitor the benching and fill placement operations.

Unless specifically designed, temporary slopes shall not exceed steeper than a ratio of two (2) horizontal to one (1) vertical where workers or equipment will occupy space at the toe or of the movement of the excavated slope will jeopardize the stability of an adjacent structure. Temporary slopes exceeding ten (10) feet in vertical height should have a slope stability analysis. Temporary slopes exceeding twenty (20) feet in vertical height should have shear strength testing performed to assess the in-situ strength characteristics.

Permanent cut slopes shall not be excavated to a final grade steeper than a ratio of three (3) horizontal to one (1) vertical without a specific slope stability analysis. Specific shear strength testing should be performed to assess the in-situ strength characteristics for permanent slopes steeper than four (4) horizontal to one (1) vertical.

Special consideration must also be given to the stability of the natural cut ground when supporting substantial fills, to structural fills themselves, and to cut surfaces in natural soil and rock excavations. The evaluation of slope stability aspects of this site and the proposed development is beyond the scope of this exploration. Relatively detailed grading plans will have to be developed before meaningful evaluation of slope stability can be accomplished. All slope stability evaluations should be performed by qualified geotechnical engineering personnel prior to the initiation of any significant grading activities at this site.

CONSTRUCTION CONSIDERATIONS

PSI should be retained to provide observation and testing of construction activities involved in the foundation, earthwork, and related activities of this project. PSI cannot accept responsibility for conditions that deviate from those described in this report, nor for the performance of the foundation system if not engaged to also provide construction observation and testing for this project.

Moisture Sensitive Soils/Weather Related Concerns

The upper fine-grained soils encountered at this site are expected to be sensitive to disturbances caused by construction traffic and to changes in moisture content. During wet weather periods, increases in the moisture content of the soil can cause significant reduction in the soil strength and support capabilities. In addition, soils that become wet may be slow to dry and thus significantly retard the progress of grading and compaction activities. It will, therefore, be advantageous to perform earthwork and foundation construction activities during dry weather.

Drainage and Groundwater Considerations

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

Excavations

In Federal Register, Volume 54, Number 209 (October 1989), the United States Department of Labor, Occupational Safety and Health Administration (OSHA) amended its "Construction Standards for Excavations, 29 CFR, part 1926, Subpart P". This document was issued to better enhance the safety of workers entering trenches or excavations. It is mandated by this federal regulation that excavations, whether they be utility trenches, basement excavation or footing excavations, be constructed in accordance with the new OSHA guidelines. It is PSI’s understanding that these regulations are being strictly enforced and if they are not closely followed, the owner and the contractor could be liable for substantial penalties.

The contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. The contractor's "responsible person", as defined in 29 CFR Part 1926, should evaluate the soil exposed in the excavations as part of the contractor's safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and federal safety regulations.

PSI is providing this information solely as a service to our client. PSI does not assume responsibility for construction site safety or the contractor's or other parties’ compliance with local, state, and federal safety or other regulations.

GEOTECHNICAL RISK

The concept of risk is an important aspect of the geotechnical evaluation. The primary reason for this is that the analytical methods used to develop geotechnical recommendations do not comprise an exact science. The analytical tools which geotechnical engineers use are generally empirical and must be used in conjunction with engineering judgment and experience. Therefore, the solutions and recommendations presented in the geotechnical evaluation should not be considered risk-free and, more importantly, are not a guarantee that the interaction between the soils and the proposed construction will perform as planned. The engineering recommendations presented in the preceding section constitutes PSI’s professional estimate of those measures that are necessary for the proposed improvements to perform according to the proposed design based on the information generated and referenced during this evaluation, and PSI’s experience in working with these conditions.

REPORT LIMITATIONS

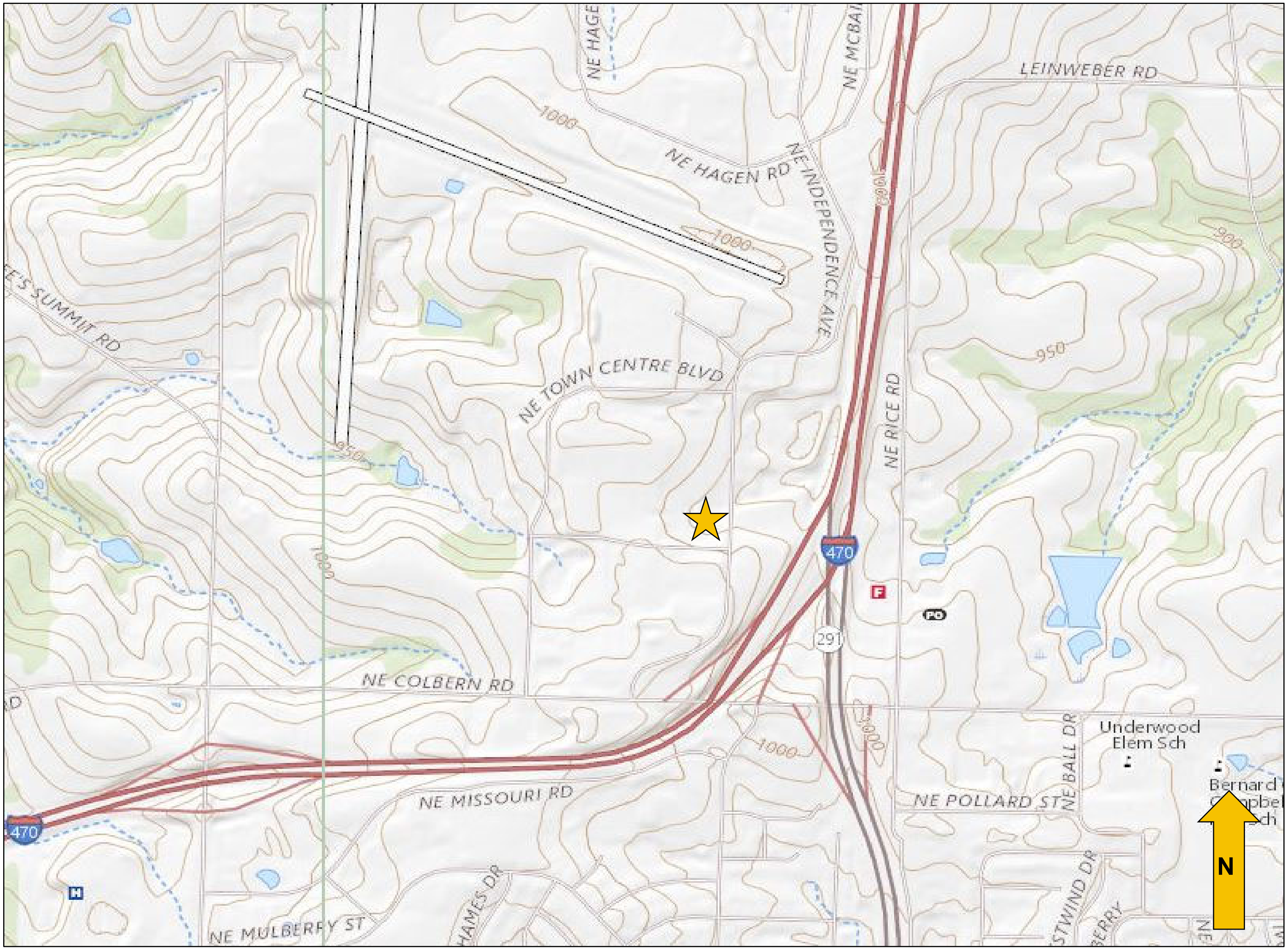
The recommendations submitted are based on the available subsurface information obtained by PSI and design details furnished by Davidson Architecture & Engineering. If there are revisions to the plans for this project or if deviations from the subsurface conditions noted in this report are encountered during construction, PSI should be notified immediately to determine if changes in the recommendations are required. If PSI is not retained to perform these functions, PSI will not be responsible for the impact of those conditions on the project.

The geotechnical engineer warrants that the findings, recommendations, specifications, or professional advice contained herein have been made in accordance with generally accepted professional geotechnical engineering practices in the local area. No other warranties are implied or expressed.

After the plans and specifications are more complete, the geotechnical engineer should be retained and provided the opportunity to review the final design plans and specifications to check that our engineering recommendations have been properly incorporated into the design documents. At that time, it may be necessary to submit supplementary recommendations. This report has been prepared for the exclusive use of Lee’s Summit Subaru for the specific application to the proposed detail center to be constructed at 2105 Northeast Independence Avenue in Lee’s Summit, Missouri.

APPENDIX A - TOPOGRAPHIC MAP

Intertek-PSI



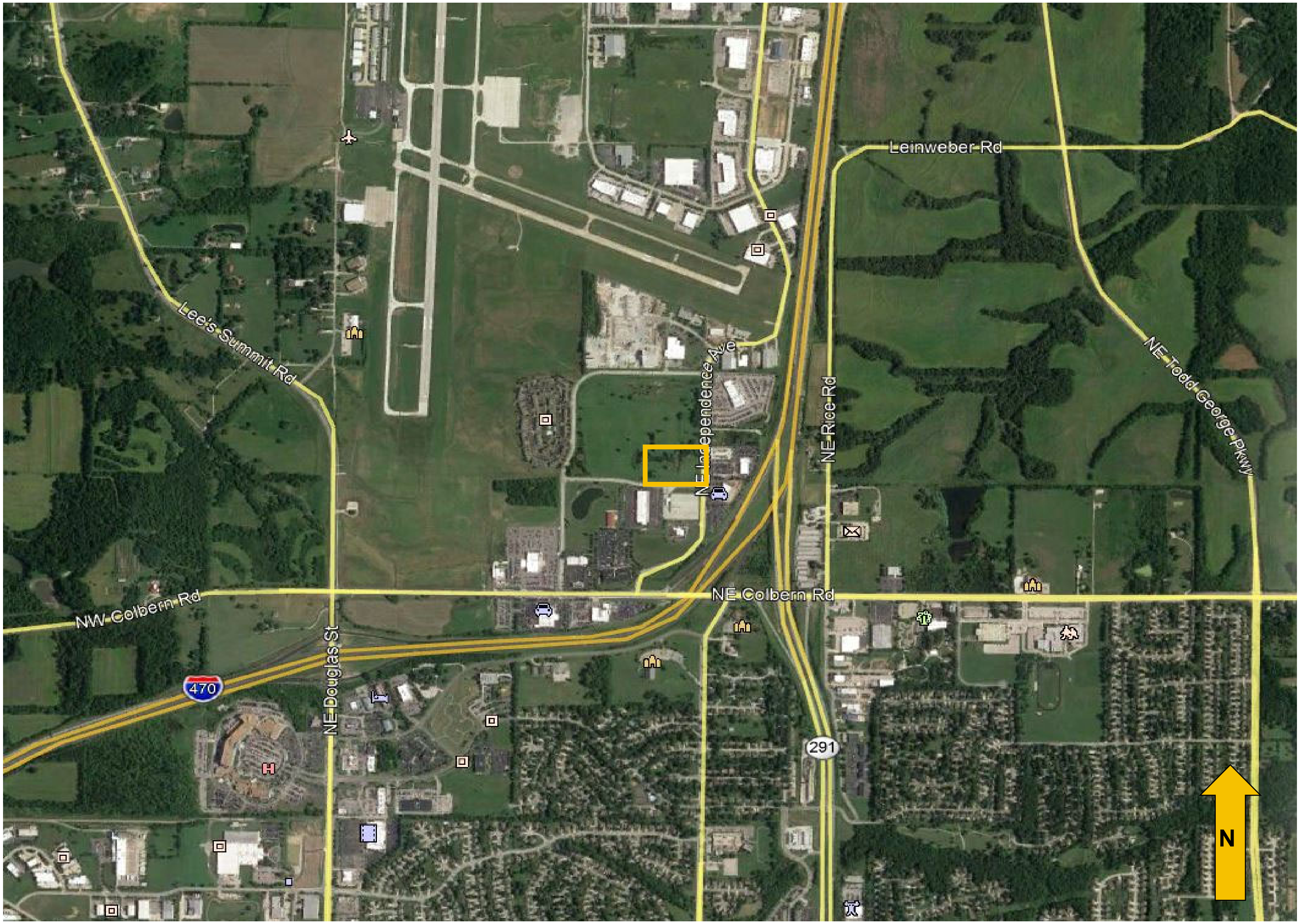
Topographic Drawing
Proposed Detail Center
2150 NE Independence Avenue
Lee's Summit, Missouri

Intertek-PSI Project No.: 0338-2128

Drawn By: IMS

APPENDIX B - SITE VICINITY MAP

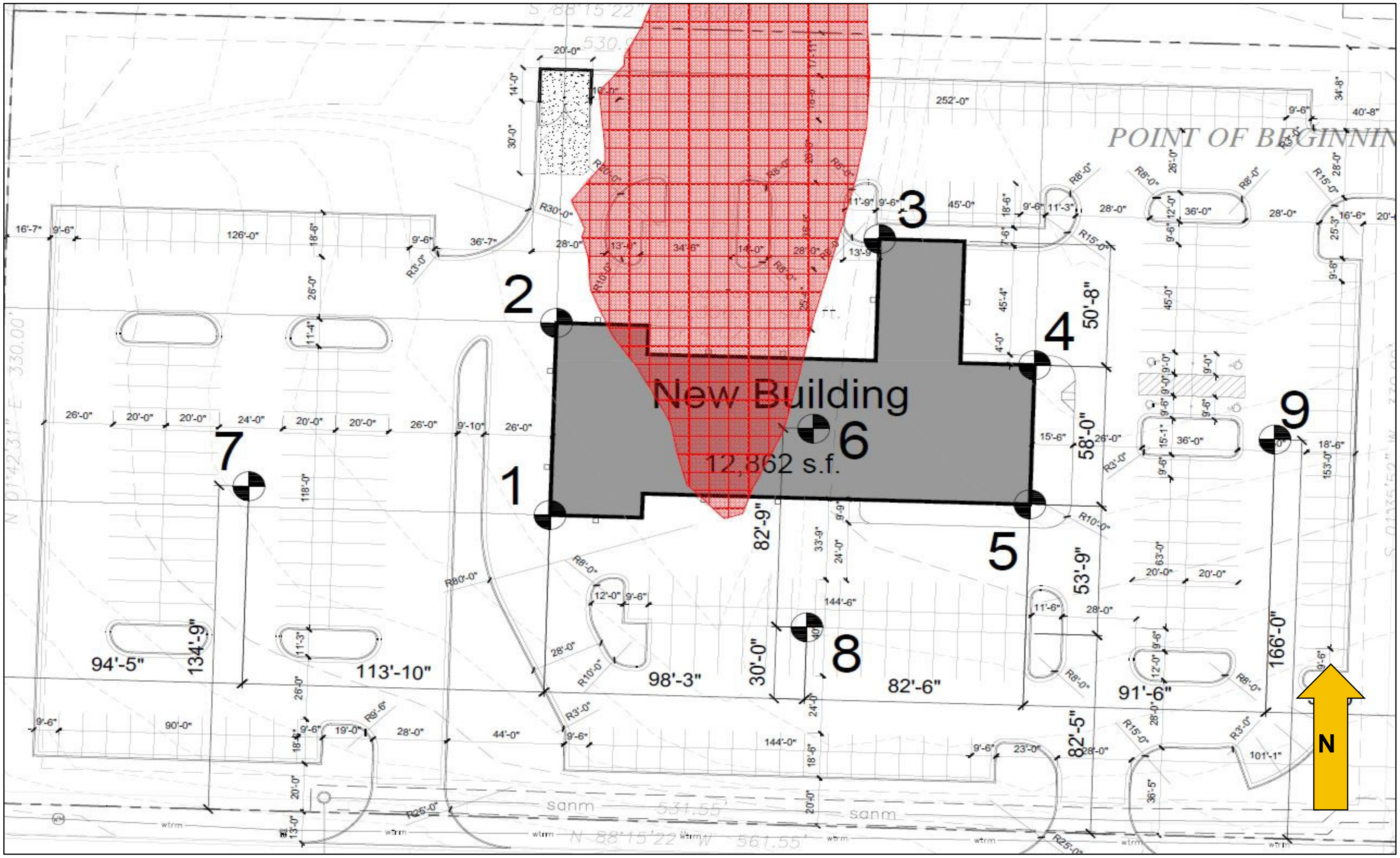
Intertek-PSI



Site Vicinity Plan Proposed Detail Center 2150 NE Independence Avenue Lee's Summit, Missouri	Intertek-PSI Project No.:	0338-2128	
	Aerial Year:	2019	Drawn By:
	Drawing Date:	9/29/20	IMS

APPENDIX C – BORING LOCATION PLAN

Intertek-PSI



Boring Location Diagram Proposed Detail Center 2150 NE Independence Avenue Lee's Summit, Missouri	Intertek-PSI Project No.:	0338-2128
	Date: 9/29/2020	Drawn By: IMS

Intertek-PSI

Boring Location Diagram Proposed Detail Center 2150 NE Independence Avenue Lee's Summit, Missouri	Intertek-PSI Project No.:	0338-2128
	Date: 9/29/2020	Drawn By:

APPENDIX D – BORING LOGS

DATE STARTED: 9/18/20
DATE COMPLETED: 9/18/20
COMPLETION DEPTH 19.5 ft
BENCHMARK: N/A
ELEVATION: 993 ft
LATITUDE:
LONGITUDE:
STATION: N/A **OFFSET:** N/A
REMARKS: N_{60} denotes the normalization to 60% efficiency as described in ASTM D4633.

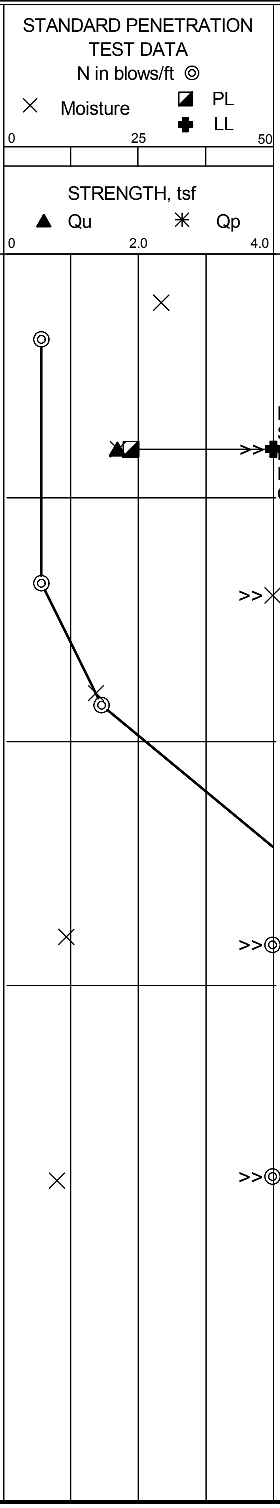
DRILL COMPANY: PSI, Inc.
DRILLER: SD **LOGGED BY:** LN
DRILL RIG: CME-55LC
DRILLING METHOD: Hollow Stem Auger
SAMPLING METHOD: SS/ ST
HAMMER TYPE: Automatic
EFFICIENCY 84%
REVIEWED BY: IS

BORING B-01

Water		
▽	While Drilling	not observed
▼	Upon Completion	not observed
▽	Delay	N/A

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) Push Pressure (ST)	Moisture, %	Additional Remarks
	0			**ORGANIC LAYER- APPROXIMATELY 7 INCHES**				
				HIGH PLASTICITY CLAY Dark brown to light brown	CH			
		1	15			2-2-3 N_{60}=7	29	
990								
		2	10				21	DD = 98 pcf Sat.=83% LL = 66 PL = 24 Q_u = 1.7 tsf
	5							
				Light brown to reddish brown				
		3	18			1-1-4 N_{60}=7	63	
985								
				WEATHERED SHALE				
				WEATHERED LIMESTONE				
		4	18	**WEATHERED SHALE** Olive to gray		4-5-8 N_{60}=18	17	
	10							
980								
		5	16			7-39-50/4	12	
	15			**SHALE**				
975								
		6	10			27-50/4	10	
				Boring terminated at approximately 19 1/2 feet.				



Professional Service Industries, Inc.
1211 W. Cambridge Circle Drive
Kansas City, KS 66103
Telephone: (913) 310-1600

PROJECT NO.: 338-2128
PROJECT: Detail Center
LOCATION:
Lee's Summit, MO

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-02

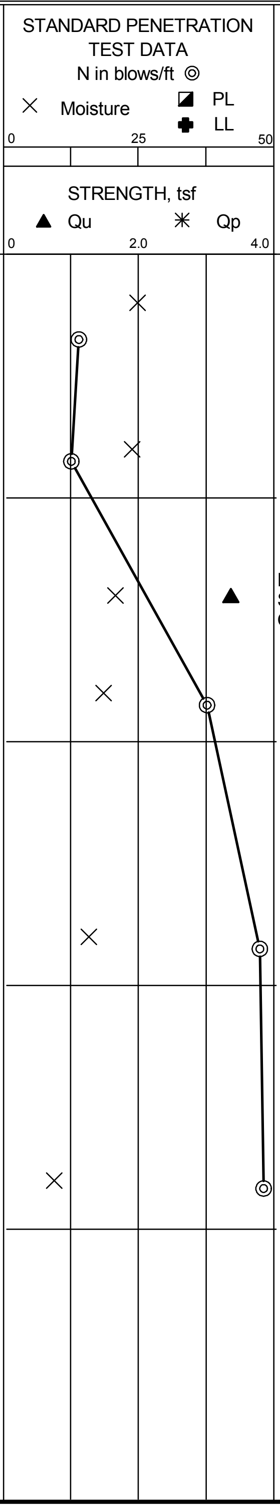
DATE STARTED: 9/18/20
DATE COMPLETED: 9/18/20
COMPLETION DEPTH 20.0 ft
BENCHMARK: N/A
ELEVATION: 991 ft
LATITUDE:
LONGITUDE:
STATION: N/A **OFFSET:** N/A
REMARKS: N_{60} denotes the normalization to 60% efficiency as described in ASTM D4633.

DRILL COMPANY: PSI, Inc.
DRILLER: SD **LOGGED BY:** LN
DRILL RIG: CME-55LC
DRILLING METHOD: Hollow Stem Auger
SAMPLING METHOD: SS/ ST
HAMMER TYPE: Automatic
EFFICIENCY 84%
REVIEWED BY: IS

Water		
∇	While Drilling	not observed
▼	Upon Completion	not observed
⊻	Delay	N/A

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) Push Pressure (ST)	Moisture, %	Additional Remarks
	0			**ORGANIC LAYER- APPROXIMATELY 4 INCHES**				
990				**HIGH PLASTICITY CLAY** Brown to gray, roots	CH			
		1	16			3-4-6 N_{60}=14	25	
		2	18			4-4-5 N_{60}=13	24	
				WEATHERED SHALE Gray to olive				
	5							
985								
		3	19				21	DD = 111 pcf Sat.=111% Q_u = 3.4 tsf
		4	18			4-12-15 N_{60}=38	19	
	10							
980								
		5	18			5-15-19 N_{60}=48	16	
	15							
975								
		6	16	**SHALE** Gray		6-22-50/4	9	
	20			Boring terminated at approximately 20 feet				



Professional Service Industries, Inc.
1211 W. Cambridge Circle Drive
Kansas City, KS 66103
Telephone: (913) 310-1600

PROJECT NO.: 338-2128
PROJECT: Detail Center
LOCATION:
Lee's Summit, MO

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED: 9/18/20
DATE COMPLETED: 9/18/20
COMPLETION DEPTH 19.5 ft
BENCHMARK: N/A
ELEVATION: 988 ft
LATITUDE:
LONGITUDE:
STATION: N/A **OFFSET:** N/A
REMARKS: N_{60} denotes the normalization to 60% efficiency as described in ASTM D4633.

DRILL COMPANY: PSI, Inc.
DRILLER: SD **LOGGED BY:** LN
DRILL RIG: CME-55LC
DRILLING METHOD: Hollow Stem Auger
SAMPLING METHOD: SS/ ST
HAMMER TYPE: Automatic
EFFICIENCY 84%
REVIEWED BY: IS

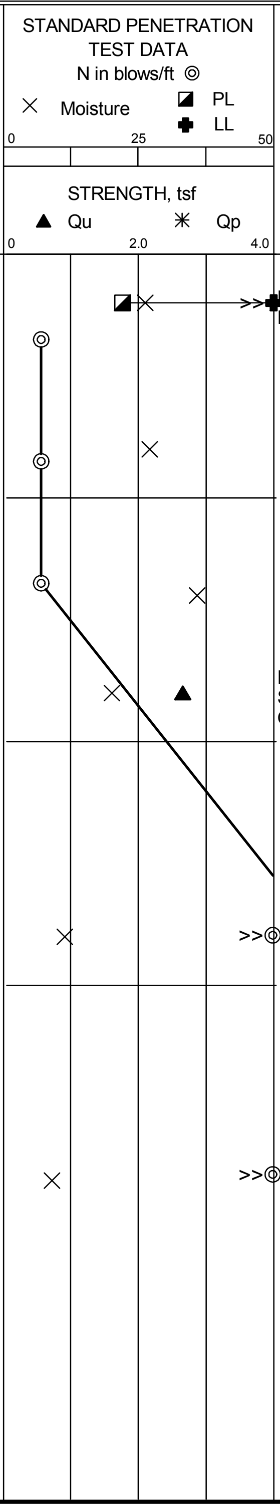
BORING B-03

Water		
▽ While Drilling	not observed	
▼ Upon Completion	not observed	
▽ Delay	N/A	

BORING LOCATION:

Elevation (feet)	Depth, (feet)
	0
985	
	5
980	
	10
975	
	15
970	

Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) Push Pressure (ST)	Moisture, %	Additional Remarks
		ORGANIC LAYER- APPROXIMATELY 2 INCHES				
1	16	**HIGH PLASTICITY CLAY** Light brown to brown	CH	2-2-3 N_{60}=7	26	LL = 68 PL = 22
2	18	Light brown to light gray		2-2-3 N_{60}=7	27	
3	18	**WEATHERED SHALE** Gray to light brown to olive		1-2-3 N_{60}=7	36	
4	13				20	DD = 111 pcf Sat.=109% Q_u = 2.7 tsf
5	17	**SHALE** Gray		11-32-50/5	11	
6	9			31-50/3	9	
		Boring terminated at approximately 19 1/2 feet.				



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1211 W. Cambridge Circle Drive
Kansas City, KS 66103
Telephone: (913) 310-1600

PROJECT NO.: 338-2128
PROJECT: Detail Center
LOCATION:
Lee's Summit, MO

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-04

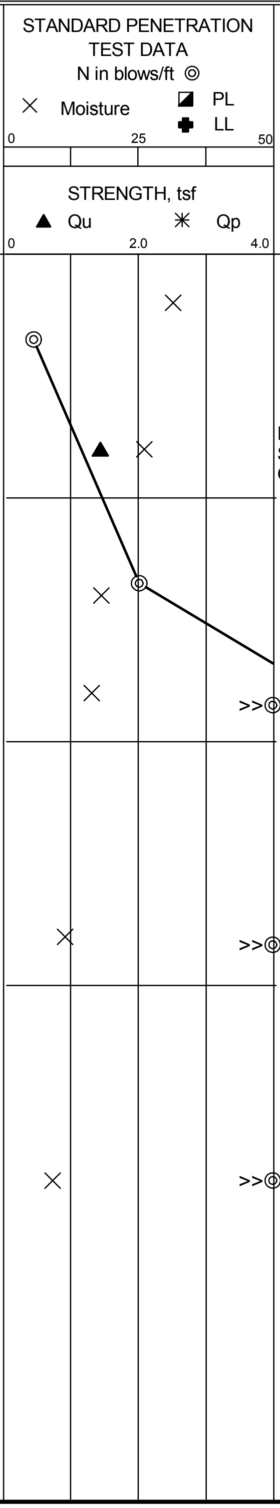
DATE STARTED: 9/18/20
DATE COMPLETED: 9/18/20
COMPLETION DEPTH 19.5 ft
BENCHMARK: N/A
ELEVATION: 986 ft
LATITUDE:
LONGITUDE:
STATION: N/A **OFFSET:** N/A
REMARKS: N_{60} denotes the normalization to 60% efficiency as described in ASTM D4633.

DRILL COMPANY: PSI, Inc.
DRILLER: SD **LOGGED BY:** LN
DRILL RIG: CME-55LC
DRILLING METHOD: Hollow Stem Auger
SAMPLING METHOD: SS/ ST
HAMMER TYPE: Automatic
EFFICIENCY 84%
REVIEWED BY: IS

Water		
▽	While Drilling	not observed
▼	Upon Completion	not observed
▽	Delay	N/A

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) Push Pressure (ST)	Moisture, %	Additional Remarks
	0			**ORGANIC LAYER- APPROXIMATELY 3 INCHES**				
985		1	8	**HIGH PLASTICITY CLAY** Grayish brown to light brown	CH	2-2-2 N_{60}=6	32	
		2	12				26	DD = 101 pcf Sat.=108% Q_u = 1.4 tsf
980	5			**WEATHERED SHALE** Light brown to olive				
		3	18			2-5-13 N_{60}=25	18	
		4	18			5-18-27 N_{60}=63	16	
975	10							
		5	15	**SHALE** Gray		12-39-50/3	11	
970	15							
		6	12			28-50	9	
				Boring terminated at approximately 19 1/2 feet.				



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Telephone: (913) 310-1600

PROJECT NO.: 338-2128
PROJECT: Detail Center
LOCATION:
Lee's Summit, MO

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED: 9/18/20
DATE COMPLETED: 9/18/20
COMPLETION DEPTH 19.5 ft
BENCHMARK: N/A
ELEVATION: 988 ft
LATITUDE:
LONGITUDE:
STATION: N/A **OFFSET:** N/A
REMARKS: N_{60} denotes the normalization to 60% efficiency as described in ASTM D4633.

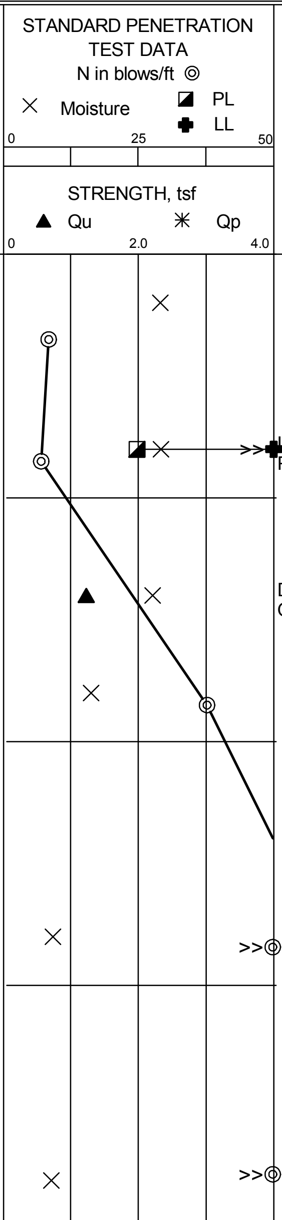
DRILL COMPANY: PSI, Inc.
DRILLER: SD **LOGGED BY:** LN
DRILL RIG: CME-55LC
DRILLING METHOD: Hollow Stem Auger
SAMPLING METHOD: SS/ ST
HAMMER TYPE: Automatic
EFFICIENCY 84%
REVIEWED BY: IS

BORING B-05

Water		
▽	While Drilling	not observed
▼	Upon Completion	not observed
▽	Delay	N/A

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) Push Pressure (ST)	Moisture, %	Additional Remarks
	0			**ORGANIC LAYER- APPROXIMATELY 2 INCHES**				
				HIGH PLASTICITY CLAY Gray	CH			
		1	8			2-2-4 N_{60}=8	29	
985		2	16			2-2-3 N_{60}=7	29	LL = 61 PL = 25
	5	3	13				28	DD = 102 pcf Q_u = 1.2 tsf
				WEATHERED SHALE Brown to gray				
980		4	18			5-4-23 N_{60}=38	16	
	10							
975				**SHALE** Gray				
		5	10			28-50/4	9	
	15							
970		6	9			34-50/3	9	
				Boring terminated at approximately 19 1/2 feet.				



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Kansas City, KS 66103
Telephone: (913) 310-1600

PROJECT NO.: 338-2128
PROJECT: Detail Center
LOCATION:
Lee's Summit, MO

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-06

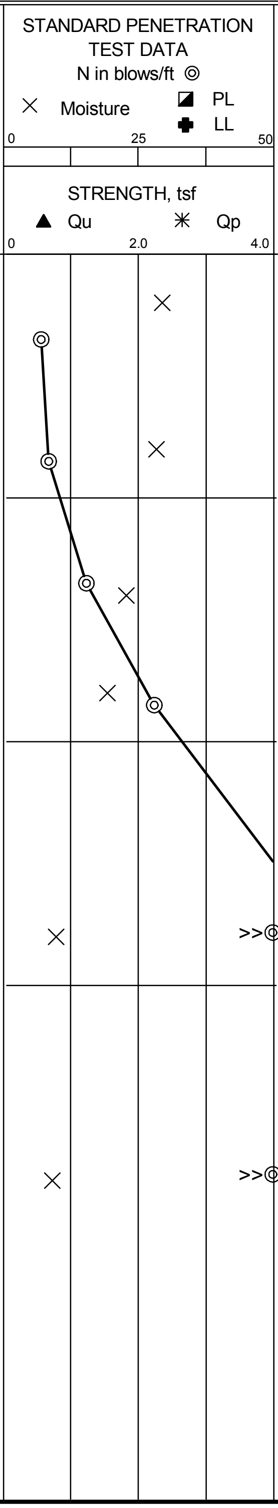
DATE STARTED: 9/18/20
DATE COMPLETED: 9/18/20
COMPLETION DEPTH 19.5 ft
BENCHMARK: N/A
ELEVATION: 992 ft
LATITUDE:
LONGITUDE:
STATION: N/A **OFFSET:** N/A
REMARKS: N_{60} denotes the normalization to 60% efficiency as described in ASTM D4633.

DRILL COMPANY: PSI, Inc.
DRILLER: SD **LOGGED BY:** LN
DRILL RIG: CME-55LC
DRILLING METHOD: Hollow Stem Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY 84%
REVIEWED BY: IS

Water		
▽	While Drilling	not observed
▼	Upon Completion	not observed
▽	Delay	N/A

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0			**HIGH PLASTICITY CLAY**				
990		1	16	Gray to brown	CH	2-2-3 N_{60}=7	30	
		2	16	**WEATHERED SHALE** Olive to brown to gray		2-3-3 N_{60}=8	28	
	5							
985		3	15			2-4-7 N_{60}=15	23	
		4	17			4-8-12 N_{60}=28	19	
	10							
980				**SHALE** Gray				
		5	10			23-50/4	10	
	15							
975								
		6	9			24-50/3	9	
				Boring terminated at approximately 19 1/2 feet.				



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Telephone: (913) 310-1600

PROJECT NO.: 338-2128
PROJECT: Detail Center
LOCATION:
Lee's Summit, MO

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-07

DATE STARTED: 9/18/20
DATE COMPLETED: 9/18/20
COMPLETION DEPTH 10.0 ft
BENCHMARK: N/A
ELEVATION: 998 ft
LATITUDE:
LONGITUDE:
STATION: N/A **OFFSET:** N/A
REMARKS: N_{60} denotes the normalization to 60% efficiency as described in ASTM D4633.

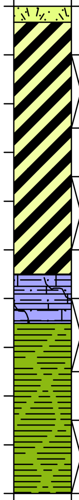
DRILL COMPANY: PSI, Inc.
DRILLER: SD **LOGGED BY:** LN
DRILL RIG: CME-55LC
DRILLING METHOD: Hollow Stem Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY 84%
REVIEWED BY: IS

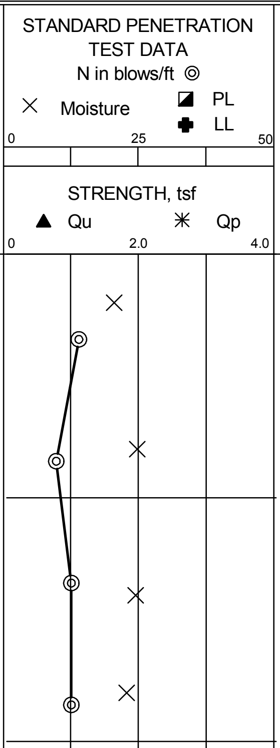
Water		
▽	While Drilling	not observed
▼	Upon Completion	not observed
▽	Delay	N/A

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %
	0				**ORGANIC LAYER- APPROXIMATELY 4 INCHES**			
					HIGH PLASTICITY CLAY Brown to gray	CH		21
		☒	1	12			3-5-5 N_{60}=14	
995		☒	2	15			3-3-4 N_{60}=10	25
	5				**WEATHERED LIMESTONE AND CLAY**			
					WEATHERED SHALE			
		☒	3	18			9-5-4 N_{60}=13	25
990		☒	4	18			3-4-5 N_{60}=13	23
	10				Boring terminated at approximately 10 feet.			

Graphic Log





Additional Remarks

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PROJECT NO.: 338-2128
PROJECT: Detail Center
LOCATION:
Lee's Summit, MO

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-08

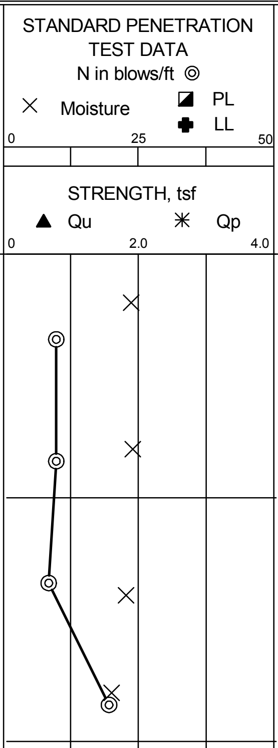
DATE STARTED: 9/18/20
DATE COMPLETED: 9/18/20
COMPLETION DEPTH 10.0 ft
BENCHMARK: N/A
ELEVATION: 992 ft
LATITUDE:
LONGITUDE:
STATION: N/A **OFFSET:** N/A
REMARKS: N_{60} denotes the normalization to 60% efficiency as described in ASTM D4633.

DRILL COMPANY: PSI, Inc.
DRILLER: SD **LOGGED BY:** LN
DRILL RIG: CME-55LC
DRILLING METHOD: Hollow Stem Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY 84%
REVIEWED BY: IS

Water		
▽	While Drilling	not observed
▼	Upon Completion	not observed
▼	Delay	N/A

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0			**ORGANIC LAYER- APPROXIMATELY 3 INCHES**				
990		1	16	**HIGH PLASTICITY CLAY** Dark gray to brown	CH	3-3-4 N_{60}=10	24	
	5	2	18			3-3-4 N_{60}=10	24	
985		3	17	**WEATHERED SHALE** Gray to brown		2-2-4 N_{60}=8	23	
		4	18			3-5-9 N_{60}=20	20	
	10			Boring terminated at approximately 10 feet.				



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PROJECT NO.: 338-2128
PROJECT: Detail Center
LOCATION: Lee's Summit, MO

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED: 9/18/20
DATE COMPLETED: 9/18/20
COMPLETION DEPTH 10.0 ft
BENCHMARK: N/A
ELEVATION: 987 ft
LATITUDE:
LONGITUDE:
STATION: N/A **OFFSET:** N/A
REMARKS: N_{60} denotes the normalization to 60% efficiency as described in ASTM D4633.

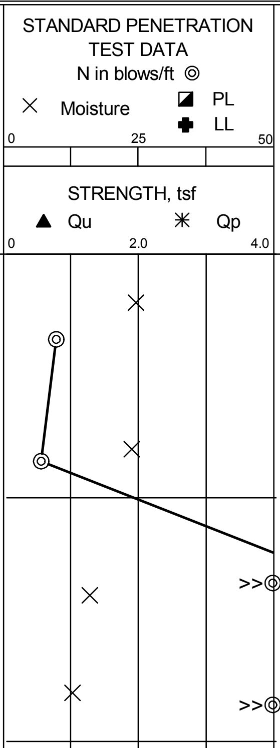
DRILL COMPANY: PSI, Inc.
DRILLER: SD **LOGGED BY:** LN
DRILL RIG: CME-55LC
DRILLING METHOD: Hollow Stem Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY 84%
REVIEWED BY: IS

BORING B-09

Water		
▽	While Drilling	not observed
▼	Upon Completion	not observed
▽	Delay	N/A

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0					**ORGANIC LAYER- APPROXIMATELY 6 INCHES**				
985				1	14	**WEATHERED SHALE** Brown to gray		3-3-4 N_{60}=10	25	
				2	12			3-2-3 N_{60}=7	24	
	5									
980				3	17	**SHALE** Gray		7-18-28 N_{60}=64	16	
				4	17			9-25-35 N_{60}=84	13	
	10					Boring terminated at approximately 10 feet.				



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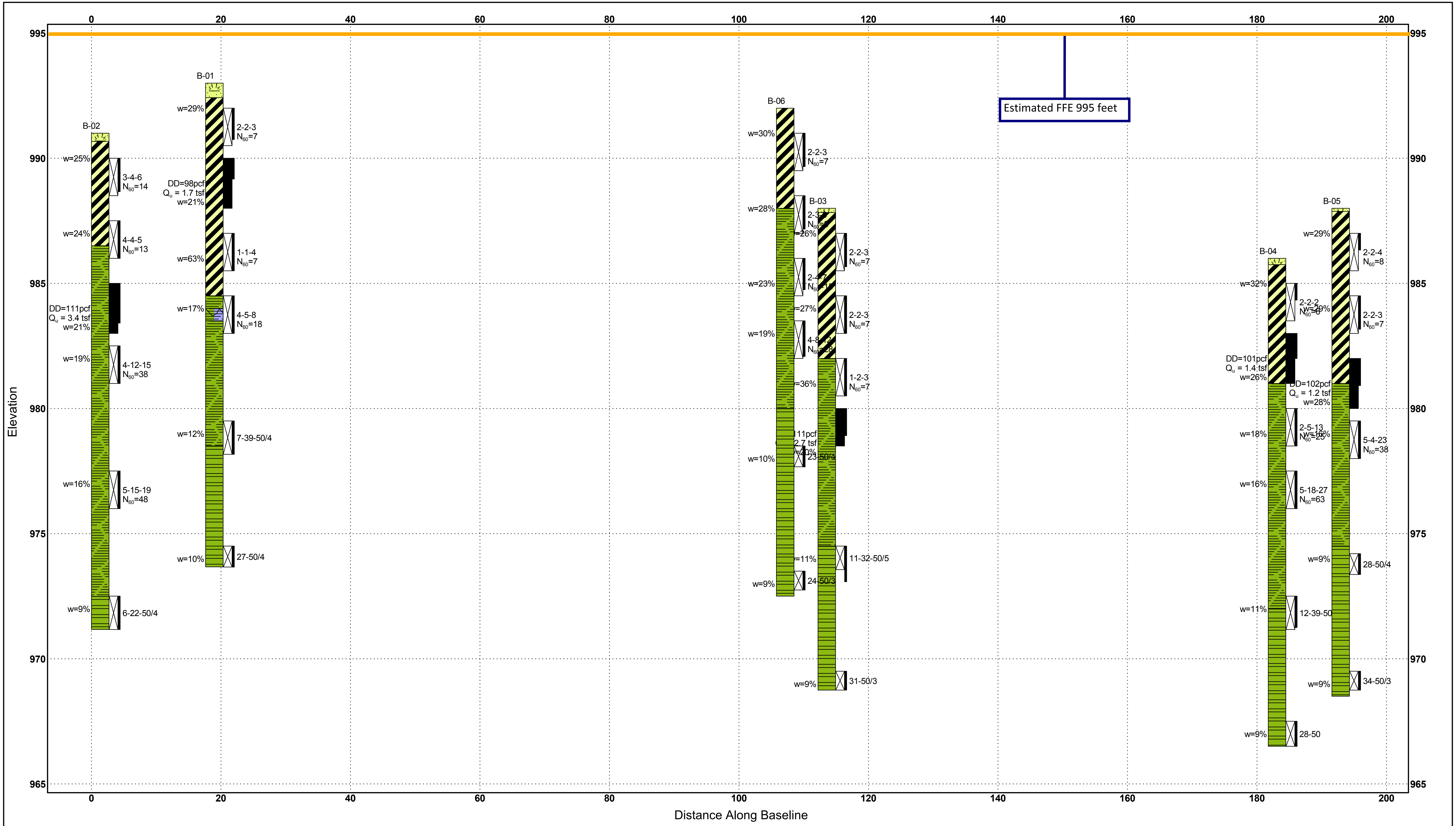
1211 W. Cambridge Circle Drive
Kansas City, KS 66103
Telephone: (913) 310-1600

PROJECT NO.: 338-2128
PROJECT: Detail Center
LOCATION:
Lee's Summit, MO

The stratification lines represent approximate boundaries. The transition may be gradual.



Professional Service Industries, Inc.
1211 W. Cambridge Circle Drive
Kansas City, KS 66103

Profile

Detail Center
PSI Project Number: 338-2128 Lee's Summit, MO

APPENDIX E – GENERAL NOTES/SOIL CLASSIFICATION CHART

GENERAL NOTES

SAMPLE IDENTIFICATION

The Unified Soil Classification System (USCS), AASHTO 1988 and ASTM designations D2487 and D-2488 are used to identify the encountered materials unless otherwise noted. Coarse-grained soils are defined as having more than 50% of their dry weight retained on a #200 sieve (0.075mm); they are described as: boulders, cobbles, gravel or sand. Fine-grained soils have less than 50% of their dry weight retained on a #200 sieve; they are defined as silts or clay depending on their Atterberg Limit attributes. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size.

DRILLING AND SAMPLING SYMBOLS

SFA: Solid Flight Auger - typically 4" diameter flights, except where noted.
HSA: Hollow Stem Auger - typically 3¼" or 4¼ I.D. openings, except where noted.
M.R.: Mud Rotary - Uses a rotary head with Bentonite or Polymer Slurry
R.C.: Diamond Bit Core Sampler
H.A.: Hand Auger
P.A.: Power Auger - Handheld motorized auger

☒ SS: Split-Spoon - 1 3/8" I.D., 2" O.D., except where noted.
■ ST: Shelby Tube - 3" O.D., except where noted.
▯ RC: Rock Core
↓ TC: Texas Cone
✋ BS: Bulk Sample
▞ PM: Pressuremeter
CPT-U: Cone Penetrometer Testing with Pore-Pressure Readings

SOIL PROPERTY SYMBOLS

N: Standard "N" penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2-inch O.D. Split-Spoon.
N_{60}: A "N" penetration value corrected to an equivalent 60% hammer energy transfer efficiency (ETR)
Q_u: Unconfined compressive strength, TSF
Q_p: Pocket penetrometer value, unconfined compressive strength, TSF
w%: Moisture/water content, %
LL: Liquid Limit, %
PL: Plastic Limit, %
PI: Plasticity Index = (LL-PL),%
DD: Dry unit weight, pcf
▼, ▽, ▼ Apparent groundwater level at time noted

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Relative Density	N - Blows/foot
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	50 - 80
Extremely Dense	80+

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

GRAIN-SIZE TERMINOLOGY

Component	Size Range
Boulders:	Over 300 mm (>12 in.)
Cobbles:	75 mm to 300 mm (3 in. to 12 in.)
Coarse-Grained Gravel:	19 mm to 75 mm (¾ in. to 3 in.)
Fine-Grained Gravel:	4.75 mm to 19 mm (No.4 to ¾ in.)
Coarse-Grained Sand:	2 mm to 4.75 mm (No.10 to No.4)
Medium-Grained Sand:	0.42 mm to 2 mm (No.40 to No.10)
Fine-Grained Sand:	0.075 mm to 0.42 mm (No. 200 to No.40)
Silt:	0.005 mm to 0.075 mm
Clay:	<0.005 mm

PARTICLE SHAPE

Description	Criteria
Flat:	Particles with width/thickness ratio > 3
Elongated:	Particles with length/width ratio > 3
Flat & Elongated:	Particles meet criteria for both flat and elongated

RELATIVE PROPORTIONS OF FINES

Descriptive Term	% Dry Weight
Trace:	< 5%
With:	5% to 12%
Modifier:	>12%

GENERAL NOTES

(Continued)

CONSISTENCY OF FINE-GRAINED SOILS

Q_U - TSF	N - Blows/foot	Consistency
0 - 0.25	0 - 2	Very Soft
0.25 - 0.50	2 - 4	Soft
0.50 - 1.00	4 - 8	Firm (Medium Stiff)
1.00 - 2.00	8 - 15	Stiff
2.00 - 4.00	15 - 30	Very Stiff
4.00 - 8.00	30 - 50	Hard
8.00+	50+	Very Hard

MOISTURE CONDITION DESCRIPTION

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 water table

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term	% Dry Weight
Trace:	< 15%
With:	15% to 30%
Modifier:	>30%

STRUCTURE DESCRIPTION

Description	Criteria
Stratified:	Alternating layers of varying material or color with layers at least ¼-inch (6 mm) thick
Laminated:	Alternating layers of varying material or color with layers less than ¼-inch (6 mm) thick
Fissured:	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided:	Fracture planes appear polished or glossy, sometimes striated

Description	Criteria
Blocky:	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed:	Inclusion of small pockets of different soils
Layer:	Inclusion greater than 3 inches thick (75 mm)
Seam:	Inclusion 1/8-inch to 3 inches (3 to 75 mm) thick extending through the sample
Parting:	Inclusion less than 1/8-inch (3 mm) thick

SCALE OF RELATIVE ROCK HARDNESS

Q_U - TSF	Consistency
2.5 - 10	Extremely Soft
10 - 50	Very Soft
50 - 250	Soft
250 - 525	Medium Hard
525 - 1,050	Moderately Hard
1,050 - 2,600	Hard
>2,600	Very Hard

ROCK BEDDING THICKNESSES

Description	Criteria
Very Thick Bedded	Greater than 3-foot (>1.0 m)
Thick Bedded	1-foot to 3-foot (0.3 m to 1.0 m)
Medium Bedded	4-inch to 1-foot (0.1 m to 0.3 m)
Thin Bedded	1¼-inch to 4-inch (30 mm to 100 mm)
Very Thin Bedded	½-inch to 1¼-inch (10 mm to 30 mm)
Thickly Laminated	1/8-inch to ½-inch (3 mm to 10 mm)
Thinly Laminated	1/8-inch or less "paper thin" (<3 mm)

ROCK VOIDS

Voids	Void Diameter
Pit	<6 mm (<0.25 in)
Vug	6 mm to 50 mm (0.25 in to 2 in)
Cavity	50 mm to 600 mm (2 in to 24 in)
Cave	>600 mm (>24 in)

GRAIN-SIZED TERMINOLOGY

(Typically Sedimentary Rock)

Component	Size Range
Very Coarse Grained	>4.76 mm
Coarse Grained	2.0 mm - 4.76 mm
Medium Grained	0.42 mm - 2.0 mm
Fine Grained	0.075 mm - 0.42 mm
Very Fine Grained	<0.075 mm

ROCK QUALITY DESCRIPTION

Rock Mass Description	RQD Value
Excellent	90 -100
Good	75 - 90
Fair	50 - 75
Poor	25 -50
Very Poor	Less than 25

DEGREE OF WEATHERING

Slightly Weathered:	Rock generally fresh, joints stained and discoloration extends into rock up to 25 mm (1 in), open joints may contain clay, core rings under hammer impact.
Weathered:	Rock mass is decomposed 50% or less, significant portions of the rock show discoloration and weathering effects, cores cannot be broken by hand or scraped by knife.
Highly Weathered:	Rock mass is more than 50% decomposed, complete discoloration of rock fabric, core may be extremely broken and gives clunk sound when struck by hammer, may be shaved with a knife.

SOIL CLASSIFICATION CHART

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	●	**GW**	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
			○	**GP**	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	○	**GM**	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
			▨	**GC**	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)	■	**SW**	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			░	**SP**	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	░	**SM**	SILTY SANDS, SAND - SILT MIXTURES
			▨	**SC**	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	▥	**ML**	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			▨	**CL**	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			▤	**OL**	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50	▥	**MH**	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
			▨	**CH**	INORGANIC CLAYS OF HIGH PLASTICITY
			▦	**OH**	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			▦	**PT**	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

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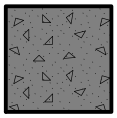
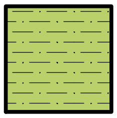
psi

Graphic Symbols for Materials and Rock Deposits



CONCRETE
Portland Cement Concrete

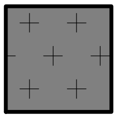
BITUMINOUS CONCRETE



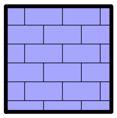
CLAYSTONE

COAL
Coal, Anthracite Coal

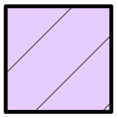
CONGLOMERATE/BRECCIA
Conglomerate, Breccia



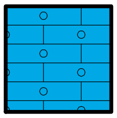
IGNEOUS ROCK
Anorthsite, Basalt, Metabasalt, Diabase
(Gabbro), Gabbro,
Granite/Granodionite, Homfels,
Pegmatite, Rhyolite/Metarhyolite



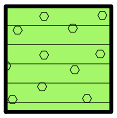
LIMESTONE
Limestone, Dolomite



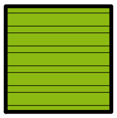
METAMORPHIC ROCK
Amphibolite, Gneiss, Marble, Phyllite,
Quartzite, Schist, Serpentinite, Slate



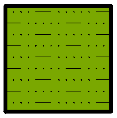
CHERT



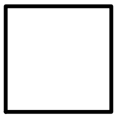
SANDSTONE
Sandstone, Orthoquarzite
(Sandstone)



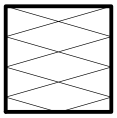
SHALE



SILTSTONE



NO RECOVERY



VOID

APPENDIX F – DRILL, FIELD AND LAB TESTING PROCEDURES

Drilling and Sampling Procedures

The soil borings were performed with a truck-mounted rotary head drill rig. Borings were advanced using 3¼-inch inside diameter hollow-stem augers. Representative samples were obtained employing split-spoon and thin-wall tube sampling procedures in general accordance with ASTM procedures.

Field Tests and Measurements

Penetration Tests and Split-Barrel Sampling of Soils

During the sampling procedure, Standard Penetration Tests (SPT) were performed at regular intervals (2½-foot intervals to 10 feet and 5-foot intervals thereafter) to obtain the standard penetration value (N) of the soil. The results of the standard penetration test indicate the relative density and comparative consistency of the soils, and thereby provide a basis for estimating the relative strength and compressibility of the soil profile components. The split-barrel sampler provides a soil sample for identification purposes and for laboratory tests appropriate for soil obtained from a sampler that may produce large shear strain while obtaining the sample.

Thin-Walled (Shelby) Tube Geotechnical Sampling of Soils

Thin-walled tube samples are utilized to obtain a relatively undisturbed specimen suitable for laboratory tests of structural properties or other tests that might be influenced by soil properties. A relatively undisturbed sample is obtained by pressing a thin-walled metal tube (typically an outside diameter 3 inches) into the in-situ soil, removing the soil-filled tube, and sealing the ends to reduce the soil disturbance or moisture loss. These samples may be utilized in the laboratory to obtain the following information or perform the following tests: Unconfined Compressive Strength (q_u), Laboratory Determination of Water Content, Wet and Dry Density, Percent Saturation, and Atterberg Limits

Water Level Measurements

Water level observations were attempted during and upon completion of the drilling operation using a 100-foot tape measure. The depths of observed water levels in the boreholes are noted on the boring logs presented in the appendix of this report. In the borings where water was unable to be observed during the field activities, in relatively impervious soils, the accurate determination of the groundwater elevation may not be possible even after several days of observation. Seasonal variations, temperature and recent rainfall conditions may influence the levels of the groundwater table and volumes of water will depend on the permeability of the soils.

Ground Surface Elevations

The elevations at the ground surface of the borings were estimated using the client provided topographic maps. The elevations should only be considered as accurate as the method used in their determination.

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Laboratory Testing Program

In addition to the field investigation, a supplemental laboratory-testing program was conducted to determine additional engineering characteristics of the foundation materials necessary in analyzing the behavior of the soils as it relates to the construction of the proposed structures. The laboratory testing program is as follows:

Laboratory Determination of Water (Moisture) Content of Soil by Mass

The water content is a significant index property used in establishing a correlation between soil behavior and its index properties. The water content is used in expressing the phase relationship of air, water, and solids in a given volume of material. In fine grained cohesive soils, the behavior of a given soil type often depends on its water content. The water content of a soil along with its liquid and plastic limits as determined by Atterberg Limit testing, is used to express its relative consistency or liquidity index.

Atterberg Limits

The Atterberg Limits are defined by the liquid limit (LL) and plastic limit (PL) states of a given soil. These limits are used to determine the moisture content limits where the soil characteristics changes from behaving more like a fluid on the liquid limit end to where the soil behaves more like individual soil particles on the plastic limit end. The liquid limit is often used to indicate if a soil is a low or high plasticity soil. The plasticity index (PI) is difference between the liquid limit and the plastic limit. The plasticity index is used in conjunction with the liquid limit to assess if the material will behave like a silt or clay. The material can also be classified as an organic material by comparing the liquid limit of the natural material to the liquid limit of the sample after being oven-dried.

Unconfined Compressive Strength of Cohesive Soil (q_u)

The primary purpose of the unconfined compressive strength test is to obtain the undrained compressive strength of soils that possess sufficient cohesion to permit testing in the unconfined state. Unconfined compressive strength (q_u) is the compressive stress at which an unconfined cylindrical specimen of soil will fail in a simple compression test. In this test method, unconfined compressive strength is taken as the maximum load obtained per unit area or the load per unit area at 15% axial strain, whichever is obtained first during the performance of a test. For the unconfined compressive strength test, the shear strength (s_u) is calculated to be half of the compressive stress at failure.