GEOTECHNICAL ENGINEERING REPORT
FOR
COLUMBIA/BOONE COUNTY
JOINT COMMUNICATIONS

911 MONOPLE RADIO TOWER
COLUMBIA, MISSOURI

JULY 20, 2015

Crockett GTL Project Number: G15046

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GEOTECHNICAL - TESTING LAB
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Columbia, Missouri 65202
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July 20, 2015

Joint Communications Radio Network
609 E Walnut Street
Columbia, MO 65201

Attn: Mr. Dave Dunford

Re: Geotechnical Engineering Report
911 Monopole Radio Tower
Columbia, Missouri
Crockett GTL Project Number: G15046

Dear Mr. Dunford:

Crockett Geotechnical - Testing Lab (Crockett GTL) has completed the geotechnical engineering services for the referenced project. This report should be read in its entirety. This report presents the results of our field explorations, laboratory testing, and recommendations for design and construction of the referenced project.

We appreciate the opportunity to be of service and look forward to working with you during the construction phase of this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,

Shane Steinman, E.I.
Project Manager

Eric H. Lidholm, P.E.
Principal Engineer
Missouri: E-23265

STATE OF MISSOURI
ERIC H. LIDHOLM
NUMBER
PE-23265
PROFESSIONAL ENGINEER

Enclosures
cc: 1 – Client (.PDF)
1 – File

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Geotechnical Engineering Report
911 Monopole Radio Tower
Columbia, Missouri
Crockett GTL Project Number: G15046
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1 INTRODUCTION

Crockett Geotechnical - Testing Lab (CGTL) has conducted a geotechnical exploration for the proposed development. The purpose of our exploration was to:

- characterize and evaluate the subsurface conditions,
- provide design and construction recommendations for:
    - earthwork
    - foundations
    - seismic considerations

2 SITE AND PROJECT INFORMATION

2.1 SITE LOCATION AND DESCRIPTION

Item	Description
Location	This site is located near the southeastern corner of the Elliot Battle Elementary School property located at 2600 Battle Avenue in the city of Columbia, Missouri.
Approximate GPS Coordinates	Latitude: 38.974681° Longitude: -92.221980°
Existing improvements	This tower site is undeveloped.
Current ground cover	Recently graded. Mostly bare soil and some weeds.
Existing topography	Relatively level.

2.2 PROJECT DESCRIPTION

Item	Description
Proposed structures	Monopole Tower, 180 feet tall Possible equipment building

Item	Description
Estimated loads (assumed)	Vertical: 40 kips Shear: 30 kips Moment: 3,600 k-ft Uplift: N/A
Grading (approximate)	For this proposal we have assumed site grading to consist of less than approximately 5 feet of cut and fill.
Cut and fill slopes	Final slopes are assumed to be no steeper than 3H:1V (Horizontal to Vertical)
Free-standing retaining walls	None.
Below grade areas	None.

3 SUBSURFACE CONDITIONS

3.1 FIELD EXPLORATION AND LABORATORY TESTING

One (1) boring was drilled for this project at the approximate location indicated on the Boring Location Plan included in the Appendix of this report. The boring location was designated and staked by Boone County. The ground surface elevation indicated on the boring log is approximate and was obtained from Boone County Parcel Viewer using the terrain feature. The boring elevation was rounded to the nearest foot. 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 a track mounted CME-45 drill rig. Representative samples were obtained using thin-walled tube sampling procedures. The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification. Information provided on the boring log attached to this report includes soil descriptions, consistency evaluations, boring depth, sampling intervals, and groundwater conditions. The boring was backfilled with auger cuttings prior to the drill crew leaving the site.

The field log was prepared by the drill crew. The final boring log included with this report represents the engineer's interpretation of the field log and includes modifications based upon laboratory tests and observation made of the samples. The descriptions of the soil on the final boring log is in general accordance with the Unified Soil Classification System which is included in the Appendix of this report.

Detailed information regarding the material encountered and the results of field sampling and laboratory testing are shown on the Boring Log included in the Appendix of this report.

3.2 ENCOUNTERED SUBSURFACE CONDITIONS

Lean to fat clay was encountered from the ground surface to a depth of approximately 7 feet at the boring location. The lean to fat clay was stiff to very stiff in consistency. Underlying the lean to fat clay was fat clay which extended to a depth of approximately 10 feet.

Underlying the lean to fat clay and fat clay was lean to fat clay that was visually identified as glacial drift. The glacial drift was very stiff to hard in consistency and extended to boring termination depth of 50 feet.

Detailed descriptions of the encountered materials are listed on the boring log included in the Appendix of this report. Strata lines indicate the approximate location of changes in material types. The transition between material types may be gradual.

3.3 GROUNDWATER

Groundwater was encountered at a depth of 28 feet while drilling, 32 feet at the completion of drilling, and at 30 feet ½ hour after the completion of drilling. Once groundwater was encountered, the water level remained fairly constant and rapidly filled between each sampling interval.

Pockets, lenses, and stringers of sand were encountered in the glacial soils found in the vicinity of the referenced project. These sand pockets are normally discontinuous and often contain water of variable quality and quantity. These sand pockets may be encountered during foundation excavation.

Groundwater levels depend on seasonal and climatic variations, and other factors not evident at the time the boring was performed, and may be present at different levels in the future. Therefore, groundwater levels during construction or at other times in the life of the structure may be at different levels than those indicated on the boring logs. In addition, without extended periods of observation in piezometers or observation wells, accurate groundwater level measurements may not be possible, particularly in low permeability soils.

The borehole was backfilled prior to departing the project site. Groundwater records are indicated on the boring log included in the Appendix of this report.

4 GEOTECHNICAL RECOMMEDATIONS

4.1 EARTHWORK

At the completion of stripping and grubbing, we recommend the exposed subgrade be thoroughly evaluated before the start of any fill operations. We recommend the geotechnical engineer be retained to evaluate the bearing material for the foundations and subgrade soils. Subsurface conditions, as identified by the field and laboratory testing programs have been reviewed and evaluated with respect to the proposed project plans known to us at this time.

4.1.1 Site Preparation

All existing utility backfill, and any otherwise unsuitable material should be removed from the construction areas prior to placing structural fill. After stripping and grubbing, the site should be proofrolled to aid in locating loose or soft areas. Proofrolling can be performed with a loaded tandem axle dump truck. Soft, wet, dry and low-density soil should be removed or be moisture conditioned and recompacted in place as structural fill prior to placing new structural fill.

Where fill is placed on existing slopes steeper than 5H:1V, benches should be cut into the existing slopes prior to fill placement. The benches should have a vertical face height of 1 to 3 feet and should be cut wide enough to accommodate the compaction equipment. We recommend structural fill slopes be overfilled and then cut back to develop an adequately compacted slope face.

4.1.2 Structural Fill Requirements

Compacted structural fill should consist of approved materials free of organic matter and debris. Frozen material should not be used and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted for evaluation prior to use.

Structural Fill Requirements		
Material Type	USCS Classification	Acceptable Uses
Lean Clay and Clayey Sand	CL & SC (LL<40)	All locations
Lean to Fat Clay	CL-CH (40<LL<50)	>24 inches below slabs on grade unless PI<23
Fat Clay	CH (LL≥50+)	>24 inches below slabs on grade
Well Graded Granular 1. MoDOT Type V or similar	GM	All locations

<table>
<tr><th colspan="3">Structural Fill Requirements</th></tr>
<tr><td rowspan="2">Low Volume Change Material [1, 2]</td><td>CL
CL-CH (40<LL<50 & PI<23)</td><td>All locations</td></tr>
<tr><td colspan="2">1. Similar to MoDOT Type 1 crushed limestone aggregate, limestone screenings, or granular material such as sand, gravel or crushed stone containing at least 18% low plasticity fines.
2. Low plasticity cohesive soil or granular soil having at least 18% low plasticity fines.</td></tr>
<tr><td>Soil Fill Lift Thickness</td><td colspan="2">9 inches or less when using heavy self-propelled compaction equipment
6-inches or less when using hand guided or light self-propelled equipment</td></tr>
<tr><td rowspan="2">Soil Compaction Requirements [1]</td><td colspan="2">95% of standard Proctor dry density (ASTM D-698)</td></tr>
<tr><td colspan="2">1. We recommend the engineered fill be tested for moisture content and compaction during placement. Should the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.</td></tr>
<tr><td>Compaction Moisture Content Requirements
• Cohesive
• Granular</td><td colspan="2">
From standard Proctor optimum moisture content (OMC) to 4% above the standard Proctor OMC.
Workable moisture content. Shall not pump when proofrolled</td></tr>
</table>

4.1.3 Grading and Drainage

Final surrounding grades should be sloped away from the structure on all sides to prevent ponding of water. Collected water should discharge at least 10 feet beyond the footprint of the tower support structure.

4.1.4 Earthwork Construction

In periods of dry weather, the surficial soils may be of sufficient strength to allow fill construction on the stripped and grubbed ground surface. However, unstable subgrade conditions could develop if the soils are wet or subjected to repetitive construction traffic. Should unstable subgrade conditions be encountered, stabilization measures will need to be employed.

Upon completion of filling and grading, care should be taken to maintain the subgrade moisture content prior to construction of floor slabs and pavements. Construction traffic over the completed subgrade should be avoided to the extent practical. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. If the subgrade should become frozen, desiccated, saturated, or disturbed, the affected material should be removed or these materials should be scarified, moisture conditioned, and recompacted prior to floor slab and pavement construction.

The geotechnical engineer should be retained during the construction phase of the project to observe earthwork/fill placement and to perform necessary tests and observations during subgrade preparation; proof-rolling; placement and compaction of controlled compacted fills; backfilling of excavations into the completed subgrade, and just prior to construction of building floor slabs.

4.1.5 Temporary Excavations

The Occupational Safety and Health Administration (OSHA) has developed regulations to provide for the safety of workers entering excavations. Temporary excavations will probably be required during grading operations. All operations should be performed under the supervision of qualified site personnel in accordance with OSHA Excavation and Trench Safety Standards.

4.2 Foundation Recommendations

The subsurface data obtained from the boring was analyzed to evaluate potential foundation design alternatives. It is our professional opinion the self-support tower can be supported by either a shallow, spread footing foundation system or by a drilled pier foundation system bearing within the native clay. The equipment building can be supported by a shallow foundation system bearing on stiff native clay or compacted structural fill. Design recommendations and construction considerations for shallow foundations follow:

4.2.1 Shallow Foundation Design Recommendations

Shallow Foundation Design Recommendations	
Net allowable bearing pressure [1] • From 0 to 3 Feet • From 3 to 13 Feet • Deeper than 13 Feet 1. Net allowable bearing pressure is based on a factor of safety of 3.0.	 Ignore 3,000 psf 5,500 psf
Allowable overstress for transient loads (i.e. snow, wind, seismic)	33%

Shallow Foundation Design Recommendations	
Ultimate passive pressure (equivalent fluid pressure) [1, 2, 3] 1. The sides of the spread footing foundation excavations must be nearly vertical and the concrete should be placed neat against the vertical faces for the passive earth pressure values to be valid. 2. Passive resistance in the frost zone should be neglected. 3. Some movement of the footing will be required to mobilize resistance from passive pressure and sliding friction.	270 pcf
Coefficient of sliding friction	0.32
Minimum embedment below finished grade for frost protection	30 inches
Approximate Settlement [1] • Total • Differential 1. Foundation settlement will depend upon the variations within the subsurface soil profile, the tower's structural loading conditions, the embedment depth of the footings, the thickness of compacted fill (if any), and the quality of the earthwork operations.	< 1 inch < ¾ inch

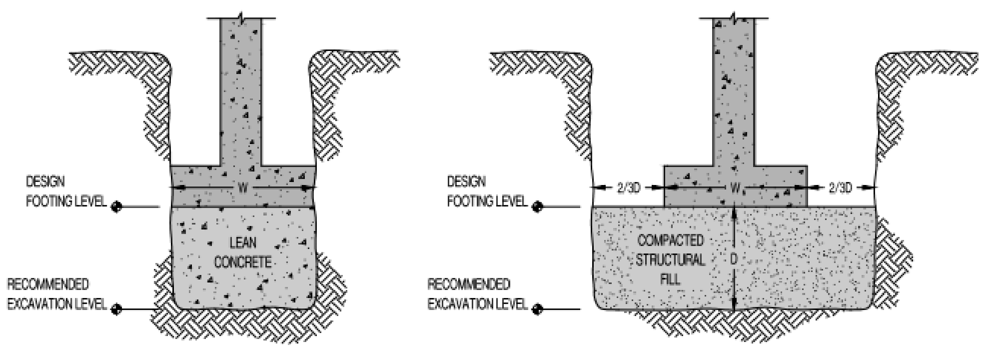
Uplift resistance for spread footing foundations may be computed as the sum of the effective weight of the foundation element and the effective weight of the soil overlying the foundation. We recommend using a soil unit weight of 120 pounds per cubic foot (pcf) for structural fill overlying the footing placed as described in this section of this report. A unit weight of 150 pcf could be used for reinforced footing concrete. We recommend a minimum factor of safety of 1.5 be utilized for uplift calculations.

4.2.2 Shallow Foundation Construction Considerations

The base of all foundation excavations should be free of water and loose soil and rock prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Should the soil at the foundation bearing level become excessively dry, disturbed, saturated, or frozen the affected soil should be removed prior to placing concrete. Place a lean concrete mud-mat over the bearing soils if the excavations must remain open over night or for an extended period of time. It is recommended the geotechnical engineer be retained to observe and test the soil foundation bearing materials.

Although groundwater was not encountered at or above the anticipated shallow foundation bearing elevation, it may be encountered during foundation excavation. In addition, some surface and/or perched groundwater may enter foundation excavations during construction. It is anticipated any water entering foundation excavations from these sources can be removed using sump pumps or gravity drainage.

If unsuitable bearing soils are encountered in footing excavations, the excavations should be extended deeper to suitable soils and the footings should bear directly on these soils at the lower level or on lean concrete backfill placed in the excavations. The footings could also bear on properly compacted backfill extending down to the suitable soils. Overexcavation for compacted backfill placement below footings should extend laterally beyond all edges of the footings at least 8 inches per foot of overexcavation depth below footing base elevation. The overexcavation should then be backfilled up to the footing base elevation with well graded granular material placed in lifts of 9 inches or less in loose thickness and compacted to at least 98 percent of the material's maximum standard effort maximum dry density (ASTM D 698). The lean concrete backfill and overexcavation-and-backfill procedures are described in the diagram below.



LEAN CONCRETE BACKFILL

OVEREXCAVATION / BACKFILL

NOTE:
EXCAVATIONS IN SKETCHES SHOWN VERTICAL FOR CONVENIENCE. EXCAVATIONS SHOULD BE SLOPED AS NECESSARY FOR SAFETY.

4.2.3 Drilled Pier Foundation Design Recommendations

The proposed structure can be founded on straight shaft drilled piers bearing in suitable glacial drift. The design parameters provided in the following table are based on the results of field and laboratory testing, published values, and our past experience with similar soil conditions.

Drilled Pier Design Parameters						
Approximate Depth (feet) [1]	Allowable Skin Friction (psf) [2]	Allowable End Bearing Pressure (psf) [3]	Allowable Passive Pressure (psf) [2]	Cohesion (psf)	Strain ε_{50} (in./in) [4]	Lateral Subgrade Modulus (pci) [4]
0 - 3	Ignore	Ignore	Ignore	Ignore	Ignore	Ignore

Drilled Pier Design Parameters						
Approximate Depth (feet) [1]	Allowable Skin Friction (psf) [2]	Allowable End Bearing Pressure (psf) [3]	Allowable Passive Pressure (psf) [2]	Cohesion (psf)	Strain ε_{50} (in./in) [4]	Lateral Subgrade Modulus (pci) [4]
3 – 13	250	NR [5]	1,250	1,250	0.009	370
13 - 30	600	7,500 [3]	3,000	3,000	0.005	1,000
› 30	500	7,500 [3]	2,500	2,500	0.006	830

1. A moist unit weight of 125 pcf can be used for soil above groundwater
   An effective unit weight of 63 pcf can be used for soil below groundwater
   CGTL should observe pier excavations to evaluate whether conditions are consistent with those encountered in our boring.
2. The skin friction and passive pressure values are based on a constant (rectangular) pressure distribution for cohesive soils and bedrock.
   Skin friction and passive pressure should be neglected within 3 feet of the final grade.
   Allowable skin friction based on a FOS=3.0.
3. Minimum pier length of 4 diameters required. CGTL should be contacted if the pier length is less than four times the pier diameter as modifications to our design parameters may be warranted.
   Allowable end bearing based on a FOS=3.0.
4. Lateral subgrade modulus and strain values are to be utilized with LPILE software.
5. NR = Not Recommended

Drilled piers should have a minimum shaft diameter of 30 inches. The above-indicated cohesion values are ultimate values without factors of safety. The end bearing, skin friction, and passive resistance are allowable parameters with factors of safety. The values given in the above table are based on our boring and past experience with similar material types.

4.2.4 Drilled Pier Foundation Construction Considerations

Pier drilling through the upper native soils is not expected to be difficult based upon the material encountered in the boring. However, special drilling techniques may be required to penetrate potential gravel and cobble zones that could be encountered in the glacial drift materials. The contractor should be aware boulders, although not encountered in our boring, are sometimes present within glacial drift in this area.

Groundwater was encountered in the boring while drilling with the solid stem augers and the groundwater rapidly filled the borehole between each sampling interval. Groundwater should be anticipated during future pier drilling and the contractor should be prepared to handle wet drilling conditions.

Temporary casing may be needed to advance drilled pier excavations. Temporary casing should also be installed when personnel enter the shafts to clean and/or test the bearing surface.

For proper performance of the drilled pier foundation system, it is critical for the bottom of pier excavations to be cleaned of any water and loose material prior to placing reinforcing steel and concrete. A minimum shaft diameter of at least 30 inches is required for entry of construction and testing personnel, and to facilitate clean-out and possible dewatering of the pier excavation.

Concrete should be placed soon after excavating to minimize bearing surface disturbance. Any water accumulating in the pier excavation should be pumped from the excavation or the water level should be allowed to stabilize and then concrete should be placed using the tremie method.

If concrete will be placed as the temporary casing is being removed, we recommend the concrete mixture be designed with a slump of about 5 to 7 inches to reduce the potential for arching when removing the casing. While removing the casing from a pier excavation during concrete placement, the concrete inside the casing should be maintained at a sufficient level to resist any earth and hydrostatic pressures outside the casing during the entire casing removal procedure.

We recommend a CGTL engineer or their representative be present on a full-time basis during drilling activities to evaluate the materials removed from the drilled pier excavations to determine when adequate capacity has been developed, to observe the base of the drilled pier to determine that the cuttings have been adequately removed, and also to observe the concreting techniques.

Although obvious signs of harmful gases such as methane, carbon monoxide, etc., were not noted in the boring during the geotechnical drilling operations, gas could be encountered in the drilled shaft excavations during construction. The contractor should check for gas and/or oxygen deficiency prior to any workers entering the excavation for observation and manual cleanup.

4.3 Seismic Considerations

The 2012 International Building Code requires the average properties in the upper 100 feet of the subsurface profile a site profile determination extending a depth of 100 feet for seismic site classification. The drilling scope performed for this project had one boring that extended to a maximum depth of approximately 50.0 feet.

Seismic Site Classification	
Code Used	2012 International Building Code (IBC)
Site Classification	D

Additional exploration to greater depths could be considered to confirm the conditions below the current depth of exploration. Alternatively, a geophysical exploration could be utilized in order to attempt to justify a more favorable seismic site class.

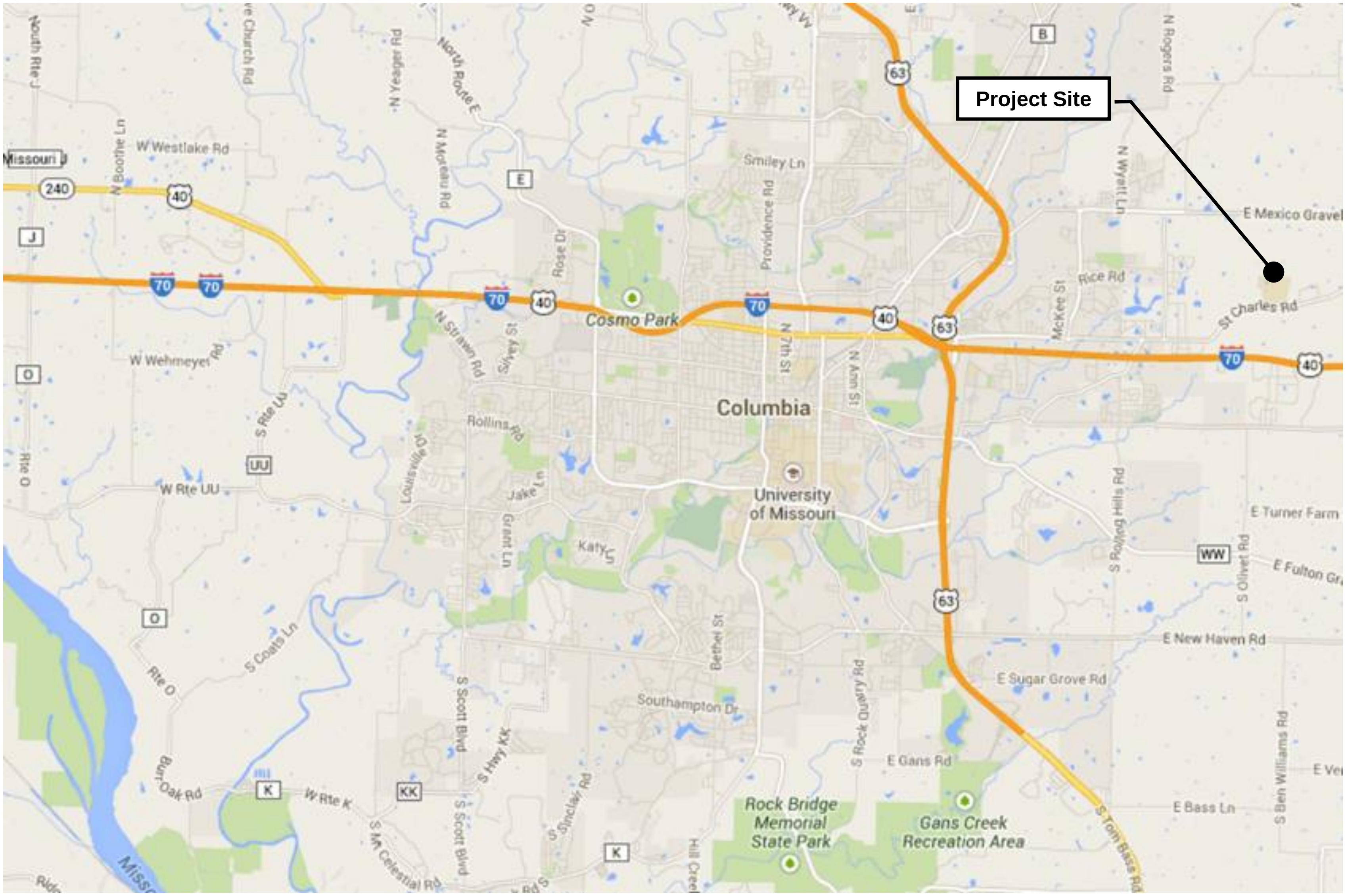
5 GENERAL COMMENTS

The recommendations provided herein are for the exclusive use of our client. Our recommendations are specific only to the project described herein and are not meant to supersede more stringent requirements of local ordinances or codes. The recommendations are based on subsurface information obtained at our boring locations, sample locations, our understanding of the project as described in this report, and geotechnical engineering practice consistent with the current standard of care. No warranty is expressed or implied. CGTL should be contacted if conditions encountered are not consistent with those described.

CGTL should be provided with a set of final plans and specifications, once they are available, to review whether our recommendations have been understood and applied correctly and to assess the need for additional exploration or analysis. Failure to provide these documents to CGTL may nullify some or all of the recommendations provide herein. In addition, any changes in the planned project or changes in site conditions may require revised or additional recommendations on our part.

The final part of our geotechnical service should consist of direct observation during construction to observe that conditions actually encountered are consistent with those described in this report and to assess the appropriateness of the analyses and recommendations contained herein. CGTL cannot assume liability or responsibility for the adequacy of recommendations without being retained to observe construction.

APPENDIX



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PROJECT NO.: G15046

SITE LOCATION MAP

911 MONOPLE RADIO TOWER
COLUMBIA, MISSOURI

Prepared By:
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PROJECT NO: G15046

BORING LOCATION PLAN

911 MONOPOLE RADIO TOWER
COLUMBIA, MISSOURI

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BORING NUMBER B-1

CLIENT Columbia/Boone County Joint Communications
PROJECT NAME 911 Monopole Radio Tower
PROJECT NUMBER G15046
PROJECT LOCATION Columbia, Missouri
DATE STARTED 7/14/15 **COMPLETED** 7/14/15
GROUND ELEVATION 860 ft **HOLE SIZE** 4"
DRILLING CONTRACTOR IPES
GROUND WATER LEVELS:
DRILLING METHOD 4" SSA
▽ **AT TIME OF DRILLING** 28.00 ft / Elev 832.00 ft
LOGGED BY Friedman **CHECKED BY** Lidholm
▼ **AT END OF DRILLING** 32.00 ft / Elev 828.00 ft
NOTES Borehole backfilled upon completion
▼ **0.5hrs AFTER DRILLING** 30.00 ft / Elev 830.00 ft

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY LENGTH	BLOW COUNTS (N VALUE)	POCKET PEN. (psf)	UNC. COMP. (psf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0	LEAN TO FAT CLAY: Brown and gray, trace rust stains, trace lignite, trace gravel, stiff to very stiff										
		ST 1	12		4500		104	22			
		ST 2	15		8000	4250	107	21			
7.0	853.0										
	FAT CLAY: Dark brown to brown, trace gravel, stiff	ST 3	14		2500	2500	92	30			
10		ST 4	10		2500		100	22			
10.0	850.0										
	LEAN TO FAT CLAY Brown and gray, trace lignite, trace gravel, trace sandy, occasional sandy zones, very stiff to hard (Glacial Drift)										
		ST 5	20		6500		104	23			
20		ST 6	20		7500	5920	112	18			
		ST 7	23		7000		115	18			
30	▽ ▼ ▼	ST 8	24		7000	6550	111	19			
		ST 9	19		5000		103	23			
40	--: becomes dark gray to gray	ST 10	24		6000	3840	107	23			
	--: becomes brown to light brown, trace gray, sandy clay to clayey sand	ST 11	24		5500		110	20			
50		ST 12	22		8000			27			
50.0	810.0										

No Refusal
Bottom of borehole at 50.0 feet.

BORING LOG LEGEND AND NOMENCLATURE

Sample Type	Description
AU	Auger sample, disturbed, obtained from auger cuttings
NR	No recovery or lost sample
RC	Rock core, diamond core bit, nominal 2-inch diameter rock sample (ASTM D 2113)
ST	Thin walled (Shelby) tube sample, relatively undisturbed (ASTM D 1587)
SPT	Split spoon sample, disturbed (ASTM D 1586)
VA	Shear vane (ASYM D 2753)

Grain Size Terminology	
Boulders	Larger than 12-inches
Cobbles	3-inches to 12-inches
Gravel	Retained on #4 sieve to 3-inches
Sand	Retained on #200 sieve but passes #4 sieve
Silt or Clay	Passes #200 sieve

Descriptor	Relative Proportion of Sand and Gravel	Relative Proportion of Fines
Trace	Less than 15% by dry weight	Less than 5% by dry weight
With	15% to 30% by dry weight	5% to 12% by dry weight
Modifier	More than 30% by dry weight	More than 12% by dry weight

Relative Density of Coarse grained Soils	
Descriptive Term	SPT N-Value, Blows/Foot
Very Loose	0 - 3
Loose	4 - 9
Medium Dense	10 – 29
Dense	30 – 49
Very Dense	50+

Consistency of Fine Grained Soils		
Descriptive Term	SPT N-Value, Blows/Foot	Unconfined Compressive Strength, psf
Very Soft	0 - 2	0 – 500
Soft	2 - 3	500 – 1,000
Medium	4 - 9	1,000 – 2,000
Stiff	10 – 29	2,000 – 4,000
Very Stiff	30 – 49	4,000 – 8,000
Hard	50+	8,000+

USCS Soil Classification System				
Major Divisions			Group Symbol	Group Name
coarse grained soils more than 50% retained on #200 sieve	gravel >50% of coarse fraction retained on #4 (4.75 mm) sieve	clean gravel <5% small than #200 sieve	GW	well-graded gravel, fine to coarse gravel
			GP	poorly graded gravel
		gravel with >12% fines	GM	silty gravel
			GC	clayey gravel
	sand >50% of coarse fraction passes #4 (4.75 mm) sieve	clean sand	SW	well-graded sand, fine to coarse sand
			SP	poorly graded sand
		sand with >12% fines	SM	silty sand
			SC	clayey sand
fine grained soils more than 50% passes #200 sieve	silt and clay liquid limit < 50	inorganic	ML	silt
			CL	clay
		organic	OL	organic silt, organic clay
	silt and clay liquid limit ≥ 50	inorganic	MH	silt of high plasticity, elastic silt
			CH	clay of high plasticity, fat clay
		organic	OH	organic clay, organic silt
highly organic soils			PT	peat

Weathering	Description of Rock Properties
Fresh	No discoloration. Not oxidized.
Slightly weathered	Discoloration or oxidation of most surfaces but or short distance from fractures
Moderately weathered	Discoloration or oxidation extends from fractures, usually throughout. All fractured surfaces are oxidized or discolored.
Severely weathered	Discoloration or oxidation throughout. All fractured surfaces are oxidized or discolored. Surfaces are friable.
Decomposed	Resembles a soil. Partial or complete remnant rock structure may be present.

Rock Quality Designator (RQD)	
RQD, %	Rock Quality
90 – 100	Excellent
75 – 90	Good
50 – 75	Fair
25 – 50	Poor
0 - 25	Very poor

Joint, Bedding, and Foliation Spacing in Rock		
Spacing	Joints	Bedding/Foliation
< 2-inches	Very close	Very thin
2-inches – 1-foot	Close	Thin
1-foot – 3-feet	Moderately Close	Medium
3-feet – 10-feet	Wide	Thick
>10-feet	Very Wide	Very thick