REPORT OF GEOTECHNICAL EXPLORATION
TOMAHAWK CREEK CONDOS
LEAWOOD, KANSAS

Presented to:

TOMAHAWK CREEK CONDOMINIUMS
Leawood, Kansas

Attn: Ms. Cynthia Selder

Prepared by:

Darryl Cain, P.E.
Tadele M. Akalu

Kruger Technologies, Inc.
Lenexa, Kansas

KTI Project No. 410051G

June 18, 2010

GEOTECHNICAL ■ ENVIRONMENTAL ■ TESTING ■ INSPECTION
14705 W. 114TH TERRACE ■ LENEXA, KANSAS 66215 ■ VOICE 913-498-1114 ■ FAX 913-498-1116 ■ EMAIL KTIKC@KTIONLINE.COM

June 18, 2010

Ms. Cynthia Selder
Tomahawk Creek Condominiums, Inc
11600 Tomahawk Creek Parkway
Leawood, Kansas 66211

Re: KTI Project No. 410051G
Tomahawk Creek Condominiums
Leawood, Kansas

Dear Ms. Selder:

Kruger Technologies, Inc. (KTI) has completed the soil evaluation for the above referenced project. The purpose of this report is to describe the surface and subsurface conditions encountered at the site, analyze and evaluate this information, and prepare a summary of existing conditions, subsurface material characteristics, and geotechnical design recommendations.

We thank you for the opportunity to work with Tomahawk Creek Condominiums, Inc. If you have any questions, please contact us at 913.498.1114.

Respectfully submitted,
Kruger Technologies, Inc. (KTI)

DARRYL EDWARD CAIN
LICENSED
18764
KANSAS
PROFESSIONAL ENGINEER

Darryl E. Cain, P.E.
Kansas: 18764

Tadele M. Akalu
Laboratory Manager

Cc: Dave Nelsen – Norton & Schmidt

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LEAWOOD, KANSAS

INTRODUCTION

This report presents the findings of soil conditions and subsequent recommendations concerning the geotechnical exploration and engineering analysis for Building 11618 constructed at Tomahawk Creek Condominiums.

The purpose of this report is to describe the surface and subsurface conditions encountered at the site, analyze and evaluate this information, and prepare a summary of existing conditions, subsurface materials characteristics and geotechnical design recommendations.

FIELD EXPLORATION PROCEDURES

Five (5) test borings around Building 11618 were completed on May 7, 2010. The borings were field located jointly with the client representative from Norton & Schmidt and KTI on May 5, 2010. The approximate boring locations are shown on an attached Boring Location Diagram.

Three borings were drilled using an all-terrain mounted CME-55 drill rig and two borings were drilled by hand auger. Advancement of the test holes was accomplished using 4-inch O.D. continuous flight augers. Soil sampling was performed by hydraulically pushing thin wall (steel) Shelby tubes, and by driving split-barrel samplers (Standard Penetration Test).

Site soils and bedrock materials were visually and manually classified in general accordance with ASTM D 2488 by the drill crew chief as drilling progressed. All of the soil samples were delivered to the laboratory for applicable testing and verification of the field classifications. The boring logs were created as the borings were advanced, and the logs were supplemented with information from the laboratory tests to present data concerning the depth and classification of the various strata, water levels, and other pertinent information. The boring logs are attached in Appendix I.

During advancement of the borings, groundwater was not encountered. It should be noted that water level determinations made in relatively impervious (clay) soils might not present a reliable indication of the actual water table. However, water level determinations made in relatively pervious (sand/silt) soils are considered an accurate indication of the water table at the time that those measurements are made. Fluctuations in the water table should be expected with changing seasons and annual differences.

LABORATORY TESTS

Laboratory tests were performed on the recovered samples to evaluate the engineering characteristics and for additional verification of the field classifications in accordance with ASTM D 2487. The results of these tests, including in-situ moisture content, dry density, plasticity (Atterberg Limits) and unconfined compressive strength are presented in Appendix II.

SITE CONDITIONS

At the time of our field exploration, the boring locations were grass-covered with some trees present sporadically across the site. Additionally, standing water was present at the front side of the building. It was identified that the drainage slopes and gutter down spouts were running water towards the building and parking garages instead of away from the building.

PROJECT DESCRIPTION

The purpose of this project is to provide further analysis of the subsurface conditions and to analyze the fill strength and moisture content of the soil on the north, west and south sides of Building 11618. We understand that the retaining wall on the south side of the building is nearing a state of failure and requires re-construction.

GEOLOGY/SUBSURFACE CONDITIONS

The site soils consist of fill materials and undisturbed weathered shale. Soils classifications were identified from all boring samples. Based on the laboratory test results, the soils exhibited dry densities ranging from 97.1 to 115.2 pounds per cubic foot (pcf) and moisture contents ranging from 13.8 to 31.5 percent. Unconfined compressive strength of the fill soils ranges from 984 to 3239 pounds per square foot (psf). The Unified Soil Classification System (USCS) classifies low plasticity (lean) clay soils as CL, medium plasticity (lean to fat) clay soils as CL/CH, and high plasticity (fat) clay soils as CH.

Auger refusal on shale occurred at Boring B-1 = 12.0 feet, Boring B-2 = 14.0 feet and at Boring B-3 = 12.0 feet below existing grade. At the time of drilling, groundwater was not encountered.

Borings B-1, B-2 and B-3 soil fill consisted of fat clay material to approximately elevation 4 feet below subgrade. From 4 feet below subgrade to auger refusal near 12 feet was a native weathered gray shale with an n value of 50 blows in 3 inches. Borings B-4 and B-5 were hand augers and encountered the weathered grey shale near elevation 4.5 to 6 feet below subgrade.

DESIGN CRITERIA AND RECOMMENDATIONS

Laboratory test results of the recovered samples showed the following characteristics that were used as criteria for determining the recommendations for bearing values and design data:

In-Situ Moisture .... 13.8 to 31.5 %
Dry Density .... 91.3 to 111.5 pcf
Liquid Limit .... 50 to 65%
Plasticity Index .... 27 to 43
Unconfined Compressive Strength .... 984 to 3239 psf

Existing Utilities

Utilities were located as part of the drilling conducted on site. Any utilities within the remedial construction area should be relocated. Excavations created by removal of the existing lines should be cut wide enough to allow for use of appropriate construction equipment to recompact the fill. In addition, the base of the excavations should be thoroughly evaluated by a representative of KTI prior to placement of fill.

Surface Drainage

In order to reduce the problems related to water infiltration, it is recommended that the final grade around the structure perimeters have a positive slope extending at least six feet away from the structure, or a subsurface perimeter drainage system should be installed. All gutters and down spouts should drain away from Building 11618. This system should be graded away from the building to either connect to a storm drain system or drain to daylight.

Subsurface Drainage

Although groundwater was not detected during boring operations, infiltration of surface water and/or perched groundwater could occur. The soil borings taken indicated that the fill material used to construct the building pad was lean to fat clay with weathered shale which are susceptible to shrinking and swelling. Also evident from the soil borings is the weathered shale layer underlying the fat clays. Clays by nature have a very low permeability, thus water will not travel through a clay soil. In this case water has infiltrated the clay layer building pad which may have become freely saturated. The water in the clay building pad cannot escape due to the impermeable shale layer located under the clay layer. Once the clay layer becomes saturated the building pad becomes more susceptible to movement, thus differential settlement may occur.

Reviewing the soils test data also provided insight with regards to the percent moisture. The current tests indicate the percent moistures are lower than the percent moisture taken from samples in the March 26, 1998 Geotechnical Report by GeoSystems. It should be expected that with the higher annual rainfall this area has experienced over the last two years the moisture levels should be much higher than the moisture levels tested 12 years ago. The lower in-situ moisture contents indicate that the water infiltration is not a ground water problem. The problem is the surface drainage runoff from parking areas and roof tops.

The unconfined compressive strength tests conducted on the soil samples were taken at elevations varying below subgrade from 1 foot to 4 feet. Each unconfined compressive test location was determined by the actual sample condition obtained from the field. The unconfined compressive test indicates the bearing capacity of the soil sample in pounds per square foot. The unconfined compressive strengths of the samples tested ranged from 984 to 3239 psf. The lower unconfined compressive strengths indicate a lower bearing capacity for the building foundation.

It would be prudent to construct a drain system around the perimeter of below-grade structures or footings. The perimeter drain system should consist of a 4 to 6 inch PVC or equivalent pipe with at least ¼-inch perforations routed to a sump or by gravity to the exterior. The pipe should be laid with the perforations down and enveloped with gravel. The gravel should be surrounded with Mirafi 140N filter cloth or equivalent. At a minimum the west, east and south sides of building 11618 should have an under drain system installed. The north side of the building would benefit from the under drain system, if pavement work is conducted as part of this project. See Figure 1 Pipe Under Drain detail for reference.

Also a roof drain system should also be installed to divert the roof gutters away from the building. The underground perimeter drain system and the roof drains system should not be connected as one drainage system. The roof drain system should consist of 4 to 6 inch solid drain pipe and have all gutter drain spouts connected to this drain system taking roof water away from the foundation.

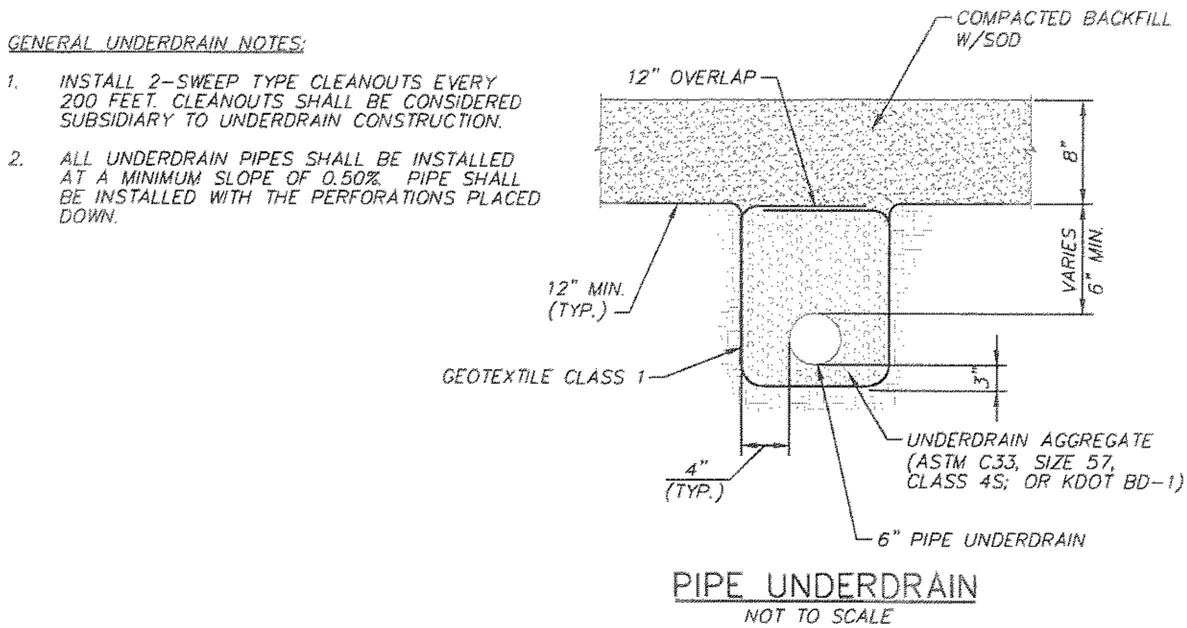


Figure 1 – Pipe Under Drain

Excavation Considerations

We believe that the project soils are Type B as classified in the OSHA Excavation Standard Handbook 29 CFR Parts 1926.650 through 1926.652. Type B soils are characterized by cohesive soils above the water table with unconfined compressive strengths greater than 0.5 tons per square foot (tsf) but less than and 1.5 tsf. Type B soils include any fill soils meeting or exceeding the above criteria, as well as undisturbed soils with unconfined compressive strengths of >1.5 tsf which are subject to vibration from traffic. Temporary excavation slopes for Type B soils can be one horizontal to one vertical with a maximum excavation depth of 20 feet.

Excavations deeper than 20 feet may require the use of supplemental shoring and will require the preparation of an excavation design prepared by a registered professional engineer. Competent bedrock material may generally be cut vertically.

Retaining Wall Considerations

The block retaining wall on the south side of Building 11618 is nearing a state of failure. The slope instability is primarily due to saturated soils and the loss of the soil friction. Saturated soils become heavy and exert an over-burdened pressure upon the retaining wall. The retaining wall may not have been designed for such high over-burdened retaining pressure, thus is nearing a state of failure.

The lowered slope stability of the south retaining wall is primarily due to surface water infiltration. The surface water may be infiltrating behind the wall from the gutter down spouts exiting behind the wall. This added water decreases the strength of the soil. This water gets trapped between the shale layer and eventually reduces the friction strength of the soil between the embankment soil above the wall and the founding shale layer, thus a slope failure occurs. The surface water and gutter drain spouts should be diverted away from the building and the south retaining wall.

It is recommended that the current retaining wall be replaced with a new retaining wall designed for additional over-burden pressure and perhaps a more substantial retaining wall such as cast-in-place concrete with a footing anchoring system or a Segmental Retaining Wall (SRW) should be utilized. The new retaining wall should include a drainage system behind the wall including clean gravel to aid in draining the excess water from behind the wall and reducing the over-burden pressure.

Segmental Retaining Walls

Design Procedures: The proposed segmental retaining wall should be designed in accordance with the current edition of the National Concrete Masonry Association's (NCMA's) Design Manual For Segmental Retaining Walls. If big blocks are used for construction of the wall, then the wall should be designed in accordance with the manufacturer's recommendations using generally accepted factors of safety. The factors of safety generally accepted in the SRW industry are those presented in NCMA's Design Manual for Segmental Retaining Walls.

Global Stability Analysis: A global stability analysis of the wall system must be performed as part of the design. The following geotechnical parameters can be used in a global stability analysis for the proposed SRW:

Site Cohesive Soils

Friction angle = 18°

Cohesion = 50 psf

Wet Unit Weight = 120 pcf

Site Granular Soils

Friction angle = 32°

Cohesion = 0 psf

Wet Unit Weight = 120 pcf

Site Weathered Shale

Friction angle = 24°

Cohesion = 50 psf

Wet Unit Weight = 120 pcf

Lateral Earth Pressures For Retaining Wall Design

The following K values may be used for the evaluation of lateral soil resistance for retaining walls:

Site Cohesive Soils (Estimated ϕ of 18°)
K_a = 0.55
K_p = 1.90
K_o = 0.70
Coefficient of sliding friction = 0.30
Wet density of in place soil, average (γ) = 125 pcf

Granular backfill (Estimated ϕ of 35°)
K_a = 0.30
K_p = 3.33
K_o = 0.43
Coefficient of sliding friction = 0.47
Wet density of in-place granular backfill = 130 pcf

Site Shale Bedrock (Estimated ϕ of 27°)
K_a = 0.40
K_p = 2.65
K_o = 0.55
Coefficient of sliding friction = 0.55
Wet density of in-place shale bedrock = 135 pcf

Building Foundation Considerations

It appears that the building is experiencing settlement in several locations and has had some remedial measures taken to address building settlement. It appears that the settlement is due to consolidation of the fill materials below the building due to poor drainage around the building perimeter. Water is infiltrating in and around the building perimeter contributing to the differential consolidation and settlement of the founding soils and slab-on-grade. This water infiltration is evident due to the irregular settlement patterns the building is exhibiting.

An alternative foundation anchoring system is required to reverse the present settlement and raise the building to its original elevation. Foundation underpinning and/or drilled piers are an adequate foundation stabilization method used to prevent further settlement, but do not provide an ability to raise the building to its original elevation. It is recommended to utilize a helical anchor system around the entire building perimeter. Helical anchors are drilled into the subgrade around the building perimeter at a spacing designed by the engineer. The helical anchors are installed by hydraulic methods and act as a driving anchor to raise the building back to its original elevation.

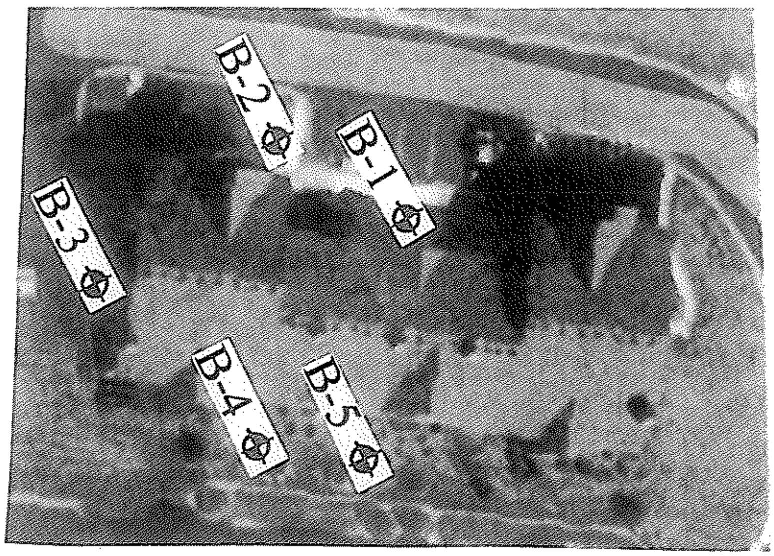
REMARKS

It is recommended that the geotechnical engineer be retained to review the plans and specifications for the project so that an evaluation and comments can be provided regarding the proper incorporation of information from this geotechnical report into the final construction documents. We further recommend that the geotechnical engineer be retained during construction phases for earthwork and foundations to provide observation and testing to aid in determining that design intent has been accomplished.

The findings in this report are based on data acquired to date and are assumed to be representative of conditions at locations between borings. Due to the fact that the area at the borings is very small relative to the overall site, we make no statement warranting the conditions below our borings or at other locations throughout the site. In addition, we do not warrant that the general strata logged at the borings are necessarily typical of the remaining areas of the site.

Reports shall not be reproduced except in full, without written approval of KTI. Information in this report applies only to the referenced project in its present configuration and location and shall not be used for any other project or location.

BORING LOCATION DIAGRAM



Boring Location Diagram
Tomahawk Creek Condominiums
Leawood, KS

KTI
kruger technologies, inc.

Drawn: DEC	**Date:** 05/24/10	**Job No.:** 410051G

APPENDIX I

Boring Logs

LOG OF TEST BORING
BORING B-1

PROJECT: Tomahawk Creek Condominiums
CLIENT: Tomahawk Creek Condominiums
PROJECT NO.: 410051G **START:** 5/7/10
BORING LOCATION: See Boring Location Plan
METHOD OF DRILLING: 4-inch continous flight augers
INITIAL WATER None **DELAYED WATER**

DATE: 2010-05-21
ELEVATION:
FINISH: 5/7/10
LOGGER: TMA
DATE CHECKED:

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Sample # & Type	Density pcf	Moist-ure, %	LL	PI	Qp, tsf	Qu, psf
0		Ts	Top soil							
	1/6" 2/6" 3/6"	FILL	Fill, clay with weathered shale, brown & gray, moist	1, SS						
2		CH	Fat clay with gravel, reddish brown, medium stiff, moist	1, ST	91.3	31.5			2.0	2054
4			weathered shale, brown & gray, stiff moist	2, ST						
6	8/6" 12/6" 21/6"		weathered shale, gray, stiff moist	2, SS						
8	22/6" 37/6" 50/4"	Sh		3, SS						
10	22/6" 50/5"			4, SS						
	50/3"			5, SS						
12			Drilling discontinued at auger refusal at 12 feet							
14										

Notes:

LOG OF TEST BORING
BORING B-2

PROJECT: Tomahawk Creek Condominiums
CLIENT: Tomahawk Creek Condominiums
PROJECT NO.: 410051G **START:** 5/7/10
BORING LOCATION: See Boring Location Plan
METHOD OF DRILLING: 4-inch continous flight augers
INITIAL WATER None **DELAYED WATER**

DATE: 2010-05-21
ELEVATION:
FINISH: 5/7/10

LOGGER: TMA
DATE CHECKED:

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Sample # & Type	Density pcf	Moisture, %	LL	PI	Qp, tsf	Qu, psf
0–2.5	1/6" 2/6" 3/6"	Ts	Top soil Fill, fat clay, brown & gray, moist	1, SS						
2.5–4.5		CH	Fat clay, grayish brown, stiff, moist	1, ST	100.3	25.3	65	43	3.25	3239
4.5–6.5		CH	Fat clay with weathered shale, brown & gray, stiff moist	2, ST	100.8	26.3			4.0	
6.5–14	9/6" 19/6" 30/6"	Sh	weathered shale, gray, hard, moist	2, SS						
	10/6" 21/6" 31/6"			3, SS						
	12/6" 21/6" 27/6"			4, SS						
	13/6" 31/6" 50/5"			5, SS						
	27/6" 50/3"			6, SS						
14			Drilling discontinued at auger refusal at 14 feet							

Notes:

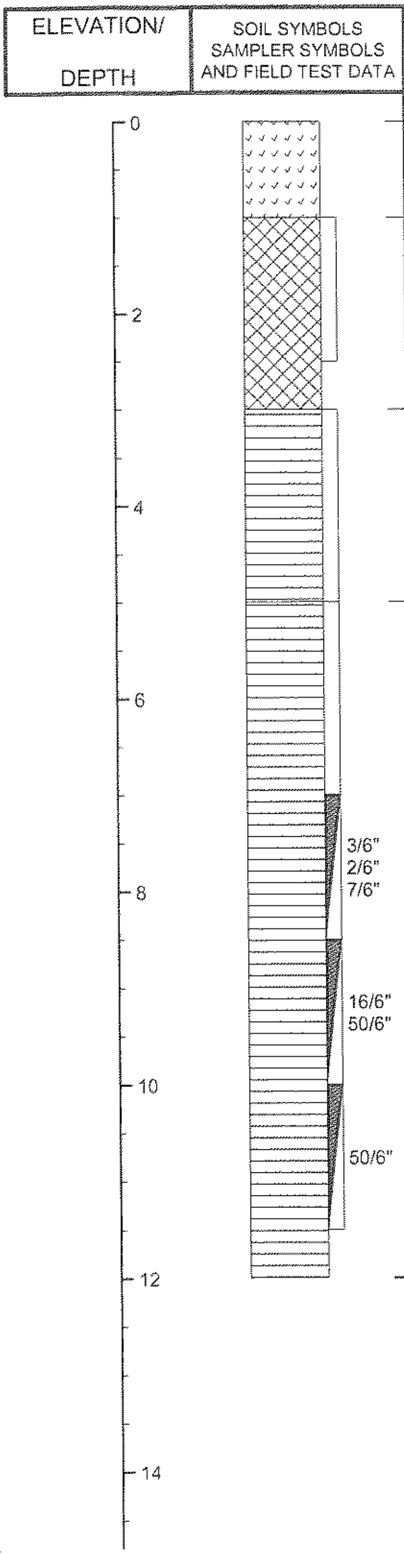
LOG OF TEST BORING

BORING B-3

PROJECT: Tomahawk Creek Condominiums
CLIENT: Tomahawk Creek Condominiums
PROJECT NO.: 410051G **START:** 5/7/10
BORING LOCATION: See Boring Location Plan
METHOD OF DRILLING: 4-inch continous flight augers
INITIAL WATER None **DELAYED WATER**

DATE: 2010-05-21
ELEVATION:
FINISH: 5/7/10

LOGGER: TMA
DATE CHECKED:



USCS	Description	Sample # & Type	Density pcf	Moist-ure, %	LL	PI	Qp, tsf	Qu, psf
Ts	Top soil							
FILL	Fill, lean clay with weathered shale, brown & gray, moist	1, ST	99.2	22.4			1.75	1431
Sh	Shale with gravel, grayish brown, stiff, moist	2, ST	111.5	13.8				
	with trace gravel	2, ST	104.8	22.7				
Sh	weathered shale, gray, stiff moist	1, SS						
	become hard	2, SS						
		3, SS						
	Drilling discontinued at auger refusal at 12 feet							

Notes:

LOG OF TEST BORING
BORING B-4

PROJECT: Tomahawk Creek Condominiums
CLIENT: Tomahawk Creek Condominiums
PROJECT NO.: 410051G **START:** 5/7/10
BORING LOCATION: See Boring Location Plan
METHOD OF DRILLING: Hand Auger
INITIAL WATER None **DELAYED WATER**

DATE: 2010-05-21
ELEVATION:
FINISH: 5/7/10
LOGGER: TMA
DATE CHECKED:

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Sample # & Type	Density pcf	Moist-ure, %	LL	PI	Qp, tsf	Qu, psf
0		Ts	Top soil							
		FILL	Fill, lean to fat clay with weathered shale, brown & gray, moist	1, ST	102.6	18.4	50	27	2.50	
1.5										
		Sh	become dark gray	2, ST	113.4	17.1			2.75	2503
3										
4.5		Sh	Weathered shale,gray, very stiff, moist	3, ST	110.5	18.3				
6			Drilling discontinued at auger refusal at 7 feet							
7.5										
9										
10.5										

Notes:

LOG OF TEST BORING

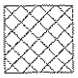
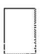
BORING B-5

PROJECT: Tomahawk Creek Condominiums
DATE: 2010-05-21
CLIENT: Tomahawk Creek Condominiums
ELEVATION:
PROJECT NO.: 410051G
START: 5/7/10
FINISH: 5/7/10
BORING LOCATION: See Boring Location Plan
METHOD OF DRILLING: Hand Auger
LOGGER: TMA
INITIAL WATER None
DELAYED WATER
DATE CHECKED:

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Sample # & Type	Density pcf	Moist-ure, %	LL	PI	Qp, tsf	Qu, psf
0		Ts	Top soil							
			Fill, lean clay with weathered shale, brown & gray, moist							
		FILL		1, ST	106.4	20.4			1.25	2953
1.5										
			become dark gray							
3		CL		2, ST	110.0	16.4			1.0	
			Weathered shale, gray & reddish brown, moist							
4.5										
		Sh		3, ST	97.1	27.4	57	33	1.0	984
6			Drilling discontinued at auger refusal at 6 feet							
7.5										
9										
10.5										

Notes:

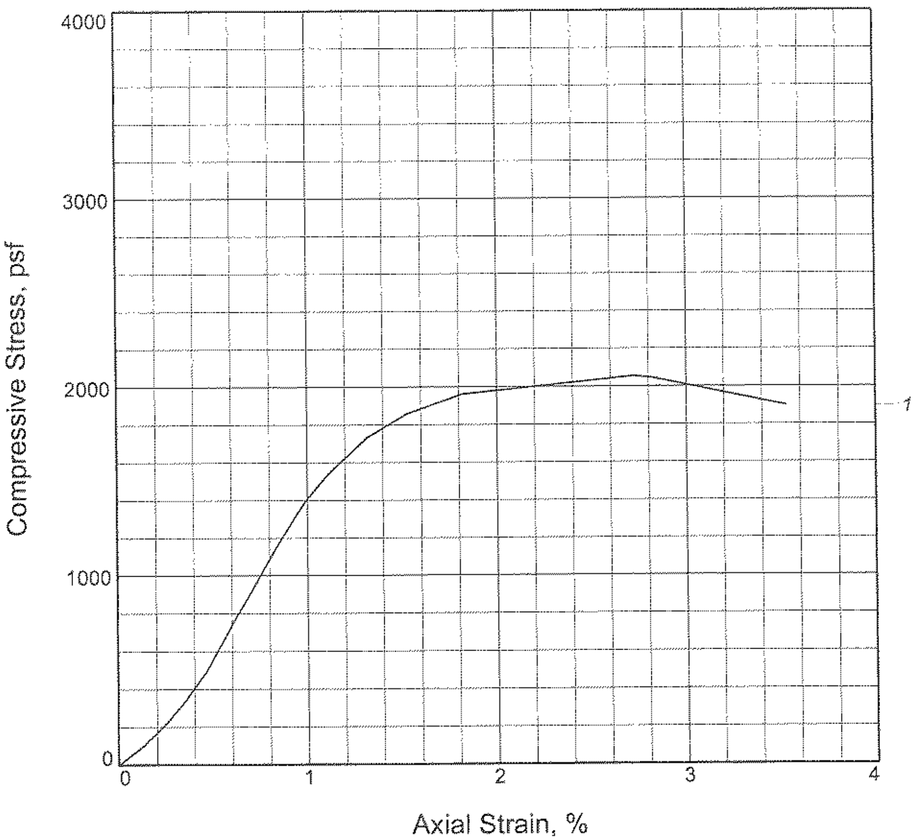
KEY TO SYMBOLS

Symbol	Description
strata symbols	
	Topsoil
	Fill
	High plasticity clay
	Shale
Soil Samplers	
	Split Spoon - 1 3/8 I.D., 2" O.D. except where noted
	Shelby Tube - 3" O.D., except where noted

APPENDIX II

Laboratory Results

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	2054			
Undrained shear strength, psf	1027			
Failure strain, %	2.7			
Strain rate, in./min.	0.05			
Water content, %	31.5			
Wet density, pcf	120.1			
Dry density, pcf	91.3			
Saturation, %	99.6			
Void ratio	0.8596			
Specimen diameter, in.	2.87			
Specimen height, in.	5.59			
Height/diameter ratio	1.95			

Description: Fat clay with gravel, reddish brown, medium stiff, moist

LL =	**PL =**	**PI =**	**Assumed GS=** 2.72	**Type:** ST

Project No.: 410051G
Date Sampled:
Remarks:

Figure ________

Client: Tomahawk Creek Condominiums

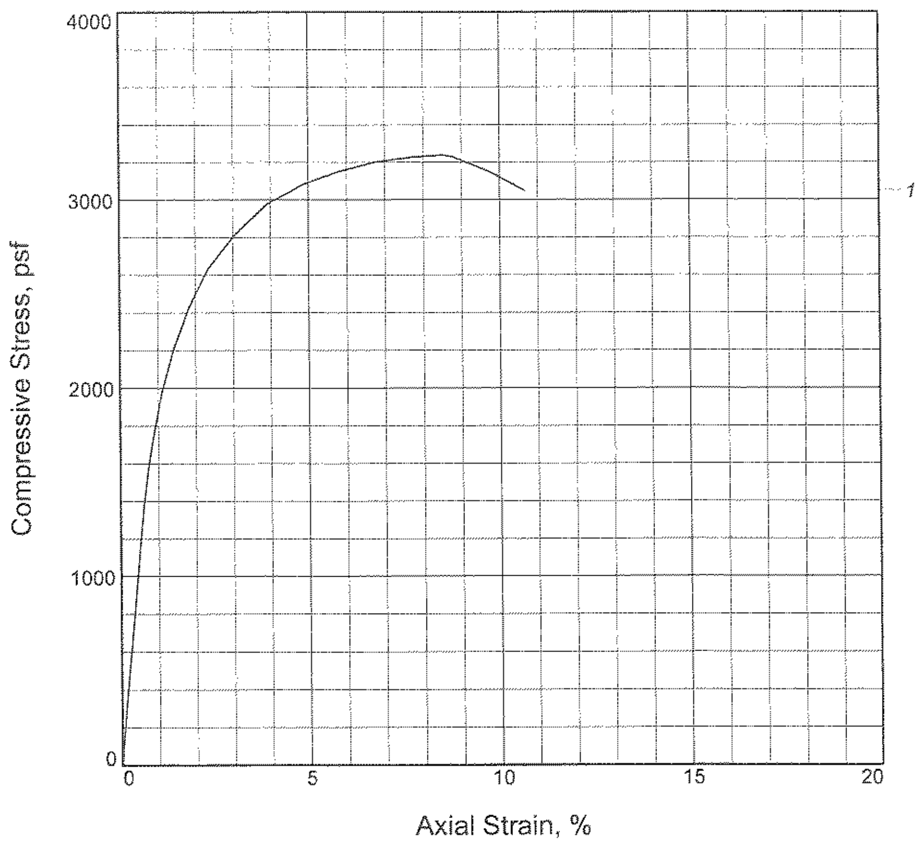
Project: Tomahawk Creek Condominiums

Source of Sample: B-1 **Depth:** 2.5
Sample Number: 1

UNCONFINED COMPRESSION TEST
KRUGER TECHNOLOGIES, INC.
LENEXA, KS

Tested By: TMA **Checked By:** Darryl Cain, P.E.

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	3239			
Undrained shear strength, psf	1619			
Failure strain, %	8.5			
Strain rate, in./min.	0.05			
Water content, %	25.3			
Wet density, pcf	125.7			
Dry density, pcf	100.3			
Saturation, %	99.2			
Void ratio	0.6925			
Specimen diameter, in.	2.85			
Specimen height, in.	5.63			
Height/diameter ratio	1.97			

Description: Fat clay, grauyish brown, stiff, moist

LL = 65	**PL =** 22	**PI =** 43	**Assumed GS=** 2.72	**Type:** ST

Project No.: 410051G
Date Sampled:
Remarks:

Figure _______

Client: Tomahawk Creek Condominiums

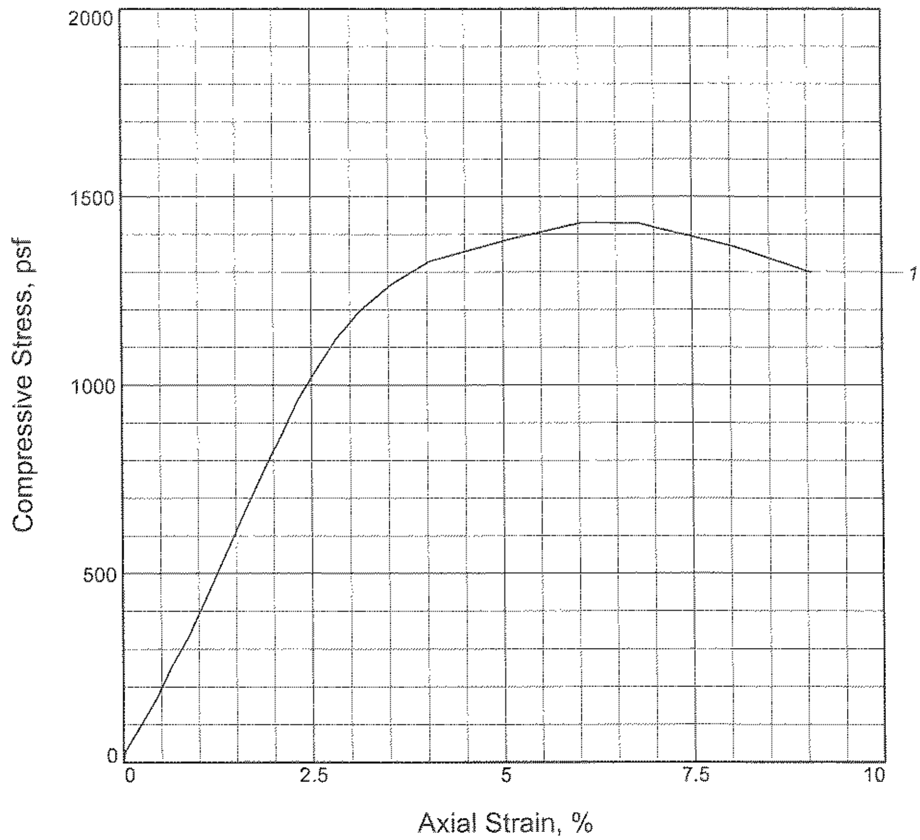
Project: Tomahawk Creek Condominiums

Source of Sample: B-2 **Depth:** 2.5
Sample Number: 1

UNCONFINED COMPRESSION TEST
KRUGER TECHNOLOGIES, INC.
LENEXA, KS

Tested By: TMA **Checked By:** Darryl Cain, P.E.

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	1431			
Undrained shear strength, psf	715			
Failure strain, %	6.0			
Strain rate, in./min.	0.05			
Water content, %	22.4			
Wet density, pcf	121.4			
Dry density, pcf	99.2			
Saturation, %	85.5			
Void ratio	0.7126			
Specimen diameter, in.	2.83			
Specimen height, in.	5.42			
Height/diameter ratio	1.92			

Description: Fill, lean clay with weathered shale, brown & gray, moist

LL =	PL =	PI =	Assumed GS= 2.72	Type:

Project No.: 410051G

Date Sampled:

Remarks:

Figure ________

Client: Tomahawk Creek Condominiums

Project: Tomahawk Creek Condominiums

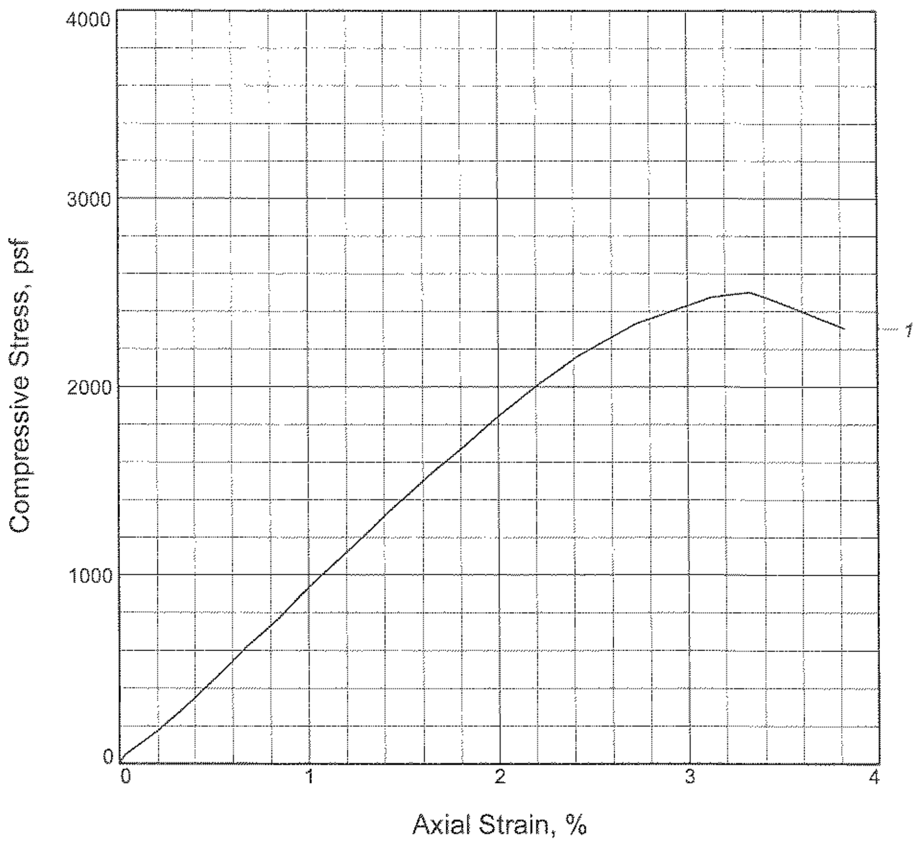
Source of Sample: B-3 **Depth:** 1

Sample Number: 1

UNCONFINED COMPRESSION TEST
KRUGER TECHNOLOGIES, INC.
LENEXA, KS

Tested By: TMA **Checked By:** Darryl Cain, P.E.

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	2503			
Undrained shear strength, psf	1251			
Failure strain, %	3.3			
Strain rate, in./min.	0.05			
Water content, %	17.1			
Wet density, pcf	132.9			
Dry density, pcf	113.4			
Saturation, %	93.8			
Void ratio	0.4969			
Specimen diameter, in.	2.83			
Specimen height, in.	5.62			
Height/diameter ratio	1.98			

Description: become dark gray

LL =	PL =	PI =	Assumed GS= 2.72	Type: ST

Project No.: 410051G
Date Sampled:
Remarks:

Figure ________

Client: Tomahawk Creek Condominiums

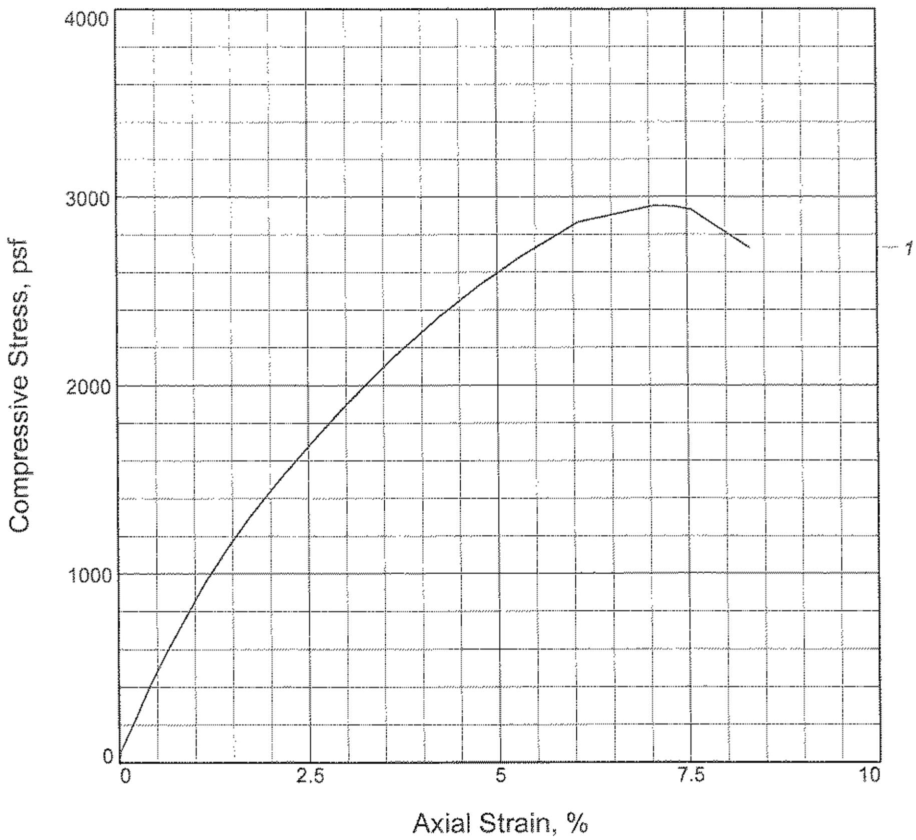
Project: Tomahawk Creek Condominiums

Source of Sample: B-4 **Depth:** 2
Sample Number: 2

UNCONFINED COMPRESSION TEST
KRUGER TECHNOLOGIES, INC.
LENEXA, KS

Tested By: TMA **Checked By:** Darryl Cain, P.E.

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	2953			
Undrained shear strength, psf	1477			
Failure strain, %	7.1			
Strain rate, in./min.	0.05			
Water content, %	20.4			
Wet density, pcf	128.1			
Dry density, pcf	106.4			
Saturation, %	93.1			
Void ratio	0.5961			
Specimen diameter, in.	2.75			
Specimen height, in.	5.60			
Height/diameter ratio	2.03			

Description: Fill, lean clay with weathered shale, brown & gray, moist

LL =	PL =	PI =	Assumed GS= 2.72	Type: TMA

Project No.: 410051G
Date Sampled:
Remarks:

Figure ________

Client: Tomahawk Creek Condominiums

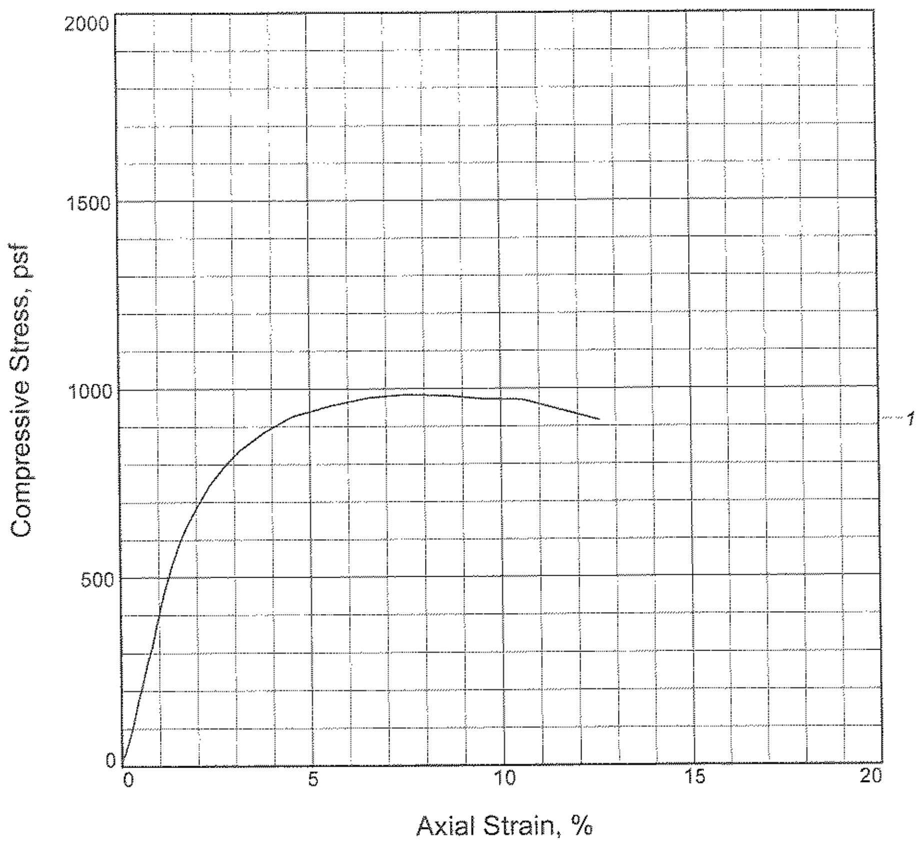
Project: Tomahawk Creek Condominiums

Source of Sample: B-5 **Depth:** 0.33
Sample Number: 1

UNCONFINED COMPRESSION TEST
KRUGER TECHNOLOGIES, INC.
LENEXA, KS

Tested By: TMA **Checked By:** Darryl Cain P.E.

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	984			
Undrained shear strength, psf	492			
Failure strain, %	7.6			
Strain rate, in./min.	0.05			
Water content, %	27.4			
Wet density, pcf	123.8			
Dry density, pcf	97.1			
Saturation, %	99.8			
Void ratio	0.7482			
Specimen diameter, in.	2.83			
Specimen height, in.	5.59			
Height/diameter ratio	1.98			

Description: Weathered shale, gray & reddish brown, moist

LL = 57	**PL =** 24	**PI =** 33	**Assumed GS=** 2.72	**Type:** ST

Project No.: 410051G
Date Sampled:
Remarks:

Figure _______

Client: Tomahawk Creek Condominiums

Project: Tomahawk Creek Condominiums

Source of Sample: B-5 **Depth:** 4
Sample Number: 3

UNCONFINED COMPRESSION TEST
KRUGER TECHNOLOGIES, INC.
LENEXA, KS

Tested By: TMA **Checked By:** Darryl Cain, P.E.

SUMMARY OF LABORATORY TEST RESULTS

Boring	Depth (Ft)	Sample No./Type	Natural Moisture %	Natural Dry Density (pcf)	Unconfined Compressive Strength (psf)	Atterberg Limits		Swell/Consolidation		Soil Type
						Liquid Limit %	Plasticity Index %	Swell Pressure (psf)	Volume Change %	
B-1	2.5-4.5	1, ST	31.5	91.3	2054					
B-1	4.5-6.5	2, ST								
B-2	2.5-4.5	1, ST	25.3	100.3	3239	65	43			CH
B-2	4.5-6.5	2, ST	26.3	100.8						
B-3	1.0-3.0	1, ST	22.4	99.2	1431					
B-3	3.0-5.0	1, ST	13.8	111.5						
B-3	5.0-7.0	3, ST	22.7	104.8						
B-4	0.5-2.0	1, ST	18.4	102.6		50	27			CH
B-4	2.0-4.0	2, ST	17.1	113.4	2503					
B-4	4.0-6.0	3, ST	18.3	110.5						
B-5	0.5-2.0	1, ST	20.4	106.4	2953					
B-5	2.0-4.0	2, ST	16.4	110.0						
B-5	4.0-6.0	3.ST	27.4	97.1	984	57	33			CH

GLOSSARY OF GEOTECHNICAL TERMS

ALLUVIUM	Sediments deposited by streams, including riverbeds and floodplains.
ARGILLACEOUS	Rocks composed of or having a notable portion of fine silt and/or clay in their composition.
ATTERBERG LIMITS	Water contents, in percentage of dry weight of soil, that correspond to the boundaries between the states of consistency, i.e. the boundary between the liquid and plastic states (liquid limit) and the boundary between the plastic and solid states (plastic limit).
BEDROCK-IN-PLACE	Continuous rock mass which essentially has not moved from its original depositional position.
CALCAREOUS	Containing calcium carbonate determined by effervescence when tested with dilute hydrochloric acid.
CHANNEL SANDSTONE	Sandstone that has been deposited in a streambed or other channel eroded into the underlying beds.
COLLUVIAL	Rock debris of various sizes loose from in-place bedrock mass, often shifted down gradient in conjunction with soil.
CROSS-BEDDING	Stratification which is inclined to the original horizontal surface upon which the sediment accumulated.
FISSILE BEDDING	Term applied to bedding which consists of laminae less than 2 millimeters in thickness.
FORMATION	A distinctive body of rock that serves as a convenient unit for study and mapping.
FOSSIL DETRITUS	The accumulation of broken, fragmented fossil debris.
FOSSILIFEROUS	Containing organic remains.
GLACIAL ERRATIC	A transported rock fragment different from the bedrock on which it lies, either free or as part of a sediment.
GLACIAL TILL	Nonsorted, nonstratified sediment carried or deposited by a glacier.
GLACIOFLUVIAL	Primarily deposited by streams from glaciers.
GROUP	A lithostratigraphic unit consisting of two or more formations.
JOINT	A fracture in a rock along which no appreciable displacement has occurred.
LIMESTONE	A sedimentary rock composed mostly of calcium carbonate ($CaCO_3$).

LOESS	A homogenous, nonstratified, unindurated deposit consisting predominantly of silt, with subordinate amounts of very fine sand and/or clay.
MICA	A mineral group, consisting of phyllosilicates, with sheetlike structures.
MEMBER	A specially developed part of a varied formation is called a member, if it has considerable geographic extent.
NODULE	A small, irregular, knobby, or rounded rock that is generally harder than the surrounding rock.
PERMEABILITY	The capacity of a material to transmit a fluid.
RECOVERY	The percentage of bedrock core recovered from a core run length.
RELIEF	The difference in elevation between the high and low points of a land surface.
RESIDUAL SOIL	Soil formed in place by the disintegration and decomposition of rocks and the consequent weathering of the mineral materials.
ROCK QUALITY DESIGNATION (RQD)	Refers to percentage of core sample recovered in unbroken lengths of 4 inches or more.
SANDSTONE	Sedimentary rock composed mostly of sand sized particles, usually cemented by calcite, silica, or iron oxide.
SERIES	A time-stratigraphic unit ranked next below a system.
SHALE	A fine-grained plastic sedimentary rock formed by consolidation of clay and mud.
STRATIGRAPHY	Branch of geology that treats the formation, compositions, sequence, and correlation of the stratified rocks as parts of the earth's crust.
SYSTEM	Designates rocks formed during a fundamental chronological unit, a period.
UNCONFORMITY	A surface of erosion or nondeposition, usually the former, which separates younger strata from older rocks.
WEATHERING	The physical and chemical disintegration and decomposition of rocks and minerals.

General Notes

Laboratory Test Symbols	
Symbol	**Definition**
LL	Liquid Limit (ASTM D4318)
PL	Plastic Limit (ASTM D4318)
PI	Plasticity Index (LL minus PL)
Qu	Unconfined Compressive Strength, Pounds per Square Foot (psf)
Qp	Pocket Penetrometer Reading, Tons per Square Foot (TSF)
RQD	Rock Quality Designation % (Sum of rock core pieces >4 inches/length of core run)

Common Soil Classification Symbols

Clay	
Symbol	**Soil Type**
CL	Low plasticity clay
CL-ML	Low plasticity clay and silt
CL/CH	Medium plasticity clay
CH	High plasticity clay

Silt	
Symbol	**Soil Type**
ML	Low plasticity silt
MH	High plasticity silt

Sand	
Symbol	**Soil Type**
SW	Well graded sand
SP	Poorly graded sand
SM	Silty sand
SC	Clayey sand

Gravel	
Symbol	**Soil Type**
GW	Well graded gravel
GP	Poorly graded gravel
GM	Silty gravel
GC	Clayey gravel

Descriptive Terminology

Cohesionless Soils

Relative Density Term	"N" Value
Very Loose	0 - 4
Loose	5 - 9
Medium Dense	10 - 29
Dense	30 – 49
Very Dense	50 or more

Cohesive Soils

Consistency Term	"N" Value
Very soft	0 – 2
Soft	3 – 4
Medium	5 – 8
Stiff	9 – 15
Very Stiff	16 - 30
Hard	> 30

Relative Proportions and Sizes

Term	Range
Trace	< 5%
A Little	5 – 15%
Some	15 – 30%
With	30 – 50%

Material	Size
Boulder	> 12"
Cobble	3" – 12"
Gravel	4.75 - 76.2 mm
Sand	0.075 – 4.75 mm
Silt and Clay	< 0.075 mm