Geotechnical Engineering Report

Proposed Public Safety Building and Elderly Duplex Buildings
Wyandotte, OK
November 30, 2011
Terracon Project No. 04115228

Prepared for:
Eastern Shawnee Tribe of Oklahoma
Wyandotte, Oklahoma

Prepared by:
Terracon Consultants, Inc.
Tulsa, Oklahoma

November 30, 2011

Terracon

Eastern Shawnee Tribe of Oklahoma
10080 S. Bluejacket Rd.
Wyandotte, OK 74370

Attn: Ms. Kristi Laughlin
E: klaughlin@estoo.net
P: 918-666-5151

Re: Geotechnical Engineering Report
Proposed Public Safety Building and Elderly Duplex Buildings
Wyandotte, Oklahoma
Terracon Project Number: 04115228

Dear Ms. Laughlin:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. This study was performed in general accordance with our proposal number P04110499 dated October 31, 2011. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations, floor slabs, and pavements for the proposed project.

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

Sincerely,
Terracon Consultants, Inc.
Cert. of Auth. #CA-4531 exp. 6/30/13

Atefeh Fathi, E.I.
Project Manager

REGISTERED PROFESSIONAL ENGINEER
11/30/11
CONRAD S. KOEHLER
20784
OKLAHOMA

Conrad S. Koehler, P.E.
Oklahoma No. 20784

AF:CSK:tm

Enclosures
Addressee (3 via US Mail and 1 via email)

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GEOTECHNICAL ENGINEERING REPORT
PUBLIC SAFETY BUILDING & ELDERLY DUPLEX BUILDINGS
WYANDOTTE, OKLAHOMA

Terracon Project No. 04115228
November 30, 2011

1.0 INTRODUCTION

This geotechnical engineering report has been completed for the proposed Public Safety Building and Elderly Duplex Buildings to be constructed in Wyandotte, Oklahoma. A total of nine borings, designated B-1 through B-9, were performed to depths of approximately 3 to 15 feet below the existing ground surface. Logs of the borings along with a site location map and boring location plans are included in Appendix A of this report.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- subsurface soil and rock conditions
- groundwater conditions
- earthwork
- floor slab subgrade preparation
- foundation design and construction
- pavement design and construction

2.0 PROJECT INFORMATION

2.1 Project Description

ITEM	DESCRIPTION
Site layout	See Appendix A, Figure A-3, Boring Location Plan.
Buildings	**Elderly Duplexes:** 4 single-story buildings with approximate footprint area of 3,200 ft^2 for each building. **Public Safety Building:** single-story building with approximate footprint area of 5,500 ft^2.
Building Construction	slab-on-grade
Maximum loads	Columns: 75 kips (assumed) Walls: 3 kips/ft. (assumed)
Grading	A grading plan for the proposed project has not been completed at this time; however, we assume minimal cut and/or fill is required to develop final grades.

2.2 Site Location and Description

ITEM	DESCRIPTION
Location	South of E. 100 Road and west of S. 695 Road in Wyandotte, Oklahoma.
Existing improvements	Existing buildings at the northeast side of the site.
Current ground cover	Grass and bare ground
Existing topography	Relatively flat

3.0 SUBSURFACE CONDITIONS

3.1 Typical Profile

Based on the results of the borings, subsurface conditions on the project site can be generalized as follows:

Description	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency/Density
Surface[1]	3 inches	Topsoil	NA
Stratum 1	3 to 14 feet	Lean clay and fat clay with chert fragments	Medium stiff to very stiff
Stratum 2[2]	To boring termination depths of about 3 to 14 feet	Broken chert with various amount of clay	Dense to very dense

1- Encountered in boring B-1 through B-4, B-8, and B-9.

2- Auger refusal was encountered in this stratum at depths of about 4 to 10 feet at some borings.

The native clays have variable plasticity with the following measured liquid limits, plastic limits, and plasticity indices:

Sample Location, Depth	Liquid Limit, (%)	Plastic Limit, (%)	Plasticity Index, (%)
Boring B-4, 5.0 – 6.5 ft.	50	28	22
Boring B-5, 8.5 – 10.0 ft.	78	26	52
Boring B-6, 0.5 – 2.0 ft.	39	21	18
Boring B-8, 0.5 – 2.0 ft.	36	24	12

Conditions encountered at each boring location are indicated on the individual boring logs. Stratification boundaries on the boring logs represent the approximate location of changes in soil and rock types; in-situ, the transition between materials may be gradual. Details for each of the borings can be found on the boring logs in Appendix A of this report.

3.2 Groundwater

The boreholes were observed while drilling and immediately after completion for the presence and level of groundwater. The water levels observed are noted on the attached boring logs, and are summarized below.

Boring Number	Depth to groundwater while drilling, ft.	Depth to groundwater after drilling, ft.
B-1	Not encountered	Not encountered
B-2	Not encountered	Not encountered
B-3	Not encountered	Not encountered
B-4	14	Not encountered
B-5	13.5	Not encountered
B-6	Not encountered	Not encountered
B-7	Not encountered	Not encountered
B-8	Not encountered	Not encountered
B-9	Not encountered	Not encountered

The groundwater level observations made during our exploration provide an indication of the groundwater conditions at the time the borings were drilled. Longer monitoring in piezometers or cased holes, sealed from the influence of surface water, would be required to evaluate long-term groundwater conditions. During some periods of the year, perched water could be present at various depths. Fluctuations in groundwater levels should be expected throughout the year depending upon variations in the amount of rainfall, runoff, evaporation, and other hydrological factors not apparent at the time the borings were performed.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Based on conditions encountered in the borings, the buildings can be supported on footings bearing in a combination of tested and approved native soil and new fill.

Because of the presence of moderate to high plasticity clay soils, we recommend that a minimum thickness of low plasticity engineered fill be constructed beneath slab-on-grade floors.

Expansive soils are present on this site. This report provides recommendations to help mitigate the effects of soil shrinkage and expansion. However, even if these procedures are followed, some movement and cracking in structures should be anticipated. The severity of cracking and other damage such as uneven floor slabs will probably increase if any modification of the site results in excessive wetting or drying of the expansive soils. Eliminating the risk of movement

and distress may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction. We would be pleased to discuss other construction alternatives with you upon request. Details regarding this low-volume change zone are provided in this report in section **4.5 FLOOR SLAB.**

Subgrade improvement procedures are recommended beneath pavements to help provide more uniform pavement support.

Broken chert bedrock was encountered at depths of about 3 feet beneath the existing ground surface at some locations. Excavations extending into the broken chert will be difficult and may require special excavation techniques.

Recommendations regarding the design and construction of foundations and the support of floor slabs and pavement are provided below.

4.2 Earthwork

4.2.1 Site Preparation

Areas within the limits of construction should be stripped and cleared of surface vegetation, topsoil, and debris.

After stripping and performing the recommended overexcavations, the subgrade should be proofrolled to aid in locating loose or soft areas. Proofrolling can be performed with a loaded tandem axle dump truck weighing at least 25 tons. Unsuitable soils should be removed or compacted in place prior to placing fill.

After completing the proofrolling, and before placing any fill, the exposed subgrade should be scarified to a minimum depth of 9 inches, moisture conditioned, and compacted as recommended in Section **4.2.3 Compaction Requirements**.

4.2.2 Material Types

Engineered fill should meet the following material property requirements:

Fill Type [1]	USCS Classification	Acceptable Location for Placement
Imported Low Volume Engineered Fill [2]	CL or SC (PI ≤ 18)	All locations and elevations
On-Site Soils	CL, CH	The on-site clay soils have variable plasticity. It should be feasible to re-use the on-site clay soils at depths greater than 2 feet below finish grades. If it is desired to use the on-site clays within the upper 2 feet, additional testing should be performed during construction to verify the materials plasticity. Lime treatment could be performed to reduce soil plasticity.[3]

1. Controlled, compacted fill should consist of approved materials that are free of organic matter and debris and contain maximum rock size of 3 inches. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the geotechnical engineer for evaluation prior to its use.
2. Low plasticity cohesive soil or granular soil having at least 15% low plasticity fines.
3. We estimate approximately 4 to 6 percent hydrated lime, based on the materials dry unit weight, will be required. The actual amount should be determined in the field as the amount required to reduce the plasticity index to a value of 18 or less.

4.2.3 Compaction Requirements

The scarified and compacted subgrade and fill should be moisture conditioned and compacted using recommendations in the following table:

ITEM	DESCRIPTION
Subgrade Scarification Depth	9-inches
Fill Lift Thickness	9-inches or less in loose thickness
Compaction Requirements [1]	At least 95% of the materials maximum standard Proctor dry density (ASTM D-698)
Moisture Content	0 to 3% above the material's optimum moisture content, determined in accordance with ASTM D-698, the standard Proctor procedure

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

4.2.4 Utility Trench Backfill

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

4.2.5 Site Drainage

All grades must provide effective drainage away from the buildings during and after construction. Water permitted to pond next to the building can result in greater soil movements than those discussed in this report. These greater movements can result in unacceptable differential floor slab movements, cracked slabs and walls, and roof leaks. Estimated movements described in this report are based on effective drainage for the life of the structure and cannot be relied upon if effective drainage is not maintained.

Exposed ground should be sloped at a minimum 5 percent away from the building for at least 10 feet beyond the perimeter of the buildings. After building construction and landscaping, we recommend verifying final grades to document that effective drainage has been achieved. Grades around the structures should also be periodically inspected and adjusted as necessary, as part of the structure's maintenance program.

Planters located within 10 feet of the structures should be self-contained to prevent water accessing the building and pavement subgrade soils. Sprinkler mains and spray heads should be located a minimum of 5 feet away from the building lines. Low-volume, drip style landscaped irrigation should not be used near the building. Roof runoff should be collected in drains or gutters. Roof drains and downspouts should discharge onto pavements which slope away from the building or down spouts should extend a minimum of 10 feet away from structures.

4.2.6 Construction Considerations for Earthwork

Upon completion of filling and grading, care should be taken to maintain the subgrade moisture content prior to construction of floor slabs and footings. Construction traffic over the completed subgrade should be avoided to the extent practical. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. If the subgrade should become frozen, desiccated, saturated, or disturbed, the affected material should be removed or these materials should be scarified, moisture conditioned, and recompacted prior to floor slab construction.

The geotechnical engineer should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during subgrade

preparation; proofrolling; placement and compaction of controlled compacted fills; backfilling of excavations into the completed subgrade, and just prior to construction of building floor slabs.

4.3 Foundations

The proposed buildings can be supported on shallow footings bearing in the native clay soils or tested and approved new engineering fill. A combination of observation and testing by the geotechnical engineer will be required during footing construction to verify suitable bearing materials are encountered.

Design recommendations for footing foundations for the proposed buildings are presented in the following paragraphs.

4.3.1 Footing Foundation Design Recommendations

DESCRIPTION	Column	Wall
Net allowable bearing pressure [1]	2,000 psf	
Minimum width	30 inches	16 inches
Minimum embedment (below lowest finished exterior grade) [2]	24 inches	
Estimated total movement	< 1 inch	
Estimated differential movement	< ¾ inch	
Allowable passive pressure (rectangular pressure distribution) [3]	750 psf	
Coefficient of sliding friction [4]	0.30	

1. The recommended allowable bearing pressure is based on footings bearing in tested and approved new fill and medium stiff to very stiff, native clay. The net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation.
2. Minimum depth applies to both perimeter footings and footings in unheated areas. Minimum depth will provide frost protection. Interior footings should extend at least 12 inches below the final adjacent subgrade to provide minimum confinement.
3. Allowable passive pressure value considers a factor of safety of about 2. Passive pressure value applies to undisturbed medium stiff to very stiff, native clay, or tested and approved new engineered fill. If formed footings are constructed, the space between the formed side of a footing and excavation sidewall should be cleaned of all loose material, debris, and water and backfilled with tested and approved, cohesive fill compacted to at least 95 percent of the material's standard Proctor dry density. Passive resistance should be neglected for the upper 2 feet of the soil below the final adjacent grade due to strength loss from freeze-thaw and shrink-swell.
4. Coefficient of friction value is an ultimate value and does not contain a factor of safety.

4.3.2 Construction Considerations for Shallow Foundations

If unsuitable bearing soils are encountered in footing excavations, the excavations should be extended deeper to suitable soils and the footings could bear directly on these soils at the lower level or on lean concrete backfill placed in the excavations. Alternately, the footings could also bear on properly compacted backfill extending down to the suitable soils. Overexcavation for compacted backfill placement below footings should extend laterally beyond all edges of the footings at least 8 inches per foot of overexcavation depth below elevation with approved fill materials placed in lifts of 9 inches or less in loose thickness and compacted to at least 98 percent of the material's maximum standard Proctor dry density (ASTM D-698).

4.4 Seismic Considerations

Code Used	Site Classification
2006 International Building Code (IBC) [1]	C [2]

1. In general accordance with the *2006 International Building Code,* Table 1613.5.2.
2. The 2006 International Building Code (IBC) requires a site soil profile determination extending a depth of 100 feet for seismic site classification. A geophysical exploration could be utilized in order to attempt to justify a higher seismic site class.

4.5 Floor Slabs

4.5.1 Design Recommendations

ITEM	DESCRIPTION
Floor slab support	24-inch low volume change zone is required [1]

1. Because of the moderate to high shrink-swell potential of the subgrade soils, we recommend a low volume change layer be developed below the floor slab. This layer should be at least 24 inches thick and should meet the Low Volume Engineered Fill criteria outlined in this report in section 4.2 **Earthwork**.

The use of a vapor retarder should be considered beneath concrete slabs on grade that will be covered with wood, tile, carpet or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

4.5.2 Construction Considerations for Floor Slabs

We recommend that the subgrade be maintained in a relatively moist condition until the floor slab is constructed. If the subgrade should become desiccated prior to construction of the floor slab, the affected material should be removed or the materials scarified, moistened, and

recompacted. Upon completion of grading operations in the building area, care should be taken to maintain the recommended subgrade moisture content and density prior to construction of the building floor slab.

4.6 Pavements

4.6.1 Typical Pavement Sections

Based on the results of the borings and anticipated grade changes, the pavement subgrade could consist of native clay soils or new engineered fill.

To improve subgrade support, we recommend that the upper 8 inches of the pavement subgrade be treated with fly ash. We recommend that a minimum of 13 to 15 percent class "C" fly ash, based on the material's compacted dry unit weight, be used to treat the subgrade soils. The actual amount of fly ash should be determined in the field during construction as the amount required to stabilize the subgrade and reduce the material's plasticity index to a value of 18 or less. Fly ash treatment should be performed according to ODOT Specifications.

Typical, minimum alternative pavement sections are outlined below. The sections are based on a subgrade CBR value of 3 for the untreated subgrade. Also, the sections assume that automobile parking pavements will be traveled only by automobiles and drive-lane pavements will be traveled by no more than 5 trucks per day having a gross weight of 50,000 pounds or equivalent trafficking. Periodic maintenance should be planned to extend the pavement life. Other pavement sections could be considered.

MINIMUM PAVEMENT RECOMMENDATIONS		
	Drive Lanes	**Automobile Parking**
Pavement Section I		
Asphaltic Concrete	2.0" Type "C" AC[1]	3.0" Type "C" AC[1]
Over Aggregate Base	2.5" Type "A" AC[1]	6.0" Aggregate Base[2]
Over Treated Subgrade	6.0" Aggregate Base[2]	8.0" Treated Subgrade[2]
	8.0" Treated Subgrade[2]	
Pavement Section II		
3,500 psi Air Entrained Portland Cement Concrete	6.0" Concrete	5.0" Concrete
Over Treated Subgrade	8.0" Treated Subgrade[2]	8.0" Treated Subgrade[2]

1. AC = Asphaltic Concrete
2. Oklahoma Department of Transportation Standard Specifications

NOTE: We recommend that 7-inch thick reinforced concrete pads be provided in front of and beneath trash receptacles. The dumpster trucks should be parked on the rigid concrete pavement when the trash receptacles are lifted. The concrete pads should be supported on at least 4 inches of ODOT Type "A" aggregate base over a 8-inch fly ash treated subgrade.

4.6.2 Pavement Drainage

Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration.

4.6.3 Pavement Maintenance

The pavement sections provided in this report represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Preventive maintenance should be planned and provided for through an on-going pavement management program. Preventive maintenance activities are intended to slow the rate of pavement deterioration, and to preserve the pavement investment. Preventive maintenance consists of both localized maintenance (e.g. crack and joint sealing and patching) and global maintenance (e.g. surface sealing). Preventive maintenance is usually the first priority when implementing a planned pavement maintenance program and provides the highest return on investment for pavements. Prior to implementing any maintenance, additional engineering observation is recommended to determine the type and extent of preventive maintenance. Even with periodic maintenance, some movements and related cracking may still occur and repairs may be required.

4.7 Additional Construction Considerations

Chert bedrock was encountered at relatively shallow depths at the borings. Based on our experience, bedrock formations that can be penetrated by the flight augers used in our drilling operation can sometimes be excavated using large heavy-duty track-mounted excavation equipment fitted with rock excavation attachments. However, special techniques such as the

use of pneumatic rock breakers may be required in narrow, confined excavations. Excavations below auger refusal will require special rock removal techniques such as pneumatic hammers or blasting.

5.0 GENERAL COMMENTS

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

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

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

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

APPENDIX A

FIELD EXPLORATION

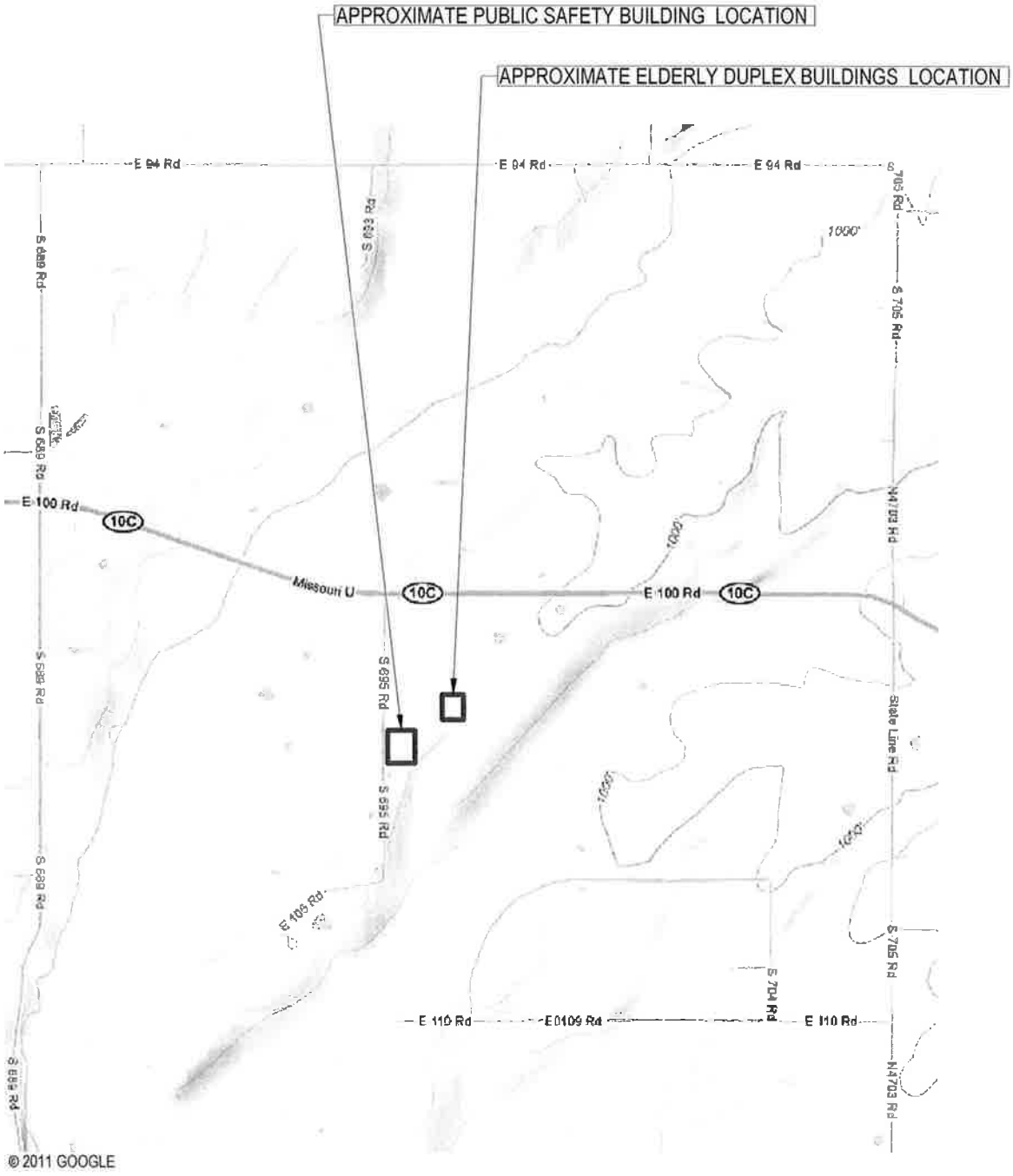
Field Exploration Description

The boring locations were established in the field by Terracon personnel by taping or pacing from existing reference features. Terracon determined the approximate ground surface elevations at the borings using an engineer's level. The top of a fire hydrant located at the east side of South 695 road was used as a benchmark. The approximate ground surface elevations at the borings, based on an arbitrary elevation of 100.0 feet for the benchmark, are shown near the top of the boring logs. The elevations shown on the logs have been rounded to the nearest 0.5 feet. The boring locations and elevations should be considered accurate only to the degree implied by the methods used to define them.

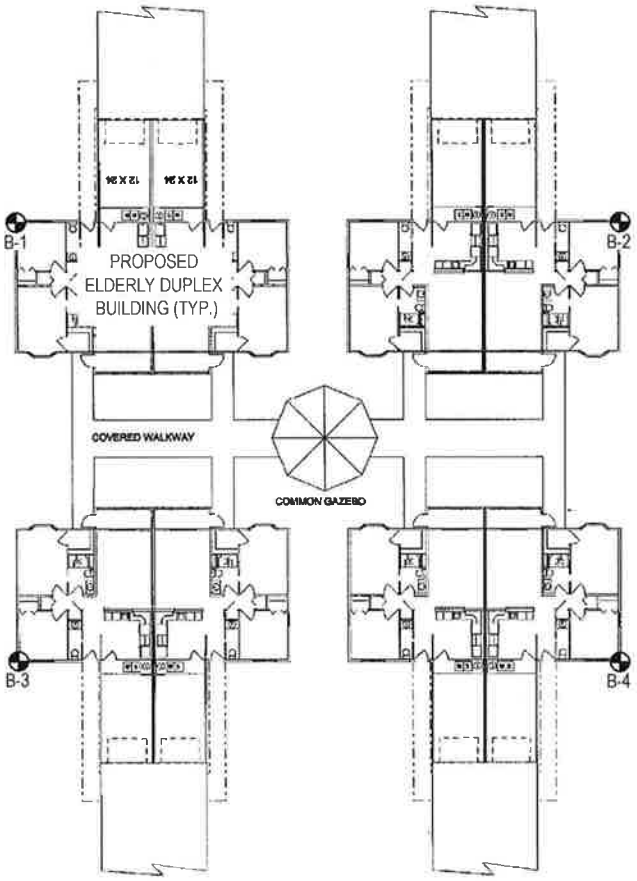
The borings were drilled with an ATV-mounted rotary drill rig using continuous flight solid-stem augers to advance the boreholes. Representative samples were obtained by the split-barrel sampling procedure. The split-barrel sampling procedure uses a standard 2-inch, O.D. split-barrel sampling spoon that is driven into the bottom of the boring with a 140-pound drive hammer falling 30 inches. The number of blows required to advance the sampling spoon the last 12 inches, or less, of an 18-inch sampling interval or portion thereof, is recorded as the standard penetration resistance value, N. The N value is used to estimate the in-situ relative density of granular soils and, to a lesser degree of accuracy, the consistency of cohesive soils and the hardness of weathered bedrock. The sampling depths, penetration distances, and N values are reported on the boring logs. The samples were tagged for identification, sealed to reduce moisture loss and returned to the laboratory for further examination, testing and classification.

An automatic SPT hammer was used to advance the split-barrel sampler in the borings performed on this site. Generally, a greater efficiency is achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. The effect of the automatic hammer's efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

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



Project Mngr: AF	Project No. 04115228	Terracon Consulting Engineers and Scientists	SITE LOCATION MAP	EXHIBIT NO.
Drawn By: DC	Scale: SEE BAR SCALE	10930 EAST 56th STREET TULSA, OKLAHOMA 74146	GEOTECHNICAL EXPLORATION	A-2
Checked By: AF	File No 04115228	PH. (918) 250-0461 FAX (918) 250-4570	PROPOSED PUBLIC SAFETY BUILDING AND ELDERLY DUPLEX BUILDINGS	
Approved By: CSK	Date: NOVEMBER 2011		WYANDOTTE, OKLAHOMA	



BASE DRAWING PROVIDED BY EASTERN SHAWNEE TRIBE OF OKLAHOMA

N

50 0 25 50

APPROXIMATE SCALE IN FEET

LEGEND
BORING LOCATION

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

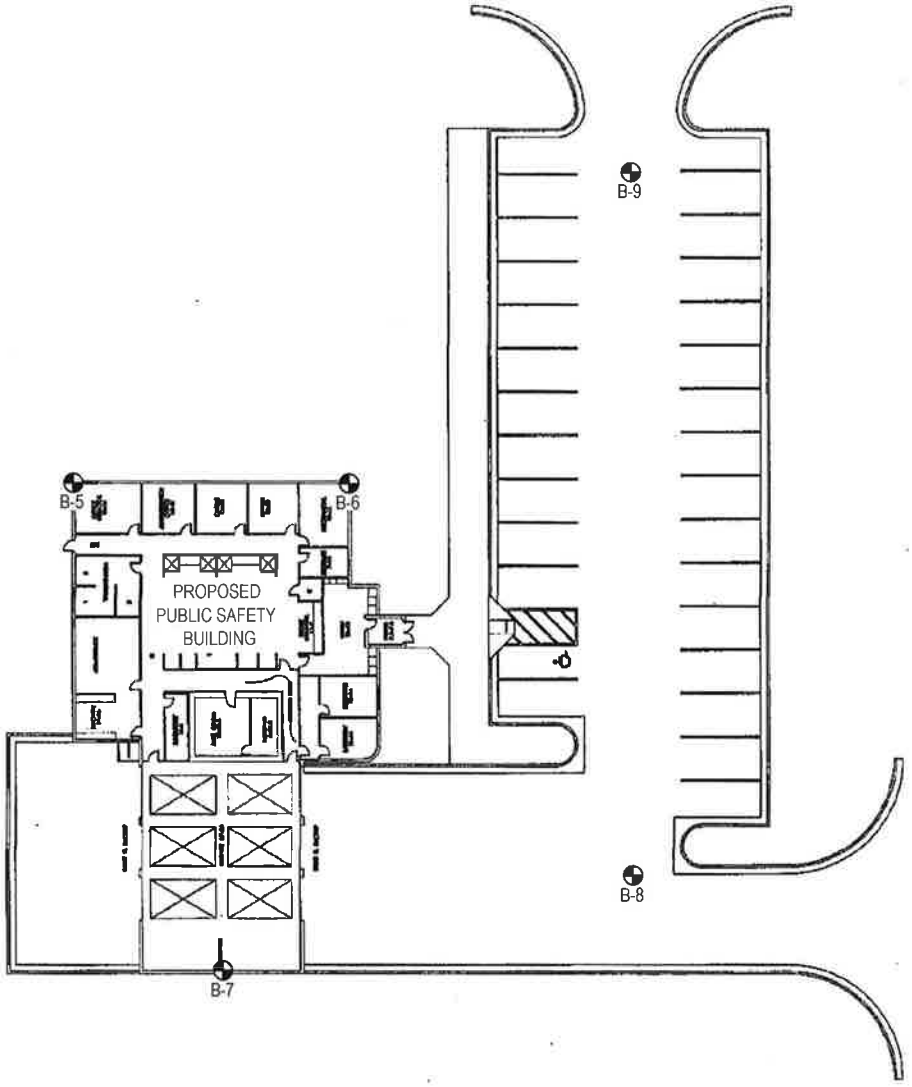
Project Mngr:	AF
Drawn By:	DC
Checked By:	AF
Approved By:	CSK
Project No.:	04115228
Scale:	SEE BAR SCALE
File No:	04115228
Date:	NOVEMBER 2011

Terracon
Consulting Engineers and Scientists
10930 EAST 56th STREET TULSA, OKLAHOMA 74146
PH. (918) 250-0461 FAX (918) 250-4570

BORING LOCATION PLAN

GEOTECHNICAL EXPLORATION
PROPOSED PUBLIC SAFETY BUILDING AND ELDERLY DUPLEX BUILDINGS
WYANDOTTE, OKLAHOMA

EXHIBIT NO.
A-3



BASE DRAWING PROVIDED BY EASTERN SHAWNEE TRIBE OF OKLAHOMA

N

50 0 25 50

APPROXIMATE SCALE IN FEET

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BORING LOCATION PLAN

GEOTECHNICAL EXPLORATION
PROPOSED PUBLIC SAFETY BUILDING AND ELDERLY DUPLEX BUILDINGS
WYANDOTTE, OKLAHOMA

EXHIBIT NO.
A-4

LOG OF BORING NO. B-1

CLIENT **Eastern Shawnee Tribe of Oklahoma**

SITE **SEC of E100 Road & S695 Road Wyandotte, Oklahoma**

PROJECT **Elderly Duplex and Public Safety Building**

Approx. Surface Elev.: 106 ft

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES SPT-N BLOWS / ft.	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED COMPRESSION, psf
	3" Topsoil				PA					
	LEAN CLAY with chert fragments, dark brown, medium stiff		CL	1	SS	12	5	25		
					PA					
	3 103									
	CLAYEY BROKEN CHERT+ with chert and clay seams, light gray, dense to very dense		CL	2	SS	12	22/6" 50/6"	15		
					PA					
		5		3	SS	3	50/3"	41		
					PA					
	7 99									
	BOTTOM OF BORING									
	Auger refusal at 7 feet									
	+Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.									

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft				
WL	▽ N/E	WD	▼ N/E	AB
WL	▼		▼	
WL				

Terracon

BORING STARTED	11-9-11		
BORING COMPLETED	11-9-11		
RIG	ATV	FOREMAN	T.S.
APPROVED	CSK	JOB #	04115228

BOREHOLE BORING LOGS-5228.GPJ 2011 TULSA.GDT 11/30/11

LOG OF BORING NO. B-2

CLIENT **Eastern Shawnee Tribe of Oklahoma**

SITE **SEC of E100 Road & S695 Road Wyandotte, Oklahoma**

PROJECT **Elderly Duplex and Public Safety Building**

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES SPT-N BLOWS / ft.	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED COMPRESSION, psf
	Approx. Surface Elev.: 99 ft									
	3" Topsoil				PA					
	LEAN CLAY with chert fragments, brown, very stiff		CL	1	SS	6	20	20		
					PA					
	3 96									
	CLAYEY BROKEN CHERT+		CL	2	SS	3	50/5"	8		
	4 with chert and clay seams, brown, very dense 95				PA					
	BOTTOM OF BORING									
	Auger refusal at 4 feet									
	+Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.									

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft				
WL	▽ N/E	WD	▼ N/E	AB
WL	▽		▼	
WL				

Terracon

BORING STARTED	11-9-11		
BORING COMPLETED	11-9-11		
RIG	ATV	FOREMAN	T.S.
APPROVED	CSK	JOB #	04115228

BOREHOLE BORING LOGS-5228.GPJ 2011 TULSA.GDT 11/30/11

LOG OF BORING NO. B-3

CLIENT **Eastern Shawnee Tribe of Oklahoma**

SITE **SEC of E100 Road & S695 Road Wyandotte, Oklahoma**

PROJECT **Elderly Duplex and Public Safety Building**

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES SPT-N BLOWS / ft.	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED COMPRESSION, psf
	Approx. Surface Elev.: 101 ft									
	3" Topsoil				PA					
	LEAN CLAY with chert fragments, brown, very stiff		CL	1	SS	8	41	12		
	3 / 98									
	CLAYEY BROKEN CHERT+ with chert and clay seams, light gray, dense to very dense		CL	2	SS	3	50/5"	6		
					PA					
		5	CL	3	SS	10	22/6" 50/4"	33		
					PA					
				4	SS	3	50/5"	10		
					PA					
		10								
	13.7 / 87.5			5	SS	0	50/2"			
	BOTTOM OF BORING									

+Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft				
WL	▽ N/E	WD	▼ N/E	AB
WL	▽		▼	
WL				

Terracon

BORING STARTED	11-10-11		
BORING COMPLETED	11-10-11		
RIG	ATV	FOREMAN	T.S.
APPROVED	CSK	JOB #	04115228

BOREHOLE BORING LOGS-5228.GPJ 2011 TULSA.GDT 11/30/11

LOG OF BORING NO. B-4

CLIENT
Eastern Shawnee Tribe of Oklahoma

SITE
SEC of E100 Road & S695 Road
Wyandotte, Oklahoma

PROJECT
Elderly Duplex and Public Safety Building

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES SPT-N BLOWS / ft.	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED COMPRESSION, psf	
	Approx. Surface Elev.: 98 ft										
	3" Topsoil				PA						
	LEAN CLAY with chert fragments, brown to reddish-brown, very stiff		CL	1	SS	8	35	19			
					PA						
			CL	2	SS	18	64	20			
					PA						
	5 93	5									
	FAT CLAY with broken chert, brown, very stiff		CH	3	SS	18	26/6" 50/6"	26			S-3 LL=50 PL=28 PI=22
	6.5 91.5				PA						
	CLAYEY BROKEN CHERT+ with chert and clay seams, brown, medium dense to dense			4	SS	18	39	19			
		10			PA						
	▽			5	SS	18	22	22			
	15 83	15									
	BOTTOM OF BORING										
	+Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.										

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 14	WD	▽ N/E AB
WL	▽		▽
WL			

Terracon

BORING STARTED	11-10-11		
BORING COMPLETED	11-10-11		
RIG	ATV	FOREMAN	T.S.
APPROVED	CSK	JOB #	04115228

BOREHOLE BORING LOGS-5228.GPJ 2011 TULSA.GDT 11/30/11

LOG OF BORING NO. B-5

CLIENT
Eastern Shawnee Tribe of Oklahoma

SITE **SEC of E100 Road & S695 Road**
Wyandotte, Oklahoma

PROJECT
Elderly Duplex and Public Safety Building

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES SPT-N BLOWS / ft.	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED COMPRESSION, psf	
	Approx. Surface Elev.: 109 ft										
	LEAN CLAY with chert fragments, dark brown, stiff to very stiff				PA						
			CL	1	SS	10	19	18			
					PA						
			CL	2	SS	6	10	17			
					PA						
		5	CL	3	SS	18	45	25			
					PA						
	8.5 100.5										
	FAT CLAY with chert fragments, reddish-brown, very stiff		CH	4	SS	18	23	39			S-4 LL=78 PL=26 PI=52
		10			PA						
	13.5 95.5 ▽										
	13.8 95 **BROKEN CHERT+** light gray, very dense			5	SS	3	50/4"	13			
	BOTTOM OF BORING										

+Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 13.5	WD	▼ N/E AB
WL	▼		▼
WL			

Terracon

BORING STARTED	11-10-11		
BORING COMPLETED	11-10-11		
RIG	ATV	FOREMAN	T.S.
APPROVED	CSK	JOB #	04115228

BOREHOLE BORING LOGS-5228.GPJ 2011 TULSA.GDT 11/30/11

LOG OF BORING NO. B-6

CLIENT
Eastern Shawnee Tribe of Oklahoma

SITE
SEC of E100 Road & S695 Road
Wyandotte, Oklahoma

PROJECT
Elderly Duplex and Public Safety Building

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES SPT-N BLOWS / ft.	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED COMPRESSION, psf	
	Approx. Surface Elev.: 103 ft										
	LEAN CLAY dark brown, medium stiff		CL	1	PA SS	12	6	17			S-1 LL=39 PL=21 PI=18
	2 101										
	LEAN CLAY with chert fragments, brown, very stiff		CL	2	PA SS	14	37	16			
	5 98	5		3	PA SS	2	50/2"	8			
	BROKEN CHERT+ light gray, very dense			4	PA SS	0	50/2"				
	10 93	10			PA						
	BOTTOM OF BORING Auger refusal at 10 feet +Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.										

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ N/E	WD	▼ N/E AB
WL	▽		▼
WL			

Terracon

BORING STARTED	11-10-11		
BORING COMPLETED	11-10-11		
RIG	ATV	FOREMAN	T.S.
APPROVED	CSK	JOB #	04115228

BOREHOLE BORING LOGS-5228.GPJ 2011 TULSA.GDT 11/30/11

LOG OF BORING NO. B-7

CLIENT **Eastern Shawnee Tribe of Oklahoma**

SITE **SEC of E100 Road & S695 Road Wyandotte, Oklahoma**

PROJECT **Elderly Duplex and Public Safety Building**

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES SPT-N BLOWS / ft.	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED COMPRESSION, psf
	Approx. Surface Elev.: 99 ft									
	LEAN CLAY with chert fragments, reddish-brown, medium stiff				PA					
			CL	1	SS	18	6	36		
					PA					
	3 96									
	CLAYEY BROKEN CHERT+ light gray, very dense		CL	2	SS	12	50/6"	19		
					PA					
		5								
	6 93			3	SS	0	50/0"			
	BOTTOM OF BORING Auger refusal at 6 feet +Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.									

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft				
WL	▽ N/E	WD	▼ N/E	AB
WL	▽		▼	
WL				

Terracon

BORING STARTED	11-10-11		
BORING COMPLETED	11-10-11		
RIG	ATV	FOREMAN	T.S.
APPROVED	CSK	JOB #	04115228

BOREHOLE BORING LOGS-5228.GPJ 2011 TULSA.GDT 11/30/11

LOG OF BORING NO. B-8

CLIENT
Eastern Shawnee Tribe of Oklahoma

SITE **SEC of E100 Road & S695 Road**
Wyandotte, Oklahoma

PROJECT
Elderly Duplex and Public Safety Building

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES SPT-N BLOWS / ft.	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED COMPRESSION, psf	
	Approx. Surface Elev.: 100.5 ft										
	3" Topsoil				PA						
	LEAN CLAY with chert fragments, dark brown, stiff		CL	1	SS	12	12	22			S-1 LL=36 PL=24 PI=12
					PA						
		3									
	BROKEN CHERT+ light gray, very dense	3.5 / 97		2	SS	6	50/6"	5			
	BOTTOM OF BORING										

+Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft				
WL	▽ N/E	WD	▼ N/E	AB
WL	▼		▼	
WL				

Terracon

BORING STARTED	11-10-11		
BORING COMPLETED	11-10-11		
RIG	ATV	FOREMAN	T.S.
APPROVED	CSK	JOB #	04115228

BOREHOLE BORING LOGS-5228.GPJ 2011 TULSA.GDT 11/30/11

LOG OF BORING NO. B-9

CLIENT
Eastern Shawnee Tribe of Oklahoma

SITE
SEC of E100 Road & S695 Road
Wyandotte, Oklahoma

PROJECT
Elderly Duplex and Public Safety Building

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES SPT-N BLOWS / ft.	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED COMPRESSION, psf
	Approx. Surface Elev.: 100.5 ft									
	3" Topsoil				PA					
	LEAN CLAY with chert fragments, brown, very stiff		CL	1	SS	18	24/6" 50/6"	10		
	2.5 98				PA					
	3.1 **BROKEN CHERT+** light gray, very dense 97.5			2	SS	0	50/0"			
	BOTTOM OF BORING									

+Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft				
WL	▽ N/E	WD	▼ N/E	AB
WL	▽		▼	
WL				

Terracon

BORING STARTED	11-10-11		
BORING COMPLETED	11-10-11		
RIG	ATV	FOREMAN	T.S.
APPROVED	CSK	JOB #	04115228

APPENDIX B

LABORATORY TESTING

Laboratory Testing

Samples retrieved during the field exploration were taken to the laboratory for further observation by the project geotechnical engineer and were classified in accordance with the Unified Soil Classification System (USCS) described in Appendix A. The field descriptions were modified as necessary and an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials.

Laboratory tests were conducted on selected soil samples. The laboratory test results are presented on the boring logs next to the respective samples. Laboratory tests were performed in general accordance with the applicable ASTM, local or other accepted standards.

Selected soil samples obtained from the site were tested for the following engineering properties:

- Water content
- Atterberg limits

APPENDIX C

SUPPORTING DOCUMENTS

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS:	Split Spoon – 1-3/8" I.D., 2" O.D., unless otherwise noted	HS:	Hollow Stem Auger
ST:	Thin-Walled Tube - 2" O.D., unless otherwise noted	PA:	Power Auger
RS:	Ring Sampler - 2.42" I.D., 3" O.D., unless otherwise noted	HA:	Hand Auger
DB:	Diamond Bit Coring - 4", N, B	RB:	Rock Bit
BS:	Bulk Sample or Auger Sample	WB:	Wash Boring or Mud Rotary

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value".

WATER LEVEL MEASUREMENT SYMBOLS:

WL:	Water Level	WS:	While Sampling	N/E:	Not Encountered
WCI:	Wet Cave in	WD:	While Drilling		
DCI:	Dry Cave in	BCR:	Before Casing Removal		
AB:	After Boring	ACR:	After Casing Removal		

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels may not be possible with only short-term observations.

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

CONSISTENCY OF FINE-GRAINED SOILS

Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-value (SS) Blows/Ft.	Consistency
< 500	<2	Very Soft
500 – 1,000	2-3	Soft
1,001 – 2,000	4-6	Medium Stiff
2,001 – 4,000	7-12	Stiff
4,001 – 8,000	13-26	Very Stiff
8,000+	26+	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Standard Penetration or N-value (SS) Blows/Ft.	Ring Sampler (RS) Blows/Ft.	Relative Density
0 – 3	0-6	Very Loose
4 – 9	7-18	Loose
10 – 29	19-58	Medium Dense
30 – 49	59-98	Dense
50+	99+	Very Dense

RELATIVE PROPORTIONS OF SAND AND GRAVEL

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

GRAIN SIZE TERMINOLOGY

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

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other Constituents	Percent of Dry Weight
Trace	< 5
With	5 – 12
Modifiers	> 12

PLASTICITY DESCRIPTION

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

Exhibit C-1

UNIFIED SOIL CLASSIFICATION SYSTEM

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

[A] Based on the material passing the 3-in. (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

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

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.

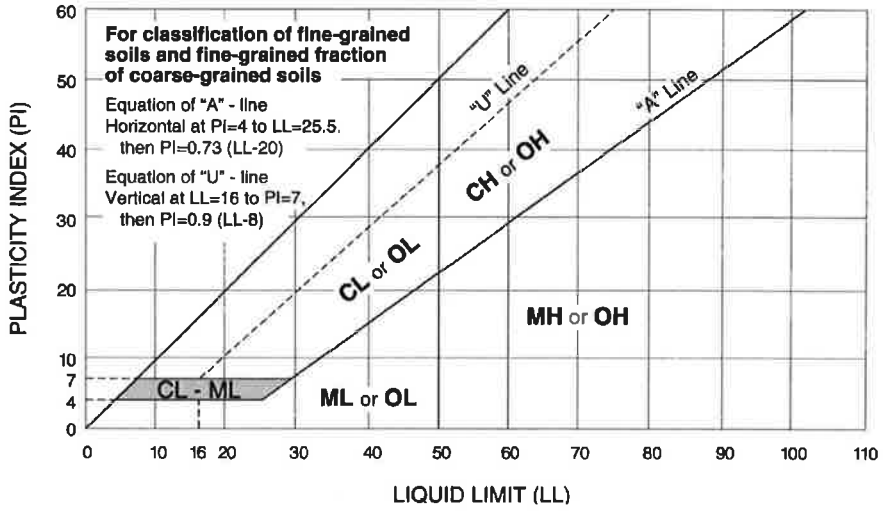

Exhibit C-2

GENERAL NOTES

Sedimentary Rock Classification

DESCRIPTIVE ROCK CLASSIFICATION:

Sedimentary rocks are composed of cemented clay, silt and sand sized particles. The most common minerals are clay, quartz and calcite. Rock composed primarily of calcite is called limestone; rock of sand size grains is called sandstone, and rock of clay and silt size grains is called mudstone or claystone, siltstone, or shale. Modifiers such as shaly, sandy, dolomitic, calcareous, carbonaceous, etc. are used to describe various constituents. Examples: sandy shale; calcareous sandstone.

LIMESTONE	Light to dark colored, crystalline to fine-grained texture, composed of $CaCo_3$, reacts readily with HCl.
DOLOMITE	Light to dark colored, crystalline to fine-grained texture, composed of $CaMg(CO_3)_2$, harder than limestone, reacts with HCl when powdered.
CHERT	Light to dark colored, very fine-grained texture, composed of micro-crystalline quartz ($Si0_2$), brittle, breaks into angular fragments, will scratch glass.
SHALE	Very fine-grained texture, composed of consolidated silt or clay, bedded in thin layers. The unlaminated equivalent is frequently referred to as siltstone, claystone or mudstone.
SANDSTONE	Usually light colored, coarse to fine texture, composed of cemented sand size grains of quartz, feldspar, etc. Cement usually is silica but may be such minerals as calcite, iron-oxide, or some other carbonate.
CONGLOMERATE	Rounded rock fragments of variable mineralogy varying in size from near sand to boulder size but usually pebble to cobble size (½ inch to 6 inches). Cemented together with various cementing agents. Breccia is similar but composed of angular, fractured rock particles cemented together.

PHYSICAL PROPERTIES:

DEGREE OF WEATHERING

Slight	Slight decomposition of parent material on joints. May be color change.
Moderate	Some decomposition and color change throughout.
High	Rock highly decomposed, may be extremely broken.

HARDNESS AND DEGREE OF CEMENTATION

Limestone and Dolomite:

Hard	Difficult to scratch with knife.
Moderately Hard	Can be scratched easily with knife, cannot be scratched with fingernail.
Soft	Can be scratched with fingernail.

Shale, Siltstone and Claystone

Hard	Can be scratched easily with knife, cannot be scratched with fingernail.
Moderately Hard	Can be scratched with fingernail.
Soft	Can be easily dented but not molded with fingers.

Sandstone and Conglomerate

Well Cemented	Capable of scratching a knife blade.
Cemented	Can be scratched with knife.
Poorly Cemented	Can be broken apart easily with fingers.

BEDDING AND JOINT CHARACTERISTICS

Bed Thickness	Joint Spacing	Dimensions
Very Thick	Very Wide	>10′
Thick	Wide	3′ - 10′
Medium	Moderately Close	1′ - 3′
Thin	Close	2″ - 1′
Very Thin	Very Close	.4″ - 2″
Laminated	—	.1″ - .4″

Bedding Plane	A plane dividing sedimentary rocks of the same or different lithology.
Joint	Fracture in rock, generally more or less vertical or transverse to bedding, along which no appreciable movement has occurred.
Seam	Generally applies to bedding plane with an unspecified degree of weathering.

SOLUTION AND VOID CONDITIONS

Solid	Contains no voids.
Vuggy (Pitted)	Rock having small solution pits or cavities up to ½ inch diameter, frequently with a mineral lining.
Porous	Containing numerous voids, pores, or other openings, which may or may not interconnect.
Cavernous	Containing cavities or caverns, sometimes quite large.

Terracon