

November 1, 2012

12-1164

Anderson Engineering of MN, LLC.
13605 1st Ave N, Suite 100
Plymouth, MN 55441

Attn: Mr. Adam Thiele, EIT, LSIT

RE: Geotechnical Investigation-Jefferson
Barracks National Cemetery Sanitary
Sewer Relocation-St Louis, MO

Dear Mr. Thiele:

At your firm's request, we have conducted a geotechnical investigation for the proposed relocation of the Jefferson Barracks National Cemetery sanitary sewer in St. Louis, Missouri.

Scope of Services

The scope of our services for this project consisted of investigating the site's subsurface conditions by drilling three (3) test borings along a portion of the proposed new sewer alignment to depths of 16½ to 25.1 ft. (elev. 492.4 to 494±).

The locations of the borings that were chosen by Anderson Engineering of MN, LLC, are indicated on the enclosed boring logs with respect to the Sheridan Road plan that was provided to our firm and they were staked in the field by our firm. Ground surface elevations were determined using the top of the manhole northeast of the administration building as a benchmark at elevation 509.25. The scope of services also consisted of a laboratory testing program and engineering analyses of the soil-structure interaction with subsequent excavation support and earthwork recommendations.

Site Description

The proposed sewer relocation will be situated just south of the south right of way line of Sheridan Road east and west of the entrance to the cemetery at Jefferson Drive. Most of the area, except at the Sheridan Road/Jefferson Drive intersection is a well maintained lawn area with a variety of existing underground utilities, fences and low retaining walls and these features appear on the Sheridan Road topographic survey. Ground surface elevations at the borings varied from 510 to 517.5.

Proposed Development

We understand that the scope of this construction project will consist of the relocation of approximately 450 feet of sanitary sewer from its current location to along the southern right of way of Sheridan Road. The depth of the new line is reported to be approximately 12 to 17 feet below the existing ground surface.

Subsurface Conditions

The soils encountered in the test borings included natural soils composed of reworked loess and residuum from the underlying Mississippian limestone. Beneath a thin veneer of topsoil, reworked loess that was deposited by massive windstorms following the glacial periods was encountered to a depth of 15 feet (elev. 495 to 502.5±). The reworked loess was composed of lean, yellow brown and light gray mottled clay (CL). Consistencies, based upon laboratory and field data, ranged from stiff to very stiff and unconfined compressive strengths on disturbed samples varied from 1.00 to 5.42 T.S.F. while standard penetration tests indicated N values of 6 to 13 blows per foot. The higher shear strengths and N values at B-3 were most likely influenced by desiccation of the soils by the nearby trees and by the drought conditions experienced regionally last summer.

The residuum below the loess was weathered in place from the underlying St. Louis formation and it was composed of fat, reddish brown clay with gravel and limestone stringers (layers). N values in residuum ranged from 16 to 76+ blows per foot while an unconfined compressive strength on a cohesive sample (B-3, 16-16½ ft.) indicated an ultimate strength of 4.04 T.S.F. Rig refusal and/or boring termination were reached at depths of 16½ to 21 feet beneath the surface (elev. 493.5 to 500.8). The limestone was cored at B-3 from 16.7 to 25.1 ft. and the recovered core was described as being medium bedded and hard. The recovery ratio for the core run was 93% while the RQD (Rock Quality Designation) was 63%.

Groundwater Observations

Groundwater observations were made during drilling, at completion and they were dry during the limited monitoring period. The recent drought conditions are felt to have influenced the lack of perched groundwater. It is felt that dewatering of temporary excavations will be necessary as the groundwater regimen recharge after the recent drought conditions, particularly in the weathered bedrock zone just above sound bedrock.

Temporary Excavation Recommendations

The results of the test borings indicate that bedrock excavation will be necessary at depths exceeding 18 feet (elev. 497±) at B-2 and 16½ feet (elev. 501±) at B-3.

The soils encountered at the borings classify as OSHA Type B soils and, theoretically, temporary excavation slopes would be stable at 1H:1V. However, the relative proximity of existing nearby roads, utilities and structures will not permit open-cut excavation and open-cut excavation is not recommended in view of the potential damage threat to nearby infrastructure elements. Temporary excavations should be braced using trench boxes, steel sheeting or other appropriate means. Temporary excavation support may be designed to resist the following equivalent lateral pressures:

	Active	Active	At-Rest	At-Rest	Passive	Passive
Depth	Drained, P.C.F.	Undrained, P.C.F.	Drained, P.C.F.	Undrained, P.C.F.	Drained, P.C.F.	Drained, P.C.F.
0-15	60	95	80	105	255	190
15-Rock	80	100	90	105	160	130
Imported Clean Granular Material	30	75	45	80	425	245

Drained values should be used above the static water level, while undrained values should be used below the static water level.

Site Earthwork

Backfill for the relocated sewer above the granular bedding may consist of excavated soils and/or granular materials. The backfill should be placed 6" or less lifts and compacted to a dry density of at least 95% of the standard proctor maximum dry density (ASTM D 698) or to 90% of the modified proctor maximum dry density (ASTM D 1557) Moisture contents should be controlled within a range of $\pm 4\%$ for standard proctor control density or within a range of -1% to +6% for modified proctor control density.

Seismicity

Based on the subsurface conditions encountered and areal geology, the site class would be closest to C in accordance with the provisions of IBC 2009. Liquefaction potential for the site is low, although some vertical and horizontal displacement should be expected during a major earthquake.

Conclusions

The geotechnical investigation, including exploration, testing and analyses has been completed for the proposed sanitary sewer relocation at the Jefferson Barracks National Cemetery. The analyses, conclusions and recommendations contained in this report are based on the site conditions and project descriptions presented in this report and the subsurface conditions disclosed by the exploratory borings. The conclusions and recommendations presented are professional opinions based on the above conditions, professional judgment and experience.

If, during design and construction, changes occur either in the proposed construction, due to natural causes or construction operations at the site, from a substantial lapse in time, or should subsurface conditions encountered during construction differ materially from those presented, we should be contacted to review any changes in circumstances and conditions to evaluate the effects on the analyses, conclusions and recommendations presented.

The borings were spaced to obtain a reasonably accurate picture of the subsurface conditions. However, variations in the subsurface conditions not indicated by the borings are always possible. These data are supplied for the benefit of the designers and owner, and do not express or imply any warranty of the subsurface conditions. Completed foundation excavations, foundation construction, site grading, backfill and pavement construction should be observed and tested during the construction phase by a qualified professional to verify the subsurface conditions and the design assumptions.

The scope of our services does not include any environmental assessment or investigation for the presence or absence of hazardous or toxic materials in the soil, groundwater or surface water within or beyond the site studied. Any statements in this report regarding odors, staining of soils, or other unusual conditions observed are strictly for the information of our client. If you have any questions concerning this investigation, feel free to call.

Very truly yours,

GEOTECHNICS

A handwritten signature in cursive script, reading "Ronald W. Craven".

Ronald W. Craven, P.E.
Geotechnical Services Department Manager
Missouri PE No. 020124

Encl.

A P P E N D I X

FIELD INVESTIGATION

LABORATORY INVESTIGATION

BORING LOGS - GENERAL INFORMATION

BORING LOGS

ROCK CORE PHOTOGRAPH

FIELD INVESTIGATION

The field investigation consisted of a site inspection, subsurface exploration and sampling, as well as field testing and visual classification of the soils encountered. The site inspection provided information concerning existing topography and recent manmade alterations. During this inspection the locations and ground elevations for each of the borings were provided.

Subsurface exploration and sampling was conducted in an effort to define the soil profile and to obtain representative and undisturbed samples of the various soils encountered for the purposes of the laboratory investigation.

Test borings were completed with a CME drill rig equipped with 3¼ inch I.D. diameter hollow stem augers. The hollow stem augers permit convenient access to the undisturbed soil below the auger bit and allow the driller to obtain a soil sample at any desired depth.

As the test borings were advanced, two methods of sampling were employed to recover soils from the undisturbed strata below the auger bit. Representative disturbed samples were obtained from a standard split spoon. These samples were recovered by driving a 2" O.D. (1 3/8 " I.D.) Split Spoon Sampler in accordance with ASTM D 1586-84(92). Relatively undisturbed samples were obtained in cohesive soils by hydraulically pushing a thin walled seamless tube sampler into the soil in accordance with ASTM D 1587-83. These Shelby Tubes were 3 inches in outside diameter.

The recovered samples were described in the field according to color, texture, grain size, plasticity and consistency, as recommended by ASTM D 2488-93, "Description of Soils (Visual-Manual Procedures)". Split spoon samples were sealed in glass jars and labeled while Shelby Tube Samples were sealed within the tubes and also labeled. The samples were all carefully stored for later use in the laboratory testing program.

Field tests were conducted in an effort to establish the shearing strength of the soil. Though the results of these tests were not used alone as a basis for shearing strength determination, they were helpful in predicting the behavior of the soil mass. Further laboratory testing and evaluation in conjunction with the field testing program was essential in determining the soil conditions.

The field testing program included the Standard Penetration Test conducted in accordance with ASTM D 1586-84(92). In this test, administered during the split spoon sampling procedure, a 2" O.D. (1 3/8" I.D.) 18" long, standard split spoon was driven into the soil through a depth of 18" by a 140 pound weight dropped a distance of 30 inches. The penetration resistance, "N", was recorded as the number of blows, from the falling weight, required to drive the sampler through the final 12 inches. This penetration resistance provided a measure of the relative density of cohesionless soils and an estimate of the consistency of cohesive materials.

Recovered cohesive samples were tested by the use of a calibrated penetrometer. The values from this test were considered an approximate measure of the consistency of the cohesive soils. The penetrometer values as well as the measures of penetration resistance were later correlated with the results of the laboratory tests conducted on cohesive soil samples obtained from the split spoon and Shelby Tubes.

The results of the field tests on each soil sample, as well as the soil descriptions, were recorded on boring logs as the subsurface exploration progressed. These boring logs, which are included in this report, were later modified to reflect the more elaborate analysis provided by the laboratory testing program.

LABORATORY INVESTIGATION

The laboratory investigation involved the completion of classification tests on undisturbed as well as disturbed samples of the soils obtained from the various soil layers encountered beneath the construction site.

Representative samples from the various soil strata were tested in accordance with ASTM Specifications for the natural moisture content, liquid limit, plastic limit and particle size. These parameters were used in identifying the soils through the Unified Soil Classification System. This System, which is standardized and widely accepted, enables the Geotechnical Engineer to classify a soil using quantitative test results. Predictions of the soil behavior during and after construction may readily be made through the use of this comparative type of classification.

Relatively undisturbed Shelby Tube and disturbed split spoon samples of the cohesive soils were tested to determine the unconfined compressive strength. These tests were conducted with controlled strain by the use of a hand-operated compression apparatus with a double proving ring in accordance with ASTM D 2166-91. The results of some of the tests must be considered, recognizing that split spoon samples are disturbed and that these samples, when tested, will provide slightly conservative values in relation to the probable conditions in the field. The relatively undisturbed Shelby Tube samples, however, should approach the condition of the soils in-situ and the results of unconfined compression tests on these samples should be fairly accurate.

BORING LOGS **GENERAL INFORMATION**

I. DRILLING AND SAMPLING SYMBOLS:

HA - Hollow Continuous Flight Auger

SS - Split Spoon Sample (2" O.D. - 1 3/8" I.D.) obtained following the Standard Penetration Test

2ST - Shelby Tube Sample (2" O.D.)

3ST - Shelby Tube Sample (3" O.D.)

NQ-Rock Core (NQ - 2" Diameter)

II. SOIL IDENTIFICATION:

The soils have been identified by Visual-Manual procedures in accordance with ASTM Standards. Where specifically noted, the soils have been classified using the Unified Soil Classification System. Classification estimates are in parentheses.

III. SOIL PROPERTY SYMBOLS:

MC - Natural Moisture Content in %.

DRY WT.- Unit Dry Weight in pounds per cubic foot.

LL - Liquid Limit in %.

PL - Plastic Limit in %.

Qp - Unconfined compressive strength in tons per square foot. Calibrated penetrometer value.

Qu - Unconfined compressive strength in tons per square foot. Obtained in laboratory at controlled rate of strain.

BLOWS - The "blows" are the recorded results of the Standard Penetration Test. In this field test, a standard split spoon sampler (2" O.D.- 1 3/8" I.D.) is driven into the soil for a total penetration of 18" by a 140-pound hammer which is repeatedly dropped freely for a distance of 30 inches.

The number of blows are recorded for each 6 inches of penetration, and the penetration resistance, "N", is considered as the number of blows required for the last 12 inches of penetration.

EXAMPLE: 3/8/6/ "N" = 14 blows/foot

Should the sampler not penetrate the full 18 inches, the results are recorded as follows:

EXAMPLE: 6/21/100 - 3".

This means that 6 blows were required for the first 6 inches of penetration, 21 blows were required for the second 6 inches of penetration, and 100 blows were required for the last 3 inches of penetration.

Groundwater level at 24 hours following boring completion.

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IV. APPROXIMATE RELATIVE DENSITY AND CONSISTENCY OF SOILS ON THE BASIS OF THE STANDARD PENETRATION TEST:

<u>NONCOHESIVE SOILS</u>		<u>COHESIVE SOILS*</u>	
<u>BLOWS/FT.** RELATIVE DENSITY</u>		<u>BLOWS/FT ** CONSISTENCY</u>	
0 - 4	Very Loose	0 - 2	Very Soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium Dense	4 - S	Medium
30 - 50	Dense	8 - 15	Stiff
50+	Very Dense	15 - 30	Very Stiff
	30+	Hard	

* Use with caution

**Penetration Resistance "N"

V. QUANTITATIVE EXPRESSIONS FOR THE CONSISTENCY OF CLAYS:

UNCONFINED COMPRESSIVE STRENGTH

CONSISTENCY T.S.F. FIELD IDENTIFICATION

Very Soft	0 - 0.25	Easily penetrated several inches by fist.
Soft	0.25 - 0.5	Easily penetrated several inches by thumb.
Medium	0.5 - 1.0	Penetrated by thumb with moderate effort.
Stiff	1.0 - 2.0	Readily indented by thumb but penetrated only with great effort.
Very Stiff	2.0 - 4.0	Readily indented by thumbnail.
Hard	4.0+	Indented with difficulty by thumbnail.

MAJOR DIVISIONS			GRAPH SYMBOL	GROUP SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS More than 50% of Material is LARGER than No. 200 Sieve Size	GRAVEL AND GRAVELLY SOILS More than 50% of Coarse Fraction RETAINED on No. 4 Sieve	CLEAN GRAVELS (Little or No Fines)		GW	Well-Graded Gravel, Gravel-Sand Mixture, Little or No Fines
				GP	Poorly-Graded Gravel, Gravel-Sand Mixtures, Little or No Fines
		GRAVELS WITH FINES (Appreciable Amount of Fines)		GM	Silty Gravel, Gravel-Sand-Silt Mixtures
				GC	Clayey Gravel, Gravel-Sand-Clay Mixtures
	SAND AND SANDY SOILS More than 50% of Coarse Fraction PASSING on No. 4 Sieve	CLEAN SAND (Little or No Fines)		SW	Well-Graded Sand, Gravely Sands, Little or No Fines
				SP	Poorly-Graded Sand, Gravely Sands, Little or No Fines
		SANDS WITH FINES (Appreciable Amount of Fines)		SM	Silty Sand, Sand-Silt Mixtures
				SC	Clayey Sand, Sand-Clay Mixtures
FINE GRAINED SOILS More than 50% of Material is SMALLER than No. 200 Sieve Size	SILTS AND CLAYS Liquid Limit LESS than 50%			ML	Inorganic Silt and Very Fine Sand, Rock Flour, Silty or Clayey Fine Sand or Clayey Silt with Slight Plasticity
				CL	Inorganic Clay of Low to Medium Plasticity, Gravely Clay, Sandy Clay, Silty Clay, Lean Clay
				OL	Organic Silt and Organic Silty Clay of Low Plasticity
	SILTS AND CLAYS Liquid Limit GREATER than 50%			MH	Inorganic Silt, Micaceous or Diatomaceous Fine Sand or Silty Soil, Elastic Silt
				CH	Inorganic Clay of High Plasticity, Fat Clay
				OH	Organic Clay of Medium to High Plasticity, Organic Silt
HIGHLY ORGANIC SOILS				PT	Peat, Humus, Swamp Soils with High Organic Contents

SOIL CLASSIFICATION CHART

NOTES:

- 1) DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS.
- 2) IN THE CASE OF COMBINATIONS, THE PREDOMINANT MATERIAL WILL BE IN HEAVY SYMBOL.

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Soil & Material Testing

L3 316 North 2nd Street, Oakridge, IL Ph (617) 953-0870 - Fax (617) 953-9805
 100 4510 Park Grove Rd, Linnville, MO Ph (520) 821-4000 - Fax (520) 821-4012
 L3 310 N. Third Street, Suite 100, Burlington, UK Ph (510) 753-1836 - Fax (510) 753-9805
 Internet Address: www.kimmar.com

UNIFIED SOIL CLASSIFICATION SYSTEM - ASTM D 2487 -

Project No.: 12-1164

Project: Jefferson Barracks National Cemetery
Sanitary Sewer RelocationClient: Anderson Engineering of MN, LLC

Boring No.: 1

Boring LogRig: CME 75Location: St. Louis, MODriller: MAS

SUBSURFACE PROFILE					SAMPLE				Standard Penetration Test blows/ft.	Water Content % Wp ----- WI
Depth (ft.)	Symbol	Description	Qp, t.s.f.	Dry Density, P.C.F.	Depth/Elev.	Number	Type	Blows/ft.	Qu, T.S.F.	
0		Ground Surface			510.0					
		Topsoil(<3"), Fill: Lean Clay w/Gravel, Silty, Yellow Brown, (CL)			508.5 1.5	0	HA			19.0
		Lean Clay, Silty, Yellow Brown Mottled Light Gray, Very Stiff, (CL)	2.00	98.9		1	SS	7	2.51	23.0
5		Stiff, (CL)	2.50	101.1		2	SS	10	1.42	24.0
		Stiff to Medium, (CL)	0.50	101.0		3	SS	7	1.00	23.8
10		Stiff, (CL)	1.50	101.6		4	SS	8	1.43	22.9
15		Fat Clay w/Gravel, Reddish Brown, Stiff, (CH)			495.0 15.0	5	SS	16		22.2
		End of Boring @ 16½ ft.			493.5 16.5					
20										
25										
30										

Drill Method: 3 1/4" HSABoring Started: 10/18/2012Boring Completed: 10/18/2012Tested By: JRLLogging By: PEB
GEOTECHNICS
Soil & Material Testing

Groundwater Elev. During Drilling: ▽

Groundwater Elev. @ Comp.: ▽

Groundwater Elev. @ Hrs.: ▽

Boring Location: Sta. 24+40, 35' Rt.

Sheet 1 of 1

Project No.: 12-1164

Project: Jefferson Barracks National Cemetery
Sanitary Sewer Relocation

Client: Anderson Engineering of MN, LLC

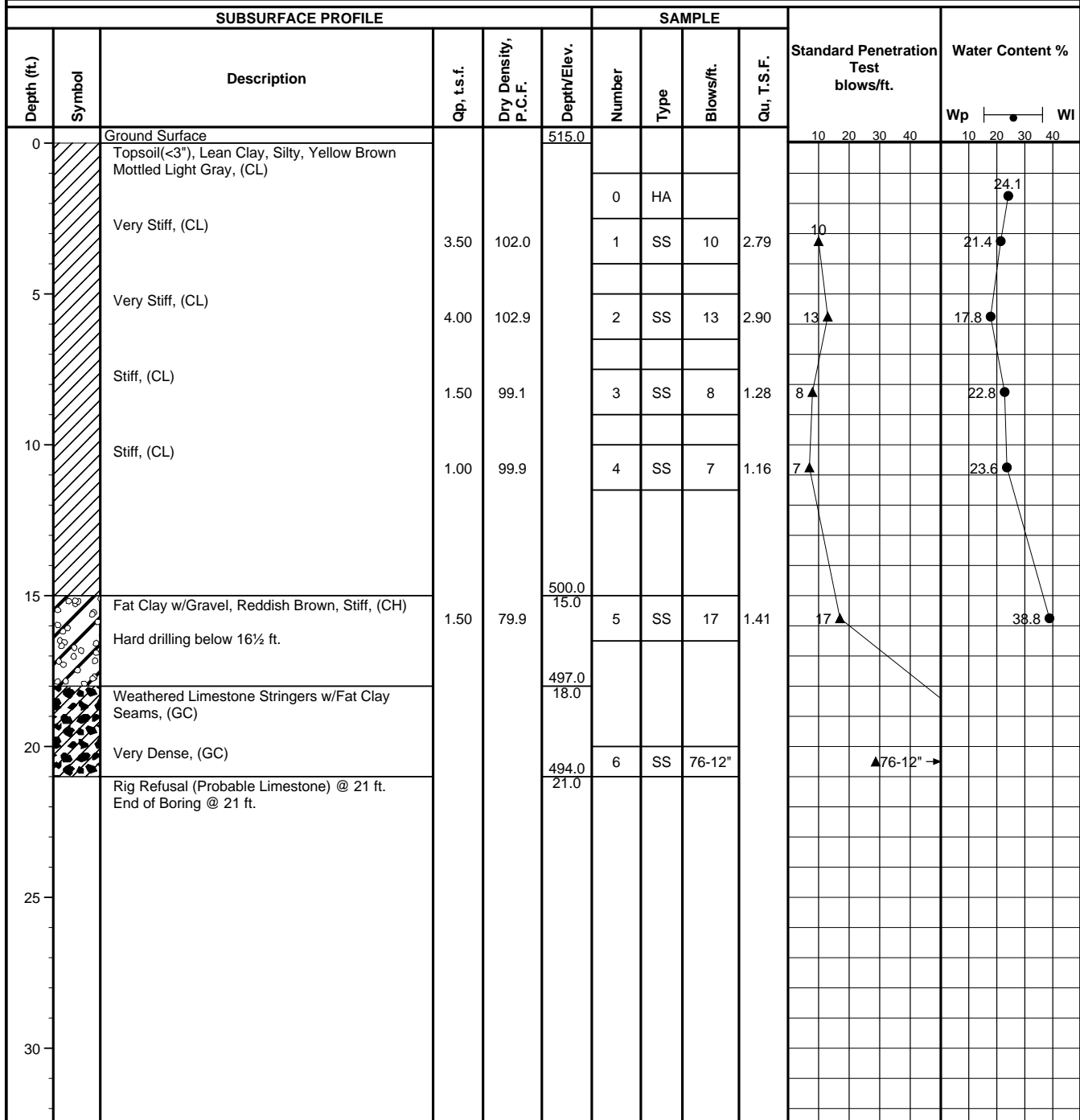
Boring No.: 2

Boring Log

Rig: CME 75

Location: St. Louis, MO

Driller: MAS



Drill Method: 3 1/4" HSA

Boring Started: 10/18/2012

Boring Completed: 10/18/2012

Tested By: JRL

Logging By: PEB

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Soil & Material Testing

Groundwater Elev. During Drilling: ▽

Groundwater Elev. @ Comp.: ▽

Groundwater Elev. @ Hrs.: ▽

Boring Location: Sta. 26+50, 70' Rt.

Sheet 1 of 1

Project No.: 12-1164

Project: Jefferson Barracks National Cemetery
Sanitary Sewer Relocation

Client: Anderson Engineering of MN, LLC

Boring No.: 3

Boring Log

Rig: CME 75

Location: St. Louis, MO

Driller: MAS

SUBSURFACE PROFILE					SAMPLE				Standard Penetration Test blows/ft.	Water Content % Wp ----- Wl
Depth (ft.)	Symbol	Description	Qp, t.s.f.	Dry Density, P.C.F.	Depth/Elev.	Number	Type	Blows/ft.		
0		Ground Surface			517.5					
		Topsoil(<3"), Lean Clay, Silty, Yellow Brown Mottled Light Gray, (CL)				0	HA			
		Dry, Hard, (CL)	3.50			1	SS	10		19.5
5		Dry, Hard, (CL)	3.00	99.4		2	SS	6	6	15.9
		Moist, Very Stiff, (CL)	1.50	105.8		3	SS	13	13	15.4
10		Very Stiff, (CL)	1.50	103.7		4	SS	9	9	16.9
										18.9
15		Fat Clay w/Gravel, Reddish Brown, Hard, (CH)	2.25	102.4	502.5 15.0	5	SS	10	10	24.0
		Rig Refusal @ 16.7 ft. Began NQ-2" Core @ 16.7 ft.			500.8 16.7					
20		Limestone, Light Gray, Medium Bedded, Hard, Occasional Clay-Filled Seams Cored 8.4 ft. Recovery Ratio=93%, RQD= 63%				Run 1	NQ-2			
25		End of Boring @ 25.1 ft.			492.4 25.1					
30										

Drill Method: 3 1/4" HSA/NQ-2" Core

Boring Started: 10/18/2012

Boring Completed: 10/18/2012

Tested By: JRL

Logging By: PEB

GEOTECHNICS
 Soil & Material Testing

Groundwater Elev. During Drilling: ∇

Groundwater Elev. @ Comp.: ∇

Groundwater Elev. @ Hrs.: ∇

Boring Location: Sta. 27+25, 35' Rt.

Sheet 1 of 1

Jefferson Barracks National Cemetery
Sanitary Sewer Relocation-St. Louis, MO

NQ-2" Rock Core B-3, 16.7 to 25.1 ft.
10/18/2012



Jefferson Barracks National Cemetery
Sanitary Sewer Relocation-St. Louis, MO

NQ-2" Rock Core B-3, 16.7 to 25.1 ft.
10/18/2012