**COMMONWEALTH OF KENTUCKY**
**BEFORE THE PUBLIC SERVICE COMMISSION**



In the Matter of:

| | |
|---|---|
| APPLICATION OF NEW CINGULAR WIRELESS PCS, LLC | ) |
| FOR ISSUANCE OF A CERTIFICATE OF PUBLIC | ) |
| CONVENIENCE AND NECESSITY TO CONSTRUCT | ) |
| A WIRELESS COMMUNICATIONS FACILITY AT | )CASE: **2008-00388** |
| 6600 INDIAN MOUND DRIVE, MT. STERLING, | ) |
| MONTGOMERY COUNTY, KENTUCKY, 40353 | ) |

SITE NAME: EDWINGTON (252G0173)

**********

**Supplemental Documentation**

Please find attached hereto the Geotechnical Investigation Report prepared by Terracon Consultants, Inc., of Nashville, Tennessee dated December 19, 2008. The geotech report was previously unavailable at the time of filing.

Please file with the Commission at your earliest convenience.

Sincerely,

Todd R. Briggs
Briggs Law Office, PSC
17300 Polo Fields Lane
Louisville, KY 40245
(502) 254-9756
Counsel for New Cingular Wireless PCS, LLC

# GEOTECHNICAL ENGINEERING REPORT

## PROPOSED EDWINGTON TOWER
## INDIAN MOUND ROAD
## MOUNT STERLING, KENTUCKY

**TERRACON PROJECT NO.: 57087327**
**December 19, 2008**

*Prepared For:*

**NSORO, LLC**
**Louisville, Kentucky**

*Prepared by:*

Terracon

**Louisville, Kentucky**

December 19, 2008

Terracon
Consulting Engineers & Scientists

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Nashville. Tennessee 37211
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Nsoro, LLC
10830 Penion Drive
Louisville, Kentucky 40299

Attention: Gregory Taylor

**Re: Geotechnical Engineering Report**
**Proposed Edwington Tower**
**Indian Mound Road**
**Mount Sterling, Kentucky**
**Terracon Project No. 57087327**

Dear Mr. Taylor:

The results of our subsurface exploration are attached. The purpose of this exploration was to obtain information on subsurface conditions at the proposed project site and, based on this information, to provide recommendations regarding the design and construction of foundations for the proposed tower.

Terracon's geotechnical design parameters and recommendations within this report apply to the existing planned tower height and would apply to adjustments in the tower height, up to a 20% increase or decrease in height, as long as the type of tower does not change. If changes in the tower height dictate a change in tower type (i.e. - monopole to a self-support, self-support to a guyed tower), Terracon should be contacted to evaluate our recommendations with respect to these changes.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service to you in any way, please feel free to contact us.

Sincerely,
Terracon

Shaikh Z. Rahman, EIT.
Project Engineer

Timothy G. LaGrow, P.E.
Kentucky No. 17758

STATE OF KENTUCKY
TIMOTHY G. LaGROW
17758
REGISTERED PROFESSIONAL ENGINEER

n:\Projects\2008\57087327\G57087357.doc

Attachments: Geotechnical Engineering Report

*Copies Roy Johnson, Medley's Project Management, 3605 Mattingly Road, Buckner, Kentucky 40010 (4 hard copies, 1 pdf)*

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GEOTECHNICAL ENGINEERING REPORT

**PROPOSED EDWINGTON TOWER**
**INDIAN MOUND ROAD**
**MOUNT STERLING, KENTUCKY**
**TERRACON PROJECT NO.: 57087327**
**December 19, 2008**

## 1.0 INTRODUCTION

The purpose of this report is to describe the subsurface conditions encountered in the boring, analyze and evaluate the test data, and provide recommendations regarding the design and construction of foundations and earthwork for the proposed tower. One boring extending to a depth of about 22 ½ feet below the existing ground surface was drilled at the site. An individual boring log and a boring location plan are included with this report.

## 2.0 PROJECT DESCRIPTION

Terracon understands the proposed project will consist of the construction of a 200 to 260-foot self supporting tower. A median height of 240 feet was used in this report. Exact tower loads are not available, but based on our past experience are anticipated to be as follows:

| | |
|---|---|
| Vertical Load: | 600 kips |
| Horizontal Shear: | 80 kips |
| Uplift: | 500 kips |

A small, lightly loaded equipment building will also be constructed. Wall and floor loads for this building are not anticipated to exceed 1 kip per linear foot and 100 pounds per square foot, respectively. At the time of the site visit, the property was a gently sloping, wooded tract. Site clearing was required for the drill rig access. Existing grades within the 100-foot by 100-foot leased area were not available as of this writing. According to the site candidate information package (SCIP), the tower will be built at El. 961. Based on observed topography, minimal grading operations are anticipated.

## 3.0 EXPLORATION PROCEDURES

### 3.1 Field Exploration

The subsurface exploration consisted of drilling and sampling one (1) boring at the site to a depth of about 22 ½ feet below existing grade. The boring was advanced at the center of the site, staked by the project surveyor. Ground surface elevation at the boring location was obtained from the SCIP provided by the client. The location and elevation of the boring should be considered accurate only to the degree implied by the means and methods used to define them.

The boring was drilled with an ATV-mounted rotary drill rig using hollow stem augers to advance the borehole. Representative soil samples were obtained by the split-barrel sampling procedure in general accordance with the appropriate ASTM standard. In the split-barrel sampling procedure, the number of blows required to advance a standard 2-inch O.D. split-barrel sampler the last 12 inches of the typical total 18-inch penetration by means of a 140-pound hammer with a free fall of 30 inches, is the standard penetration resistance (SPT) value (N-Value). This value is used to estimate the in-situ relative density of cohesionless soils and the consistency of cohesive soils. The sampling depths, penetration distance, and SPT N-Values are shown on the boring log. The samples were sealed and delivered to the laboratory for testing and classification.

Auger refusal was encountered at a depth of about 7½ feet below the existing ground surface. The boring was extended into the refusal materials using a diamond bit attached to the outer barrel of a double core barrel. The inner barrel collected the cored material as the outer barrel was rotated at high speeds to cut the rock. The barrel was retrieved to the surface upon completion of each drill run. Once the core samples were retrieved, they were placed in a box and logged. The rock was later classified by an engineer and the "percent recovery" and rock quality designation (RQD) were determined.

The "percent recovery" is the ratio of the sample length retrieved to the drilled length, expressed as a percent. An indication of the actual in-situ rock quality is provided by calculating the sample's RQD. The RQD is the percentage of the length of broken cores retrieved which have core segments at least 4 inches in length compared to each drilled length. The RQD is related to rock soundness and quality as illustrated below:

**Table 1 – Rock Quality Designation (RQD)**

| Relation of RQD and In-situ Rock Quality | |
|---|---|
| RQD (%) | Rock Quality |
| 90 - 100 | Excellent |
| 75 - 90 | Good |
| 50 - 75 | Fair |
| 25 - 50 | Poor |
| 0 -25 | Very Poor |

A field log of the boring was prepared by a subcontract driller. This log included visual classifications of the materials encountered during drilling as well as the driller's interpretation of the subsurface conditions between samples. The final boring log included with this report represents an interpretation of the driller's field log and a visual classification of the soil samples made by the Geotechnical Engineer.

### 3.2 Laboratory Testing

The samples were classified in the laboratory based on visual observation, texture and plasticity. The descriptions of the soils indicated on the boring log are in accordance with the enclosed General Notes and the Unified Soil Classification System. Estimated group symbols according to the Unified Soil Classification System are given on the boring log. A brief description of this classification system is attached to this report.

The laboratory testing program consisted of performing water content tests on representative soil samples. Information from these tests was used in conjunction with field penetration test data to evaluate soil strength in-situ, volume change potential, and soil classification. Results of these tests are provided on the boring log.

A representative sample of rock core was tested for unconfined compressive strength and density. Results of these tests are also provided on the boring log at the appropriate horizon.

Classification and descriptions of rock core samples are in accordance with the enclosed General Notes, and are based on visual and tactile observations. Petrographic analysis of thin sections may indicate other rock types. Percent recovery and rock quality designation (RQD) were calculated for these samples and are noted at their depths of occurrence on the boring log.

## 4.0 EXPLORATORY FINDINGS

### 4.1 Subsurface Conditions

Conditions encountered at the boring location are indicated on the boring log. Stratification boundaries on the boring log represent the approximate location of changes in soil types and the transition between materials may be gradual. Water levels shown on the boring log represent the conditions only at the time of our exploration. Based on the results of the boring, subsurface conditions on the project site can be generalized as follows.

Beneath about 10 inches of topsoil, the boring encountered silty clay (CL-ML) and lean clay (CL) extending to auger refusal at about 7 ½ feet below grade. Weathered limestone fragments were encountered at the soil/bedrock interface. The clays exhibited a very stiff to hard consistency based on standard penetration test values in the range of about 13 to over 50 blows per foot (bpf). The presence of weathered limestone fragments within the soil matrix most likely inflated the higher blow count.

Rock coring techniques were employed to sample the refusal materials. The core sample consists of moderately weathered, moderately hard, very thin to thin bedded limestone with a few weathered seams. Core recovery was 100 percent. Bedrock quality to a depth of about 17 ½ feet below grade is considered poor as defined by an RQD value of 29 percent.

Good quality rock was encountered below 17 ½ feet as defined by an RQD value of 84 percent. Coring operations were terminated at a depth of approximately 22½ feet below existing grade.

### 4.2 Site Geology

A review of the Geologic Quadrangle Map, Mount Sterling Quadrangle, Kentucky (1976), published by the United States Geological Survey (USGS) indicates that the site is underlain by the Grant Lake member of the Ashlock Formation. This member consists of limestone (80%) and mudstone. The limestone is greenish to brownish gray and fine grained. The mudstone is greenish gray with interbedded limestone. Thickness of the Grant Lake limestone varies from 65 to 95 feet.

### 4.3 Groundwater Conditions

No groundwater was encountered during the auger drilling portion of the borehole. Water was used to advance the borehole during rock coring operations. The introduction of water into the borehole precluded obtaining accurate groundwater level readings at the time of drilling operations. Long term observation of the groundwater level in monitoring wells, sealed from the influence of surface water, would be required to obtain accurate groundwater levels on the site.

It should be recognized that fluctuations of the groundwater table may occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the boring was performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring log. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

## 5.0 ENGINEERING RECOMMENDATIONS

Based on the encountered subsurface conditions, the tower can be constructed on drilled piers or on a mat foundation. The lightly loaded equipment building can be supported on shallow spread footings. Drilled pier and shallow foundation recommendations are presented in the following paragraphs.

## 5.1 Tower Foundation

**Drilled Pier Alternative:** Based on the results of the boring, the following tower foundation design parameters have been developed:

**Table 2 - Drilled Pier Foundation Design Parameters**

| Depth * (feet) | Description ** | Allowable Skin Friction (psf) | Allowable End Bearing Pressure (psf) | Allowable Passive Pressure (psf) | Internal Angle of Friction (Degree) | Cohesion (psf) | Lateral Subgrade Modulus (pci) | Strain, &50 (in/in) |
|---|---|---|---|---|---|---|---|---|
| 0 – 3 | Topsoil and Silty Clay | Ignore | Ignore | Ignore | - | - | Ignore | Ignore |
| 3 – 7½ | Lean Clay | 425 | 3,000 | 1,500 | 0 | 1,500 | 125 | 0.007 |
| 7½ - 22½ | Limestone *** | 3,500 | 20,000 | 7,000 | 0 | 70,000 | 3,000 | 0.00001 |

* Pier inspection is recommended to adjust pier length if variable soil/rock conditions are encountered.
** A total unit weight of 120 and 160 pcf can be estimated for the lean clay and limestone, respectively.
*** The pier should be embedded a minimum of 3 feet into limestone to mobilize these higher rock strength parameters. Furthermore, it is assumed the rock socket will be extended using coring techniques rather than blasting/shooting.

The above indicated cohesion, friction angle, lateral subgrade modulus and strain values have no factors of safety, and the allowable skin friction and the passive resistances have factors of safety of 2. The cohesion, internal friction angle, lateral subgrade modulus and strain values given in the above table are based on the boring, published correlation values and Terracon's past experience with similar soil/rock types. These values should, therefore, be considered approximate. To mobilize the higher rock strength parameters, the pier should be socketed at least 3 feet into bedrock. Furthermore, it is assumed that the rock socket is developed using coring rather than blasting techniques. The allowable end bearing pressure provided in the table has an approximate factor of safety of at least 3. Total settlement of drilled piers designed using the above parameters is not anticipated to exceed ½ inch.

The upper 3 feet of topsoil and lean clay should be ignored due to the potential affects of frost action and construction disturbance. To avoid a reduction in uplift and lateral resistance caused by variable bedrock depths and bedrock quality, it is recommended that a minimum pier length and minimum rock socket length be stated on the design drawings. Bedrock was encountered in our boring below a depth of about 7 ½ feet, but could vary between tower legs, or if the tower is moved from the location of our boring. Considering the site geology, variable rock depths should be anticipated if the tower location is moved from the location of the boring. If the tower center is moved from the planned location, Terracon should be notified to review the recommendations and determine whether an additional boring is required. To facilitate pier length adjustments that may be necessary because of variable rock conditions, it is recommended that a Terracon representative observe the drilled pier excavation.

A drilled pier foundation should be designed with a minimum shaft diameter of 30 inches to facilitate clean out and possible dewatering of the pier excavation. Temporary casing may be required during the pier excavation in order to control possible groundwater seepage and support the sides of the excavation in weak soil zones. Care should be taken so that the sides and bottom of the excavations are not disturbed during construction. The bottom of the shaft should be free of loose soil or debris prior to reinforcing steel and concrete placement.

A concrete slump of at least 6 inches is recommended to facilitate temporary casing removal. It should be possible to remove the casing from a pier excavation during concrete placement provided that the concrete inside the casing is maintained at a sufficient level to resist any earth and hydrostatic pressures outside the casing during the entire casing removal procedure.

**Mat Foundation Alternative**: The mat foundation can be designed using the following natural soil/engineered fill parameters. These parameters are based on the findings of the boring, a review of published correlation values and Terracons experience with similar soil conditions. These design parameters also assume that the base of the mat foundation will rest on natural soils or well-graded crushed stone that is compacted and tested on a full time basis.

**Table 3 - Mat Foundation Design Parameters**

| Depth (feet) | Description | Allowable Contact Bearing Pressure (psf) | Allowable Passive Pressure (psf) | Coefficient of Friction, Tan δ | Vertical Modulus of Subgrade Reaction (pci) |
|---|---|---|---|---|---|
| 0 - 2 | Topsoil and Silty Clay | Ignore | Ignore | - | |
| ≥ 2 | Silty and Lean Clay or Crushed Stone Fill | 3,000 | Ignore | 0.35 | 125 |

To assure that soft soils are not left under the mat foundation, it is recommended that a geotechnical engineer observe the foundation subgrade prior to concrete placement. Provided the above recommendations are followed, total mat foundation settlements are not anticipated to exceed about 1 inch. Differential settlement should not exceed 50 percent of the total settlement.

## 5.2 Equipment Building Foundations

The proposed equipment shed may be supported on shallow footings bearing on stiff natural soils. The equipment building foundations should be dimensioned using a net allowable soil bearing pressure of 2,000 pounds per square foot (psf). In using net allowable soil pressures for footing dimensioning, the weight of the footings and backfill over the footings need not be considered. Furthermore, the footings should be at least 12 inches wide and a minimum of 2.0 feet square.

The geotechnical engineer or a qualified representative should observe the foundation excavations to verify that the bearing materials are suitable for support of the proposed loads. If, at the time of such observation, any soft soils are encountered at the design foundation elevation, the excavations should be extended downward so that the footings rest on stiff soils. If it is inconvenient to lower the footings, the proposed footing elevations may be re-established by backfilling after the undesirable material has been removed.

The recommended soil bearing value should be considered an upper limit, and any value less than that listed above would be acceptable for the foundation system. Using the value given, total settlement would be about 1 inch or less with differential settlements being less than 75 percent of total settlement. Footings should be placed at a depth of 2.0 feet, or greater, below finished exterior grade for protection against frost damage.

### 5.3 Parking and Drive Areas

The drive that accesses the site will be surfaced with crushed stone. Parking and drive areas that are surfaced with crushed stone should have a minimum thickness of 6 inches and be properly placed and compacted as outlined herein. The crushed stone should meet Kentucky Transportation Cabinet specifications and applicable local codes.

A paved section consisting only of crushed graded aggregate base course should be considered a high maintenance section. Regular care and maintenance is considered essential to the longevity and use of the section. Site grades should be maintained in such a manner as to allow for adequate surface runoff. Any potholes, depressions or excessive rutting that may develop should be repaired as soon as possible to reduce the possibility of degrading the soil subgrade.

### 5.4 Site Preparation

Site preparation should begin with the removal of trees with roots, vegetation, topsoil and any loose, soft or otherwise unsuitable materials from the construction area. The geotechnical engineer should evaluate the actual stripping depth, along with any soft soils that require undercutting at the time of construction.

Any fill and backfill placed on the site should consist of approved materials that are free of organic matter and debris. Suitable fill materials should consist of well graded crushed stone below the tower foundation and well graded crushed stone or low plasticity cohesive soil elsewhere. Low-plasticity cohesive soil should have a liquid limit of less than 45 percent and a plasticity index of less than 25 percent. The on-site soils are considered suitable for re-use as fill. However, because of the high silt content, stringent moisture control will need to be exercised to attain the desired compaction. It is recommended that during construction these soils should be further tested and evaluated prior to use as fill. Fill should not contain frozen material and it should not be placed on a frozen subgrade.

The fill should be placed and compacted in lifts of 9 inches or less in loose thickness. Fill placed below structures or used to provide lateral resistance should be compacted to at least

98 percent of the material's maximum standard Proctor dry density (ASTM D-698). Fill should be placed, compacted, and maintained at moisture contents within minus 1 to plus 3 percent of the optimum value determined by the standard Proctor test.

The geotechnical engineer should be retained to monitor fill placement on the project and to perform field density tests as each lift of fill is placed in order to evaluate compliance with the design requirements. Standard Proctor and Atterberg limits tests should be performed on the representative samples of fill materials before their use on the site.

## 6.0 GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide testing and observation during excavation, grading, foundation and construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the boring performed at the indicated location and from other information discussed in this report. This report does not reflect variations that may occur across the site, or due to the modifying effects of weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

# APPENDIX

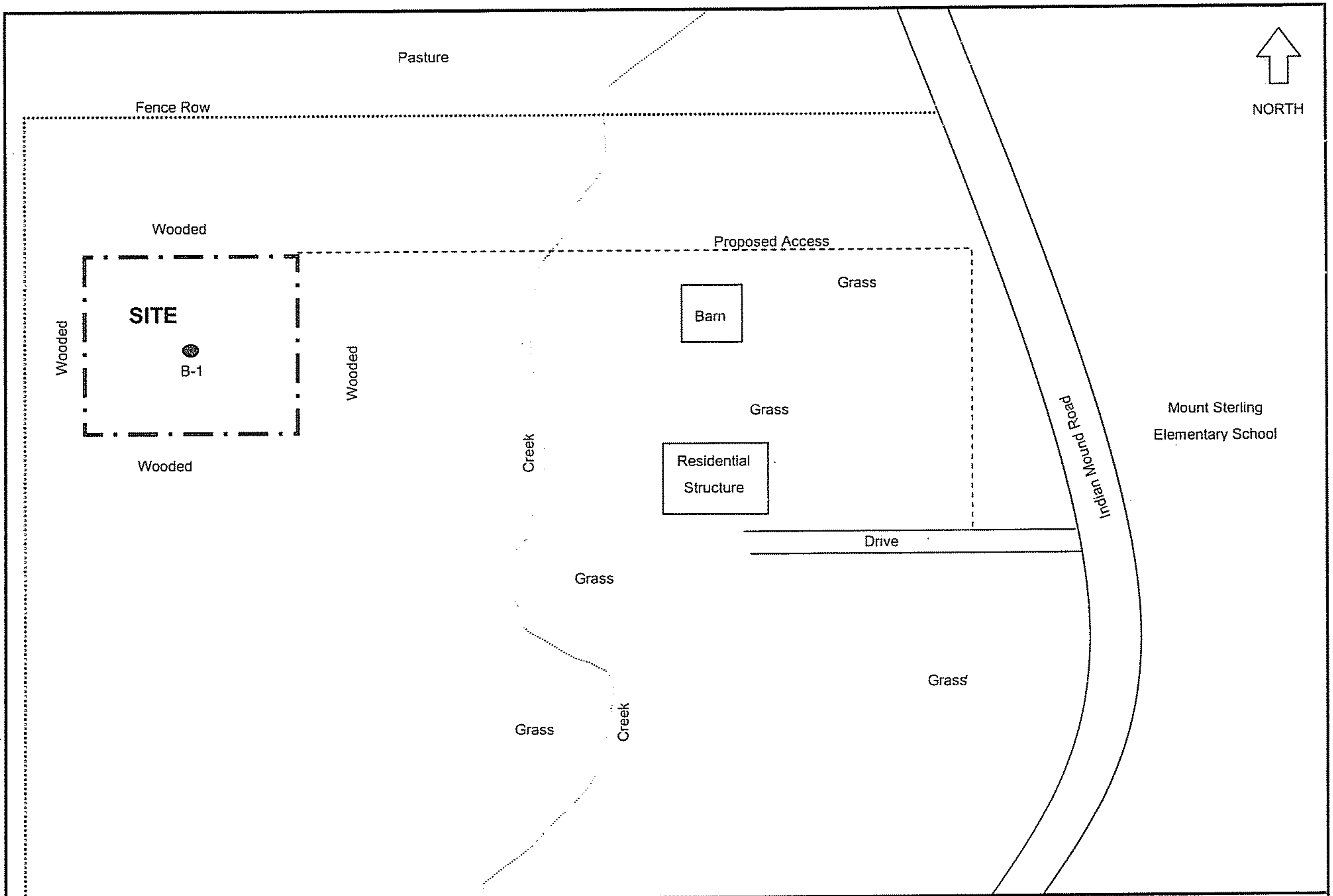


**Figure 1**

**BORING LOCATION DIAGRAM**

**SCALE: NTS**

Terracon

**nsoro, LLC**
**Edwington Site**
**Mount Sterling, Kentucky**
**PROJECT NO. 57087327**

# LOG OF BORING NO. B-1

CLIENT: Nsoro, LLC

SITE: Mt. Sterling, Kentucky

PROJECT: Edwington Tower - 240' SST

Approx. Surface Elev.: 961 ft

| Graphic depth | DESCRIPTION | Elev. | DEPTH, ft. | USCS SYMBOL | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: RECOVERY, in. | SAMPLES: SPT - N * BLOWS / ft. | TESTS: WATER CONTENT, % | TESTS: DRY UNIT WT pcf | TESTS: UNCONFINED STRENGTH, psf |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.8 | **Topsoil-10",** | 960 | | | | | | | | | |
| | **SILTY CLAY,** dark brown, very stiff, moist | | | CL ML | 1 | SS | | 16 | 27 | | |
| 3 | | 958 | | | | | | | | | |
| | **LEAN CLAY,** brown, very stiff to hard, slightly moist to moist | | | CL | 2 | SS | | 13 | 20 | | |
| | -with weathered limestone fragments below 6' | | | CL | 3 | SS | | 50/5" | 17 | | |
| 7.5 | | 953.5 | | | | | | | | | |
| | **AUGER REFUSAL AT 7.5'** **LIMESTONE,** with highly weathered 1/4 to 1" thick mudstone seams, moderately weathered, moderately hard, very thin to thin bedded, gray | | | | R-1 | DB | 100% | RQD 29% | | 165 | 11,160 psi |
| | | | | | R-2 | DB | 100% | RQD 84% | | | |
| 22.5 | | 938.5 | | | | | | | | | |
| | **CORING TERMINATED AT 22.5'** | | | | | | | | | | |

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Safety Hammer

| WATER LEVEL OBSERVATIONS, ft | | | |
|---|---|---|---|
| WL | ▽ Dry | WD | ▼ |
| WL | ▼ | | ▼ |
| WL | | | |

Terracon

| | | | |
|---|---|---|---|
| BORING STARTED | | | 12-15-08 |
| BORING COMPLETED | | | 12-15-08 |
| RIG | CME 55 | FOREMAN | Wells |
| LOGGED | SZR | JOB # | 57087327 |

# GENERAL NOTES

**DRILLING & SAMPLING SYMBOLS:**

| | | | |
|---|---|---|---|
| SS: | Split Spoon - 1-$^{3}$/8" I.D., 2" O.D., unless otherwise noted | HS: | Hollow Stem Auger |
| ST: | Thin-Walled Tube - 2" O.D., unless otherwise noted | PA: | Power Auger |
| RS: | Ring Sampler - 2.42" I.D., 3" O.D., unless otherwise noted | HA: | Hand Auger |
| DB: | Diamond Bit Coring - 4", N, B | RB: | Rock Bit |
| BS: | Bulk Sample or Auger Sample | WB: | Wash Boring or Mud Rotary |

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value"

**WATER LEVEL MEASUREMENT SYMBOLS:**

| | | | | | |
|---|---|---|---|---|---|
| WL: | Water Level | WS: | While Sampling | N/E: | Not Encountered |
| WCI: | Wet Cave in | WD: | While Drilling | | |
| DCI: | Dry Cave in | BCR: | Before Casing Removal | | |
| AB: | After Boring | ACR: | After Casing Removal | | |

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels may not be possible with only short-term observations.

**DESCRIPTIVE SOIL CLASSIFICATION:** Soil classification is based on the Unified Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

**CONSISTENCY OF FINE-GRAINED SOILS**

| Unconfined Compressive Strength, Qu, psf | Standard Penetration or N-value (SS) Blows/Ft. | Consistency |
|---|---|---|
| < 500 | <2 | Very Soft |
| 500 – 1,000 | 2-3 | Soft |
| 1,001 – 2,000 | 4-7 | Medium Stiff |
| 2,001 – 4,000 | 8-15 | Stiff |
| 4,001 – 8,000 | 16-30 | Very Stiff |
| 8,000+ | 30+ | Hard |

**RELATIVE DENSITY OF COARSE-GRAINED SOILS**

| Standard Penetration or N-value (SS) Blows/Ft. | Relative Density |
|---|---|
| 0 – 3 | Very Loose |
| 4 – 9 | Loose |
| 10 – 29 | Medium Dense |
| 30 – 49 | Dense |
| 50+ | Very Dense |

**RELATIVE PROPORTIONS OF SAND AND GRAVEL**

| Descriptive Term(s) of other constituents | Percent of Dry Weight |
|---|---|
| Trace | < 15 |
| With | 15 – 29 |
| Modifier | > 30 |

**RELATIVE PROPORTIONS OF FINES**

| Descriptive Term(s) of other constituents | Percent of Dry Weight |
|---|---|
| Trace | < 5 |
| With | 5 – 12 |
| Modifiers | > 12 |

**GRAIN SIZE TERMINOLOGY**

| Major Component of Sample | Particle Size |
|---|---|
| Boulders | Over 12 in. (300mm) |
| Cobbles | 12 in. to 3 in. (300mm to 75 mm) |
| Gravel | 3 in. to #4 sieve (75mm to 4.75 mm) |
| Sand | #4 to #200 sieve (4.75mm to 0.075mm) |
| Silt or Clay | Passing #200 Sieve (0.075mm) |

**PLASTICITY DESCRIPTION**

| Term | Plasticity Index |
|---|---|
| Non-plastic | 0 |
| Low | 1-10 |
| Medium | 11-30 |
| High | 30+ |

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# GENERAL NOTES

## Sedimentary Rock Classification

### DESCRIPTIVE ROCK CLASSIFICATION:

Sedimentary rocks are composed of cemented clay, silt and sand sized particles The most common minerals are clay, quartz and calcite Rock composed primarily of calcite is called limestone; rock of sand size grains is called sandstone, and rock of clay and silt size grains is called mudstone or claystone, siltstone, or shale. Modifiers such as shaly, sandy, dolomitic, calcareous, carbonaceous, etc. are used to describe various constituents. Examples: sandy shale; calcareous sandstone.

| | |
|---|---|
| LIMESTONE | Light to dark colored, crystalline to fine-grained texture, composed of $CaCo_3$, reacts readily with HCl. |
| DOLOMITE | Light to dark colored, crystalline to fine-grained texture, composed of $CaMg(CO_3)_2$, harder than limestone, reacts with HCl when powdered. |
| CHERT | Light to dark colored, very fine-grained texture, composed of micro-crystalline quartz ($SiO_2$), brittle, breaks into angular fragments, will scratch glass. |
| SHALE | Very fine-grained texture, composed of consolidated silt or clay, bedded in thin layers. The unlaminated equivalent is frequently referred to as siltstone, claystone or mudstone. |
| SANDSTONE | Usually light colored, coarse to fine texture, composed of cemented sand size grains of quartz, feldspar, etc. Cement usually is silica but may be such minerals as calcite, iron-oxide, or some other carbonate. |
| CONGLOMERATE | Rounded rock fragments of variable mineralogy varying in size from near sand to boulder size but usually pebble to cobble size (½ inch to 6 inches). Cemented together with various cementing agents. Breccia is similar but composed of angular, fractured rock particles cemented together. |

### PHYSICAL PROPERTIES:

#### DEGREE OF WEATHERING

| | |
|---|---|
| Slight | Slight decomposition of parent material on joints. May be color change. |
| Moderate | Some decomposition and color change throughout. |
| High | Rock highly decomposed, may be extremely broken. |

#### HARDNESS AND DEGREE OF CEMENTATION

**Limestone and Dolomite:**

| | |
|---|---|
| Hard | Difficult to scratch with knife. |
| Moderately Hard | Can be scratched easily with knife, cannot be scratched with fingernail. |
| Soft | Can be scratched with fingernail |

**Shale, Siltstone and Claystone**

| | |
|---|---|
| Hard | Can be scratched easily with knife, cannot be scratched with fingernail. |
| Moderately Hard | Can be scratched with fingernail. |
| Soft | Can be easily dented but not molded with fingers. |

**Sandstone and Conglomerate**

| | |
|---|---|
| Well Cemented | Capable of scratching a knife blade |
| Cemented | Can be scratched with knife. |
| Poorly Cemented | Can be broken apart easily with fingers |

#### BEDDING AND JOINT CHARACTERISTICS

| Bed Thickness | Joint Spacing | Dimensions |
|---|---|---|
| Very Thick | Very Wide | >10′ |
| Thick | Wide | 3′ - 10′ |
| Medium | Moderately Close | 1′ - 3′ |
| Thin | Close | 2″ - 1′ |
| Very Thin | Very Close | .4″ - 2″ |
| Laminated | — | .1″ - .4″ |

| | |
|---|---|
| Bedding Plane | A plane dividing sedimentary rocks of the same or different lithology. |
| Joint | Fracture in rock, generally more or less vertical or transverse to bedding, along which no appreciable movement has occurred |
| Seam | Generally applies to bedding plane with an unspecified degree of weathering. |

#### SOLUTION AND VOID CONDITIONS

| | |
|---|---|
| Solid | Contains no voids. |
| Vuggy (Pitted) | Rock having small solution pits or cavities up to ½ inch diameter, frequently with a mineral lining. |
| Porous | Containing numerous voids, pores, or other openings, which may or may not interconnect. |
| Cavernous | Containing cavities or caverns, sometimes quite large. |

Terracon

# UNIFIED SOIL CLASSIFICATION SYSTEM

| Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A] | | | | Soil Classification: Group Symbol | Group Name[B] |
|---|---|---|---|---|---|
| Coarse Grained Soils More than 50% retained on No. 200 sieve | Gravels More than 50% of coarse fraction retained on No. 4 sieve | Clean Gravels Less than 5% fines[C] | Cu ≥ 4 and 1 ≤ Cc ≤ 3[E] | GW | Well-graded gravel[F] |
| | | | Cu < 4 and/or 1 > Cc > 3[E] | GP | Poorly graded gravel[F] |
| | | Gravels with Fines More than 12% fines[C] | Fines classify as ML or MH | GM | Silty gravel[F,G,H] |
| | | | Fines classify as CL or CH | GC | Clayey gravel[F,G,H] |
| | Sands 50% or more of coarse fraction passes No. 4 sieve | Clean Sands Less than 5% fines[D] | Cu ≥ 6 and 1 ≤ Cc ≤ 3[E] | SW | Well-graded sand[I] |
| | | | Cu < 6 and/or 1 > Cc > 3[E] | SP | Poorly graded sand[I] |
| | | Sands with Fines More than 12% fines[D] | Fines classify as ML or MH | SM | Silty sand[G,H,I] |
| | | | Fines Classify as CL or CH | SC | Clayey sand[G,H,I] |
| Fine-Grained Soils 50% or more passes the No. 200 sieve | Silts and Clays Liquid limit less than 50 | inorganic | PI > 7 and plots on or above "A" line[J] | CL | Lean clay[K,L,M] |
| | | | PI < 4 or plots below "A" line[J] | ML | Silt[K,L,M] |
| | | organic | Liquid limit - oven dried / Liquid limit - not dried < 0.75 | OL | Organic clay[K,L,M,N] |
| | | | | | Organic silt[K,L,M,O] |
| | Silts and Clays Liquid limit 50 or more | inorganic | PI plots on or above "A" line | CH | Fat clay[K,L,M] |
| | | | PI plots below "A" line | MH | Elastic Silt[K,L,M] |
| | | organic | Liquid limit - oven dried / Liquid limit - not dried < 0.75 | OH | Organic clay[K,L,M,P] |
| | | | | | Organic silt[K,L,M,Q] |
| Highly organic soils | Primarily organic matter, dark in color, and organic odor | | | PT | Peat |

[A]Based on the material passing the 3-in. (75-mm) sieve

[B]If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C]Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D]Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E]$Cu = D_{60}/D_{10}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F]If soil contains ≥ 15% sand, add "with sand" to group name.

[G]If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H]If fines are organic, add "with organic fines" to group name.

[I]If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J]If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K]If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L]If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

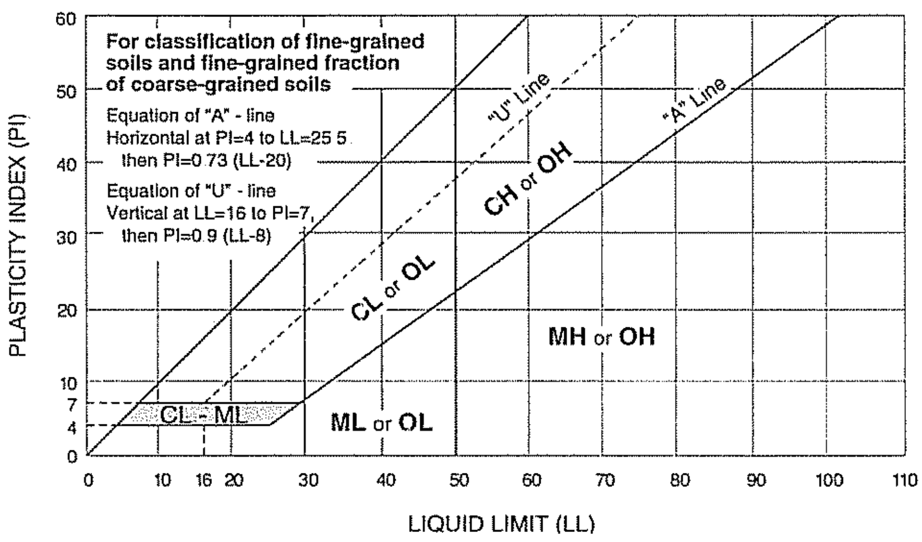
[M]If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N]PI ≥ 4 and plots on or above "A" line.

[O]PI < 4 or plots below "A" line.

[P]PI plots on or above "A" line.

[Q]PI plots below "A" line.

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