GER GeoEnvironmental Resources, Inc.
Consulting Engineers
Environmental • Groundwater • Hazardous Materials • Geotechnical • Industrial Hygiene

July 8, 2013

Eastern Shore of Virginia
Broadband Authority (ESVBA)
4174 Lankford Highway
Exmore, VA 23350

Attention: **Mr. Nicholas Pascaretti**
Executive Director

Subject: **Report of Geotechnical Investigation**
Bloxom Broadband Communication Tower
26129 Shoremain Drive
Bloxom, Accomack County, Virginia
GER Project No. 110-6268

Geo**E**nvironmental **R**esources, Inc. is pleased to present this report of geotechnical investigation for the proposed Bloxom Broadband Communication Tower in Bloxom, Virginia. These services were authorized by Mr. Nicholas Pascaretti of Eastern Shore of Virginia Broadband Authority on June 19, 2013. This report presents our understanding of the proposed project, the results of our findings and geotechnical recommendations for design and construction of the project foundations based on our findings.

Project Information

The planned project is a 120 foot tall steel monopole tower for wireless broadband communications. The site is adjacent to the Bloxom Town Hall property and located behind the structure at 26129 Shoremain Drive in Bloxom, Accocmack County, Virginia as shown on the attached drawings. The tower will be located inside a new fenced gravel compound that will be accessed by a new gravel road. A lightly loaded equipment shelter will also be located inside the compound. Structural reactions for the tower and equipment shelter are currently unknown.

Subsurface Conditions

The subsurface conditions at the site were explored with one standard soil test boring drilled to a depth of 35 feet below the existing ground surface. The boring location, shown on attached Drawing 2, was next to the proposed tower center stake that was placed at the site by others. The boring location shall be considered approximate and may not necessarily coincide with the actual final tower construction location.

The subsurface conditions encountered at the boring location are shown on the attached test boring record. The test boring record represents our interpretation of the subsurface conditions based on visual examination of the field samples obtained. Lines designating the interface between various strata on the boring record represent the approximate interface location. In addition, the transition between strata may be more gradual than indicated. Boring and standard penetration testing in accordance with ASTM D 1586 was performed at discreet intervals in accordance with generally accepted practices. Water levels shown on the boring record, if any, represent the conditions encountered at the time of the field exploration.

A brief summary of subsurface conditions encountered in the test boring are described in Table 1 below:

Table 1. *Subsurface Conditions Encountered*

Stratum	Description	Approx. Depth Below Existing Grade (feet)	Range of SPT N-values (bpf)
1	Very loose to firm, fine to medium, clayey SAND (SC)	0 - 3	4 - 11
2	Firm, fine to medium, slightly silty SAND (SP-SM) with trace gravel	3 - 27	11 - 22
3	Firm to dense, fine to coarse, silty SAND (SM) with some gravel	27 - 35	15 - 49

Groundwater was encountered at approximately 3 feet below the ground surface in the soil boring during the exploration. This may not necessarily represent the water conditions that will be encountered at the time of construction. Fluctuations in the groundwater level may occur due to variations in rainfall, evaporation, construction activity, surface runoff and other site specific factors.

Subsurface Conditions and Foundations

The subsurface conditions and project information described in the previous sections have been evaluated with regard to supporting the tower structure with various foundation alternatives. The site is located within Virginia's Coastal Plain physiographic province which typically contains loose unconsolidated soils. These soils are predominantly marine sedimentary deposits typically having low to moderate strength characteristics. Both shallow and deep foundation systems are used in this area depending upon the nature of the structure to be supported.

The monopole structure and antenna relay equipment are relatively light and do not impose significant compressive loads at the foundation level. However, the height of the proposed structure subjects it to relatively high winds which can result in significant horizontal load and overturning moment at the tower base. Resistance to the lateral and overturning forces usually governs foundation selection for this type of structure. This resistance is normally achieved through sufficient weight or embedment depth of the foundations. Although the structural loads are unknown, a single drilled shaft foundation is recommended for supporting the monopole tower to resist lateral and overturning loads based on our experience with similar projects.

Recommendations

Based on the subsurface data obtained from the site and engineering analysis of subsurface conditions and project information, the following recommendations are provided for the proposed tower and associated project construction.

Tower Foundation

- ❑ A single drilled, cast-in-place concrete pier (drilled shaft) is recommended for supporting the monopole tower. The foundation should be sized appropriately for the actual design loads with sufficient strength concrete and reinforcing steel to resist the shear, bending moment and deflection associated with the design loading. Design and construction should be in accordance with ACI 336.1.

- ❑ The minimum recommended foundation bearing depth is 20 feet below existing grade based on the boring. The minimum shaft diameter should be 4 feet, which is estimated to provide a net compressive capacity of 150 kips at this depth and deeper with an appropriate factor of safety. Final shaft dimensions should be selected to satisfy axial capacity, structural integrity and to limit rotation to ½ of a degree and top deflection of ½ of an inch under the maximum anticipated load combinations.

- ❑ The foundation should be drilled to the design tip elevation followed by removal of loose material using a cleaning tool, then installation of a reinforcing steel cage and concrete placed via tremie or pump line. Because loose soil and groundwater will be encountered during excavation, the shaft will be susceptible to collapse. Drilling will require a polymer slurry drilling fluid that is displaced during concrete placement (i.e. the wet method of construction) possibly with the use of temporary steel casing and formwork.

- ❑ A positive head of concrete that is at least 5 feet above the bottom of the tremie or bottom of the pump line should be maintained at all times during shaft construction. This will help provide good contact between the sides of the hole and concrete shaft and prevent necking and soil inclusions in the shaft section in areas of lower strength soils.

- ❑ Foundation drilling and construction should be observed by a field inspector. If soil conditions and construction methods are encountered which differ from those that are anticipated, the geotechnical engineer should be contacted.

Soil Properties

The in-situ soil properties as estimated from the boring and shown in Table 2 may be used for design of subsurface elements:

Table 2. *Estimated Soil Properties*

Depth Below Existing Grade (feet)	Moist Unit Weight, γ (pcf)	Buoyant Unit Weight, γ' (pcf)	Friction Angle, ϕ (degrees)	Cohesion in clay (psf)	Strain Parameter in clay, ε_{50}	Subgrade Modulus, k (pci) in soil
0 - 3	115	---	29	0	---	30
3 - 30	120	60	32	0	---	60
30 - 35	125	63	36	0	---	150

Ancillary Structures

- ❑ Ancillary structures inside the compound area, such as equipment shelters, platforms, etc., may be supported on shallow footings or piers designed for a maximum bearing pressure of 2,000 pounds per square foot with a minimum foundation width of 24 inches for round or rectangular pier footings and 18 inches for continuous strip footings.

- ❑ Footings should bear on firm native soils, rock or on crushed #57 stone after removal of topsoil and other unsuitable materials. The minimum depth of footings is 20 inches below final grades for bearing capacity considerations and for protective embedment.

- ❑ Settlements for these lightly loaded structures are estimated at 1 inch or less for loads of 30 kips or less per pier and 3 kips per foot for walls.

Fill & Backfill

- ❑ Representative samples of each proposed fill material should be collected before filling operations begin and tested to determine the maximum dry density, optimum moisture content, natural moisture content, gradation and plasticity. These tests are needed for quality control during construction and to determine if the fill material is acceptable.

- ❑ Fill and backfill soil should consist of low plasticity local material having a maximum of 25 percent silt and clay fines by ASTM D 1140, and liquid limit less than 30 and plasticity index less than 9 by ASTM D 4318. Fill and backfill should be constructed by spreading acceptable soil in thin, even layers not exceeding 8 inches in thickness prior to compaction. Fills should be free of debris and deleterious materials.

- ❑ Each layer of soil should be compacted to achieve a dry density not less than 95 percent of the laboratory maximum dry density as determined by ASTM D 698. The moisture content of fill soils should be maintained within ±3 percentage points of the optimum moisture content determined from the laboratory Proctor density test.

- The surface must be adequately maintained during fill construction. Where possible, the fill surface should be sloped and rolled with steel drummed equipment to improve surface runoff while construction is temporarily halted. Excavations to receive backfill should not be left open for extended periods.
- Fill should not be placed on wet or frozen ground. Fill which becomes softened from excess moisture should be aerated and recompacted to acceptable levels, or removed and replaced with new compacted fill.

Site & Civil Considerations

- Access to the site will be provided via gravel driveway. It and the compound service area should be composed of a minimum 4-inch layer of crusher-run type aggregate or crushed #3 or #57 stone over a woven geotextile fabric having a nominal 200-lb tensile strength.
- Greater stone thickness or undercutting and replacement will likely be required over areas with soft soil conditions, such as farm fields, woodlands, wetlands, etc. All topsoil, vegetation, debris, deleterious materials and otherwise unsuitable soils should be removed from the driveway and compound service areas.

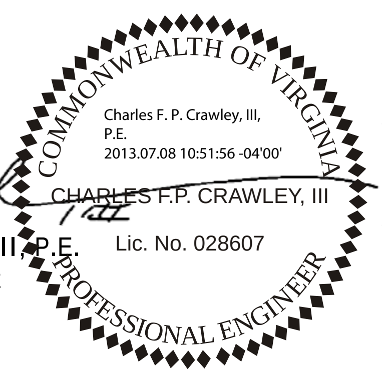
Limitations

The recommendations provided are based in part on project information provided to us. They only apply to the specific project and site discussed in this report. If the project information section in this report contains incorrect information or if additional information is available, you should convey the correct or additional information to us and retain us to review our recommendations. We can then modify our recommendations if they are inappropriate for the proposed project.

Regardless of the thoroughness of a geotechnical exploration, there is always a possibility that conditions between borings will be different from those at specific boring locations and that conditions will not be as anticipated by the designers or contractors. In addition, the construction process may itself alter soil conditions. Adequate field inspection during foundation construction can often deal with unsuitable or unanticipated soil conditions before they lead to more serious problems. Unanticipated conditions should be reported to the design team along with appropriate recommendations to solve the problems encountered.

We appreciate the opportunity to serve as your geotechnical consultant on this project and trust that you will contact us at your convenience with any questions concerning this report or the project in general.

Sincerely,
GeoEnvironmental Resources, Inc.

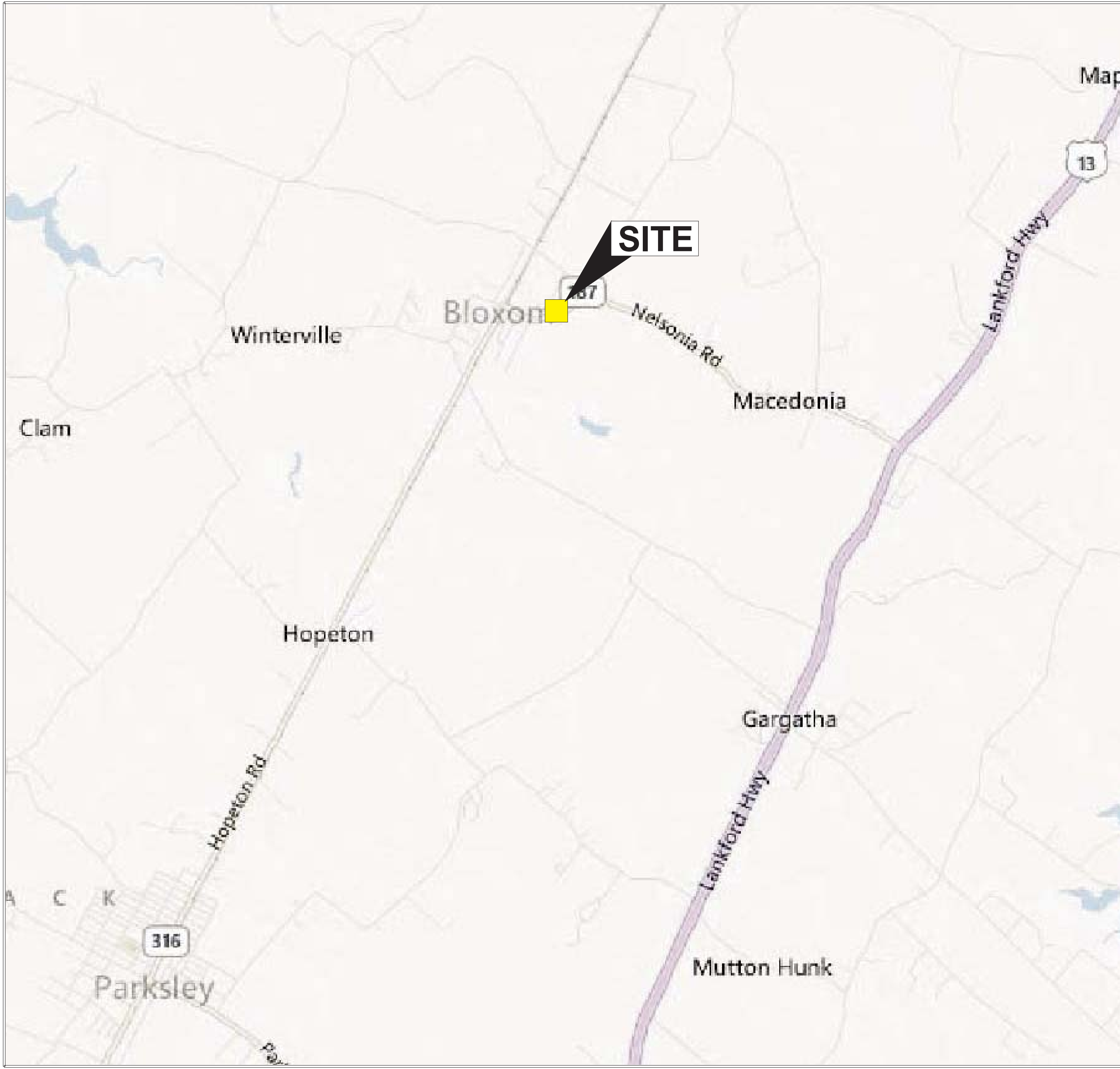


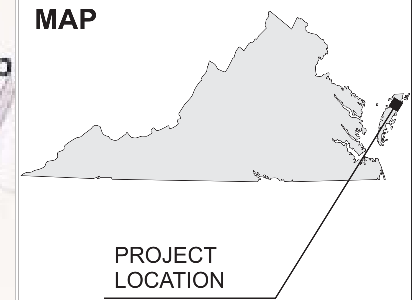
Samuel L. McKay, III, P.G.
Project Geologist

Charles F. P. Crawley, III, P.E.
Assistant Vice President

Attachments: Site Location Plan
Boring Location Plan
Test Boring Record

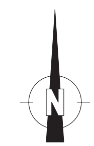
c: Arian Zoto, AZ Engineering





SOURCE:

Bing Maps
2013
(not to scale)



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2712 Southern Boulevard, Suite 101
Virginia Beach, VA 23452

SITE LOCATION PLAN

Eastern Shore Broadband Tower
Bloxom, Virginia

PROJECT NUMBER	DRAWING NUMBER
110-6268	1

LEGEND:

Soil Boring

SCALE: Not to Scale

NOTE:
The boring locations shown were not surveyed and may be several feet from the locations indicated. Boring locations shall be considered approximate.

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BORING LOCATION PLAN

Eastern Shore Broadband Tower
Bloxom, Virginia

PROJECT NUMBER	DRAWING NUMBER
110-6268	2

TEST BORING RECORDS

The enclosed test boring records represent our interpretation of the subsurface conditions encountered at the specific boring locations at the time explorations were made based on visual examination of the field samples obtained and selected laboratory classification testing if performed. The lines designating the interface between various strata on the boring records represent the approximate interface location. In addition, the transition between strata may be more gradual than indicated. Water levels shown represent the conditions only at the time of the field exploration. It is possible that soil and groundwater conditions between the individual boring locations will be different from those indicated. Boring surface and strata elevations, if shown, shall be considered approximate and are referenced to project datum shown on the plans or described in the geotechnical report unless noted otherwise.

BORING LOG LEGEND

KEY TO DRILLING SYMBOLS

Split Spoon Sample (ASTM D 1586)	Water Table at Time of Drilling	**H.S.A.** Hollow Stem Auger Drilling
Undisturbed Sample (ASTM D 1587)	Water Table after 24 hrs.	**M.R.** Mud Rotary Wash Drilling
Rock Coring (ASTM D 2113)	Boring Cave In	**PP** Pocket Penetrometer (tsf)
Roller Cone Advanced	Loss of Drilling Fluid	**REC** Core Recovery (%)
	Auger Refusal	**RQD** Rock Quality Designator (%)
	Roller Cone Refusal	**SCR** Solid Core Recovery (%)
Seepage into Borehole	Approximate Strata Change Depth Different Soil Types	Approximate Strata Change Depth Similar Soil Types

CORRELATION OF RELATIVE DENSITY AND CONSISTENCY WITH STANDARD PENETRATION TEST RESISTANCE (ASTM D 1586)§

SPT RESISTANCE (N) IN BLOWS PER FOOT

SPT N	RELATIVE DENSITY† SAND & GRAVEL
0 - 4	Very Loose
5 - 10	Loose
11 - 30	Firm
31 - 50	Dense
51 +	Very Dense

SPT N	CONSISTENCY† SILT & CLAY
0 - 2	Very Soft
3 - 4	Soft
5 - 8	Firm
9 - 15	Stiff
16 - 30	Very Stiff
31 - 50	Hard
51 +	Very Hard

ROCK QUALITY‡

FRACTURES, JOINT SPACING AND BEDDING

RQD (%)	DIAGNOSTIC DESCRIPTION	ROCK PARAMETER FIELD/LAB RATIO	SPACING	JOINTS	BEDDING
0 - 25	Very Poor	0.15	Less than 2"	Very Close	Very Thin
25 - 50	Poor	0.20	2" to 1'	Close	Thin
50 - 75	Fair	0.25	1' to 3'	Moderately Close	Medium
75 - 90	Good	0.30 to 0.70	3' to 10'	Wide	Thick
90 - 100	Excellent	0.70 to 1.00	More than 10'	Very Wide	Very Thick

HARDNESS

Very Hard - Breaking specimens requires several hard hammer blows

Hard - Hard hammer blow required to detach specimens

Moderately Hard - Light hammer blow required to detach specimens

Medium - May be scratched 1/16" deep by a knife or nail, breaks into several pieces by light hammer blow

Soft - Can be gouged readily by knife or nail, corners and edges broken by finger pressure

Very Soft - May be carved with a knife and readily broken by finger pressure

WEATHERING

Fresh - Fresh rock, bright crystals, no staining

Slight - Minimum stainaing and discoloration, open joints contain clay

Moderate - Significant portions of rock shows staining and discoloration, strong rock fragments

Severe - All rock shows staining, rock fabric evident but reduced strength

Very Severe - All rock shows staining, rock mass effectively reduced to soil with strong rock fragments remaining

Complete - Rock reduced to soil with rock fabric not discernable

§ *Resistance of a standard 2-inch O.D., 1.375-inch I.D. split spoon sampler driven by a 140 pound hammer free-falling 30 inches.*

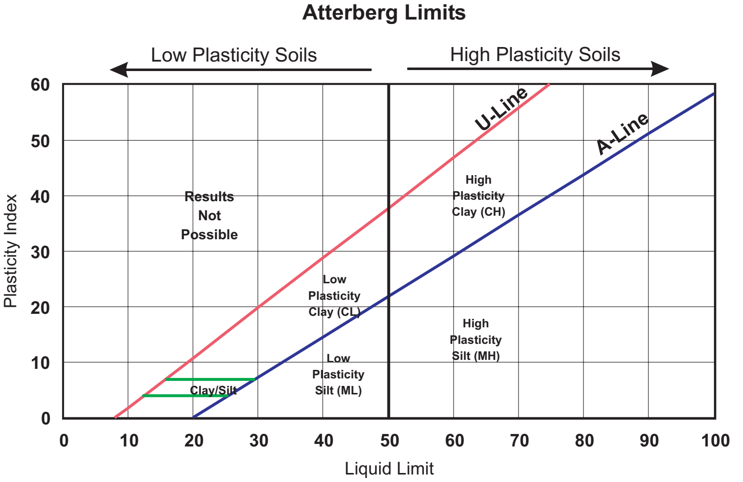
† *after Terzaghi and Peck, 1968*

‡ *after D. U. Deere, 1963, 1967*

SOIL CLASSIFICATION CHART (ASTM D 2487)

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LOW PLASTICITY LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS, CLAYEY SILTS, SILT-VERY FINE SAND MIXTURES, ROCK FLOUR
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY, SANDY, SILTY, & LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC CLAYS OF LOW PLASTICITY
		HIGH PLASTICITY LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS AND MICACEOUS, DIATOMACEOUS AND ELASTIC SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
OTHER SOILS	HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, MUCK, SWAMP SOILS WITH VERY HIGH ORGANIC CONTENTS
	UNCONTROLLED FILLS				DISTURBED SOILS WITH POSSIBLE DEBRIS AND RUBBLE, OLD CONSTRUCTION WASTES, NON-ENGINEERED BACKFILLS
	DECOMPOSED OR PARTIALLY WEATHERED ROCK				TRANSITIONAL MATERIAL BETWEEN SOIL AND ROCK WHICH MAY RETAIN THE RELICT STRUCTURE OF THE PARENT ROCK

Atterberg Limits



PARTICLE SIZE IDENTIFICATION

BOULDERS:		Greater than 300 mm (12 in.)
COBBLES:		75 mm to 300 mm (3 - 12 in.)
GRAVEL:	Coarse -	19.0 mm to 75 mm (0.75 - 3 in.)
	Fine -	4.75 mm to 19.0 mm (#4 - 0.75 in.)
SANDS:	Coarse -	2.00 mm to 4.75 mm
	Medium -	0.425 mm to 2.00 mm
	Fine -	0.075 mm to 0.425 mm
SILTS & CLAYS:		Less than 0.075 mm

PLASTICITY INDEX (PI) & SHRINK-SWELL POTENTIAL

0 - 4	None
4 - 15	Slight or Low
15 - 30	Medium to High
31+	High to Very High

ADDITIONAL RELATIVE DESCRIPTIVE VALUES

Trace < 10%	Some < 35% but > 20%
Little < 20% but > 10%	And > 35%

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TEST BORING RECORD

GeoEnvironmental Resources, Inc.	Environmental, Groundwater, Hazardous Materials, Geotechnical & Industrial Engineering Consultants		Boring #: **B-1** (Page 1 of 1)
Project: **Bloxom Broadband Tower Site**	GER Project Number: **110-6268**		Date Drilled: **7/2/2013**
Location: **Bloxom, VA**	Driller: **Fishburne**		Drill Method: **3" Mud Rotary**
Depth (ft.): **35.0**	Elevation (ft.):	Client: **Eastern Shore Broadband Authority**	Hammer Type: **Automatic**

Depth (ft)	Material Description	Ground Water
0 – 0.5	**Topsoil** - 6 inches	
0.5 – 3	**Clayey SAND (SC)** Very loose to firm, light brown, fine to medium	∇ (approx. 2.8 ft)
3 – 27	**Slightly Silty SAND (SP-SM)** Firm, tan to light grey, fine to medium, with trace gravel	
27 – 35	**Silty SAND (SM)** Firm to dense, orange, fine to coarse, with some gravel	
35	Boring terminated at 35 feet.	

Sample Depth (ft)	SPT Blows	Uncorrected Penetration Resistance (blows/foot)
0 – 2	1, 2, 2, 3	4
2 – 4	4, 3, 8, 10	11
4 – 6	7, 7, 10, 8	17
6 – 8	7, 8, 10, 10	18
8 – 10	10, 10, 12, 14	22
13 – 15	6, 7, 6, 9	13
18 – 20	8, 9, 8, 7	17
23 – 25	9, 10, 10, 8	20
28 – 30	8, 7, 8, 16	15
33 – 35	12, 25, 24, 39	49