# Geotechnical Engineering Report

**Monopole Telecommunications Tower**

**Easton, Connecticut**

September 29, 2017

Terracon Project No. J2175120

**Prepared for:**

InSite Wireless Group LLC

Boston, Massachusetts

**Prepared by:**

Terracon Consultants, Inc.

Rocky Hill, Connecticut

September 29, 2017

InSite Wireless Group LLC
6519 Towpath Road
Boston, Massachusetts 13057

Attn: Robert Mitchell / Tower Operations Manager – Northeast Region
P: (617)-877-3691
E: rmitchell@insitewireless.com

Re: Geotechnical Engineering Report
Monopole Telecommunications Tower
515 Morehouse Road
Easton, Connecticut
Terracon Project No. J2175120

Dear Mr. Mitchell:

We have completed the Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with our Task Order dated September 1, 2017 issued under the Master Services Agreement dated July 11, 2013. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design foundations for the proposed telecommunications tower and accompanying equipment cabinets and generator slabs.

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, please contact us.

Sincerely,
**Terracon Consultants, Inc.**

For

Rachael C. Gaspard
Field Geologist

STATE OF CONNECTICUT BRIAN D. OPP No. 25790 LICENSED PROFESSIONAL ENGINEER

Brian D. Opp, P.E.
Geotechnical Department Manager

## REPORT TOPICS



**Note:** This report was originally delivered in a web-based format. **Orange Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

## ATTACHMENTS

# REPORT SUMMARY

| Topic [1] | Overview Statement [2] |
|---|---|
| **Project Description** | Construction of a 150-foot high steel monopole telecommunications tower and associated appurtenances within a 70-foot by 70-foot fenced compound area. |
| **Geotechnical Characterization** | Forest mat and subsoil over native poorly graded sand with gravel underlain by shallow bedrock. |
| **Earthwork** | The removal of forest mat and subsoil and the placement of fill. Minor cuts and fills up to about 3 feet, or so, are anticipated to develop the site. Permanent soil slopes should be designed as 3 Horizontal to 1 Vertical, maximum. |
| **Shallow Foundations** | The proposed telecommunications tower and equipment cabinets may be supported using either a monolithic mat or a pier-and-pad foundation bearing directly on bedrock or a thin layer of minus ¾-inch crushed stone placed on the bedrock. Rock anchors may be used to provide adequate overturning and sliding resistance, if sufficient embedment is not achieved in the bedrock. The generator slabs may derive support from either the inorganic subsoil or the underlying bedrock. |
| **General Comments** | This section contains important information about the limitations of this geotechnical engineering report. |

1. If the reader is reviewing this report as a PDF, the topics above can be used to access the appropriate section of the report by simply clicking on the topic itself.
2. This summary is for convenience only. It should be used in conjunction with the entire report for design purposes.

# Geotechnical Engineering Report

**Monopole Telecommunications Tower**
**515 Morehouse Road**
**Easton, Connecticut**
**Terracon Project No. J2175120**
**September 29, 2017**

## INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed telecommunication tower to be located at 515 Morehouse Road in Easton, Connecticut. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Site preparation and earthwork
- Foundation design and construction
- Slab design and construction
- Seismic site classification per IBC

The geotechnical engineering scope of services for this project included the advancement of one test boring (B-1) to a depth of approximately 13 feet below ground surface (BGS) and three test probes (P-1, P-2, and P-2A) to depths ranging from about 1 to 5 feet BGS.

Maps showing the site and boring locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. The results of the field explorations are included on the boring logs in the **Exploration Results** section of this report.

## SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

| Item | Description |
|---|---|
| **Parcel Information** | 515 Morehouse Road, located southeast of Samuel Staples Elementary School, in the city of Easton, Connecticut.<br>Latitude: 41° 14' 08.10" N<br>Longitude: 73° 17' 07.34" W<br>See **Site Location** |
| **Existing Improvements** | Forested Land |
| **Current Ground Cover** | Forest Mat and Trees |
| **Existing Topography** | Steep gradient to the southeast |
| **Geology** | The *Surficial Materials Map of Connecticut, 1992,* identifies the native soils in the vicinity of the site as being glacial till. The *Bedrock Geologic Map of Connecticut, 1985,* indicates that the bedrock underlying the site, at depth, consists of the Straits Schist (Goshen Formation of Massachusetts). |

## PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed in the project planning stage. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

| Item | Description |
|---|---|
| **Information Provided** | Drawing set titled *"CT254 Easton"*, Sheet No. SP-1, revised March 15, 2017, by All-Points Technology Corporation of Killingworth, Connecticut. |
| **Project Description** | The construction of a 150-foot high steel monopole telecommunications tower, equipment shelter, generator and propane tank within a 70-foot by 70-foot fenced compound area. |
| **Estimated Maximum Loads** | ■ Tower dead load: 60 kips<br>■ Equipment pads: 150 pounds per square foot (psf). |
| **Grading/Slopes** | Minor cuts and fills up to about 3 feet, or so, are anticipated to develop the site. Permanent soil slopes should be designed as 3 Horizontal to 1 Vertical (3H:1V) maximum. |

# GEOTECHNICAL CHARACTERIZATION

## Subsurface Profile

Subsurface conditions at the exploration locations can be generalized as follows:

| Stratum | Approximate Depth to Bottom of Stratum (feet) | Material Description [1] | Consistency/Density |
|---|---|---|---|
| 1 | 1 to 3.5 | Poorly graded sand (SP), with gravel, brown | Medium dense |
| 2 | N/A | Mica Schist, slightly weathered, medium strong to strong, close to moderate joint spacing, gray | N/A |

1. Forest mat (about 2 inches in thickness) was encountered at the ground surface of the explorations.

Conditions encountered at each exploration location are indicated on the individual logs shown in the **Exploration Results** section and are attached to this report. Stratification boundaries on the logs represent the approximate location of changes in native soil/rock types; *in-situ*, the transition between materials may be gradual.

## Groundwater Conditions

Groundwater was not observed in our explorations while drilling, or for the short duration the explorations could remain open. However, groundwater may be perched on the relatively impermeable bedrock. Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were 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 logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

# GEOTECHNICAL OVERVIEW

The proposed telecommunications tower may be supported on either a monolithic mat or a pier-and-pad foundation bearing directly on bedrock or on a thin layer of minus ¾-inch crushed stone placed on the bedrock. Sand and gravel fill should not be placed directly over bedrock. Rock anchors may be used in order to provide adequate overturning and sliding resistance, if sufficient embedment is not achieved in the bedrock. The proposed equipment platform may derive support from either the inorganic subsoil or the underlying bedrock. Design recommendations are presented in the following sections.

We recommend that the exposed subgrades be thoroughly evaluated after excavation to proposed grade. We further recommend that the geotechnical engineer be retained to evaluate the bearing material for the foundation subgrade.

The **General Comments** section provides an understanding of the report limitations.

# EARTHWORK

## Site Preparation

Preparation of the site should include removal of topsoil, organic subsoil (subsoil with visible roots), or otherwise unsuitable materials. The soil subgrade should be proof rolled with a vibratory roller or heavy plate compactor. Unstable subgrades should be removed and replaced with compacted Structural Fill or ¾-inch sized crushed stone, as necessary. If required, Structural Fill may then be placed within the compound area to attain the required grade. Bedrock subgrades, if encountered, should not be steeper than 4 Horizontal to 1 Vertical (4H:1V). Low spots in the bedrock subgrade may be filled with lean concrete or ¾-inch crushed stone to provide a reasonably level surface. Bedrock subgrades do not require proof rolling.

## Reuse on Onsite Materials

Based on our visual observations of the exploration results, it is our opinion that the native poorly graded sand with gravel may be selectively reused for Common and Structural Fill, provided it is mixed with imported granular material (such that it is close to meeting our gradation requirements presented below), it is placed at moisture contents suitable to facilitate compaction, and it is compacted to the densities provided below. Cobbles and boulders should be culled from the material prior to reuse.

## Fill Material Types

Fill should meet the following material property requirements:

| Fill Type [1] | USCS Classification | Acceptable Locations for Placement |
|---|---|---|
| Structural Fill [2] | GW, GW-GM, SW, SW-SM, SP, GP | All locations and elevations, including backfill of the excavation to remove existing fill. Imported soils used as Structural Fill should meet the gradation requirements in Note 2 (below). Cobbles and boulders should be culled prior to reuse. |
| Slab Base | GW, GW-GM, SW, SW-SM, SP, GP | Select fill beneath slabs should bee the gradation requirements of CTDOT M.02.06, Grading B. |

| Fill Type [1] | USCS Classification | Acceptable Locations for Placement |
|---|---|---|
| Common Fill [3] | Varies | Common Fill may be used for general site grading. Common Fill should not be used under settlement or frost-sensitive structures. Cobbles and boulders should be culled prior to reuse. |

1. Compacted fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used. Fill should not be placed on a frozen subgrade.
2. Imported Structural Fill should consist of inorganic, readily compactable, well-graded granular soils with a maximum particle size of 6 inches and no more than 15 percent by weight passing the No. 200 sieve.
3. Common fill should have a maximum particle size of 6 inches and no more than 25 percent by weight passing the US No. 200 sieve.

## Fill Compaction Requirements

Structural Fill should meet the following compaction requirements:

| Item | Description |
|---|---|
| **Fill Lift Thickness** | ■ 8 inches or less in loose thickness when hand operated equipment is used<br>■ 12 inches of less in loose thickness when heavy compaction is used |
| **Compaction Requirements [1]** | 95 percent maximum modified Proctor dry density (ASTM D1557, Method C) |
| **Moisture Content – Granular Material** | Workable moisture levels |

1. We recommend that 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.

## Utility Trench Backfill

Trench excavations should be made with sufficient working space to permit construction including backfill placement and compaction. As utility trenches can provide a conduit for groundwater flow, trenches should be backfilled with material that approximately matches the permeability characteristics of the surrounding soil. Should higher permeability fill be used in trenches, consideration should be given to installing seepage collars and/or check dams to reduce the likelihood of migration of water through the trenches. Fill placed as backfill for utilities located below the slab should consist of compacted structural fill or suitable material.

## Grading and Drainage

We anticipate that permanent soil slopes will be required to develop the compound area. Soil slopes should be designed at 3 Horizontal (H):1 Vertical (V). Steeper grades, up to 2H:1V, may be feasible for slopes of limited height, but should be reviewed by Terracon prior to final design.

Permanent fill and cut slope surfaces should be vegetated, or covered with an erosion control mat, to protect against erosion. Temporary sedimentation and erosion control methods should be implemented during construction and left in place until the slope surface has been permanently stabilized.

Adequate drainage should be provided at the site to reduce the likelihood of an increase in moisture content of the foundation soils. Pavement should be sloped away from the compound area to reduce the likelihood of water ponding near the structures.

## Earthwork Construction Considerations

Although the exposed subgrade is anticipated to be relatively stable upon initial exposure, unstable subgrade conditions could develop during general construction operations, particularly if the soils are wetted and/or subjected to repetitive construction traffic. Should unstable subgrade conditions develop, stabilization measures will need to be employed.

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, wet, or disturbed, the affected material should be removed, or should be scarified, moisture conditioned, and recompacted.

As a minimum, temporary excavations should be sloped or braced, as required by Occupational Safety and Health Administration (OSHA) regulations, to provide stability and safe working conditions. Temporary excavations will probably be required during grading operations. The contractor, by his contract, is usually 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. All excavations should comply with applicable local, State, and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

Groundwater was not encountered at the time of our explorations. Therefore, we do not anticipate that temporary dewatering will be required.

Terracon should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during subgrade preparation; proofrolling;

placement and compaction of controlled compacted fills; backfilling of excavations in the completed subgrade; and just prior to construction of foundations.

# SHALLOW FOUNDATIONS

## Tower Foundation Design Recommendations

We recommend that the proposed telecommunications tower be supported on either a monolithic mat or a pier-and-pad foundation placed directly on the bedrock or on a thin layer of minus ¾-inch crushed stone placed on the bedrock. The size and depth of the footing will likely be dictated by providing overturning and sliding resistance, unless rock anchors are used. The mat/pad should not be supported partially on bedrock and partially on soil. The subsoil should be over excavated to allow placement of the mat/pad directly on the bedrock. Design recommendations and construction considerations for the recommended foundation system are presented in the following tables and paragraphs.

| Item | Description |
|---|---|
| **Net allowable bearing pressure** [1] | 12,000 psf |
| **Minimum embedment below finished grade for frost protection** | 42 inches |
| **Approximate total settlement** [2] | Negligible |
| **Estimated differential settlement** [2] | Negligible |
| **Total Unit Weight (**γ**)** | 165 pcf |
| **Passive pressure coefficient, $K_p$** [3] **(compacted fill around base of foundation)** | 3.0 (ultimate) |
| **Passive pressure coefficient, $K_p$** [4] **(foundation concrete cast against rock face)** | 6.0 (ultimate) |
| **Coefficient of sliding friction (bedrock)** [4] | 0.7 (ultimate) |

1. The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the foundation base elevation.
2. Foundation settlement should be neglible if founded directly on bedrock or on a few inches of ¾-inch minus crushed stone over bedrock.
3. Passive pressure calculated with this parameter should be reduced by at least a factor of safety of 3, to reflect the amount of movement required to mobilize the passive resistance.
4. Passive pressure calculated with this parameter should be reduced by at least a factor of safety of 1.5.
5. A factor of safety of at least 1.5 should be applied to the sliding resistance.

Uplift resistance for the tower foundation may be computed as the sum of the weight of the foundation element and the weight of the soil overlying the foundation. We recommend using a soil unit weight of 100 pounds per cubic foot (pcf) for engineered fill overlying the footing placed as described in this section of this report. A unit weight of 150 pcf may be used for reinforced footing concrete. A factor of safety of 1.0 may be applied to calculations of dead load; a higher factor of safety may be appropriate for loadings resisted by dead load.

## Tower Foundation Construction Considerations

Competent bedrock was encountered in the explorations at depths ranging from about 1 to 5 feet BGS. Therefore, excavation into bedrock will likely be required in order for the foundation to provide adequate resistance to overturning. Bedrock excavation can be carried out by explosive or non-explosive methods. Depending on the amount of bedrock removal, mechanical methods may be appropriate. However, the contractor should be aware that the bedrock was competent with a relatively fair RQD. If blasting is to be avoided, an increase in mechanical effort than is typical for this method may be required.

Bedrock subgrades should be no steeper than 4H:1V and free of loose rock or soil. Bedrock subgrades steeper than 4H:1V should be benched to provide a relatively level bearing surface. Minor irregularities in the level of the rock surface may be filled with lean concrete or minus ¾-inch crushed stone to provide a level working surface. The joints in competent bedrock should be tight; care should be taken not to displace the joints in the bedrock during excavation.

In order for the mat/pad not to be supported partially on bedrock and partially on soil, subsoil should be over excavated to allow placement of the mat/pad foundation on bedrock surface. The base of foundation excavations should be free of water and loose soil/broken rock prior to placing concrete. The geotechnical engineer should be retained to observe the foundation bearing materials.

Groundwater was not encountered at the time of our explorations. However, the contractor should prevent groundwater, if encountered, and surface water runoff from collecting in the excavation. Subgrade soils that become unstable because of water and/or reworking by construction activity should be replaced with compacted structural fill, as necessary.

## Rock Anchors

In order to reduce the amount of rock excavation required, rock anchors could be installed to provide uplift and sliding resistance. Either cement grouted or resin rock anchors could be used. The design, installation, and proof testing of rock anchors should be completed in accordance with the *Recommendations for Prestressed Rock and Soil Anchors* by the Post-Tensioning Institute (PTI) and manufacturer's recommendations.

| Description | Value |
|---|---|
| Ultimate bond stress[1] (cement grouted anchors) | 200 pounds per square inch (psi) |
| Unit weight of rock [2] (resin grouted anchors) | 165 pounds per cubic foot (pcf) |
| Minimum anchor bonded length | 10 feet |
| Minimum anchor unbounded length | 10 feet |

1. A factor of safety of at least 2 should be applied to the ultimate bond stress.
2. A factor of safety of 1 based on dead weight resistance may be used.

## Equipment Cabinet Foundations

Equipment cabinets and ancillary structures may be supported on slabs deriving support from the inorganic subsoil or bedrock. A minimum 12-inch thick layer of Structural Fill should be used beneath the slabs deriving support from inorganic subsoil. A minimum 12-inch thick layer of minus ¾-inch crushed stone should be used beneath the slabs deriving support from bedrock. Design recommendations for the proposed structures are presented in the following table:

## Slab Design Recommendations

| Description | Value |
|---|---|
| **Slab support (compacted minus ¾-inch crushed stone over bedrock)** | Minimum 12-inch thick layer |
| **Slab support (compacted Structural Fill over inorganic subsoil)** | |
| **Modulus of subgrade reaction** | 150 pounds per square inch per in (psi/in) for point loading |
| **Minimum embedment below finished grade for frost protection** [1,2] | 42 inches |
| **Approximate total settlement** [3] | 1 inch |
| **Estimated differential settlement** [3] | ½ inch |
| **Coefficient of sliding friction** [4,5] | 0.5 (ultimate) |

1. Consideration should be given to using dense insulation boards (Dow Styrofoam High load, or similar) under and adjacent to lightly loaded slabs-on-grade, to provide the equivalent of 42 inches of earth cover, thus reducing frost penetration.
2. Air entraining admixtures should be used for concrete exposed to freezing.
3. Settlement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the thickness of compacted fill, and the quality of the earthwork operations. Settlement of slabs deriving support from bedrock will be negligible.
4. A factor of safety of at least 1.5 should be applied to the sliding resistance.
5. If rigid insulation is used beneath the slab for frost protection, the coefficient of sliding friction between the concrete and the insulation should be based on the manufacturer's recommendation.

### Slab Construction Considerations

We anticipate shallow bedrock within the proposed compound area. Therefore, proof rolling subgrades for the equipment slabs will not be required. Removal of high spots in the bedrock surface may be required in order to achieve subgrade elevation, especially to the northwest of the tower, where cuts up to a couple of feet below the existing grade are anticipated. Bedrock subgrades should prepare as recommended in the **Tower Foundations Construction Consideration** section. Structural fill should not be placed directly on the bedrock surface.

### Seismic Considerations

| Description | Value |
|---|---|
| **Code Used** [1] | Connecticut State Building Code (CBC) |
| **Site Class** [2] | B |
| **Maximum considered earthquake ground motions (5 percent damping)** | 0.066g (1.0 second spectral response acceleration) |
| | 0.215g (0.2 second spectral response acceleration) |
| **Liquefaction potential in event of an earthquake** | Not susceptible |

1. The CBC incorporates the Seismic Design Category approach of the 2012 International Building Code (IBC).
2. The CBC uses a site soil profile determination extending a depth of 100 feet for seismic site classification. The current scope requested does not include a 100-foot soil profile determination; the boring performed for this report extended to a maximum depth of 13 feet. However, the encountered bedrock will extend to a depth of at least 100 feet.

## GENERAL COMMENTS

Our services are conducted with the understanding of the project as described in the proposal, and will incorporate collaboration with the design team as we complete our services to verify assumptions. Revision of our understanding to reflect actual conditions important to our services will be based on these verifications and will be reflected in the final report. The design team should collaborate with Terracon to confirm these assumptions and to prepare the final design plans and specifications. This facilitates the incorporation of our opinions related to implementation of our geotechnical recommendations. Any information conveyed prior to the final report is for informational purposes only and should not be considered or used for decision-making purposes.

Our analysis and opinions are based upon our understanding of the geotechnical conditions in the area, the data obtained from our site exploration and from our understanding of the project. Variations will occur between exploration point locations, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in the final report, to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our scope of services 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.

Our services and any correspondence are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third party beneficiaries intended. Any third party access to services or correspondence is solely for information purposes only. Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

# ATTACHMENTS

# EXPLORATION AND TESTING PROCEDURES

## Field Exploration

| Number of Explorations | Exploration Depth (feet) | Planned Location |
|---|---|---|
| 1 | 13 | Telecommunication Tower |
| 3 | 1 to 5 | Ancillary Equipment |

**Boring Layout and Elevations:** The locations of the explorations, which are shown on the Exploration Plan, were located in the field using a hand-held GPS unit (horizontal accuracy of approximately 10 feet). The ground elevation at the exploration locations was estimated by interpolating between contours of existing grade shown on the provided *"Compound Plan & Tower Elevation"*, Sheet No. SP-2, revised March 15, 2017, by All-Points Technology Corporation, which includes contours at 1-foot intervals. The locations and elevations of the explorations should be considered accurate only to the degree implied by the method used to define them.

**Subsurface Exploration Procedures:** Terracon monitored the advancement of one test boring (B-1) and three test probes (P-1, P-2, and P-2A) on September 15, 2017 using an all-terrain vehicle (ATV) mounted Deidrich D-50 rotary drill rig. B-1 was advanced using 4-inch diameter continuous flight solid stem augers (SSA) to a depth of about 3 feet. Competent bedrock was then cored from approximately 3 to 13 feet using an NQ2-sized core barrel.

In the split-barrel sampling procedure, which was used to take soil samples in the test borings, the number of blows required to advance a standard 2-inch O.D. split-barrel sampler typically the middle 12 inches of the total 24-inch penetration by means of a 140-pound safety-hammer with a free fall of 30 inches is the Standard Penetration Test (SPT) resistance value "N". This "N" value is used to estimate the *in-situ* relative density of cohesionless soils and consistency of cohesive soils.

The soil samples were placed in labeled glass jars and taken, along with the rock core in a wooden core box, to our laboratory for further review and classification by a Terracon geotechnical engineer. Information provided on the exploration logs attached to this report includes soil/rock descriptions, relative density and/or consistency evaluations, exploration depths, sampling intervals, and groundwater conditions. B-1 was backfilled with auger cuttings prior to the drill crew leaving the site.

P-1, P-2, and P-2A were advanced using 4-inch diameter SSA's to further evaluate the subsurface conditions within the proposed tower compound area. P-1 terminated on competent bedrock at a depth of about 5 feet BGS. P-2 and P-2A terminated upon auger refusal on probable bedrock at depths of approximately 1.5 feet and 1 foot, respectively. The probes were backfilled with auger cuttings prior to the drill crew leaving the site.

Field logs of the explorations were prepared by a Terracon field engineer. These logs included visual classifications of the materials encountered during the explorations as well as interpretation by our field engineer of the subsurface conditions between samples. Final exploration logs included with this report represent further interpretation by the geotechnical engineer of the field logs.

## Laboratory Testing

Descriptive classifications of the soils indicated on the exploration logs are in accordance with the enclosed General Notes, the Unified Soil Classification System (USCS), and the Description of Rock Properties. USCS symbols are also shown. A brief description of the USCS is attached to this report. Classification was generally by visual/manual procedures.

# SITE LOCATION AND EXPLORATION PLANS

**SITE LOCATION**

Monopole Telecommunications Tower ■ Easton, Connecticut

September 29, 2017 ■ Terracon Project No. J2175120

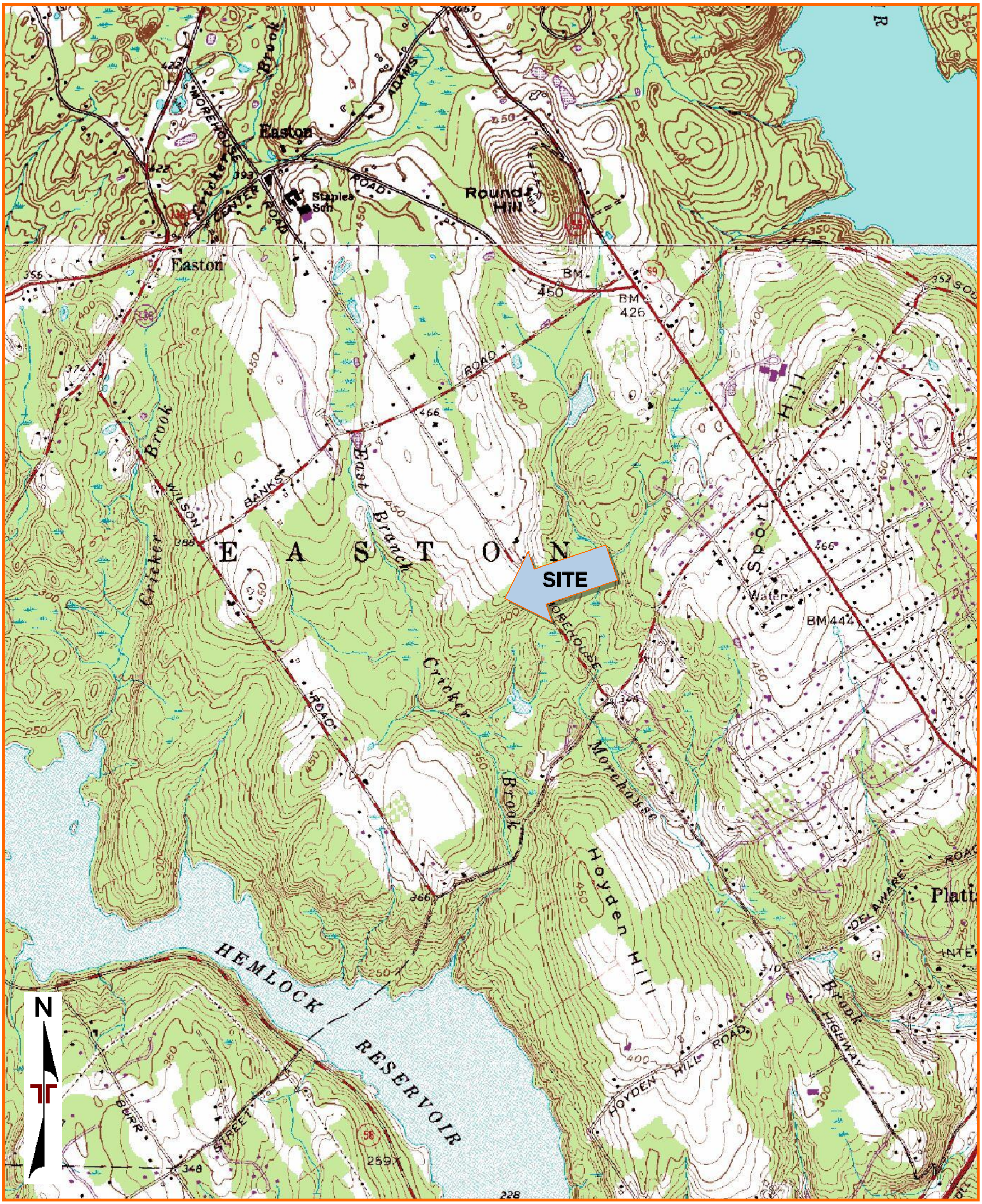



DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY QUADRANGLES INCLUDE: BOTSFORD, CT (1/1/1984) and WESTPORT, CT (1/1/1975).

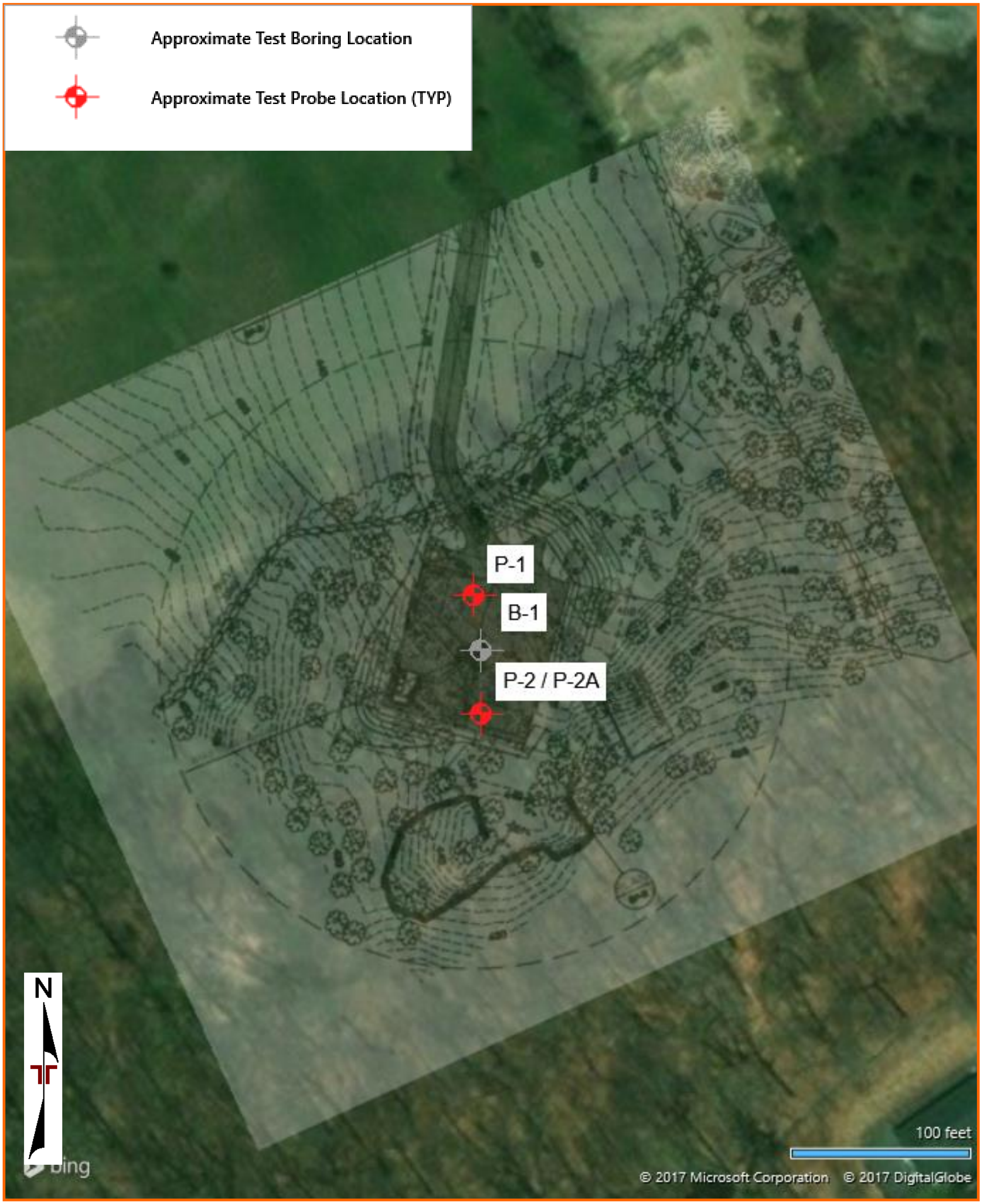



DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

# EXPLORATION RESULTS

# BORING LOG NO. B-1

| | |
|---|---|
| **PROJECT: Monopole Telecommunications Tower** | **CLIENT: InSite Wireless Group LLC Boston, Massachusetts** |
| **SITE: 515 Morehouse Road Easton, Connecticut** | |

LOCATION See Exploration Plan

Approximate Surface Elev: 441 (Ft.) +/-

| GRAPHIC LOG | DEPTH | DESCRIPTION | ELEVATION (Ft.) | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | RECOVERY (In.) | FIELD TEST RESULTS |
|---|---|---|---|---|---|---|---|---|
| | 0.2 | **FOREST MAT** | 441+/- | | | | | |
| | 3.0 | **POORLY GRADED SAND (SP)**, with gravel, brown, medium dense | 438+/- | | | | 10 | 3-5-9-50/3" N=14 |
| | 13.0 | **MICA SCHIST**, gray, slightly weathered, medium strong to strong, close to moderate joint spacing | 428+/- | 5 | | | 60 | Core Rate (min/ft): 1.5-2-2-1.5-2.5 RQD=68% |
| | | | | 10 | | | 60 | Core Rate (min/ft): 2-2-2.5-2.5-2.5 RQD=58% |

***Boring Terminated at 13 Feet***

Stratification lines are approximate. In-situ, the transition may be gradual.
Samples taken with 2" outside-diameter split spoon sampler driven by an autohammer.

Advancement Method:
4-inch diameter continuous flight solid stem augers to 3 feet, 4-inch inside diameter flush wall casing set at 3 feet and NQ2-sized core barrel to 13 feet.

Abandonment Method:
Backfilled with soil cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

**WATER LEVEL OBSERVATIONS**

*No free water observed*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

| | |
|---|---|
| Boring Started: 09-15-2017 | Boring Completed: 09-15-2017 |
| Drill Rig: Diedrich D-50 | Driller: J. Casson |
| Project No.: J2175120 | |

# PROBE LOG NO. P-1



**PROJECT: Monopole Telecommunications Tower**

**CLIENT: InSite Wireless Group LLC**
**Boston, Massachusetts**

**SITE: 515 Morehouse Road**
**Easton, Connecticut**

LOCATION See Exploration Plan

Approximate Surface Elev: 444 (Ft.) +/-

| GRAPHIC LOG | DEPTH | | ELEVATION (Ft.) | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | RECOVERY (In.) | FIELD TEST RESULTS |
|---|---|---|---|---|---|---|---|---|
| | 0.2 | **FOREST MAT** | 444+/- | | | | | |
| | | **POORLY GRADED SAND (SP)**, with gravel, brown | | | | | | |
| | 3.5 | | 440.5+/- | | | | | |
| | | **WEATHRED MICA SCHIST**, gray | | | | | | |
| | 5.0 | | 439+/- | 5 | | | | |
| | | ***Auger Refusal on Competent Bedrock at 5 Feet*** | | | | | | |

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
4-inch diameter continuous flight solid stem augers.

Abandonment Method:
Backfilled with soil cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

**WATER LEVEL OBSERVATIONS**

*No free water observed*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

| | |
|---|---|
| Probe Started: 09-15-2017 | Probe Completed: 09-15-2017 |
| Drill Rig: Diedrich D-50 | Driller: J. Casson |
| Project No.: J2175120 | |

# PROBE LOG NO. P-2

| PROJECT: Monopole Telecommunications Tower | CLIENT: InSite Wireless Group LLC<br>Boston, Massachusetts |
|---|---|
| SITE: 515 Morehouse Road<br>Easton, Connecticut | |

| GRAPHIC LOG | LOCATION See Exploration Plan<br>Approximate Surface Elev: 439 (Ft.) +/-<br>DEPTH / ELEVATION (Ft.) | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | RECOVERY (In.) | FIELD TEST RESULTS |
|---|---|---|---|---|---|---|
| | 0.2 **FOREST MAT** 439+/- | | | | | |
| | **POORLY GRADED SAND (SP)**, with gravel, brown | | | | | |
| | 1.5 437.5+/- | | | | | |
| | ***Auger Refusal on Probable Bedrock at 1.5 Feet*** | | | | | |

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
4-inch diameter continuous flight solid stem augers.

Abandonment Method:
Backfilled with soil cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

**WATER LEVEL OBSERVATIONS**

*No free water observed*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

| | |
|---|---|
| Probe Started: 09-15-2017 | Probe Completed: 09-15-2017 |
| Drill Rig: Diedrich D-50 | Driller: J. Casson |
| Project No.: J2175120 | |

# PROBE LOG NO. P-2A

| PROJECT: Monopole Telecommunications Tower | CLIENT: InSite Wireless Group LLC Boston, Massachusetts |
|---|---|
| SITE: 515 Morehouse Road Easton, Connecticut | |

LOCATION See Exploration Plan

Approximate Surface Elev: 439 (Ft.) +/-

| GRAPHIC LOG | DEPTH | | ELEVATION (Ft.) | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | RECOVERY (In.) | FIELD TEST RESULTS |
|---|---|---|---|---|---|---|---|---|
| | 0.2 | **FOREST MAT** | 439+/- | | | | | |
| | 1.0 | **POORLY GRADED SAND (SP)**, with gravel, brown | 438+/- | | | | | |
| | | ***Auger Refusal on Probable Bedrock at 1 Foot*** | | | | | | |

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
4-inch diameter continuous flight solid stem augers.

Abandonment Method:
Backfilled with soil cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

**WATER LEVEL OBSERVATIONS**

*No free water observed*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

| | |
|---|---|
| Probe Started: 09-15-2017 | Probe Completed: 09-15-2017 |
| Drill Rig: Diedrich D-50 | Driller: J. Casson |
| Project No.: J2175120 | |

# SUPPORTING INFORMATION

# GENERAL NOTES

## DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

**Monopole Telecommunications Tower ■ Easton, Connecticut**

**9/29/2017 ■ J2175120**

Terracon GeoReport

| SAMPLING | WATER LEVEL | FIELD TESTS |
|---|---|---|
| Rock Core<br>Standard Penetration Test | ▽ **Water Initially Encountered**<br>▽ **Water Level After a Specified Period of Time**<br>▼ **Water Level After a Specified Period of Time**<br><br>Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations. | **N** **Standard Penetration Test Resistance (Blows/Ft.)**<br>**(HP)** **Hand Penetrometer**<br>**(T)** **Torvane**<br>**(DCP)** **Dynamic Cone Penetrometer**<br>**UC** **Unconfined Compressive Strength**<br>**(PID)** **Photo-Ionization Detector**<br>**(OVA)** **Organic Vapor Analyzer** |

### DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil 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.

### LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no ctual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

### STRENGTH TERMS

| **RELATIVE DENSITY OF COARSE-GRAINED SOILS** (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance | | **CONSISTENCY OF FINE-GRAINED SOILS** (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance | | | **BEDROCK** | |
|---|---|---|---|---|---|---|
| **Descriptive Term (Density)** | **Standard Penetration or N-Value Blows/Ft.** | **Descriptive Term (Consistency)** | **Unconfined Compressive Strength Qu, (tsf)** | **Standard Penetration or N-Value Blows/Ft.** | **Standard Penetration or N-Value Blows/Ft.** | **Descriptive Term (Consistency)** |
| Very Loose | 0 - 3 | Very Soft | less than 0.25 | 0 - 1 | < 20 | Weathered |
| Loose | 4 - 9 | Soft | 0.25 to 0.50 | 2 - 4 | 20 - 29 | Firm |
| Medium Dense | 10 - 29 | Medium Stiff | 0.50 to 1.00 | 4 - 8 | 30 - 49 | Medium Hard |
| Dense | 30 - 50 | Stiff | 1.00 to 2.00 | 8 - 15 | 50 - 79 | Hard |
| Very Dense | > 50 | Very Stiff | 2.00 to 4.00 | 15 - 30 | >79 | Very Hard |
| | | Hard | > 4.00 | > 30 | | |

| **RELATIVE PROPORTIONS OF SAND AND GRAVEL** | | **RELATIVE PROPORTIONS OF FINES** | |
|---|---|---|---|
| **Descriptive Term(s) of other constituents** | Percent of Dry Weight | **Descriptive Term(s) of other constituents** | **Percent of Dry Weight** |
| Trace | <15 | Trace | <5 |
| With | 15-29 | With | 5-12 |
| Modifier | >30 | Modifier | >12 |

| **GRAIN SIZE TERMINOLOGY** | | **PLASTICITY DESCRIPTION** | |
|---|---|---|---|
| **Major Component of Sample** | **Particle Size** | **Term** | **Plasticity Index** |
| Boulders | Over 12 in. (300 mm) | Non-plastic | 0 |
| Cobbles | 12 in. to 3 in. (300mm to 75mm) | Low | 1 - 10 |
| Gravel | 3 in. to #4 sieve (75mm to 4.75 mm) | Medium | 11 - 30 |
| Sand | #4 to #200 sieve (4.75mm to 0.075mm | High | > 30 |
| Silt or Clay | Passing #200 sieve (0.075mm) | | |

| Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A] | | | | Soil Classification: Group Symbol | Soil Classification: 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-inch (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] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[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.

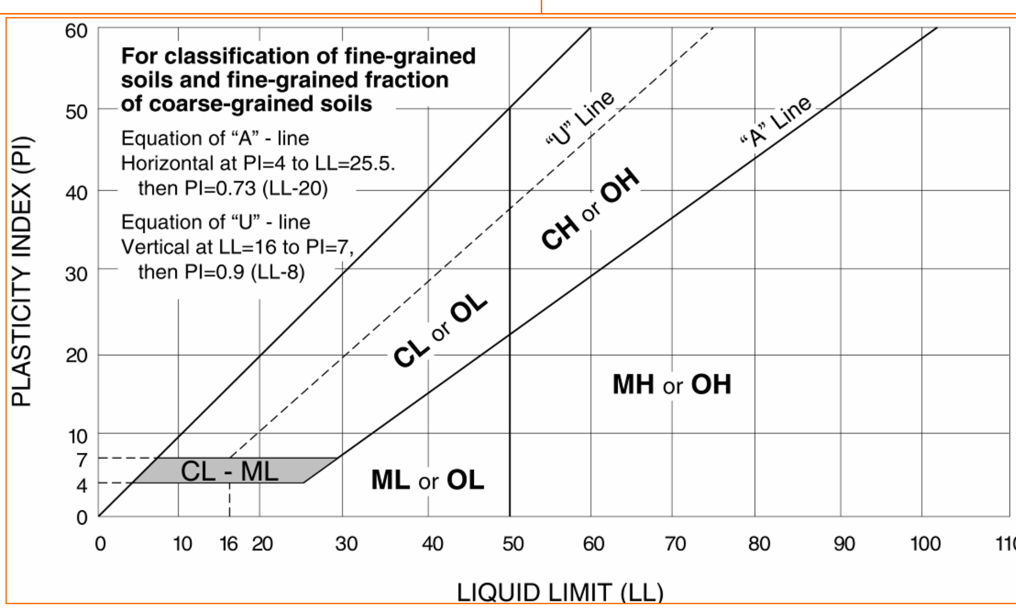
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[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.



# DESCRIPTION OF ROCK PROPERTIES

| WEATHERING | |
|---|---|
| **Term** | **Description** |
| **Unweathered** | No visible sign of rock material weathering, perhaps slight discoloration on major discontinuity surfaces. |
| **Slightly weathered** | Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker externally than in its fresh condition. |
| **Moderately weathered** | Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a continuous framework or as corestones. |
| **Highly weathered** | More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones. |
| **Completely weathered** | All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact. |
| **Residual soil** | All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported. |

| STRENGTH OR HARDNESS | | |
|---|---|---|
| **Description** | **Field Identification** | **Uniaxial Compressive Strength, PSI (MPa)** |
| **Extremely weak** | Indented by thumbnail | 40-150 (0.3-1) |
| **Very weak** | Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife | 150-700 (1-5) |
| **Weak rock** | Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer | 700-4,000 (5-30) |
| **Medium strong** | Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer | 4,000-7,000 (30-50) |
| **Strong rock** | Specimen requires more than one blow of geological hammer to fracture it | 7,000-15,000 (50-100) |
| **Very strong** | Specimen requires many blows of geological hammer to fracture it | 15,000-36,000 (100-250) |
| **Extremely strong** | Specimen can only be chipped with geological hammer | >36,000 (>250) |

| DISCONTINUITY DESCRIPTION | | | |
|---|---|---|---|
| **Fracture Spacing (Joints, Faults, Other Fractures)** | | **Bedding Spacing (May Include Foliation or Banding)** | |
| **Description** | **Spacing** | **Description** | **Spacing** |
| **Extremely close** | < ¾ in (<19 mm) | **Laminated** | < ½ in (<12 mm) |
| **Very close** | ¾ in – 2-1/2 in (19 - 60 mm) | **Very thin** | ½ in – 2 in (12 – 50 mm) |
| **Close** | 2-1/2 in – 8 in (60 – 200 mm) | **Thin** | 2 in – 1 ft (50 – 300 mm) |
| **Moderate** | 8 in – 2 ft (200 – 600 mm) | **Medium** | 1 ft – 3 ft (300 – 900 mm) |
| **Wide** | 2 ft – 6 ft (600 mm – 2.0 m) | **Thick** | 3 ft – 10 ft (900 mm – 3 m) |
| **Very Wide** | 6 ft – 20 ft (2.0 – 6 m) | **Massive** | > 10 ft (3 m) |

Discontinuity Orientation (Angle): Measure the angle of discontinuity relative to a plane perpendicular to the longitudinal axis of the core. (For most cases, the core axis is vertical; therefore, the plane perpendicular to the core axis is horizontal.) For example, a horizontal bedding plane would have a 0 degree angle.

| ROCK QUALITY DESIGNATION (RQD*) | |
|---|---|
| **Description** | **RQD Value (%)** |
| **Very Poor** | 0 - 25 |
| **Poor** | 25 – 50 |
| **Fair** | 50 – 75 |
| **Good** | 75 – 90 |
| **Excellent** | 90 - 100 |

*The combined length of all sound and intact core segments equal to or greater than 4 inches in length, expressed as a percentage of the total core run length.

Reference: U.S. Department of Transportation, Federal Highway Administration, Publication No FHWA-NHI-10-034, December 2009 Technical Manual for Design and Construction of Road Tunnels – Civil Elements

Terracon