



GREGG DRILLING, LLC.
GEOTECHNICAL AND ENVIRONMENTAL INVESTIGATION SERVICES

7/25/19

Yeh & Associates, Inc.
Attn: Jon Blanchard

Subject: CPT Site Investigation
Avila Beach CSD WWTF Improvements
Avila Beach, California
GREGG Project Number: 190588SH

Dear Mr. Blanchard:

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

| | | | |
|----|----------------------------------|---------|-------------------------------------|
| 1 | Cone Penetration Tests | (CPTU) | <input checked="" type="checkbox"/> |
| 2 | Pore Pressure Dissipation Tests | (PPD) | <input checked="" type="checkbox"/> |
| 3 | Seismic Cone Penetration Tests | (SCPTU) | <input type="checkbox"/> |
| 4 | UVOST Laser Induced Fluorescence | (UVOST) | <input type="checkbox"/> |
| 5 | Groundwater Sampling | (GWS) | <input type="checkbox"/> |
| 6 | Soil Sampling | (SS) | <input type="checkbox"/> |
| 7 | Vapor Sampling | (VS) | <input type="checkbox"/> |
| 8 | Pressuremeter Testing | (PMT) | <input type="checkbox"/> |
| 9 | Vane Shear Testing | (VST) | <input type="checkbox"/> |
| 10 | Dilatometer Testing | (DMT) | <input type="checkbox"/> |

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 me at 714-863-0988.

Sincerely,
GREGG Drilling, LLC.

Frank Stolfi
HRSC Division Manager, Gregg Drilling, LLC.



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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) |
|-----------------------------|-----------|--------------------------|-------------------------------------|------------------------------|---|
| C-1 | 7/24/2019 | 100.39 | - | - | 67.2 |
| C-2 | 7/24/2019 | 85.3 | - | - | 75.2 |
| C-3 | 7/24/2019 | 75.46 | - | - | 19.0 |
| C-4 | 7/24/2019 | 75.3 | - | - | - |



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Cone Penetration Test Coordinates

-Table 2-

| CPT Sounding Identification | Date | Lat or Northing | Long or Easting | Elevation (Feet) |
|-----------------------------|-----------|-----------------|-----------------|------------------|
| C-1 | 7/24/2019 | 35.18199 | -120.73331 | UNKNOWN |
| C-2 | 7/24/2019 | 35.18229 | -120.733016 | UNKNOWN |
| C-3 | 7/24/2019 | 35.18211 | -118.73297 | UNKNOWN |
| C-4 | 7/24/2019 | 35.18241 | -120.732717 | UNKNOWN |



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. Weemeees, "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. Lutenegeger, "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

Cone Penetration Testing Procedure (CPT)

Gregg Drilling carries out all Cone Penetration Tests (CPT) using an integrated electronic cone system, *Figure CPT*.

The cone takes measurements of tip resistance (q_c), sleeve resistance (f_s), and penetration pore water pressure (u_2). Measurements are taken at either 2.5 or 5 cm intervals during penetration to provide a nearly continuous profile. CPT data reduction and basic interpretation is performed in real time facilitating on-site decision making. The CPT parameters are stored electronically for further analysis and reference. All CPT soundings are performed in accordance with revised ASTM standards (D 5778-12).

The 5mm thick porous plastic filter element is located directly behind the cone tip in the u_2 location. A new saturated filter element is used on each sounding to measure both penetration pore pressures as well as measurements during a dissipation test (PPDT). Prior to each test, the filter element is fully saturated with oil under vacuum pressure to improve accuracy.

When the sounding is completed, the test hole is backfilled according to client specifications. If grouting is used, the procedure generally consists of pushing a hollow tremie pipe with a “knock out” plug to the termination depth of the CPT 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.

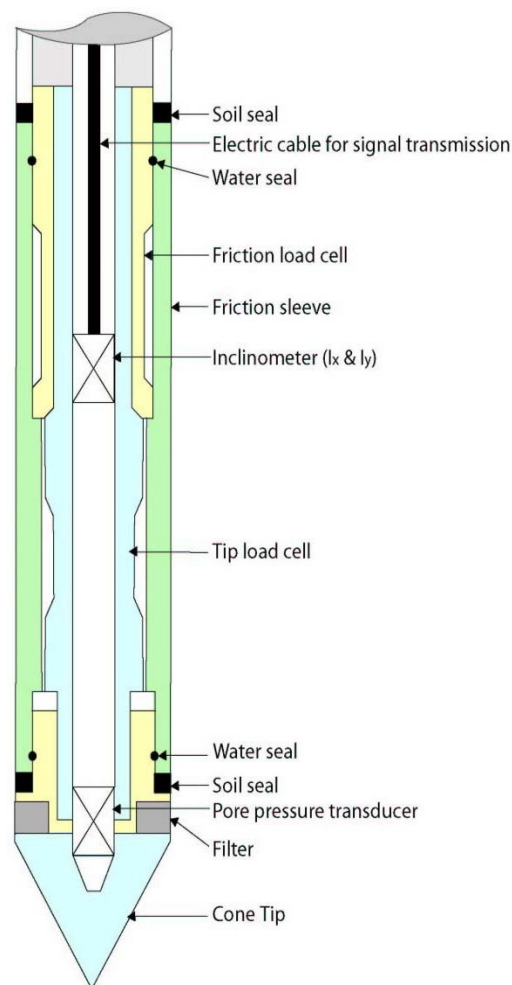


Figure CPT

Gregg 15cm² Standard Cone Specifications

| Dimensions | |
|---------------------------------|-----------------------|
| Cone base area | 15 cm ² |
| Sleeve surface area | 225 cm ² |
| Cone net area ratio | 0.85 |
| | |
| Specifications | |
| Cone load cell | |
| Full scale range | 180 kN (20 tons) |
| Overload capacity | 150% |
| Full scale tip stress | 120 MPa (1,200 tsf) |
| Repeatability | 120 kPa (1.2 tsf) |
| | |
| Sleeve load cell | |
| Full scale range | 31 kN (3.5 tons) |
| Overload capacity | 150% |
| Full scale sleeve stress | 1,400 kPa (15 tsf) |
| Repeatability | 1.4 kPa (0.015 tsf) |
| | |
| Pore pressure transducer | |
| Full scale range | 7,000 kPa (1,000 psi) |
| Overload capacity | 150% |
| Repeatability | 7 kPa (1 psi) |

Note: The repeatability on site will depend somewhat on ground conditions, abrasion, maintenance and zero load stability.

Cone Penetration Test Data & Interpretation

The Cone Penetration Test (CPT) data collected are presented in graphical and electronic form in the report. The plots include interpreted Soil Behavior Type (SBT) based on the charts described by Robertson (2009 & 2010). Typical plots display SBT based on the non-normalized charts of Robertson (2010). For CPT soundings deeper than 30m, we recommend the use of the normalized charts of Robertson (2009) which can be displayed as SBTn, upon request. The report can also include spreadsheet output of computer calculations of basic interpretation in terms of SBT and SBTn and various geotechnical parameters using current published correlations based on the comprehensive review by Lunne, Robertson and Powell (1997), as well as recent updates by Robertson and Cabal (Guide to Cone Penetration Testing, 2015). The interpretations are presented only as a guide for geotechnical use and should be carefully reviewed. Gregg Drilling does not warranty the correctness or the applicability of any of the geotechnical parameters interpreted by the software and does not assume any liability for use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used in the software. Some interpretation methods require input of the groundwater level to calculate vertical effective stress. An estimate of the in-situ groundwater level has been made based on field observations and/or CPT results, but should be verified by the user.

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. Note that it is not always possible to clearly identify a soil type based solely on q_t , 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 correct soil behavior type.

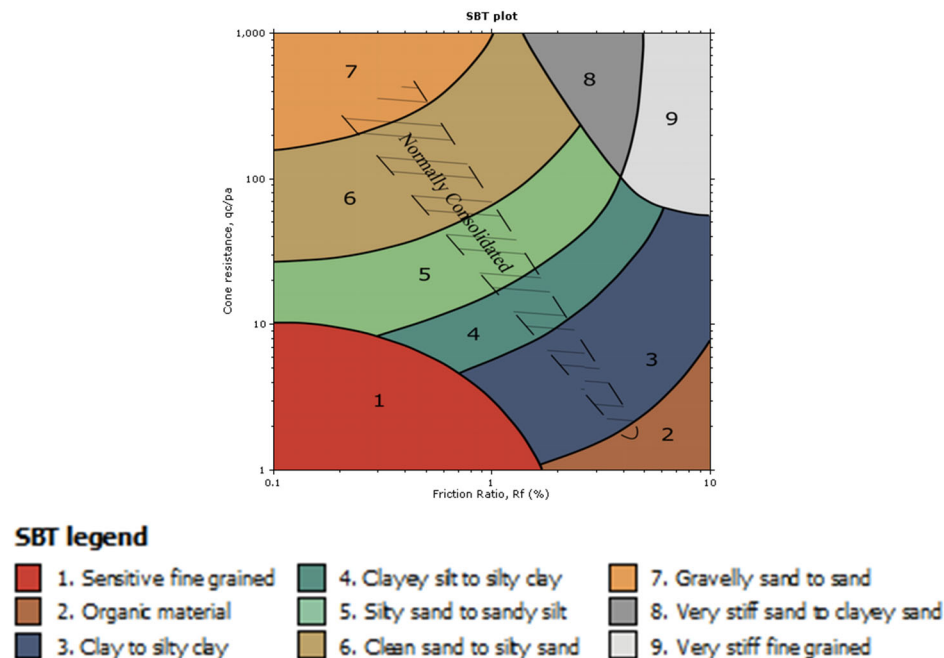


Figure SBT (After Robertson, 2010) – Note: Colors may vary slightly compared to plots

Cone Penetration Test (CPT) Interpretation

Gregg uses a commercial CPT interpretation and plotting software (CPeT-IT <https://geologismiki.gr/products/cpet-it/>). The software takes the CPT data and performs basic interpretation in terms of soil behavior type (SBT) and various geotechnical parameters using current published empirical correlations based on the comprehensive review by Lunne, Robertson and Powell (1997) and updated by Robertson and Cabal (2015). The interpretation is presented in tabular format. The interpretations are presented only as a guide for geotechnical use and should be carefully reviewed. Gregg does not warranty the correctness or the applicability of any of the geotechnical parameters interpreted by the software and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used in the software.

The following provides a summary of the methods used for the interpretation. Many of the empirical correlations to estimate geotechnical parameters have constants that have a range of values depending on soil type, geologic origin and other factors. The software uses 'default' values that have been selected to provide, in general, conservatively low estimates of the various geotechnical parameter.

Presented below is a list of formulas used for the estimation of various soil properties. The formulas are presented in SI unit system and assume that all components are expressed in the same units.

:: Unit Weight, g (kN/m³) ::

$$g = g_w \cdot \left(0.27 \cdot \log(R_f) + 0.36 \cdot \log\left(\frac{q_t}{p_a}\right) + 1.236 \right)$$

where g_w = water unit weight

:: Permeability, k (m/s) ::

$$I_c < 3.27 \text{ and } I_c > 1.00 \text{ then } k = 10^{0.952 - 3.04 I_c}$$

$$I_c \leq 4.00 \text{ and } I_c > 3.27 \text{ then } k = 10^{-4.52 - 1.37 I_c}$$

:: N_{SPT} (blows per 30 cm) ::

$$N_{60} = \left(\frac{q_c}{p_a} \right) \cdot \frac{1}{10^{1.1268 - 0.2817 I_c}}$$

$$N_{1(60)} = Q_{tn} \cdot \frac{1}{10^{1.1268 - 0.2817 I_c}}$$

:: Young's Modulus, E_s (MPa) ::

$$(q_t - \sigma_v) \cdot 0.015 \cdot 10^{0.55 I_c + 1.68}$$

(applicable only to $I_c < I_{c_cutoff}$)

:: Relative Density, D_r (%) ::

$$100 \cdot \sqrt{\frac{Q_{tn}}{k_{OCR}}} \quad \text{(applicable only to SBT}_n\text{: 5, 6, 7 and 8 or } I_c < I_{c_cutoff}\text{)}$$

:: State Parameter, ψ ::

$$\psi = 0.56 - 0.33 \cdot \log(Q_{tn,CS})$$

:: Drained Friction Angle, ϕ (°) ::

$$\phi = \phi'_{cv} + 15.94 \cdot \log(Q_{tn,CS}) - 26.88$$

(applicable only to SBT_n: 5, 6, 7 and 8 or $I_c < I_{c_cutoff}$)

:: 1-D constrained modulus, M (MPa) ::

If $I_c > 2.20$

$a = 14$ for $Q_{tn} > 14$

$a = Q_{tn}$ for $Q_{tn} \leq 14$

$M_{CPT} = a \cdot (q_t - \sigma_v)$

If $I_c \leq 2.20$

$$M_{CPT} = 0.03 \cdot (q_t - \sigma_v) \cdot 10^{0.55 I_c + 1.68}$$

:: Small strain shear Modulus, G_0 (MPa) ::

$$G_0 = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 I_c + 1.68}$$

:: Shear Wave Velocity, V_s (m/s) ::

$$V_s = \left(\frac{G_0}{\rho} \right)^{0.50}$$

:: Undrained peak shear strength, S_u (kPa) ::

$$N_{kt} = 10.50 + 7 \cdot \log(F_r) \text{ or user defined}$$

$$S_u = \frac{(q_t - \sigma_v)}{N_{kt}}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c_cutoff}$)

:: Remolded undrained shear strength, $S_u(rem)$ (kPa) ::

$$S_{u(rem)} = f_s \quad \text{(applicable only to SBT}_n\text{: 1, 2, 3, 4 and 9 or } I_c > I_{c_cutoff}\text{)}$$

:: Overconsolidation Ratio, OCR ::

$$k_{OCR} = \left[\frac{Q_{tn}^{0.20}}{0.25 \cdot (10.50 + 7 \cdot \log(F_r))} \right]^{-1.25} \text{ or user defined}$$

$$OCR = k_{OCR} \cdot Q_{tn}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c_cutoff}$)

:: In situ Stress Ratio, K_0 ::

$$K_0 = (1 - \sin \phi') \cdot OCR^{\sin \phi'}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c_cutoff}$)

:: Soil Sensitivity, S_t ::

$$S_t = \frac{N_s}{F_r}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c_cutoff}$)

:: Peak Friction Angle, ϕ' (°) ::

$$\phi' = 29.5^\circ \cdot B_q^{0.121} \cdot (0.256 + 0.336 \cdot B_q + \log Q_t)$$

(applicable for $0.10 < B_q < 1.00$)

References

ASTM D5778-12, 2012, Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils. ASTM West Conshohocken, USA

Lunne, T., Robertson, P.K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice.

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Robertson, P.K., 2010, "Soil Behavior type from the CPT: an update", 2nd International Symposium on Cone Penetration Testing, Huntington Beach, CA, Vol.2. pp 575-583

Robertson, P.K. and Cabal, K.L., "Guide to Cone Penetration Testing for Geotechnical Engineering", 6th Edition, 2015, 145 p. Free online, <http://www.greggdrilling.com/technical-guides>.

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, pp. 791-803, 1986.

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CPT BORINGS

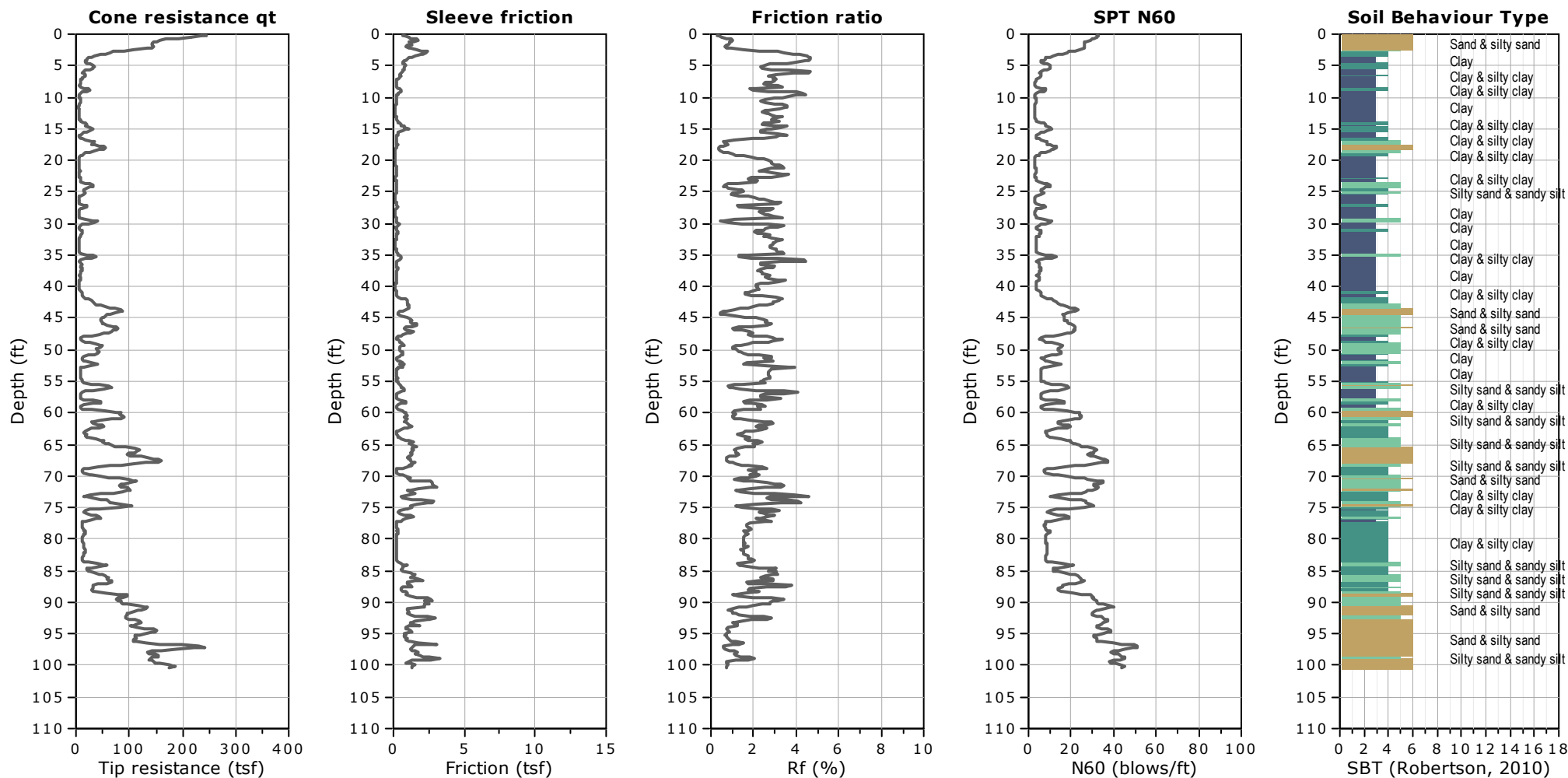


CLIENT: YEH & ASSOCIATES, INC.

FIELD REP: JAMIE C.

SITE: AVILA BEACH CSD WWTF IMPROVEMENTS - 2850 AVILA BEACH DRIVE, AVILA BEACH, CA

Total depth: 100.39 ft, Date: 7/24/2019



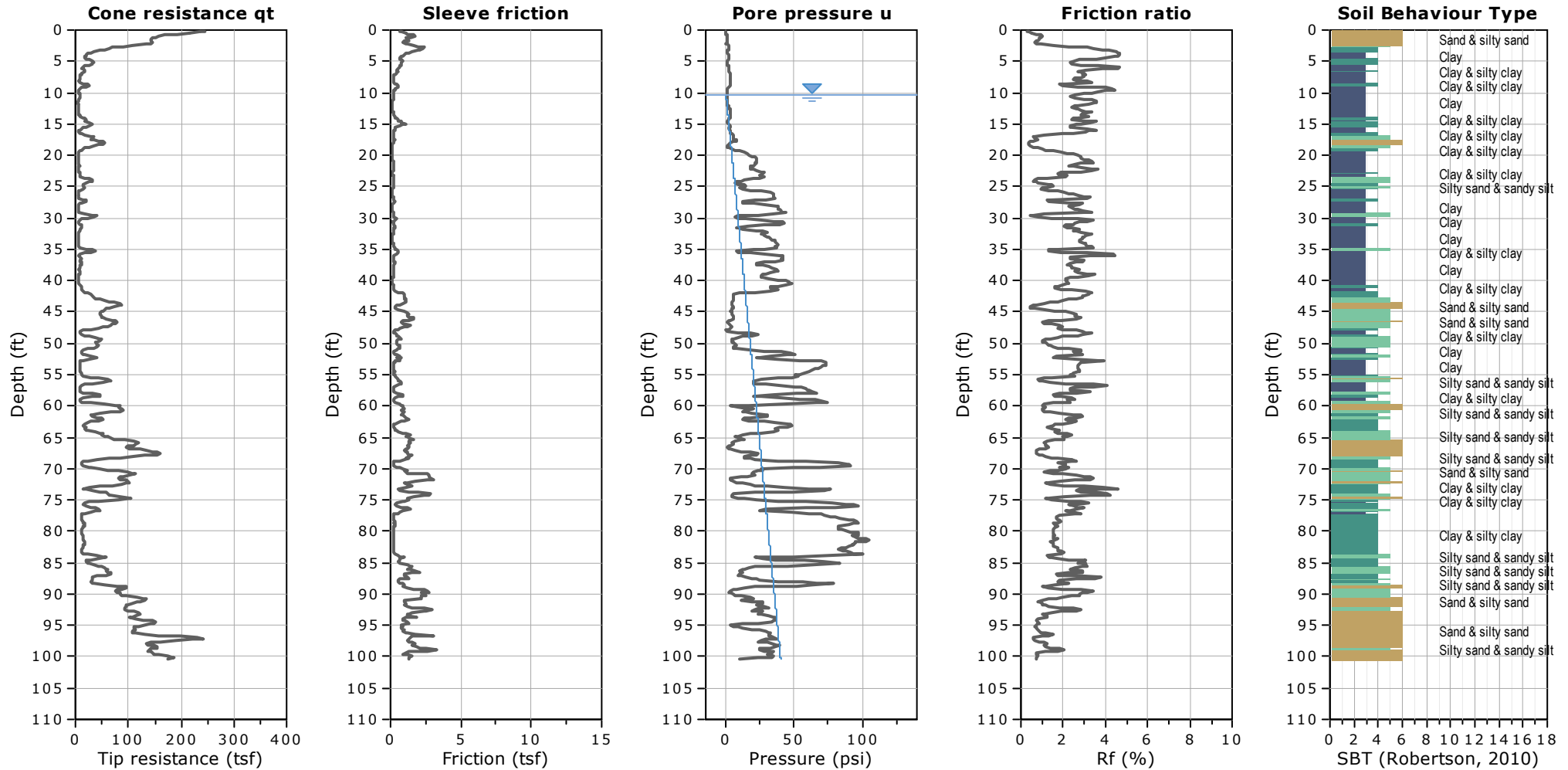


CLIENT: YEH & ASSOCIATES, INC.

Field Rep: JAMIE C.

SITE: AVILA BEACH CSD WWTF IMPROVEMENTS - 2850 AVILA BEACH DRIVE, AVILA BEACH, CA

Total depth: 100.39 ft, Date: 7/24/2019



WATER TABLE FOR ESTIMATING PURPOSES ONLY

SBTn legend

- | | | |
|---------------------------|------------------------------|-----------------------------------|
| 1. Sensitive fine grained | 4. Clayey silt to silty clay | 7. Gravely sand to sand |
| 2. Organic material | 5. Silty sand to sandy silt | 8. Very stiff sand to clayey sand |
| 3. Clay to silty clay | 6. Clean sand to silty sand | 9. Very stiff fine grained |

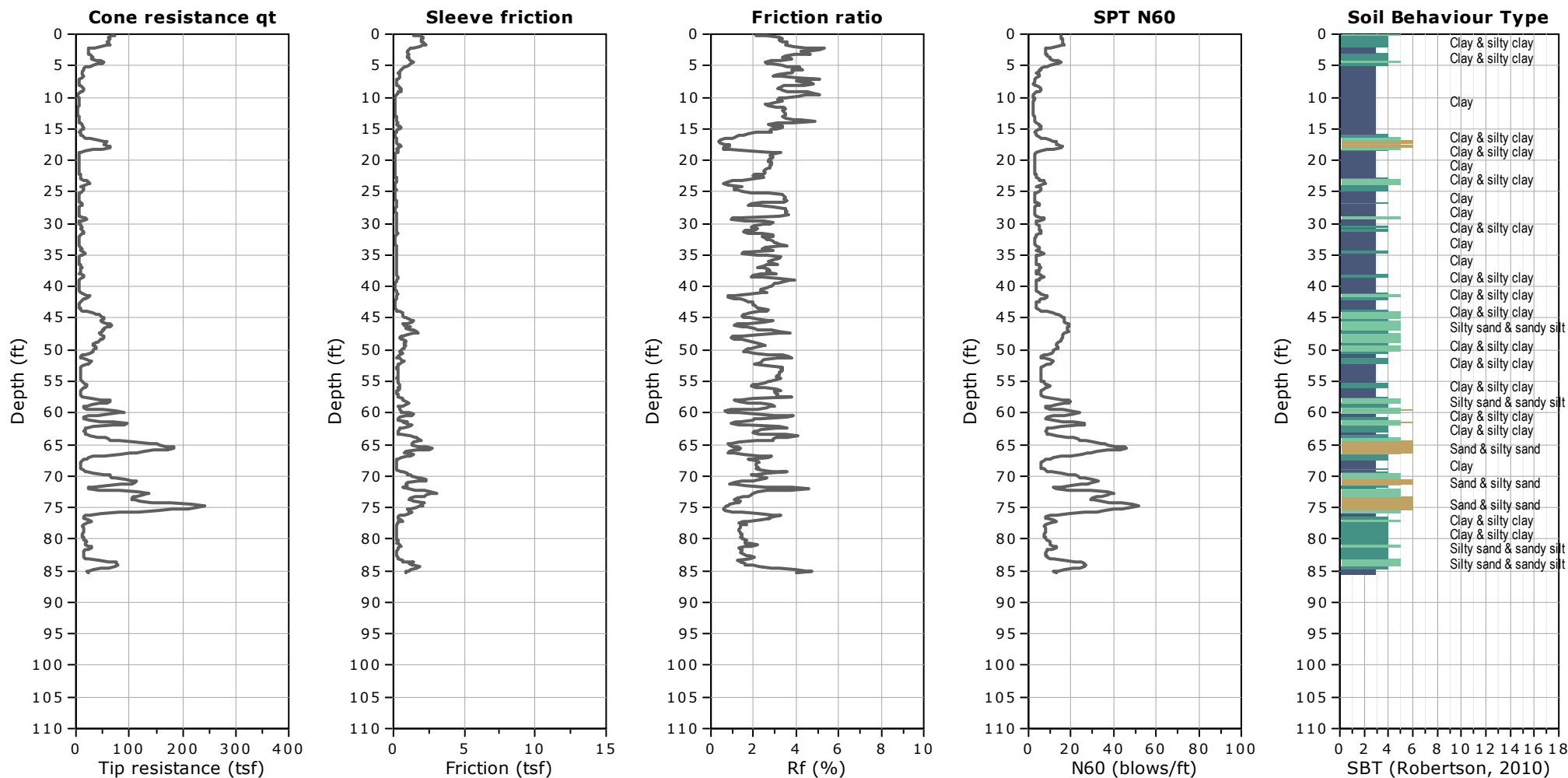


CLIENT: YEH & ASSOCIATES, INC.

SITE: AVILA BEACH CSD WWTF IMPROVEMENTS - 2850 AVILA BEACH DRIVE, AVILA BEACH, CA

FIELD REP: JAMIE C.

Total depth: 85.30 ft, Date: 7/24/2019



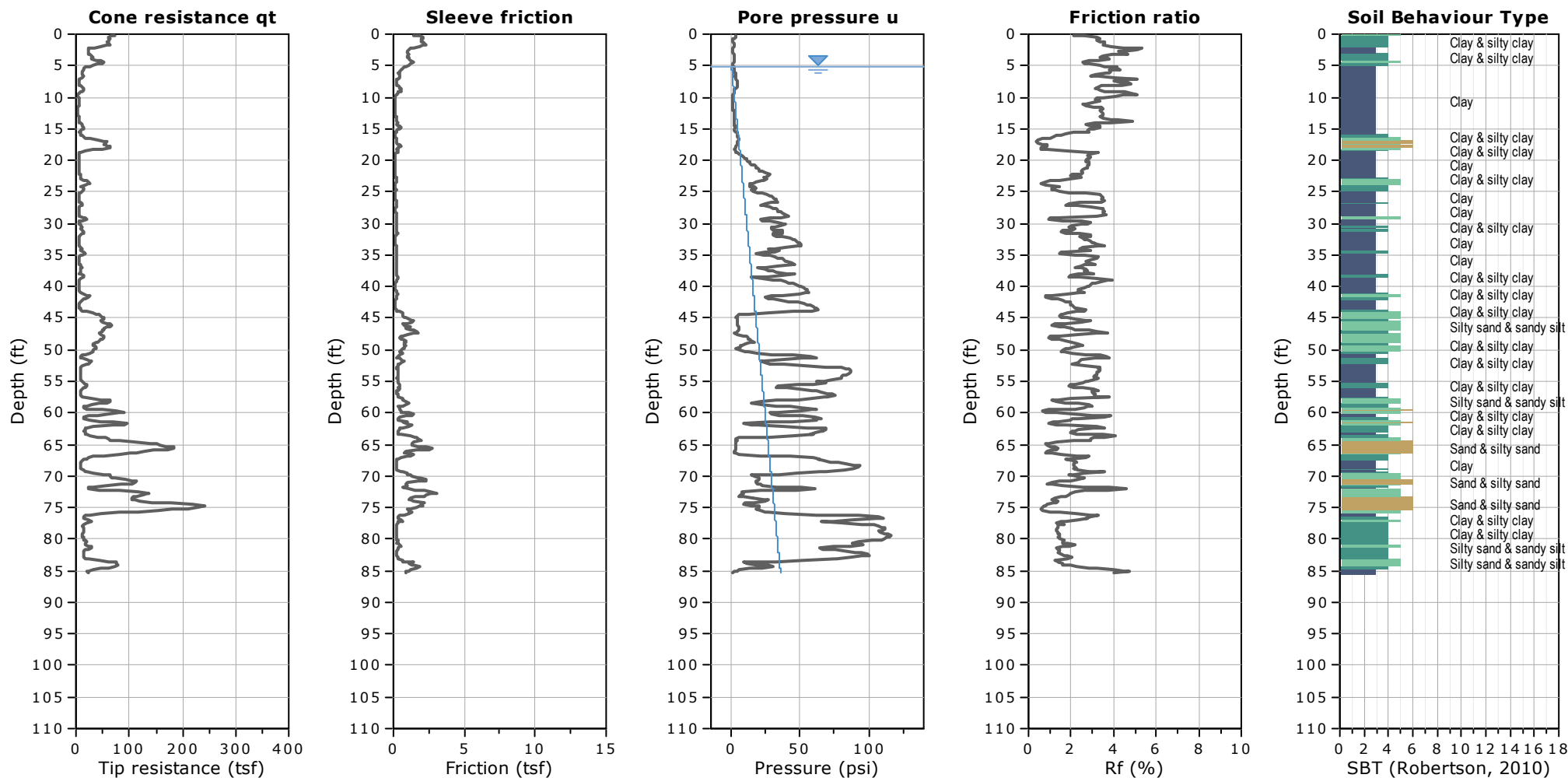


CLIENT: YEH & ASSOCIATES, INC.

Field Rep: JAMIE C.

SITE: AVILA BEACH CSD WWTF IMPROVEMENTS - 2850 AVILA BEACH DRIVE, AVILA BEACH, CA

Total depth: 85.30 ft, Date: 7/24/2019



WATER TABLE FOR ESTIMATING PURPOSES ONLY

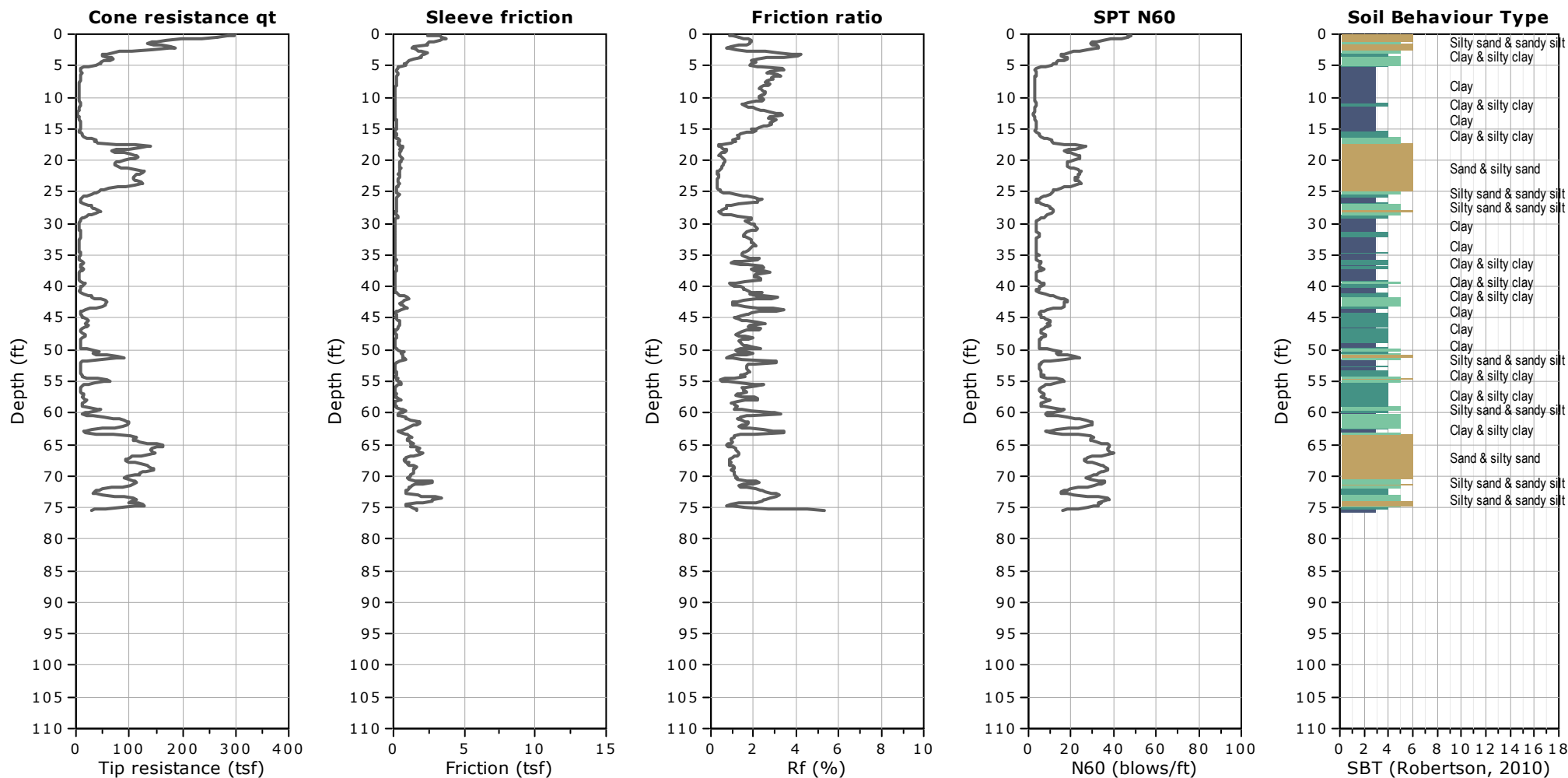


CLIENT: YEH & ASSOCIATES, INC.

SITE: AVILA BEACH CSD WWTF IMPROVEMENTS - 2850 AVILA BEACH DRIVE, AVILA BEACH, CA

FIELD REP: JAMIE C.

Total depth: 75.46 ft, Date: 7/24/2019



SBTn legend

- | | | |
|---------------------------|------------------------------|-----------------------------------|
| 1. Sensitive fine grained | 4. Clayey silt to silty clay | 7. Gravely sand to sand |
| 2. Organic material | 5. Silty sand to sandy silt | 8. Very stiff sand to clayey sand |
| 3. Clay to silty clay | 6. Clean sand to silty sand | 9. Very stiff fine grained |

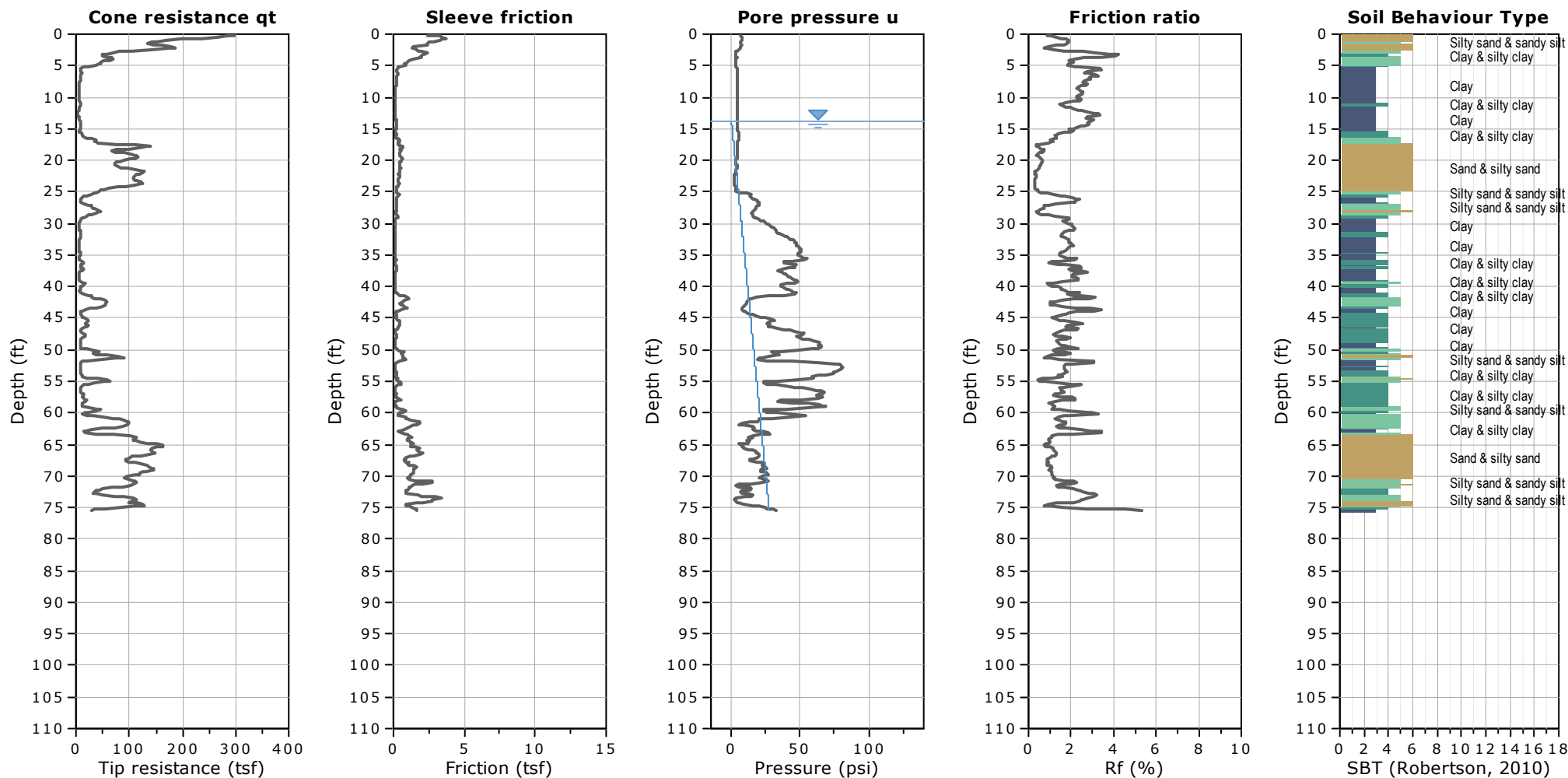


CLIENT: YEH & ASSOCIATES, INC.

Field Rep: JAMIE C.

SITE: AVILA BEACH CSD WWTF IMPROVEMENTS - 2850 AVILA BEACH DRIVE, AVILA BEACH, CA

Total depth: 75.46 ft, Date: 7/24/2019



WATER TABLE FOR ESTIMATING PURPOSES ONLY

- SBTn legend**
- | | | |
|---------------------------|------------------------------|-----------------------------------|
| 1. Sensitive fine grained | 4. Clayey silt to silty clay | 7. Gravely sand to sand |
| 2. Organic material | 5. Silty sand to sandy silt | 8. Very stiff sand to clayey sand |
| 3. Clay to silty clay | 6. Clean sand to silty sand | 9. Very stiff fine grained |

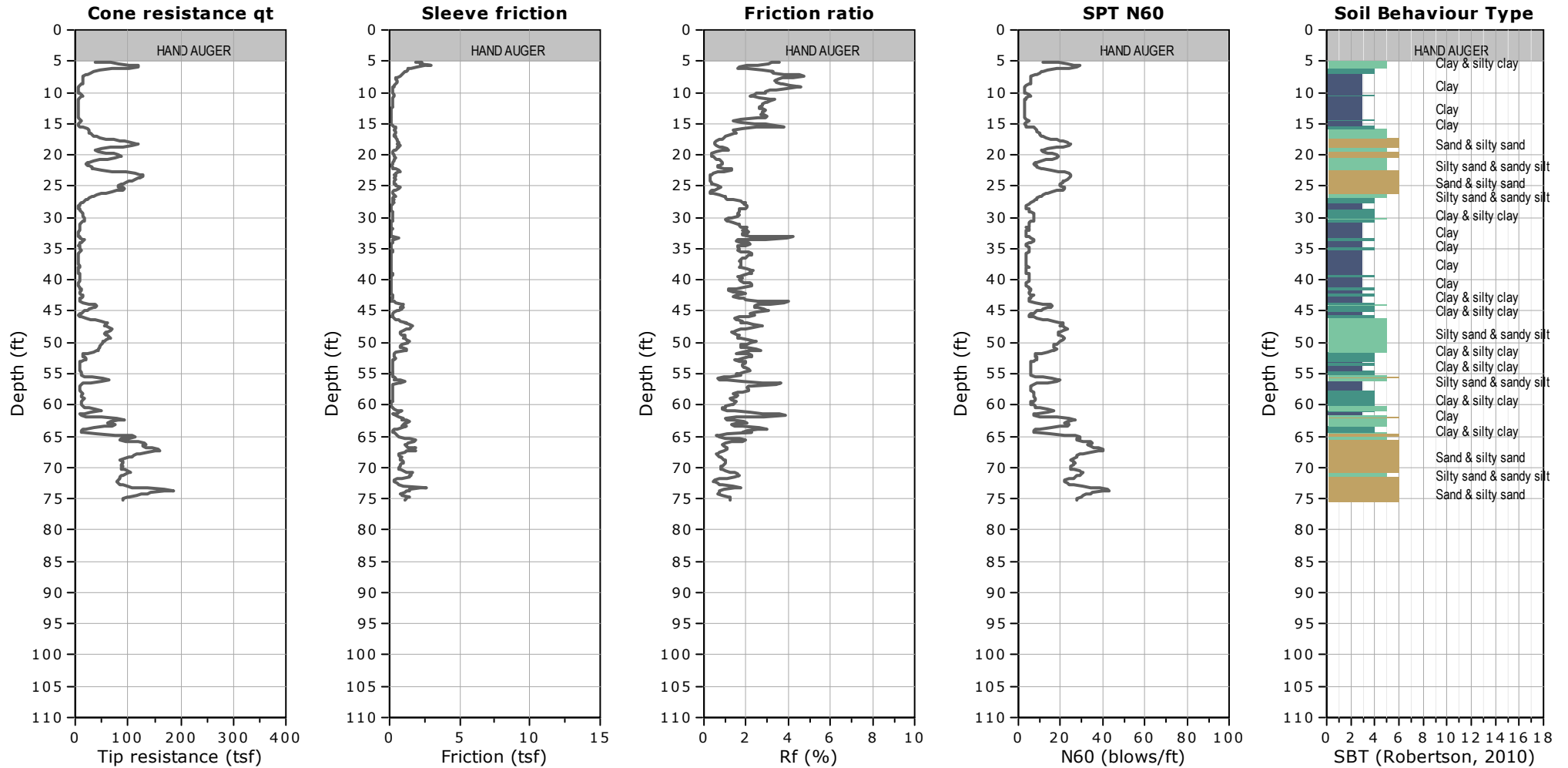


CLIENT: YEH & ASSOCIATES, INC.

SITE: AVILA BEACH CSD WWTF IMPROVEMENTS - 2850 AVILA BEACH DRIVE, AVILA BEACH, CA

FIELD REP: JAMIE C.

Total depth: 75.30 ft, Date: 7/24/2019



SBTn legend

- | | | |
|---------------------------|------------------------------|-----------------------------------|
| 1. Sensitive fine grained | 4. Clayey silt to silty clay | 7. Gravely sand to sand |
| 2. Organic material | 5. Silty sand to sandy silt | 8. Very stiff sand to clayey sand |
| 3. Clay to silty clay | 6. Clean sand to silty sand | 9. Very stiff fine grained |

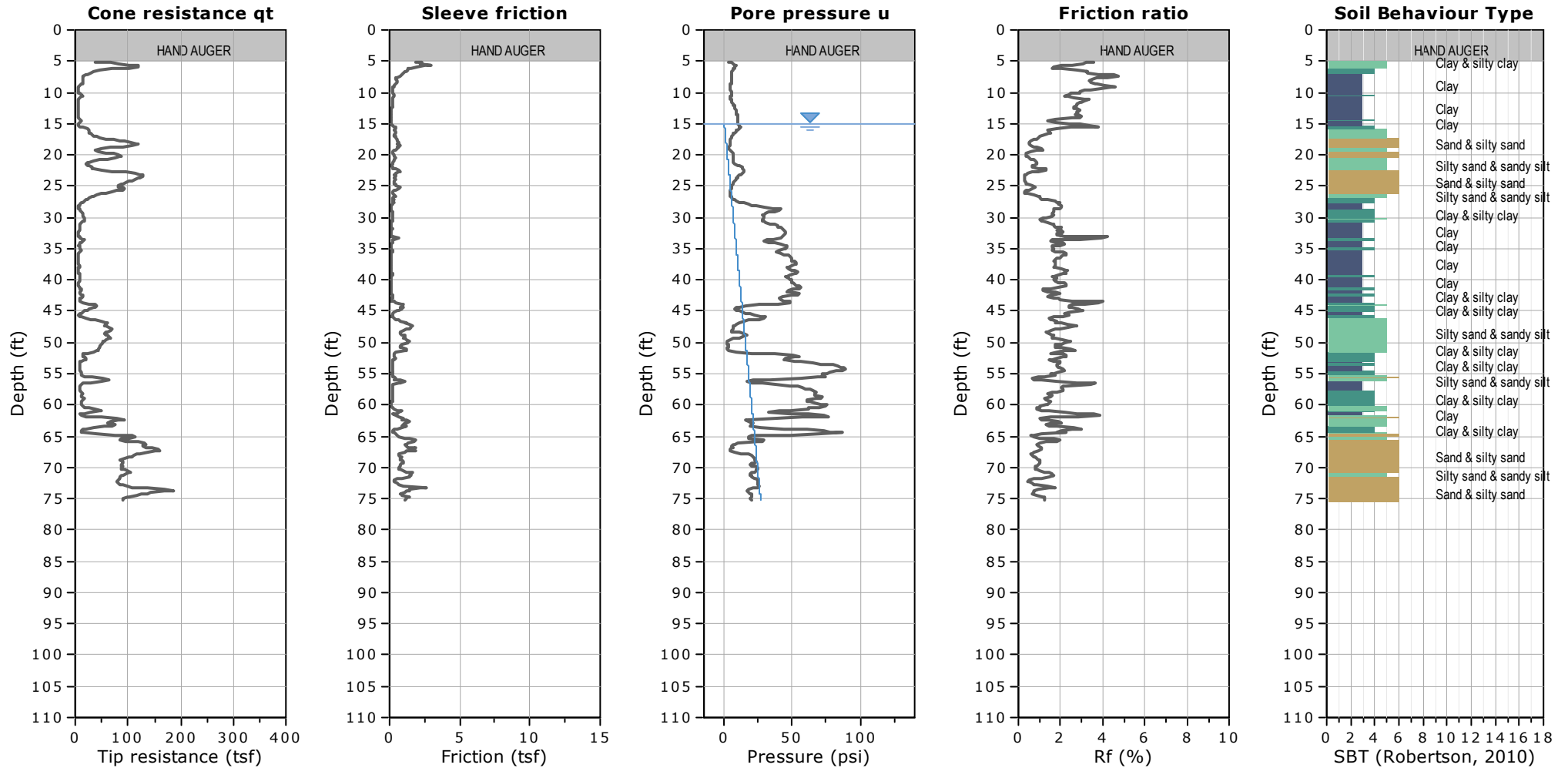


CLIENT: YEH & ASSOCIATES, INC.

Field Rep: JAMIE C.

SITE: AVILA BEACH CSD WWTF IMPROVEMENTS - 2850 AVILA BEACH DRIVE, AVILA BEACH, CA

Total depth: 75.30 ft, Date: 7/24/2019



WATER TABLE FOR ESTIMATING PURPOSES ONLY

SBTn legend

- | | | |
|---------------------------|------------------------------|-----------------------------------|
| 1. Sensitive fine grained | 4. Clayey silt to silty clay | 7. Gravely sand to sand |
| 2. Organic material | 5. Silty sand to sandy silt | 8. Very stiff sand to clayey sand |
| 3. Clay to silty clay | 6. Clean sand to silty sand | 9. Very stiff fine grained |



PORE PRESSURE DISSIPATION

Pore Pressure Dissipation Tests (PPDT)

Pore Pressure Dissipation Tests (PPDT's) conducted at various intervals can be used to measure equilibrium water pressure (at the time of the CPT). If conditions are hydrostatic, the equilibrium water pressure can be used to determine the approximate depth of the ground water table. A PPDT is conducted when penetration 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.

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 it reaches equilibrium, *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 and Lunne et al. 1997.

A summary of the pore pressure dissipation tests is summarized in Table 1.

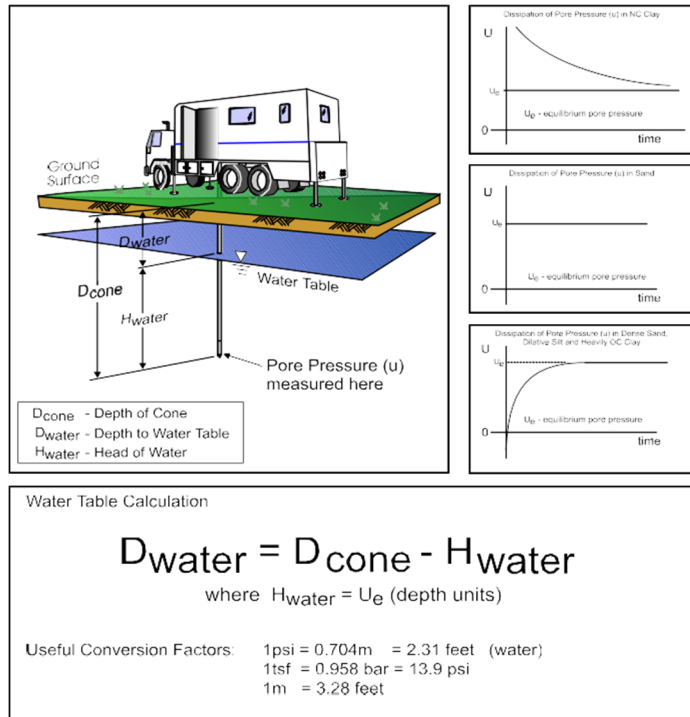


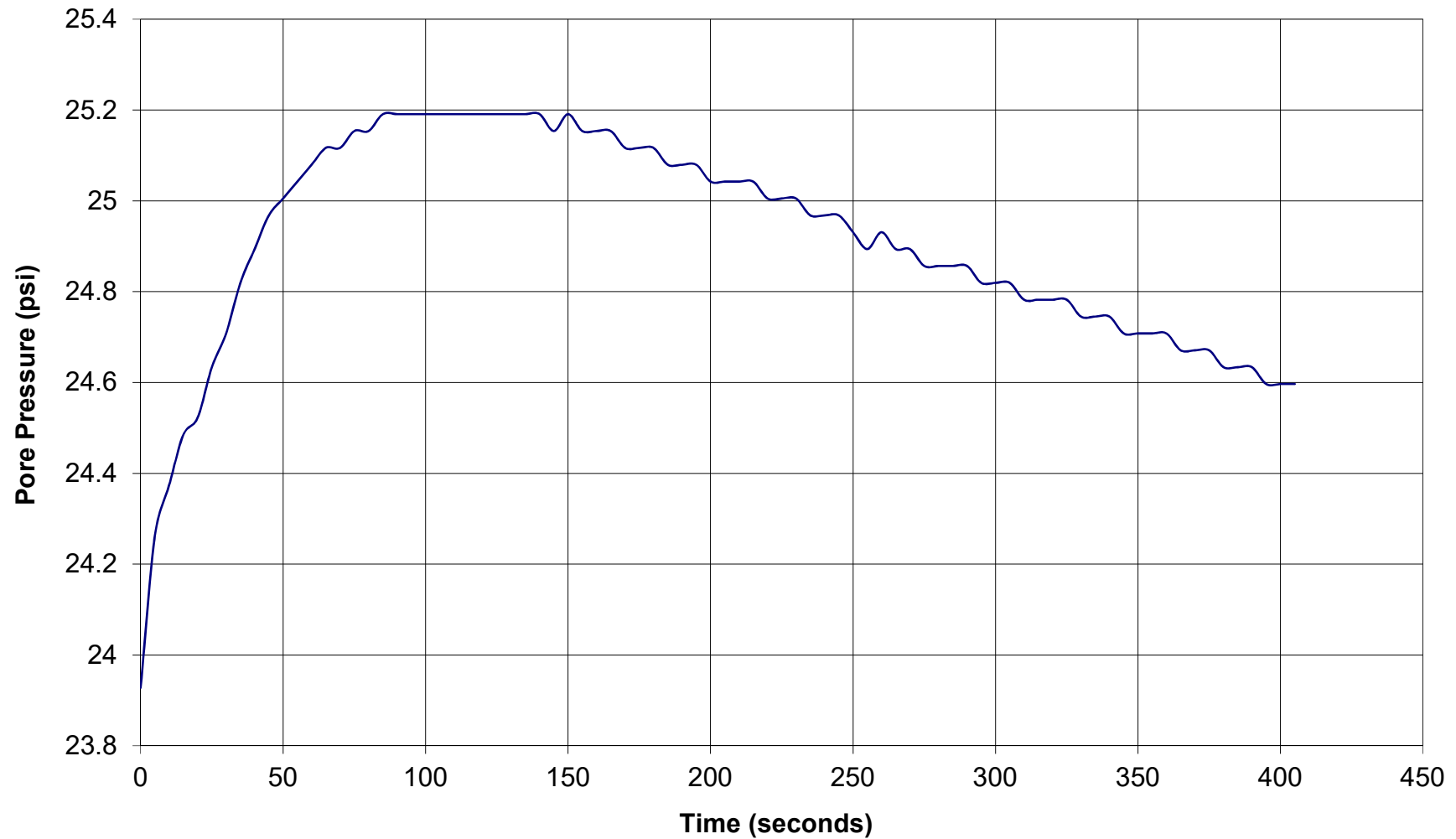
Figure PPDT



GREGG DRILLING & TESTING

Pore Pressure Dissipation Test

Sounding: C-1
Depth: 67.257015
Site: AVILA BEACH
Engineer: JAMIE C.

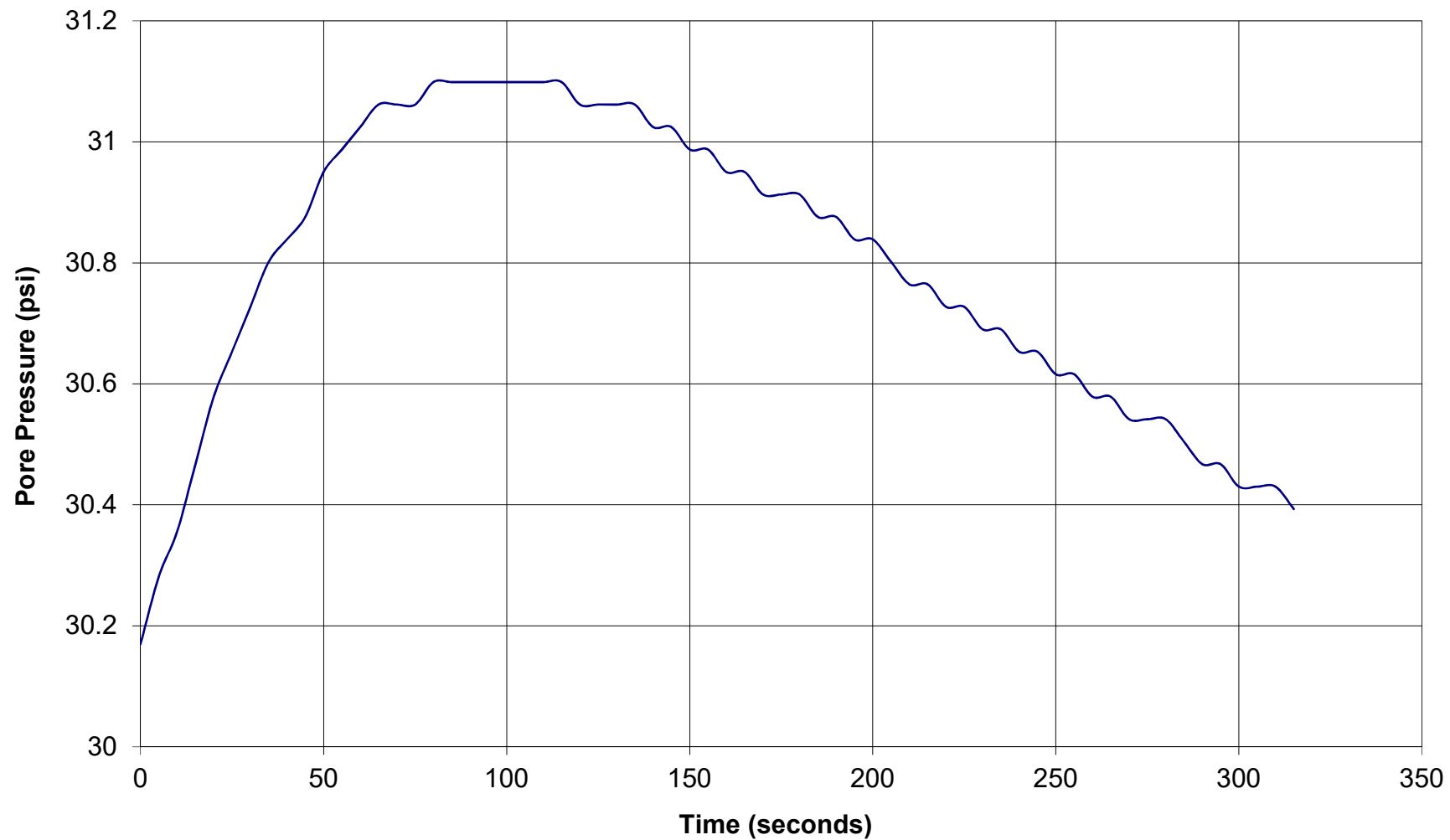




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Pore Pressure Dissipation Test

Sounding: C-2
Depth: 75.2950485
Site: AVILA BEACH
Engineer: JAMIE C.





GREGG DRILLING & TESTING

Pore Pressure Dissipation Test

Sounding: C-3
Depth: 19.028814
Site: AVILA BEACH
Engineer: JAMIE C.

