REPORT OF SHEAR WAVE VELOCITY TESTING

Colonel's Pointe Industrial Park Site Class
Chester County, South Carolina
S&ME Project No. 1611-11-159

Prepared For:

Alliance Consulting Engineers, Inc.
PO Box 8147
Columbia, South Carolina 29202-8147

Prepared By:

S&ME, Inc.
134 Suber Road
Columbia, South Carolina 29210

April 18, 2011

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Alliance Consulting Engineers, Inc.
PO Box 8147
Columbia, South Carolina 29202-8147

Attention: Rebecca Murrell, EIT
Engineering Associate

Reference: **REPORT OF SHEAR WAVE VELOCITY TESTING**
Colonel's Pointe Industrial Park Site Class
Chester County, South Carolina
S&ME Project No. 1611-11-159

Dear Ms. Murrell:

As requested, S&ME, Inc. has conducted Multi-Channel Analysis of Shear Waves (MASW) testing at the above referenced site. This work was performed in general accordance with S&ME Proposal No. 1614-6546-08R1 dated December 17, 2008, and under the Master Service Agreement (MSA) contract with Alliance Consulting Engineers.

The purpose of this exploration was to provide the recommended seismic site classification according to IBC 2006 based on measured shear wave velocities. The recommendations contained herein are not valid for design without the confirmation of an additional design level investigation after the locations of proposed structures are determined.

S&ME appreciates this opportunity to work with Alliance Consulting Engineers, Inc. as your geotechnical engineering consultant on this project. Please contact us at (803) 561-9024 if you have any questions or need any additional information regarding this report.

Sincerely,
S&ME, Inc.

SOUTH CAROLINA LICENSED PROFESSIONAL ENGINEER No. 25467 04/18/11 MICHAEL D. HARRIS, JR.

SOUTH CAROLINA S&ME, INC. No. C00473 CERTIFICATE OF AUTHORIZATION

Michael (Trapp) Harris, PE
Geotechnical Dept. Manager

James T. Palmer, PE
Engineering Manager

PROJECT INFORMATION

Information about the project was obtained through e-mail correspondence from Bethany Ravan of Alliance to Marty Baltzegar of S&ME on December 4, 2008. Vicinity, topographic, and aerial maps with approximate parcel boundaries were also provided on the same date. Our field work was performed in general accordance with S&ME Proposal No. 1614-6546-08R1 dated July 17, 2008, and under the Master Service Agreement (MSA) contract with Alliance Consulting Engineers.

The Colonel's Pointe Business Park site is approximately 109 acres and is located on SC Highway 9 on the north side in Richburg, South Carolina. The property is bordered by SC 9 to the south, Lewisville High School to the east, and wooded forestland to the north and west. The existing site consists of open fields in southern portion while the central and northern portions of the site are primarily wooded. Potential proposed construction would likely consist of light to medium industrial facilities.

EXPLORATION PROCEDURES

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^{TM}. 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^{TM}) exclusively, particularly when the ReMi^{TM} array geometry is linear.

At each of the three test locations shown on the attached "MASW Testing 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 and 10 feet and surface waves generated by both 2- and 10-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 three separate velocity profiles developed at each of the test locations are attached.

SEISMIC CONSIDERATIONS

Seismic induced ground shaking at the foundation is the effect taken into account by seismic-resistant design provisions of the 2006 International Building Code (IBC).

IBC Site Class

This site has been classified according to one of the Site Classes defined in IBC Section 1613.5 (Table 1613.5.2) using the procedures described in Section 1613.5.5.1. 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 1613.5.3, tables 1613.5.3(1) and 1613.5.3(2).

The site was then categorized using the method described in section 1613.5.5.1, paragraph 3.1 (V_S method). Average shear wave velocity over a depth of 100 feet was 868, 948, and 1185 feet per second for the three profiles conducted. Based on this approach, the Seismic Site Class according to the 2006 IBC is **Site Class D**. The site class should be established for each individual site development within the park during the design level geotechnical exploration.

Design Spectral Values

S&ME determined the spectral response parameters for the site using the general procedures outlined under the 2006 International Building Code Section 1613.5. This approach utilizes a mapped acceleration response spectrum corresponding to an earthquake having a 2 percent statistical probability of exceedance in 50 years to determine the spectral response acceleration at the top of seismic bedrock for any period.

The 2006 International Building Code seismic provisions of Section 1613 use the 2002 Seismic Hazard Maps published by the National Earthquake Hazard Reduction Program (NEHRP) to define the base rock motion spectra. The 2002 seismic hazard maps used in Section 1613 of the 2006 IBC have been updated several times since their original publication, reflecting updated knowledge of the probabilistic hazard in different parts of the country as well as advances in the understanding of seismic wave propagation and damping through the various soil and rock strata.

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 1613.5.3, tables 1613.5.3(1) and 1613.5.3(2). For purposes of computation, the Code includes mapped induced acceleration at frequencies of 5 hertz (S_S) and 1 hertz (S_1), which are then used to derive the remainder of the response spectra at all other frequencies. Mapped S_S and S_1 values represent motion at the top of bedrock. The surface ground motion response spectrum, accounting for inertial effects within the soil column overlying rock, is then determined for the design earthquake using spectral coefficients F_A and F_V for the appropriate Site Class.

The design ground motion at any period is taken as 2/3 of the smoothed spectral acceleration as allowed in section 1613.5.4. The design spectral response acceleration values at short periods S_{DS} and at one second periods S_{D1} are tabulated below for the unimproved soil profile. Peak ground acceleration (PGA) was obtained by dividing the S_{DS} value by 2.5.

Table 2 – Design Spectral Values

Value	2002 Seismic Hazard Maps Site Class D
S_{DS}	0.40 g
S_{D1}	0.19 g
PGA	0.16 g

For a structure having an Occupancy Category classification of I, II, or III, the S_{DS} and S_{D1} values obtained from the 2006 IBC (2002 Seismic Hazard Maps) are consistent with Seismic Design Category C as defined in section 1613.5.6.

Recommendations for Additional Exploration

The shear wave velocity profiles provide some indication of the range of conditions that may be encountered at the site. However, the spacing and number of profiles does not provide a reliable basis for design. A seismic site class determination should be conducted on each proposed parcel development prior to design.

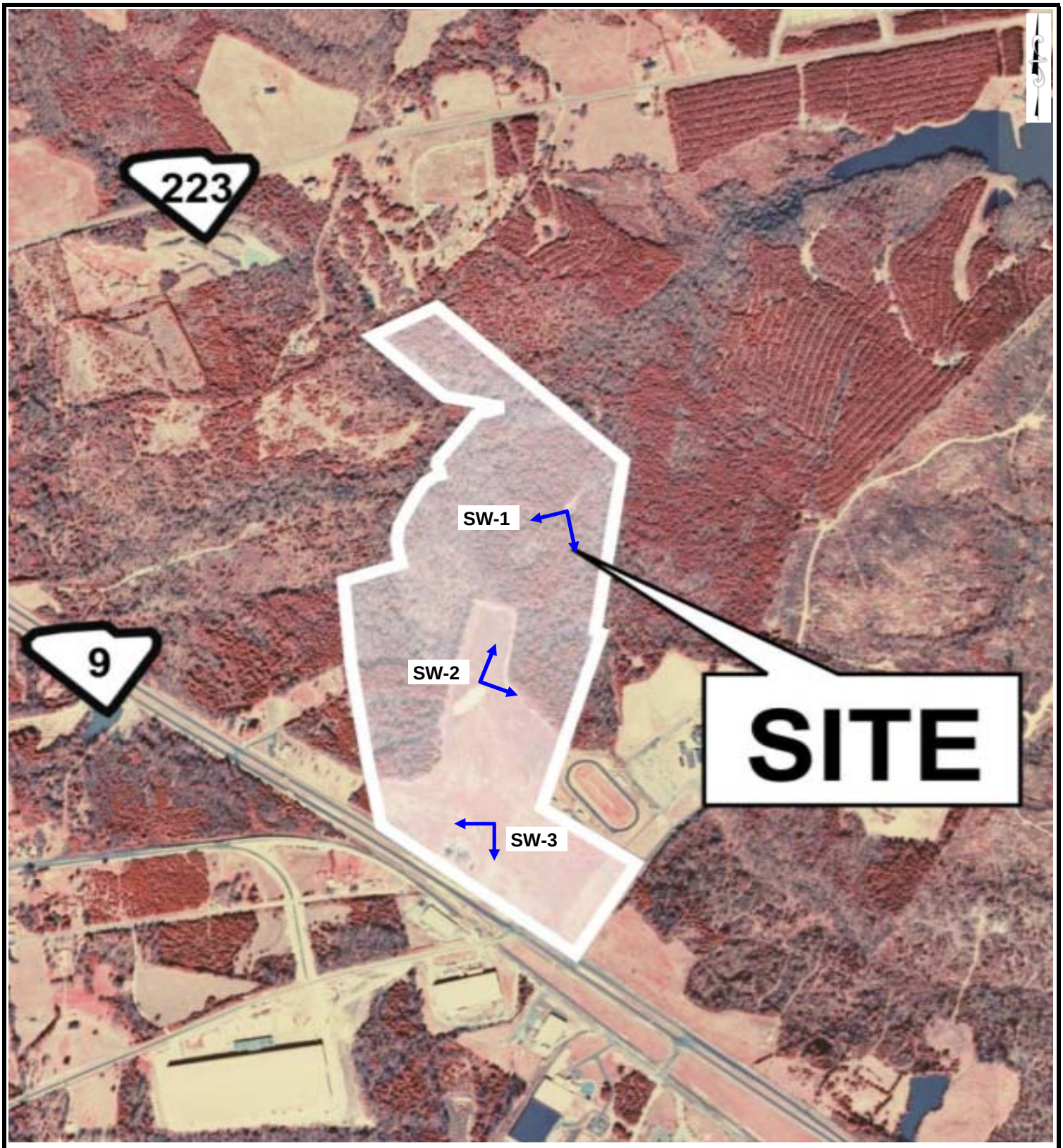
QUALIFICATIONS OF REPORT

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 test, 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, railway, pavement area or roadway.

SOURCE: Google Maps 2011

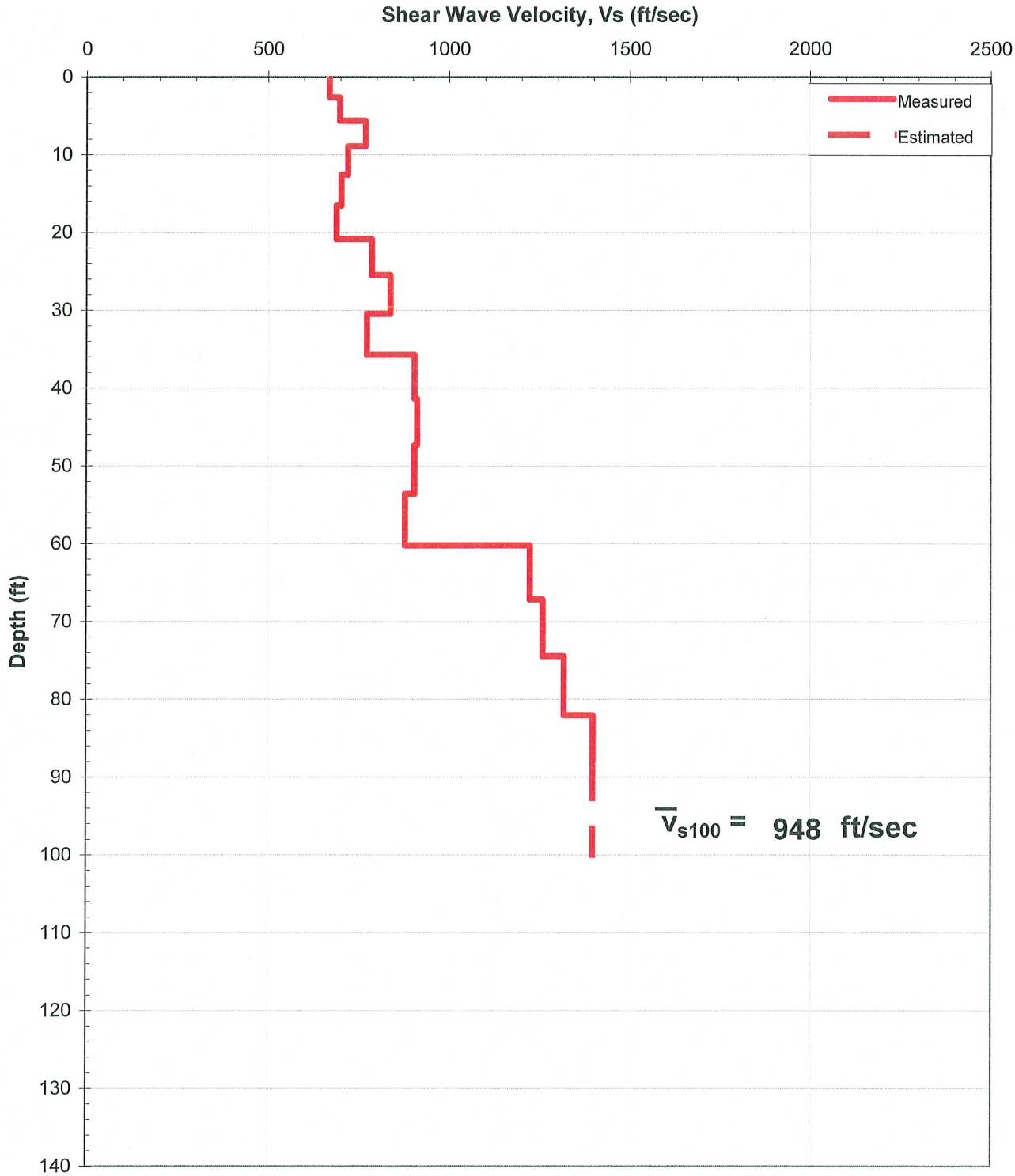
SCALE:	NTS	S&ME	SITE LOCATION MAP COLONEL'S POINTE IP SITE CLASS CHESTER COUNTY, SOUTH CAROLINA	FIGURE NO:
CHECKED BY:	JTP			1
DRAWN BY:	TH			
DATE:	04/18/11		JOB NO. 1611-11-159	



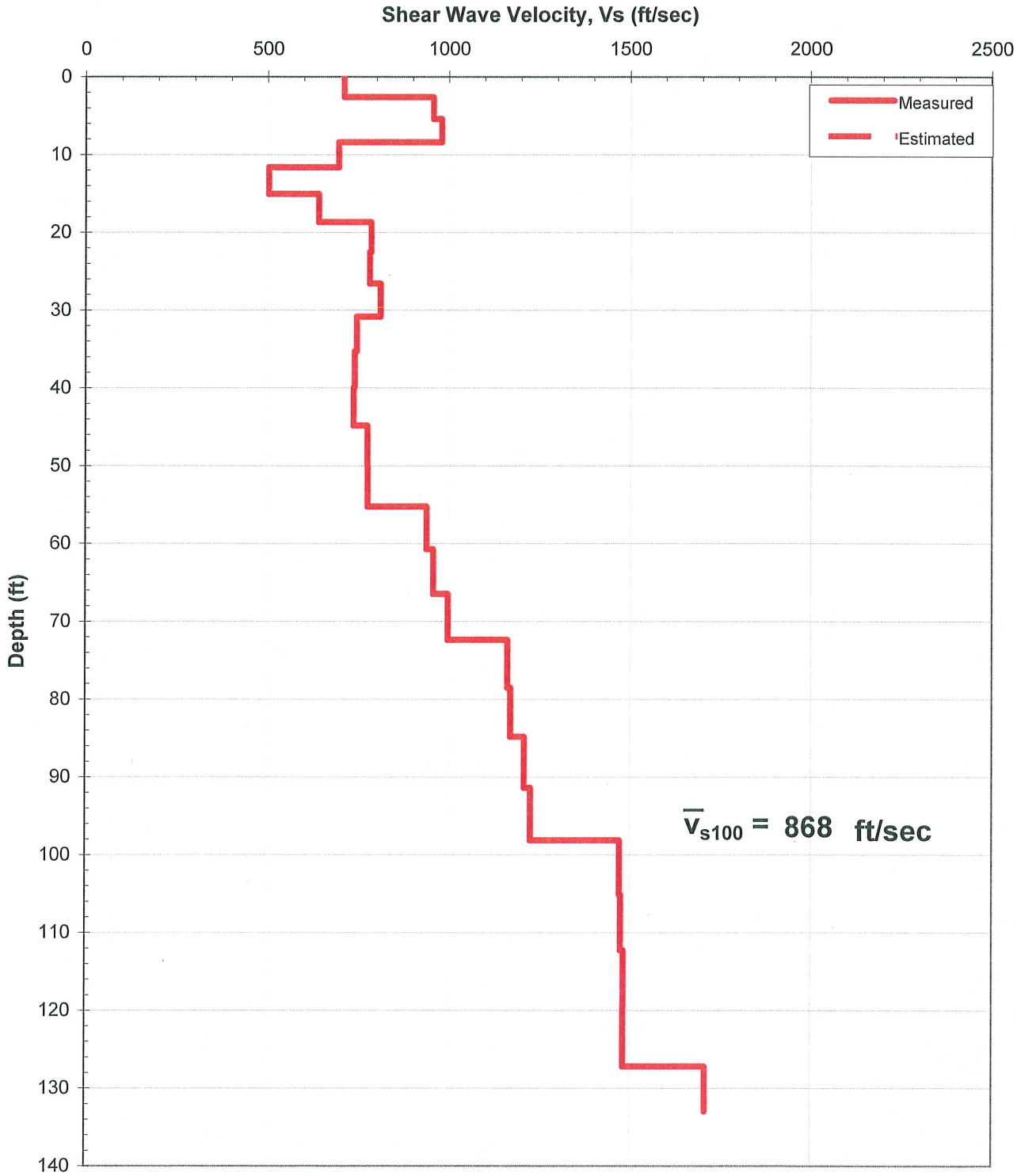
SOURCE: Alliance Consulting Engieers aerial site plan dated December 3, 2008.

SCALE:	NTS	S&ME	MASW TESTING LOCATION PLAN COLONEL'S POINTE IP SITE CLASS CHESTER COUNTY, SOUTH CAROLINA	FIGURE NO:
CHECKED BY:	JTP			2
DRAWN BY:	TH			
DATE:	04/18/11		JOB NO. 1611-11-159	

Shear Wave Velocity Profile SW-1
Colonel's Pointe Industrial Park
Chester County, South Carolina
1611-11-159



Shear Wave Velocity Profile SW-2
Colonel's Pointe Industrial Park
Chester County, South Carolina
1611-11-159



Shear Wave Velocity Profile SW-3
Colonel's Pointe Industrial Park
Chester County, South Carolina
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