

**GEOTECHNICAL EXPLORATION
PROPOSED MONOPOLE TOWER
VANDERBILT LOVE CIRCLE WIND TURBINES
NASHVILLE, TENNESSEE
GEOSERVICES PROJECT NO.: 31-111050**

Prepared For:

Logan Patri Engineering, Inc.
630-C Southgate Avenue
Nashville, Tennessee 37203

Prepared by:



GEOServices, LLC
163 Business Park Drive
Suite 15
Lebanon, Tennessee 37087

June 6, 2011

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FIGURE 1: BORING LOG



June 6, 2011

Logan Patri Engineering, Inc.
630-C Southgate Avenue
Nashville, Tennessee 37203

Attention: Mr. Rao Patri, P.E.

**Re: Report of Geotechnical Exploration
Proposed Monopole Towers
Vanderbilt Love Circle Wind Turbines
Nashville, Tennessee
GEO Services Project No. 31-111050**

Dear Mr. Patri:

GEO Services, LLC has completed the requested exploration and herewith submits the subsurface findings and recommendations. Our services were in general accordance with the current services agreement with you, dated May 13, 2011.

PURPOSE AND SCOPE

The purpose of this geotechnical exploration is to characterize the subsurface conditions at the site and provide geotechnical parameters so that Logan Patri Engineering may design a foundation system. Our scope of services for this task included drilling two soil borings and preparing this report. This report presents available project information, describes the site and subsurface conditions, and presents soil parameters pertaining to foundation design.

PROJECT DESCRIPTION

The project information was supplied to GEOServices on May 11, 2011. The information supplied generally consisted of site location information and general tower information. GEOServices understands the proposed new towers for the wind turbines at this site are monopole structures that are 60 feet tall.

The geotechnical information presented in this report is based on the available project information, the tower location, and the subsurface materials described in this report. If any of the noted information is incorrect, please inform GEOServices in writing so that we can amend the recommendations presented in this report. GEOServices cannot be responsible for the implementation of its recommendations when it is not notified of changes in conditions.

SITE LOCATION

The site is planned to be located at Vanderbilt Love Circle Renewable Technologies Center in Love Circle Park in Nashville, Tennessee.

EXPLORATION

Under the direction of GEOServices, a subcontractor utilized a track-mounted drill rig to advance two borings within the approximate location of the proposed windmill towers. The borings were offset approximately 20 feet from the planned windmill turbine locations due to the inability to drill through the deep fill materials. The borings were advanced to an auger refusal depth of 2.5 and 4.7 feet below the existing surface elevation. The drill crew worked in general accordance with ASTM D6151 (HSA Drilling). The drill crew worked in general accordance with ASTM D2113 (Diamond Core Drilling). Upon completion, the boring was checked for the presence of groundwater and was subsequently backfilled. The samples will be retained for 30 days from the date of this report before being discarded.

SUBSURFACE CONDITIONS

The table below provides a subsurface description of a generalized nature to highlight the major subsurface stratification features and material characteristics. The boring logs should be reviewed for specific information at the boring locations. The boring logs includes soil descriptions, stratifications, penetration resistance, and groundwater information at the approximate location of the samples observed. The stratifications shown on the boring log represent the conditions only at the actual boring location. Variations may occur and should be expected across the site. The stratifications represent the approximate boundary between subsurface materials and the actual transition may be gradual.

**Table 1 – Subsurface Conditions
 Boring B-1**

| Depth (ft below ground surface) | Description | Recovery | Rock Quality Designation | |
|---------------------------------|--|----------|--------------------------|-----|
| 0 – 2.5 | Shotrock / Clay – brown; slightly moist (FILL) | N/A | N/A | N/A |

**Table 2 – Subsurface Conditions
 Boring B-2**

| Depth (ft below ground surface) | Description | Recovery (%) | Rock Quality Designation - RQD (%) | |
|---------------------------------|--|--------------|------------------------------------|------|
| 0 – 4.7 | Shotrock / Clay – brown; slightly moist (FILL) | N/A | N/A | N/A |
| 4.7 – 9.7 | Limestone – gray and light gray; hard; fined grained; horizontal bedding | 58.3 | 33.3 | Poor |
| 9.7 – 14.7 | Limestone – gray and light gray; hard; fined grained; horizontal bedding | 80.8 | 45 | Poor |

GROUNDWATER INFORMATION

Subsurface water was not encountered in either boring (B-1 and B-2) at the time of drilling. Subsurface water levels may fluctuate due to seasonal changes in precipitation amounts or due to construction activities in the area. Additionally, discontinuous zones of perched water may exist within the overburden.

FOUNDATION PARAMETERS

GEOServices was not informed of the type of foundation planned to support the tower at this location, but based on our experience we expect it to be a mat / spread footing type foundation or a drilled pier foundation. Therefore, we are providing design parameters for each of the foundation types.

Spread Footing / Mat Foundation

Based on the information obtained at boring B-1 during this exploration, and considering a factor of safety of 3 with respect to general shear failure, we assess the allowable bearing pressures to be used for design of a mat type foundation to be as follows:

Bearing Capacity

| Depth Range (ft) | Allowable Bearing Pressure (psf) |
|-----------------------------|---|
| 0 – Refusal | Neglect |
| Limestone Bedrock | 5,000 |

Pier Foundation

If a drilled pier foundation system is utilized to support the proposed turbine towers, parameters recommended for the design are as follows:

Subsurface Parameters for Pier Foundations at the Tower

| Depth Range (ft) | Wet Unit Weight (pcf) | Allowable End Bearing (psf) | Cohesion (psf) ⁽¹⁾ | Effective Angle of Internal Friction Φ ⁽¹⁾ (°) | Ultimate Frictional Resistance ⁽²⁾ (psf/ft) | K ⁽³⁾ (pci) | Strain Factor E50 |
|-------------------|-----------------------|-----------------------------|-------------------------------|--|--|------------------------|-------------------|
| 0 – Refusal | Neglect | Neglect | Neglect | Neglect | Neglect | Neglect | Neglect |
| Limestone Bedrock | 145 | 5,000 | 3,000 | 28 | 27.3 | 200 | 0.001 |

(1) Based on N values and conservative estimates based upon prudent engineering judgment. If the structure is considered a “critical structure” or if actual values are needed, laboratory testing should be performed to determine the soil’s strength parameters.

(2) Friction of concrete against undisturbed natural soil. Taken as 55% of the Undrained Shear Strength of fine grained soils. Frictional resistance in a cohesionless soil is a function of depth and therefore should be calculated with depth. Use $K=1$ to calculate frictional resistance in a cohesionless soil ($f = K \cdot \sigma'_v \cdot \tan(\delta^\circ)$).

(3) Lateral Modulus of subgrade reaction.

*The wet unit weights listed in the table are based on prudent engineering judgment and do not reflect the buoyant unit weight of the soils below the groundwater table. The buoyant unit weight is the unit weight of soil minus the unit weight of water.

The upper shotrock/clay fill should be ignored due to the lack of documentation of properly placed fill activities. At the actual turbine locations, we expect that the fill to be 8 to 10 feet deep. The above provided values are based on our subsurface findings, published values and, our past experience with similar soil types. These values should, therefore be considered approximate.

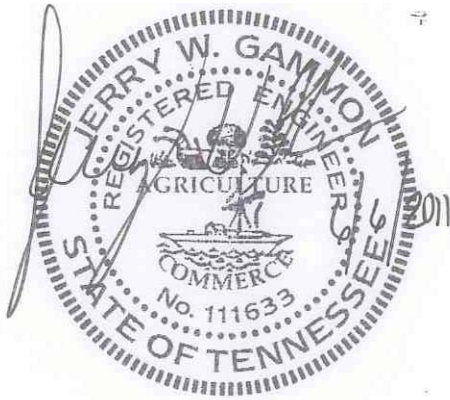
LIMITATIONS

This report has been prepared in accordance with generally accepted geotechnical engineering practice for specific application to this project. This report is for our geotechnical work only, and no environmental assessment efforts have been performed. The conclusions and recommendations contained in this report are based upon applicable standards of our practice in this geographic area at the time this report was prepared. No other warranty, expressed or implied, is made.

CLOSURE

We appreciate this opportunity to be of continuing service to you and look forward to assisting you with future projects. If you have any questions or comments do not hesitate to contact our office to discuss the details of this report. If you have any questions or comments regarding this report, please contact the undersigned at (615) 547-9314.

GEOServices, LLC



Jerry W. Gammon, P.E.
Nashville Manager

A handwritten signature in black ink, appearing to read "Dennis A. Huckaba".

Dennis A. Huckaba, P.E.
Principal

GENERAL NOTES

FINE AND COARSE GRAINED SOIL PROPERTIES

PARTICLE SIZE

| | |
|----------------|----------------------|
| BOULDERS: | GREATER THAN 300 mm |
| COBBLES: | 75 mm to 300 mm |
| GRAVEL: | 4.74 mm to 75 mm |
| COARSE SAND: | 2 mm to 4.74 mm |
| MEDIUM SAND: | 0.425 mm to 2 mm |
| FINE SAND: | 0.075 mm to 0.425 mm |
| SILTS & CLAYS: | LESS THAN 0.075 mm |

COARSE GRAINED SOILS (SANDS & GRAVELS)

| N-VALUE | RELATIVE DENSITY |
|---------|------------------|
| 0 - 4 | VERY LOOSE |
| 5 - 10 | LOOSE |
| 11 - 30 | MEDIUM DENSE |
| 31 - 50 | DENSE |
| OVER 50 | VERY DENSE |

FINE GRAINED SOILS (SILTS & CLAYS)

| N-VALUE | CONSISTENCY | Qu, PSF |
|---------|-------------|-------------|
| 0 - 2 | VERY SOFT | 0 - 500 |
| 3 - 4 | SOFT | 500 - 1000 |
| 5 - 8 | FIRM | 1000 - 2000 |
| 9 - 15 | STIFF | 2000 - 4000 |
| 16 - 30 | VERY STIFF | 4000 - 8000 |
| OVER 31 | HARD | 8000 + |

STANDARD PENETRATION TEST (ASTM D1586)

THE STANDARD PENETRATION TEST AS DEFINED BY ASTM D1586 IS A METHOD TO OBTAIN A DISTURBED SOIL SAMPLE FOR EXAMINATION AND TESTING AND TO OBTAIN RELATIVE DENSITY AND CONSISTENCY INFORMATION. THE 1.4 INCH I.D./2.0 INCH O.D. SAMPLER IS DRIVEN 3-SIX INCH INCREMENTS WITH A 140 LB. HAMMER FALLING 30 INCHES. THE BLOW COUNTS REQUIRED TO DRIVE THE SAMPLER THE FINAL 2 INCREMENTS ARE ADDED TOGETHER AND DESIGNATED THE N-VALUE. AT TIMES, THE SAMPLER CAN NOT BE DRIVEN THE FULL 18 INCHES. THE FOLLOWING REPRESENTS OUR INTERPRETATION OF THE STANDARD PENETRATION TEST WITH VARIATIONS.

BLOWS/FOOT (N-VALUE)

DESCRIPTION

| | |
|-------------|--|
| 25..... |25 BLOWS DROVE SAMPLER 12" AFTER INITIAL 6" SEATING |
| 75/10"..... |75 BLOWS DROVE SAMPLER 10" AFTER INITIAL 6" SEATING |
| 50/PR..... |PENETRATION REFUSAL OF SAMPLER AFTER INITIAL 6" SEATING |

SAMPLING SYMBOLS

| | |
|-------|---------------------|
| ST: | UNDISTURBED SAMPLE |
| SS: | SPLIT SPOON SAMPLE |
| CORE: | ROCK CORE SAMPLE |
| AU: | AUGER OR BAG SAMPLE |

SOIL PROPERTY SYMBOLS

| | |
|------|--------------------------------------|
| N: | STANDARD PENETRATION, BPF |
| M: | MOISTURE CONTENT % |
| LL: | LIQUID LIMIT % |
| PI: | PLASTICITY INDEX % |
| Qp: | POCKET PENETROMETER VALUE, TSF |
| Qu: | UNCONFINED COMPRESSIVE STRENGTH, TSF |
| DUW: | DRY UNIT WEIGHT, PCF |

ROCK PROPERTIES

ROCK HARDNESS

ROCK QUALITY DESIGNATION (RQD)

| PERCENT | QUALITY |
|-----------|-----------|
| 90 TO 100 | EXCELLENT |
| 75 TO 90 | GOOD |
| 50 TO 75 | FAIR |
| 25 TO 50 | POOR |
| 0 TO 25 | VERY POOR |

| | |
|------------------|--|
| VERY SOFT: | ROCK DISINTEGRATES OR EASILY COMPRESSES TO TOUCH: CAN BE HARD TO VERY HARD SOIL. |
| SOFT: | ROCK IS COHERANT BUT BREAKS EASILY TO THUMB PRESSURE AT SHARP EDGES AND CRUMBLES WITH FIRM HAND PRESSURE. |
| MODERATELY HARD: | SMALL PIECES CAN BE BROKEN OFF ALONG SHARP EDGES BY CONSIDERABLE HARD THUMB PRESSURE: CAN BE BROKEN BY LIGHT HAMMER BLOWS. |
| HARD: | ROCK CAN NOT BE BROKEN BY THUMB PRESSURE, BUT CAN BE BROKEN BY MODERATE HAMMER BLOWS. |
| VERY HARD: | ROCK CAN BE BROKEN BY HEAVY HAMMER BLOWS. |



Vanderbilt Love Circle Windmill Turbine
 Nashville, Tennessee
 GEOServices Project #31-111050

LOG OF BORING **B-1**

SHEET 1 OF 1

DRILLER Mike Warren
 ON-SITE REP. _____

BORING NO. / LOCATION B-1

DRY ON COMPLETION ? Yes

DATE May 25, 2011 SURFACE ELEV. _____ FT.
 REFUSAL: Yes DEPTH 2.5 FT. ELEV. _____ FT.
 SAMPLED _____ FT. _____ M
 TOP OF ROCK DEPTH _____ FT. ELEV. _____ FT.
 BEGAN CORING DEPTH _____ FT. ELEV. _____ FT.
 FOOTAGE CORED (LF) _____ FT.
 BOTTOM OF HOLE DEPTH 2.5 FT. ELEV. -2.5 FT.

WATER LEVEL DATA (IF APPLICABLE)

COMPLETION: DEPTH Dry FT.
 ELEV. _____ FT.
 AFTER 24 HRS. DEPTH N/A FT.
 ELEV. _____ FT.

BORING ADVANCED BY: _____ POWER AUGERING X WASHBORING _____

| STRATUM DEPTH | | SAMPLE DEPTH | | SAMPLE OR RUN NO. | SAMPLE TYPE | FIELD RESULTS | | LABORATORY RESULTS | | | STRATUM DESCRIPTION |
|---------------|-------|--------------|--------|-------------------|-------------|---------------|----|--------------------|----|----|--|
| FT. | ELEV. | FROM FT. | TO FT. | | | N-Value | Qp | LL | PI | %M | |
| - | - | | | | | | | | | | TOPSOIL (4 INCHES) |
| 2.5 | -2.5 | | | | | | | | | | Shotrock / Clay - brown; slightly moist; (FILL) |
| | | | | | | | | | | | AUGER REFUSAL AT 2.5 FEET |
| 5.0 | -5.0 | | | | | | | | | | |
| 7.5 | -7.5 | | | | | | | | | | |
| 10.0 | -10.0 | | | | | | | | | | |
| 12.5 | -12.5 | | | | | | | | | | |
| 15.0 | -15.0 | | | | | | | | | | |
| 17.5 | -17.5 | | | | | | | | | | |
| 20.0 | -20.0 | | | | | | | | | | |

REMARKS: _____



Vanderbilt Love Circle Windmill Turbine
Nashville, Tennessee
GEOservices Project #31-111050

LOG OF BORING B-2

SHEET 1 OF 1

DRILLER Mike Warren

ON-SITE REP. _____

BORING NO. / LOCATION B-2

DRY ON COMPLETION ? Yes

DATE May 25, 2011 SURFACE ELEV. _____ FT.
 REFUSAL: Yes DEPTH 4.7 FT. ELEV. _____ FT.
 SAMPLED _____ FT. _____ M
 TOP OF ROCK DEPTH _____ FT. ELEV. _____ FT.
 BEGAN CORING DEPTH 4.7 FT. ELEV. -4.7 FT.
 FOOTAGE CORED (LF) 10.0 FT.
 BOTTOM OF HOLE DEPTH 14.7 FT. ELEV. -14.7 FT.

WATER LEVEL DATA (IF APPLICABLE)

COMPLETION: DEPTH Dry FT.
 ELEV. _____ FT.
 AFTER 24 HRS. DEPTH N/A FT.
 ELEV. _____ FT.

BORING ADVANCED BY: _____ POWER AUGERING X WASHBORING _____

| STRATUM DEPTH | | SAMPLE DEPTH | | SAMPLE OR RUN NO. | SAMPLE TYPE | FIELD RESULTS | | LABORATORY RESULTS | | | STRATUM DESCRIPTION |
|---------------|-------|--------------|--------|-------------------|-------------|---------------|----|--------------------|----|----|--|
| FT. | ELEV. | FROM FT. | TO FT. | | | N-Value | Qp | LL | PI | %M | |
| - | - | | | | | | | | | | TOPSOIL (4 INCHES) |
| 2.5 | -2.5 | | | | | | | | | | Shotrock / Clay - brown; slightly moist; (FILL) |
| 5.0 | -5.0 | | | | | | | | | | AUGER REFUSAL AT 4.7 FEET BEGIN CORING |
| 7.5 | -7.5 | | | | | | | | | | Limestone - gray and light gray; hard; fine grained; horizontal bedding |
| | | | | | | | | | | | Run #1 (4.7-9.7) Rec=58.3% RQD=33.3% |
| 10.0 | -10.0 | | | | | | | | | | |
| 12.5 | -12.5 | | | | | | | | | | Run #2 (9.7-14.7) Rec=80.8% RQD=45% |
| 15.0 | -15.0 | | | | | | | | | | CORING TERMINATED AT 14.7 FEET |
| 17.5 | -17.5 | | | | | | | | | | |
| 20.0 | -20.0 | | | | | | | | | | |

REMARKS: _____