GEOTECHNICAL ENGINEERING SERVICES
REPORT

For the:

PROPOSED BROWNSBURG CELL TOWER
1630 SOUTH GREEN STREET
BROWNSBURG, INDIANA

Prepared for:

Verizon Wireless
c/o Comtech Services, Inc.
17827 Commerce Drive
Westfield, Indiana 46074

Prepared by:

Professional Service Industries, Inc.
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PSI PROJECT NUMBER 0016-452

May 20, 2011

psi Information To Build On
Engineering • Consulting • Testing

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Verizon Wireless
c/o Comtech Services, Inc.
17827 Commerce Drive
Westfield, Indiana 46074

Attn: Mr. Mike Clodfelter

Re: Geotechnical Engineering Services Report
Proposed Brownsburg Cell Tower
1630 South Green Street
Brownsburg, Indiana
PSI Project Number 0016-452

Dear Mr. Clodfelter:

Thank you for choosing Professional Service Industries, Inc. (PSI) as your consultant for the referenced project. Per your authorization, PSI has completed a geotechnical engineering study for the referenced cell tower project in Brownsburg, Indiana. The results of the study are discussed in the accompanying report, three (3) copies of which are enclosed.

If you have any questions pertaining to this report, please contact our office at (317) 876-7723. PSI would be pleased to continue providing geotechnical services throughout the implementation of the project, and we look forward to working with you and your organization on this and future projects.

Respectfully submitted,
PROFESSIONAL SERVICE INDUSTRIES, INC.

Eric J. Brown, E.I.
Geotechnical Department Manager

Mark J. Carlson, P.E.
Chief Engineer

3 copies – Client

Enclosures

The geotechnical recommendations presented in this report are based on the available project information, the proposed location of the tower, and orientation of the equipment shelter structure on the site and the subsurface materials described in this report. If any of the information noted above is incorrect, please inform PSI in writing so that we may amend the recommendations presented in this report if appropriate and if desired by the client. PSI will not be responsible for the implementation of its recommendations when it is not notified of changes in the project.

Purpose and Scope of Services

The purpose of this study was to explore the subsurface conditions at the site and to prepare recommendations for foundation systems for the proposed construction. PSI's contracted scope of services included drilling two (2) soil test borings at the site to planned depths varying between about 15 to 50 feet below the ground surface, select laboratory testing, and preparation of this geotechnical report. This report briefly outlines the testing procedures, presents available project information, describes the site and subsurface conditions, and presents recommendations regarding the following:

- Grading procedures for site development.
- Review of geologic setting
- Foundation types, depths and allowable bearing capacities.
- Seismic coefficients for use in seismic design.
- Floor slab recommendations and subgrade modulus
- Comments regarding factors that could impact construction and performance of the proposed construction.

The scope of services did not include an environmental assessment for determining the presence or absence of wetlands, or hazardous or toxic materials in the soil, bedrock, surface water, groundwater, or air on, below, or around this site. Any statements in this report or on the boring logs regarding odors, colors, and unusual or suspicious items or conditions are strictly for informational purposes. Prior to further development of this site, an environmental assessment is advisable.

PSI's scope also did not provide any service to investigate or detect the presence of moisture, mold or other biological contaminants in or around any structure, or any service that was designed or intended to prevent or lower the risk of the occurrence or the amplification of the same. Client should be aware that mold is ubiquitous to the environment with mold amplification occurring when building materials are impacted by moisture. Client should be aware that site conditions are outside of PSI's control, and that mold amplification will likely occur, or continue to occur, in the presence of moisture. As such, PSI cannot and shall not be held responsible for the occurrence or reoccurrence of mold amplification.

SITE AND SUBSURFACE CONDITIONS

Site Location and Description

The site for the proposed "Brownsburg Cell Tower" is located along Indiana State Route 267 near Brownsburg, Indiana. More specifically, the project site is located 1630 South Green Street and is situated immediately west of (behind) the existing "Park 267" building at the same address. The site Latitude and Longitude is approximately N 39° 49' 15.1" and W 86° 24' 9.9", respectively. The project site is bordered by commercially-developed properties to the north, south and east, and a wooded parcel to the west. White Lick Creek is situated about 1400 feet to the west of the project site. At the time of drilling, the site was surficially covered with crushed aggregate base material. Surface water runoff appeared to generally flow from east to west (based on the topographic mapping provided).

Site Geology

Based on the on-line geologic map provided by the Indiana Geological Survey (available at http://igs.indiana.edu/arcims/statewide/index.html) the proposed site is located on the Tipton Till Plain (which is part of the Central Till Plain Region). The overburden soils in the project area consist primarily of glacial loam till deposits from the Huron-Erie Lobe of the Wisconsinan-age Glacier. The thickness of the unconsolidated glacial till deposits in the project area is reported to range from about 100 to 150 feet. The site is mapped as underlain by bedrock of the Mississippian system, primarily siltstone with lenses of crinoidal limestone of the Borden Group formation.

Subsurface Conditions

The site subsurface conditions were explored with two (2) soil test borings (i.e., a single boring at the proposed tower site, and one (1) boring at the equipment enclosure area). The boring near the proposed tower locale extended to approximately 50 feet below existing grade, whereas the test boring for the adjacent equipment shelter extended to approximately 15 feet below the existing ground surface. The boring locations and depths were selected by PSI and reviewed with Comtech Services prior to drilling. PSI personnel staked the borings in the field by measuring distances from available surface features. The surface elevations at the boring locales were interpolated from topographical lines shown on the provided site grading plan. PSI recommends that the surface elevations at the boring locations be surveyed prior to construction activities.

The borings were advanced utilizing 3¼ inch inside diameter, hollow-stem auger drilling methods. Soil samples were obtained during the drilling process. Select soil samples were later tested in the laboratory to obtain soil material properties for the foundation recommendations. Drilling, sampling, and laboratory testing was accomplished in general accordance with ASTM procedures.

The borings disclosed that approximately 15 inches of crushed aggregate base material is surficially present at the test boring locales. The soils encountered beneath the aggregate base primarily included silty clay glacial till soil extending to a depth of about 22 feet below existing grade. The upper fine-grained soil mass is underlain by granular soil which was encountered in Boring B-1 at depth increments of between about 22 to 32 feet below existing grade. The granular soil stratum is then underlain by silty clay glacial till which extended to the terminal depth of Boring B-1 (i.e., about 50 feet below existing site grade).

Based on the results of visual classification, the fine-grained glacial till soils are classified as low plasticity silty clay (CL) in accordance with the Unified Soil Classification System (USCS), whereas the granular soil is classified as silty sand (SM). The standard penetration N-values (i.e.,"blow counts") within the silty clay glacial till soils generally indicate consistencies stiff to hard, whereas the SPT N values indicate a dense relative density with in the granular soil strata.

The moisture contents of the fine-grained soils in the upper 10 feet ranged from about 10 to 23 percent with an average value of about 14 percent. The following Table briefly summarizes the range of results from the field and laboratory testing programs. Please refer to the attached boring logs and laboratory data sheets for more specific information:

Soil Strata Type	Approximate Strata Depth Increment, feet	RANGE OF VALUES	
		Standard penetration test "blow counts," N	Natural Insitu Moisture content, %
Silty Clay (CL)	1 to 23	5 to 42	9 to 23
Sand (SM)	23 to 33	22 to 44	N.A.
Silty Clay (CL) (Glacial Till)	33 to 50	SSR *	10

*SSR = Split Spoon Refusal (greater than 50 blows for one six inch increment)

The above subsurface description is of a generalized nature to highlight the major subsurface stratification features and material characteristics. The boring logs included in the Appendix should be reviewed for specific information at individual boring locations. These records include soil/rock descriptions, stratifications, penetration resistances, and locations of the samples and laboratory test data. The stratifications shown on the boring logs represent the conditions only at the actual boring locations. Variations may occur and should be expected between boring locations. The stratifications represent the approximate boundary between subsurface materials and the actual transition may be gradual. Water level information obtained during field operations is also shown on these boring logs. The samples that were not altered by laboratory testing will be retained for 60 days from the date of this report and then will be discarded.

Groundwater Level Measurements

During drilling activities, free groundwater was encountered in Boring B-1 at a depth of about 26 feet below existing site grade, whereas at Boring B-2 the depth to free ground water was about 13 feet below grade. At the completion of drilling activities free ground water was observed at a depth of about 9 feet below existing grade in both of PSI's two (2) test borings.

In fine-grained soils, the depth of the soil color change from brown to gray can be an indicator of the prevailing groundwater level. Above the prevailing groundwater level, fine-grained soils oxidize to a brown color. At this site, the transition from brown to gray soils generally occurred at an average depth of approximately 13 feet below existing grade. Please note that the groundwater level at the site, as well as perched water levels and volumes, will fluctuate based on variations in rainfall, snowmelt, evaporation, surface run-off and other related hydrogeologic factors. The water level measurements presented in this report are the levels that were measured at the time of PSI's field activities.

GEOTECHNICAL EVALUATION

Geotechnical Discussion

There exists a single geotechnical-related issue at this site which may affect the performance of the foundations for this structure or could adversely impact construction activities. The following summarizes this issue:

- Aeration and drying of the wetter on-site insitu soils may be required during site grading and compacting operations. Reducing the moisture content of the clay soils may be necessary to achieve proper compaction and establish stable subgrade conditions. **If grading and compaction operations take place during a wet or cold season of the year, lime stabilization (or other form of chemical modification) may be necessary to expedite site grading and achieve the required level of soil compaction.**

Soil Compaction

Since this site predominantly consists of fine-grained cohesive soils, it may become difficult to achieve the required soil compaction and subgrade stability due to high soil moisture contents. Aeration and drying of some of the wetter on-site insitu soils will be required during site grading and compacting operations. Reducing the moisture content of the clay soils will be necessary to achieve proper compaction and establish stable subgrade conditions for support of foundations, floor slabs, and pavements.

If grading and compaction operations take place during a wet or cold season of the year, lime stabilization (or other form of chemical modification) may be necessary to expedite site grading and achieve the required level of soil compaction.

GEOTECHNICAL RECOMMENDATIONS

The following geotechnical-related recommendations have been developed on the basis of the subsurface conditions encountered and PSI's understanding of the proposed development. If any changes in the project criteria occur, a review must be made by PSI to determine if modifications to our recommendations will be required.

Site Preparation

PSI recommends that topsoil, vegetation, roots, soft, organic, frozen, or unsuitable soils in the construction areas be stripped from the site and either wasted or stockpiled for later use in non-structural areas. The heavily organic soils appear to be limited to the upper 12-inches of the site (i.e., the tilth zone). It should also be noted that it is not unusual for topsoil thickness to vary from these values in an open field. Oftentimes the topsoil can be deeper in low-lying areas, where erosion, wind and precipitation can deposit this material. There may be areas of the site that require additional, or possibly less stripping for the reasons discussed above. A representative of the geotechnical engineer should determine and document the depth of removal at the time of construction.

After stripping to the proposed subgrade level, as required, the tower compound area and access drive should be proof-rolled with a loaded tandem axle dump truck or similar heavy rubber tired vehicle (typically with an axial load greater than 10 tons). Soils that are observed to rut or deflect excessively (typically greater than 1 inch) under the moving load should be undercut and replaced with properly compacted low plasticity fill material.

The proof-rolling and undercutting activities should be witnessed by a representative of the geotechnical engineer and should be performed during a period of dry weather. Care should be taken during construction activities not to allow excessive drying or wetting of exposed soils. The subgrade soils should be scarified and compacted to at least 95% of the materials' standard Proctor maximum dry density, in general accordance with ASTM procedures, to a depth of at least 12 inches below the surface. New fill for the tower, associated support structures and access drive should not be placed on frozen ground.

After subgrade preparation and observation have been completed, fill placement required to establish grade may begin. Low-plasticity structural fill materials placed beneath the lightly loaded structural features or slabs should be free of organic or other deleterious materials and have a maximum particle size of less than 3-inches. Low-plasticity soils are defined as having a liquid limit less than forty-five (45) and plasticity index less than twenty-five (25). The on-site glacial till silty clay is suitable for use as structural fill, but some moisture conditioning may be needed to achieve compaction. A representative of PSI should be on-site to observe, test, and document the placement of the fill. If the fill is too dry, water should be uniformly applied and thoroughly mixed into the soil by disking or scarifying. Close moisture content control will be required to achieve the recommended degree of compaction. If engineered fill placement must proceed during a wet or cool time of the year, it will likely be infeasible to re-use the on-site soils as engineered fill, and imported fill materials will be required. If wet or cool season earthwork is necessary, PSI recommends the use of imported fill materials meeting the requirements for "B Borrow" as specified by the Indiana Department of Transportation (INDOT) 2010 Standard Specifications, Section 211.

Fill should be placed in maximum loose lifts of 8 inches and compacted to at least 95% of the materials' standard Proctor maximum dry density, and within a range of the optimum moisture content as designated in the table below, as determined in general accordance with ASTM procedures. Each lift of compacted-engineered fill should be tested and documented by a representative of the geotechnical engineer prior to placement of subsequent lifts. The edges of compacted fill should extend a minimum of 5 feet beyond the tower and building footprint, or a distance equal to the depth of fill beneath the footings, whichever is greater. The measurement should be taken from the outside edge of the footing to the toe of the excavation prior to sloping.

In utility trenches and shallow foundation excavations (or other areas where structural fill is required and large compaction equipment cannot be used) **well-graded granular engineered fill** should be placed as backfill. PSI recommends the use of material meeting the gradation requirements for No. 53 or No. 73 coarse aggregate as specified by the Indiana Department of Transportation (INDOT) 2010 Standard Specification Section 904.05 (Structure Backfill). Well graded granular fill meeting the INDOT B Borrow specification may also be used. Engineered structural fill must be placed in accordance with the recommendations stated in this section of the report.

The fill placed should be tested and documented by a geotechnical technician and directed by a geotechnical engineer to evaluate the placement of fill material. It should be noted that the geotechnical engineer of record can only certify the testing that is performed and the work observed by that engineer or staff in direct report to that engineer. The fill compaction should be evaluated in accordance with the following Table:

MATERIAL TESTED	PROCTOR TYPE	MINIMUM % DRY DENSITY	PLACEMENT MOISTURE CONTENT RANGE	FREQUENCY OF TESTING *1
Structural Cohesive Fill (Clay)	Standard	95%	-1 to +3 %	1 per 5,000 ft^2 / lift
Structural Granular Fill (Sand)	Standard	95%	-2 to +2 %	1 per 5,000 ft^2 / lift
Random Fill (Non-load bearing)	Standard	90%	-3 to +3 %	1 per 5,000 ft^2 / lift
Utility Trench Backfill	Standard	95%	-1 to +3 %	1 per 150 lineal ft. / lift

*1 Minimum 2 tests per lift of fill placed.

Tested fill materials that do not achieve either the required dry density or moisture content range shall be recorded, the location noted, and reported to the Contractor and Owner. A re-test of that area should be performed after the Contractor performs remedial measures.

Foundation Recommendations

Monopole cellular towers are typically supported on either drilled pier foundations or a mat foundation system. This report provides design recommendations for both design concepts.

Drilled Pier Foundation Recommendations

The monopole-tower can be supported on a drilled pier foundation system. The following parameters are provided for support of the proposed tower on drilled pier foundations. The Table below summarizes the soil design parameters which should be used for uplift and lateral stability analyses based on the LPILE or COM-624 computer programs. The LPILE or COM624P parameters are given for the designer that analyzes the lateral applied load. This Table also outlines the parameters for use in the design of the downward allowable capacity of the drilled piers on and through the soil. The allowable soil bearing pressure at the base of the drilled pier foundation will depend upon the final base elevation.

Typical Soil Type	Depth Range, Below Grade (ft)	Approximate Insitu Soil Shear Strength (psf)	Allowable Downward Side Friction (psf)	Allowable Uplift Side Friction (psf)	Static Lateral Modulus, K (pci)	Cyclic Lateral Modulus, K (pci)	Strain Factor, E_{50}
Silty Clay	0 to 5	NEGLECT UPPER FIVE (5) FEET					
Silty Clay	5 to 22	1250	500	200	150	75	0.0050
Sand	22 to 32	$\Phi = 36°$	750	300	100	75	---
Silty Clay	32 to 50	2,200	1,000	400	1000	125	0.0050

The prevailing groundwater level has been estimated to be at approximately 9 feet below existing grade for the proposed tower. Effective soil unit weights of 120 pounds per cubic foot (pcf) and 60 pounds per cubic foot (pcf) should be used above and below the water table, respectively. Due to the disturbance at the soil in the installation of the pier, PSI recommends that the upper 5 feet be ignored for the design of the foundation system.

Based on the above soil information, it is estimated that the settlement of the drilled pier should be less than approximately 0.5 inch if bearing in the stiff glacial till or sand at a minimum depth of about 20 feet below existing site grade and using **a net allowable bearing pressure of 5,000 psf**. The net allowable bearing pressure can be increased to 10,000 psf by extending the drilled shafts to the hard glacial till stratum at a minimum depth of approximately 33 feet below the existing ground surface.

Drilled Pier- Construction Considerations

It is recommended that PSI be retained to provide observation and testing of construction activities involved in the foundation, earthwork, and related activities of this project. PSI cannot accept any responsibility for any conditions which deviate from those described in this report, nor for the performance of the foundation if not engaged to also provide construction observation and testing for this project.

PSI recommends the use of a temporary steel casing extending the length of the drilled pier to reduce sloughing of the sandy soils. The temporary casing should be twisted or vibrated ahead of the drilling to help maintain a stable excavation. The contractor may elect to screw/vibrate the temporary casing.

Drilling fluid will be required to control the inflow of water into the excavation and prevent sands within the excavation from becoming "quick". Free groundwater was encountered at a depth of about 9 feet below existing grade (at the time of PSI's drilling activities). Please note that ground water levels can be present at relatively shallow depths during other times of the year depending upon climatic and rainfall conditions. **Please note that, if groundwater is encountered, it is likely that saturated sand within the excavation will become "quick" if an appropriate head of drilling fluid is not maintained in the shaft. If the sands became "quick", they will be loosened, effectively reducing in allowable bearing pressure and increasing potential settlements.**

Drilled pier concrete should be placed by tremie methods. The foundation contractor should have available suitable lengths of temporary steel casing as well as drilling fluid and tremie pipes at the site during drilled pier construction. For concrete placed by tremie methods, we recommend using a mixture designed for a slump in the range of 7 to 9 inches.

To help reduce lateral movement of the cell tower foundation due to horizontal shear loads, it is necessary to place the drilled shaft concrete in intimate contact with undisturbed natural soil. Any voids or enlargements in the drilled shaft due to over-excavation or caving soil conditions must be filled with concrete at the time the pier concrete is placed. **It should also be emphasized that there exists the potential for boulders or "floaters" to be encountered within the glacial till while drilling the piers. PSI recommends that no attempt be made to "bell" the bottom of the piers.** Any voids or enlargements in the drilled shaft due to over-excavation or caving soil conditions must be filled with concrete at the time the drilled pier is installed.

The drilled shaft design and construction procedures should be reviewed with the chosen contractor prior to the onset of work activity. PSI would be pleased to review the plans and specifications for the foundation work once they are prepared, so that we may have the opportunity to comment on the effect of the soil and groundwater conditions on the design and on the contractor's proposed methods.

Mat Foundation Recommendations

As an alternative to a drilled pier foundation system, the monopole tower could be supported on a mat foundation bearing on the natural stiff glacial till silty clay bearing at least 8 feet below existing site grade (i.e., approximately at elevation 862 MSL). **At this minimum elevation the mat foundation can be designed for a maximum allowable soil contact pressure (based on dead load plus live load) of 4,000 pounds per square foot (psf).** The mat foundation element must be proportioned such that the vertical resultant force passes through the middle one-third (the kern) of the mat element. Based on the soil information, it is estimated that the settlement of the mat foundation should be less than approximately 1-inch.

For design purposes, a coefficient of sliding friction can be taken as 0.35. The allowable passive equivalent fluid pressure can be taken as 180 pcf based on the water table being below the bottom of the proposed foundation. The values presented above were calculated based on positive foundation drainage being provided to prevent the buildup of hydrostatic pressure.

Equipment Shelter Foundation Recommendations

Based on PSI's experience, support shelters are typically constructed on a monolithic turned-down concrete slab-on-grade foundation. **The foundation may be designed for a maximum allowable soil bearing pressure of 2,000 pounds per square foot (psf) bearing on firm native soil or properly placed and compacted fill.** PSI recommends a minimum width of 18 inches for the continuous perimeter stem element of the slab foundation to minimize the possibility of a local bearing capacity failure. The aforementioned allowable soil bearing pressure is valid for footings which bear in the medium to stiff silty clay glacial till soil (i.e., at a minimum depth of about 3 feet below existing grade).

Exterior footings and footings in unheated areas should be located at a depth of 36 inches or deeper below the final exterior grade to provide adequate frost protection. If the building is to be constructed during the winter months or if footings will likely be subjected to freezing temperatures after foundation construction, then the footings should be protected from freezing. PSI recommends that interior footings be a minimum depth of 18 inches below the finished floor elevation.

The foundation excavations should be observed and documented by a representative of PSI prior to steel or concrete placement to assess that the foundation materials are consistent with the materials discussed in this report, and therefore are capable of supporting the design loads. Soft or loose soil zones encountered at the bottom of the footing excavations, as indicated by blows with a dynamic cone penetrometer (DCP) equivalent to N-values of less than 10 blows per foot, should be removed to the level of suitable natural soils, and replaced with adequately compacted structural fill. Fill materials placed below the foundations where unsuitable materials are removed should extend 1 foot outside the foundation limits for every 1 foot in thickness between the intended bearing surface and the underlying, suitable natural soils.

Alternately, the foundations may be extended through unsuitable soils to bear on the underlying suitable material. Cavities formed as a result of excavation of soft or loose soil zones should be backfilled with lean concrete or dense graded compacted crushed stone.

After opening, footing excavations should be observed and concrete placed as quickly as possible to avoid exposure of the footing bottoms to wetting and drying. Surface run-off water should be drained away from the excavations and not be allowed to pond. If possible, the foundation concrete should be placed during the same day the excavation is made. If it is required that footing excavations be left open for more than one day, they should be protected to reduce evaporation or entry of moisture.

Based on the known subsurface conditions and site geology, laboratory testing and past experience, PSI anticipates that properly designed and constructed footings supported on the recommended materials should experience total and differential settlement of less than one 1-inch and 0.5 inch, respectively.

The floor slab can be grade supported on naturally existing competent silt clay or properly compacted/engineered fill. PSI recommends that a minimum four-inch thick free draining granular mat be placed beneath the floor slab to enhance drainage. Polyethylene sheeting should be placed to act as a vapor retarder where the slab will be in contact with moisture sensitive equipment or materials, as directed by the design engineer. The decision to locate the vapor retarder in direct contact with the slab or beneath the layer of granular fill should be made by the design engineer after considering the moisture sensitivity of subsequent floor finishes, anticipated project conditions and the potential effects of slab curling and cracking. The floor slabs should have an adequate number of joints to reduce cracking resulting from differential movement and shrinkage.

For subgrade prepared as recommended and properly compacted fill, a modulus of subgrade reaction, ***k* value, of 100 pounds per cubic inch (pci)** may be used in the grade slab design based on correlation to values typically resulting from a 1 ft. x 1 ft. plate load test. However, depending on how the slab load is applied, the value will have to be geometrically modified. The value should be adjusted for larger areas using the following expression for cohesive and cohesionless soil:

Modulus of Subgrade Reaction, $k_s = (\frac{k}{B})$ for cohesive soil and

$$k_s = k\,(\frac{B+1}{2B})^2 \text{ for cohesionless soil}$$

where: k_s = coefficient of vertical subgrade reaction for loaded area,
k = coefficient of vertical subgrade reaction for 1 square foot area, and
B = effective width of area loaded, in feet

The precautions listed below should be followed for construction of slab-on-grade pads. These details will not reduce the amount of movement, but are intended to reduce potential damage should some settlement of the supporting subgrade take place. Some increase in moisture content is inevitable as a result of development and associated landscaping. However, extreme moisture content increases can be largely controlled by proper and responsible site drainage, building maintenance and irrigation practices.

Cracking of slab-on-grade concrete is normal and should be expected. Cracking can occur not only as a result of heaving or compression of the supporting soil and/or bedrock material, but also as a result of concrete curing stresses. The occurrence of concrete shrinkage cracks and problems associated with concrete curing may be reduced and/or controlled by limiting the slump of the concrete, proper concrete placement, finishing, and curing, and by the placement of crack control joints at frequent intervals, particularly where re-entrant slab corners occur. The American Concrete Institute (ACI) recommends a maximum panel size (in feet) equal to approximately three times the thickness of the slab (in inches) in both directions. For example, control joints are recommended at a maximum spacing of 12 feet based on a slab thickness of 4-inches.

Earthquake and Seismic Design Consideration

The 2009 International Building Code requires a site class for the calculation of earthquake design forces. This class is a function of soil type (i.e., depth of soil and strata types). Based on the depth to rock and the estimated shear strength of the soil at the boring locations, **Site Class "D"** is recommended. The USGS-NEHRP probabilistic ground motion values near Latitude 39.8209° and Longitude -86.4028° are as follows:

Period (seconds)	2% Probability of Event in 50 years * (%g)	Site Coefficients	Max. Spectral Acceleration parameters	Design Spectral Acceleration parameters	
PGA	8.1	---	---	–	
0.2 (S_s)	20.4	F_a = 1.6	S_{ms} = 0.326	S_{Ds}= 0.218	T_0= 0.126
1.0 (S_1)	8.6	F_v = 2.4	S_{m1} = 0.206	S_{D1}= 0.138	T_s= 0.632

The Site Coefficients, F_a and F_v were interpolated from IBC 2006 Tables 1613.5.3(1) and 1613.5.3(2) as a function of the site classifications and the mapped spectral response acceleration at the short (S_s) and 1 second (S_1) periods.

According to Section 1802.2.6 and 1802.2.7 of IBC 2006, sites supporting structures in design category "C" and below must be evaluated for slope instabilities, liquefaction and surface rupture due to faulting or lateral spreading. A detailed study of these effects was beyond PSI's scope of services. However, the following Table presents a qualitative assessment of these issues considering the site class, the subsurface soil properties, the groundwater elevation, and probabilistic ground motions:

Hazard	Relative Risk	Comments
Liquefaction	Low	The soil within the upper 50 feet of the subsurface profile is a relatively dense and/or cohesive soil
Slope Stability	Low	The site is relatively flat and does not/will not incorporate significant cut or fill slopes
Surface Rupture	Low	The site is not underlain by a mapped Holocene-aged fault

A more detailed evaluation of these issues can be performed for an additional scope and/or fee.

Soil Resistivity Measurements

Soil resistivity measurements were taken at the project site in accordance with ASTM G-57-95A. The measurements were taken along perpendicular axis with the electrode spacing at 2.5, 12.5 and 20 feet, driven to depths of 1.5, 7.5 and 12 inches respectively. PSI is providing this information for use by others in the design of systems and equipment associated with the cell tower. PSI provides no analysis relative to this data or the use of this data by others.

The following Table summarizes the testing results:

Electrode Spacing		Measured Resistance, Ohms	Calculated Resistivity, Ohm-feet	Calculated Resistivity, Ohm-cm
Feet	Meters	Test No. 1 (North-South)		
2.5	0.76	5.1	80	2440
12.5	3.81	3.6	283	8620
20.0	6.10	1.7	214	6510
Feet	Meters	Test No. 2 (East-West)		
2.5	0.76	7.0	110	3350
12.5	3.81	2.9	228	6940
20.0	6.10	1.3	163	4980
Feet	Meters	Average Calculated Resistivity		
2.5	0.76	6.1	95	2900
12.5	3.81	3.3	255	7780
20.0	6.10	1.5	188	5750

Based on the results of testing performed during the course of our geotechnical study, the moisture content of the near-surface soil was about 23% at the time of the soil resistivity testing. Also, the ambient air temperature was approximately 51° F and the relative humidity about 85 %. Dry weather conditions prevailed at the time of the testing procedure.

Utilities Trenching

Excavation for utility trenches shall be performed in accordance with OSHA regulations as stated in 29 CFR Part 1926. It should be noted that utility trench excavations have the potential to degrade the properties of the adjacent fill materials. Utility trench walls that are allowed to move laterally can lead to reduced bearing capacity and increased settlement of adjacent structural elements and overlying slabs.

Backfill for utility trenches is as important as the original subgrade preparation or structural fill placed to support either a foundation or slab. Therefore, it is imperative that the backfill for utility trenches be placed to meet the project specifications for the structural fill of this project. PSI recommends that flowable fill or lean mix concrete be utilized for utility trench backfill. If on-site soils are placed as trench backfill, the backfill for the utility trenches should be placed in 4 to 6 inch loose lifts and compacted to a minimum of 95% of the maximum dry density achieved by the standard Proctor test. The backfill soil should be moisture conditioned to be within 2% of the optimum moisture content as

determined by the standard Proctor test. Up to 4 inches of bedding material placed directly under the pipes or conduits placed in the utility trench can be compacted to the 90% compaction criteria with respect to the standard Proctor. Compaction testing should be performed for every 200 cubic yards of backfill place or each lift within 200 linear feet of trench, which ever is less. Backfill of utility trenches should not be performed with water standing in the trench. If granular material is used for the backfill of the utility trench, the granular material should have a gradation that will filter protect the backfill material from the adjacent soils. If this gradation is not available, a geosynthetic non-woven filter fabric should be used to reduce the potential for the migration of fines into the backfill material. All well-graded granular backfill material shall be compacted to meet the above compaction criteria. An evenly-graded granular backfill material (i.e., the type of material typically used for pipe bedding) should be compacted to achieve a relative density greater than 75% or as specified by the geotechnical engineer for the specific material used.

Siltation Control

The Clean Water Act, implemented in 1990 includes a federal permit program called the National Pollutant Discharge Elimination System (NPDES). This program requires that projects sites in excess of 1 acre or are part of a development which exceeds 1 acre be covered under a permit. This typically includes the development of a storm water pollution prevention plan (SWPPP) as well as period inspections (typically once a week plus after significant rainfall). PSI is available to assist with these services.

CONSTRUCTION CONSIDERATIONS

PSI should be retained to provide observation and testing of construction activities involved in the foundation, earthwork, and related activities of this project. PSI cannot accept responsibility for conditions that deviate from those described in this report, nor for the performance of the foundation system if not engaged to also provide construction observation and testing for this project.

Moisture Sensitive Soils/Weather Related Concerns

The upper fine-grained soils encountered at this site will be sensitive to disturbances caused by construction traffic and to changes in moisture content. During wet weather periods, increases in the moisture content of the soil can cause significant reduction in the soil strength and support capabilities. In addition, soils that become wet may be slow to dry and thus significantly retard the progress of grading and compaction activities. It will, therefore, be advantageous to perform earthwork and foundation construction activities during dry weather.

Drainage and Groundwater Considerations

PSI recommends that the Contractor determine the actual groundwater levels at the site at the time of the construction activities to assess the impact groundwater may have on construction. Water should not be allowed to collect in the foundation excavations, on floor slab areas, or on prepared subgrades of the construction area either during or after construction. Undercut or excavated areas should be sloped toward one corner to facilitate removal of collected rainwater, groundwater, or surface runoff. Positive site drainage should be provided to reduce infiltration of surface water around the perimeter of the building and beneath the floor slab. The grades should be sloped away from the building and surface drainage should be collected and discharged such that water is not permitted to infiltrate the backfill and floor slab areas of the building.

During drilling activities, free groundwater was encountered in Boring B-1 at a depth of about 26 feet below existing site grade, whereas at Boring B-2 the depth to free ground water was about 13 feet below grade. At the completion of drilling activities free ground water was observed at a depth of about 9 feet below existing grade in both of PSI's two (2) test borings. If free water is encountered within excavations for footings or utilities, it should be removed by pumping from sumps within the excavations. If excessive water seepage occurs or if the rate of seepage cannot be controlled with normal pumping techniques, the Geotechnical engineer should be consulted.

Excavations

In Federal Register, Volume 54, Number 209 (October 1989), the United States Department of Labor, Occupational Safety and Health Administration (OSHA) amended its "Construction Standards for Excavations, 29 CFR, part 1926, Subpart P". This document was issued to better enhance the safety of workers entering trenches or excavations. It is mandated by this federal regulation that excavations, whether they be utility trenches, basement excavation or footing excavations, be constructed in accordance with the new OSHA guidelines. It is PSI's understanding that these regulations are being strictly enforced and if they are not closely followed, the owner and the contractor could be liable for substantial penalties.

The contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. The contractor's "responsible person", as defined in 29 CFR Part 1926, should evaluate the soil exposed in the excavations as part of the contractor's safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and federal safety regulations.

PSI is providing this information solely as a service to our client. PSI does not assume responsibility for construction site safety or the contractor's or other parties' compliance with Local, State, and Federal safety or other regulations.

GEOTECHNICAL RISK

The concept of risk is an important aspect of the geotechnical evaluation. The primary reason for this is that the analytical methods used to develop geotechnical recommendations do not comprise an exact science. The analytical tools which geotechnical engineers use are generally empirical and must be used in conjunction with engineering judgment and experience. Therefore, the solutions and recommendations presented in the geotechnical evaluation should not be considered risk-free and, more importantly, are not a guarantee that the interaction between the soils and the proposed structure will perform as planned. The engineering recommendations presented in the preceding section constitutes PSI's professional estimate of those measures that are necessary for the proposed structure to perform according to the proposed design based on the information generated and referenced during this evaluation, and PSI's experience in working with these conditions.

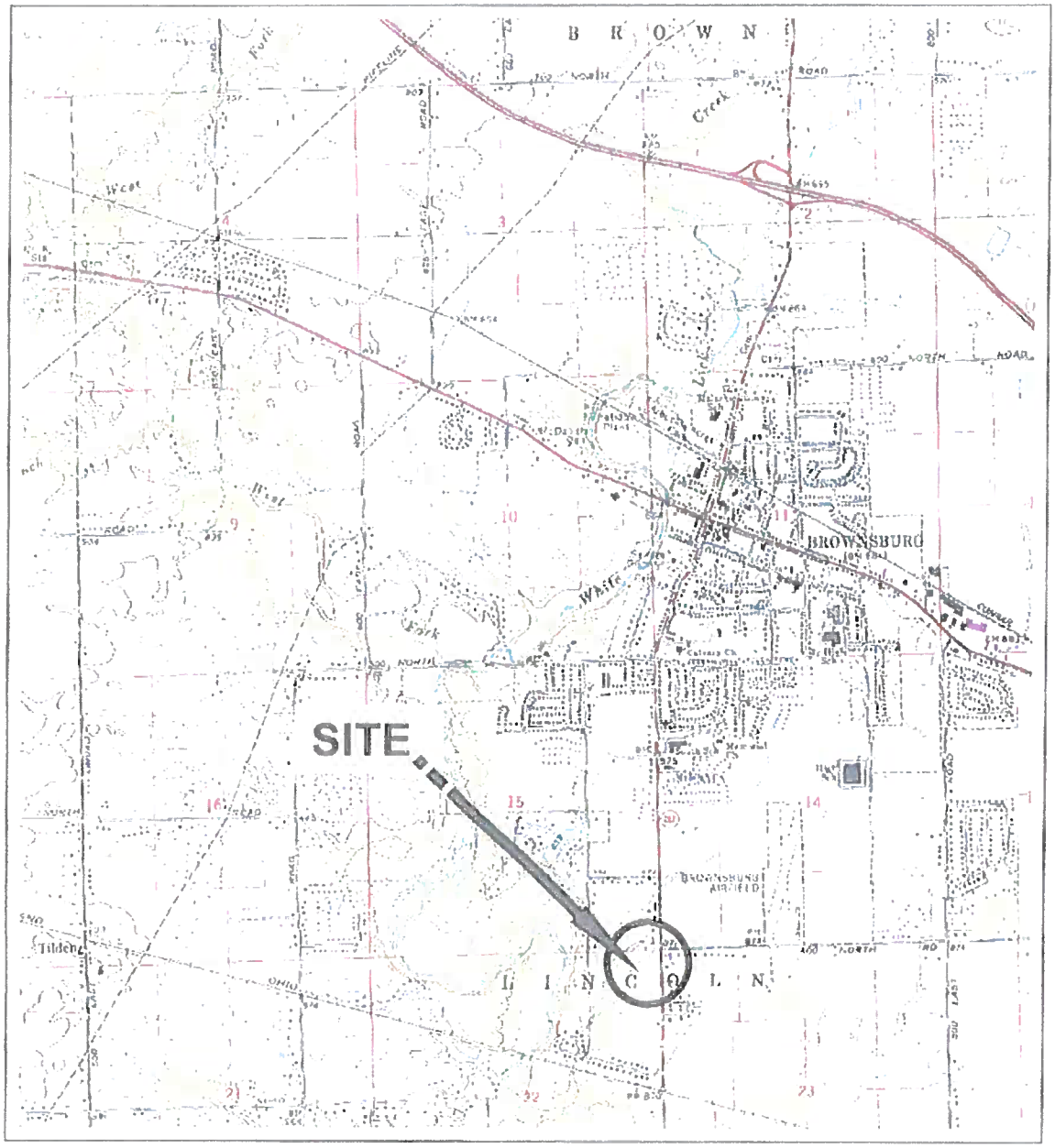
REPORT LIMITATIONS

The recommendations submitted are based on the available subsurface information obtained by PSI and design details furnished by Verizon Wireless and Comtech Services. If there are revisions to the plans for this project or if deviations from the subsurface conditions noted in this report are encountered during construction, PSI should be notified immediately to determine if changes in the foundation recommendations are required. If PSI is not retained to perform these functions, PSI will not be responsible for the impact of those conditions on the project.

The geotechnical engineer warrants that the findings, recommendations, specifications, or professional advice contained herein have been made in accordance with generally accepted professional geotechnical engineering practices in the local area. No other warranties are implied or expressed.

After the plans and specifications are more complete, the geotechnical engineer should be retained and provided the opportunity to review the final design plans and specifications to check that our engineering recommendations have been properly incorporated into the design documents. At that time, it may be necessary to submit supplementary recommendations. This report has been prepared for the exclusive use of Verizon Wireless, Comtech Services, (and their designated consultants) for the specific application to the proposed "Brownsburg Cell Tower" to be located at 1630 South Green Street in Brownsburg, Indiana.

Appendix

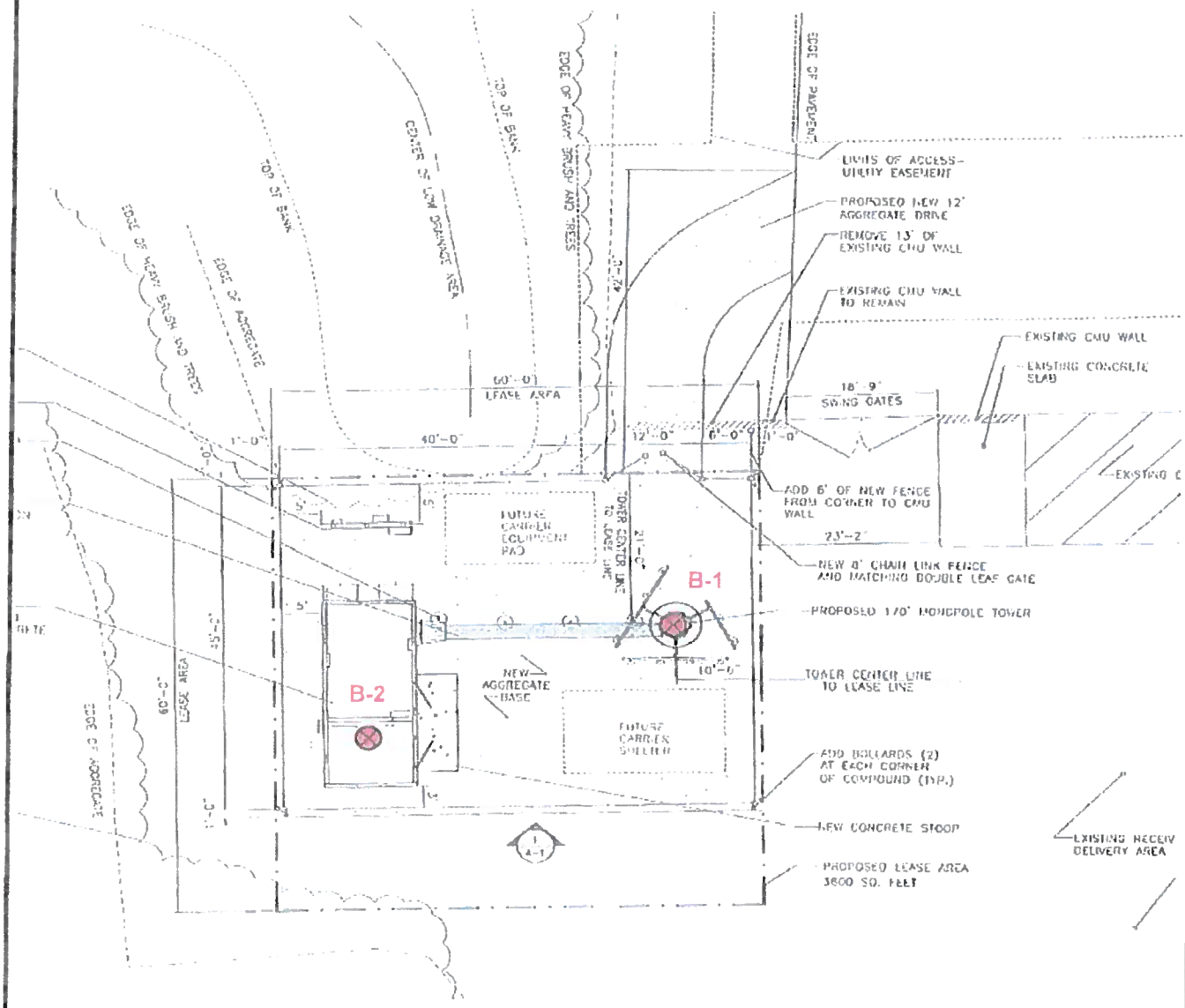


PSI Information To Build On Engineering • Consulting • Testing Professional Service Industries, Inc.	Project: Proposed Brownsburg Cell Tower Client: Comtech Services Location: Brownsburg, Indiana PSI Job No.: 0016-452 Date: May 2011 Scale: N.A.	**Figure 1 Site Vicinity Map**

PSI, Inc., 5362 West 78th Street, Indianapolis, Indiana 46268

BORING LOCATION PLAN

SOURCE:	DATE:	SCALE:
Site Plan provided by: Comtech Services	May-11	As Shown



ENLARGED SITE PLAN
SCALE: 1/8"=1'-0"

psi Information To Build On
Engineering • Consulting • Testing
5362 West 78th Street Indianapolis, Indiana, 46268
phone 317 -876- 7723- fax 317-876-8155

⊗ BORING LOCATION

PSI PROPOSAL No.: 0016-452
Project: Proposed Brownsburg Cell Tower
Location: 1630 South Green Street
Brownsburg, Indiana

Professional Service Industries, Inc.
5362 West 78th Street
Indianapolis, IN 46268
Telephone: (317) 876-7723
Fax: (317) 876-8155

LOG OF BORING B-1

PSI Job No.: 0016452
Project: Brownsburg 2 Cell Tower
Location: 1630 S. Green Street
Brownsburg, Indiana

Drilling Method: 3 1/4" I.D.Hollow Stem Auger
Sampling Method: SS
Hammer Type: Automatic
Boring Location:

WATER LEVELS

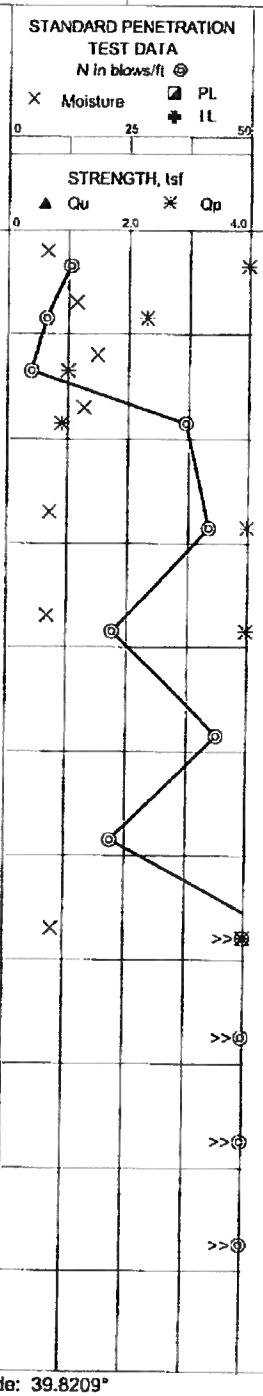
While Drilling	26 feet
Upon Completion	9.5 feet
Delay	N/A

Station: N/A
Offset: N/A

Surface Elev.: 869.5 ft

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0			AGGREGATE BASE - 14 inches				
		1	16	SILTY CLAY - trace sand - trace gravel - stiff - brown	CL	14-7-6 N=13	8	
865	5	2	18	SANDY SILT - trace clay - trace gravel - medium stiff - gray	MLS	3-3-5 N=8	14	
		3	18			2-2-3 N=5	19	
860	10	4	16	SILTY CLAY - trace sand - trace gravel - medium stiff - brown	CL	7-13-24 N=37	16	
855	15	5	18			10-13-29 N=42	9	
850	20	6	18	SILTY CLAY - and sand - trace gravel (TILL) hard - gray	CL	8-11-11 N=22	9	
845	25	7	12	SILTY SAND - and gravel - wet - medium dense to dense - gray	SM	13-19-25 N=44		
840	30	8	18			21-11-11 N=22		
835	35	9	18	SILTY CLAY - and sand - trace gravel (TILL) very stiff - gray	CL	49-50/5"	10	
830	40	10	4	Large rock fragments - possible boulder - very dense - gray		50/5"		
825	45	11	0			50/5"		
820	50	12	0			50/5"		

Boring caved 27.5 feet after auger removal.
TEST BORING TERMINATED AT 50 FET



Completion Depth:	50.0 ft
Date Boring Started:	5/13/11
Date Boring Completed:	5/13/11
Logged By:	Jason Sumler
Drilling Contractor:	Hoosier Drilling

Sample Types: Auger Cutting, Split-Spoon, Rock Core, Shelby Tube, Hand Auger, Calif. Sampler, Texas Cone

Latitude: 39.8209°
Longitude: -86.4028°
Drill Rig: CM - 55
Remarks:

The stratification lines represent approximate boundaries. The transition may be gradual.

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Indianapolis, IN 46268
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Fax: (317) 876-8155

LOG OF BORING B-2

PSI Job No.: 0016452
Project: Brownsburg 2 Cell Tower
Location: 1630 S. Green Street
Brownsburg, Indiana

Drilling Method: 3 1/4" I.D.Hollow Stem Auger
Sampling Method: SS
Hammer Type: Automatic
Boring Location:

WATER LEVELS

While Drilling	13.5 feet
Upon Completion	9.0 feet
Delay	N/A

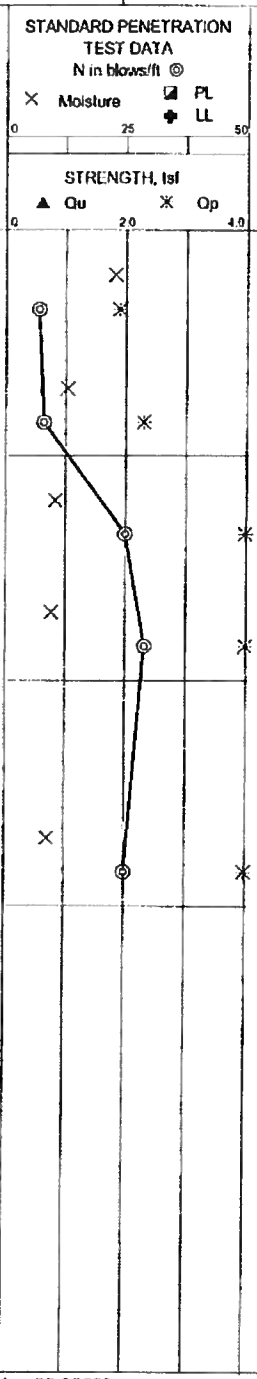
Station: N/A
Offset: N/A

Surface Elev.: 869.5 ft

Elevation (feet)	Depth (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0					AGGREAGTE BASE - 15 inches				
				1	16	SILTY CLAY - trace sand - medium stiff - brown - sand seams at 3 to 4 feet	CL	5-3-4 N=7	23	
865	5			2	18			1-3-5 N=8	13	
				3	18	SILTY CLAY - trace sand - trace gravel - medium stiff to very stiff	CL	7-12-13 N=25	10	
860	10			4	18	- sand seams at 9 feet		9-14-15 N=29	10	
						SILTY CLAY - trace sand - trace gravel - very stiff - brown	CL			
855	15			5	18	SILTY CLAY - and sand - trace gravel (TILL) very stiff - gray	CL	7-10-15 N=25	9	

Boring caved 10 feet after auger removal.

TEST BORING TERMINATED AT 15 FEET.



Completion Depth:	15.0 ft
Date Boring Started:	5/13/11
Date Boring Completed:	5/13/11
Logged By:	Jason Sumler
Drilling Contractor:	Hoosier Drilling

Sample Types:
- Auger Cutting
- Split-Spoon
- Rock Core
- Shelby Tube
- Hand Auger
- Calif. Sampler
- Texas Cone

Latitude: 39.8209°
Longitude: -86.4028°
Drill Rig: CM - 55
Remarks:

The stratification lines represent approximate boundaries. The transition may be gradual.

KEY TO SYMBOLS

Aggregate Base

USCS Low Plasticity Clay

USCS Sandy Silt

USCS Silty Sand

HSA = Hollow Stem Auger

CFA = Continuous Flight Auger

SPT = Standard Penetration Test

DCP = Dynamic Cone Penetrometer

SS = Split-spoon Sampler

ST = Shelby Tube Sampler

RC = Rock Core

DD = Dry Density

LL = Liquid Limit

PL = Plastic Limit

Qu = Unconfined Compressive Strength

Qp = Pocket Penetrometer

RQD = Rock Quality Designation

REC'D = Rock Core Recovery Percentage

PID = Photo Ionic Detector (ppm)

MR* = Unable to determine depth of water due to mud rotary drilling methods

The borings were advanced into the ground using hollow stem augers. At regular intervals throughout the boring depths, soil samples were obtained with either a 1.4-inch I.D., 2.0-inch O.D., split-spoon sampler or a 3-inch diameter Shelby tube. The split-spoon sampler was first seated 6-inches to penetrate any loose cuttings and then driven an additional foot where possible with blows of a 140 pound hammer falling 30-inches. The number of hammer blows required to drive the sampler each 6-inch increment is recorded in the field. The penetration resistance "N-value" is redesignated as the number of hammer blows required to drive the sampler the final foot and, when properly evaluated, is an index to cohesion for clays and relative density for sands. The split-spoon sampling procedures used during this exploration are in general accordance with ASTM Designation D 1586.

Relatively undisturbed Shelby tube samples were obtained by forcing a section of 3-inch diameter steel tubing into the soil at the desired sampling levels. This sampling procedure was in general accordance with ASTM Designation D 1587. Each tube, together with the encased soil, was carefully removed from the ground, sealed and transported to the laboratory for testing.

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PSI Job No.: 0016452
Project: Brownsburg 2 Cell Tower
Location: 1630 S. Green Street
Brownsburg, Indiana

General Notes

psi Information To Build On
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DRILLING & SAMPLING SYMBOLS

SS	Split Spoon – 1 3/8" I.D., 2" O.D. except where noted	AS	Auger Sample
ST	Shelby Tube – 3" O.D., except where noted	HA	Hand Auger Boring
PA	Power Auger	BS	Bag Sample
PS	Piston Sample – 3" diameter	RC	Rock Core with Diamond Bit, NX size, except where noted
WB	Wash Boring	RB	Roller Bit
WS	Wash Sample	N/A	Not applicable or available

Standard Penetration Test "N" Value – Blows per foot after an initial 6" seating of a 140 pound hammer falling 30" on a 2" O.D. split spoon, except where noted.

Water Level Measurement Notations & Symbols

While Drilling	When noted during drilling or sampling process
Upon Completion	After all drilling tools are removed from borehole
Delay	Number of hours after completion
N/R	Not Recorded
None	No measurable water level found in borehole

Water levels indicated on the boring logs are the levels measured in the boring at the time indicated. The accurate determination of ground water levels may not be possible with short term observations, especially in impervious soils. The levels shown may fluctuate throughout the year with variations in precipitation, evaporation, runoff, and other hydrogeologic factors.

Particle Sizes

Boulder	Greater than 6" (>152.4mm)
Cobbles	3" to 6" (76.2mm to 152.4mm)
Gravel	Coarse 1/4" to 3" (19.05mm to 76.2mm)
Gravel	Fine (#4) 3/16" to 3/4" (4.75mm to 19.05mm)
Sand	Coarse (#10) to (#4) (2.00mm to 4.75mm)
Sand	Medium (#40) to (#10) (0.425mm to 2.00mm)
Sand	Fine (#200) to (#40) (0.074mm to 0.425mm)
Silt	Minus (#200) (0.005mm to 0.074mm)
Clay	Less than 0.005mm (<0.005mm)

CLASSIFICATION

Cohesive Soil - Unconfined Compressive Strength

Consistency		q_u (tons/sq. ft.)
Very Soft	-	Less than 0.25
Soft	-	0.25 to 0.49
Medium	-	0.50 to 0.99
Stiff	-	1.00 to 1.99
Very Stiff	-	2.00 to 3.99
Hard	-	≥ 4.00

Cohesionless Soil

Relative Density		"N" Value (Blows/ft)
Very Loose	-	0 - 4
Loose	-	5 - 9
Medium	-	10 - 29
Dense	-	30 - 49
Very Dense	-	50 - 79
Extremely Dense	-	≥ 80

Cohesive Soil – Per ASTM D 2488

Consistency		Criteria
Very Soft	-	Thumb will penetrate soil more than 1 inch
Soft	-	Thumb will penetrate soil about 1 inch
Firm	-	Thumb will indent soil about ¼ inch
Hard	-	Thumb will not indent soil but readily indented with thumbnail
Very Hard	-	Thumbnail will not indent soil

Soil Constituents

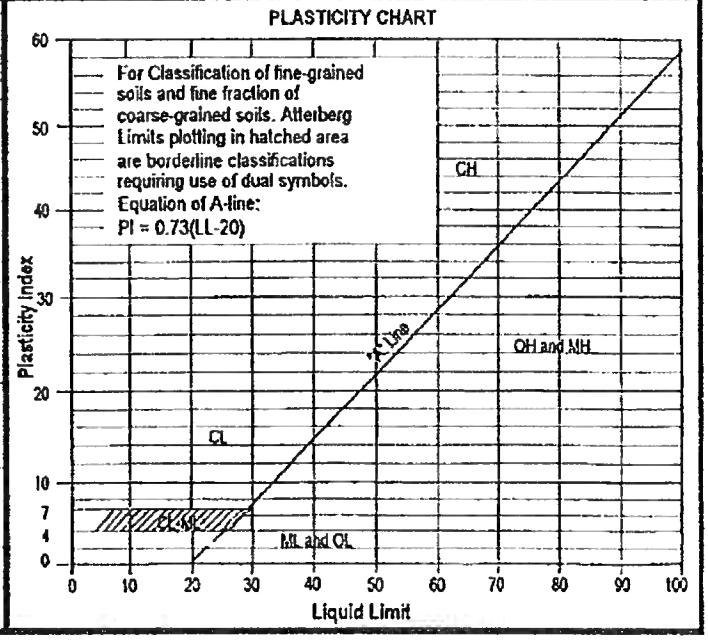
Trace	Less than 10%
Trace to Some	10% to 19%
Some	20% to 34%
And	35% - 50%

Soil Description Terminology

If clay content is sufficient so that clay appears to dominate soil properties then clay becomes the primary noun with the other major soil constituent as modifiers, i.e., silty clay. Other minor soil constituents may be added according to estimates of soil constituents present, e.g., silty clay - trace to some sand.

Unified Soil Classification

Major Divisions			Group Symbols	Typical Names	Laboratory Classification Criteria	
Coarse Grained Soils (More than half of material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean Gravels (Little or no fines)	GW	Well graded gravels, gravel-sand mixtures, little or no fines	$Cu = \frac{D_{60}}{D_{10}}$ greater than 4; $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines	Not meeting all gradation requirements for GW.	
		Gravels with fines (Appreciable amount of fines)	GM d / GM u	Silty gravels, gravel-sand-silt mixtures	Atterberg limits below "A" line or PI less than 4	Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols.
			GC	Clayey gravels, gravel-sand-clay mixtures	Atterberg limits above "A" line with PI greater than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean Sands (Little or no fines)	SW	Well graded sands, gravelly sands, little or no fines	$Cu = \frac{D_{60}}{D_{10}}$ greater than 6; $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			SP	Poorly graded sands, gravelly sands, little or no fines	Not meeting all gradation requirements for SW.	
		Sands with fines (Appreciable amount of fines)	SM d / SM u	Silty sands, sand-silt mixtures	Atterberg limits below "A" line or PI less than 4	Limits plotting in hatched zone with PI between 4 and 7 are borderline cases requiring use of dual symbols.
			SC	Clayey sands, sand-clay mixtures	Atterberg limits above "A" line with PI greater than 7	
Fine Grained Soils (More than half of material is smaller than No. 200 sieve size)	Silts and Clays (liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity		
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays		
			OL	Organic silts and organic silty clays of low plasticity		
	Silts and Clays (liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts		
			CH	Inorganic clays of high plasticity, fat clays		
			OH	Organic clays of medium to high plasticity, organic silts		
	Highly Organic Soils		Pt	Peat and other highly organic soils		

Determine percentage of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse grained soils are classified as follows:
Less than 5%.....GW, GP, SW, SP
More than 12%.....GM, GC, SM, SC
5 to 12%.....Borderline cases requiring dual symbols

PLASTICITY CHART