APPENDIX D

CONE PENETROMETER TEST RESULTS

NORTH ANNA COL

DATA REPORT REV. 0
JANUARY 23, 2007

MACTEC PROJECT NO. 6468-06-1472

MACTEC

DOCUMENTATION OF TECHNICAL REVIEW
SUBCONTRACTOR WORK PRODUCT

Project Name: Dominion North Anna COL

Project Number: 6468-06-1472

Project Manager: Steve Criscenzo

Project Principal: Al Tice

The summary sheet from the report described below was found to have a date error on probe C-917 and a duplicate line for C-913. A revised summary sheet has been prepared by the named subcontractor retained in accordance with the MACTEC QAPD. The revised summary sheet has been reviewed by a MACTEC technically qualified person. The attached revised summary sheet is approved in accordance with section QS-7 of MACTEC's QAPD. The revised summary sheet is included in the Geotechnical Data Report, Rev 0 issued January 23, 2007.

The information and data contained in the attached revised summary sheet are hereby released by MACTEC for project use.

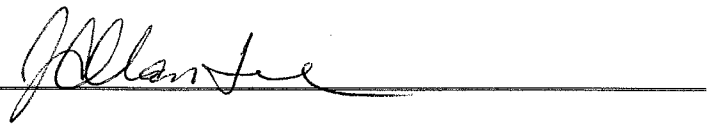
REPORT : Summary Sheet, Rev 2 only to be inserted in Rev. 1 CPT Site Investigation, North Anna COL, Gregg Project No. 06-101SC

Dated October 5, 2006 , Revised dated 11-06-06. Summary sheet rev 2 date 1-19-07.

SUBCONTRACTOR: Gregg In Situ, Inc

1112 Pasture Lane, Columbia, SC 229201

DATE OF ACCEPTANCE : 1-19-07

TECHNICAL REVIEWER: 

PROJECT PRINCIPAL J. Allan Tice

DCN NA COL-189

SUMMARY OF REVISIONS REV. 2 CPT REPORT (table 1 only revised and issued)

1. Cone Penetration Test Sounding Summary – Table 1. Reissued table to delete duplicate entry for CPT-913, to correct depth of CPT-913 from 20 to 1.8 feet and to correct mis-dating of CPT-917.
2. No revisions to remainder of Rev.1 and entire Rev.1 is not reissued.

NA COL 189

Cone Penetration Test Sounding Summary

-Table 1-

CPT Sounding Identification	Date	Termination Depth (Feet)	Depth of Groundwater Samples (Feet)	Depth of Soil Samples (Feet)	Depth of Pore Pressure Dissipation Tests (Feet)
CPT-901a	9/21/06	15.1	-	-	-
CPT-901	9/21/06	20.0	-	-	-
CPT-902	9/21/06	29.0	-	-	29.0
CPT-903	9/21/06	29.0	-	-	-
CPT-904a	9/21/06	2.3	-	-	-
CPT-904b	9/21/06	35.6	-	-	21.5
CPT-904	9/21/06	2.5	-	-	-
CPT-905	9/21/06	45.6	-	-	-
CPT-906a	9/21/06	2.6	-	-	-
CPT-906b	9/21/06	2.1	-	-	-
CPT-906	9/21/06	1.6	-	-	-
CPT-907	9/21/06	13.1	-	-	-
CPT-908	9/22/06	28.1	-	-	-
CPT-909	9/20/06	60.0	-	-	-
CPT-910a	9/19/06	25.1	-	-	-
CPT-910	9/18/06	15.3	-	-	-
CPT-911	9/22/06	15.3	-	-	13.3
CPT-912	9/25/06	2.8	-	-	-
CPT-913a	9/22/06	1.8	-	-	-
CPT-913	9/22/06	1.8	-	-	-
CPT-913b	9/22/06	20.0	-	-	-
CPT-914	9/25/06	31.0	-	-	-
CPT-915	9/20/06	54.0	-	-	-

PCN NA COL 194

Rev 2 902 1-19-07

CPT-916	9/21/06	49.1	-	-	-
CPT-917	9/20/06	49.2	-	-	22.1
CPT-918	9/18/06	25.1	-	-	-
CPT-919	9/20/06	25.1	-	-	-
CPT-920	9/18/06	25.1	-	-	-
CPT-921	9/25/06	30.0	-	-	-
CPT-922	9/22/06	20.3	-	-	-
CPT-923	9/22/06	22.2	-	-	-

Rev. 2
MACTEC
1-19-07

DCN NA COL 194

MACTEC

DOCUMENTATION OF TECHNICAL REVIEW
SUBCONTRACTOR WORK PRODUCT

Project Name: Dominion North Anna COL

Project Number: 6468-06-1472

Project Manager: Steve Criscenzo

Project Principal: Al Tice

The revised report described below has been prepared by the named subcontractor retained in accordance with the MACTEC QAPD. The work and revised report have been reviewed by a MACTEC technically qualified person. Comments on the work or revised report, if any, have been satisfactorily addressed by the subcontractor. The attached revised report is approved in accordance with section QS-7 of MACTEC's QAPD

The information and date contained in the attached revised report are hereby released by MACTEC for project use.

REPORT : Rev. 1 CPT Site Investigation, North Anna COL, Gregg Project No. 06-101SC

Dated October 5, 2006 , Revised dated 11-06-06

SUBCONTRACTOR: Gregg In Situ, Inc

1112 Pasture Lane, Columbia, SC 229201

DATE OF ACCEPTANCE : 11-06-06

TECHNICAL REVIEWER: J. Allan Tice

PROJECT PRINCIPAL J. Allan Tice

DCN NA COL-140

SUMMARY OF REVISIONS IN REV. 1 CPT REPORT

1. Cone PenetrationTest Sounding Summary – Table 1. Replaced table to correct mis-numbering of CPT-907 and CPT-917.
2. Plots for correct CPT-907 inserted. No plots for CPT-907 were included in the original report.
3. Replaced plots for CPT-917 with correct plots.
4. Removed plot of Pore Pressure Dissipation Test labeled CPT-907 and replaced with plot correctly labeled CPT-917.

GREGG IN SITU, INC.

GEOTECHNICAL AND ENVIRONMENTAL INVESTIGATION SERVICES

~~Dup~~ JBJ ~~Copy~~ 11-6-06

October 5, 2006

Rev. 1 11-6-06 JBJ MACTEC

Mactec
Attn: Al Tice
3301 Atlantic Ave.
Raleigh, North Carolina 27604

Subject: CPT Site Investigation
North Anna ~~College~~ JBJ 10/11/06
Virginia
GREGG Project Number: 06-101SC

Dear Mr. Tice:

The following report presents the results of GREGG Drilling & Testing's Cone Penetration Test investigation for the above referenced site. The following testing services were performed:

1	Cone Penetration Tests	(CPTU)	☒
2	Pore Pressure Dissipation Tests	(PPD)	☒
3	Seismic Cone Penetration Tests	(SCPTU)	☒
4	Resistivity Cone Penetration Tests	(RCPTU)	☐
5	UVIF Cone Penetration Tests	(UVIFCPTU)	☐
6	Groundwater Sampling	(GWS)	☐
7	Soil Sampling	(SS)	☐
8	Vapor Sampling	(VS)	☐
9	Vane Shear Testing	(VST)	☐
10	SPT Energy Calibration	(SPTE)	☐

A list of reference papers providing additional background on the specific tests conducted is provided in the bibliography following the text of the report. If you would like a copy of any of these publications or should you have any questions or comments regarding the contents of this report, please do not hesitate to contact our office at (925) 313-5800.

Sincerely,
GREGG Drilling & Testing, Inc.

Peter Robertson
Technical Operations

Rev. 1 JBJ 11-6-06

TOTAL PAGES IN DOCUMENT: ~~93~~

Rev. 1 DCN NA COL - 141
JBJ 11-6-06
~~DCN NA COL 95~~

1112 Pasture Lane • Columbia, South Carolina 29201 • (803) 253-7633 • FAX (803) 253-7634
OTHER OFFICES: LOS ANGELES • SAN FRANCISCO • HOUSTON
www.greggdrilling.com

GREGG IN SITU, INC.

GEOTECHNICAL AND ENVIRONMENTAL INVESTIGATION SERVICES

Cone Penetration Test Sounding Summary

-Table 1-

CPT Sounding Identification	Date	Termination Depth (Feet)	Depth of Groundwater Samples (Feet)	Depth of Soil Samples (Feet)	Depth of Pore Pressure Dissipation Tests (Feet)
CPT-901a	9/21/06	15.1	-	-	-
CPT-901	9/21/06	20.0	-	-	-
CPT-902	9/21/06	29.0	-	-	29.0
CPT-903	9/21/06	29.0	-	-	-
CPT-904a	9/21/06	2.3	-	-	-
CPT-904b	9/21/06	35.6	-	-	21.5
CPT-904	9/21/06	2.5	-	-	-
CPT-905	9/21/06	45.6	-	-	-
CPT-906a	9/21/06	2.6	-	-	-
CPT-906b	9/21/06	2.1	-	-	-
CPT-906	9/21/06	1.6	-	-	-
CPT-907	9/21/06	13.1	-	-	-
CPT-908	9/22/06	28.1	-	-	-
CPT-909	9/20/06	60.0	-	-	-
CPT-910a	9/19/06	25.1	-	-	-
CPT-910	9/18/06	15.3	-	-	-
CPT-911	9/22/06	15.3	-	-	13.3
CPT-912	9/25/06	2.8	-	-	-
CPT-913a	9/22/06	1.8	-	-	-
CPT-913	9/22/06	20.0	-	-	-
CPT-913b	9/22/06	20.0	-	-	-
CPT-913	9/22/06	20.0	-	-	-
CPT-914	9/25/06	31.0	-	-	-

Rev. 1

1112 Pasture Lane • Columbia, South Carolina 29201 • (803) 253-7633 • FAX (803) 253-7634
OTHER OFFICES: LOS ANGELES • SAN FRANCISCO • HOUSTON
www.greggdrilling.com

Rev 1 11-6-06

CPT-915	9/20/06	54.0	-	-	-
CPT-916	9/21/06	49.1	-	-	-
CPT-917	9/21/06	49.2	-	-	22.1
CPT-918	9/18/06	25.1	-	-	-
CPT-919	9/20/06	25.1	-	-	-
CPT-920	9/18/06	25.1	-	-	-
CPT-921	9/25/06	30.0	-	-	-
CPT-922	9/22/06	20.3	-	-	-
CPT-923	9/22/06	22.2	-	-	-

1 Rev. 1

Rev. 1 11-6-06
JAJ
MACTEC

Cone Penetration Testing Procedure (CPT)

Gregg In Situ, Inc. carries out all Cone Penetration Tests (CPT) using an integrated electronic cone system, *Figure CPT*. The soundings were conducted using a 20 ton capacity cone with a tip area of 15 cm^2 and a friction sleeve area of 225 cm^2. The cone is designed with an equal end area friction sleeve and a tip end area ratio of 0.85.

The cone takes measurements of cone bearing (q_c), sleeve friction (f_s) and penetration pore water pressure (u_2) at 5-cm intervals during penetration to provide a nearly continuous hydrogeologic log. CPT data reduction and interpretation is performed in real time facilitating on-site decision making. The above mentioned parameters are stored on disk for further analysis and reference. All CPT soundings are performed in accordance with revised (2002) ASTM standards (D 5778-95).

The cone also contains a porous filter element located directly behind the cone tip (u_2), *Figure CPT*. It consists of porous plastic and is 5.0mm thick. The filter element is used to obtain penetration pore pressure as the cone is advanced as well as Pore Pressure Dissipation Tests (PPDT's) during appropriate pauses in penetration. It should be noted that prior to penetration, the element is fully saturated with silicon oil under vacuum pressure to ensure accurate and fast dissipation.

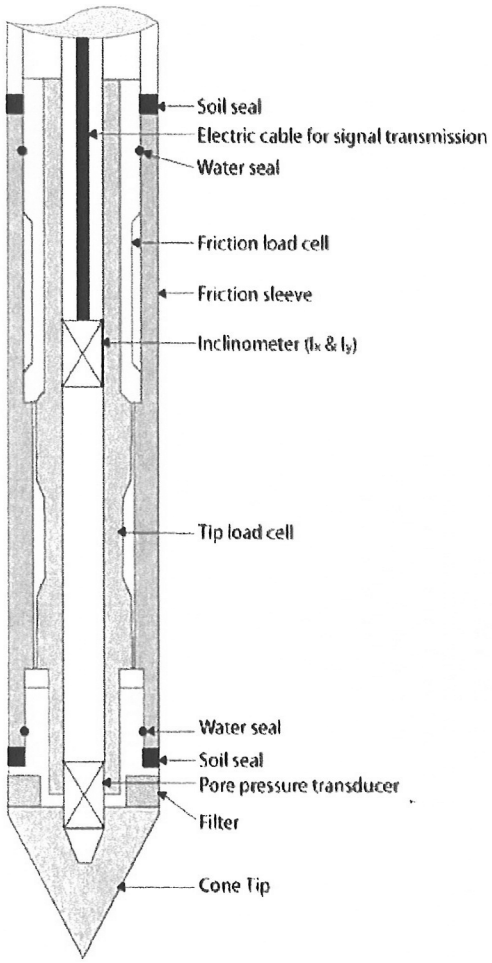


Figure CPT

When the soundings are complete, the test holes are grouted using a Gregg In Situ support rig. The grouting procedures generally consist of pushing a hollow CPT rod with a "knock out" plug to the termination depth of the test hole. Grout is then pumped under pressure as the tremie pipe is pulled from the hole. Disruption or further contamination to the site is therefore minimized.

Cone Penetration Test Data & Interpretation

Soil behavior type and stratigraphic interpretation is based on relationships between cone bearing (q_c), sleeve friction (f_s), and pore water pressure (u_2). The friction ratio (R_f) is a calculated parameter defined by $100f_s/q_c$ and is used to infer soil behavior type. Generally:

Cohesive soils (clays)

- High friction ratio (R_f) due to small cone bearing (q_c)
- Generate large excess pore water pressures (u_2)

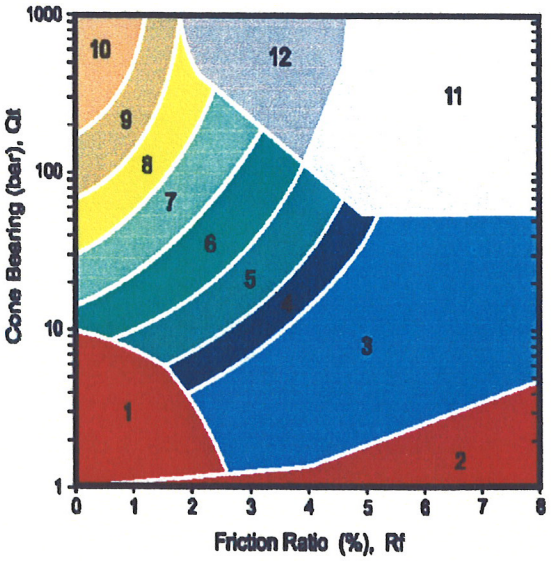
Cohesionless soils (sands)

- Low friction ratio (R_f) due to large cone bearing (q_c)
- Generate very little excess pore water pressures (u_2)

A complete set of baseline readings are taken prior to and at the completion of each sounding to determine temperature shifts and any zero load offsets. Corrections for temperature shifts and zero load offsets can be extremely important, especially when the recorded loads are relatively small. In sandy soils, however, these corrections are generally negligible.

The cone penetration test data collected from your site is presented in graphical form in Appendix CPT. The data includes CPT logs of measured soil parameters, computer calculations of interpreted soil behavior types (SBT), and additional geotechnical parameters. A summary of locations and depths is available in Table 1. Note that all penetration depths referenced in the data are with respect to the existing ground surface.

Soil interpretation for this project was conducted using recent correlations developed by Robertson, 1990, *Figure SBT*. Note that it is not always possible to clearly identify a soil type based solely on q_c, f_s, and u_2. In these situations, experience, judgment, and an assessment of the pore pressure dissipation data should be used to infer the soil behavior type.



ZONE	Qt/N	SBT
1	2	Sensitive, fine grained
2	1	Organic materials
3	1	Clay
4	1.5	Silty clay to clay
5	2	Clayey silt to silty clay
6	2.5	Sandy silt to clayey silt
7	3	Silty sand to sandy silt
8	4	Sand to silty sand
9	5	Sand
10	6	Gravely sand to sand
11	1	Very stiff fine grained*
12	2	Sand to clayey sand*

*over consolidated or cemented

Figure SBT

Pore Pressure Dissipation Tests (PPDT)

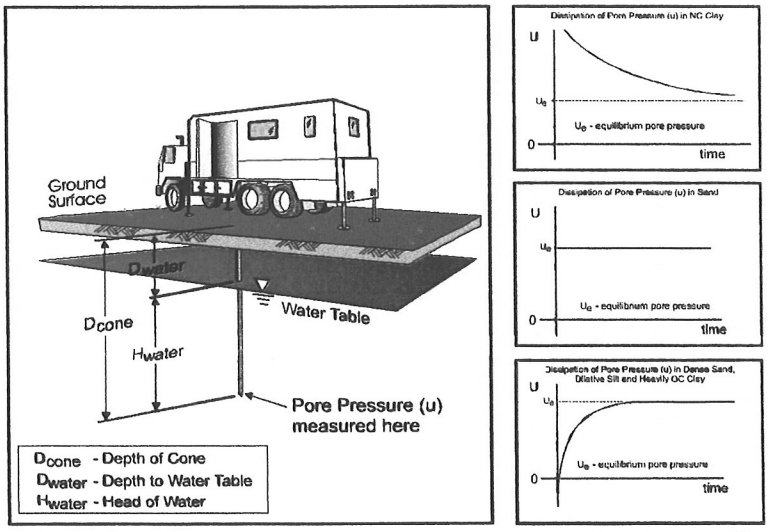
Pore Pressure Dissipation Tests (PPDT's) conducted at various intervals measured hydrostatic water pressures and determined the approximate depth of the ground water table. A PPDT is conducted when the cone is halted at specific intervals determined by the field representative. The variation of the penetration pore pressure (u) with time is measured behind the tip of the cone and recorded by a computer system.
Pore pressure dissipation data can be interpreted to provide estimates of:

- Equilibrium piezometric pressure
- Phreatic Surface
- In situ horizontal coefficient of consolidation (c_h)
- In situ horizontal coefficient of permeability (k_h)

In order to correctly interpret the equilibrium piezometric pressure and/or the phreatic surface, the pore pressure must be monitored until such time as there is no variation in pore pressure with time, *Figure PPDT*. This time is commonly referred to as t_{100}, the point at which 100% of the excess pore pressure has dissipated.

A complete reference on pore pressure dissipation tests is presented by Robertson et al. 1992.

A summary of the pore pressure dissipation tests is summarized in Table 1. Pore pressure dissipation data is presented in graphical form in Appendix PPDT.



Water Table Calculation

$$D_{water} = D_{cone} - H_{water}$$

where $H_{water} = U_e$ (depth units)

Useful Conversion Factors: 1psi = 0.704m = 2.31 feet (water)
1tsf = 0.958 bar = 13.9 psi
1m = 3.28 feet

Figure PPDT

Bibliography

Lunne, T., Robertson, P.K. and Powell, J.J.M., "Cone Penetration Testing in Geotechnical Practice" E & FN Spon. ISBN 0 419 23750, 1997

Roberston, P.K., "Soil Classification using the Cone Penetration Test", Canadian Geotechnical Journal, Vol. 27, 1990 pp. 151-158.

Mayne, P.W., "NHI (2002) Manual on Subsurface Investigations: Geotechnical Site Characterization", available through www.ce.gatech.edu/~geosys/Faculty/Mayne/papers/index.html, Section 5.3, pp. 107-112.

Robertson, P.K., R.G. Campanella, D. Gillespie and A. Rice, "Seismic CPT to Measure In-Situ Shear Wave Velocity", Journal of Geotechnical Engineering ASCE, Vol. 112, No. 8, 1986 pp. 791-803.

Robertson, P.K., Sully, J., Woeller, D.J., Lunne, T., Powell, J.J.M., and Gillespie, D.J., "Guidelines for Estimating Consolidation Parameters in Soils from Piezocone Tests", Canadian Geotechnical Journal, Vol. 29, No. 4, August 1992, pp. 539-550.

Robertson, P.K., T. Lunne and J.J.M. Powell, "Geo-Environmental Application of Penetration Testing", Geotechnical Site Characterization, Robertson & Mayne (editors), 1998 Balkema, Rotterdam, ISBN 90 5410 939 4 pp 35-47.

Campanella, R.G. and I. Weemees, "Development and Use of An Electrical Resistivity Cone for Groundwater Contamination Studies", Canadian Geotechnical Journal, Vol. 27 No. 5, 1990 pp. 557-567.

DeGroot, D.J. and A.J. Lutenegger, "Reliability of Soil Gas Sampling and Characterization Techniques", International Site Characterization Conference - Atlanta, 1998.

Woeller, D.J., P.K. Robertson, T.J. Boyd and Dave Thomas, "Detection of Polyaromatic Hydrocarbon Contaminants Using the UVIF-CPT", 53rd Canadian Geotechnical Conference Montreal, QC October pp. 733-739, 2000.

Zemo, D.A., T.A. Delfino, J.D. Gallinatti, V.A. Baker and L.R. Hilpert, "Field Comparison of Analytical Results from Discrete-Depth Groundwater Samplers" BAT EnviroProbe and QED HydroPunch, Sixth national Outdoor Action Conference, Las Vegas, Nevada Proceedings, 1992, pp 299-312.

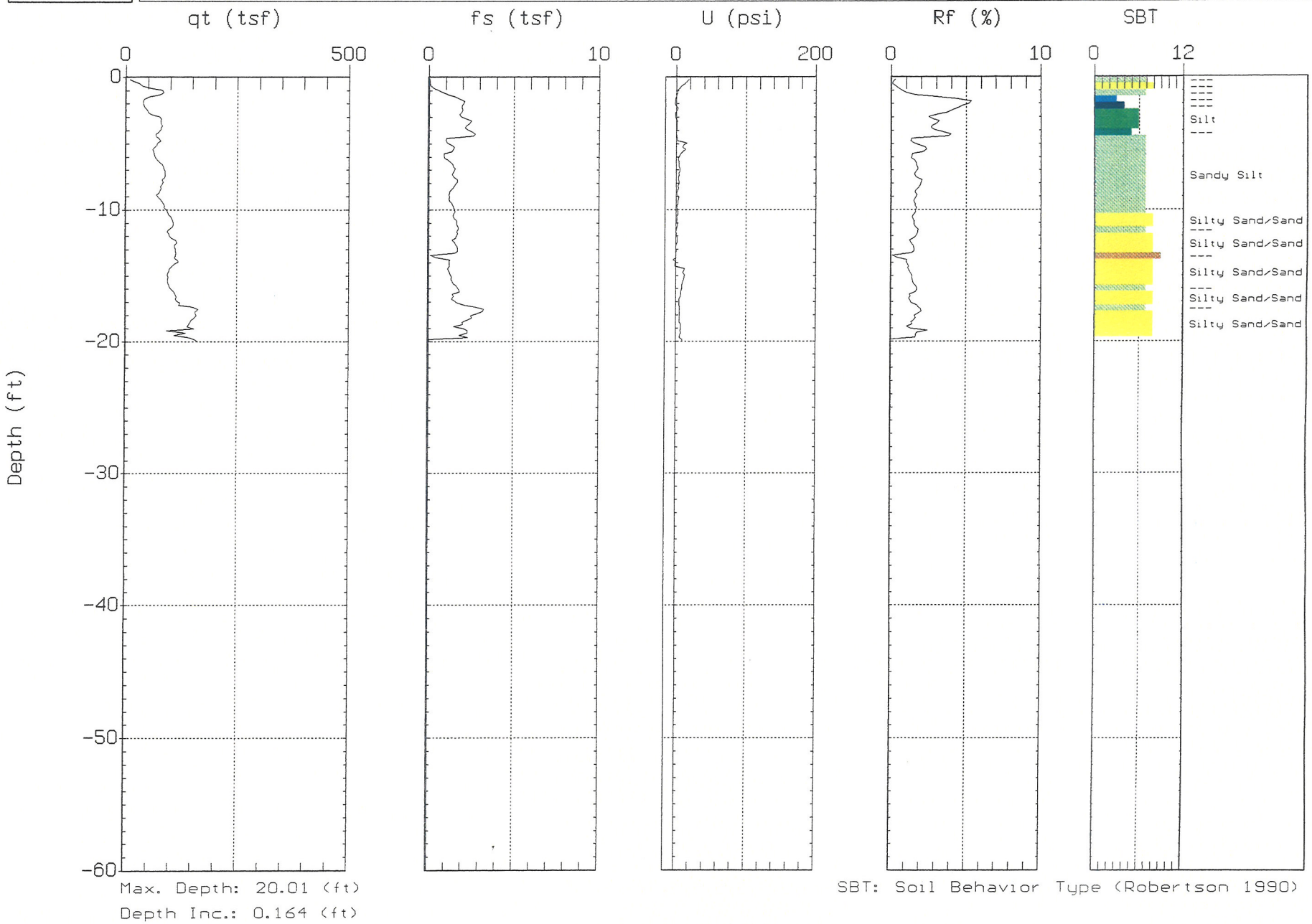
Copies of ASTM Standards are available through www.astm.org

GREGG

MACTEC

Site: NORTH ANNA COL.
Location: CPT-901

Operator: R.AGUILAR
Date: 09/21/06 07:12



Max. Depth: 20.01 (ft)
Depth Inc.: 0.164 (ft)

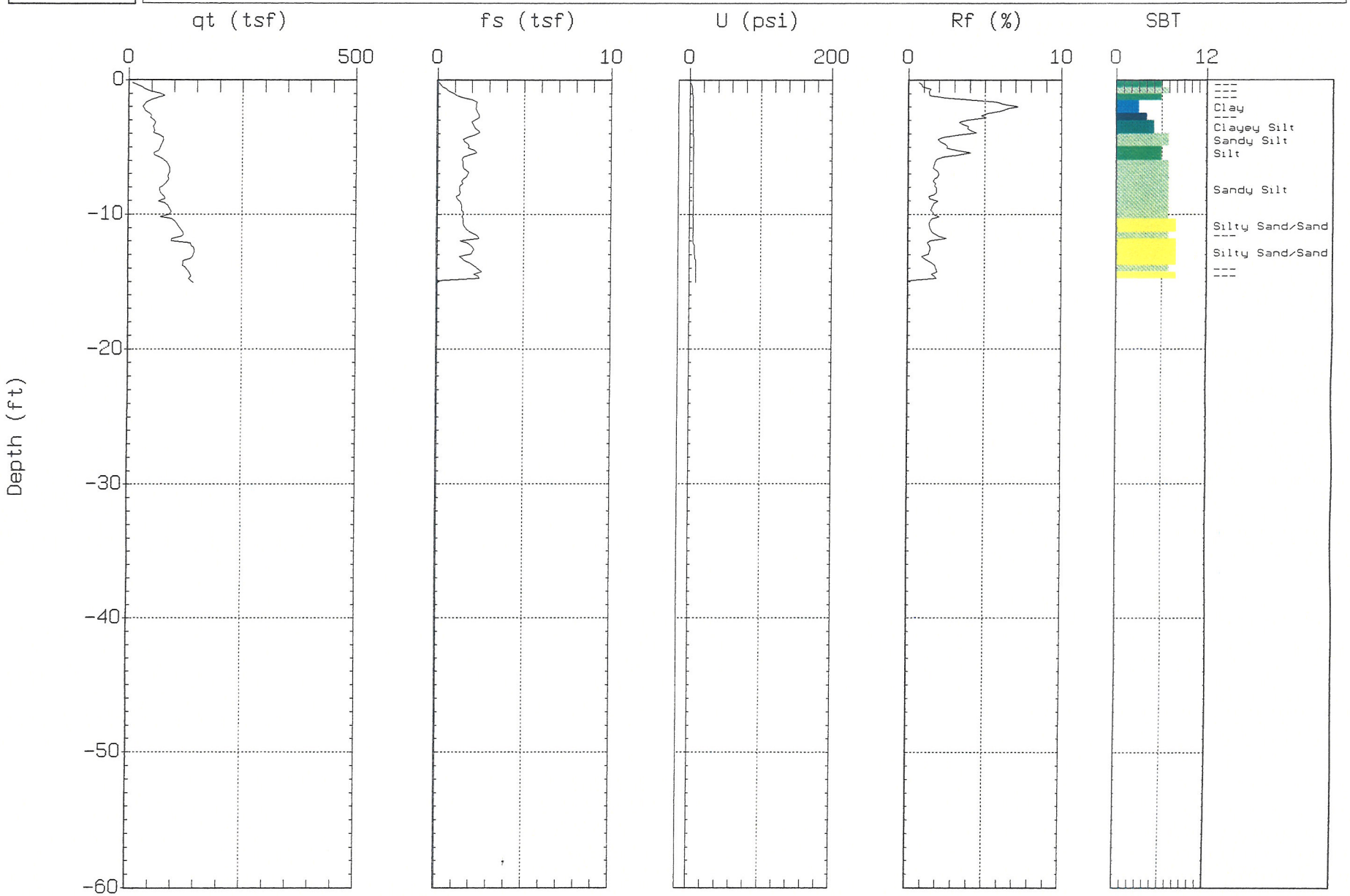
SBT: Soil Behavior Type (Robertson 1990)

GREGG

MACTEC

Site: NORTH ANNA COL.
Location: CPT-901a

Operator: R.AGUILAR
Date: 09/21/06 07:51



Max. Depth: 15.09 (ft)
Depth Inc.: 0.164 (ft)

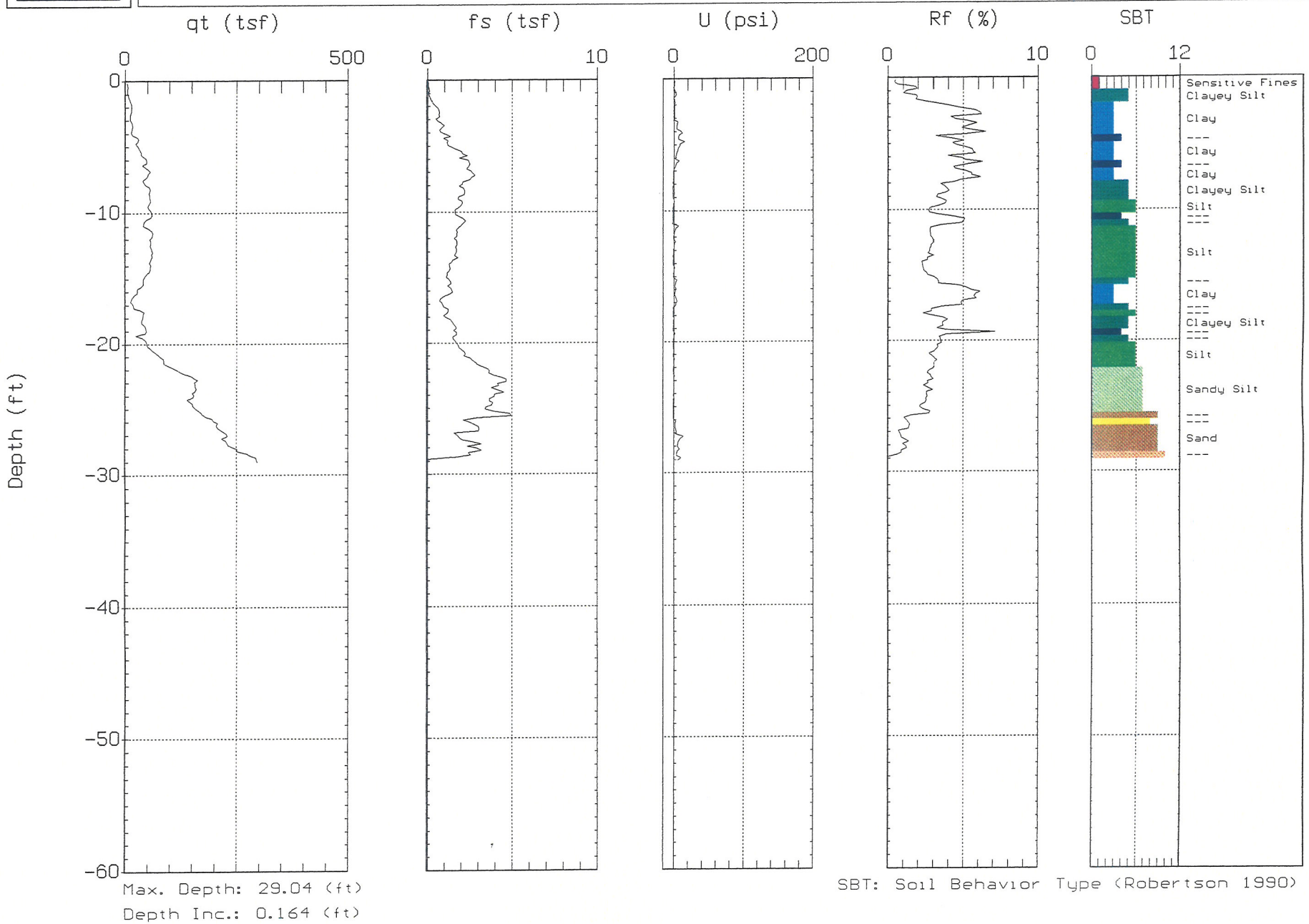
SBT: Soil Behavior Type (Robertson 1990)

GREGG

MACTEC

Site: NORTH ANNA COL.
Location: CPT-902

Operator: R.AGUILAR
Date: 09/21/06 05:27

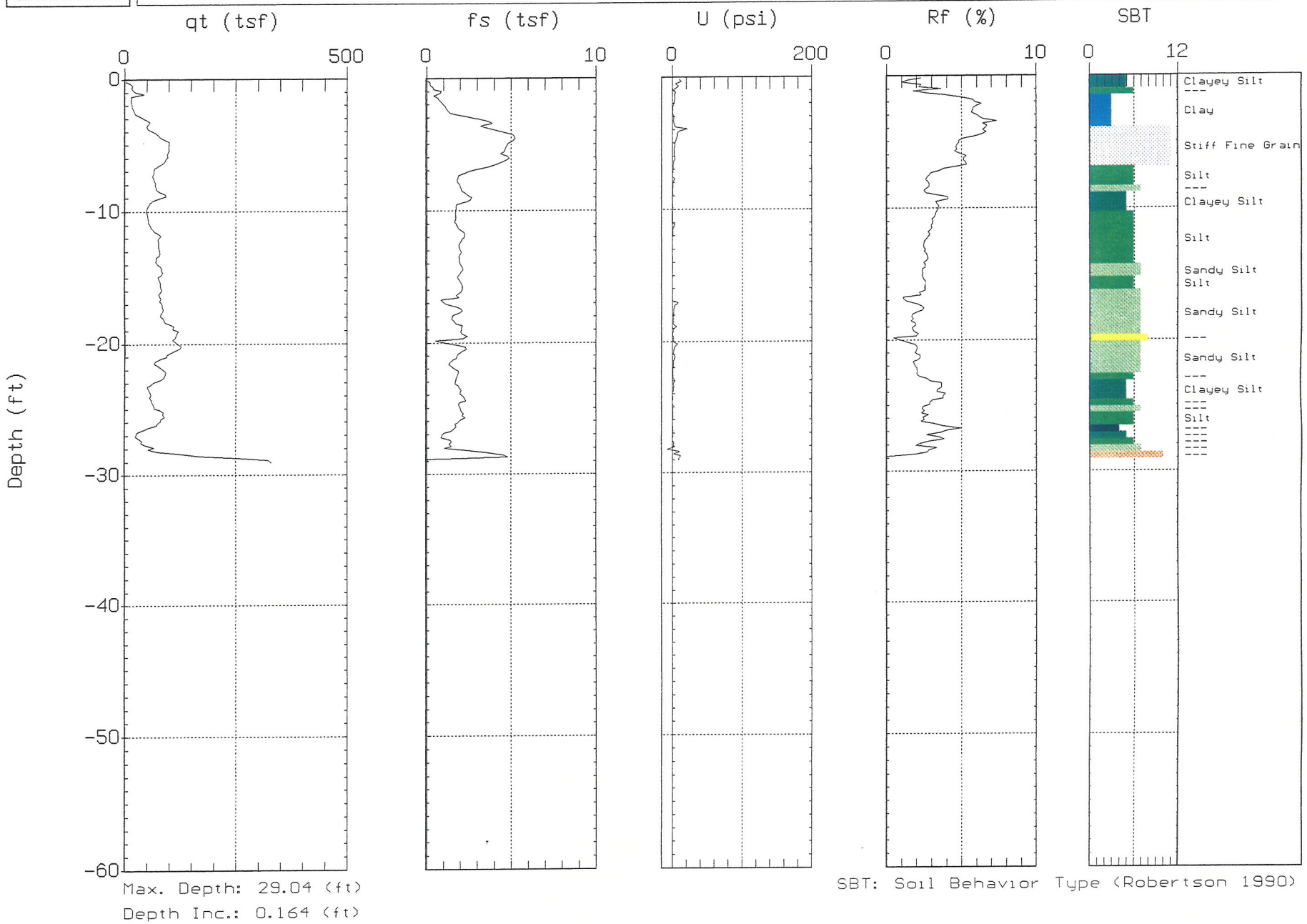


GREGG

MACTEC

Site: NORTH ANNA COL.
Location: CPT-903

Operator: R.AGUILAR
Date: 09/20/06 13:34



Max. Depth: 29.04 (ft)
Depth Inc.: 0.164 (ft)

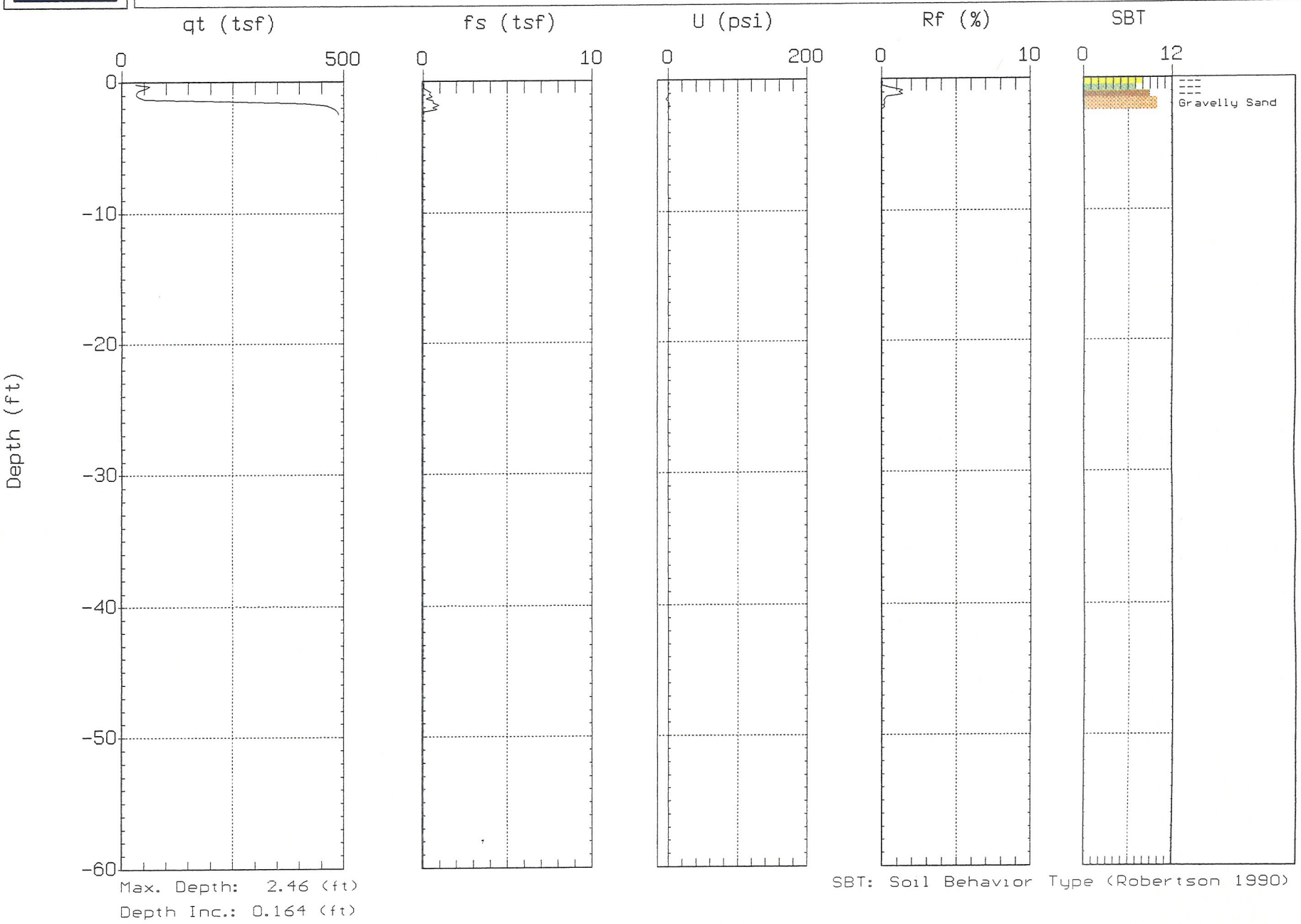
SBT: Soil Behavior Type (Robertson 1990)

GREGG

MACTEC

Site: NORTH ANNA COL.
Location: CPT-904

Operator: R.AGUILAR
Date: 09/21/06 11:01



Max. Depth: 2.46 (ft)
Depth Inc.: 0.164 (ft)

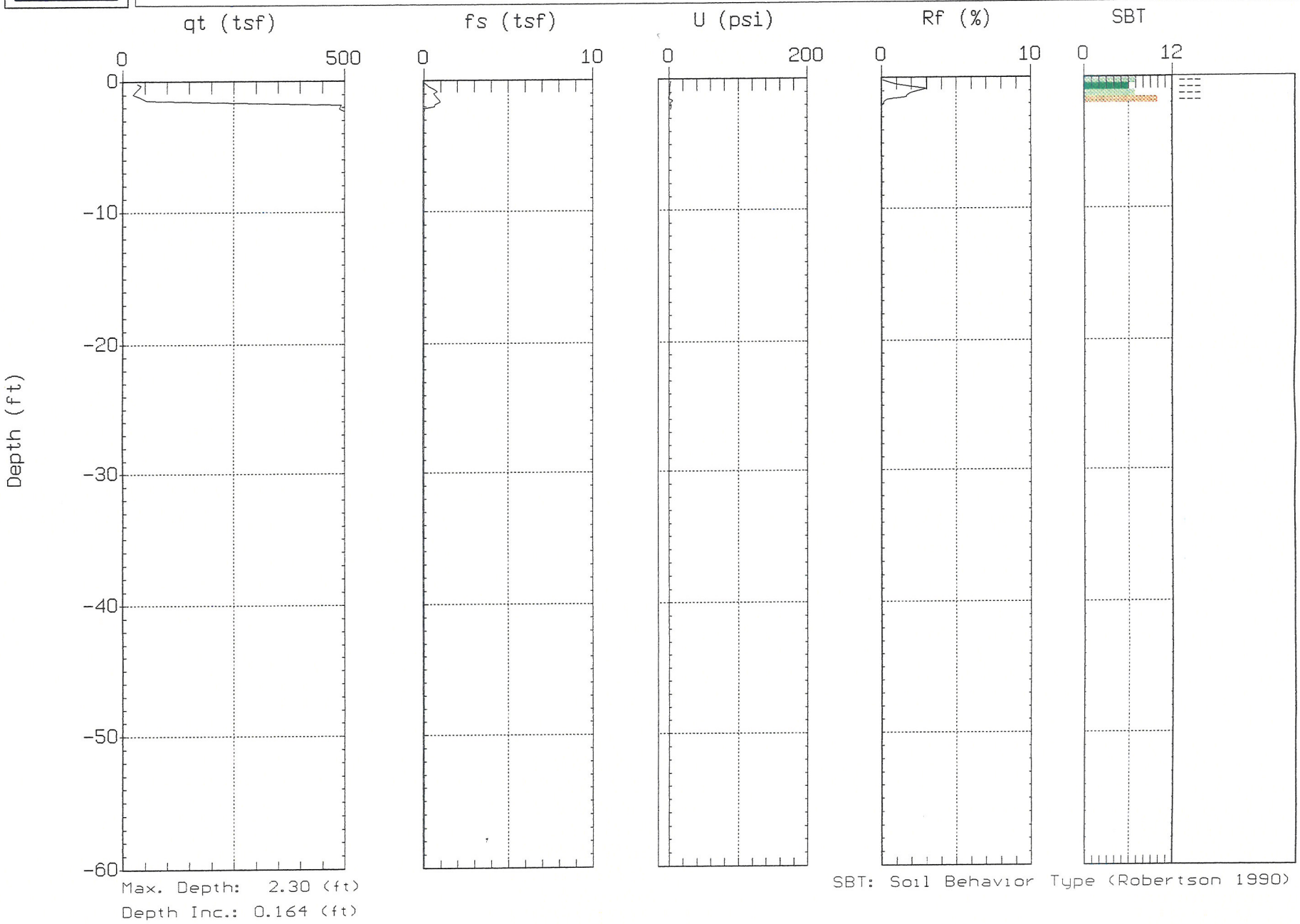
SBT: Soil Behavior Type (Robertson 1990)

GREGG

MACTEC

Site: NORTH ANNA COL.
Location: CPT-904a

Operator: R.AGUILAR
Date: 09/21/06 11:24

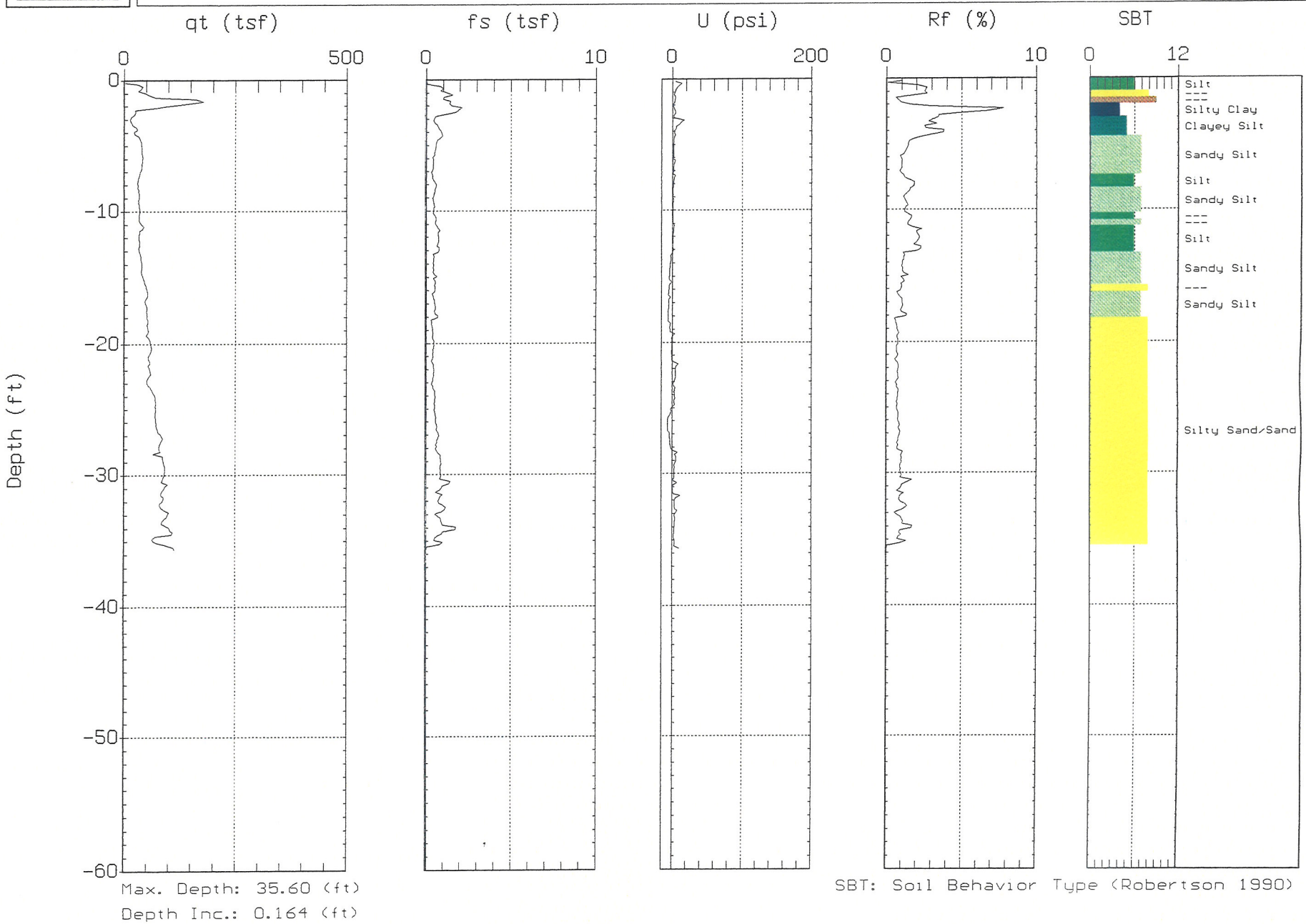


GREGG

MACTEC

Site: NORTH ANNA COL.
Location: CPT-904b

Operator: R.AGUILAR
Date: 09/21/06 11:36



Max. Depth: 35.60 (ft)
Depth Inc.: 0.164 (ft)

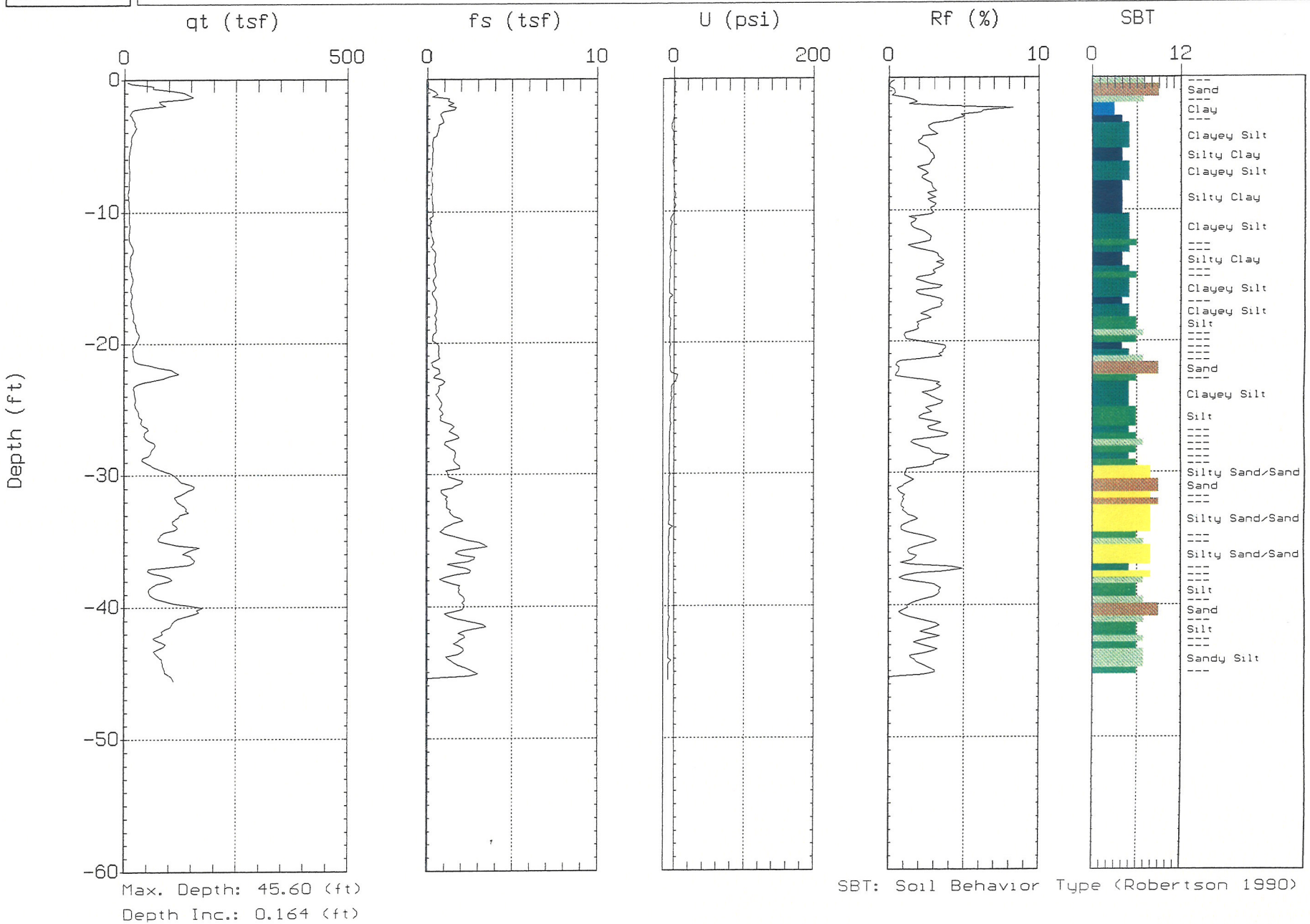
SBT: Soil Behavior Type (Robertson 1990)

GREGG

MACTEC

Site: NORTH ANNA COL.
Location: CPT-905

Operator: R.AGUILAR
Date: 09/21/06 12:22



Max. Depth: 45.60 (ft)
Depth Inc.: 0.164 (ft)

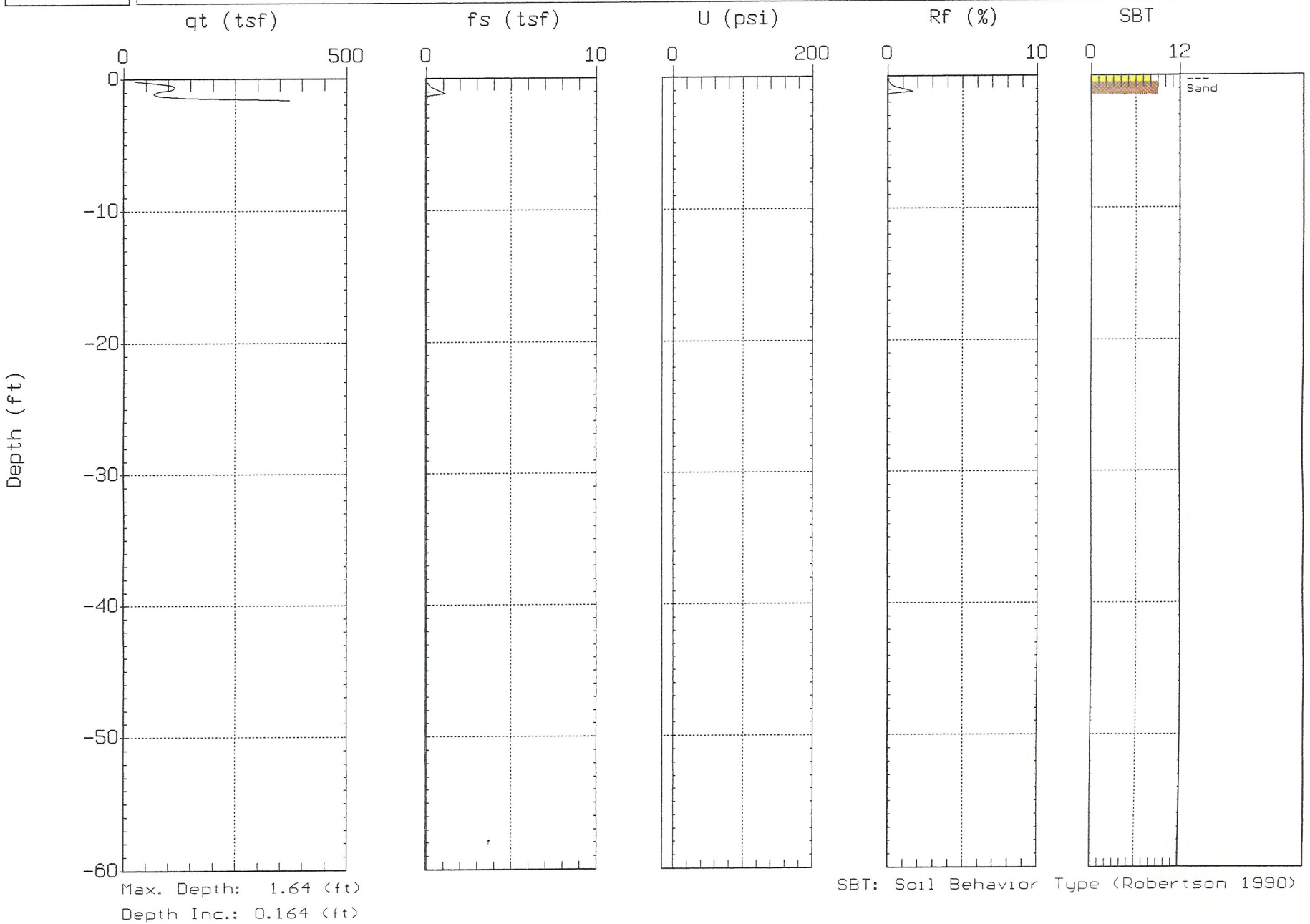
SBT: Soil Behavior Type (Robertson 1990)

GREGG

MACTEC

Site: NORTH ANNA COL.
Location: CPT-906

Operator: R.AGUILAR
Date: 09/21/06 13:08

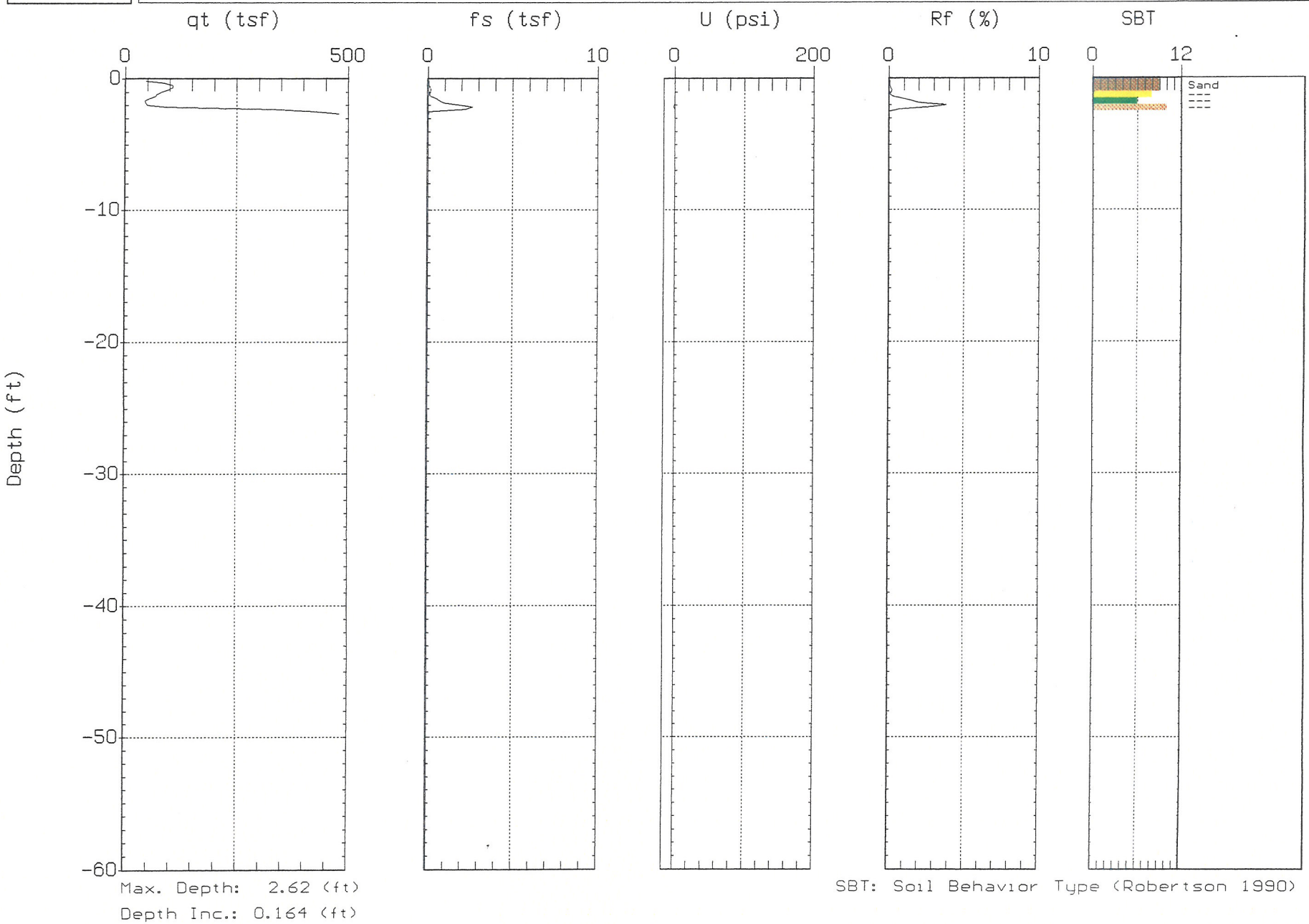


GREGG

MACTEC

Site: NORTH ANNA COL.
Location: CPT-906a

Operator: R.AGUILAR
Date: 09/21/06 13:29



Max. Depth: 2.62 (ft)
Depth Inc.: 0.164 (ft)

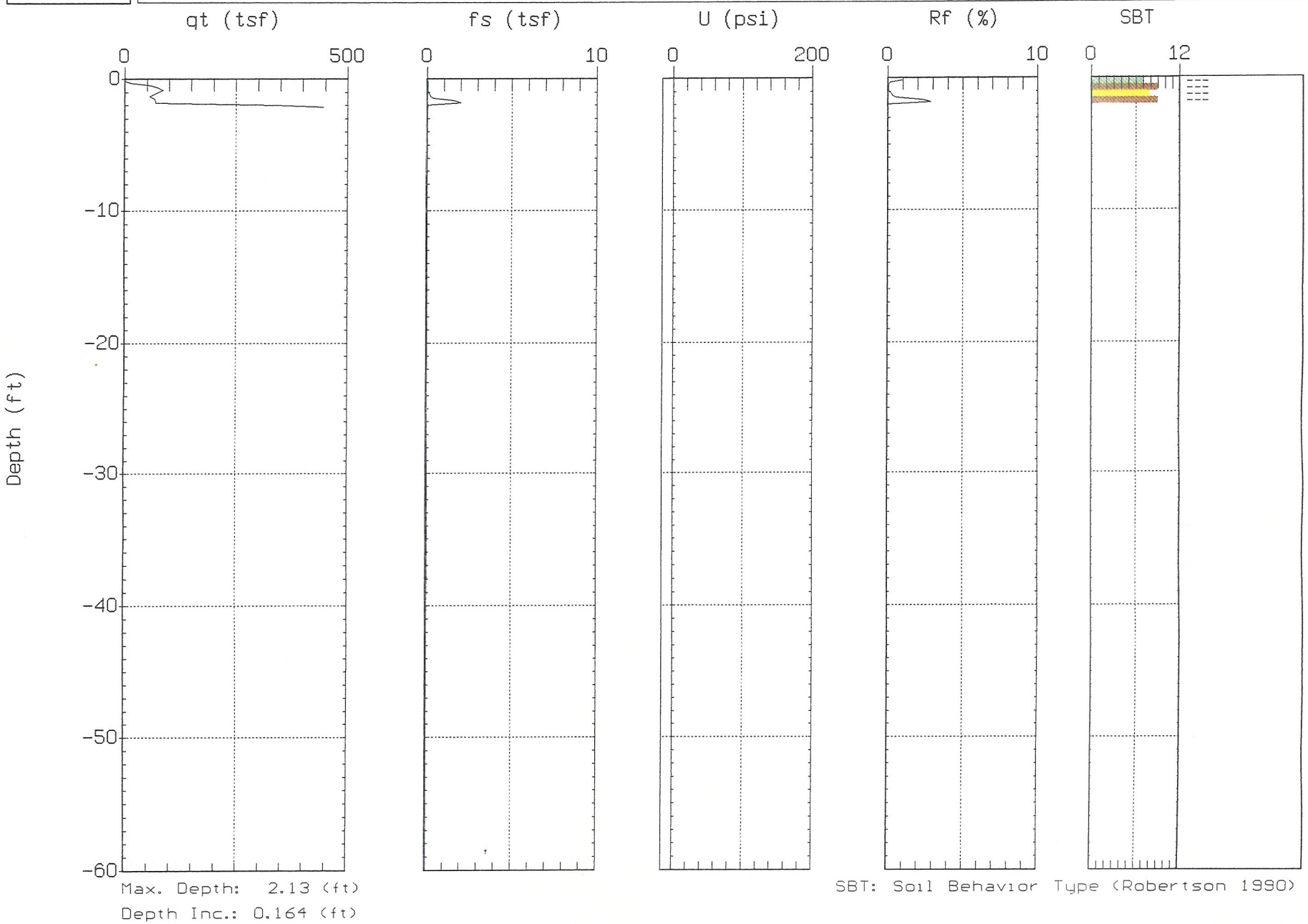
SBT: Soil Behavior Type (Robertson 1990)

GREGG

MACTEC

Site: NORTH ANNA COL.
Location: CPT-906b

Operator: R.AGUILAR
Date: 09/21/06 13:37



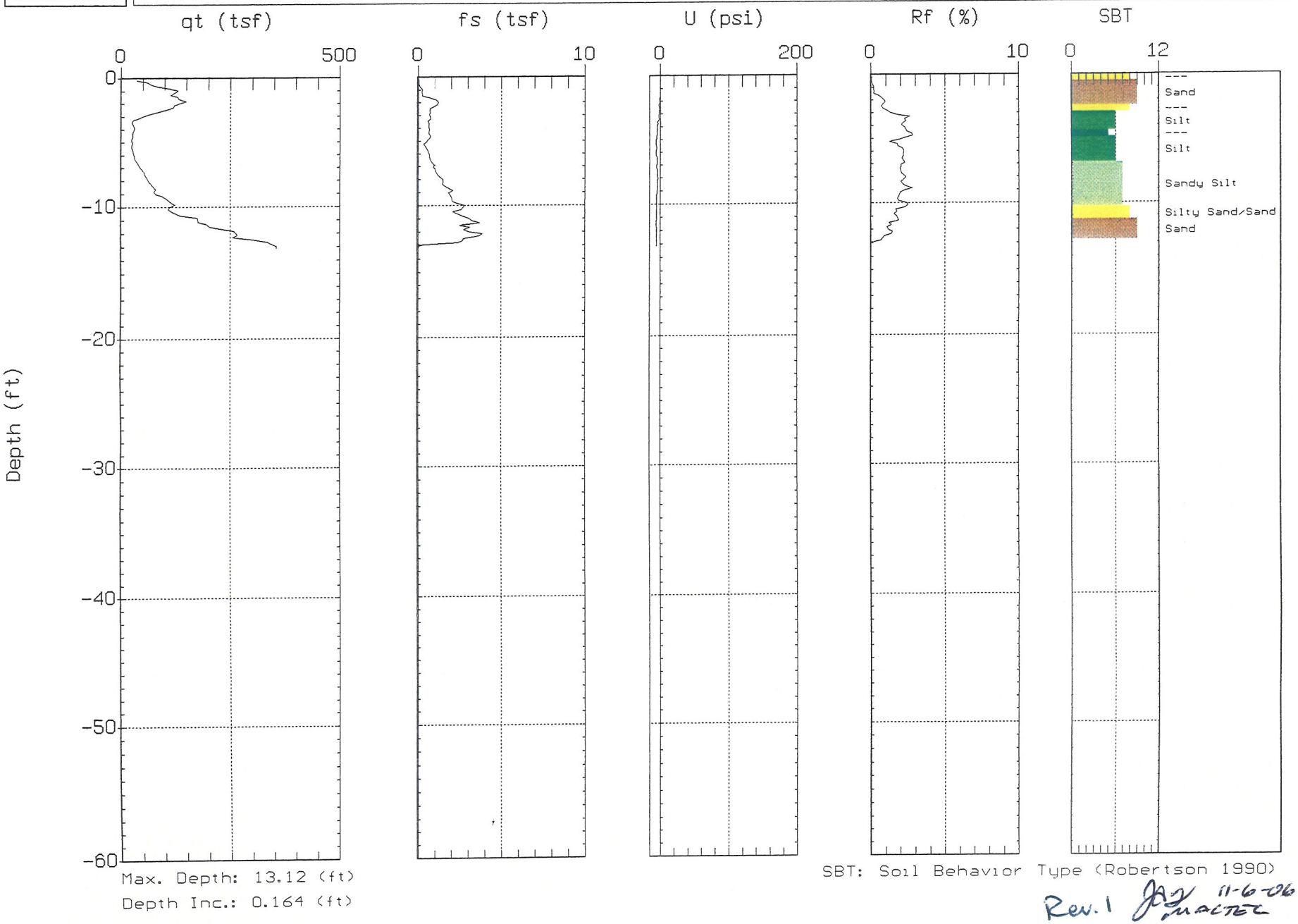
GREGG

MACTEC

Site: NORTH ANNA COL.
Location: CPT-907 1

Operator: R.AGUILAR
Date: 09/21/06 13:49

Rev.1



Max. Depth: 13.12 (ft)
Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson 1990)

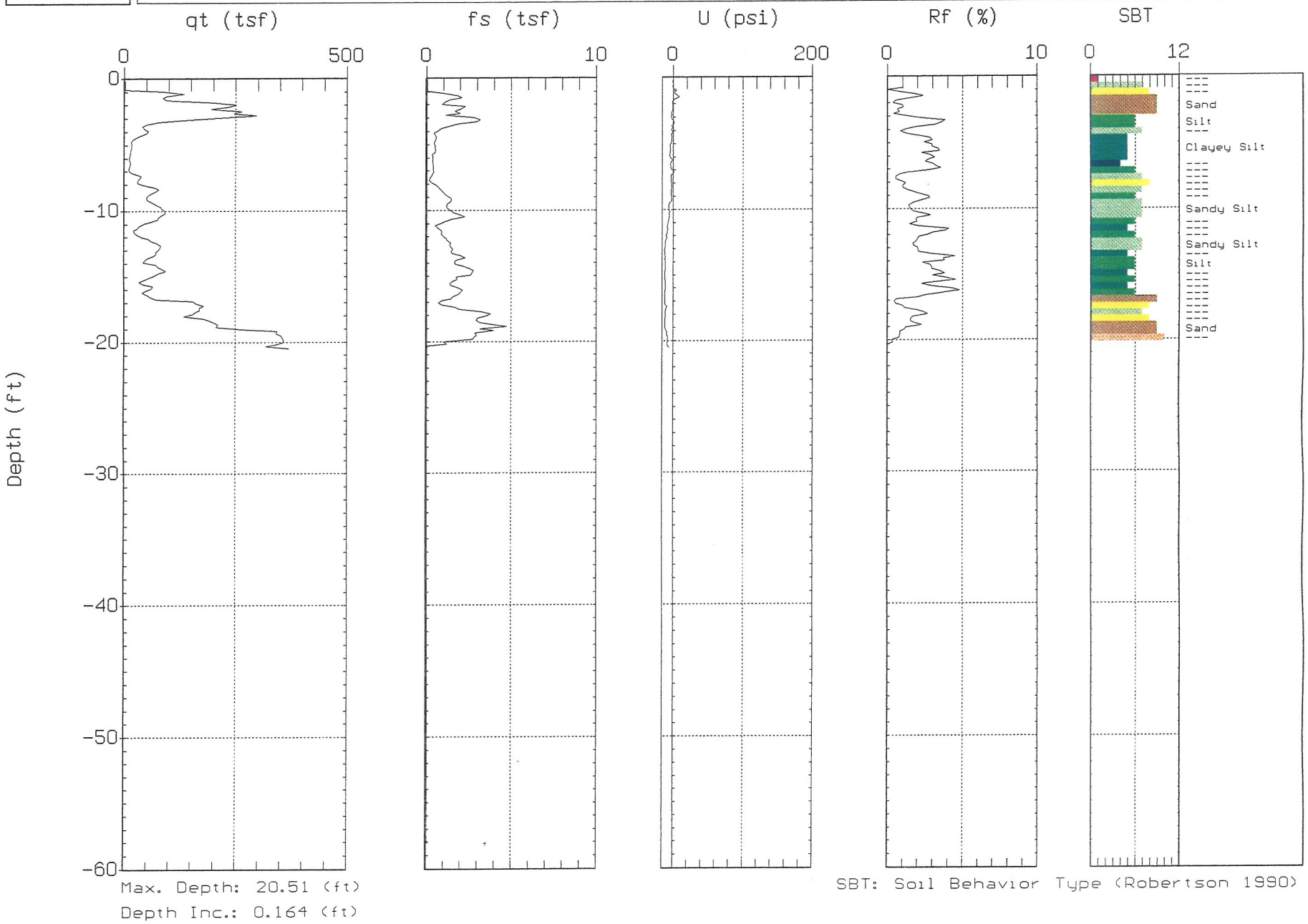
Rev.1 JAA 11-6-06 MACTEC

GREGG

MACTEC

Site: NORTH ANNA COL.
Location: CPT-908

Operator: R.AGUILAR
Date: 09/22/06 05:35

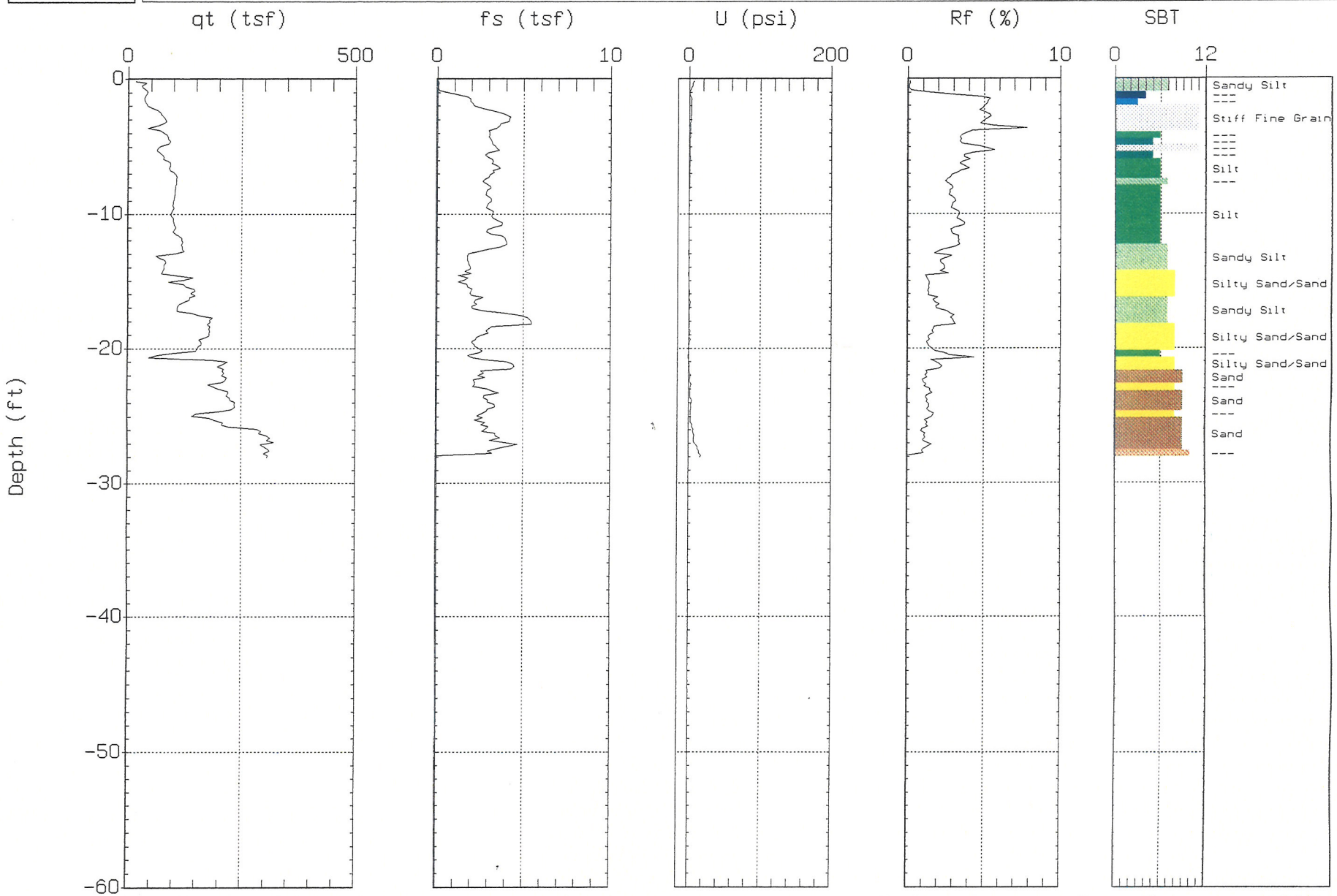


GREGG

MACTEC

Site: NORTH ANNA COL.
Location: CPT-909

Operator: R.AGUILAR
Date: 09/20/06 08:38



Max. Depth: 28.05 (ft)
Depth Inc.: 0.164 (ft)

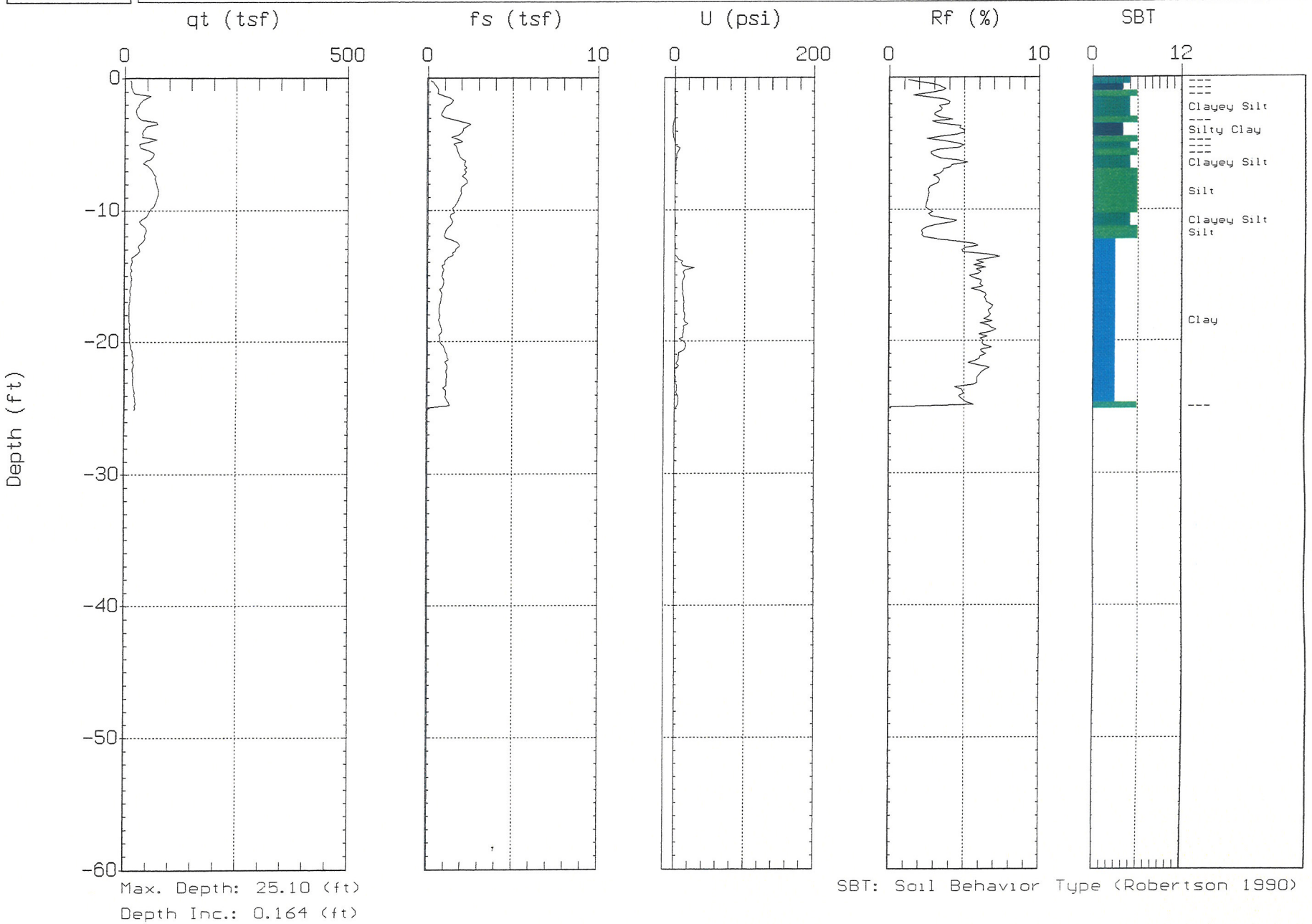
SBT: Soil Behavior Type (Robertson 1990)

GREGG

MACTEC

Site: NORTH ANNA COL.
Location: CPT-910

Operator: R.AGUILAR
Date: 09/18/06 12:25



Max. Depth: 25.10 (ft)
Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson 1990)