Geotechnical Engineering Report

City of Savannah 63rd Street Relief Line
Savannah, Georgia

April 19, 2011
Terracon Project No. ES115039

Prepared for:
EMC Engineering Services, Inc.
Savannah, Georgia

Prepared by:
Terracon Consultants, Inc.
Savannah, Georgia

April 19, 2011

EMC Engineering Services, Inc.
23 E. Charlton Street
Savannah, Georgia 31401

Attn: Mr. Ben Lockhart, P.E.
P: [912] 232-6533
E: Ben_Lockhart@emc-eng.com

Re: Geotechnical Engineering Report
City of Savannah 63rd Street Relief Line
Savannah, Georgia
Terracon Project No: ES115039

Dear Mr. Lockhart:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above-referenced project. The service was performed in general accordance with our proposal No.PES110163. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork, design and construction of 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.

Zengxuan (Frank) Li, Ph.D., P.E.
Senior Engineer

Guoming Lin, Ph.D., P.E.
Senior Principal

Enclosures
cc: 1 – Client (PDF)
1 – File

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EXECUTIVE SUMMARY

A geotechnical investigation has been performed for the proposed City of Savannah 63rd Street Relief Line in Savannah, Georgia. The field exploration program consisted of seven (7) cone penetration test (CPT) soundings to a maximum depth of 56 feet below the existing ground surface (BGS), five (5) standard penetration test (SPT) borings to a maximum depth of 55 feet BGS and twelve (12) hand auger borings to a depth of 6 feet BGS. The following geotechnical considerations were identified:

- Subsurface conditions along the project alignment are relatively variable. Three generalized profiles of soil strata are identified, which represent subsurface soil conditions at different exploration locations.
- Based on the encountered soil conditions, three sets of soil parameters are recommended for sheet pile design, corresponding to the three generalized profiles.
- For seismic design, the site shall be classified as Site Class D in accordance with the International Building Code (IBC) 2006, Section 1613.

This summary should be used in conjunction with the entire report for design purposes. It should be recognized that details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled **GENERAL COMMENTS** should be read for an understanding of the report limitations.

GEOTECHNICAL ENGINEERING REPORT
CITY OF SAVANNAH 63RD STREET RELIEF LINE
SAVANNAH, GEORGIA

Terracon Project No. ES115039
April 19, 2011

1.0 INTRODUCTION

A geotechnical engineering report has been completed for the proposed City of Savannah 63rd Street Relief Line in Savannah, Georgia. The field exploration program consisted of seven (7) cone penetration test (CPT) soundings to a maximum depth of 56 feet below the existing ground surface (BGS), five (5) standard penetration test (SPT) borings to a maximum depth of 55 feet BGS and twelve (12) hand auger borings to a depth of 6 feet BGS. CPT sounding logs, SPT boring logs and hand auger boring logs, along with a site location map and exploration location plan are included in Appendix A of this report.

The purpose of this study is to provide subsurface information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- groundwater conditions
- foundation design and construction
- seismic considerations

2.0 PROJECT INFORMATION

2.1 Project Description

ITEM	DESCRIPTION
Proposed Improvement	A new drainage system includes junction boxes, box culverts and cast-in-place concrete and asphalt pavements. The installation of the drainage system will require excavation to depths on the order of 20 feet deep and the potential installation and removal of sheet piles or other methods as temporary shoring to support the excavation.
Finished floor elevation	Not applicable.
Maximum loads	Not applicable.
Maximum allowable settlement	Not provided. We assume one inch of total settlement and 0.5 inches of differential settlement between joints.
Grading (Cut or Fill)	Excavation to an approximate depth of 20 feet below grade and backfill to existing grade.

2.2 Site Location and Description

ITEM	DESCRIPTION
Location	The site is located along Abercorn Street to 63^{rd} Street to 60^{th} Street in Savannah, Georgia. Latitude: 32.0333°, Longitude: -81.0975°
Existing improvements	The alignment has existing stormwater drainage piping and paved roadways. There are various residential structures along the alignment.
Current ground cover	Asphalt and concrete roadways.
Existing topography	Elevations vary along the alignment. No survey work was performed for this geotechnical investigation.

3.0 SUBSURFACE CONDITIONS

3.1 Typical Profile

Based on the results of the field exploration, subsurface conditions along the project alignment are relatively variable. We have generated three generalized profiles, designated as profile I through profile III, which represent subsurface conditions along different reaches of the alignment.

Profile I representing the subsurface soil conditions from C-1 to B-4

Description	Approximate Elevation of Bottom of Stratum (feet)	Material Encountered	SPT Blow Count and/or N60 Derived from CPT Sounding
Stratum 1	1 to 4	Soft sandy clay, with interbedded thin sand layers	2 to 4
Stratum 2	-19 to -21	Medium dense to dense silty sands, with interbedded clay layers	10 to 45
Stratum 3	-28	Stiff sandy clay	12 to 17
Stratum 4	Undetermined. Explorations were terminated within this stratum	Dense silty sand	30 to 40

Description	Approximate Elevation of Bottom of Stratum (feet)	Material Encountered	SPT Blow Count and/or N60 Derived from CPT Sounding

Note:

Elevation survey was not performed as part of this geotechnical exploration. The surface elevations were extrapolated from the elevations in the geotechnical engineering report prepared by ECS Ltd for EMC Engineering Services, inc., dated April 27, 2001. The elevations should be considered approximate.

Profile II representing the subsurface soil conditions from C-2, C-3 to B-6.

Description	Approximate Elevation of Bottom of Stratum (feet)	Material Encountered	SPT Blow Count and/or N60 Derived from CPT Sounding
Stratum 1	-1 to 3	Medium dense silty sand, with interbedded thin clay layer	10 to 30
Stratum 2	-6 to -1	Medium stiff sandy clay, with interbedded sand layer	5 to 7
Stratum 3	Undetermined. Explorations were terminated within this stratum	Medium dense to dense silty sand, with interbedded thin clay layer	10 to 40

Note:

Elevation survey was not performed as part of this geotechnical exploration. The surface elevations were extrapolated from the elevations in the geotechnical engineering report prepared by ECS Ltd for EMC Engineering Services, inc., dated April 27, 2001. The elevations should be considered approximate.

Profile III representing the subsurface soil conditions from C-5, C-7, C-9, C-11, B-8, B-10 and B-12.

Description	Approximate Elevation of Bottom of Stratum (feet)	Material Encountered	SPT Blow Count and/or N60 Derived from CPT Sounding
Stratum 1	1 to 13	Medium dense silty sand, with interbedded thin clay layer	13 to 33
Stratum 2	-4 to 8	Soft sandy clay	1 to 3
Stratum 3	-13 to 3	Loose to medium dense silty sand, with interbedded clay layer	7 to 33
Stratum 4	-36 to -22	Soft to stiff sandy clay, with interbedded sand layer	2 to 14
Stratum 5	Undetermined. Explorations were terminated within this stratum.	Medium dense to dense silty sand	11 to 37

Description	Approximate Elevation of Bottom of Stratum (feet)	Material Encountered	SPT Blow Count and/or N60 Derived from CPT Sounding

Note:

Elevation survey was not performed as part of this geotechnical exploration. The surface elevations were extrapolated from the elevations in the geotechnical engineering report prepared by ECS Ltd for EMC Engineering Services, inc., dated April 27, 2001. The elevations should be considered approximate.

Details of subsurface conditions encountered at each exploration location are presented on the individual exploration logs in Appendix A of this report. Stratification boundaries on the logs represent the approximate depth of changes in soil types; and the transition between materials may be gradual.

3.2 Groundwater

Groundwater was encountered at depths of 4 to 6 feet below existing ground surface during SPT borings. It should be noted that groundwater levels tend to fluctuate with seasonal and climatic variations, as well as with construction activities. As such, the possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project. The groundwater table should be checked prior to construction to assess its effect on site work and other construction activities.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

The following evaluation and recommendations are based upon our understanding of the proposed construction and the results of the field exploration. If the above-described project conditions are incorrect or changed after this report, or subsurface conditions encountered during construction are different from those reported, Terracon should be notified and these recommendations must be re-evaluated to make appropriate revisions.

4.1 Recommendations on Drainage Structure Support

Excavation required for the installation of box culverts and junction boxes will remove overburden soils. In general, the weight of soil to be removed should be greater than the weight of box culverts or junction boxes resulting in a reduction of stresses within the subgrade soil below the drainage structures. Strictly speaking, the box culverts and junction boxes should not cause consolation settlements in addition to re-compaction of subgrade soil which should be small and tolerable. However, as shown in the soil boring and CPT sounding profiles, the soils along the alignment are variable. Depending on the depth of excavation, the subgrade soils may be soft clays that are not suitable for subgrade support or in unstable condition. Placement of concrete structures on unstable subgrade can result in movements or settlements of the structures. It is important that the subgrade along the entire alignment be inspected and tested during construction. Unsuitable or unstable subgrade, if encountered, should be repaired in accordance with the following procedures.

- After excavating to the required subgrade elevation, a technician should inspect the bottom of the excavation for soil suitability and stability. The technician should perform hand auger borings with dynamic penetrometer tests to a depth of at least 5 ft below the subgrade to verify the soil conditions and bearing capacity.
- If unsuitable materials such as organic soils or soft clays are encountered during subgrade inspection, they must be undercut and replaced with suitable structural fill or graded aggregates. If subgrade soils are unstable due to excessive moisture content, the unstable soils should be excavated and re-compacted under favorable weather conditions or replaced with graded aggregates. The depth and extent of the undercut should be determined on-site by a Geotechnical Engineer based on the conditions of the weak material.

We recommend all box culverts and junction boxes be placed over a bedding layer consisting of 12 inches of #57 stone over a layer of filter fabric. The #57 stone should help dewatering effort to allow water to run through. The filter fabric is intended to control migration of fine sands into the voids within the #57 stone. A net bearing capacity of 1500 pounds per square foot is recommended for the box culvert design.

4.2 Recommendations on Excavation Shoring Design and Construction

4.2.1 Recommendations on Excavation Shoring Design

Based on the soil conditions encountered, we recommend the following soil parameters be used for the excavation shoring design. Three tables with recommended soil parameters are included, corresponding to the three typical profiles in section 3.1. Any surcharge or additional load behind the sheet pile should be considered in the design.

Recommended Soil Parameters for Profile I

Bottom Elevation (ft)	Material Description	T.U.W. (pcf)	E.U.W. (pcf)	Fi	C (psf)	Ko	Ka	Kp
3	Soft sandy clay	115	50	0	400	1	1	1
-21	Medium dense to dense silty sand	125	60	33	0	0.46	0.29	3.39
-28	Stiff sandy clay	120	55	0	2000	1	1	1
Undetermined	Dense silty sand	125	60	33	0	0.46	0.29	3.39

Note: E.U.W.: Total Unit Weight, pcf;
E.U.W.: Effective Unit Weight, pcf;
Fi: Angle of Internal Friction, degree;
C: Cohesion, psf
Ko: Coefficient of At Rest Earth Pressure;
Kp: Coefficient of Passive Earth Pressure;
Ka: Coefficient of Active Earth Pressure;

Recommended Soil Parameters for Profile II

Bottom Elevation (ft)	Material Description	T.U.W. (pcf)	E.U.W. (pcf)	Fi	C (psf)	Ko	Ka	Kp
3	Medium dense silty sand	125	60	30	0	0.5	0.33	3.0
-21	Medium stiff sand clay	120	55	0	1000	1	1	1
Undetermined	Medium dense silty sand	125	60	30	0	0.5	0.33	3.0

Note: E.U.W.: Total Unit Weight, pcf;
E.U.W.: Effective Unit Weight, pcf;
Fi: Angle of Internal Friction, degree;
C: Cohesion, psf
Ko: Coefficient of At Rest Earth Pressure;
Kp: Coefficient of Passive Earth Pressure;
Ka: Coefficient of Active Earth Pressure;

Recommended Soil Parameters for Profile III

Bottom Elevation (ft)	Material Description	T.U.W. (pcf)	E.U.W. (pcf)	Fi	C (psf)	Ko	Ka	Kp
7	Medium dense, silty sand	125	60	30	0	0.5	0.33	3.0
2	Soft sandy clay	115	50	0	500	1	1	1
-5	Medium dense silty sand	125	60	30	0	0.5	0.33	3.0
-29	Medium stiff clay	120	55	0	1000	1	1	1
Undetermined	Medium dense to dense sand	125	60	33	0	0.46	0.29	3.39

Note: E.U.W.: Total Unit Weight, pcf;
E.U.W.: Effective Unit Weight, pcf;
Fi: Angle of Internal Friction, degree;
C: Cohesion, psf
Ko: Coefficient of At Rest Earth Pressure;
Kp: Coefficient of Passive Earth Pressure;
Ka: Coefficient of Active Earth Pressure;

4.2.2 Construction Considerations

Construction of the proposed relief line will require excavation to a maximum depth of approximately 20 feet below existing grades. There are many residential houses located near the proposed alignment. Based on the distance of the houses to the construction site and our experience with similar projects, we recommend the owner of the project and the design/construction team to take precautionary measures to avoid damage to the adjacent structures to protect the property owners as well as the City and the design/construction team against frivolous claims. The following precautionary measures are recommended based on our experiences in similar projects.

Communications We recommend that the City communicate with local communities, especially adjacent residences, about the construction schedule, sequence and potential impact to their properties from the proposed construction. The residences should be provided with a point of contact to answer their questions and address their concerns.

Pre-construction condition survey We recommend a pre-construction survey be performed for the structures located close to the construction site or potentially having the most significant impact from the construction activities. The pre-construction survey should include documentation of existing cracks and any other noticeable distresses on the structures.

Monitoring during construction Depending on the outcome of the condition survey and the method of construction, the existing structures may be monitored during construction. The monitoring may include recording the changes of existing cracks and ground vibration. We recommend the pre-condition survey and monitoring be performed by the City and its consultants, not by the contractor. Groundwater monitoring should be performed considering the depth of dewatering. The consultant to be retained by the City should prepare plans for monitoring based on the construction plan and results from the pre-condition survey.

Dewatering Groundwater was encountered at approximately 4 to 6 feet below the existing ground surface. We anticipate dewatering will be needed for excavation. We recommend that the groundwater be lowered to a depth of at least two feet below the bottom of the excavation. The contractor should determine the method of dewatering. It is important to note that extensive dewatering could cause a drop in groundwater level outside the sheet pile walls which may have detrimental impact to the existing structures. If possible, we recommend that dewatering be limited to inside the excavation. Furthermore, dewatering should be performed as short duration as necessary. Monitoring of groundwater levels may be performed if extensive dewatering is required where structures exist in the close proximity.

Potential Hard Installation Dense soils were encountered at several of the exploration locations. The contractor should review the soil conditions and use proper equipment to install the excavation support to the design tip elevations.

Backfill Placement All material to be used for backfill should be evaluated and tested by Geotechnical Engineer to determine their suitability for backfill. In general, backfill material should be granular materials containing less than 25% fines passing the No. 200 sieve. All backfills should be placed in thin (eight to ten inches loose) lifts and compacted to a minimum of 95% of the soil's modified proctor maximum dry density (ASTM D-1557). In most cases, the on-site soils have moisture content above optimum value. Some manipulation of the moisture content will be required during the filling operation to obtain the required degree of compaction. The manipulation of the moisture content is highly dependent on weather conditions and site drainage conditions. Therefore, the contractor should prepare both dry and wet fill materials to obtain the specified compaction during grading. Sufficient density tests should be performed to confirm the required compaction of the fill material. Based on the findings of field exploration, sandy soils classified as SP-SM, SM, and SC may be suitable backfill material, while the clayey soils classified as CL or CH will not be acceptable backfill material.

4.3 Seismic Design Parameters

Based on the findings from the subsurface exploration and our knowledge of the local geological formation in the project area, the site can be classified as Site Class D in accordance with IBC 2006. The seismic design parameters obtained based on IBC 2006 are summarized in table below. The design response spectrum curve, as presented in the appendix, was developed based on the S_{DS} and S_{D1} values according to IBC 2006.

Summary of Seismic Design Parameters

Site Location (Lat. – Long.)	Site Classification	S_s	S_1	F_a	F_v	S_{DS}	S_{D1}
32.033312° -81.097485°	D	0.393g	0.120g	1.486	2.32	0.389g	0.186g

1. In general accordance with the *2006 International Building Code,* Table 1613.5.2.
2. The 2006 International Building Code requires a site soil profile determination extending a depth of 100 feet for seismic site classification. The current scope does not include 100 foot soil profile determination. Explorations for this project were extended to a maximum depth of 56 feet. The seismic site class definition was provided in consideration of the overall soil conditions as well as the general geology of the area.

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 explorations performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between exploration locations, 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, and 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

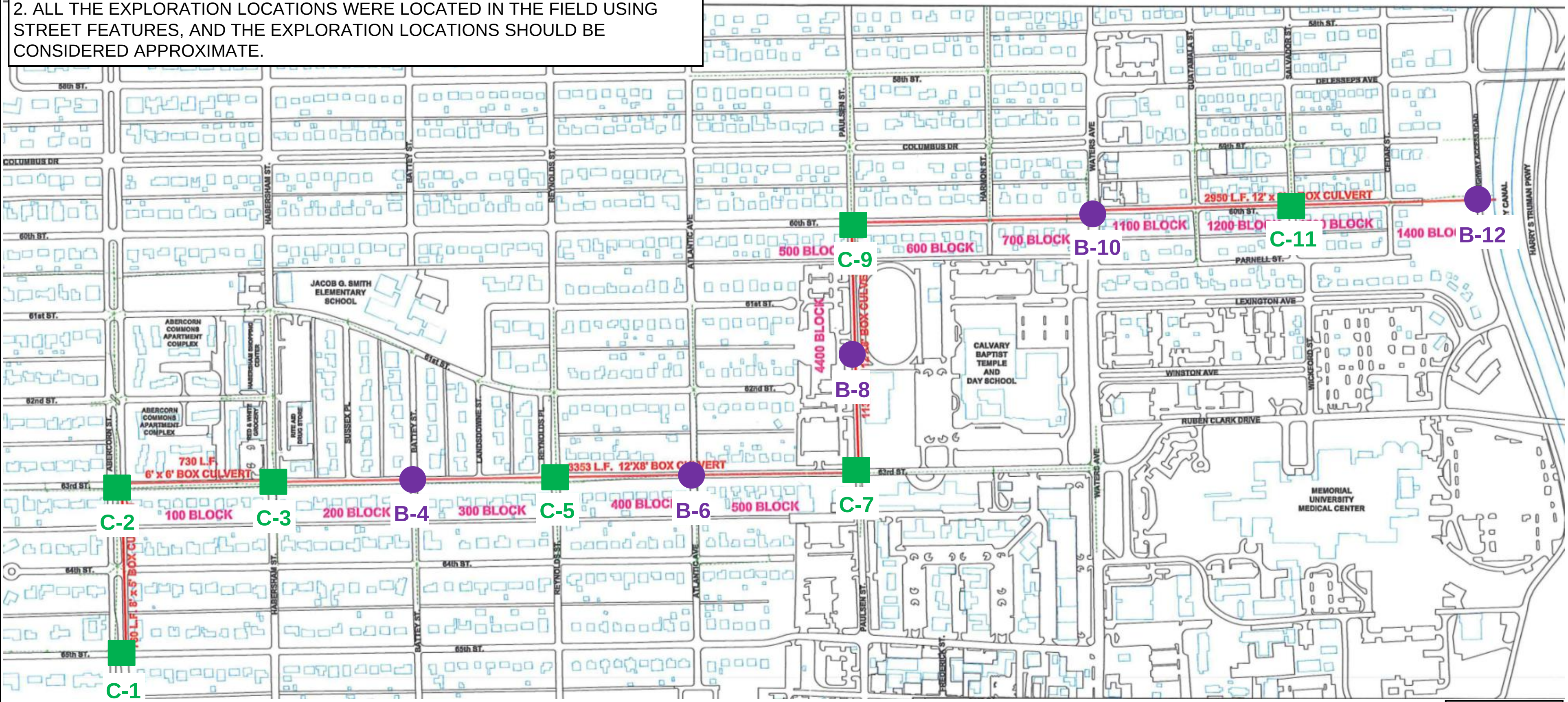
N

Project Manager: ZL	Project No. ES115039	Terracon Consulting Engineers & Scientists	SITE LOCATION MAP	Exhibit
Drawn by: WL	Scale: N.T.S.	2201 Rowland Avenue Savannah, Georgia 31404	CITY OF SAVANNAH 63RD ST RELIEF LINE	A-1
Checked by: ZL	File Name:	PH. (912) 629-4000 FAX. (912) 629-4001	SAVANNAH, GEORGIA	
Approved by: GL	Date: 4/12/2011			

NOTES:

1. THIS EXPLORATION LOCATION PLAN WAS MODIFIED FROM THE SITE LAYOUT PREPARED BY EMC ENGINEERING SERVICES, INC. TITLED "63rd STREET RELIEF LINE DRAINAGE IMPROVEMENT", DATED MARCH 2011 FOR CITY OF SAVANNAH.

2. ALL THE EXPLORATION LOCATIONS WERE LOCATED IN THE FIELD USING STREET FEATURES, AND THE EXPLORATION LOCATIONS SHOULD BE CONSIDERED APPROXIMATE.



N

LEGEND:

CPT

SPT

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

Project Manager: ZL	Project No. ES115039
Drawn by: WL	Scale: N.T.S.
Checked by: ZL	File Name:
Approved by: GL	Date: 4/12/2011

Terracon
Consulting Engineers & Scientists

2201 Rowland Avenue Savannah, Georgia 31404
PH. (912) 629-4000 FAX. (912) 629-4001

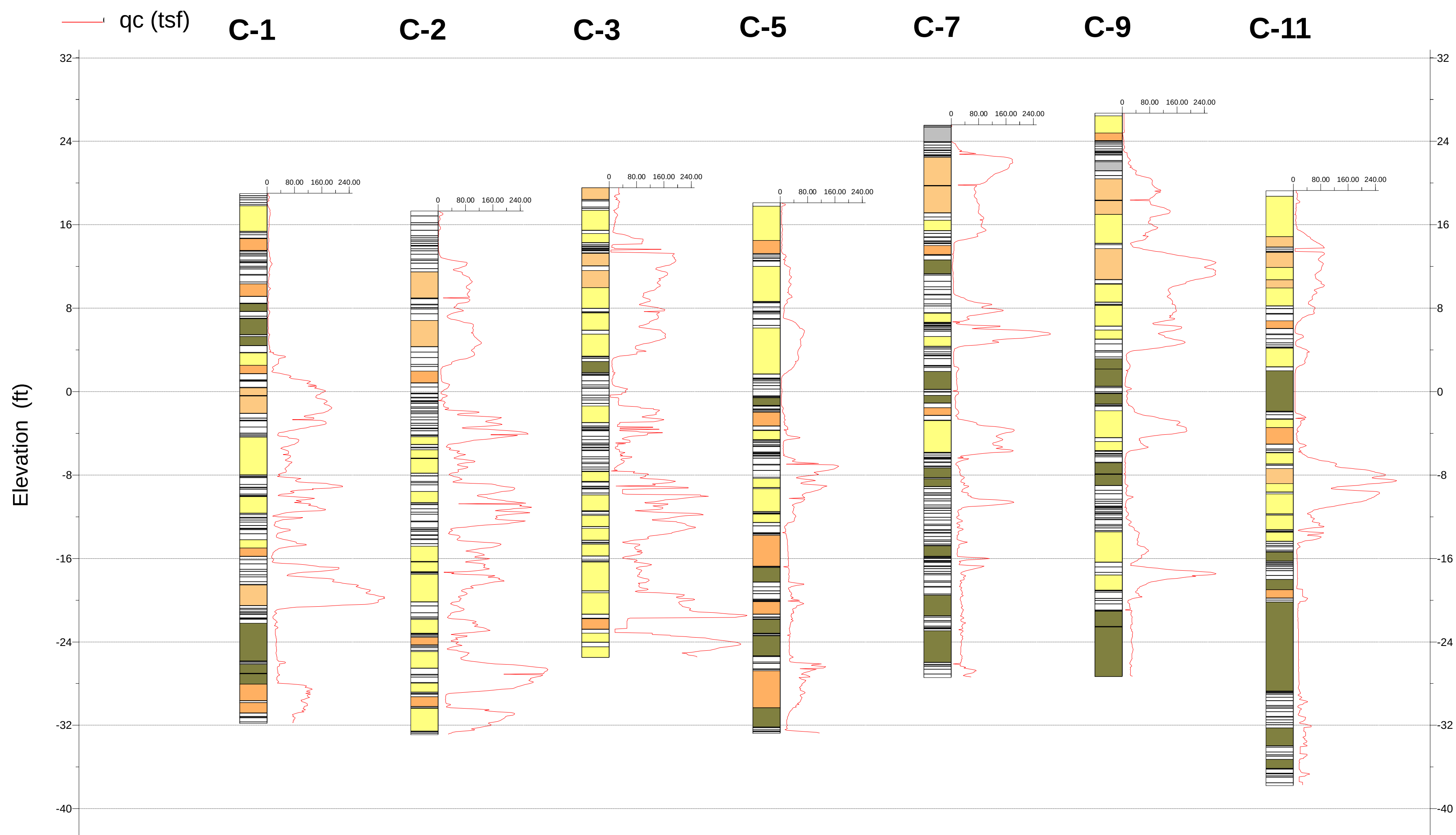
EXPLORATION LOCATION PLAN

CITY OF SAVANNAH 63RD ST RELIEF LINE

SAVANNAH, GEORGIA

Exhibit

A-2



NOTE:
ELEVATION SURVEY WAS NOT PERFORMED AS PART OF THIS GEOTECHNICAL EXPLORATION, THE SURFACE ELEVATIONS WERE EXTRAPOLATED FROM THE ELEVATIONS IN THE GEOTECHNICAL ENGINEERING REPORT PREPARED BY ECS LTD FOR EMC ENGINEERING SERVICES, INC., DATED APRIL 27, 2001. THE ELEVATIONS SHOULD BE CONSIDERATED APPROXIMATE.

Project Manager: ZL	Project No. ES115039
Drawn by: WL	Scale: N.T.S.
Checked by: ZL	File Name:
Approved by: GL	Date: 4/9/2011

Terracon
Consulting Engineers & Scientists

2201 Rowland Avenue Savannah, Georgia 31404
PH. (912) 629-4000 FAX. (912) 629-4001

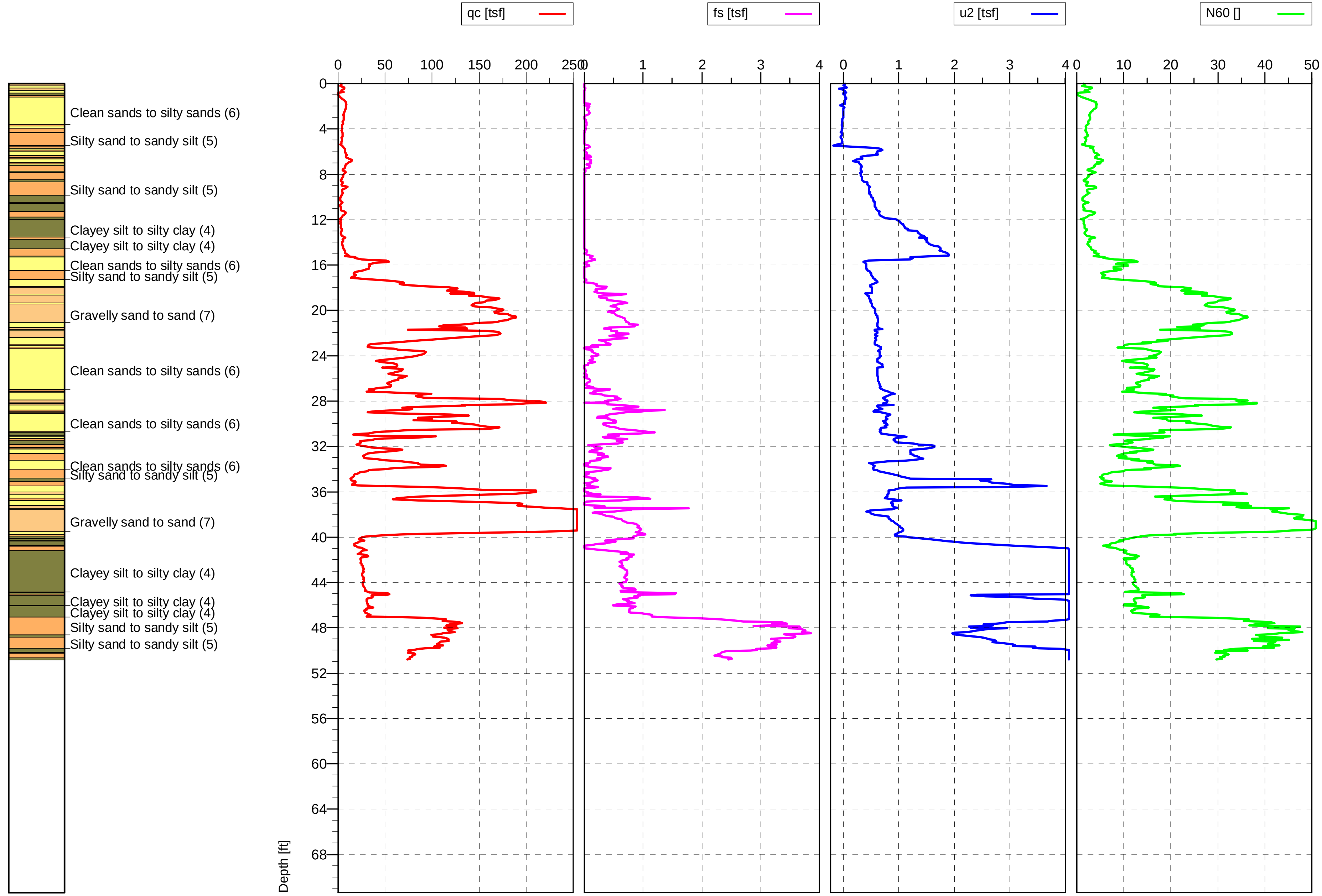
CPT SOUNDINGS CROSS SECTION

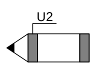
CITY OF SAVANNAH 63RD ST RELIEF LINE

SAVANNAH, GEORGIA

Exhibit

A-3

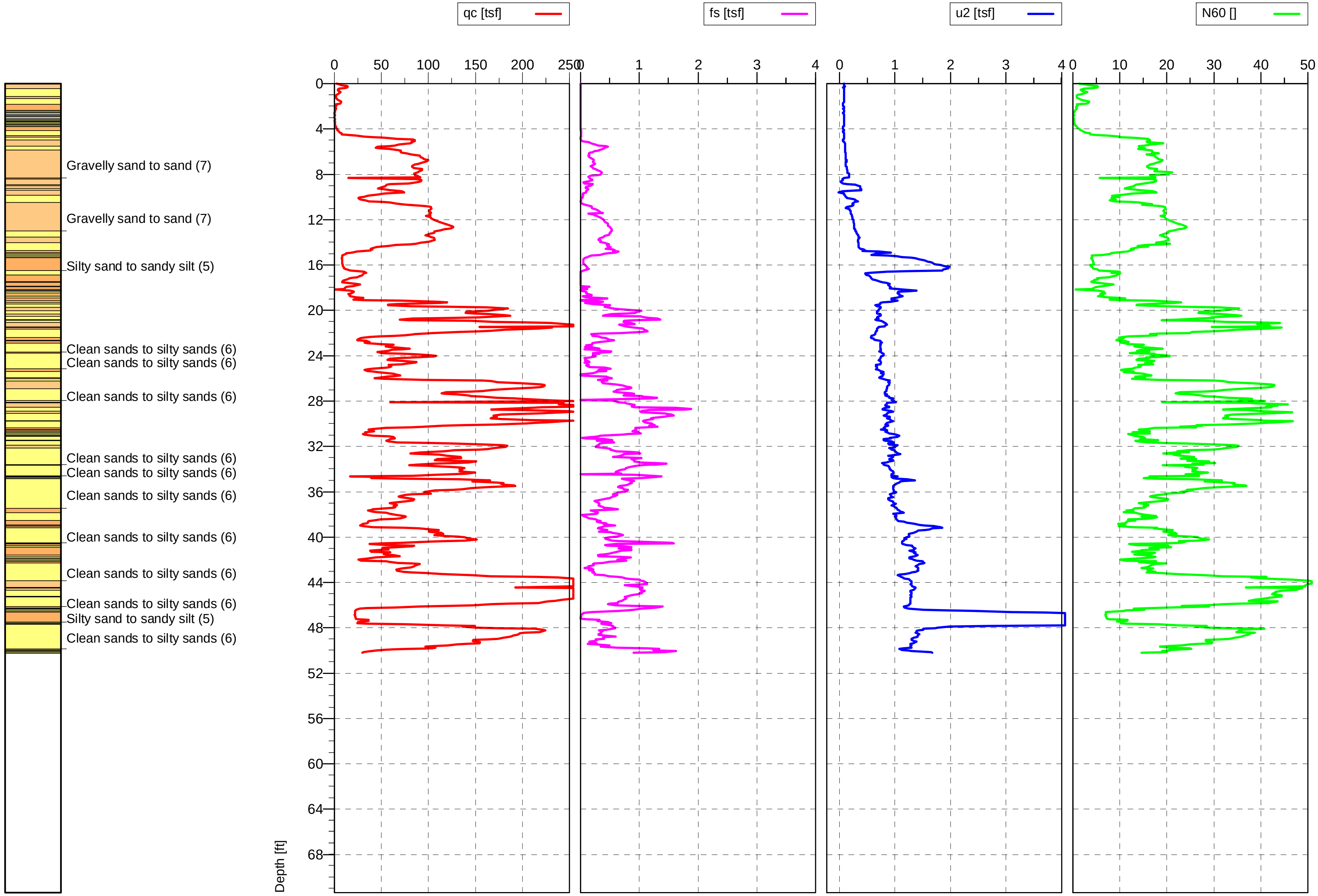




Terracon

Cone No: 0
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Savannah, Georgia	Position:	Ground level:	Test no: C-1
Project ID: ES115036	Client: EMC Engineering Services, Inc.	Date: 4/6/2011	Scale: 1 : 150
Project: City of Savannah 63rd St. Relief Line		Page: 1/1	Fig:
		File: C1.cpd	



Terracon

Cone No: 0
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Savannah, Georgia	Position:	Ground level:	Test no: C-2
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Project: City of Savannah 63rd St. Relief Line		Page: 1/1	Fig:
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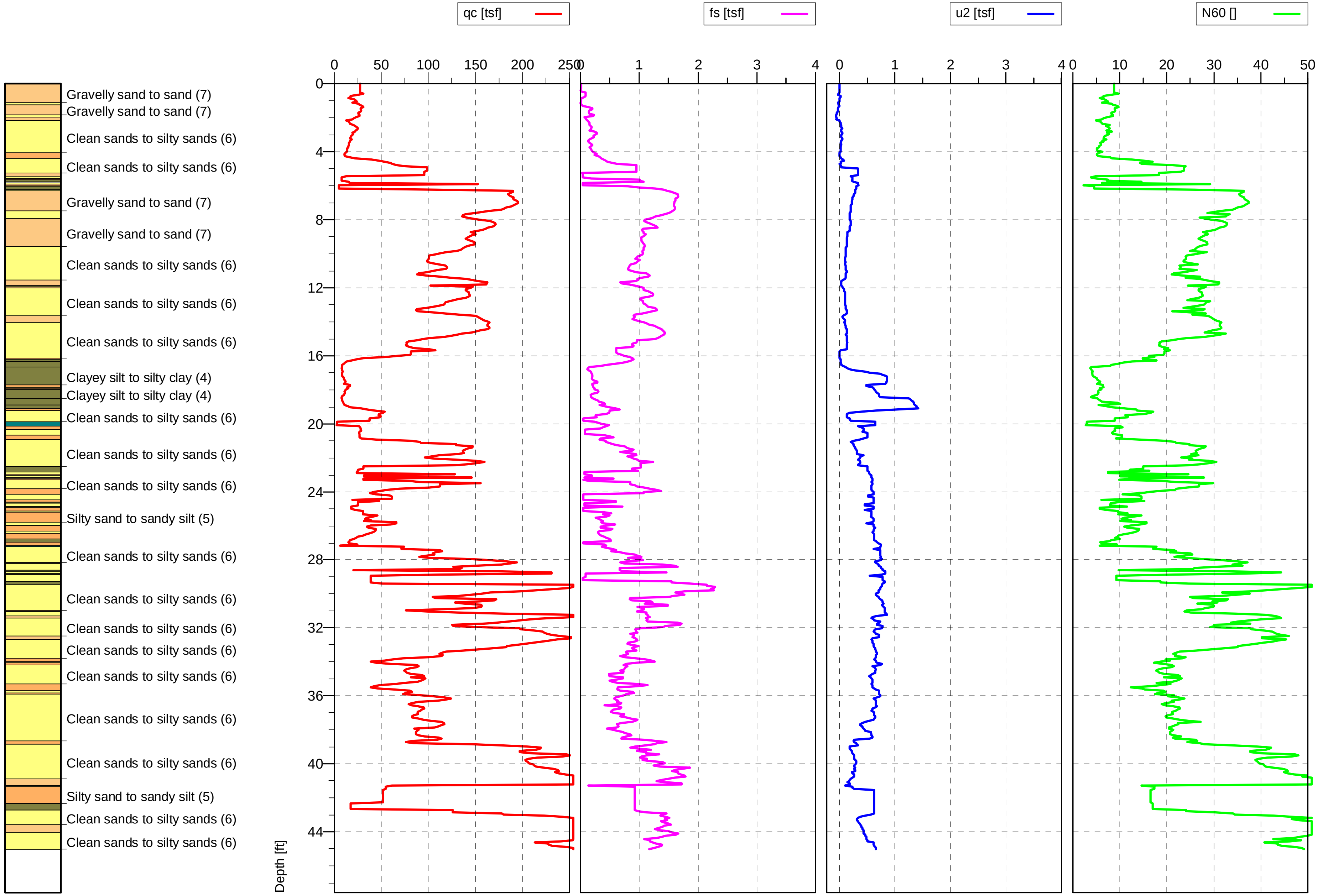

U2

Cone No: 0
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Savannah, Georgia	Position:	Ground level:	Test no: C-3
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Project: City of Savannah 63rd St. Relief Line		Page: 1/1	Fig:
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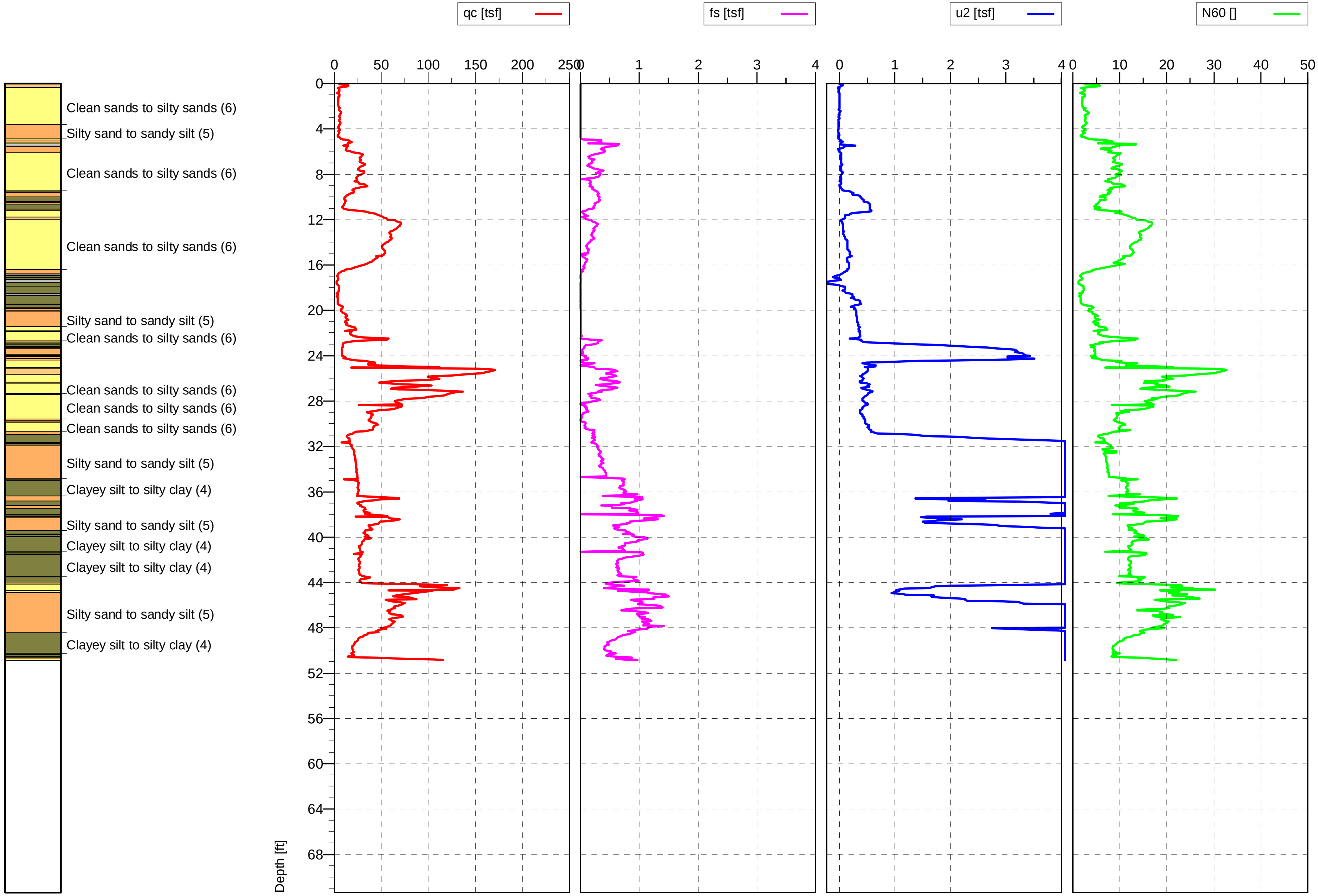

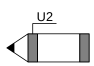

Terracon

Cone No: 0
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Savannah, Georgia	Position:	Ground level:	Test no: C-5
Project ID: ES115039	Client: EMC Engineering Services, Inc.	Date: 4/6/2011	Scale: 1 : 150
Project: City of Savannah 63rd St. Relief Line		Page: 1/1	Fig:
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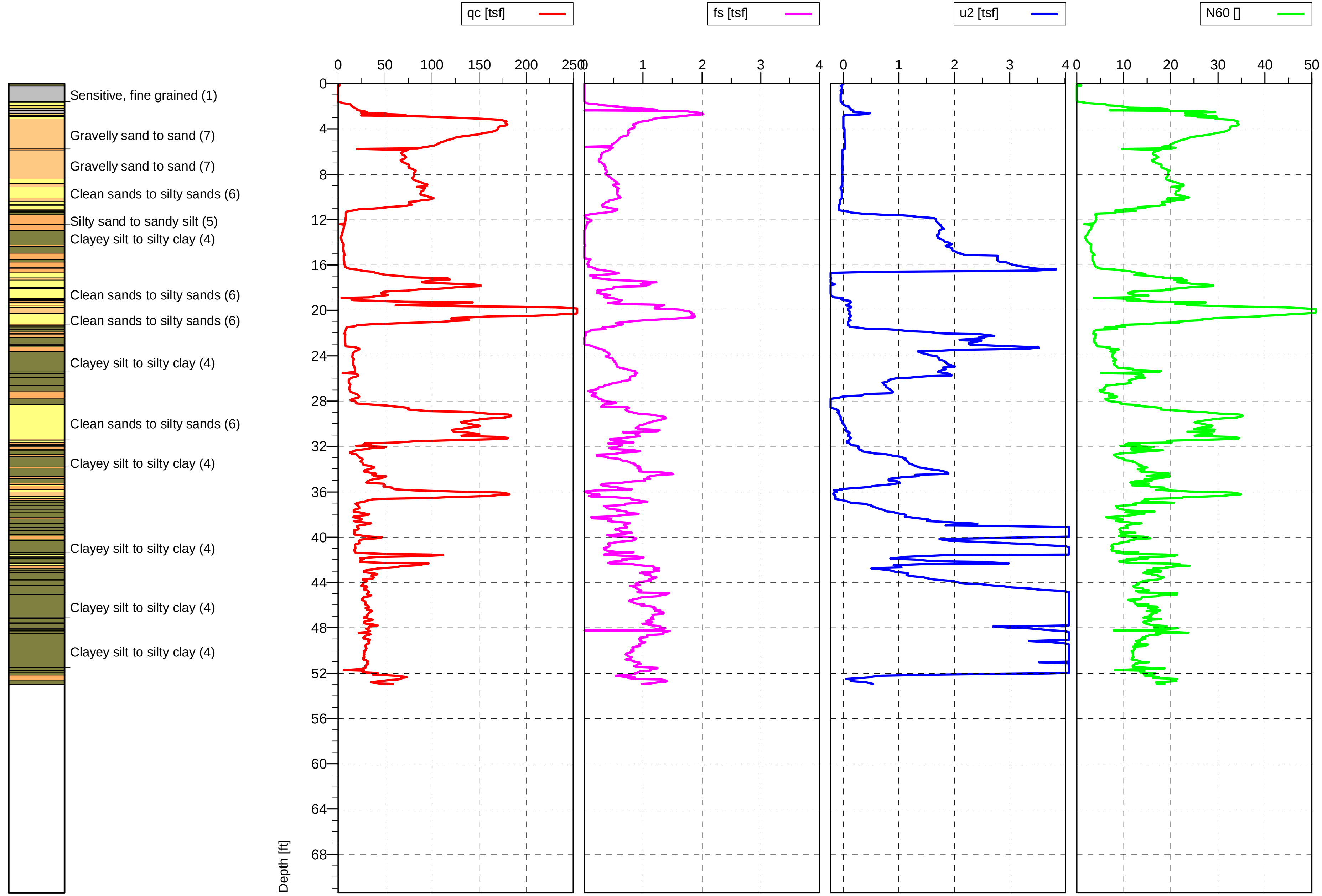

Terracon

U2

Cone No: 0
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Savannah, Georgia	Position:	Ground level:	Test no: C-7
Project ID: ES115039	Client: EMC Engineering Services, Inc.	Date: 4/6/2011	Scale: 1 : 150
Project: City of Savannah 63rd St. Relief Line		Page: 1/1	Fig:
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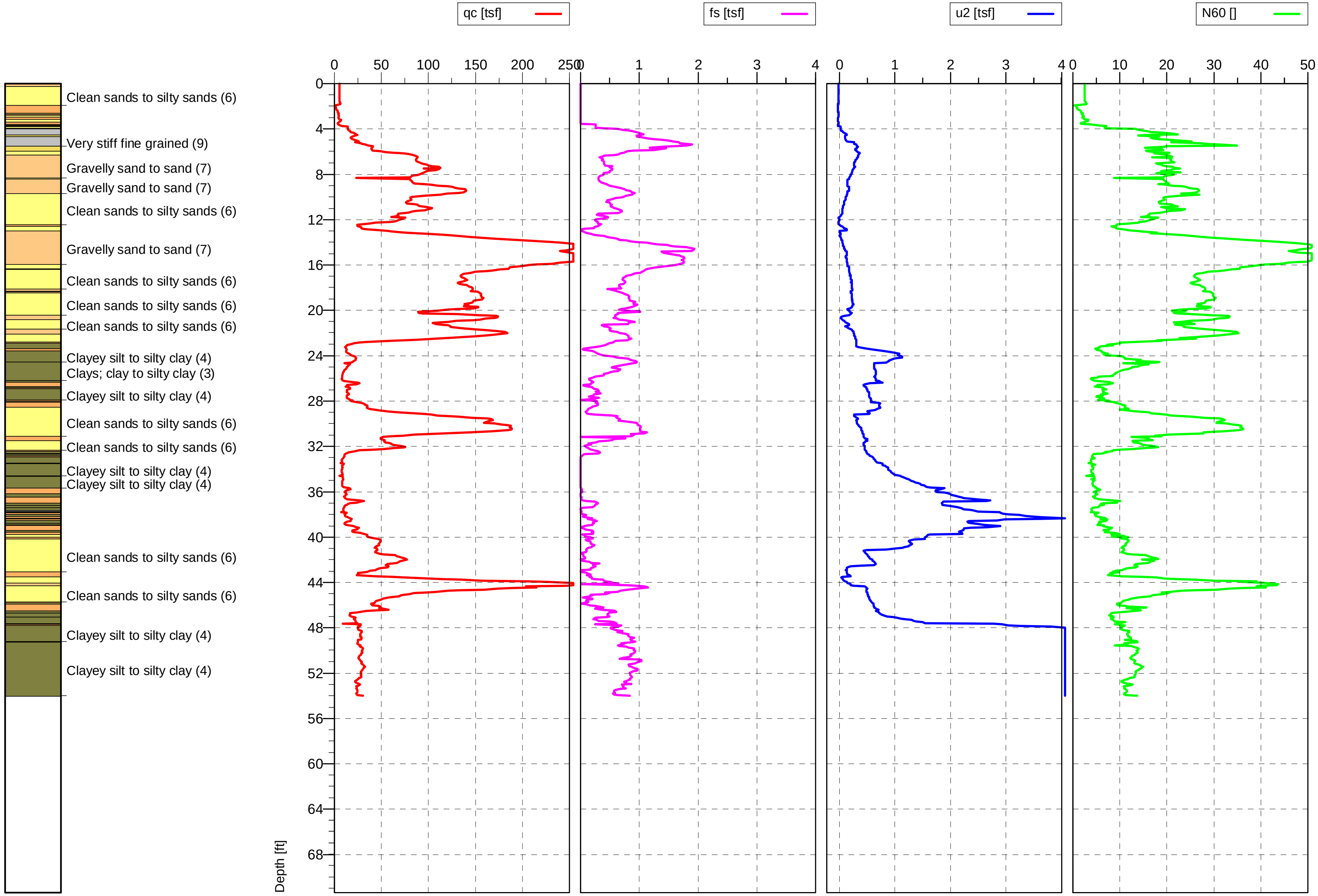

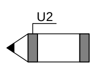

Cone No: 0
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Savannah, Georgia	Position:	Ground level:	Test no: C-9
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Project: City of Savannah 63rd St. Relief Line		Page: 1/1	Fig:
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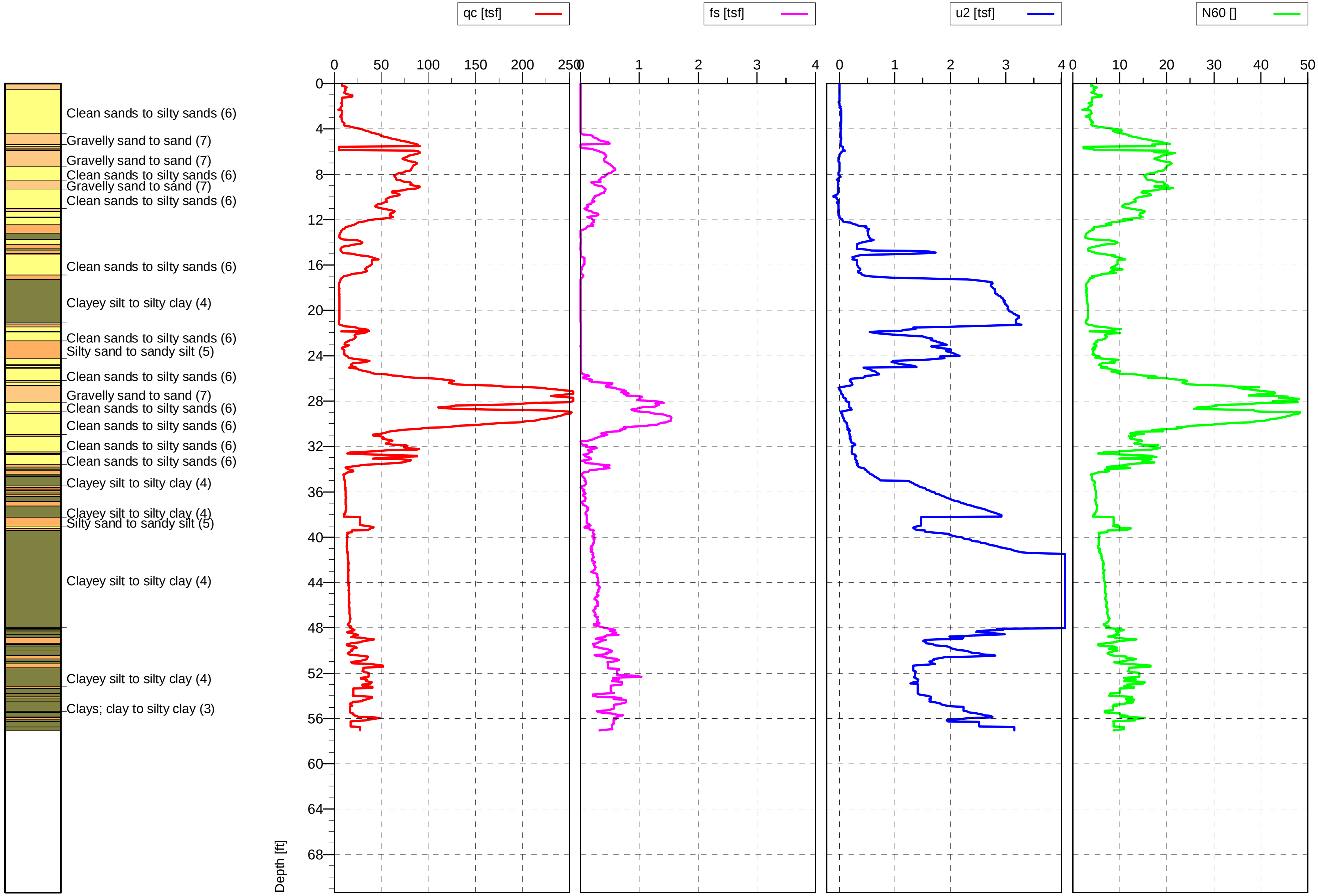
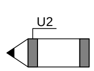
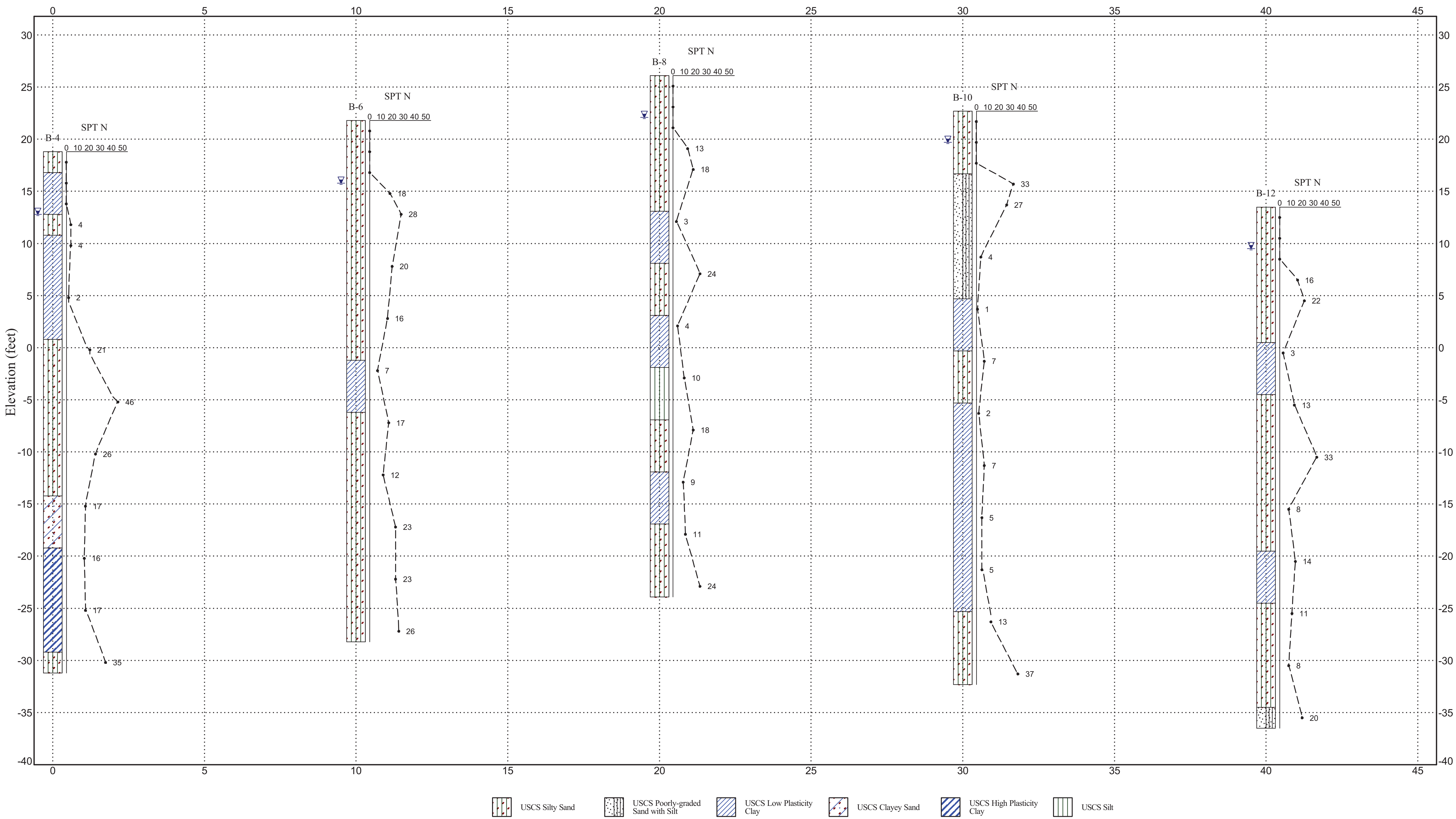




Cone No: 0
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Savannah, Georgia	Position:	Ground level:	Test no: C-11
Project ID: ES115039	Client: EMC Engineering Services, Inc.	Date: 4/6/2011	Scale: 1 : 150
Project: City of Savannah 63rd St. Relief Line		Page: 1/1	Fig:
		File: C11.cpd	



NOTE:

ELEVATION SURVEY WAS NOT PERFORMED AS PART OF THIS GEOTECHNICAL EXPLORATION. THE SURFACE ELEVATIONS WERE EXTRAPOLATED FROM THE ELEVATIONS IN THE GEOTECHNICAL ENGINEERING REPORT PREPARED BY ECS LTD FOR EMC ENGINEERING SERVICES, INC., DATED APRIL 27, 2001. THE ELEVATIONS SHOULD BE CONSIDERATED APPROXIMATE.

Terracon

Standard Penetration Test (SPT) Boring Cross-Section	Figure:
Project Name: City of Savannah 63rd Street Relief Line	
Project Number: ES115039	
Project Location: Savannah, Georgia	

PROJECT No. ES115039

City of Savannah 63rd Street Relief Line
Savannah, Georgia

LOG OF BORING NO. B-4

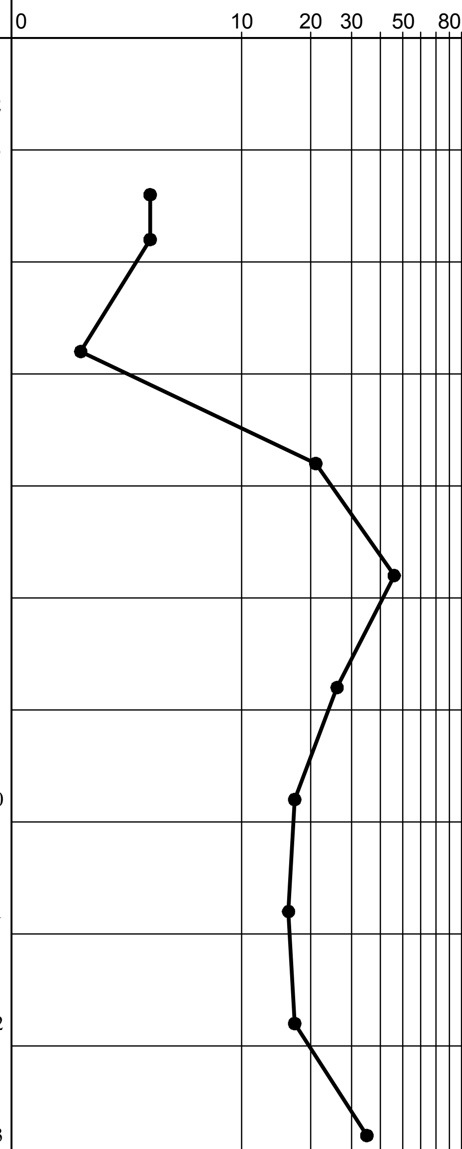
DATE :	4/6/2011	LOGGED BY:	JM
DRILLING METHOD:	Mud Rotary	HAMMER TYPE:	Safety
DRILLING RIG:	CME-55	DRILLER:	Old South Drilling
WATER LEVEL @ TOB:	6	WATER LEVEL @ 24 hrs:	NA

NOTES:
Soil classified in accordance with ASTM D2488. The SPT blow counts have not been adjusted for overburden pressure.

DEPTH (feet)	MATERIAL DESCRIPTION	ELEVATION (feet)	SAMPLE NO/TYPE	N VALUE
	Brown, silty fine SAND (SM), moist		HA1	
	Brown, sandy lean CLAY (CL), moist	15.0	HA2	
5	Olive-gray, sandy lean CLAY (CL), moist		HA3	
	Very loose, brown and tan, silty fine SAND (SM), with clay clasts, moist		SS4	4
10	Soft, gray, sandy lean CLAY (CL), wet	10.0	SS5	4
15	Very soft, brown and gray, sandy lean CLAY (CL), wet	5.0	SS6	2
20	Medium dense, gray, silty SAND (SM), wet	0.0	SS7	21
25	Dense, gray, silty fine SAND (SM), wet	-5.0	SS8	46
30	Medium dense, gray, silty fine SAND (SM), with trace clay, wet	-10.0	SS9	26
35	Medium dense, gray, clayey coarse SAND (SC), with gravels, with broken shell fragments, wet	-15.0	SS10	17
40	Very stiff, gray, sandy fat CLAY (CH), moist	-20.0	SS11	16
45	Very stiff, gray, sandy fat CLAY (CH), moist	-25.0	SS12	17
50	Dense, gray, silty coarse SAND (SM), with trace clay, wet	-30.0	SS13	35

END OF BORING @ 50.0 ft

STANDARD PENETRATION TEST DATA (blows/foot)



24-hrs water table

Water table at end of the boring

PROJECT No. ES115039

City of Savannah 63rd Street Relief Line
Savannah, Georgia

LOG OF BORING NO. B-6

DATE :	4/6/2011	LOGGED BY:	JM
DRILLING METHOD:	Mud Rotary	HAMMER TYPE:	Safety
DRILLING RIG:	CME-55	DRILLER:	Old South Drilling
WATER LEVEL @ TOB:	6	WATER LEVEL @ 24 hrs:	NA

NOTES:
Soil classified in accordance with ASTM D2488. The SPT blow counts have not been adjusted for overburden pressure.

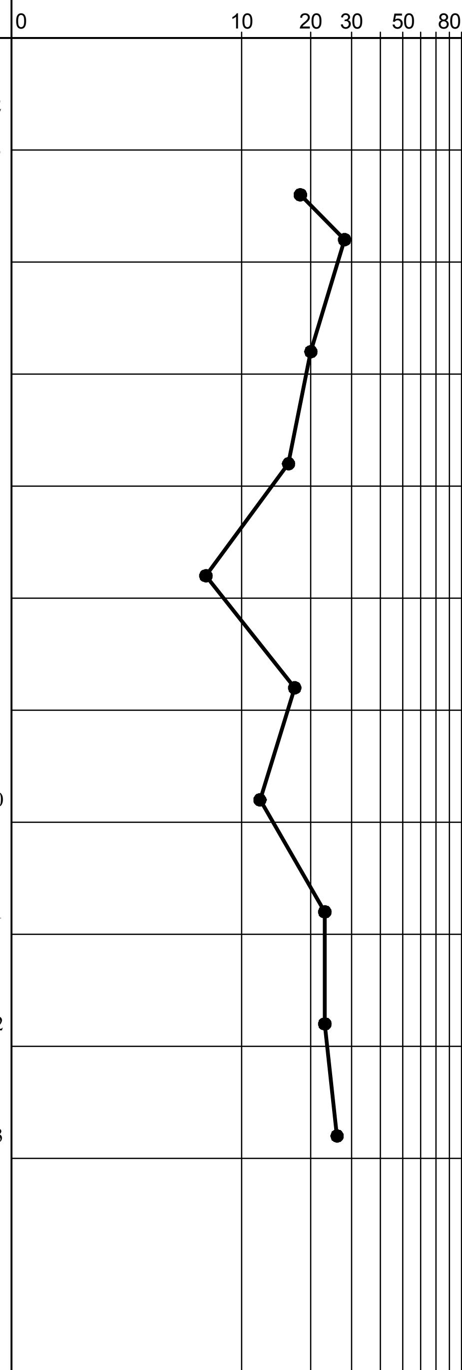
MATERIAL DESCRIPTION	SAMPLE NO/TYPE	N VALUE
Light brown, silty SAND (SM), with trace clay, moist	HA1	
Brown, silty fine SAND (SM), moist	HA2	
Tan, silty fine SAND (SM), moist	HA3	
Medium dense, brown and light orange, silty fine SAND (SM), moist	SS4	18
Medium dense, brown and light orange, silty fine SAND (SM), moist	SS5	28
Medium dense, tan, silty fine SAND (SM), wet	SS6	20
Medium dense, tan, light orange and gray, silty fine SAND (SM), wet	SS7	16
Medium stiff, gray, sandy lean CLAY (CL), wet	SS8	7
Medium dense, gray, silty fine SAND (SM), wet	SS9	17
Medium dense, gray, silty SAND (SM), with clay clasts, wet	SS10	12
Medium dense, olive-gray, silty fine SAND (SM), wet	SS11	23
Medium dense, olive-gray, silty fine SAND (SM), wet	SS12	23
Medium dense, gray, silty coarse SAND (SM), wet	SS13	26

END OF BORING @ 50.0 ft

DEPTH (feet): 5, 10, 15, 20, 25, 30, 35, 40, 45, 50

ELEVATION (feet): 20.0, 15.0, 10.0, 5.0, 0.0, -5.0, -10.0, -15.0, -20.0, -25.0

STANDARD PENETRATION TEST DATA (blows/foot)



24-hrs water table

Water table at end of the boring

PROJECT No. ES115039

City of Savannah 63rd Street Relief Line
Savannah, Georgia

LOG OF BORING NO. B-8

DATE :	4/6/2011	LOGGED BY:	JM
DRILLING METHOD:	Mud Rotary	HAMMER TYPE:	Safety
DRILLING RIG:	CME-55	DRILLER:	Old South Drilling
WATER LEVEL @ TOB:	4	WATER LEVEL @ 24 hrs:	NA

NOTES:
Soil classified in accordance with ASTM D2488. The SPT blow counts have not been adjusted for overburden pressure.

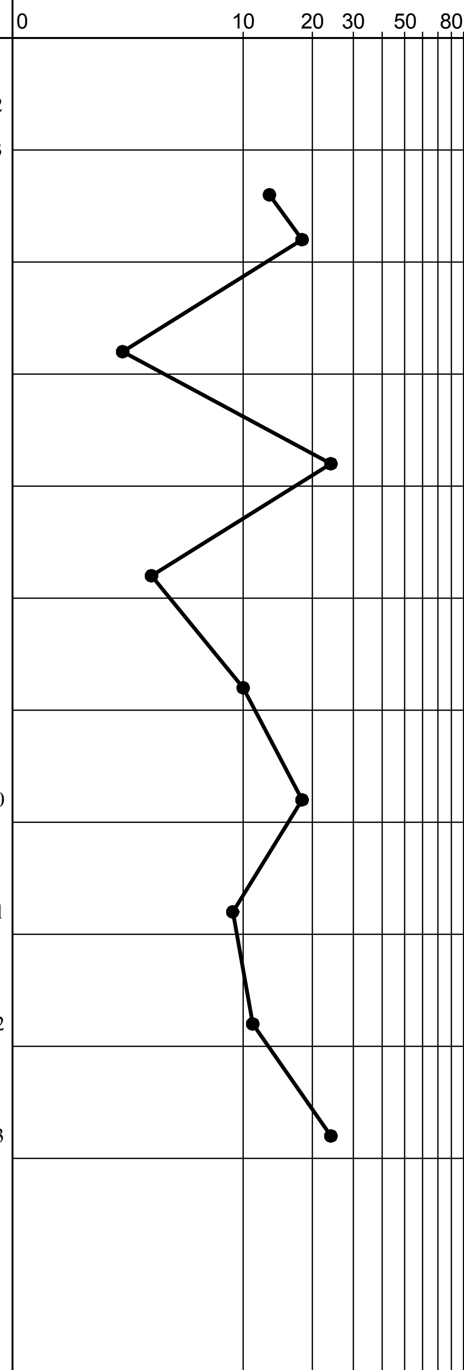
MATERIAL DESCRIPTION	SAMPLE NO/TYPE	N VALUE
Tan and light orange, silty fine SAND (SM), moist	HA1	
Tan and light orange, silty fine SAND (SM), moist	HA2	
Tan and light orange, silty fine SAND (SM), moist	HA3	
Medium dense, gray, silty fine SAND (SM), wet	SS4	13
Medium dense, tan and light orange, silty fine SAND (SM), with clay clasts, wet	SS5	18
Soft, gray, lean CLAY (CL), wet	SS6	3
Medium dense, gray, silty fine SAND (SM), wet	SS7	24
Soft, gray, sandy lean CLAY (CL), with broken shell fragments, wet	SS8	4
Stiff, olive-gray, sandy SILT (ML), wet	SS9	10
Medium dense, gray, silty SAND (SM), wet	SS10	18
Stiff, olive-gray, sandy lean CLAY (CL), wet	SS11	9
Medium dense, gray, silty fine SAND (SM), wet	SS12	11
Medium dense, gray, silty coarse SAND (SM), wet	SS13	24

END OF BORING @ 50.0 ft

DEPTH (feet): 5, 10, 15, 20, 25, 30, 35, 40, 45, 50

ELEVATION (feet): 25.0, 20.0, 15.0, 10.0, 5.0, 0.0, -5.0, -10.0, -15.0, -20.0

STANDARD PENETRATION TEST DATA (blows/foot)



24-hrs water table
Water table at end of the boring

Terracon

PROJECT No. ES115039

City of Savannah 63rd Street Relief Line
Savannah, Georgia

LOG OF BORING NO. B-10

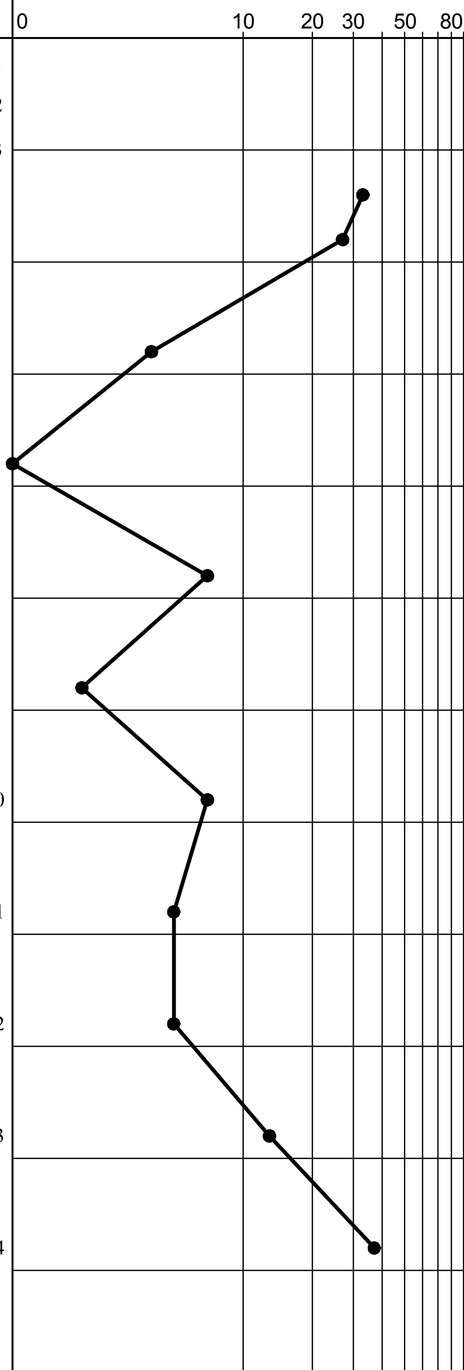
DATE :	4/5/2011	LOGGED BY:	JM
DRILLING METHOD:	Mud Rotary	HAMMER TYPE:	Safety
DRILLING RIG:	CME-55	DRILLER:	Old South Drilling
WATER LEVEL @ TOB:	3	WATER LEVEL @ 24 hrs:	NA

NOTES:
Soil classified in accordance with ASTM D2488. The SPT blow counts have not been adjusted for overburden pressure.

DEPTH (feet)	MATERIAL DESCRIPTION	ELEVATION (feet)	SAMPLE NO/TYPE	N VALUE
	Dark brown, silty SAND (SM), with woods, with broken shell fragments, moist		HA1	
	Light brown, silty SAND (SM), moist	20.0	HA2	
5	Light brown and light orange, clayey SAND (SC), moist		HA3	
	Dense, tan and light brown, fine SAND with silt (SP-SM), moist		SS4	33
10	Medium dense, tan and light brown, fine SAND with silt (SP-SM), moist	15.0	SS5	27
15	Very loose, gray, fine SAND with silt (SP-SM), wet	10.0	SS6	4
20	Very soft, gray lean CLAY (CL), wet	5.0	SS7	1
25	Loose, gray, silty coarse SAND (SM), with broken shell fragments, wet	0.0	SS8	7
30	Very soft, gray, sandy lean CLAY (CL), wet	-5.0	SS9	2
35	Medium stiff, gray, lean CLAY (CL), wet	-10.0	SS10	7
40	Medium stiff, gray, lean CLAY (CL), wet	-15.0	SS11	5
45	Medium stiff, gray, sandy lean CLAY (CL), wet	-20.0	SS12	5
50	Medium dense, gray, silty SAND (SM), wet	-25.0	SS13	13
55	Medium dense, gray, silty SAND (SM), wet	-30.0	SS14	37

END OF BORING @ 55.0 ft

STANDARD PENETRATION TEST DATA (blows/foot)



24-hrs water table

Water table at end of the boring

PROJECT No. ES115039

City of Savannah 63rd Street Relief Line
Savannah, Georgia

LOG OF BORING NO. B-12

DATE :	4/5/2011	LOGGED BY:	JM
DRILLING METHOD:	Mud Rotary	HAMMER TYPE:	Safety
DRILLING RIG:	CME-55	DRILLER:	Old South Drilling
WATER LEVEL @ TOB:	4	WATER LEVEL @ 24 hrs:	NA

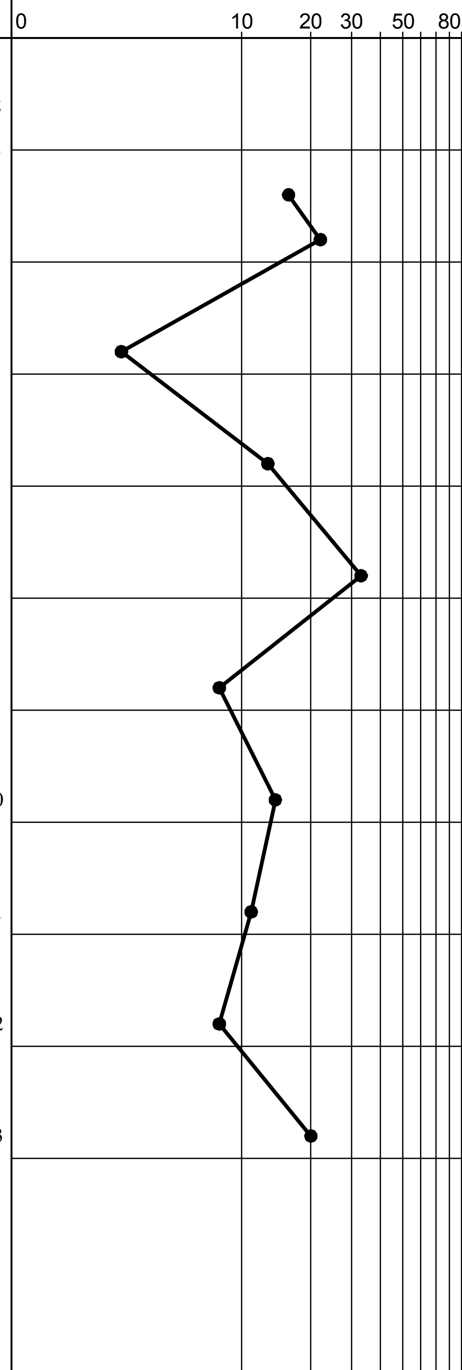
NOTES:
Soil classified in accordance with ASTM D2488. The SPT blow counts have not been adjusted for overburden pressure.

DEPTH (feet): 5, 10, 15, 20, 25, 30, 35, 40, 45, 50

MATERIAL DESCRIPTION	ELEVATION (feet)	SAMPLE NO/TYPE	N VALUE
Brown, silty SAND (SM), moist		HA1	
Dark brown, clayey SAND (SC), moist	10.0	HA2	
Light brown, silty fine SAND (SM), moist		HA3	
Medium dense, dark brown, silty SAND (SM), with clay clasts, moist		SS4	16
Medium dense, light brown, silty SAND (SM), moist	5.0	SS5	22
Soft, gray, sandy lean CLAY (CL), moist	0.0	SS6	3
Medium dense, gray, silty coarse SAND (SM), with a lot of gravels and broken shell fragments, wet	-5.0	SS7	13
Dense, light brown and gray, silty SAND (SM), wet	-10.0	SS8	33
Loose, gray, silty SAND (SM), wet	-15.0	SS9	8
Stiff, gray, sandy lean CLAY (CL), wet	-20.0	SS10	14
Medium dense, gray,silty SAND (SM), wet	-25.0	SS11	11
Loose, gray, silty SAND (SM), wet	-30.0	SS12	8
Medium dense, gray, fine SAND with silt (SP-SM), wet	-35.0	SS13	20

END OF BORING @ 50.0 ft

STANDARD PENETRATION TEST DATA (blows/foot)



24-hrs water table

Water table at end of the boring

Terracon

Hand Auger Boring Log
Project Name: City of Savannah 63rd Street Relief Line
Project Number: ES115039
Project Location: Savannah, Georgia

C-1		
Depth Below Grade (inch)	**Material Description**	**USCS CLASSIFICATION**
0 to 30	Black and dark brown, sandy CLAY	CL
30 to 60	Black and dark brown, sandy CLAY, with tan streaks	CL
60 to 72	Black and dark brown, sandy CLAY, with tan/red streaks	CL
Groundwater not Encountered		

C-2		
Depth Below Grade (inch)	**Material Description**	**USCS CLASSIFICATION**
0 to 24	Light brown, light orange and tan, silty fine SAND	SM
24 to 48	Tan, fine SAND with silt	SP-SM
48 to 72	Tan and light orange, silty fine SAND, wet	SM
Groundwater not Encountered		

C-3		
Depth Below Grade (inch)	**Material Description**	**USCS CLASSIFICATION**
0 to 36	Brown and light orange, silty SAND, w/ clay clasts	SM
36 to 72	Brown and light orange, sandy CLAY	CL
Groundwater not Encountered		

C-5		
Depth Below Grade (inch)	**Material Description**	**USCS CLASSIFICATION**
0 to 12	Brown silty SAND, with clay clasts	SM
12 to 72	Tan and light orange, silty SAND, with clay clasts	SM
Groundwater not Encountered		

C-7		
Depth Below Grade (inch)	**Material Description**	**USCS CLASSIFICATION**
0 to 72	Light brown and light orange, silty fine SAND	SM
Groundwater not Encountered		

C-9		
Depth Below Grade (inch)	**Material Description**	**USCS CLASSIFICATION**
0 to 24	Light brown, silty fine SAND, with trace roots	SM
24 to 72	Light brown, sandy CLAY	CL
Groundwater not Encountered		

C-11		
Depth Below Grade (inch)	**Material Description**	**USCS CLASSIFICATION**
0 to 24	Light brown, silty fine SAND, with trace roots	SM
24 to 72	Light brown, sandy CLAY	CL
Groundwater not Encountered		

FIELD EXPLORATION DESCRIPTION

Our field exploration program consisted of a total of 7 cone penetration test (CPT) soundings, 5 standard penetration test (SPT) borings, and 12 hand auger borings. The desired exploration locations were marked in the field by the Terracon field engineer using existing street features. The exploration locations as shown in the Exploration Location Plan should be considered accurate only to the degree implied by the means and methods used to define them.

The CPT soundings were performed in accordance with ASTM D 5778 using a Pagani rig mounted on a rubber track vehicle. During a CPT sounding, an electronically instrumented cone was hydraulically pushed through the soil to measure tip stress, sleeve friction and pore water pressure at two-centimeter intervals (approximately 1 inch). Based on the published empirical relationships, the measured data was used to derive stratigraphic profile and to estimate soil engineering properties. Prior to each CPT sounding, hand auger boring was performed to a depth of 6 ft BGS and the borehole was backfilled with in situ material. CPT cone was pushed in the backfilled borehole from 0 to 6 ft.

The SPT borings were drilled with truck-mounted CME-55 drilling rig using Mud Rotary techniques. Samples of the soil encountered in the borings were obtained using split-barrel sampling procedures. In the split barrel sampling procedure, the number of blows required to advance a standard 2-inch O.D. split barrel sampler the last 12 inches of the typical total 18-inch penetration by means of a 140-pound hammer with a free fall of 30 inches, is the standard penetration resistance value (SPT-N). This value is used to estimate the in situ relative density of cohesionless soils and consistency of cohesive soils. A safety hammer was used to advance the split-barrel sampler in the borings performed on this site. Prior to each SPT boring, hand auger boring was performed to a depth of 6 ft BGS.

Hand auger borings were conducted in general accordance with ASTM D 1452-80, Standard Practice for Soil Investigation and Sampling by Auger Borings. In this test, hand auger boring is drilled by rotating and advancing a bucket auger to the desired depths while periodically removing the auger from the hole to clear and examine the auger cuttings. The soils were classified in accordance with ASTM D 2488.

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APPENDIX B
SUPPORTING INFORMATION

Project Name: City of Savannah 63rd Street Relief Line
Terracon Project No.: ES115039
Project Location: Savannah, Georgia

Summary of Soil Laboratory Test

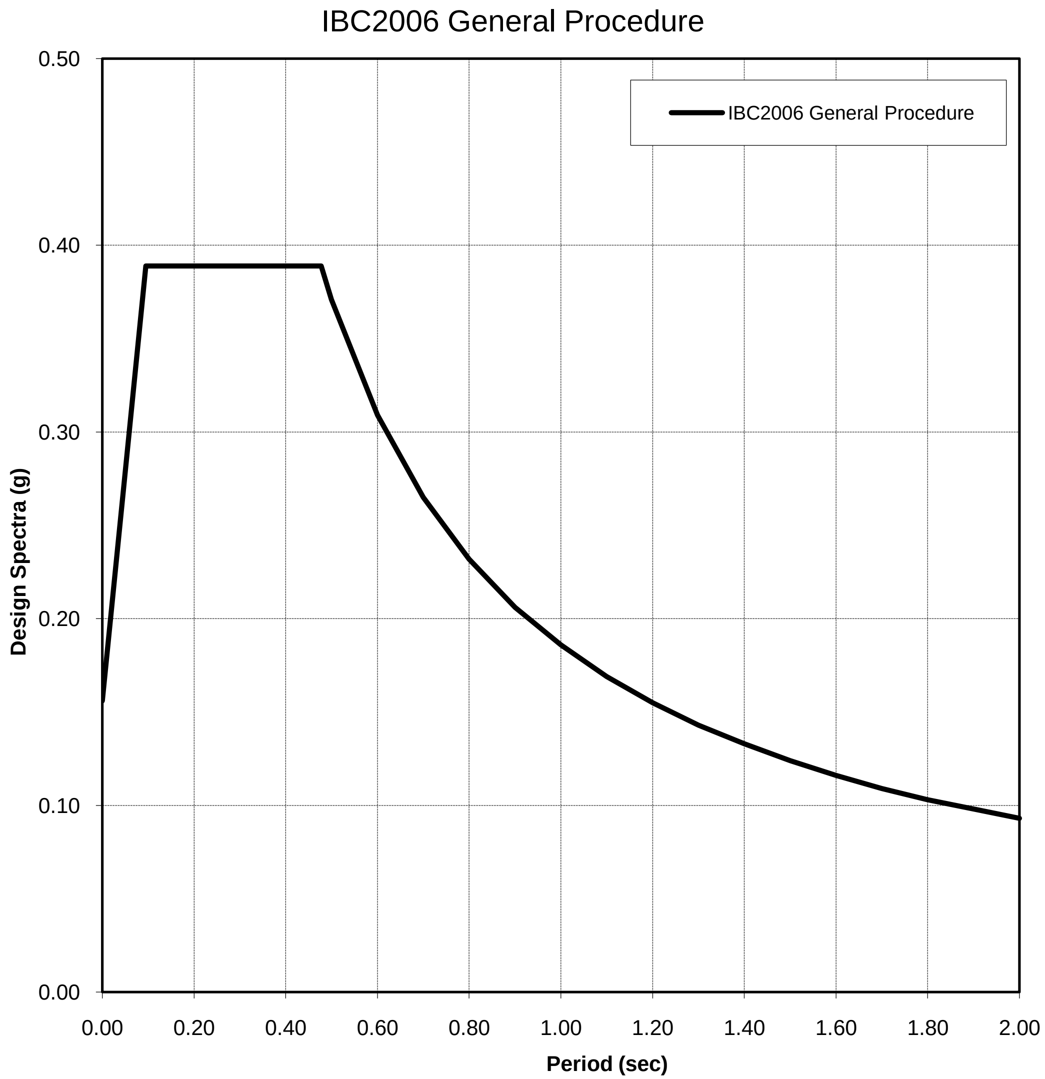
Location	Sample No.	Sample Depth (ft)	Material Description	USCS	Natural Moisture content (%)	#200 Passing (%)	Plastic Index (%)	Liquid Limit (%)
B-4	SS12	43 to 45	gray, sandy fat clay	CH	101.7		44	123
B-6	SS5	8 to 10	brown and light orange, silty fine sand	SM		12.8		
B-6	SS8	23 to 25	gray, sandy lean clay	CL	22.2		17	43
B-6	SS11	43 to 45	olive-gray, silty fine sand	SM		20.0		
B-10	SS5	8 to 10	tan and light brown, fine sand with silt	SP-SM		10.1		
B-12	SS5	8 to 10	light brown, silty sand	SM		28.6		
B-12	SS12	43 to 45	gray, silty sand	SM		40.2		
B-12	SS13	48 to 50	gray, fine sand with silt	SP-SM	26.5	6.6		

IBC2006 General Procedure
Project Name: City of Savannah 63rd Street Relief Line
Project Number: ES115039

Terracon

Conterminous 48 States
2003 NEHRP Seismic Design Provisions
Latitude = 32.03331
Longitude = -81.09746
Design Response Spectrum for Site Class D
SDs = 2/3 x SMs and SD1 = 2/3 x SM1
Site Class D - Fa = 1.486, Fv = 2.32

Period (sec)	Sa (g)	Sd (inches)
0.000	0.156	0.000
0.095	0.389	0.035
0.200	0.389	0.152
0.477	0.389	0.866
0.500	0.371	0.907
0.600	0.309	1.088
0.700	0.265	1.270
0.800	0.232	1.451
0.900	0.206	1.633
1.000	0.186	1.814
1.100	0.169	1.996
1.200	0.155	2.177
1.300	0.143	2.358
1.400	0.133	2.540
1.500	0.124	2.721
1.600	0.116	2.903
1.700	0.109	3.084
1.800	0.103	3.265
1.900	0.098	3.447
2.000	0.093	3.628



GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS:	Split Spoon – 1-$^{3}/_{8}$" I.D., 2" O.D., unless otherwise noted H	S:	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	0 – 1	Very Soft
500 – 1,000	2 – 4	Soft
1,001 – 2,000	4 – 8	Medium Stiff
2,001 – 4,000	8 – 15	Stiff
4,001 – 8,000	15 – 30	Very Stiff
8,000+ >	30	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Standard Penetration or N-value (SS) Blows/Ft.	Relative Density
0 – 3	Very Loose
4 – 9	Loose
10 – 29	Medium Dense
30 – 49	Dense
> 50	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

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification: Group Symbol	Soil Classification: 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 ≥ 4 and 1 ≤ Cc ≤ 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 ≥ 6 and 1 ≤ Cc ≤ 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.