Geotechnical Engineering Report

Retaining Walls A and B
Along 91st Street South
from South Memorial Drive to South Mingo Road
Tulsa County, Oklahoma

June 25, 2021
Terracon Project No. 04195149

Prepared for:
Garver, LLC
Tulsa, Oklahoma

Prepared by:
Terracon Consultants, Inc.
Oklahoma City, Oklahoma

June 25, 2021

Garver, LLC.
6450 South Lewis, Suite 300
Tulsa, Oklahoma 74136

Attn: Mr. Michael Winterscheidt, P.E.
P: [918] 250 5922
E: MLWinterscheidt@garverusa.com

Re: Geotechnical Engineering Report
Retaining Walls A and B Along 91st Street South
From South Memorial Drive to South Mingo Road
Tulsa County, Oklahoma
Terracon Project No. 04195149

Dear Mr. Winterscheidt:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. The scope of our services was outlined in Terracon's Proposal No. P04195149 dated July 8, 2019

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. 6/30/21

Jeff Dean, P.E.
Senior Engineer

LICENSED PROFESSIONAL ENGINEER
MICHAEL H. HOMAN
15777
OKLAHOMA
6/25/2021

Michael H. Homan
Senior Principal
Oklahoma No. 15777

Copies to: Addressee (1 via email)

TABLE OF CONTENTS

Page

APPENDIX D - SUPPORTING DOCUMENTS

Exhibit D-1	General Notes
Exhibit D-2	Unified Soil Classification System
Exhibit D-3	Sedimentary Rock Classification

GEOTECHNICAL ENGINEERING REPORT
RETAINING WALLS A AND B ALONG 91ST STREET
BETWEEN MEMORIAL DRIVE AND MINGO ROAD
TULSA COUNTY, OKLAHOMA

Terracon Project No. 04195149

June 25, 2021

1.0 INTRODUCTION

This report presents the results of our geotechnical engineering services performed for proposed Retaining Walls A and B that are part of the widening and improvements to 91st Street South between South Memorial Drive and South Mingo Road in Tulsa County, Oklahoma. Terracon's geotechnical scope of work for this report included the advancement of six test borings ranging in depth from approximately 19 feet to 35 feet below existing site grades. Five additional borings were added to obtain thin-walled tube samples for conducting unconfined compression tests. This report includes the borings for Cast in Place, CIP, retaining walls A and B. The original scope of work included a Retaining Wall C, but it has been excluded from the scope of this project.

This report describes the subsurface conditions encountered in the borings, reports test results, and provides boring logs with Standard Penetration Test and unconfined compression test results.

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Site Layout	See Appendix A, Exhibits A-1 to A-2.
Structures	This project will involve constructing two Cast in Place (CIP) retaining walls (Walls A & B) according to AASHTO standards. Based on the plans provided, the CIP walls will have maximum total design heights ranging from 7 to 8 feet. The length of the CIP walls varies from approximately 675 feet for Wall A to 552 feet for Wall B. We understand that the walls will be designed using the AASHTO Load and Resistance Factor Design (LFRD) method. Retaining Wall C has been excluded from the project.

2.2 Site Location and Description

Item	Description
Location	The project is located on 91st Street between South Memorial Drive and South Mingo Road in Tulsa.

3.0 SUBSURFACE CONDITIONS

3.1 Geology

The geology of this site consists of the clay shales and sandy shales of the Nowata Unit. This unit also contains minor amounts of lenticular sandstone in the lower portion and a few limestones that are typically less than one foot thick. The total thickness of the Nowata unit is approximately 60 feet near the Oklahoma / Kansas state line and increases in thickness southward to a maximum of about 200 feet near Broken Arrow. Topographically, the unit is most often flat to slightly rolling with a few round hills. Alluvial deposits of sand silt, clay, gravel and/or combinations of these are found along flood plains and banks of streams

3.2 Typical Subsurface Profile

Specific 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 included in Appendix A of this report. 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 (feet)	Material Encountered	Consistency/Density
Stratum 1[1]	13.5 to boring termination depths	Lean to fat clay with varying amounts of silt and sand	Very soft to hard
Stratum 1[2]	5.0 feet	Sand with varying amounts of silt	Loose
Stratum 2[3]	Encountered to boring termination depths	Weathered shale	Hard
Stratum 2[4]	Encountered to boring termination depths	Lean clay with varying amounts of sand	Very soft to stiff

[1] Borings WA-1 to WA-5 & WB-2
[2] Boring WB-1
[3] Borings WA-1 to WA-5
[4] Borings WB-1 & WB-2

Laboratory tests were conducted on selected soil samples and the test results are presented on the borings logs in Appendix A and on the report form in Appendix B.

The following table indicates the ground surface elevations and the approximate elevations of stratification changes at the respective boring locations.

	Wall - A, Approximate Stratification Boundary Elevations (feet)				
Strata	**WA-1**	**WA-2**	**WA-3**	**WA-4**	**WA-5**
Overburden Soils (ground elevation)	695.2	698.5	698.6	693.6	690.8
Weathered shale	681.7	685.0	685.1	680.1	677.3
Boring Termination elevation	676.3	679.2	679.6	674.6	672.1

	Wall - B, Approximate Stratification Boundary Elevations (feet)	
Strata	**WB-1**	**WB-2**
Overburden Soils (ground elevation)	675.5	675.3
Boring Termination elevation	645.1	640.3

3.3 Groundwater

The borings were monitored while drilling and immediately after completing the drilling activities for the presence and level of groundwater. At these times, groundwater was observed at the following depths:

Boring No.	Water Level While Drilling Depth (ft.) / Elevation (ft.)	Water Level After Boring Completion[1] Depth (ft.) / Elevation (ft.)
WA-1	Dry	Dry
WA-2	Dry	Dry
WA-3	Dry	Dry
WA-4	Dry	Dry
WA-5	Dry	Dry
WB-1	13.5	15.0
WB-2	13.5	15.0

[1] Groundwater was not measured 24 hours after boring completion, because the borings were located on the roadway and therefore, they were backfilled immediately after completion.

Long-term monitoring with observation wells, sealed from the influence of surface water, would be required to accurately define the potential range of groundwater conditions at this site. Fluctuations in the groundwater level should be expected due to seasonal variations in the amount of rainfall, runoff, and other factors not apparent at the time the borings were drilled. The possibility of groundwater level fluctuations and the presence of perched and artesian water should be considered when designing and developing the construction plans for the project.

4.0 ANALYSIS AND RECOMMENDATIONS

4.1 Geotechnical Design Parameters

Soil parameters were estimated based on the results of our field exploration, visual classification of soils, laboratory test results (soil classification and index parameters), literature review, and our experience with similar materials and projects with similar scope.

4.1.1 Soil Shear Strength Parameters

The following design shear strength parameters were used to perform the stability analyses summarized in Section **4.2 Retaining Wall Stability Analysis**. Effective strength parameters (friction angle and cohesion) are based on drained conditions to account for the long-term stability and total stress parameters are based on undrained cohesion to account for short-term stability.

Material Type	Total Unit Weight (pcf)	Effective Stress (Drained) Shear Strength Parameters		Total Stress (Undrained) Shear Strength Parameters	
		c′, psf	ϕ′, degrees	c, psf	ϕ, degrees
Retained Zone[1] (New Fill – Cohesionless Soil)	120	0	30	0	30
Retained Zone[1] (Existing Lean to Fat Clay with Sand)	120	0	30	Varies from 200 to 1500	0
Foundation Zone	140	0	35	0	35
Cast-In- Place (CIP) Wall[2]	150	4,000	30	4,000	30

1. The soil parameters provided are based on average values for the lean clay and silty-clayey sand encountered in the borings.

2. c = 4,000 psf used for global stability analyses of the CIP walls to prevent the failure surface from extending through the wall.

4.2 Retaining Wall Stability Analyses

Our analyses of the Cast-In-Place (CIP) walls considered the following:

- Slide program was used to analyze the global stability of the walls
- The height of Walls A and B are 7 ft and 8 ft from the bottom of footings, respectively, per final elevation views provided by client

- 2 ft of compacted crushed stone aggregate base material was placed beneath Wall B to improve the overall capacity. Structural fill per geotechnical engineering report needs to be used.
- Backfill soil is compacted granular material with a minimum friction angle of 30 degree and a unit weight of 120 pcf
- No hydrostatic pressure is considered behind the wall. It is assumed that the fill materials are granular, and enough drainage is provided behind/through the wall
- 75 psf of pedestrian surcharge load (per ASSHTO LRFD Bridge Design Specification) is considered on the active side on Wall A
- 240 psf of live load surcharge load (per ASSHTO LRFD Bridge Design Specification) is considered on the active side in Wall B
- Friction ratio between clay and footing is equal to 0.35
- Friction ratio between crushed stone aggregate base and footing is equal to 0.55
- Ground surface behind and in front of the walls are not sloped
- The ultimate bearing capacities of soil used in the analysis of Wall A was previously submitted on May 6, 2021
- The ultimate bearing capacity on top of at least 2 ft of aggregate beneath Wall B footing is 4800 psf
- The bottom of footings are 2 ft below the ground surface on the toe side
- The analysis does not include structural analysis of reinforced concrete
- No seismic analysis was performed in the analysis

4.2.1 Global Stability Analysis of Retaining Walls

The AASHTO LRFD Bridge Design Specifications recommends that global (overall) stability of the retaining wall, retained slope, and foundation soil be evaluated using limiting equilibrium methods of analysis, in which a single Factor of Safety (FOS) is generated by slope stability software.

The computer program SLIDE was used to evaluate global stability of the CIP retaining walls. The graphical outputs of the global stability analyses are included in Appendix C. A summary of the results of our global stability analyses for the cross-sections analyzed is given in Section **4.2.2 Summary of Retaining Wall Stability Analyses**.

4.2.2 Summary of Retaining Wall Stability Analyses

Lean to fat clay with varying amounts of sand was encountered in borings drilled for the CIP retaining walls at depths varying from 13.5 to 35 feet. Groundwater and soft soils were encountered in borings WB-1 and WB-2 at depths of 13.5 to 15 feet. To reduce the loading impact to these soils from Retaining Wall B, we recommend construction of a geogrid reinforced 2-foot thick layer of crushed stone aggregate base. We recommend that a layer of geogrid be placed at the bottom of the crushed stone aggregate base and one foot above the bottom of the aggregate base. Footing foundations bearing on stiff lean clay or compacted crushed aggregate base meeting ODOT Type A can be designed using the parameters listed in the following table:

DESCRIPTION	Continuous footings bearing on Soil/Bedrock
Bearing Material	Retaining Wall A: Lean to fat clay with varying amounts of sand Retaining Wall B: Crushed aggregate base (ODOT Type A)
Nominal Bearing Resistance[1]	Retaining Wall A: 5,100 psf Retaining Wall B: 4,800 psf
Resistance Factor for Bearing, φ_b[2]	0.55
Coefficient of Friction Value, (tan δ)[3]	Retaining Wall A: 0.35 Retaining Wall B: 0.55
Resistance Factor for Sliding Resistance, φ_t[2]	Retaining Wall A: 1.0 Retaining Wall B: 1.0
Minimum Width[4]	Retaining Wall A: 4.25 ft Retaining Wall B: 7.25 ft
Minimum Embedment Depth Below Finished Grade[4]	Retaining Wall A: 2.0 ft Retaining Wall B: 2.0 ft

1. AASHTO LRFD Bridge Design Specifications, 7th Edition, 2014
2. Table 10.5.5.2.2-1 AASHTO LRFD Bridge Design Specifications, 7th Edition, 2014
3. Lateral loads can be resisted by frictional resistance between the base of the footing and the underlying bearing materials. The nominal sliding resistance between the base of the footing and the underlying bearing materials can be calculated using the coefficient of friction value. Lateral loads are also resisted by the passive pressure acting on the vertical face of the footings.

Retaining wall	Soil Boring Utilized	WL (feet)	[1]E_m (feet)	H_D (feet)	B (feet)	D_K (feet)	FOS_{GS}
Wall A	WA-5	None	1	6	4.25	1.5	3.28
Wall B	WB-2	None	1	7	7.25		2.27

Table notes:
WL = Water Level elevation
E_m = Approximate embedment depth (the soil thickness above the top of foundation slab was not considered in our analyses)
H_D = Design height (total wall height = Face of the wall plus embedment depth)
B = Footing Width
D_K = Shear Key Depth
CDR = Capacity Demand Ratio in accordance to AASHTO LRFD 2014
DS = Direct Sliding
BC = Bearing Capacity
e_{ecc} = Eccentricity
FOS = Factor of Safety for global stability based on Allowable Stress Design (ASD) methodology, in accordance with AASHTO LRFD 2014
GS = Global Stability

4.3 Settlement of Retaining Walls

The wall settlement will depend upon the variations within the subsurface soil profile, the structural loading conditions and the quality of the earthwork operations. Because of the variations associated with these parameters, Terracon cannot accurately estimate settlements under all design scenarios. Assuming the retaining walls are founded on competent, well compacted, subgrade or geogrid-reinforced and properly constructed crushed stone aggregate base material, it is our opinion that the maximum total settlements will be on the order of less than 1 inch along the CIP retaining walls. The maximum differential settlements are not expected to exceed the total settlement for the CIP walls. However, these values should be evaluated by the wall designer to confirm that the wall can tolerate this magnitude of total and differential settlement. The estimated total maximum settlements are presented in the following table:

Retaining wall	**Total Settlement Estimates** (inches)
A	<1.0
B	<1.0

4.4 Wall Drainage Recommendations

Care should be taken in the design and during construction to develop and maintain rapid, positive drainage away from the retaining wall areas. Water should not be allowed to pond adjacent to either

the upslope or downslope sides of the retaining walls. We recommend that drainage swales with sufficient gradients be constructed along both the upslope and toe sides of the wall to direct surface water away from the walls. Proper surface drainage is needed to prevent water from flowing over the face of the walls and saturating either the fill behind the wall or the subgrade soils at the base of the walls.

If Oklahoma Department of Transportation (ODOT) Granular Backfill material is used to construct the new fill in the retained zone, we recommend that a backslope drain, comprised of a geocomposite drainage blanket, be attached to the face of the cut backslope and extend down to a collector drain pipe placed along the bottom of the reinforced zone at the base of the cut slope. The collector drain should consist of a perforated PVC pipe that is placed in free-draining aggregate such as No. 57 stone, with the stone wrapped in a geotextile filter fabric. The collector drain should be sloped to drain out beyond one or both ends of the retaining wall. The geocomposite drainage blanket should be cut off at a depth of 2 feet below the finished ground surface at the back of the retained zone to allow a minimum cover of 2 feet of compacted clayey soil over the drain to prevent the infiltration of surface water into the backslope drain.

Alternatively, select drainable aggregate fill material consisting of crushed No. 57 stone could be imported to construct the entire retained zone. If the crushed No. 57 stone is used to construct the retained zone, we recommend that a geotextile filter fabric, such as Mirafi 140N be placed between the face of the existing embankment slope and the retained zone to prevent the migration of fines from the native soils into the free-draining No. 57 stone.

4.5 Construction Considerations

The construction specifications should provide the backfill material description and design strength parameters that are required for the different fill zones so that unsuitable materials are not placed.

Areas within the limits of construction should be stripped and cleared of topsoil, vegetation, and any other deleterious material.

The design for Wall A was based upon constructing the wall foundation on compacted native stiff clay and incorporating a shear key to meet sliding resistance. The design for Wall B was based upon constructing the wall foundation on 2 feet of reinforced ODOT type A aggregate base to meet sliding resistance and improve bearing capacity. The aggregate base should be reinforced with a layer of ODOT Type II geogrid placed at the bottom of the 2 feet layer and another layer at the midpoint of the 2-foot layer.

All excavations should meet all OSHA and other applicable safety regulations. Site grading should develop positive drainage away from open excavations.

After stripping and completing any cuts, the subgrade should be proofrolled with equipment equivalent to a loaded, tandem-axle dump truck weighing at least 25 tons to locate any additional soft or unstable zones. The proof rolling should be conducted in overlapping passes in corresponding perpendicular directions (as space allows). Where the proof rolling operations detect rutting or pumping in the subgrade, the unstable soils should be undercut and replaced with an approved engineered fill as described in the following section if it cannot be effectively compacted in-place. It is likely that soft spots will be encountered since the near surface soils had elevated moisture at the time of our field investigation. We recommend maintaining good drainage during construction to promote ideal equipment mobility and optimum earthwork compaction. Proof rolling will be more difficult to achieve if water is allowed to drain into or stand within the confines of the exposed embankment area. If proof rolling is not feasible, the subgrade should be tested by T-probe or dynamic cone penetrometer, DCP, to locate and correct any soft areas in the subgrade prior to placement of any fill. Terracon should observe and test the footing excavations to verify that the recommended bearing materials are encountered.

Terracon should observe and test the footing excavations to verify that the recommended bearing materials are encountered. If loose sand or other unsuitable materials are encountered at the footing bearing elevation the unsuitable materials should be overexcavated sufficiently until suitable material is encountered. Overexcavations beneath footings should extend laterally at least 8 inches for each 12 inches of depth below the bearing level.

Footing excavations should be free of all loose materials, debris, rock fragments and water at the time concrete is placed. Sloping or temporary shoring of the sides of excavation may be required to prevent caving of the sandy materials. Concrete should be placed as soon as possible after excavations are completed to reduce the potential for wetting, drying, and disturbance of the bearing surface.

4.6 Engineered Fill Material Requirements

All fill required to develop the design subgrade elevation should be an approved material that is free of organic matter and debris as outlined in the following table.

Fill Type[1]	Acceptable Location for Placement
Crushed Aggregate Base – ODOT Type A	All Building Locations

1. Prior to any filling operations, samples of the proposed borrow and on-site materials should be obtained for laboratory Atterberg Limits and moisture-density testing. The tests will provide a basis for material acceptance and evaluation of fill compaction by in-place density testing. A qualified soil technician should perform sufficient in-place density tests during the filling operations to evaluate that proper levels of compaction, including dry unit weight and moisture content, are being attained. Controlled, compacted fill should consist of approved materials free of organic matter and debris and contain a maximum rock size of 2 inches. The proposed fill materials should be approved by the geotechnical engineer prior to placement.

2. We recommend placement of a layer of geogrid meeting ODOT Type I beneath the aggregate base.

Engineered fill should be placed and compacted in horizontal lifts, using equipment and procedures that will produce recommended moisture contents and densities throughout the lift.

4.7 Seismic Considerations

Description	Value
2009 International Building Code Site Classification (IBC)	**C - Wall A** **D - Wall B**

Note: In general accordance with the *2009 International Building Code,* Table 1613.5.2. The 2009 International Building Code (IBC) uses a site soil profile determination extending to a depth of 100 feet for seismic site classification. The current scope does not include the 100 foot soil profile determination. Borings extended to a maximum depth of 35 feet. This seismic site class definition considers that weathered shale continues below the maximum depth of the subsurface exploration. Additional exploration to deeper depths would be necessary to confirm the conditions below the current depth of exploration.

5.0 GENERAL COMMENTS

Terracon Consultants, Inc. 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 Consultants, Inc. also should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

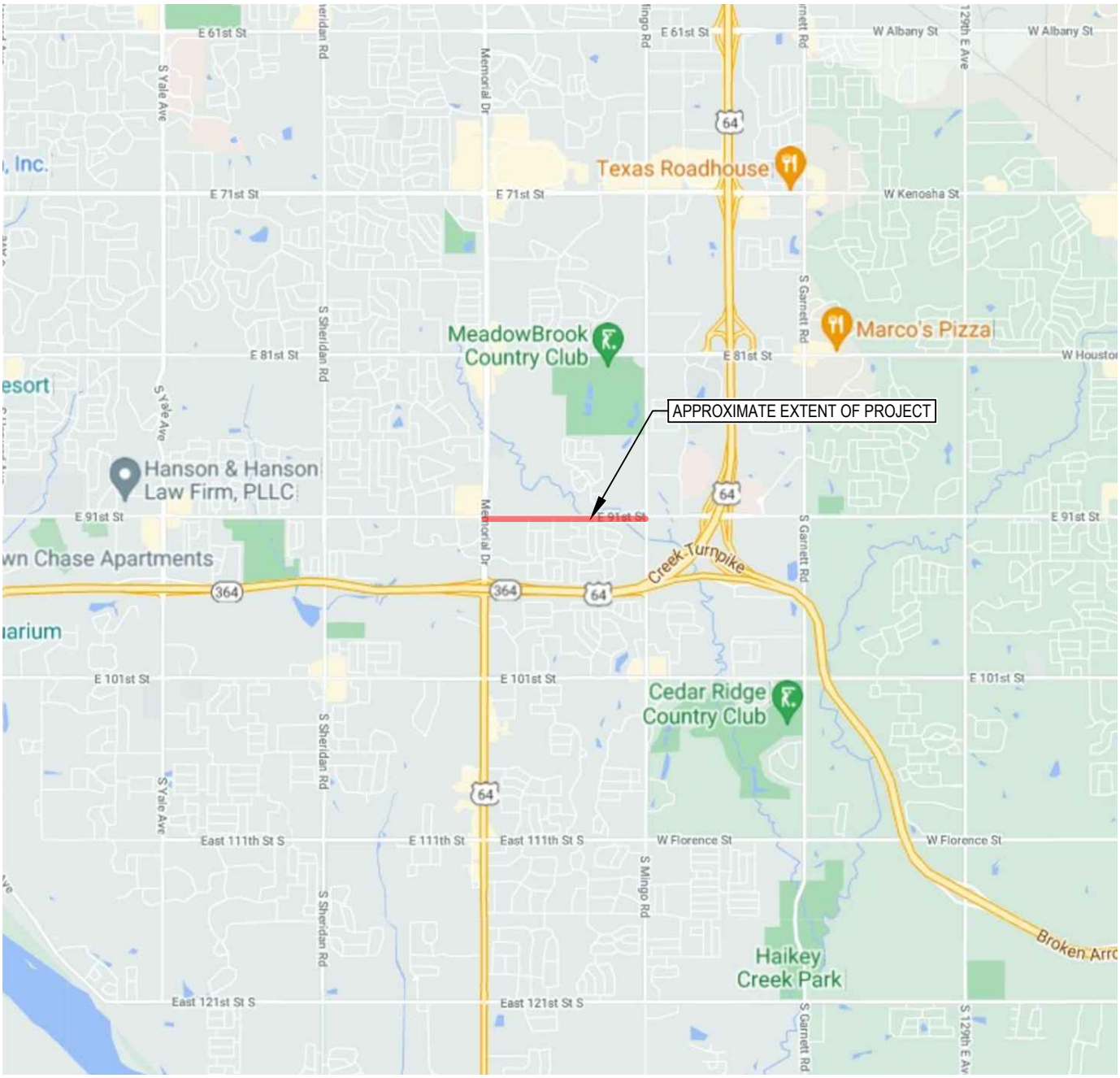
The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of 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 of this project does not include either specifically or by implication any environmental assessment of the site or identification of contaminated or hazardous materials or conditions. If the owner is concerned about the potential of such contamination, 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 expressed or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that any 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 Consultants, Inc. reviews the changes, and either verifies or modifies the conclusions of this report in writing.

APPENDIX A
FIELD EXPLORATION



5000 0 5000

APPROXIMATE SCALE IN FEET

N

Project Mngr: JLD	Project No. 04195149	Terracon Consulting Engineers and Scientists	SITE LOCATION MAP
Drawn By: MM	Scale: SEE BAR SCALE	9522 EAST 47TH PLACE, UNIT D TULSA, OKLAHOMA 74145	GEOTECHNICAL EXPLORATION
Checked By: JLD	File No. 04195149	PH. (918) 250-0461 FAX. (918) 250-4570	91ST STREET WIDENING - RETAINING WALLS
Approved By: MHH	Date: JUNE 2021		EAST 91ST STREET FROM SOUTH MEMORIAL DRIVE TO SOUTH MINGO ROAD
			TULSA, TULSA COUNTY, OKLAHOMA

EXHIBIT NO. A-1

N

120 0 120

APPROXIMATE SCALE IN FEET

LEGEND

BORING LOCATION

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

Project Mngr:	JLD
Drawn By:	MM
Checked By:	JLD
Approved By:	MHH

Project No.	04195149
Scale:	SEE BAR SCALE
File No.	04195149
Date:	JUNE 2021

Terracon
Consulting Engineers and Scientists
9522 EAST 47TH PLACE, UNIT D TULSA, OKLAHOMA 74145
PH. (918) 250-0461 FAX. (918) 250-4570

BORING LOCATION PLAN

GEOTECHNICAL EXPLORATION
91ST STREET WIDENING - RETAINING WALLS
EAST 91ST STREET FROM SOUTH MEMORIAL DRIVE TO SOUTH MINGO ROAD
TULSA, TULSA COUNTY, OKLAHOMA

EXHIBIT NO.

A-2

Field Exploration Description

Terracon personnel located the borings in the field by use of a hand held GPS device using the plans provided by the Client. The boring locations were offset from the original coordinates to be drilled through the pavement along 91st Street due to site access issues. The locations of the borings should be considered accurate only to the degree implied by the methods used to define them. The stations, offsets, and elevations for each boring were provided by Garver based upon the boring coordinates. These coordinates were correlated to the stationing and elevation data developed by the project surveyor.

Based on this survey data, the ground surface elevations at the boring locations ranged from 690.8 to 698.6 feet for Wall A and from 675.3 to 675.5 feet for Wall B. The boring locations and elevations should be considered accurate only to the degree implied by the methods used to define them.

The borings were advanced with an all-terrain mounted rotary drill rig. The borings were advanced using wash boring techniques. Representative soil samples were obtained using the split-barrel sampling procedure and thin walled tube samples.

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 a typical 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 cohesionless soils and, to a lesser degree of accuracy, the consistency of cohesive soils and the hardness of sedimentary bedrock. In the thin-walled tube sampling procedure, a seamless steel tube with a sharpened cutting end is hydraulically pushed into the bottom of the boring to obtain a relatively undisturbed cohesive soil sample. The sampling depths, penetration distances, and the 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 drive hammer was used to advance the split-barrel. A greater efficiency is achieved with the automatic drive hammer compared to the conventional safety drive hammer operated with a cathead and rope.

The drilling operation was supervised by engineer who prepared field logs. The boring logs include visual classifications of the materials encountered during drilling and the engineer's interpretation of subsurface conditions between samples. Based on the material's texture, the soil samples were described according to the attached General Notes and classified in accordance with the Unified Soil Classification System. A brief description of the Unified System

is included in the appendix. Rock descriptions are in general accordance with the General Notes for Sedimentary Rock. Petrographic analysis of the rock cores may reveal other rock types.

As required by the Oklahoma Water Resources Board, any borings deeper than 20 feet, or borings which encounter groundwater or contaminated materials must be grouted or plugged in accordance with Oklahoma State statutes. One boring log must also be submitted to the Oklahoma Water Resources Board for each 10 acres of project site area. Terracon grouted the borings and submitted a log in order to comply with the Oklahoma Water Resources Board requirements.

BORING LOG NO. WA-1

PROJECT: E. 91st Street S. Retaining Walls

CLIENT: Garver, LLC
Tulsa, Oklahoma

SITE: E. 91st Street S.: Memorial Drive to Mingo Road
Tulsa, Oklahoma

LOCATION See Exhibit A-2

Latitude: 36.0319° Longitude: -95.8811°

Station: 15+54.09 Offset: 4.41 Rt.

Approximate Surface Elev.: 695.19 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.5	694.5+/-	**Approx. 5.5" of Asphalt**						
0.8	694.5+/-	**Approx. 4" of Aggregate Base**						
2.5	692.5+/-	**SANDY LEAN CLAY (CL)**, gray and brown, medium stiff		16	8-4-4 N=8	22.1	32-16-16	56
		FAT CLAY (CH), olive, brown, and gray, stiff		15	2-4-7 N=11	18.7	52-17-35	88
			5	17	2-5-6 N=11	22.6		
8.5	686.5+/-							
		LEAN CLAY (CL), olive, brown, and gray, very stiff	10	16	7-11-13 N=24	16.8	48-23-25	98
13.5	681.5+/-							
		HIGHLY WEATHERED SHALE+, olive, brown, and gray, soft	15	11	26-50/5"	12.4	46-22-24	99
18.5	676.5+/-							
18.9	676.5+/-	**WEATHERED SHALE+**, gray, soft		5	50/5"			
		Boring Terminated at 18.9 Feet						

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.
Surface capped with asphalt.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
9522 E 47th Pl, Ste D
Tulsa, OK

Boring Started: 04-07-2021 Boring Completed: 04-07-2021

Drill Rig: 988 Driller: WD

Project No.: 04195149 Exhibit: A-4

BORING LOG NO. WA-1A

PROJECT: E. 91st Street S. Retaining Walls

CLIENT: Garver, LLC
Tulsa, Oklahoma

SITE: E. 91st Street S.: Memorial Drive to Mingo Road
Tulsa, Oklahoma

LOCATION See Exhibit A-2

Latitude: 36.0319° Longitude: -95.8811°

Station: 15+54.09 Offset: 4.41 Rt.

Approximate Surface Elev.: 695.19 (Ft.) +/-

DEPTH		ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.5	**Approx. 5.5" of Asphalt**	694.5+/-										
0.8	**Approx 4" of Aggregate Base**	694.5+/-										
2.5	**SANDY LEAN CLAY (CL)**, gray and brown	692.5+/-										
4.0	**FAT CLAY (CH)**, olive, brown, and gray	691+/-				14		4080	22.0	105		
	Boring Terminated at 4 Feet							28				

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.
Surface capped with asphalt.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
9522 E 47th Pl, Ste D
Tulsa, OK

Boring Started: 04-07-2021 Boring Completed: 04-07-2021

Drill Rig: 988 Driller: WD

Project No.: 04195149 Exhibit: A-5

BORING LOG NO. WA-2

PROJECT: E. 91st Street S. Retaining Walls

CLIENT: Garver, LLC
Tulsa, Oklahoma

SITE: E. 91st Street S.: Memorial Drive to Mingo Road
Tulsa, Oklahoma

LOCATION See Exhibit A-2

Latitude: 36.0319° Longitude: -95.8807°

Station: 16+67.96 Offset: 2.37 Lt.

Approximate Surface Elev.: 698.53 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description
0.7	698+/-	**Approx. 8" of Asphalt**
1.0	697.5+/-	**Approx 4" of Aggregate Base**
2.5	696+/-	**LEAN CLAY (CL)**, with sand, gray and brown, medium stiff
		FAT CLAY (CH), yellow, brown, and gray, stiff
8.5	690+/-	
		FAT CLAY (CH), olive, brown, yellowish brown, and gray, very stiff
13.5	685+/-	
		HIGHLY WEATHERED SHALE+, olive, brown, and gray, soft
18.5	680+/-	
19.3	679+/-	**WEATHERED SHALE+**, olive, brown, and gray, moderately hard
		Boring Terminated at 19.3 Feet

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		X	14	4-3-3 N=6		23.1		33-15-18	82
		X	16	2-4-7 N=11		18.0		56-17-39	87
5		X	15	3-4-6 N=10		17.9			
		X	16	5-9-13 N=22		19.7		51-25-26	98
10									
		X	18	17-32-50/6"		14.1			
15									
		X	9	38-50/4"					

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.
Surface capped with asphalt.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
9522 E 47th Pl, Ste D
Tulsa, OK

Boring Started: 04-07-2021 Boring Completed: 04-07-2021

Drill Rig: 988 Driller: WD

Project No.: 04195149 Exhibit: A-6

BORING LOG NO. WA-3

PROJECT: E. 91st Street S. Retaining Walls

CLIENT: Garver, LLC
Tulsa, Oklahoma

SITE: E. 91st Street S.: Memorial Drive to Mingo Road
Tulsa, Oklahoma

LOCATION See Exhibit A-2

Latitude: 36.0319° Longitude: -95.8807°

Station: 18+08.40 Offset: 1.76 Lt.

Approximate Surface Elev.: 698.60 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DESCRIPTION
0	698.6+/-	**SANDY LEAN CLAY (CL)**, gray and brown, medium stiff
2.5	696+/-	**FAT CLAY (CH)**, olive, brown, yellowish brown, and gray, stiff
8.5	690+/-	- hard below 8.5 feet
13.5	685+/-	**HIGHLY WEATHERED SHALE+**, olive, brown, gray, and yellowish brown, soft
18.5	680+/-	
19.0	679.5+/-	**WEATHERED SHALE+**, olive, brown, and gray, soft
		Boring Terminated at 19 Feet

DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0						
		10	9-3-3 N=6	20.9	45-18-27	64
		15	2-4-6 N=10	19.1	54-19-35	87
5		18	2-3-7 N=10	20.7		
		18	7-12-23 N=35	17.1	55-24-31	98
10						
		18	20-35-50/6"	15.0	48-22-26	95
15						
		6	50/6"	12.9		

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.
Surface capped with asphalt.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
9522 E 47th Pl, Ste D
Tulsa, OK

Boring Started: 04-07-2021 Boring Completed: 04-07-2021

Drill Rig: 988 Driller: WD

Project No.: 04195149 Exhibit: A-7

BORING LOG NO. WA-3A

PROJECT: E. 91st Street S. Retaining Walls

CLIENT: Garver, LLC
Tulsa, Oklahoma

SITE: E. 91st Street S.: Memorial Drive to Mingo Road
Tulsa, Oklahoma

LOCATION See Exhibit A-2

Latitude: 36.0319° Longitude: -95.8802°

Station: 18+08.40 Offset: 1.76 Lt.

Approximate Surface Elev.: 698.60 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SANDY LEAN CLAY (CL), gray and brown										
2.5	696+/-										
	FAT CLAY (CH), olive, brown, yellowish brown and gray				16						
4.0	694.5+/-										
	Boring Terminated at 4 Feet										

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.
Surface capped with asphalt.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
9522 E 47th Pl, Ste D
Tulsa, OK

Boring Started: 04-07-2021 Boring Completed: 04-07-2021

Drill Rig: 988 Driller: WD

Project No.: 04195149 Exhibit: A-8

BORING LOG NO. WA-4

PROJECT: E. 91st Street S. Retaining Walls

CLIENT: Garver, LLC
Tulsa, Oklahoma

SITE: E. 91st Street S.: Memorial Drive to Mingo Road
Tulsa, Oklahoma

LOCATION See Exhibit A-2

Latitude: 36.0319° Longitude: -95.8797°

Station: 19+79.00 Offset: 1.90 Rt.

Approximate Surface Elev.: 693.58 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.5	693+/-	**Approx. 6" of Asphalt**							
0.8	693+/-	**Approx. 4" of Aggregate Base**							
2.5	691+/-	**SANDY LEAN CLAY (CL)**, gray and brown, medium stiff			11	8-3-3 N=6	7.1	28-16-12	67
		FAT CLAY (CH), with sand, dark gray and brown, stiff			16	2-4-5 N=9	19.6	51-16-35	83
5.0	688.5+/-		5						
		LEAN CLAY (CL), dark gray and brown, stiff			13	2-3-6 N=9	18.6	47-17-30	87
8.5	685+/-								
		LEAN CLAY (CL), olive, brown, yellowish brown, and gray, hard	10		16	13-24-34 N=58	15.3	49-23-26	98
13.5	680+/-								
		HIGHLY WEATHERED SHALE+, olive, brown, gray, and yellowish brown, soft	15		12	25-50/6"	13.4		
18.5	675+/-								
19.0	674.5+/-	**WEATHERED SHALE+**, olive, brown, and gray, soft			4	50/6"	10.4		
		Boring Terminated at 19 Feet							

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.
Surface capped with asphalt.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
9522 E 47th Pl, Ste D
Tulsa, OK

Boring Started: 04-07-2021 Boring Completed: 04-07-2021

Drill Rig: 988 Driller: WD

Project No.: 04195149 Exhibit: A-9

BORING LOG NO. WA-5

PROJECT: E. 91st Street S. Retaining Walls

CLIENT: Garver, LLC
Tulsa, Oklahoma

SITE: E. 91st Street S.: Memorial Drive to Mingo Road
Tulsa, Oklahoma

LOCATION See Exhibit A-2

Latitude: 36.0319° Longitude: -95.8792°

Station: 20+98.13 Offset: 6.78 Rt.

Approximate Surface Elev.: 690.78 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.5	690.5+/-	**Approx. 6" of Asphalt**							
0.8	690+/-	**Approx. 4" of Aggregate Base**							
		LEAN CLAY (CL), with sand, gray and brown, medium stiff			15	9-4-4 N=8	16.3	28-18-10	77
		- soft below 2.5 feet			18	1-1-3 N=4	22.2		
5.0	686+/-		5						
		LEAN CLAY (CL), with sand, yellowish brown and gray, stiff			18	3-5-6 N=11	19.5	48-17-31	83
8.5	682.5+/-								
		FAT CLAY (CH), olive, brown, yellowish brown, and gray, very stiff	10		18	4-6-11 N=17	22.0	56-23-33	94
13.5	677.5+/-								
		HIGHLY WEATHERED SHALE+, olive, brown, and gray, soft	15		17	22-39-50/5"	14.0		
18.5	672.5+/-								
18.7	672+/-	**WEATHERED SHALE+**, gray, hard				50/2"	6.5		
		Boring Terminated at 18.7 Feet							

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.
Surface capped with asphalt.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
9522 E 47th Pl, Ste D
Tulsa, OK

Boring Started: 04-08-2021 Boring Completed: 04-08-2021

Drill Rig: 988 Driller: WD

Project No.: 04195149 Exhibit: A-10

BORING LOG NO. WA-5A

PROJECT: E. 91st Street S. Retaining Walls

CLIENT: Garver, LLC
Tulsa, Oklahoma

SITE: E. 91st Street S.: Memorial Drive to Mingo Road
Tulsa, Oklahoma

LOCATION See Exhibit A-2

Latitude: 36.0319° Longitude: -95.8792°

Station: 20+98.13 Offset: 6.78 Rt.

Approximate Surface Elev.: 690.78 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.5 **Approx. 6" of Asphalt**	690.5+/-										
0.8 **Approx. 4" of Aggregate Base**	690+/-										
SANDY LEAN CLAY (CL), gray and brown											
				■	20		3680	20.7	106		
4.0	687+/-										
Boring Terminated at 4 Feet							26	20.7	106		

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.
Surface capped with asphalt.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
9522 E 47th Pl, Ste D
Tulsa, OK

Boring Started: 04-08-2021 Boring Completed: 04-08-2021

Drill Rig: 988 Driller: WD

Project No.: 04195149 Exhibit: A-11

BORING LOG NO. WB-1

PROJECT: E. 91st Street S. Retaining Walls

CLIENT: Garver, LLC
Tulsa, Oklahoma

SITE: E. 91st Street S.: Memorial Drive to Mingo Road
Tulsa, Oklahoma

LOCATION See Exhibit A-2

Latitude: 36.0319° Longitude: -95.8765°

Station: 29+03.53 Offset: 14.62 Rt.

Approximate Surface Elev.: 675.45 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description
0.6	675+/-	**Approx. 7" of Asphalt**
0.9	674.5+/-	**Approx. 4" of Aggregate Base**
		SILTY SAND (SM), brown, loose
5.0	670.5+/-	
		LEAN CLAY (CL), yellowish brown and gray, stiff
		- medium stiff below 8.5 feet
13.5	662+/-	
		LEAN CLAY (CL), brown and yellowish brown, very soft
		- medium stiff below 18.5 feet
		- soft below 23.5 feet
		- with gray, soft below 28.5 feet
30.0	645.5+/-	
		Boring Terminated at 30 Feet

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
			10	11-5-3 N=8		6.6		NP	23
			9	3-4-4 N=8		3.3			
5			16	2-5-7 N=12		16.6		38-16-22	88
			18	3-3-4 N=7		20.5		35-17-18	90
10									
	▽								
	▽		18	0-0-0 N=0		26.3		28-19-9	89
15									
			18	3-3-4 N=7		24.0			
20									
			18	2-2-2 N=4		20.9			
25									
			18	0-2-2 N=4		23.6		36-16-20	97
30									

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth. Surface capped with asphalt.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

▽ *13.5' While drilling*

▽ *15' At completion of drilling*

Terracon
9522 E 47th Pl, Ste D
Tulsa, OK

Boring Started: 04-08-2021 Boring Completed: 04-08-2021

Drill Rig: 988 Driller: WD

Project No.: 04195149 Exhibit: A-12

BORING LOG NO. WB-2

PROJECT: E. 91st Street S. Retaining Walls

CLIENT: Garver, LLC
Tulsa, Oklahoma

SITE: E. 91st Street S.: Memorial Drive to Mingo Road
Tulsa, Oklahoma

LOCATION See Exhibit A-2

Latitude: 36.0318° Longitude: -95.8762°

Station: 30+11.68 Offset: 32.55 Rt.

Approximate Surface Elev.: 675.25 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.8 **Approx. 9" of Asphalt**	674.5+/-							
1.1 **Approx 4" of Aggregate Base**	674+/-							
2.5 **LEAN CLAY (CL)**, dark brown, stiff	673+/-							
LEAN CLAY (CL), brown and yellowish brown, medium stiff			SS	16	9-5-4 N=9	20.7	34-20-14	94
			SS	17	2-3-4 N=7	20.4	35-19-16	94
		5	SS	18	1-3-5 N=8	19.0		
8.5	667+/-							
LEAN CLAY (CL), with sand, yellowish brown and brown, medium stiff			SS	18	2-3-3 N=6	18.4	27-17-10	71
		10						
13.5	662+/-							
LEAN CLAY (CL), yellowish brown and brown, very soft			SS	18	0-0-0 N=0	25.5	36-16-20	91
		15						
			SS	18	0-0-0 N=0	26.0		
		20						
23.5	652+/-							
LEAN CLAY (CL), dark gray and yellowish brown, soft			SS	18	0-0-4 N=4	21.5	29-16-13	88
		25						
28.5	647+/-							
LEAN CLAY (CL), gray, stiff			SS	18	3-5-5 N=10	23.2	41-18-23	98
		30						
33.5	642+/-							
LEAN CLAY (CL), with sand, gray, stiff			SS	18	4-6-8 N=14	20.0	40-22-18	74
35.0	640.5+/-	35						
Boring Terminated at 35 Feet								

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth.
Surface capped with asphalt

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

13.5' While drilling

15' At completion of drilling

Terracon
9522 E 47th Pl, Ste D
Tulsa, OK

Boring Started: 04-08-2021 Boring Completed: 04-08-2021

Drill Rig: 988 Driller: WD

Project No.: 04195149 Exhibit: A-13

BORING LOG NO. WB-2A

PROJECT: E. 91st Street S. Retaining Walls

CLIENT: Garver, LLC
Tulsa, Oklahoma

SITE: E. 91st Street S.: Memorial Drive to Mingo Road
Tulsa, Oklahoma

LOCATION See Exhibit A-2

Latitude: 36.0318° Longitude: -95.8762°

Station: 30+11.68 Offset: 32.55 Rt.

Approximate Surface Elev.: 675.25 (Ft.) +/-

DEPTH		ELEVATION (Ft.)
0.8	**Approx. 9" of Asphalt**	674.5+/-
1.1	**Approx. 4" of Aggregate Base**	674+/-
2.5	**LEAN CLAY (CL)**, dark brown	673+/-
	LEAN CLAY (CL), brown and yellowish brown	
4.8		670.5+/-

Boring Terminated at 4.75 Feet

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
			24			21.1			

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.
Surface capped with asphalt.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
9522 E 47th Pl, Ste D
Tulsa, OK

Boring Started: 04-08-2021 Boring Completed: 04-08-2021

Drill Rig: 988 Driller: WD

Project No.: 04195149 Exhibit: A-14

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. Soil samples were classified in accordance with the Unified Soil Classification System (USCS) described in Appendix C. Samples of bedrock were classified in accordance with the general notes for Sedimentary Rock Classification. In the laboratory, the field descriptions were confirmed or modified as necessary and an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials.

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

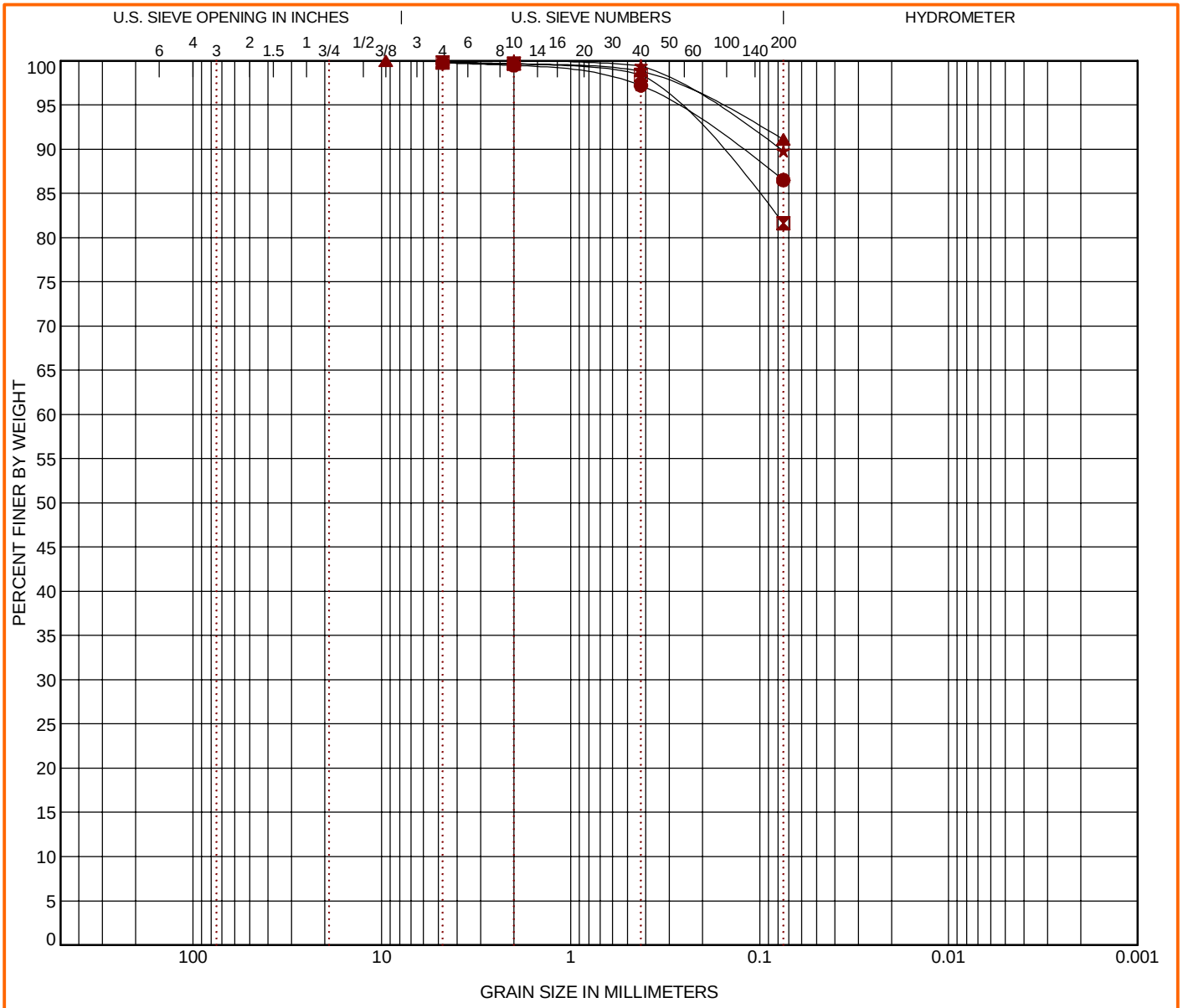
- In-situ Water Content
- Atterberg Limits
- Sieve Analysis
- Unconfined Compression

The laboratory test results are reported on the boring logs in Appendix A. Sieve analysis grain size distribution curves are provided in Appendix B.

Procedural standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	P-1	2 - 3.5	FAT CLAY (CH)	A-7-6 (31)	24.2	51	17	34		
⊠	P-2	2 - 3.5	LEAN CLAY with SAND (CL)	A-4 (6)	19.1	27	18	9		
▲	P-3	3.5 - 5	LEAN CLAY (CL)	A-7-6 (29)	22.5	47	16	31		
★	P-4	2 - 3.5	LEAN CLAY (CL)	A-4 (8)	20.7	30	20	10		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	P-1	2 - 3.5	4.75					13.3		86.5	
⊠	P-2	2 - 3.5	4.75					18.2		81.6	
▲	P-3	3.5 - 5	9.5				0.1	8.8		91.1	
★	P-4	2 - 3.5	2				0.0	10.2		89.8	

PROJECT: E. 91st Street S. Widening

PROJECT NUMBER: 04195149

SITE: E. 91st Street S.: Memorial Drive to Mingo Road
Tulsa, Oklahoma

Terracon
9522 E 47th Pl, Ste D
Tulsa, OK

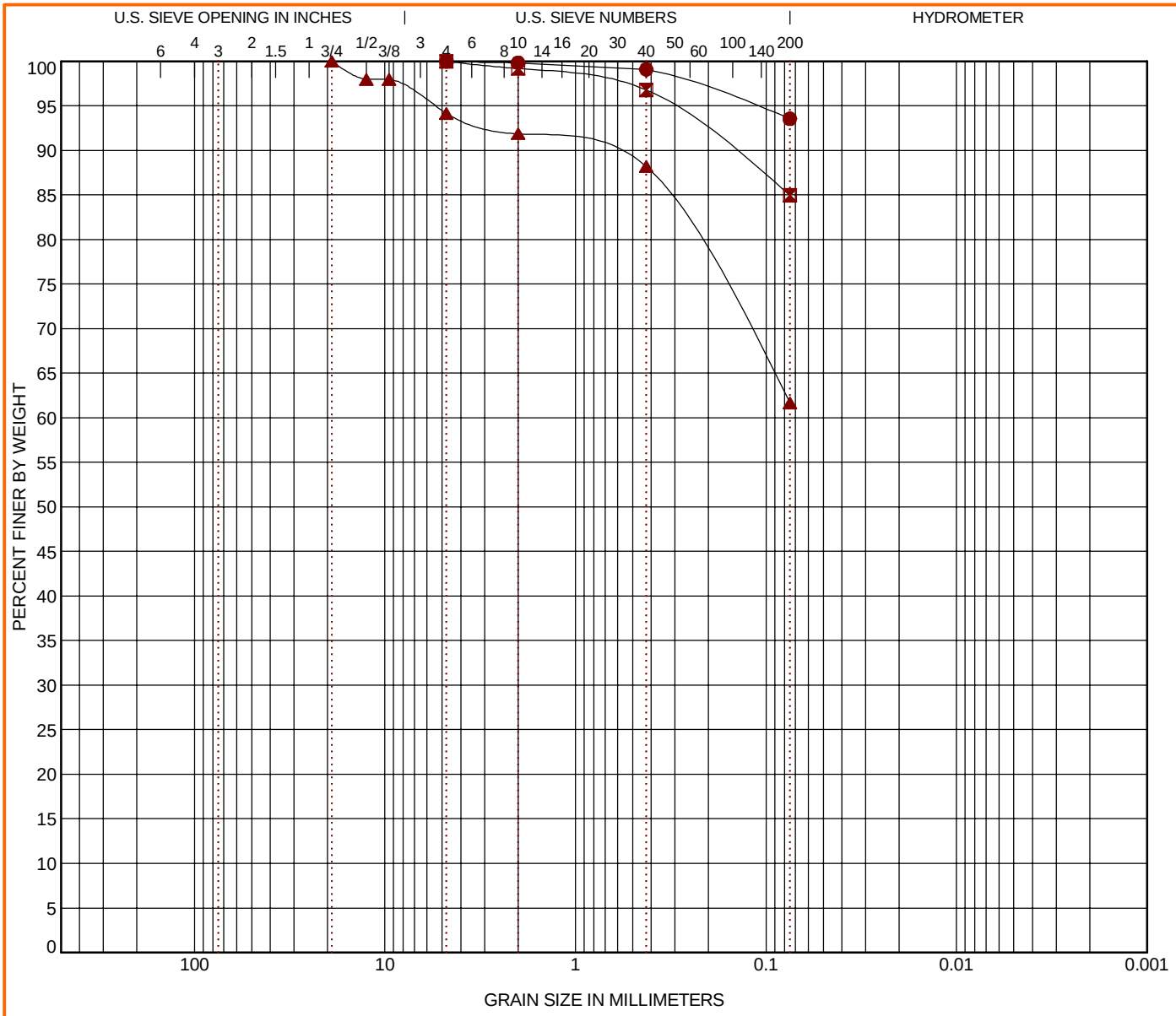
CLIENT: Garver, LLC
Tulsa, Oklahoma

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS & AASHTO DESC COMBINED 04195149 91ST STREET WIDEN.GPJ TERRACON_DATATEMPLATE.GDT 6/2/21

Exhibit B-2

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	P-5	3.5 - 5	LEAN CLAY (CL)	A-7-6 (25)	19.6	41	15	26		
⊠	P-6	2 - 3.5	LEAN CLAY with SAND (CL)	A-6 (8)	15.3	28	17	11		
▲	P-7	2 - 3.5	SANDY LEAN CLAY (CL)	A-6 (4)	15.1	27	16	11		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	P-5	3.5 - 5	4.75				0.0	6.4		93.6	
⊠	P-6	2 - 3.5	4.75				0.0	15.1		84.9	
▲	P-7	2 - 3.5	19				5.8	32.5		61.7	

PROJECT: E. 91st Street S. Widening

PROJECT NUMBER: 04195149

SITE: E. 91st Street S.: Memorial Drive to Mingo Road
Tulsa, Oklahoma

Terracon
9522 E 47th Pl, Ste D
Tulsa, OK

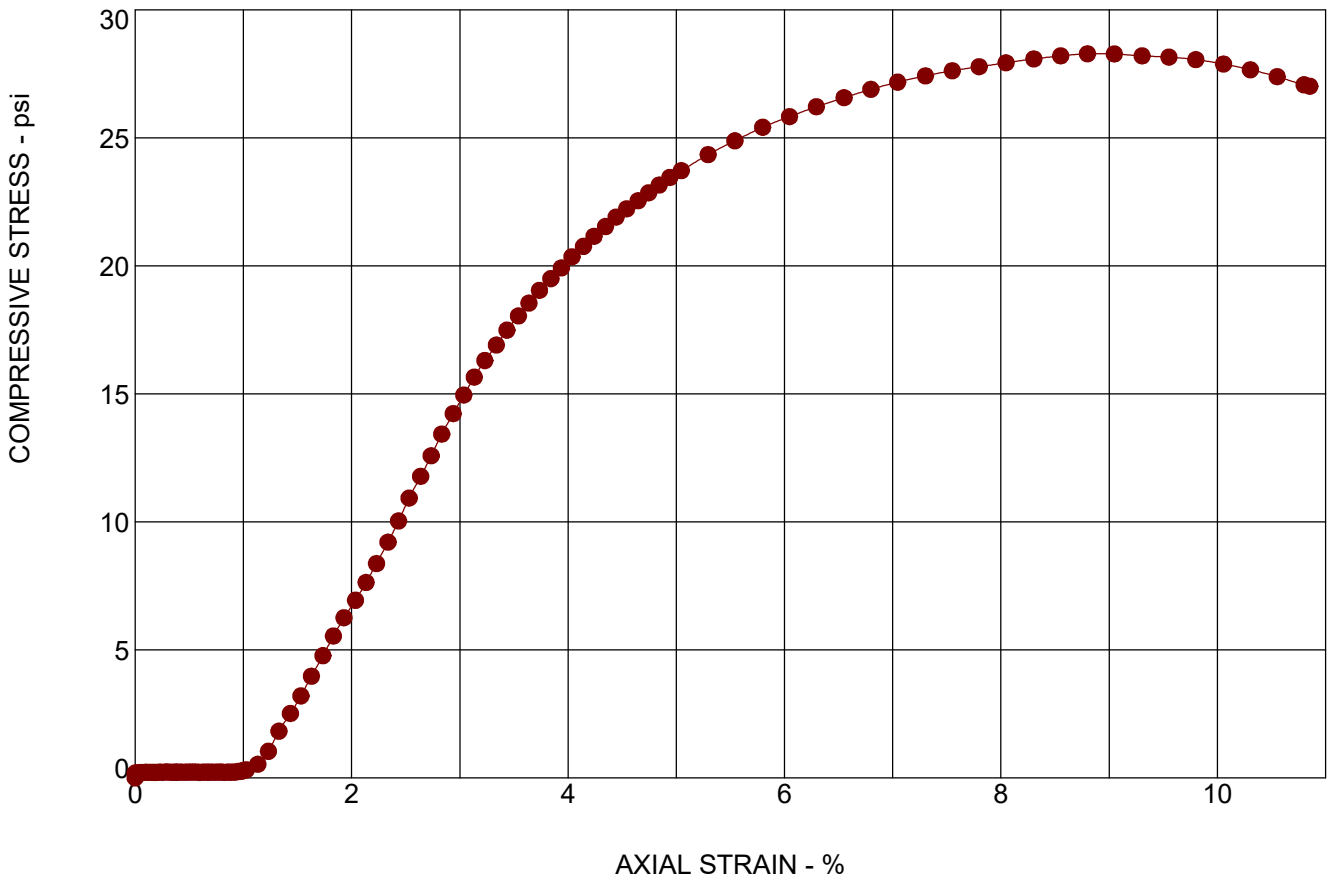
CLIENT: Garver, LLC
Tulsa, Oklahoma

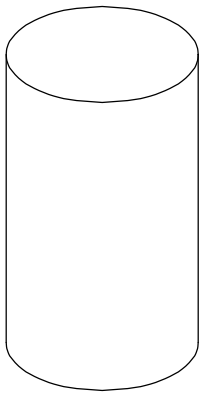
LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS & AASHTO DESC COMBINED 04195149 91ST STREET WIDEN.GPJ TERRACON_DATATEMPLATE.GDT 6/2/21

Exhibit B-3

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE MODE	SPECIMEN TEST DATA		
	Moisture Content:	%	
	Dry Density:	pcf	
	Diameter:	in.	2.85
	Height:	in.	5.55
	Height / Diameter Ratio:		1.95
	Calculated Saturation:	%	
	Calculated Void Ratio:		
	Assumed Specific Gravity:		
	Failure Strain:	%	8.80
	Unconfined Compressive Strength	(psi)	28
	Undrained Shear Strength:	(psi)	14
	Strain Rate:	in/min	0.0555
	Remarks:		

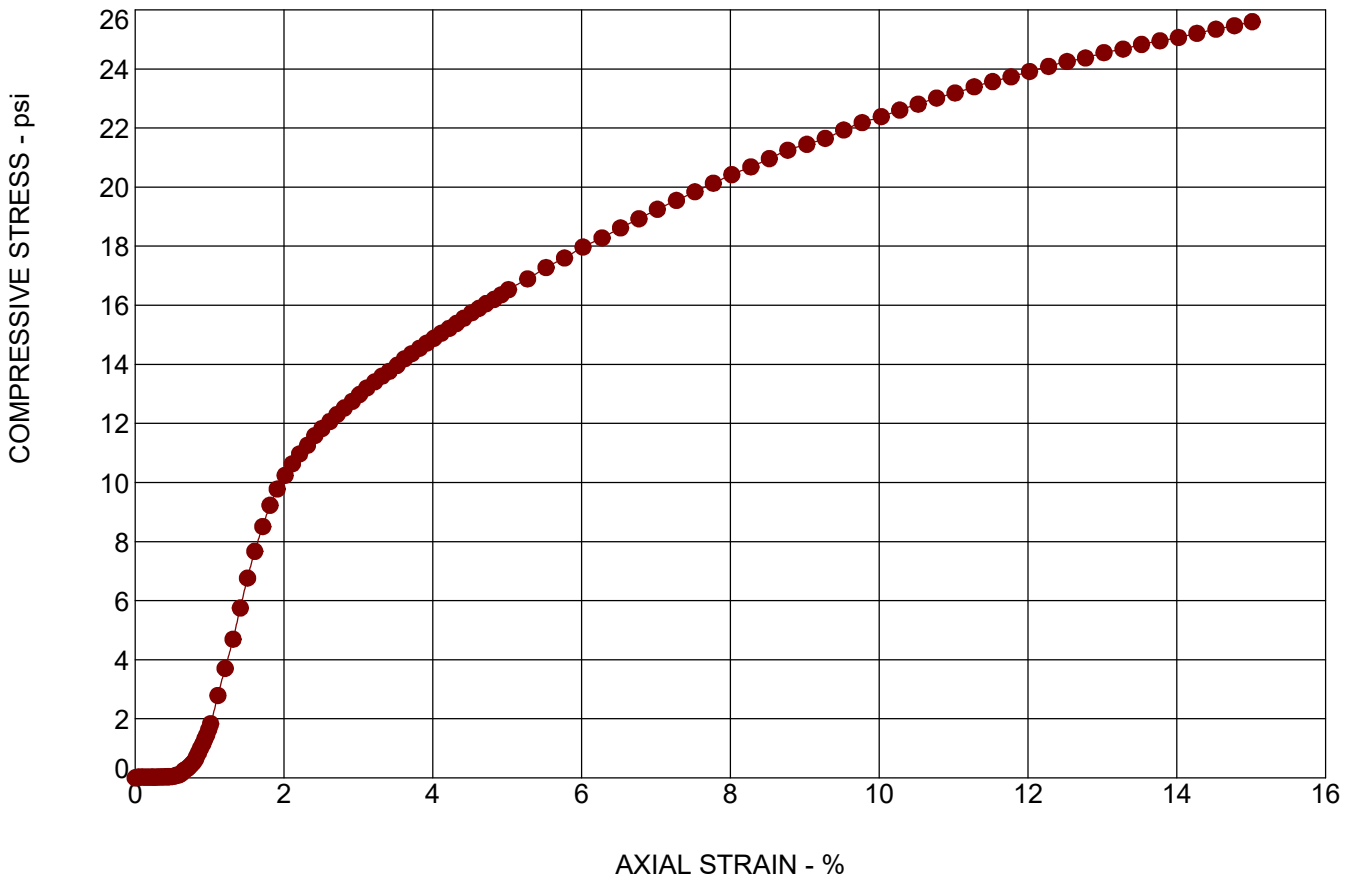
Failure Mode: (dashed)

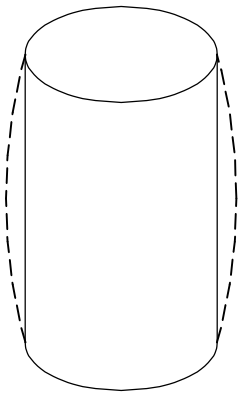
SAMPLE TYPE:	SAMPLE LOCATION: WA-1A @ 4 feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

PROJECT: E. 91st Street S. Retaining Walls	Terracon 9522 E 47th Pl, Ste D Tulsa, OK	PROJECT NUMBER: 04195149
SITE: E. 91st Street S.: Memorial Drive to Mingo Road Tulsa, Oklahoma		CLIENT: Garver, LLC Tulsa, Oklahoma
		EXHIBIT: B-4

UNCONFINED COMPRESSION TEST

ASTM D2166



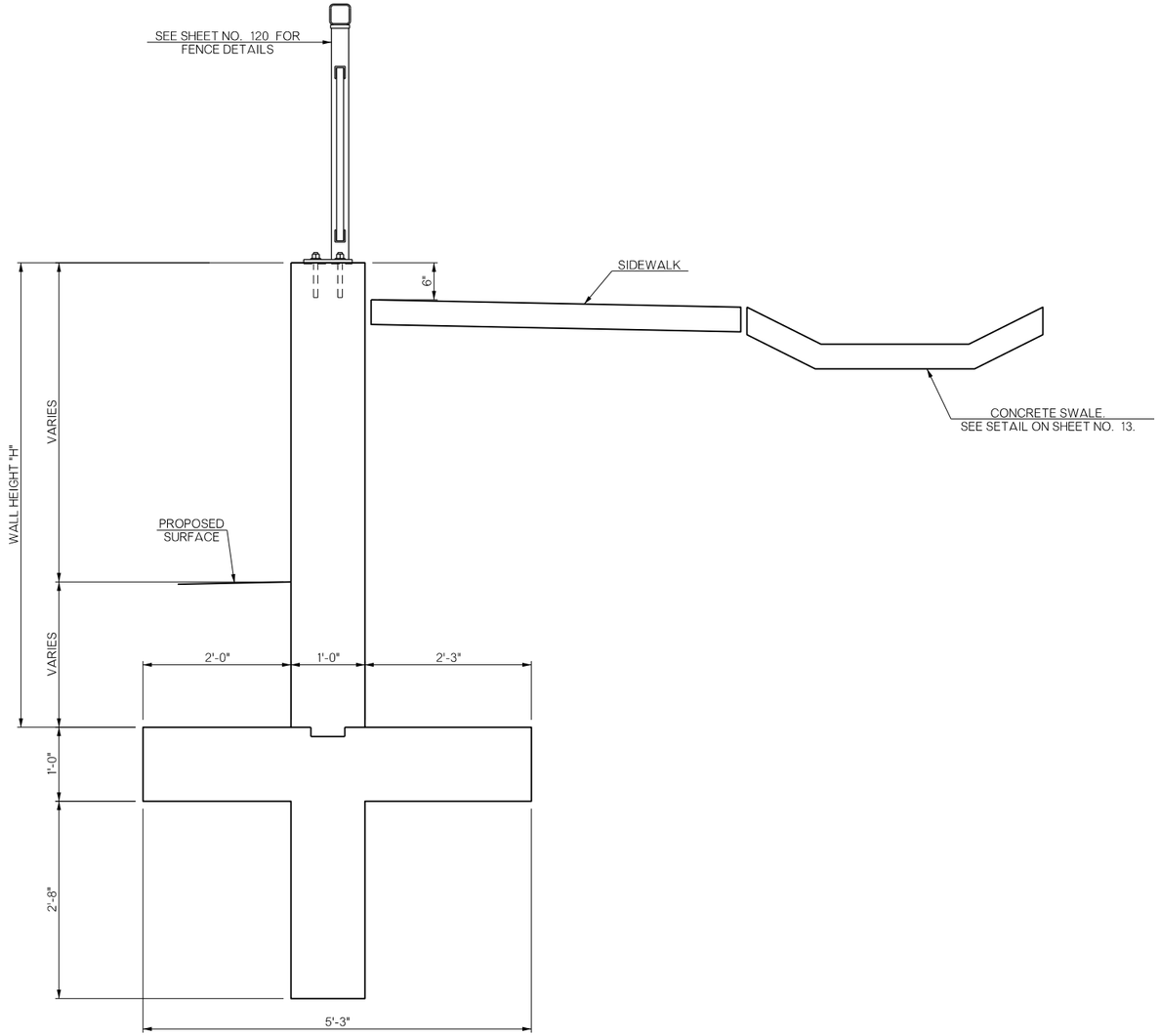
SPECIMEN FAILURE MODE	SPECIMEN TEST DATA		
 Failure Mode: Bulge (dashed)	Moisture Content:	%	20.7
	Dry Density:	pcf	106
	Diameter:	in.	2.72
	Height:	in.	5.58
	Height / Diameter Ratio:		2.05
	Calculated Saturation:	%	
	Calculated Void Ratio:		
	Assumed Specific Gravity:		
	Failure Strain:	%	15.00
	Unconfined Compressive Strength	(psi)	26
	Undrained Shear Strength:	(psi)	13
	Strain Rate:	in/min	0.0558
	Remarks:		

SAMPLE TYPE:	SAMPLE LOCATION: WA-5A @ 4 feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

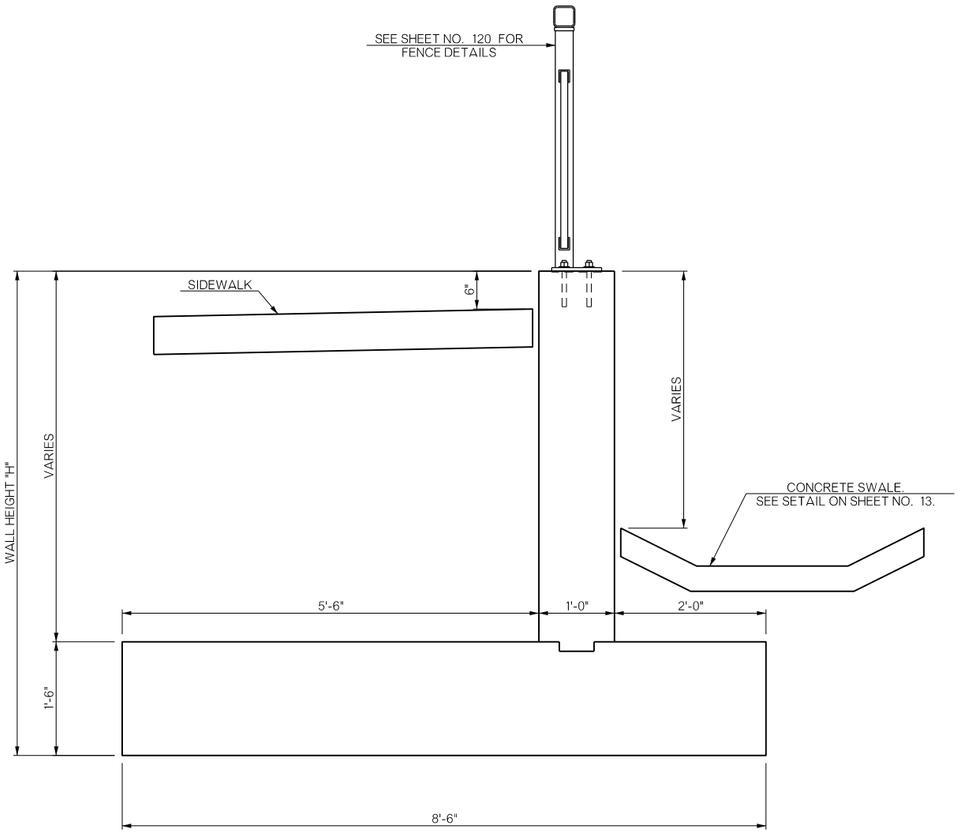
PROJECT: E. 91st Street S. Retaining Walls	Terracon 9522 E 47th Pl, Ste D Tulsa, OK	PROJECT NUMBER: 04195149
SITE: E. 91st Street S.: Memorial Drive to Mingo Road Tulsa, Oklahoma		CLIENT: Garver, LLC Tulsa, Oklahoma
		EXHIBIT: B-5

APPENDIX C

GLOBAL SLOPE STABILITY ANALYSES



TYPICAL SECTION THRU RETAINING WALL "A"



TYPICAL SECTION THRU RETAINING WALL "B"

THIS DOCUMENT IS PRELIMINARY IN NATURE AND IS NOT A FINAL, SIGNED AND SEALED DOCUMENT

RETAINING WALL DETAILS
(SHEET 1 OF 4)

ARTERIAL STREET WIDENING OF E. 91ST ST. S.
S. MEMORIAL DR. TO S. MINGO RD.
PROJECT NO. 170065-A, TMUA-W 08-11

CITY OF TULSA, OKLAHOMA
ENGINEERING SERVICES DEPARTMENT

PLANS AND ESTIMATES PREPARED BY:
6100 S. YALE AVE. SUITE 1300
TULSA, OKLAHOMA 74136
Phone: (918) 250-5922
Fax: (918) 858-0107

DRAWN	SJL	11/20	APPROVED:
DESIGNED	DPE	11/20	
SURVEY			
PROJ. MGR.			
LEAD MGR.			
FIELD MGR.			

PLAN SCALE
N/A

PROFILE SCALE
HORIZONTAL:
N/A
VERTICAL:
N/A

RECOMMENDED:

DESIGN MANAGER

CITY ENGINEER

ADVERTISE DATE:		
REVISION	BY	DATE

FILE: DRAWING: DATE:

ATLAS PAGE NO. 1003 & 1134

SHEET 116 OF 148 SHEETS

$$USER$$
WORKSPACE:$$WORKSPACE$$
$$FILE$$

$$DATE$$ $$TIME$$

Exhibit - C-1

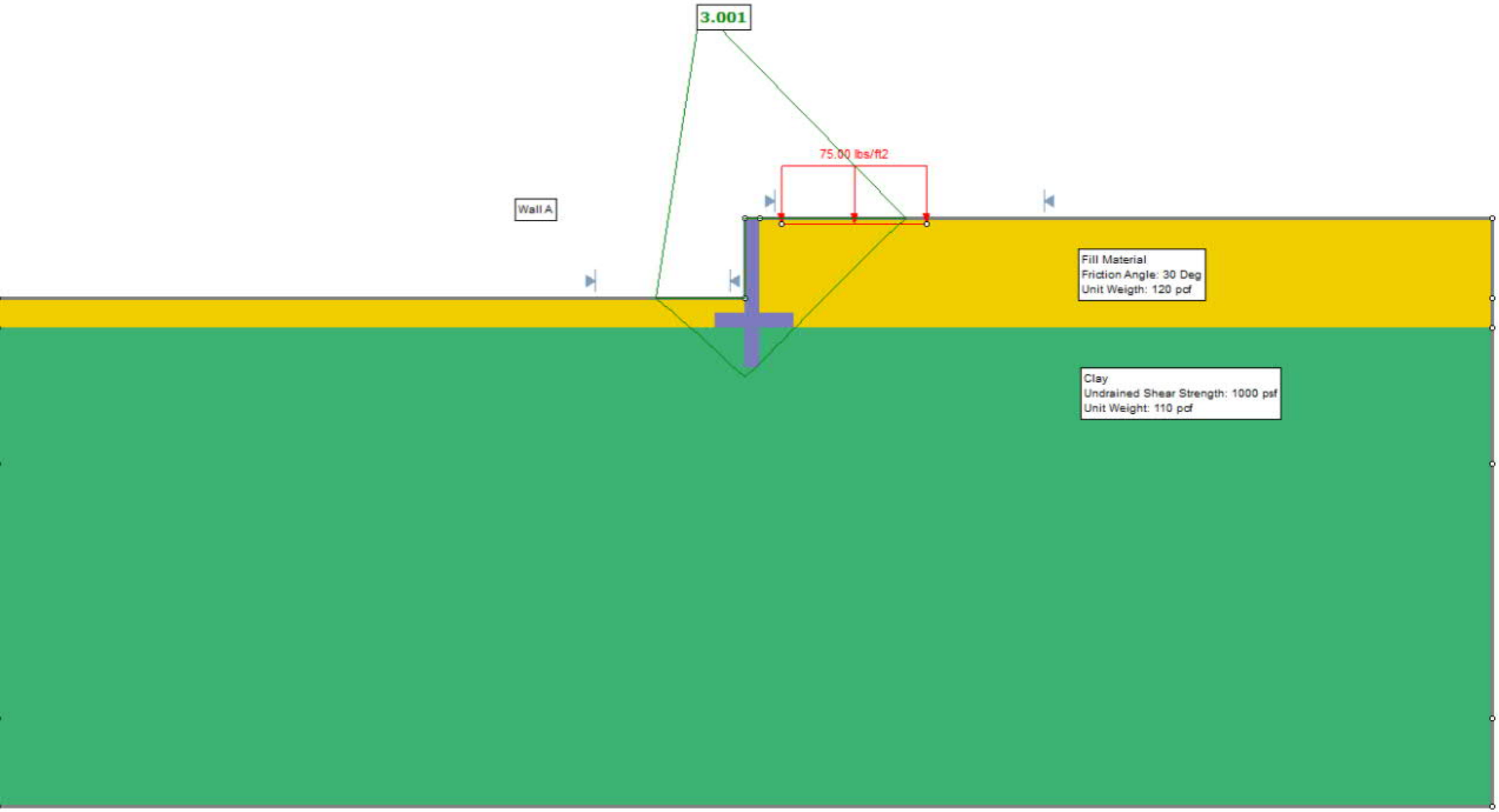

3.001
75.00 lbs/ft2
Wall A
Fill Material
Friction Angle: 30 Deg
Unit Weigth: 120 pcf
Clay
Undrained Shear Strength: 1000 psf
Unit Weight: 110 pcf

Exhibit - C-2

10
20
30
40
50
60
70
80
90
100

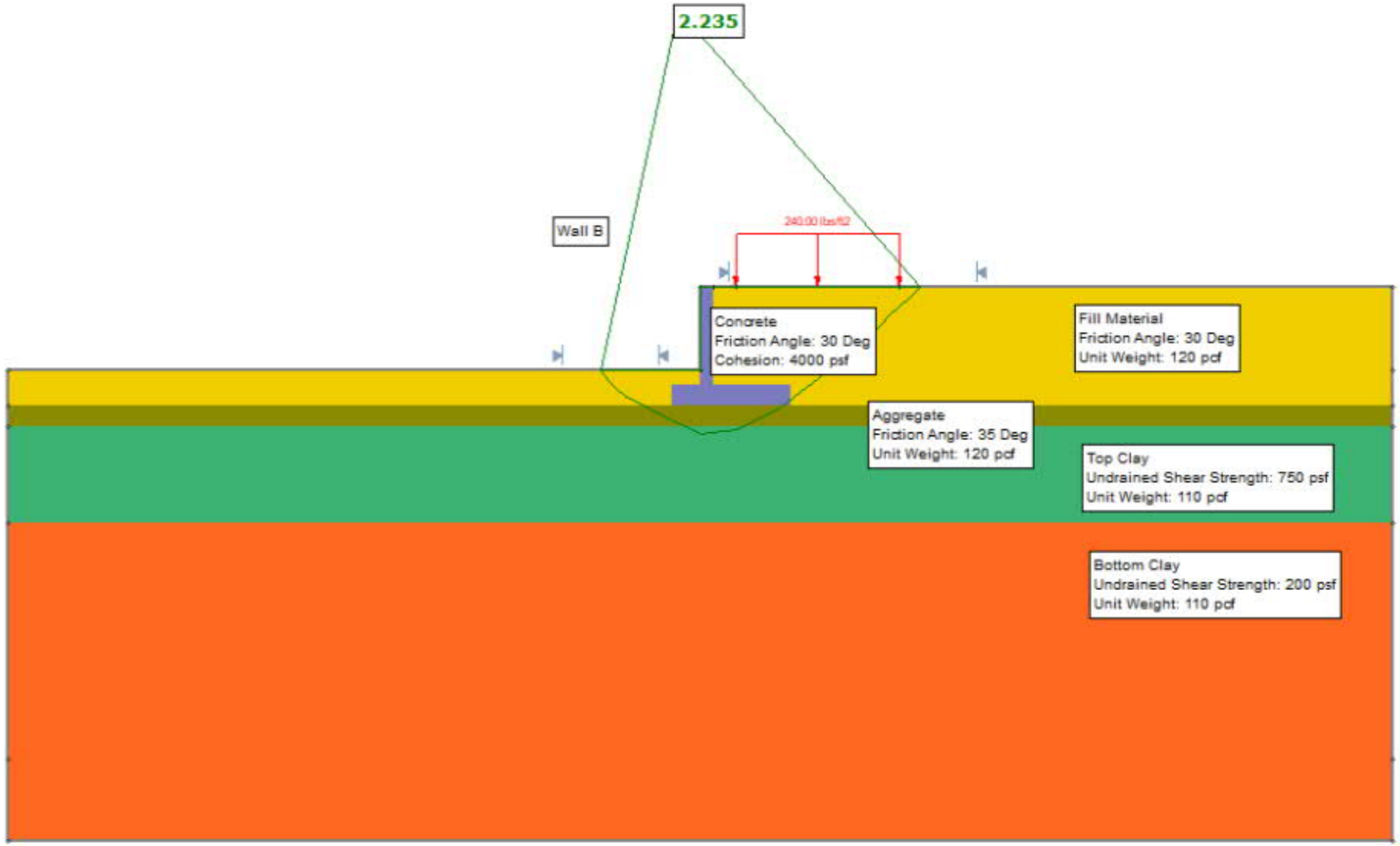


Exhibit - C-3

-10 0 10 20 30 40 50 60 70 80 90 100 110 120 130

APPENDIX D

SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

E. 91st Street S. Widening ■ Tulsa, Oklahoma

Terracon Project No. 04195149

Terracon GeoReport

SAMPLING	WATER LEVEL	FIELD TESTS
Rock Core Standard Penetration Test	**Water Initially Encountered** **Water Level After a Specified Period of Time** **Water Level After a Specified Period of Time** **Cave In Encountered** Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.	**N** Standard Penetration Test Resistance (Blows/Ft.) **(HP)** Hand Penetrometer **(T)** Torvane **(DCP)** Dynamic Cone Penetrometer **UC** Unconfined Compressive Strength **(PID)** Photo-Ionization Detector **(OVA)** Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

LOCATION AND ELEVATION NOTES

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (psi)**	**Standard Penetration or N-Value Blows/Ft.**
Very Loose	0 - 3	Very Soft	less than 3.50	0 - 1
Loose	4 - 9	Soft	3.5 to 7.0	2 - 4
Medium Dense	10 - 29	Medium Stiff	7.0 to 14.0	4 - 8
Dense	30 - 50	Stiff	14.0 to 28.0	8 - 15
Very Dense	> 50	Very Stiff	28.0 to 55.5	15 - 30
		Hard	> 55.5	> 30

RELEVANCE OF SOIL BORING LOG

The soil boring logs contained within this document are intended for application to the project as described in this document. Use of these soil boring logs for any other purpose may not be appropriate.

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 ³ 4 and 1 £ Cc £ 3 [E]		GW	Well-graded gravel [F]
			Cu < 4 and/or [Cc<1 or Cc>3.0] [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 ³ 6 and 1 £ Cc £ 3 [E]		SW	Well-graded sand [I]
			Cu < 6 and/or [Cc<1 or Cc>3.0] [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”		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-inch (75-mm) sieve.

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

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

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

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

[F] If soil contains ³ 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 ³ 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 ³ 30% plus No. 200 predominantly sand, add “sandy” to group name.

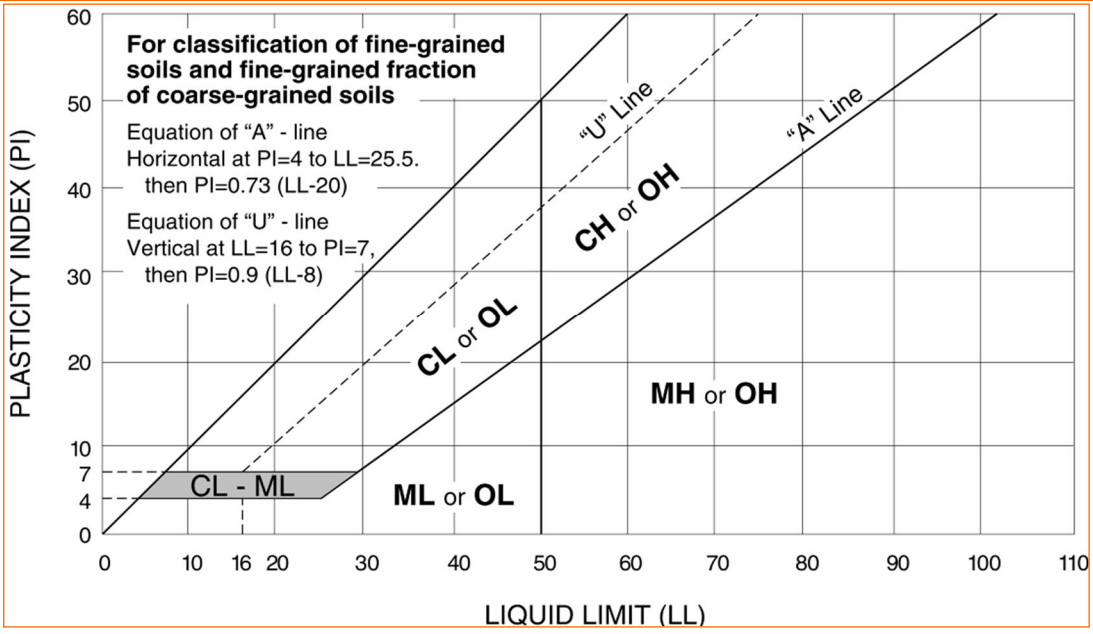
[M] If soil contains ³ 30% plus No. 200, predominantly gravel, add “gravelly” to group name.

[N] PI ³ 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.



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