# REPORT OF PRELIMINARY GEOTECHNICAL EXPLORATION

**BLACK RIVER INDUSTRIAL PARK**
**SUMTER COUNTY, SOUTH CAROLINA**
**S&ME PROJECT NO. 1611-07-021**

**Prepared For:**


**Alliance Consulting Engineers, Inc.**
**Post Office Box 8147**
**Columbia SC 29202-8147**


**Prepared By:**


S&ME

**134 Suber Road**
**Columbia, South Carolina 29210**


**February 7, 2007**

February 7, 2007

Mr. Ross Oakley, P.E.
Alliance Consulting Engineers, Inc.
Post Office Box 8147
Columbia SC 29202-8147

Reference: **Report of Preliminary Geotechnical Exploration**
Black River Industrial Park
Sumter County, South Carolina
S&ME Project No. 1611-07-021

Dear Mr. Oakley:

As requested S&ME, Inc. has conducted a preliminary geotechnical exploration at the above referenced site in general accordance with S&ME Proposal No. 1614-4906-06. The purpose of this exploration was to characterize the general surface and subsurface conditions of the site, and to provide preliminary recommendations regarding site preparation, suitability of on-site soils for use in construction, seismic site class, and preliminary foundation design parameters. This investigation was performed solely to aid in evaluation of the site's suitability for industrial development. None of the recommendations contained herein are valid for design without confirmation from an additional subsurface investigation once building locations are determined.

S&ME appreciates this opportunity to work with Alliance Consulting Engineers, Inc. as your geotechnical engineering consultant on this project. If you have any questions or need any further information in regard to this geotechnical report, please do not hesitate to contact us.

Very truly yours,
**S&ME, Inc.**

Pamela Oree, E.I.T.
Geotechnical Staff Professional

James T. Palmer, P.E.
Engineering Dept. Manager

S&ME, INC. / 134 Suber Road / Columbia, SC 29210 / p 803.561.9024 f 803.561.9177 / www.smeinc.com

**TABLE OF CONTENTS** **PAGE**

## 1.0 PROJECT INFORMATION

Information about the site was obtained via e-mail and telephone conversations between Mr. Chris Daves of S&ME and Mr. Ross Oakley of Alliance Consulting Engineers on September 18 and December 11, 2006. The 547-acre site consists of seven separate parcels located adjacent to Jefferson Road, Airport Road or North Wise Drive north of Sumter in Sumter County, South Carolina. It is our understanding that 225 acres of the approximately 547 acres (three of the seven tracts) have been previously explored. Alliance Consulting Engineers provided S&ME a site map depicting the seven parcels and their approximate acreages.

S&ME performed tests on four of the seven tracts at the project site. Currently, tract 1 consists mostly of open lawn, several cypress trees lining Diebold Drive and a large cell tower. An industrial facility borders the site to the south and east, residential homes to the west, and Jefferson Road to the north. Tracts three, five, and six consist mainly of longleaf pine and hardwood trees and various trails leading around the property. Additionally, tract five contains a medium sized spec building. Woodlands border tract three to the north and west, Jefferson Road to the south, and N. Wise Drive to the east. Woodlands border tract five to the north and west, an industrial facility to the south, and Airport Road to the east. Tract six is bordered by N. Wise Drive to the west, an industrial facility to the north, Jefferson Road to the south, and Airport Road to the east. The approximate location of the site is denoted on the Site Location Map (Figure 1) included in the Appendix.

Potential proposed construction would likely consist of light to medium industrial facilities and the associated parking and drive areas. Maximum column loads are expected to be less than 200 kips with wall loads of 3 to 4 kips per linear ft. Finished floor elevations are yet to be determined and will likely vary between the sites.

## 2.0 EXPLORATION PROCEDURES

### 2.1 Reconnaissance of the Project Area

We reviewed USGS topographic maps of the area and the USDA Soil Survey of Sumter County, South Carolina. We then walked over the site to note land use, topography, surface drainage, ground cover and existing structures, as well as access to proposed sampling points. Right-of-entry to perform borings and other fieldwork on the property was granted with acceptance of our proposal.

### 2.2 Layout and Access to Sounding Locations

Cone Penetration Test (CPT) sounding locations are approximately indicated on the Sounding Location Plan (Figure 2) included in the Appendix. Sounding locations were established in the field based on visual reference to existing site features. The soundings were located in areas where our track-mounted CPT rig could obtain relatively easy access with little or no clearing.

### 2.3 Exploration and Sampling

Shallow hand auger borings were used to obtain near surface soil samples. Hand auger boring numbers coincide with sounding location numbers. The site subsurface conditions were explored by performing twelve cone penetration test (CPT) soundings at widely spaced locations across the site. All soundings were terminated at a depth of 25 feet below existing grade. Multi-Channel Analysis of Surface Wave (MASW) arrays were conducted at three separate locations to help identify the seismic site class.

## 3.0 SITE CONDITIONS

### 3.1 Local Physiographic and Geologic Setting

***Geology of the Sumter Area.*** Shaw AFB and the city of Sumter lie immediately southeast of topographical feature termed the Citronelle Escarpment. The escarpment denotes the boundary between the upper and middle portions of the Atlantic Coastal Plain of South Carolina and is the major topographical feature of the coastal plain. The area northwest of the escarpment is termed the Santee Hills and is underlain by Tertiary age Coastal Plain residuum. Areas southeast of the escarpment, including downtown Sumter, lie within the Atlantic Flatwoods Region of the Lower Coastal Plain of South Carolina.

The Atlantic Flatwoods comprises most of the Lower Coastal Plain, extending to the Surry Escarpment 15 to 40 miles inland from the sea. The topography of this region is dominated by up to six archaic marine terraces, exposed above sea level by uplifting of the local area over the last one million years. The terraces exhibit minor surface erosion, but can be traced large distances on the basis of surface elevation. Abandoned tidal eddies on the terraces have been filled with sediments and now form shallow, poorly drained elliptical depressions on the surface, termed Carolina bays, which are commonly apparent on aerial photographs or local topographic maps. Materials comprising the terraces typically consist of a strand or beach ridge deposit of clean sands at the seaward margin, interbedded with progressively more fine grained soils to the west. The marine terraces form a thin veneer over older, underlying Coastal Plain marl locally termed the Duplin Formation.

### 3.2 Topography

The USGS Sumter East quadrangle topographic map dated 1957 indicate the site to be nearly level to gently sloping to the northeast. Elevations on the site appeared to be relatively flat to gently sloping with elevations at approximately 180 ft.

### 3.3 Ground Cover

Tracts three, five, and six are comprised mainly of longleaf pine and hardwood trees. Woodlands that border the tracts consist mainly of mature pines and hardwoods and are in scattered areas across the site. Tract one is an open grassy area. One medium sized facility was noted in the northern portion of tract five and a shack and watch tower in the central portion of tract three. A dirt road was observed entering tract three from the eastern and southern boundary off N. Wise Drive and Jefferson Road, respectively. A gravel drive was observed entering tract five from the western boundary extending from N. Wise Drive. A walking trail and dirt road was observed entering tract six from the western and eastern boundary off N. Wise Drive and Airport Road.

### 3.4 Soil Survey Data

Surface soils are generally poorly graded sands with clay, clayey sands, and sandy topsoil with thickness ranging from 5 to 7 inches. Topsoil was not encountered in several of the sounding locations.

From a qualitative standpoint, the USDA Soil Conservation Service's (SCS) Soil Surveys can often provide helpful information. The SCS surveys map the near surface soils (i.e., depths less than or equal to 6 ft) and provide general descriptions. The data is not intended to replace geotechnical evaluations and testing but it can help identify trends. The USDA Soil Survey of Sumter County indicates that the following surface soils listed in Table 1 are present thought the site.

**Table I – USDA Soil Survey Soil Series**

| Soil Series | Soil Type | Depth to Seasonal High GW Table | Permeability | Remarks |
|---|---|---|---|---|
| Coxville fine sandy loam (Cv) | ML, CL, SC | 0 – 1 ft. | Moderately slow | Soils have low to moderate shrink-swell potential, pH ranges between 4.5 and 6.0. |
| Goldsboro loamy sand (Go) | SM, SC, CL | 1.5 – 2.5 ft. | Moderate | Soils have low shrink-swell potential, pH ranges between 4.5 and 6.0. |
| Lynchburg sandy loam (Ly) | SM, CL, SC | 0 – 1 ft. | Moderate | Soils have low shrink-swell potential, pH ranges between 4.0 and 5.5. |
| Norfolk loamy sand (NoA) | SM, SC, CL | 4 – 6 ft. | Moderate | Soils have low shrink-swell potential, pH ranges between 4.5 and 6.0. |
| Rains sandy loam (Ra) | SM, SC, CL, SP-SM | 0 – 1 ft. | Moderate | Soils have low shrink-swell potential, pH ranges between 4.0 and 5.5. |
| Rutlege loamy sand (Ru) | SM, SP-SM, SM | 0 – 1 ft. | Rapid | Soils have low shrink-swell potential, pH ranges between 4.0 and 5.5. |
| Troup sand (TrB) | SP-SM, SC | > 6 ft. | Rapid to moderate | Soils have low shrink-swell potential, pH ranges between 4.0 and 5.5. |
| Wagram sand (WgB) | SM, SP-SM, SC | > 6 ft. | Rapid to moderate | Soils have low shrink-swell potential, pH ranges between 4.5 and 6.0. |

## 4.0 INTERPRETED SUBSURFACE PROFILE

The generalized subsurface conditions at the site are described below. For detailed descriptions and stratification at a particular sounding or hand auger boring location, the respective sounding or boring record should be reviewed. Due to the wide spacing of soundings and hand auger borings conducted at the site, the discussion of the subsurface conditions given below should be considered very general. Subsurface conditions at specific locations may be substantially different from the conditions encountered during this preliminary exploration.

## 4.1 Field Data

The descriptions given for the CPT soundings are "Soil Behavior Types" based on the Robertson definitions rather than textural soil classifications by the Unified Soil Classification System as is used for the SPT soil test borings. CPT soil classifications are described on the "CPT Soil Classification Legend" in Appendix B.

Sounding locations and elevations were not surveyed.

***Hand Auger Borings:*** Sandy topsoil thicknesses at our sounding and hand auger boring locations C-1 through C-12 averaged about 5 inches thick. Sounding and hand auger boring locations C-1, C-6, C-7, C-9, and C-10 did not encounter topsoil.

Hand augers were conducted to depths of 2 to 3 feet at each sounding location to help identify the near surface soils. Hand augers C-2, C-5 through C-10, and C-12 encountered poorly graded sands with clay below the sandy topsoil or ground surface to depths between 1/2 and 2-1/2 feet or boring termination. The soil encountered consisted mainly of brown, black, and gray, non-plastic fines with traces of fine to large roots.

Below the ground surface or topsoil in borings C-1, C-3, and C-11 and the poorly-graded sands with clay in borings C-5 through C-10, and C-12, our hand auger borings encountered tan, brown, and/or gray clayey sand with low to medium plasticity fines to boring termination depths between 2 and 3 feet. Below the topsoil in boring C-4 and clayey sand in boring B-9 we encountered low to medium plasticity sandy clay to a termination depth of about 2 and 3 feet, respectively.

***Cone Penetration Test (CPT) Soundings:*** Soils encountered below the ground surface during the exploration consist mainly of Sands, Gr Sand (gravelly sand), VS Sandy (very stiff sands), Sand Mix (silty and clayey sands), and VS Fine Gr (very stiff fine grained) material continuing to sounding termination depths of 25 feet. Clay material was encountered in one sounding (C-11) and Silt Mix (silty clays and clayey silts) material was encountered in three of the soundings (C-6, C-9, and C-11).

The upper 4 to 8 feet of the profile consisted generally of VS Sandy, VS Fine Gr, Sands, Gr Sands, and Sand Mix materials. Tip stresses in the upper 4 to 8 feet of the profile were between 20 and 200 tsf with sleeve stresses between 0.1 and 3 tsf. These tip stresses indicate a relative density ranging between loose and medium dense for the sands and a firm to very stiff consistency for the fine grained soils. The exception in this profile was in soundings C-6, C-9, and C-11 which encountered a silt mix or soft clay layer at a depth of about 2¼ to 5¼ feet below the existing ground surface. Tip stresses in the clays were about 10 to 20 tsf with sleeve stresses less than 1.0 tsf. The clays encountered in sounding C-11 are relatively compressible and will require either reduced footing bearing pressures or removal from within the foundation footprints.

Underlying the VS Sandy, VS Fine Gr, Sands, Gr Sands, and Sand Mix our soundings encountered Sands and Gr Sand materials. Tip stresses in the loose to very dense sand materials generally ranged from 20 to 400 tsf with sleeve stresses generally less than 2.5 tsf.

### 4.2 Groundwater

Groundwater was encountered at depths ranging from 4 to 11.5 feet, respectively, below the ground surface at the time of our exploration. Groundwater was re-measured 24 hours after the completion of the CPT soundings between 5 and 8 feet below the existing ground surface. Free subsurface water was not encountered at our hand auger boring locations at the time of our exploration.

Many of the sounding holes caved in at depths ranging from 5 to 17 feet below the existing ground surface. Hole caving often occurs within a few feet of groundwater elevations.

### 4.3 Multi-Channel Analysis of Surface Waves

Shear wave velocity measurements can be obtained using either shear wave surveys such as crosshole and downhole tests or surface wave surveys such as SASW, MASW, MAM, or ReMi™. Analysis of surface waves (R-waves) can be used to determine shear-wave velocities ($v_s$) as surface waves are fundamentally similar in behavior to shear waves (S-waves). In addition, the surface waves propagate to depths that are proportional to their frequencies (i.e., dispersion). Additional information about the use of MASW is available in the Procedures attached in the Appendix.

To measure shear-wave velocities at the subject site, S&ME performed three MASW (Multi-Channel Analysis of Surface Waves) and MAM (Microtremor Array Method) with non-linear array geometry at the test locations shown on the attached "Sounding Location Plan. The velocity profiles developed at the test location can be found in Appendix B.

## 5.0 2003 INTERNATIONAL BUILDING CODE SEISMIC FACTORS

Seismic induced ground shaking at the foundation is the effect taken into account by seismic-resistant design provisions of the 2003 International Building Code (IBC). Other effects, including landslides or soil liquefaction, are not addressed in building codes but must also be considered. Because our soundings are widely spaced, it is likely conditions will vary between the sounding locations. Each building site should be evaluated on a case by case basis when lots and building locations are established.

***IBC Site Class.*** We classified the site as one of the Site Classes defined in IBC Section 1615.1 (Table 1615.1.1) using the procedures described in Section 1615.1.5.1. The Site Class is used in conjunction with mapped spectral accelerations $S_S$ and $S_1$ to determine Site Coefficients $F_A$ and $F_V$ in IBC Section 1615.1.2, tables 1615.1.2(1) and 1615.1.2(2).

The initial step in site class definition is to check for the four conditions described for Site Class F which would require a site specific evaluation to determine site coefficients $F_A$ and $F_V$. Soils vulnerable to potential failure under item 1) including quick and highly sensitive clays or collapsible weakly cemented soils were not observed in the borings. Three other conditions, 2) peat and highly organic clays; 3) very high plasticity clays; and 4) very thick soft/medium stiff clays, were also not evident in the borings performed. Soils most susceptible to liquefaction generally consist of saturated, loose, "clean" (i.e., plasticity indices less than 5), fine (particle diameters of 0.07 to 0.25 mm) sands. Materials encountered at this site in our soundings were not considered susceptible to liquefaction due to the age of the material and the relative densities indicated.

Shear wave velocities obtained in the upper 100 feet of the soil profiles ranged from 1012 to 1094 feet per second. Our MASW arrays were conducted to a depth of 100 feet each. Based on this data and our knowledge of the general geologic profile of this area, IBC 2003 **Site Class D** represents conditions in and around the site at tracts 1, 3, and 5. Site Coefficients $F_A$ and $F_V$ may be obtained from tables 1615.1.2(1) and 1615.1.2(2).

## 6.0 CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations included in this section are based on the data obtained during our exploration. The following recommendations are given only to present a general idea of the soil conditions that can be anticipated on the sites. More in-depth subsurface investigations should be performed in future building pads and parking areas. We recommend that S&ME, Inc. be retained to perform these additional subsurface explorations.

### 6.1 Foundations

Our limited sounding data indicates that foundations for the development of light to medium industrial structures (column loads 200 kips or less) can likely be designed as conventional shallow spread footings. However, due to the very loose to medium dense relative density sands encountered in most of the soundings, some densification of footing excavation bottoms may be required.

Heavily loaded footings (column loads greater than 200 kips) may require that the footings bear at depths of 4 to 5 feet below existing grades or potentially the use of deep foundations.

Heavy area loads imposed by stacked materials or large vessels or tanks can likely be supported by mat or strip footings deepened to bear on the medium dense silty and clayey sands encountered at depths of 6 to 8.5 ft. However, depending on loading, the potential exists that large vessels or tanks will need to be supported on deep foundations.

### 6.2 Control of Subsurface Water and Surface Runoff

Subsurface water encountered in our soundings was at sufficient depths that it is not likely to impact grading with the exception of sounding C-8. If perched water or groundwater is encountered during grading, ditching or the construction of sumps and pumping will be necessary to provide a stable bearing surface for foundations or pavements.

Near the location of sounding C-4 a ditch with standing was observed. It was observed to stretch southwest in the direction of sounding C-6. Standing water was observed along the shoulder of Jefferson Road near the location of sounding C-7.

During normal rainfall periods, ditching or other provisions for drainage should be provided prior to stripping and grading in low areas. If subsurface water or infiltrating surface water is not properly controlled during construction, the subgrade soils that will support foundations, as well as pavements or floor slabs, may be damaged. Furthermore, construction equipment mobility may be impaired.

### 6.3 Site Preparation and Earthwork

Based on our limited number of soundings stripping depth will be about 2 to 8 inches over the majority of the site. In drainage features, stripping depths could be considerably greater.

The sands, sand mix, VS-sandy, and Gr sand encountered in our soundings are suitable for use as structural fill. Clays and silt mix materials will have a tendency to retain moisture and may require working or extended drying times if they are allowed to become wet.

### 6.4 Grade Slab Support and Construction

It is likely that grade slabs will be supported by virgin on-site soils or on-site borrow soils.

1 The sands, sand mix, Gr sands, and VS sandy similar to those penetrated by our soundings will generally provide adequate support to soil-supported slabs-on-grade, assuming proper preparation, moisture control, and compaction of the subgrade for static load conditions.

2 A capillary break of at least 4 inches of clean sand or crushed stone placed below floor slabs will be required in some areas.

3 We recommend you place a vapor barrier such as "Visqueen," or the equivalent, to limit moisture infiltration into finished space, or other areas where moisture infiltration will potentially cause problems. The vapor barrier should be placed below the capillary break material.

### 6.5 Pavement Subgrade and Base Material Preparation

The sands, sand mix, Gr sand, and VS sandy encountered in the CPT soundings will likely provide adequate bearing for pavements after being improved by drainage, rolling and compaction.

Drainage of subgrade material plays an important role in the performance of pavement sections. Site preparation should allow for drainage either in the form of crowning and ditching or where required under drainage.

At least one laboratory California Bearing Ratio (CBR) test should be performed upon representative soil samples of each soil type, which is proposed for use as subgrade material. This is to establish the relationship between relative compaction and CBR for the soil in question. This will also confirm that the CBR value of the soils used at the required level of compaction is equal to or greater than the CBR value assumed during design of the pavement section.

### 6.6 Recommendations for Additional Exploration

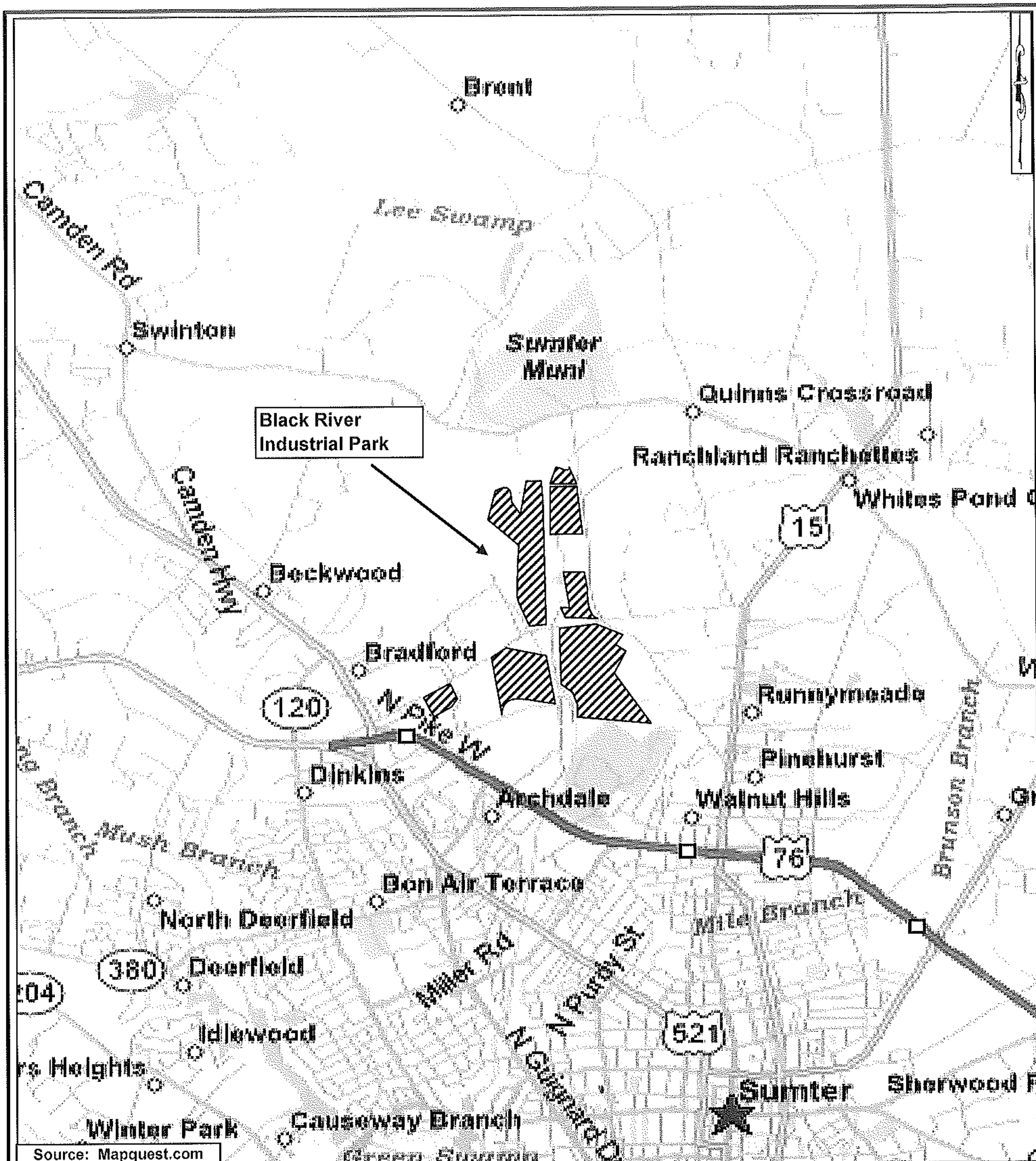
The current number of soundings provides some indication of the range of conditions that may be encountered at the site. However, the spacing and number of soundings does not allow for a statistically reliable basis for design of building foundations. Once building, parking and access drive locations are decided, we recommend additional soil test borings or cone penetration test soundings be performed in building and parking footprints prior to design of foundations.

## 7.0 QUALIFICATIONS OF REPORT

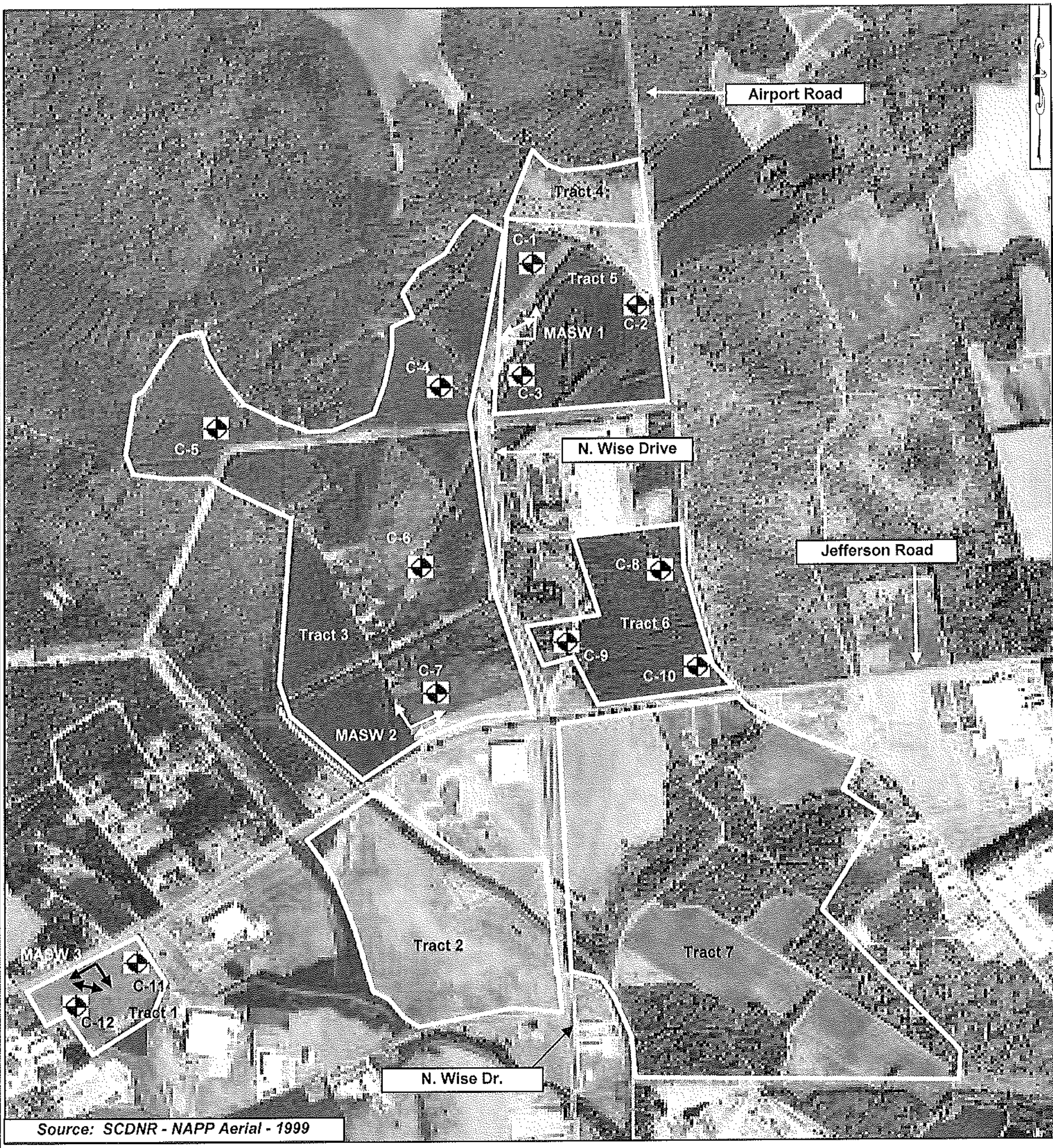
This report has been prepared in accordance with generally accepted geotechnical engineering practice for specific application to this project. The conclusions and recommendations contained in this report were based on the applicable standards of our profession at the time this report was prepared. No other warranty, express or implied, is made.

Due to the distance between each sounding, subsurface conditions can be expected to vary from the conditions described herein. This report was intended to give general information about overall site conditions only. Additional geotechnical explorations should be conducted for each proposed structure, pavement area or roadway.

# APPENDIX A




| | | | | |
|---|---|---|---|---|
| SCALE: NTS | S&ME | SITE VICINITY MAP | | FIGURE NO. |
| CHECKED BY: JTP | | BLACK RIVER INDUSTRIAL PARK | | 1 |
| DRAWN BY: PO | | SUMTER, SOUTH CAROLINA | | |
| DATE: 1/22/2007 | | S&ME PROJECT NO. | 1611-07-021 | |




| | | | | |
|---|---|---|---|---|
| SCALE: | NTS | S&ME | **SOUNDING LOCATION MAP**<br>BLACK RIVER INDUSTRIAL PARK<br>SUMTER, SOUTH CAROLINA | FIGURE NO. |
| CHECKED BY: | JTP | | | |
| DRAWN BY: | PO | | | 2 |
| DATE: | 1/22/2007 | | S&ME PROJECT NO. 1611-06-021 | |

# APPENDIX B

HAND AUGER BORING LOG
Black River Industrial Park
S&ME Job No. 1611-07-021

| LOCATION | DEPTH (in) | SOIL DESCRIPTION |
|---|---|---|
| C-1 | 0 to 36 | Clayey Sand (SC) – mostly fine to medium sand, some low plasticity fines, trace fine to large roots, moist, dark gray. |
| | 12 | - some low to medium plasticity fines, brown |
| | 36 | Hand auger boring terminated at 36 inches. |
| | | Groundwater not encountered at time of boring. |
| | | |
| C-2 | 0 to 5 | Sandy Topsoil. |
| | 5 to 24 | Poorly Graded Sand with Clay (SP.SC) – mostly fine to medium sand, trace low plasticity fines, brown. |
| | 24 | Hand auger boring terminated at 24 inches. |
| | | Groundwater not encountered at time of boring. |
| | | |
| C-3 | 0 to 7 | Sandy Topsoil. |
| | 7 to 36 | Clayey Sand (SC) – mostly fine to medium sand, some low plasticity fines, moist, gray. |
| | 36 | Hand auger boring terminated at 36 inches. |
| | | Groundwater not encountered at time of boring. |
| | | |
| C-4 | 0 to 5 | Sandy Topsoil. |
| | 5 to 24 | Sandy Clay (CL) – mostly low to medium plasticity fines, some fine to medium sand, moist, gray. |
| | | Hand auger boring terminated at 24 inches. |
| | | Groundwater not encountered at time of boring. |
| | | |
| C-5 | 0 to 7 | Sandy Topsoil. |
| | 7 to 18 | Poorly Graded Sand with Clay (SP/SC) – mostly fine sand, trace low plasticity fines, moist, brown. |
| | 18 to 24 | Clayey Sand (SC) – mostly fine to medium sand, some low to medium plasticity fines, moist, brown. |
| | 24 | Hand auger boring terminated at 24 inches. |
| | | Groundwater not encountered at time of boring. |
| | | |
| C-6 | 0 to 5 | Poorly Graded Sand with Clay (SP/SC) – mostly fine sand, few non-plastic fines, moist, gray. |
| | 5 to 24 | Clayey Sand (SC) – mostly fine to medium sand, some low plasticity fines, moist, brown. |
| | 24 | Hand auger boring terminated at 24 inches. |
| | | Groundwater not encountered at time of boring. |
| | | |

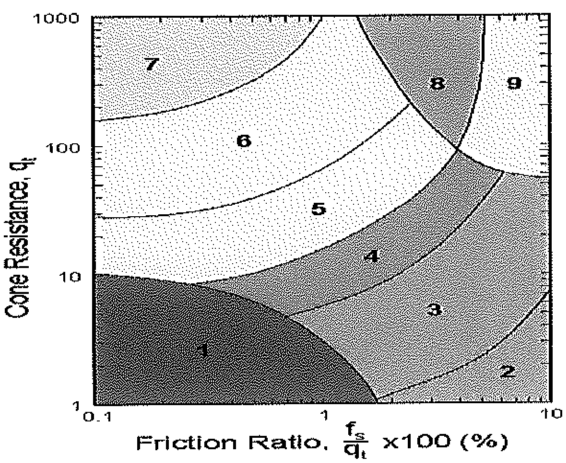
HAND AUGER BORING LOG
Black River Industrial Park
S&ME Job No. 1611-07-021

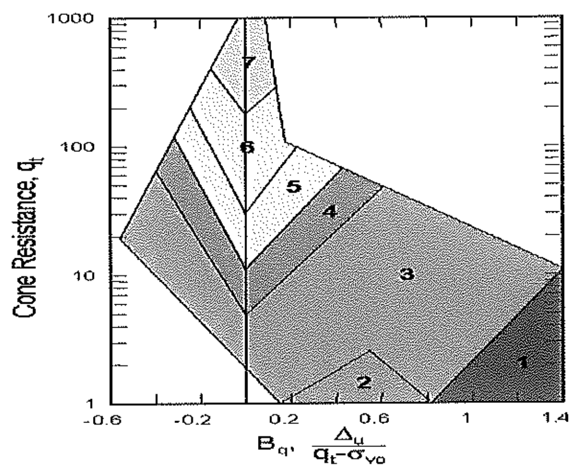
| LOCATION | DEPTH (in) | SOIL DESCRIPTION |
|---|---|---|
| C-7 | 0 to 5 | Poorly Graded Sand with Clay (SP/SC) – mostly fine to medium sand, few low plasticity fines, moist, brown. |
| | 5 to 36 | Clayey Sand (SC) – mostly fine to medium sand, some low plasticity fines, moist, light brown. |
| | 36 | Hand auger boring terminated at 36 inches. |
| | | Groundwater not encountered at time of boring. |
| | | |
| C-8 | 0 to 5 | Sandy Topsoil. |
| | 5 to 18 | Poorly Graded Sand with Clay (SP/SC) – mostly fine to medium sand, trace non-plastic fines, trace fine roots, moist, brown. |
| | 18 to 24 | Clayey Sand (SC) – mostly fine to medium sand, some low plasticity fines, moist, brown. |
| | 24 to 36 | Sandy Clay (CL) – mostly medium plasticity fines, some fine to medium sand, moist, gray, brown. |
| | 36 | Hand auger boring terminated at 36 inches. |
| | | Groundwater not encountered at time of boring. |
| | | |
| C-9 | 0 to 12 | Clayey Sand (SC) FILL – mostly fine to medium sand, some low to medium plasticity fines, moist, reddish orange. |
| | 12 to 30 | Poorly Graded Sand with Clay (SP/SC) – mostly fine to medium sand, trace non-plastic fines, trace fine roots, moist, black. |
| | 28 | - slight organic odor |
| | 30 to 36 | Clayey Sand (SC) – mostly fine to medium sand, some low plasticity fines, moist, tan/brown. |
| | 36 | Hand auger boring terminated at 36 inches. |
| | | Groundwater not encountered at time of boring. |
| | | |
| C-10 | 0 to 12 | Poorly Graded Sand with Clay (SP/SC) – mostly fine sand, few low plasticity fines, trace fine to large roots, moist, black. |
| | 6 | - brown |
| | 12 to 24 | Clayey Sand (SC) – mostly fine to medium sand, some low to medium plasticity fines, moist, tan/brown. |
| | 24 | Hand auger boring terminated at 24 inches. |
| | | Groundwater not encountered at time of boring. |
| | | |

HAND AUGER BORING LOG
Black River Industrial Park
S&ME Job No. 1611-07-021

| LOCATION | DEPTH (in) | SOIL DESCRIPTION |
|---|---|---|
| C-11 | 0 to 4 | Sandy Topsoil |
| | 4 to 24 | Clayey Sand (SC) – mostly fine to medium sand, some low plasticity fines, few fine roots, moist, brown. |
| | 24 | Hand auger boring terminated at 24 inches. |
| | | Groundwater not encountered at time of boring. |
| | | |
| C-12 | 0 to 7 | Sandy Topsoil. |
| | 7 to 30 | Poorly Graded Sand with Clay (SP/SC) – mostly fine sand, trace non-plastic fines, trace fine roots, moist, tan-brown. |
| | 30 to 36 | Clayey Sand (SC) – mostly fine to medium sand, some low plasticity fines, moist, brown. |
| | 36 | Hand auger boring terminated at 36 inches. |
| | | Groundwater not encountered at time of boring. |
| | | |

# CPT Soil Behavior Type Legend
# (Robertson et al. 1990)




| Zone | Soil Behavior Type |
|---|---|
| 1 | Sensitive, Fine Grained |
| 2 | Organic Soils-Peats |
| 3 | Clays; Clay to Silty Clay |
| 4 | Silt Mixtures; Clayey Silt to Silty Clay |
| 5 | Sand Mixtures; Silty Sand to Sandy Silt |
| 6 | Sands; Clean Sands to Silty Sands |
| 7 | Gravelly Sand to Sand |
| 8 | Very Stiff Sand to Clayey Sand* |
| 9 | Very Stiff Fine Grained* |

*Overconsolidated or Cemented

## General Notes:

UNC – Uncorrected

COR – Corrected

Class. FR – Classification based on Friction Ratio, PK Robertson , 1990, see above graph, determines Soil Behavior Type (SBT)

$N_{eq}$, Blow Counts – after PK Robertson 1990, uses Tip Stress UNC, $q_c$; atmospheric pressure, $p_a$

$\phi'$, Friction Angle - Robertson & Campanella 1988,
uses Tip Stress UNC, $q_c$;
effective overburden stress, $\sigma'_{vo}$;

$$\tan\phi' = \frac{1}{2.68} * \left[\log\left(\frac{q_c}{\sigma'_{vo}}\right) + 0.29\right]$$

$S_u$, Undrained Shear Strength - Robertson & Campanella 1988;
uses Tip Stress COR, $q_t$;
overburden stress, $\sigma_{vo}$;
$N_{kt} = 15$

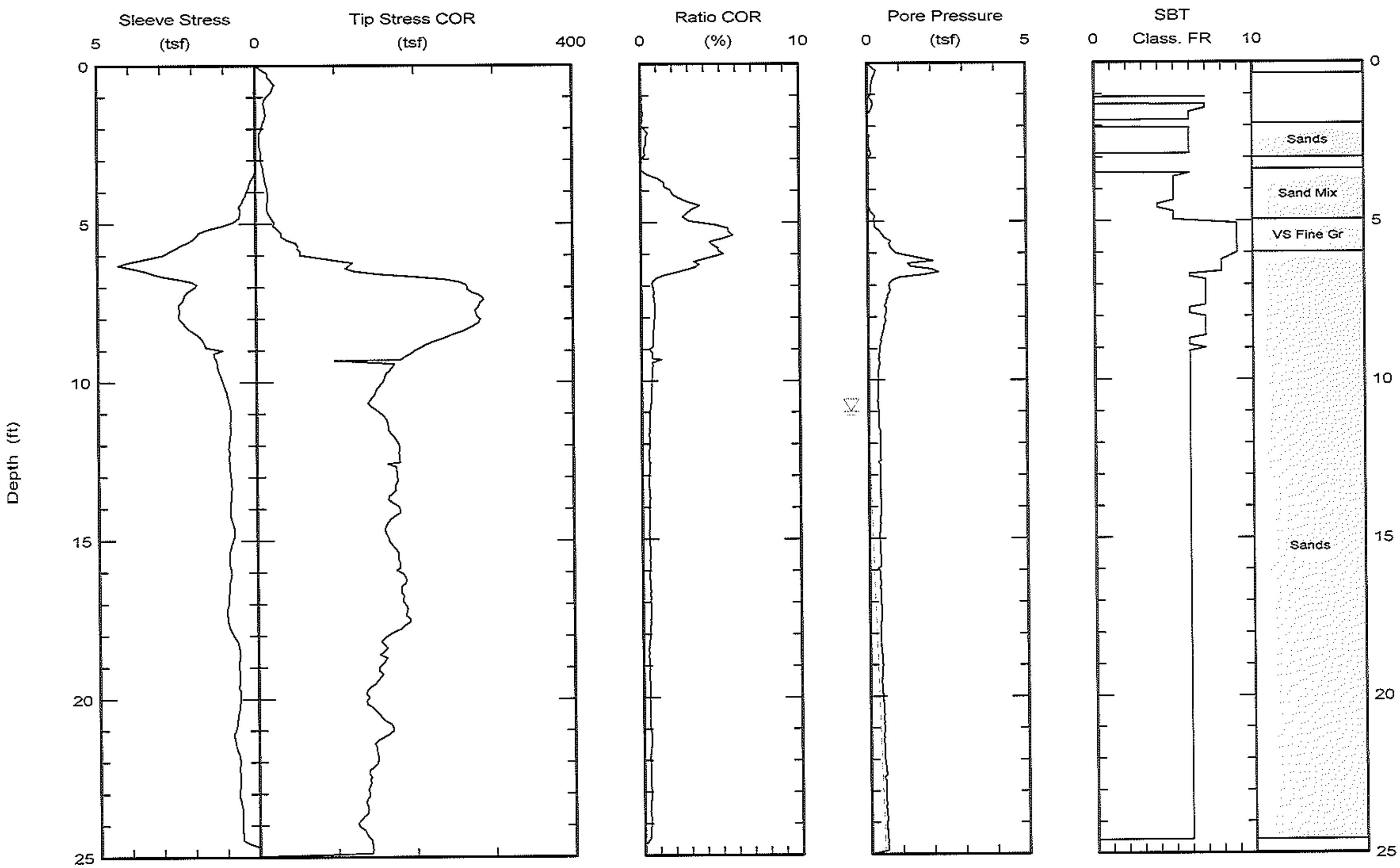
$$S_u = \left(\frac{q_t - \sigma_{vo}}{N_{kt}}\right)$$


S&ME, Inc
620 Wando Park Boulevard
Mt. Pleasant, South Carolina 29464

(843) 884-0005
(843) 881-6149 fax
www.smeinc.com

S&ME

| | | |
|---|---|---|
| S&ME Inc. (843)884-0005<br>620 Wando Park Boulevard<br>Mt. Pleasant, SC 29464<br>TCleary@smeinc.com<br>www.smeinc.com | Northing:<br>Easting:<br>Elevation: | Date: 25/Jan/2007<br>Test ID: C-1<br>Project: 1611-07-021 |
| | Client: u/a<br>Job Site: Black River Industrial Park | |



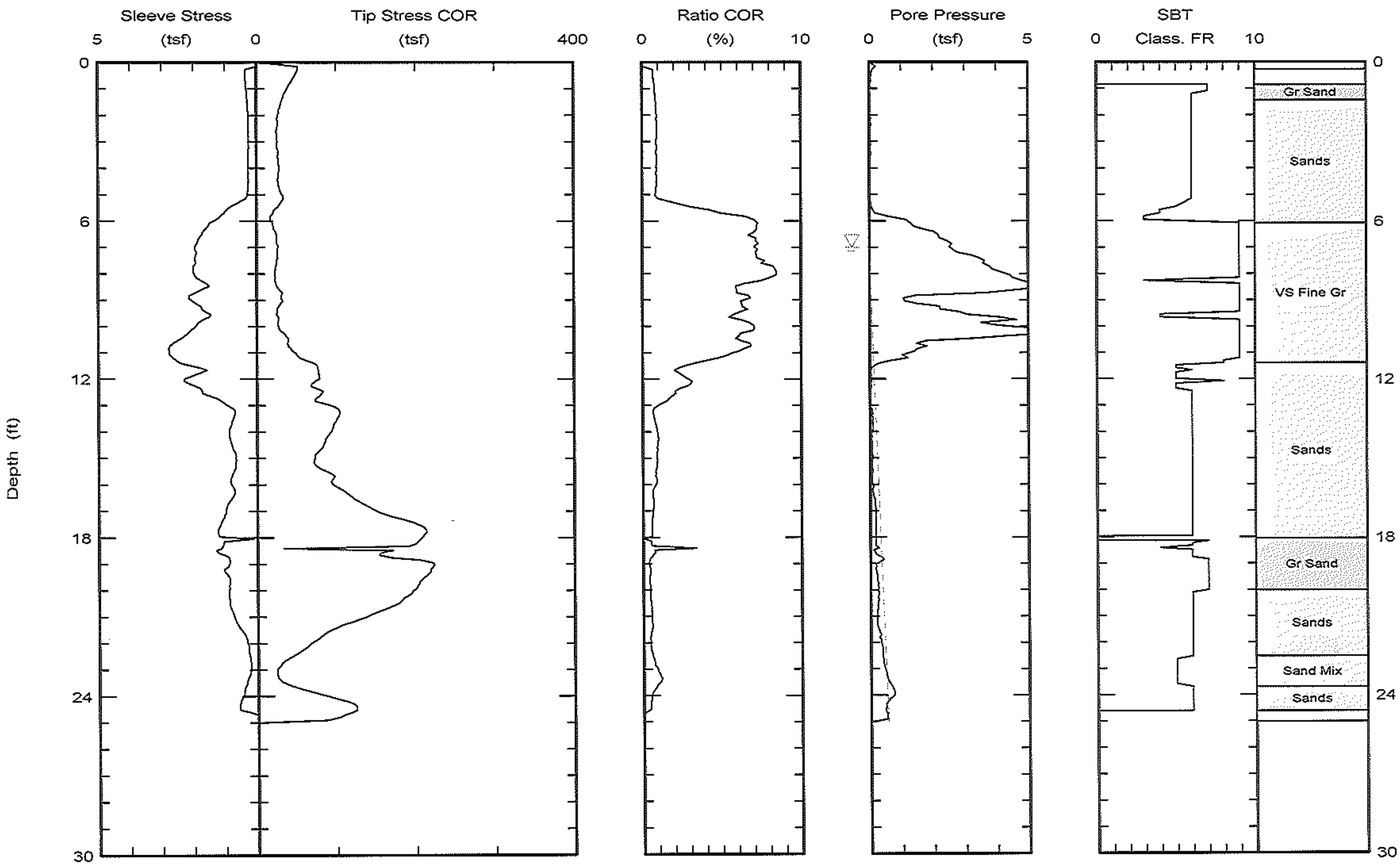

Maximum depth: 24.98 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

∇ Estimated Phreatic Surface

Test ID: C-1
File: E25J0705C.ECP

| | | |
|---|---|---|
| S&ME Inc. (843)884-0005<br>620 Wando Park Boulevard<br>Mt. Pleasant, SC 29464<br>TCleary@smeinc.com<br>www.smeinc.com | Northing:<br>Easting:<br>Elevation: | Date: 25/Jan/2007<br>Test ID: C-2<br>Project: 1611-07-021 |
| | Client: u/a<br>Job Site: Black River Industrial Park | |



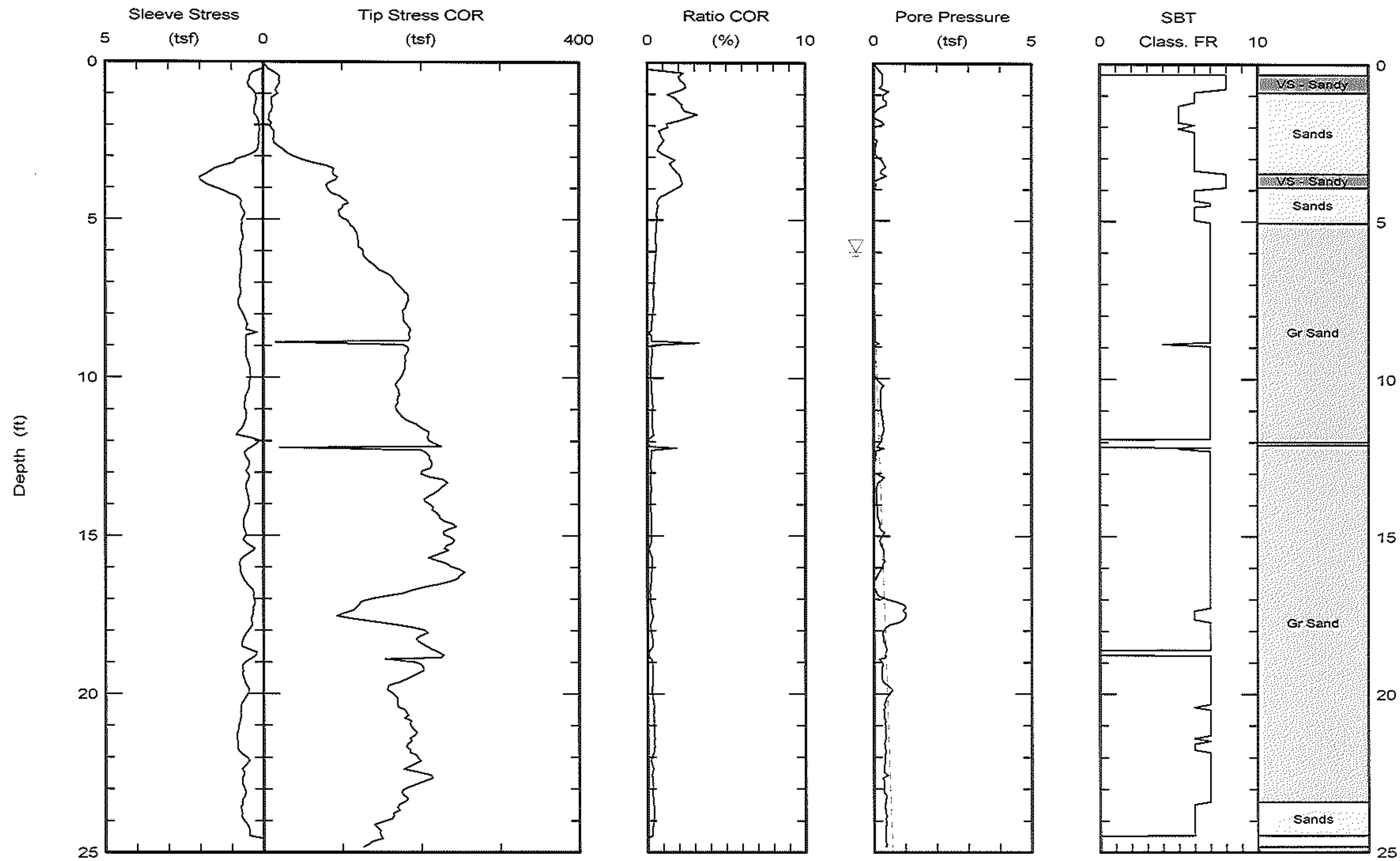

Maximum depth: 25.02 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

∇ Estimated Phreatic Surface

Test ID: C-2
File: E25J0704C.ECP

| | | |
|---|---|---|
| S&ME Inc. (843)884-0005<br>620 Wando Park Boulevard<br>Mt. Pleasant, SC 29464<br>TCleary@smeinc.com<br>www.smeinc.com | Northing:<br>Easting:<br>Elevation: | Date: 25/Jan/2007<br>Test ID: C-3<br>Project: 1611-07-021 |
| | Client: u/a<br>Job Site: Black River Industrial Park | |



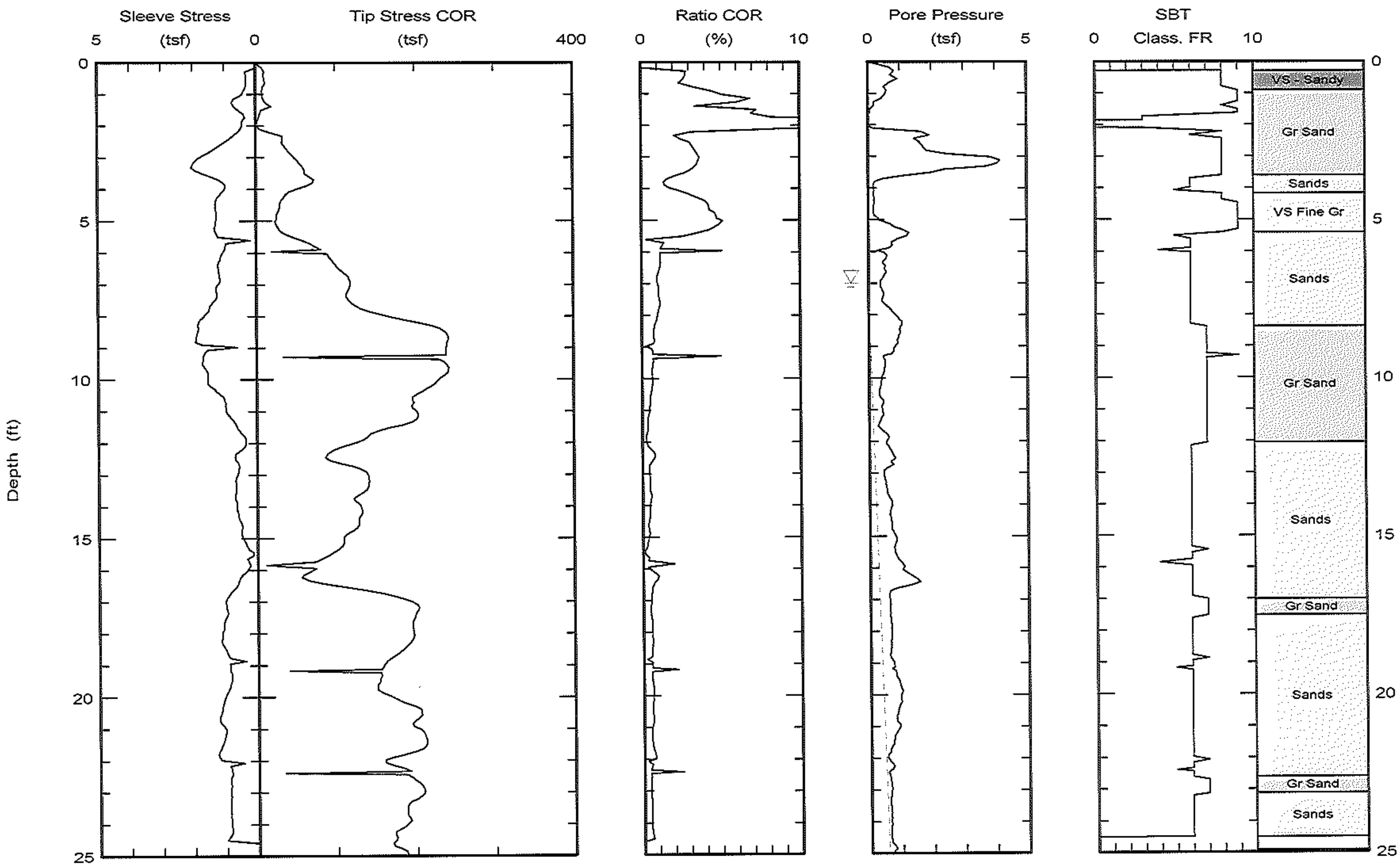

Maximum depth: 24.84 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

∇ Estimated Phreatic Surface

Test ID: C-3
File: E25J0701C.ECP

| S&ME Inc. (843)884-0005<br>620 Wando Park Boulevard<br>Mt. Pleasant, SC 29464<br>TCleary@smeinc.com<br>www.smeinc.com | Northing:<br>Easting:<br>Elevation: | Date: 25/Jan/2007<br>Test ID: C-4<br>Project: 1611-07-021 |
|---|---|---|
| | Client: u/a<br>Job Site: Black River Industrial Park | |



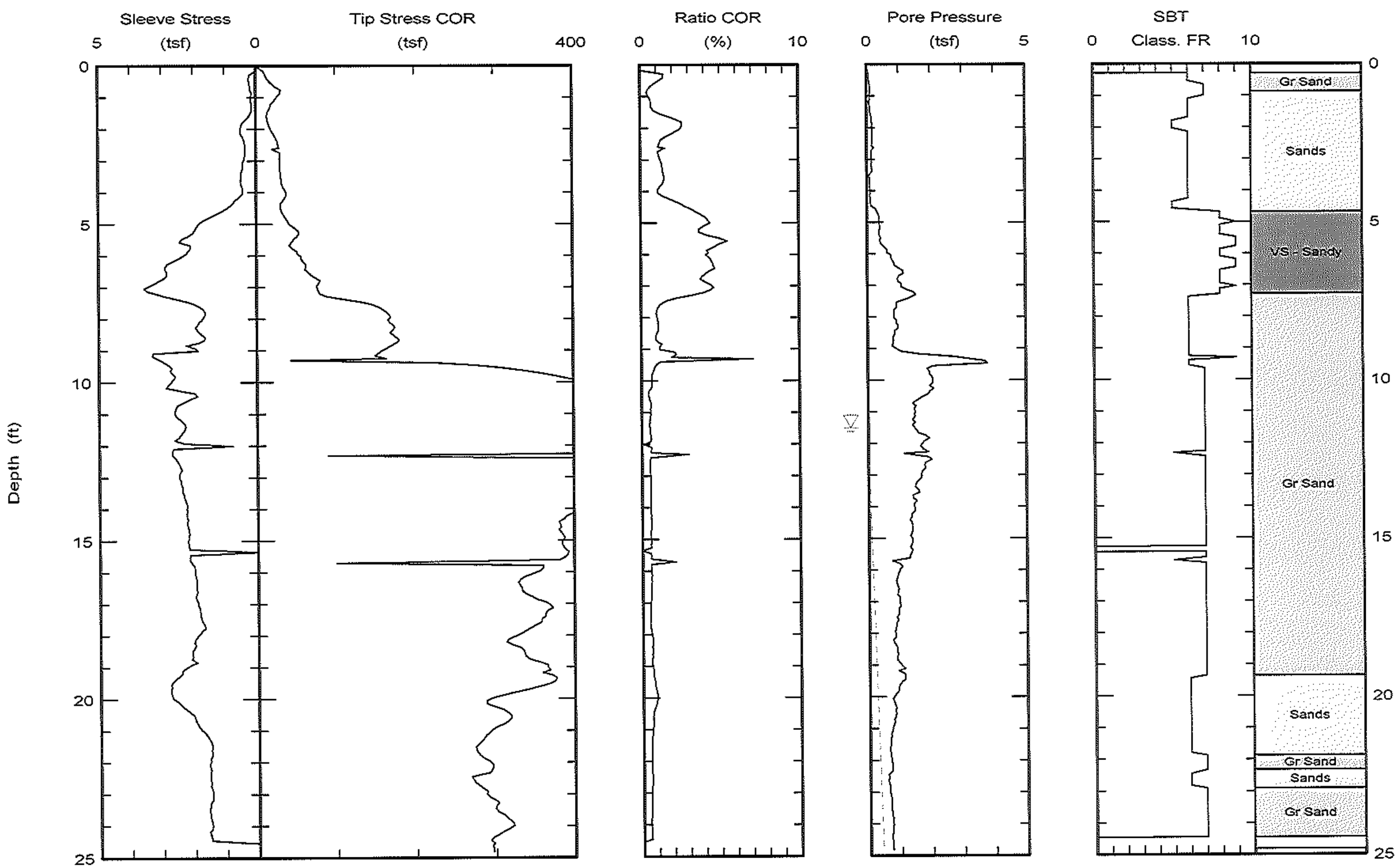

Maximum depth: 24.94 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

∇ Estimated Phreatic Surface

Test ID: C-4
File: E25J0706C.ECP

| | | | |
|---|---|---|---|
| S&ME Inc. (843)884-0005<br>620 Wando Park Boulevard<br>Mt. Pleasant, SC 29464<br>TCleary@smeinc.com<br>www.smeinc.com | Northing:<br>Easting:<br>Elevation: | Date: 25/Jan/2007<br>Test ID: C-5<br>Project: 1611-07-021 |
| | Client: u/a<br>Job Site: Black River Industrial Park | |



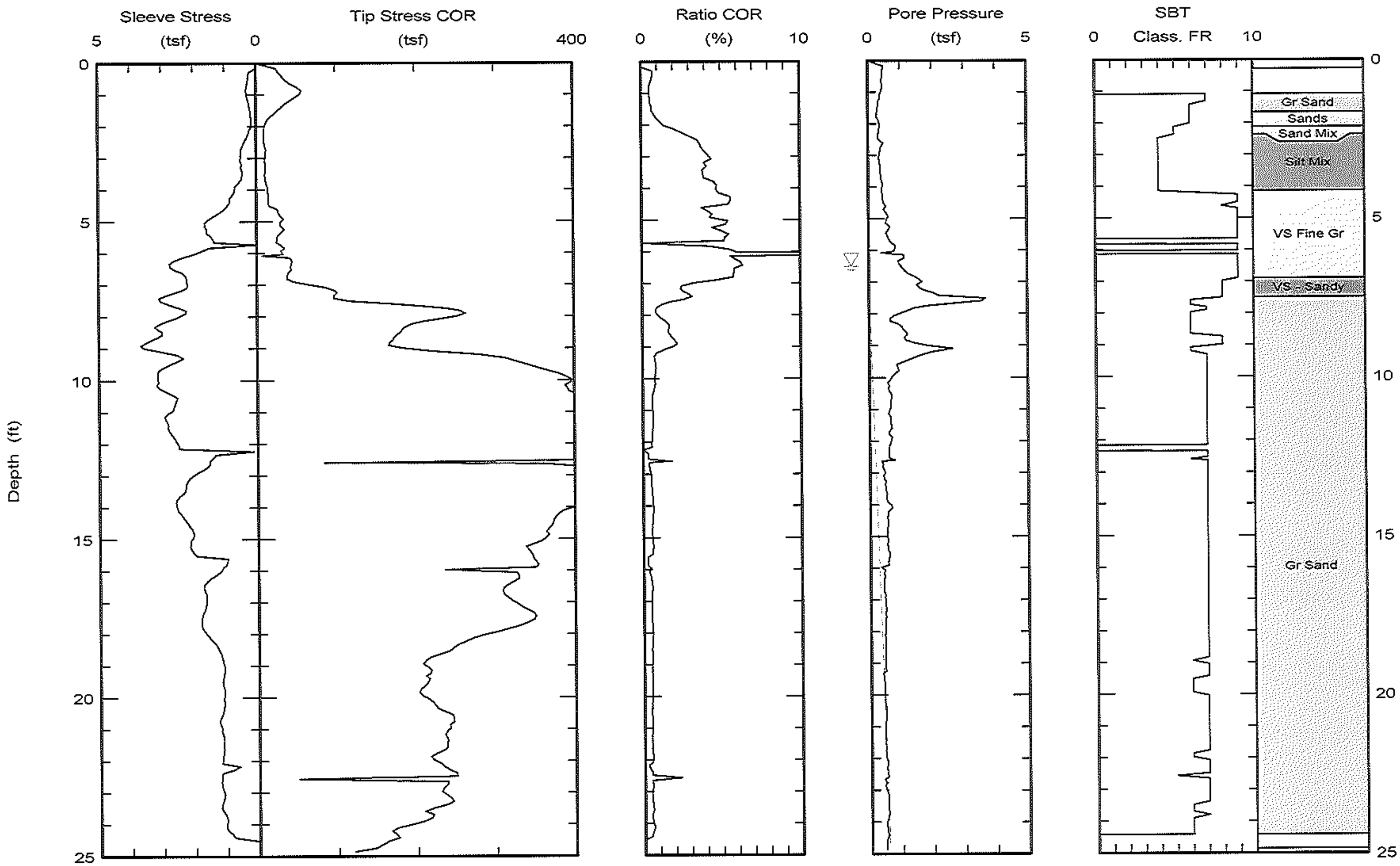

Maximum depth: 24.83 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

∇ Estimated Phreatic Surface

Test ID: C-5
File: E25J0709C.ECP

| | | |
|---|---|---|
| S&ME Inc. (843)884-0005<br>620 Wando Park Boulevard<br>Mt. Pleasant, SC 29464<br>TCleary@smeinc.com<br>www.smeinc.com | Northing:<br>Easting:<br>Elevation:<br>Client: u/a<br>Job Site: Black River Industrial Park | Date: 25/Jan/2007<br>Test ID: C-6<br>Project: 1611-07-021 |



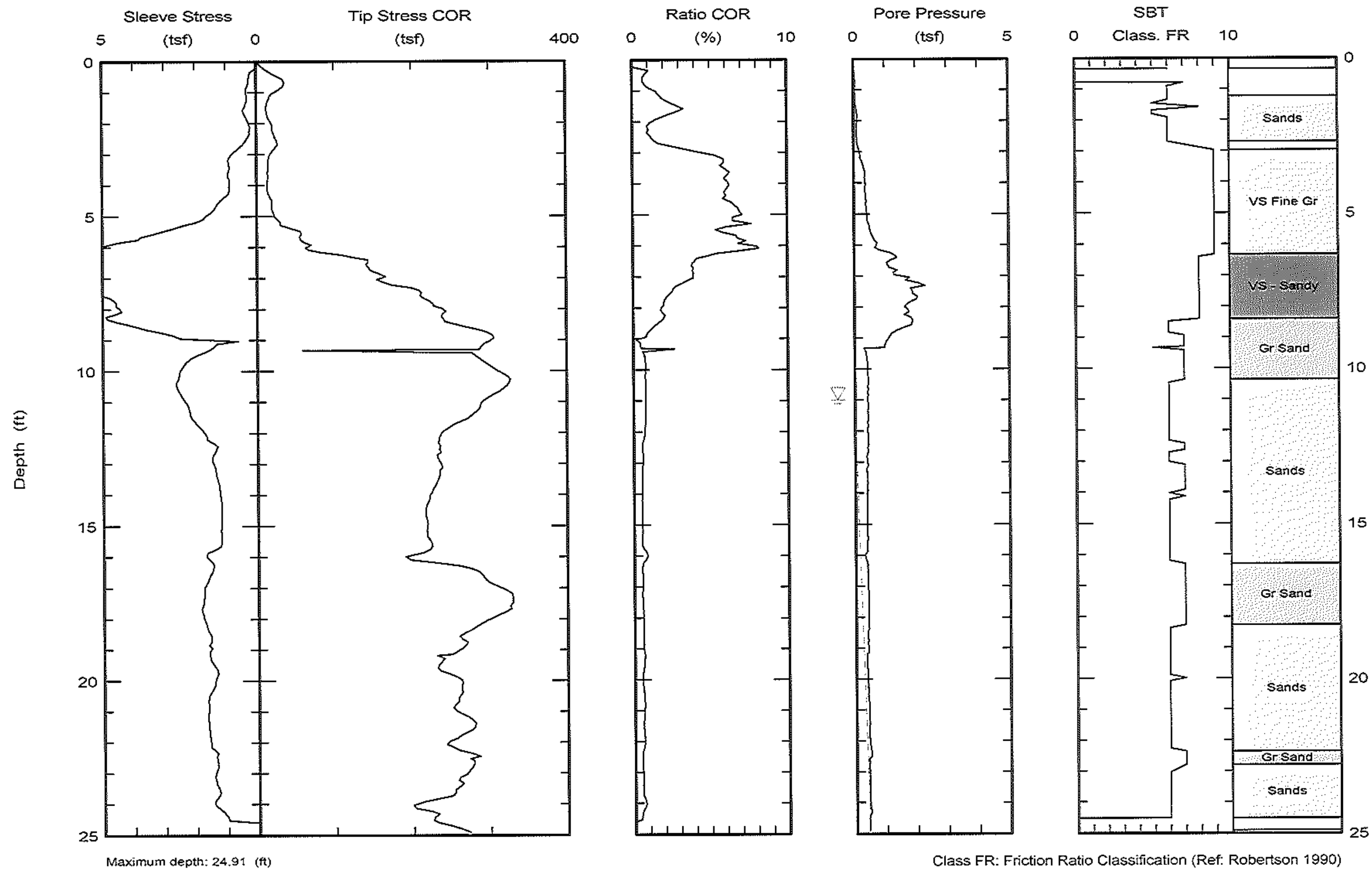

Maximum depth: 24.86 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

∇ Estimated Phreatic Surface

Test ID: C-6
File: E25J0707C.ECP

| | | |
|---|---|---|
| S&ME Inc. (843)884-0005<br>620 Wando Park Boulevard<br>Mt. Pleasant, SC 29464<br>TCleary@smeinc.com<br>www.smeinc.com | Northing:<br>Easting:<br>Elevation: | Date: 26/Jan/2007<br>Test ID: C-7<br>Project: 1611-07-021 |
| | Client: u/a<br>Job Site: Black River Industrial Park | |




Maximum depth: 24.91 (ft)

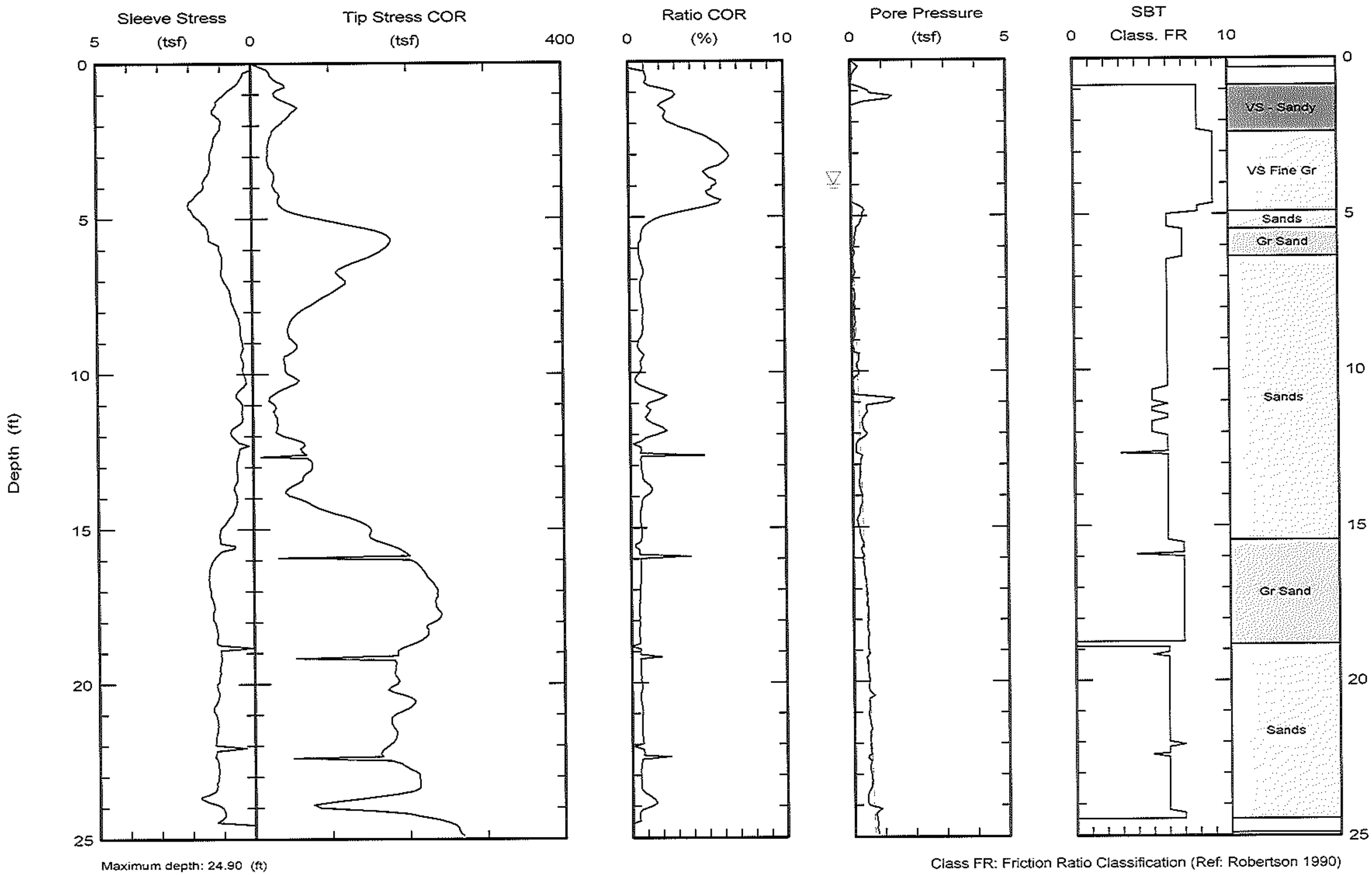
Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Estimated Phreatic Surface

Test ID: C-7

File: E26J0703C.ECP

| | | |
|---|---|---|
| S&ME Inc. (843)884-0005<br>620 Wando Park Boulevard<br>Mt. Pleasant, SC 29464<br>TCleary@smeinc.com<br>www.smeinc.com | Northing:<br>Easting:<br>Elevation: | Date: 26/Jan/2007<br>Test ID: C-8<br>Project: 1611-07-021 |
| | Client: u/a<br>Job Site: Black River Industrial Park | |



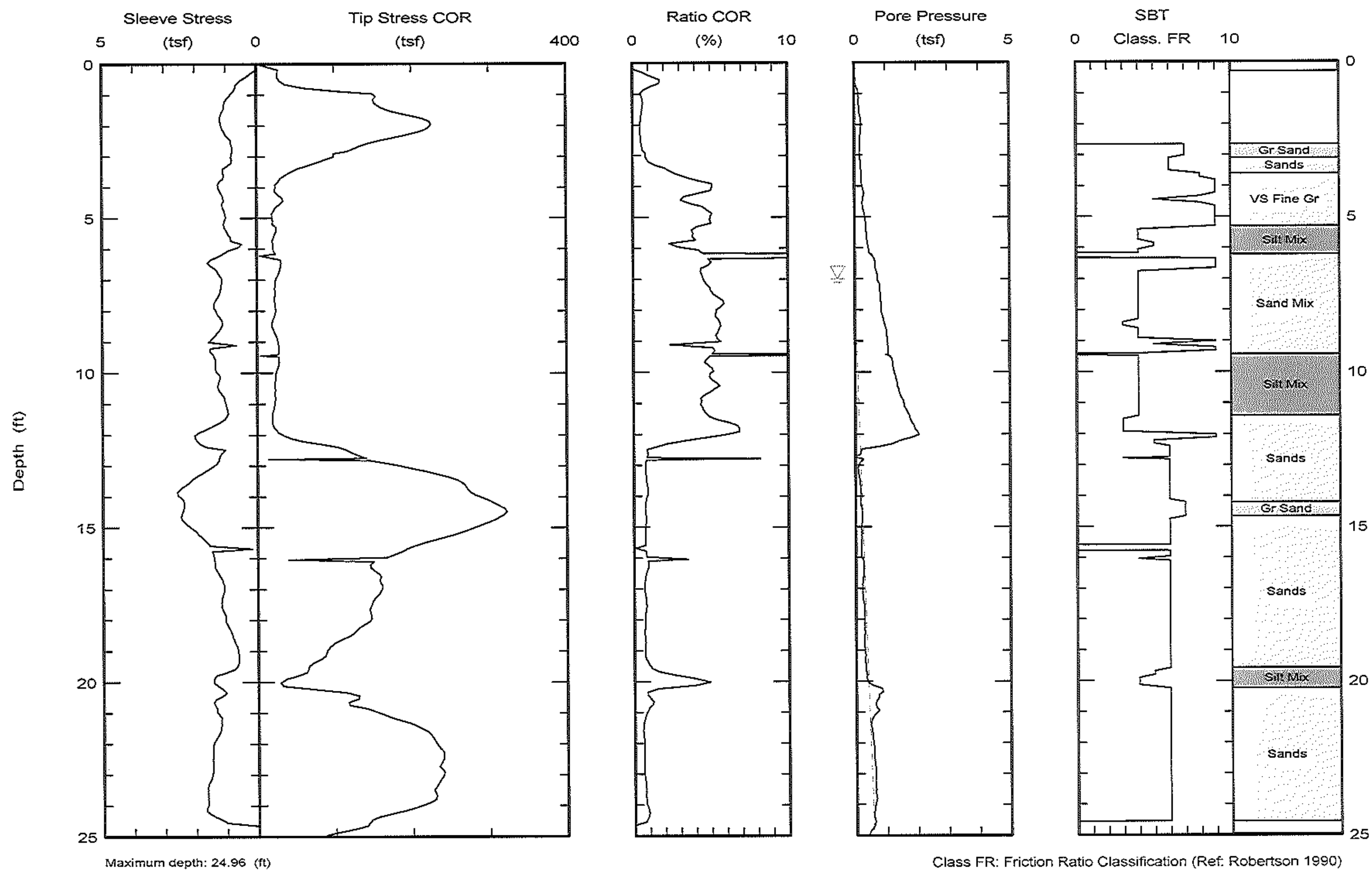

Maximum depth: 24.90 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Estimated Phreatic Surface

Test ID: C-8
File: E26J0701C.ECP

| | | |
|---|---|---|
| S&ME Inc. (843)884-0005<br>620 Wando Park Boulevard<br>Mt. Pleasant, SC 29464<br>TCleary@smeinc.com<br>www.smeinc.com | Northing:<br>Easting:<br>Elevation: | Date: 25/Jan/2007<br>Test ID: C-9<br>Project: 1611-07-021 |
| | Client: u/a<br>Job Site: Black River Industrial Park | |




Maximum depth: 24.96 (ft)

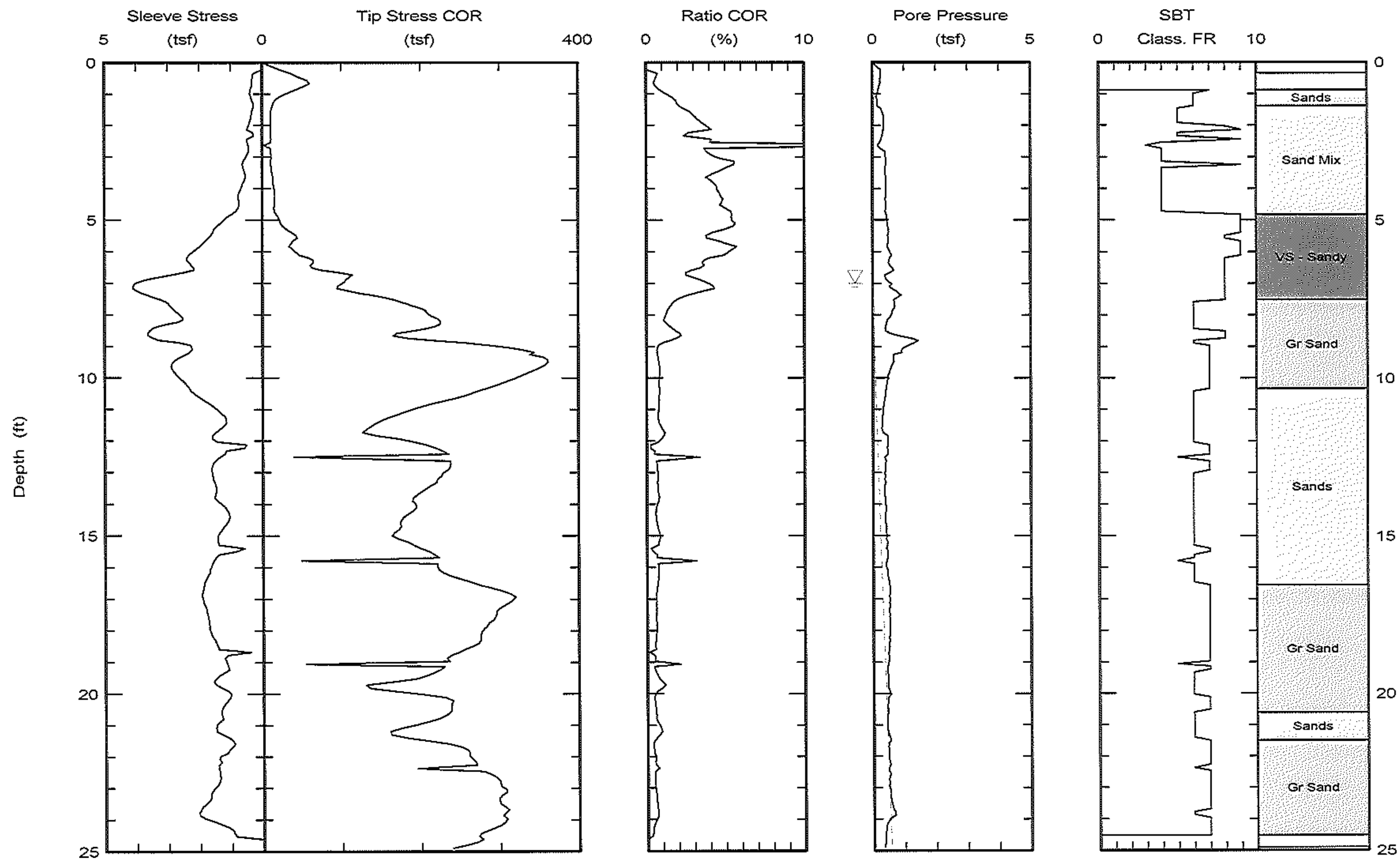
Class FR: Friction Ratio Classification (Ref: Robertson 1990)

∇ Estimated Phreatic Surface

Test ID: C-9
File: E25J0710C.ECP

S&ME Inc. (843)884-0005
620 Wando Park Boulevard
Mt. Pleasant, SC 29464
TCleary@smeinc.com
www.smeinc.com

| | |
|---|---|
| Northing:<br>Easting:<br>Elevation: | Date: 26/Jan/2007<br>Test ID: C-10<br>Project: 1611-07-021 |
| Client: u/a<br>Job Site: Black River Industrial Park | |

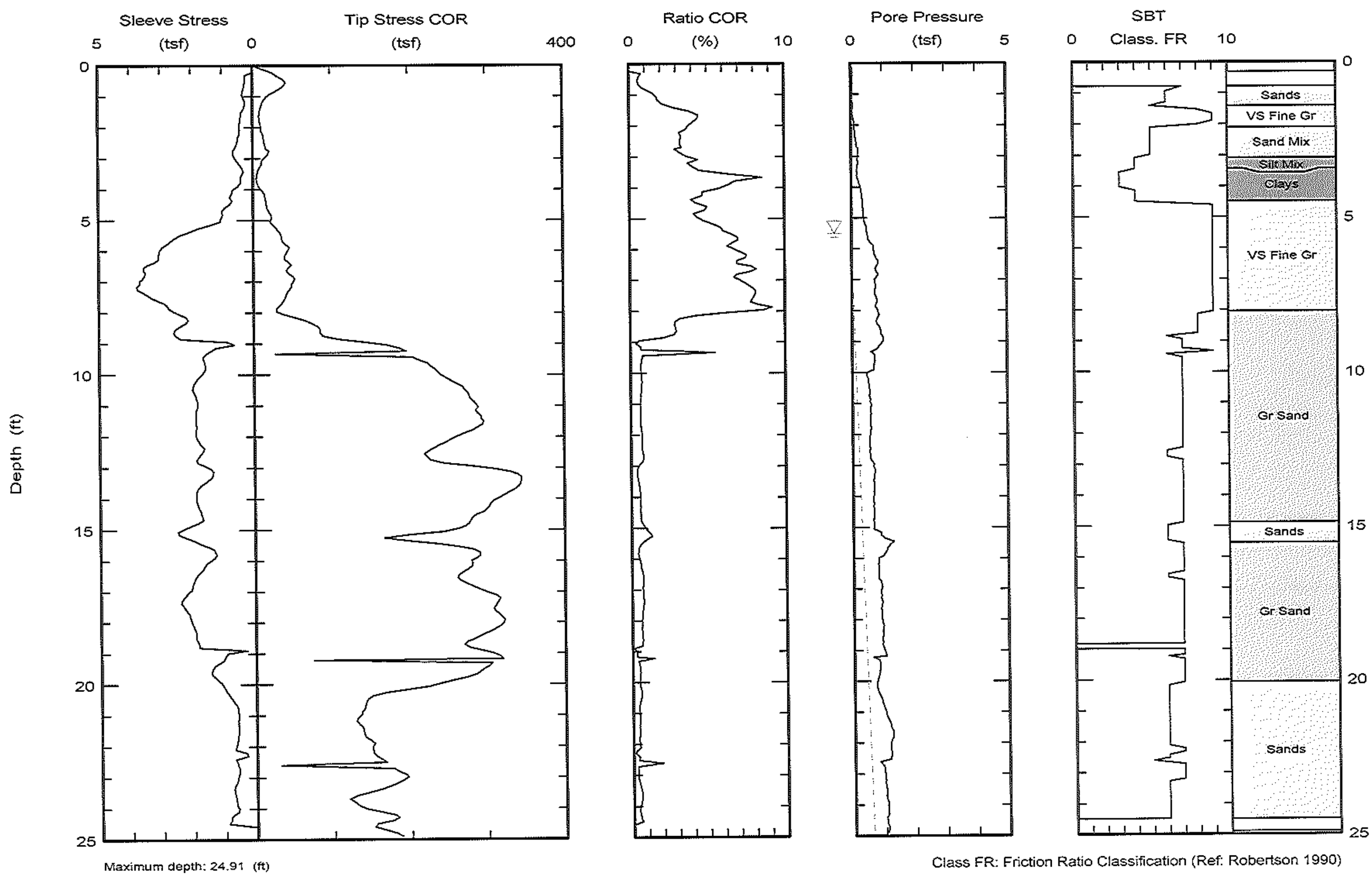



Maximum depth: 24.91 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)
∇ Estimated Phreatic Surface

Test ID: C-10
File: E26J0702C.ECP

| | | |
|---|---|---|
| S&ME Inc. (843)884-0005<br>620 Wando Park Boulevard<br>Mt. Pleasant, SC 29464<br>TCleary@smeinc.com<br>www.smeinc.com | Northing:<br>Easting:<br>Elevation: | Date: 26/Jan/2007<br>Test ID: C-11<br>Project: 1611-07-021 |
| | Client: u/a<br>Job Site: Black River Industrial Park | |

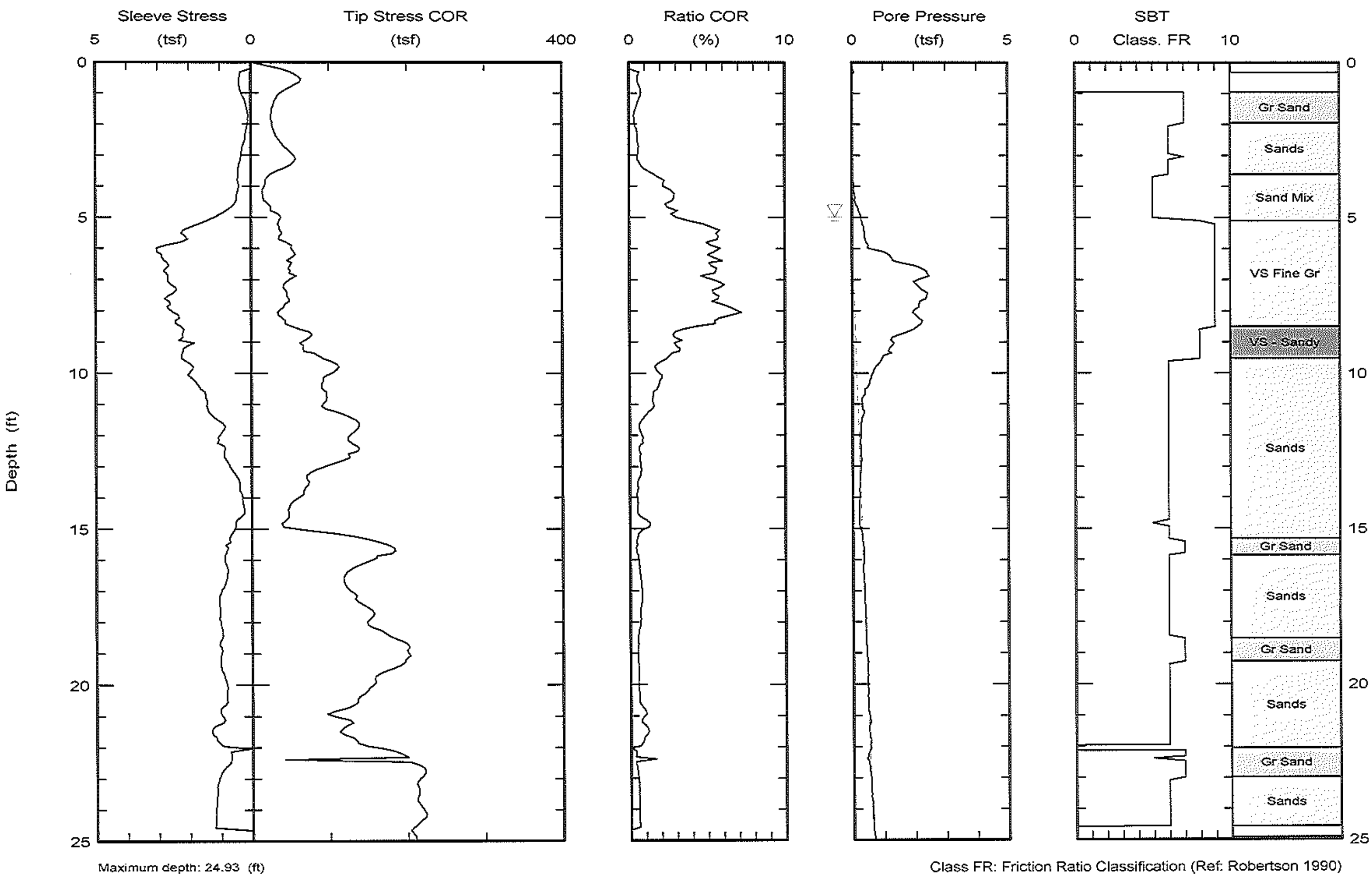



Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Estimated Phreatic Surface

Test ID: C-11
File: E26J0705C.ECP

| | | |
|---|---|---|
| S&ME Inc. (843)884-0005<br>620 Wando Park Boulevard<br>Mt. Pleasant, SC 29464<br>TCleary@smeinc.com<br>www.smeinc.com | Northing:<br>Easting:<br>Elevation: | Date: 26/Jan/2007<br>Test ID: C-12<br>Project: 1611-07-021 |
| | Client: u/a<br>Job Site: Black River Industrial Park | |




Maximum depth: 24.93 (ft)

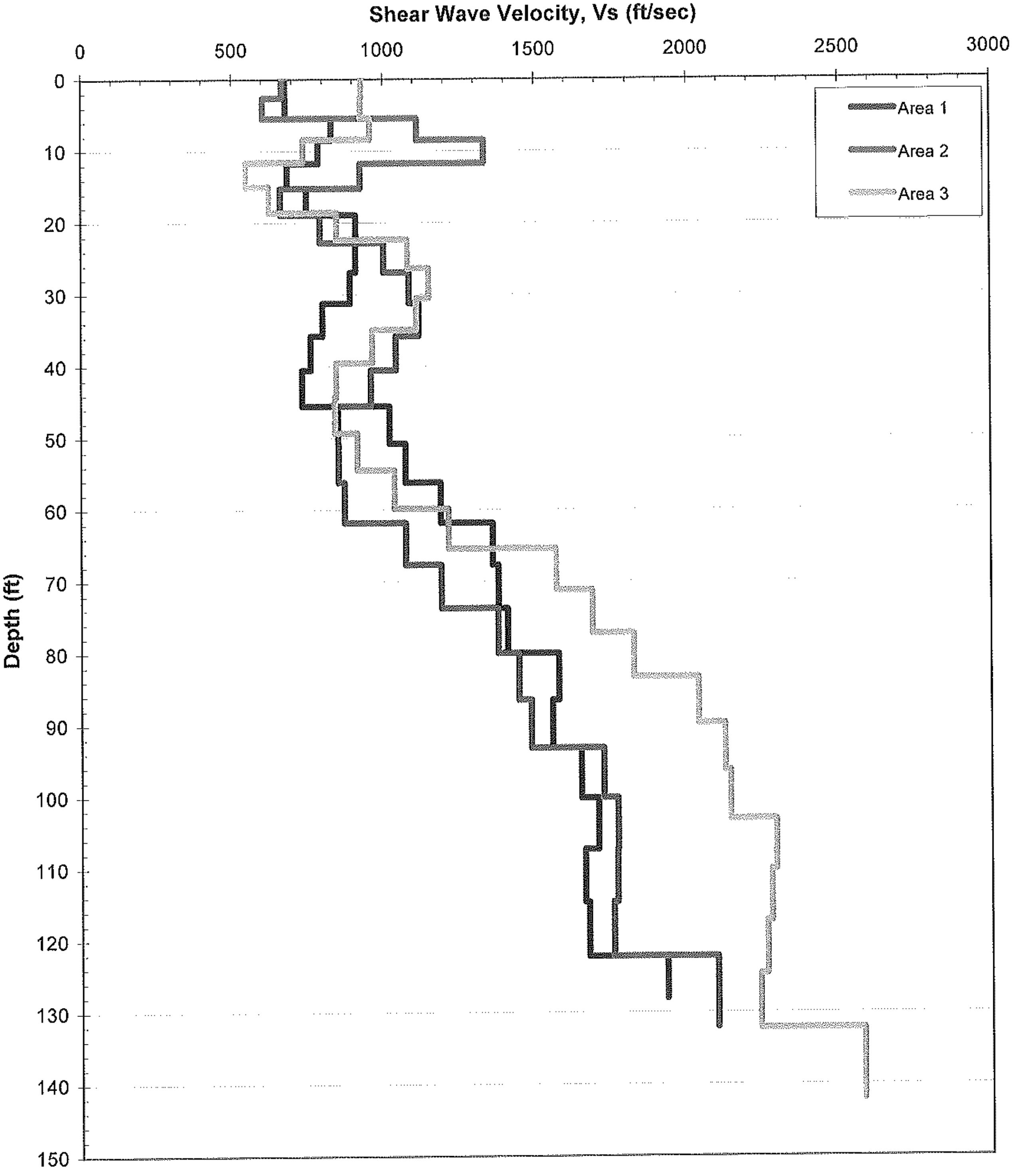
Class FR: Friction Ratio Classification (Ref: Robertson 1990)

∇ Estimated Phreatic Surface

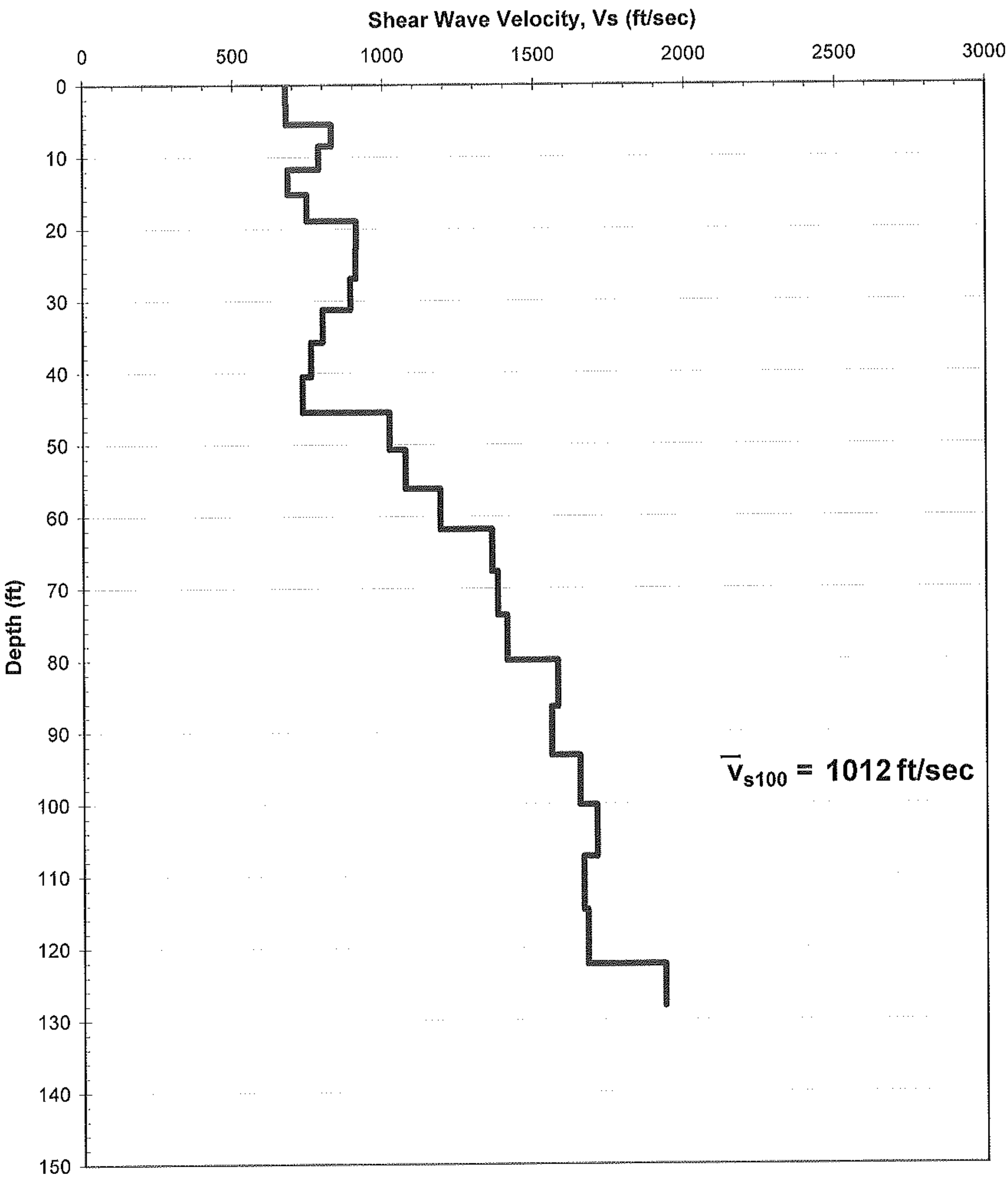
Test ID: C-12
File: E26J0706C.ECP

# APPENDIX C

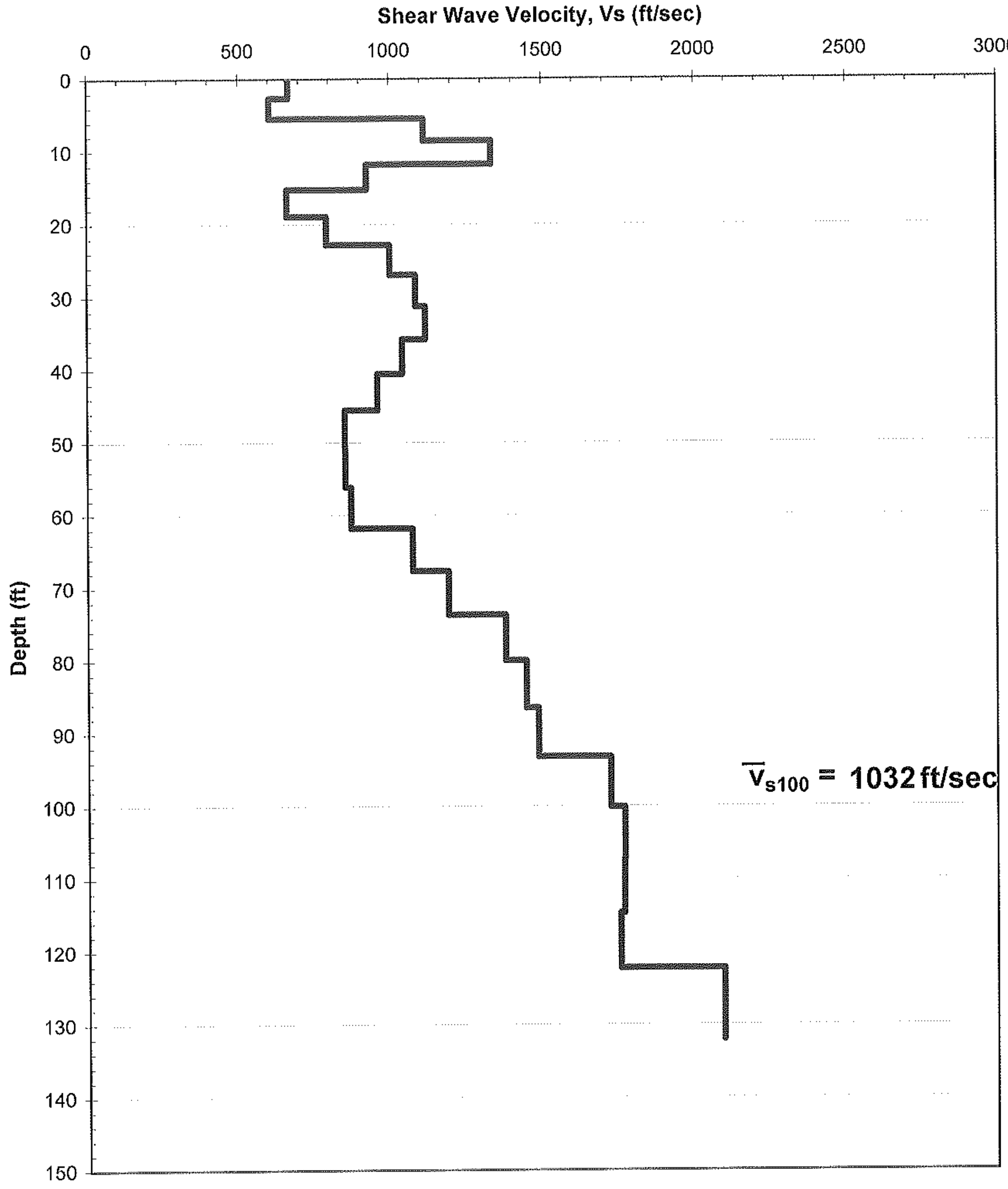
**Shear Wave Velocity Profiles**
**Black River Industrial Park**
**Sumter, South Carolina**
**1611-07-021**



**Shear Wave Velocity Profile No. 1**
**Black River Industrial Park**
**Sumter, South Carolina**
**1611-07-021**



Shear Wave Velocity Profile No. 2
Black River Industrial Park
Sumter, South Carolina
1611-07-021



## General Description of Procedures

### Field Testing of Earth Materials

***Electronic Cone Penetrometer Test (CPT) Soundings:*** CPT soundings consist of a conical pointed penetrometer which is hydraulically pushed into the soil at a slow, measured rate. Procedures for measurement of the tip resistance and side friction resistance to push generally follow those described by ASTM D-5778, "Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils." Soil classification was made on the basis of comparison of the measured tip resistance, sleeve resistance, and pore pressure values to values measured at other locations in known soil types, using experience with similar soils and exercising engineering judgment.

***Measurement of Static Water Levels:*** Groundwater level readings were made in the open sounding and hand auger boring holes immediately after completing withdrawal of the tools. All hand auger boreholes were dry at the time of boring and were backfilled after testing. Water levels were also indirectly measured by linear interpolation of the CPT pore pressure reading. All soundings were backfilled after 24 hour ground water was measured.

***Multi Channel Analysis of Surface Waves:*** Shear wave velocity measurements were performed using a Multi Channel Analysis of Surface Waves (MASW) array. The MASW array measures the travel times of surface generated vibrations to geophones mounted on the ground surface at various incremental distances along an array.

Shear wave velocity measurements can be obtained using either shear wave surveys such as crosshole and downhole tests or surface wave surveys such as SASW, MASW, MAM, or ReMi™. Analysis of surface waves (R-waves) can be used to determine shear-wave velocities ($v_s$) as surface waves are fundamentally similar in behavior to shear waves (S-waves). In addition, the surface waves propagate to depths that are proportional to their frequencies (i.e., dispersion). The surface waves are recorded at the ground surface along a spread of low-frequency geophones. Recorded surface waves are transformed from time domain into frequency domain, from which the phase characteristics of the surface waves can be determined. A dispersion curve (a.k.a., phase velocity curve, slowness curve) is developed allowing the phase velocity ($C_f$) of particular frequency waves to be calculated. The dispersion curve is then transformed into the shear-wave velocity profile through a complex inversion and iterative processing.

To measure shear-wave velocities at the subject site, S&ME performed MASW (Multi-Channel Analysis of Surface Waves) and MAM (Microtremor Array Method) with non-linear array geometry, combining the dispersion curves from both tests prior to the inversion process. Performing both MASW and MAM provides the greater depth of penetration associated with microtremor analyses (low frequency surface waves) without sacrificing resolution at shallower depths from MASW (higher frequency surface waves). In addition, our experience indicates using a combination of both methods to develop a shear wave velocity profile is more accurate than using Refraction Microtremor (ReMi™) exclusively, particularly when the ReMi™ array geometry is linear.

At the three test locations shown on the attached "Sounding Location Plan," MASW and MAM tests were performed to produce three separate shear wave velocity profiles at the site. The MASW and MAM testing was conducted using the 16-channel Geometrics ES3000 seismograph and 4.5 Hz vertical geophones. For the MASW testing, the geophones were spaced in a linear geometry at intervals of 5 feet and surface waves generated by an 8-pound sledgehammers striking a metal plate. MAM testing was conducted using an "L-shaped" array geometry with geophone spacing of 30 feet. Because the source locations of the microtremors are not known, the 2-dimensional array geometry is used for the MAM. The analysis was conducted using the OYO Corporation's SeisImager/SW software (*Pickwin v. 3.14* and *WaveEq).* The velocity profiles developed at the test locations can be found in Appendix C.