Raising Cane’s #1233 – Worcester, MA

Geotechnical Engineering Report

July 26, 2024 | Terracon Project No. J2245040

Prepared for:

Raising Cane’s Restaurants, LLC
6800 Bishop Road
Plano, Texas 75024

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July 26, 2024

Raising Cane's Restaurants, LLC
6800 Bishop Road
Plano, Texas 75024

Attn: Mr. Adam Caracci
P: (972) 769-3206
E: acaracci@raisingcanes.com

Re: Geotechnical Engineering Report
Raising Cane's #1233 – Worcester, MA
494 Lincoln Street
Worcester, Massachusetts
Terracon Project No. J2245040

Dear Mr. Caracci:

We have completed the scope of Geotechnical Engineering services for the above referenced project in general accordance with Terracon Proposal No. PJ2245040 dated June 6, 2024. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork, the design and construction of foundations and floor slabs, and pavement design for the proposed project.

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

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Note: This report was originally delivered in a web-based format. Blue Bold text in the report indicates a referenced section heading. For more interactive features, please view your project online at client.terracon.com.

Refer to each individual Attachment for a listing of contents.

Report Summary

Topic [1]	Overview Statement [2]
Project Description	A geotechnical exploration has been performed for the proposed Raising Cane's restaurant to be constructed at 494 Lincoln Street in Worcester, Massachusetts. Seven soil borings and two test pits were completed extending to depths ranging from approximately 3.5 to 8.5 feet and 2.5 to 7.5 feet, respectively, below existing site grades.
Geotechnical Characterization	■ Subsurface conditions encountered in our exploratory borings generally consisted of fill and/or native soil overlying weathered bedrock and bedrock. Approximately 0.6 to 7.0 feet of existing undocumented fill was encountered above the native soils or weathered bedrock in the majority of the borings. The encountered native soil consisted of varying amounts of sand, silt, and gravel. Weathered bedrock were encountered below the overburden soils at depths between about 1.0 to 7.0 below existing site grades. Bedrock was encountered below either the overburden soils or weathered bedrock at depths between about 2.5 to 8.5 below existing site grades. ■ Groundwater was not encountered at the time of our field exploration; however, perched water was observed at about 5 feet below existing site grades at two boring locations (B-1 and B-2). Groundwater conditions may change because of seasonal variations in rainfall, runoff, and other conditions not apparent at the time of drilling or excavations. ■ We have identified existing undocumented fill, areas of shallow bedrock, potentially unstable soils and relatively shallow perched water as geotechnical conditions that may impact the proposed construction. These conditions will require particular attention in project planning, design and during construction and are discussed in greater detail in the Geotechnical Overview section of this report.
Earthwork	Recommended earthwork on the site includes removal of existing vegetation and surface materials including topsoil, concrete, bituminous concrete, and aggregate base course, removal of existing fill, and general site/subgrade preparation including bedrock excavation.

Topic [1]	Overview Statement [2]
Shallow Foundations	Based on subsurface conditions encountered on the site, the proposed building can be supported by Shallow Foundations such as spread-footing foundation systems bearing on a minimum 12-inch-thick layer of Structural Fill or Crushed Stone placed above proofrolled native soil subgrades or bedrock.
Deep Foundations	We understand the proposed canopy structures are planned to be supported on drilled pier/shaft foundation systems. Recommendations for drilled piers/shafts for the canopy structures are provided in the Deep Foundations section of this report.
Floor Systems	A concrete slab-on-grade floor system can be used for the proposed building, provided all existing fill is removed from below the slab, and a minimum 12-inch layer of compacted floor slab base course is used over compacted Structural Fill and/or proof-rolled native soil. Design recommendations for floor systems for the proposed structures and related structural elements are presented in the Floor Slabs section of this report.
Pavements	Recommended paving sections include 3 inches asphalt over 12 inches of aggregate base in light-traffic areas and 4 inches of asphalt over 12 inches of aggregate base course in heavy-traffic areas. Additional recommendation and discussion on pavement design and constructions are presented in the Pavements section of this report.
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.

Introduction

This report presents the results of our subsurface exploration and Geotechnical Engineering services performed for the proposed Raising Cane's restaurant to be located at 494 Lincoln Street in Worcester, Massachusetts. The purpose of these services was to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and rock conditions
- Groundwater conditions
- Seismic site classification per IBC
- Site preparation and earthwork
- Demolition considerations
- Dewatering considerations
- Foundation design and construction
- Floor slab design and construction
- Pavement design and construction
- Frost considerations

The geotechnical engineering Scope of Services for this project included the advancement of test borings, laboratory testing, engineering analysis, and preparation of this report.

Drawings showing the site and boring locations are shown on the Site Location and Exploration Plan, respectively. The results of the laboratory testing performed on soil samples obtained from the site during our field exploration are included on the boring logs and as separate graphs in the Exploration Results section.

Project Description

Our initial understanding of the project was provided in our proposal and was discussed during project planning. 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	The project information described below is based on the following: - A "New Project Request for Proposal Geotechnical Investigation" document, prepared by Raising Cane's dated June 3, 2024

Item	Description
	■ Raising Cane's "Site Plan #1.2" prepared by Raising Cane's and dated May 10, 2024 ■ "ALTA Commitment for Title Insurance" issued by Stewart Title Guaranty Company and dated July 1, 2021 ■ "Option 1 – Context Site Plan" prepared by Raising Cane's and dated May 15, 2024 ■ "ALTA/NSPS Land Title Survey – Raising Cane's Restaurant, LLC" prepared by Control Points Associates, Inc., and dated May 23, 2024. Marked up by Bohler Engineering for test pit locations
Project Description	The project includes the construction of a new Raising Cane's Restaurant. Other site features include an outdoor patio area, a drive-thru with a canopy, parking and drive lanes, landscaped areas and new underground utilities.
Proposed Structure	The restaurant will consist of an approximately 2,854 square-foot, single-story building with no basement (RC Prototype 6-V-AV).
Building Construction	We anticipate the proposed building will be steel or wood framed with masonry walls and slab-on-grade construction. We understand that Raising Cane's is considering supporting the proposed canopy on drilled pier/shaft foundations rather than conventional shallow spread footing foundations.
Finished Floor Elevation	Finished floor elevation was not provided at the time of this report. We assume that the finished floor elevation will be at or near existing site grades.
Maximum Loads	In the absence of information provided by the design team, we used the following loads in estimating settlement based on our experience with similar projects. ■ Columns: 30 to 60 kips ■ Walls: 1 to 3 kips per linear foot (klf) ■ Slabs: 150 to 250 pounds per square foot (psf)
Grading/Slopes	Grading plans were not provided at the time of this report. Given the existing site grades and current development, we assume that minimal changes to existing site grades will be required.
Below-Grade Structures	None planned.

Item	Description
Pavements	Parking and driveway areas, as well as a drive-thru are planned to be included in the proposed project. We anticipate both flexible (asphalt) and rigid (concrete) paving sections will be required. We anticipate all pavements will be privately maintained and will be designed based on procedures described by the National Asphalt Pavement Associations (NAPA) and the American Concrete Institute (ACI). We assume the pavement design period is 20 year and the anticipated NAPA traffic classifications will consist of: ▪ Class I: Parking stalls and parking lots for cars and pick-up trucks, with Equivalent Single Axle Load (ESAL) up to 7,000 over 20 years ▪ Class II: Traffic consisting of home delivery trucks, trash pickup ACI traffic categories and average daily truck traffic (ADTT) are assumed to consist of: ▪ Category A: Automobile parking with an ADTT of 10 over 20 years ▪ Category B: Entrance and truck service lanes, 10 trucks per day

Terracon should be notified if any of the above information is inconsistent with the planned construction, especially the grading limits, as modifications to our recommendations may be necessary.

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	The approximately 1.04-acre project site is located at 494 Lincoln Street in Worcester, Massachusetts. The approximate Latitude/Longitude of the center of the site is 42.2948°N/ 71.4796°W. See Site Location
Existing Improvements	Former Denny's restaurant with associated drive aisles, parking, and landscaping.

Item	Description
Current Ground Cover	Asphalt, concrete, and grass.
Existing Topography (from provided topographic plan)	The site is relatively flat and ranges between approximate elevations (El.) 555 feet to El. 560 feet.

We also collected photographs at the time of our field exploration program. Representative photos are provided in our Photography Log.

Geotechnical Characterization

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of the site. Conditions observed at each exploration point are indicated on the individual logs. The individual logs can be found in the Exploration Results and the GeoModel can be found in the Figures attachment of this report.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

Model Layer	Layer Name	General Description
1	Surface Material	Topsoil / Bituminous Concrete / Aggregate Base Course
2	Fill	Varying amounts of sand, silt, and gravel, occasional to frequent cobbles and trace deleterious materials, dark brown to brown to brown-gray
3	Native Soil	Poorly graded Sand to Silty Sand to Sandy Silt with fine sand, portions contained gravel, gray to brown, medium dense to dense
4	Weathered Bedrock	Weathered Bedrock, brown-gray to dark gray, very dense
5	Bedrock	Refusal was encountered on probable bedrock at depths ranging from 3.5 to 8.5 feet below existing site

Model Layer	Layer Name	General Description
		grades. Publicly available geologic maps indicate bedrock in the area is likely Calcpelite.

Please note the following specific details regarding this GeoModel that will impact the conclusions and recommendations provided later in this report:

- The fill materials (Model Layer 2) were encountered in eight of the explorations across the site and ranged from approximately 0.6 to 7.0 feet in thickness. Fill was not encountered in one building area boring.
- Highly weathered to weathered bedrock (Model Layer 4) was encountered across the site at depths ranging from approximately 1.0 to 6.7 feet in thickness.
- Bedrock (Model Layer 5) was inferred from refusal conditions encountered at depths between about 2.5 to 8.5 below existing site grades.

Groundwater Observations

Borings and test pits were advanced using hollow-stem auger drilling techniques and a rock bucket on a mini-excavator, respectively, that allow short term groundwater observations to be made while drilling and excavating. Groundwater was not encountered at the time of our field exploration; however, perched water was observed at about 5 feet below existing site grades at two boring locations (B-1 & B-2). Groundwater conditions may change due to site development, seasonal variations in rainfall, runoff, and other conditions not apparent at the time of drilling. Long-term groundwater monitoring was outside the scope of services for this project.

Laboratory Testing

Laboratory testing was performed on soil samples collected in the field. Laboratory testing included in-situ moisture content and grain-size analysis. Results of our laboratory testing are included in the Exploration Results section of this report and summarized in the following Table:

Boring ID	Depth (feet)	GeoModel Layer	Percent Gravel	Percent Sand	Percent Fines	USCS Classification
B-1	2.5 – 4.5	3	38.0	47.4	14.6	SM
B-2	0.5 – 2.5	3	10.7	22.6	66.7	ML
B-3	0.0 – 2.0	2	32.5	40.6	26.9	SM
B-5	5.0 – 7.0	2	70.5	23.4	6.1	GP-GM

Seismic Site Class

The seismic design requirements for buildings and other structures are based on Seismic Design Category. Site Classification is required to determine the Seismic Design Category for a structure. The Site Classification is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Section 20.4 of ASCE 7 and the International Building Code (IBC). Based on the soil/bedrock properties observed at the site and as described on the exploration logs and standard penetration testing (SPT) results, it is our professional opinion that a Seismic Site Classification of B be considered for the project. Subsurface explorations at this site were extended to a maximum depth of 8.5 feet. The site properties below the boring depth to 100 feet were estimated based on our experience and knowledge of geologic conditions of the general area. Additional deeper borings or geophysical testing may be performed to confirm the conditions below the current boring depth.

Geotechnical Overview

In our opinion, based upon the geotechnical conditions encountered in the borings and test pits the site is suitable for support of the new building on conventional shallow foundations with a slab-on-grade, provided the recommendations in this report are implemented during design and construction. Recommendations for foundations are presented in the Shallow Foundations section of this report, and recommendations for slabs are presented in the Floor and Exterior Slabs section of this report. We understand the proposed canopy structures are planned to be supported on drilled pier/shaft foundation systems. Recommendations for drilled piers/shafts for the canopy structures are provided in the Deep Foundations section of this report.

We have identified existing undocumented fill, areas of shallow bedrock, potentially unstable soils and relatively shallow perched water as geotechnical conditions that may impact the proposed construction. These conditions will require particular attention in project planning, design and during construction and are discussed in greater detail in the following sections.

Existing, Undocumented Fill: Existing undocumented fill was encountered to depths up to about 0.6 to 7.0 feet in the borings drilled at the site. Existing fill could exist at other locations on the site and extend to greater depths, particularly within the area of the former building. We do not possess any information regarding whether the fill was placed under the observation of a geotechnical engineer; therefore, the fill is considered "undocumented". Undocumented fill and other unsuitable materials, such as soil with organic material, can present a greater than normal risk of post-construction movement of foundations, slabs and other site improvements supported on or above these materials. Consequently, it is our opinion existing fill on the site should not be relied upon for support of foundations and exterior concrete slabs, and should be removed from the foundation and exterior slab/rigid concrete bearing zones down to native soil. The bearing zone is defined as the area below 1H:1V lines extending downward and outward from edge of footing/slab.

Consideration can be given to leaving the existing fill in-place below proposed pavement areas, provided the owner is willing to accept some risk of movement. To take advantage of the cost benefit of not removing the entire amount of undocumented fill below pavement areas, the following protocol should be followed. Once the planned grading has been completed, the entire area should be proof rolled with a minimum 10-ton vibratory roller or heavy, rubber tire construction equipment, to aid in delineating areas of soft or otherwise unsuitable soil. Once unsuitable materials have been remediated, and the subgrade has passed the proofroll test the over excavation can be backfilled with properly compacted Structural Fill.

Even with the recommended construction procedures, there is inherent risk for the owner that compressible fill or unsuitable material, within or buried by the fill, will not be discovered. This risk of unforeseen conditions cannot be eliminated without completely removing the existing fill. The owner must be willing to accept the risk associated with constructing pavements over the undocumented fill to take advantage of the cost benefit associated with keeping undocumented fill in place.

Shallow Bedrock: Auger refusal, presumably on bedrock, was encountered at depths ranging from about 2.5 to 8.5 below existing site grades. In addition, weathered bedrock was encountered at depths of about 1.0 to 7.0 feet to below existing site grades.

Based on the proposed site layout and encountered subsurface conditions, relatively shallow bedrock was encountered within the southeast portion of the proposed building footprint and southeast portion of the site. Where shallow bedrock is encountered at or above design footing grade, it should be over-excavated to provide a minimum 12-inch-thick layer of compacted Structural Fill between the bedrock surface and bottom of footing. Excavation penetrating the bedrock may require the use of specialized heavy-duty equipment to advance the excavation and facilitate rock break-up and removal. Consideration should be given to obtaining a unit price for difficult excavation in the contract documents for the project. Additional bedrock subgrade preparation recommendations are provided in the Earthwork section.

Potentially Unstable Soils: The on-site soils have an elevated silt content and could become unstable with typical earthwork and construction traffic, especially after precipitation events. The effective drainage should be completed early in the construction sequence and maintained after construction to avoid potential issues. If possible, the grading should be performed during the warmer and drier times of the year (typically May to October). If grading is performed during the winter months (typically

November to April), an increased risk for possible undercutting and replacement of unstable subgrade will persist. Additional site preparation recommendations, including subgrade improvement and fill placement, are provided in the Earthwork section.

Shallow Perched Water: Groundwater was not encountered at the time of our field exploration; however, perched water was observed at about 5 feet below existing site grades at two boring locations (B-1 & B-2). However, groundwater levels at this site may vary due to seasonal variations and may be seasonally perched within the onsite soil or on the bedrock surface. We understand below-grade areas are not planned for the site. However, removal of existing fill, site grading and excavations for foundations and underground utilities could result in excavations approaching the level of existing groundwater.

The recommendations contained in this report are based upon the results of field and laboratory testing (presented in the Exploration Results), engineering analyses, and our current understanding of the proposed project. The General Comments section provides an understanding of the report limitations.

Earthwork

Earthwork is anticipated to include demolition, clearing and grubbing, excavations, and engineered fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria, as necessary, to render the site in the state considered in our geotechnical engineering evaluation for foundations, floor slabs, and pavements.

Demolition

The proposed building will be constructed within the footprint of the existing building which will be demolished as part of site development. Demolition of the existing building should include complete removal of all foundation systems, floor slabs, below-grade structural elements, pavements, and exterior flatwork within the proposed construction area. This should include removal of any utilities to be abandoned along with any loose utility trench backfill or loose backfill found adjacent to existing foundations. All materials derived from the demolition of existing structures and pavements should be removed from the site and properly disposed of.

Where existing foundations and/or utilities are encountered outside of the proposed building footprint and at least 5 feet beyond the outer edge of foundations and conflict with proposed utilities and pavements, they should be removed to a depth of at least 2 feet below the affected utility or design pavement subgrade elevation.

Although no evidence of underground facilities (such as septic tanks, cesspools, basements, and utilities) was observed during the exploration and site reconnaissance, such features could be encountered during construction. If unexpected fills or underground facilities are encountered, such features should be removed, and the excavation thoroughly cleaned prior to backfill placement and/or construction.

Site Preparation

Existing vegetation, topsoil, and root mats should be removed before placing new fill. Complete stripping of the topsoil should be performed in the proposed structure and parking/driveway areas.

Mature trees are located within existing landscaped islands in the footprint of the proposed expansion area, which will require removal at the onset of construction. Tree root systems can remove substantial moisture from surrounding soils. Where trees are removed, the full root ball and all associated dry and desiccated soils should be removed and replaced. The soil materials which contain less than 5 percent organics can be reused as General Fill provided the material is moisture conditioned and properly compacted depending on the anticipated future use.

Excavation

Soil

We anticipate that soil excavation for the proposed construction can be accomplished with conventional earthmoving equipment. The bottom of excavations should be thoroughly cleaned of loose soil and disturbed material prior to backfill placement and construction.

The soils to be excavated can vary significantly across the site as their classifications are based solely on the materials encountered in widely-spaced exploratory test borings. The contractor should verify that similar conditions exist throughout the proposed area of excavation. If different subsurface conditions are encountered at the time of construction, the actual conditions should be evaluated to determine any excavation modifications are necessary to maintain safe conditions.

Bedrock

Based on observations made during the subsurface exploration, relatively shallow bedrock was encountered within the southeast portion of the proposed building footprint and southeast portion of the site. Where shallow bedrock is encountered at or above design footing grade, it should be over-excavated to provide a minimum 12-inch-thick layer of compacted Structural Fill between the bedrock surface and bottom of footing.

Excavation penetrating the bedrock may require the use of specialized heavy-duty equipment to advance the excavation and facilitate rock break-up and removal. Consideration should be given to obtaining a unit price for difficult excavation in the contract documents for the project.

Subgrade Preparation

After completion of excavation for new foundations and the removal of unsuitable existing fill or other unsuitable material, and prior to placement of fill or construction of foundations, floor slabs or pavements the subgrades should be proof rolled with a minimum 10-ton vibratory roller or heavy, rubber tire construction equipment with at least six passes in perpendicular directions using a minimum 10-ton vibratory roller in open areas; or a minimum 1-ton self-propelled vibratory roller or large vibratory plate compacted in trenches or confined excavations. The proofrolling should be performed under the observation of the Geotechnical Engineer.

Areas excessively deflecting under the proofroll should be delineated and subsequently addressed by the Geotechnical Engineer. Unstable areas should be over-excavated to more competent material and replaced with compacted Structural Fill or General Fill depending on the location of the fill placement. Excessively wet or dry materials either be removed, or moisture conditioned and recompacted. Once subgrades have been properly prepared, Structural Fill may be placed in controlled lifts to achieve design foundation and slab subgrade elevations.

New foundations should bear entirely on one uniform bearing material. Where shallow bedrock is encountered at or above design footing grade, it should be over-excavated to provide a minimum 12-inch-thick layer of compacted Structural Fill between the bedrock surface and bottom of footing. The Structural Fill layer will act as a soil cushion to help reduce the potential for differential settlement to occur. Loose rock pieces should be removed within the footing bearing zone, and open bedrock joints should be chocked with Crushed Stone or filled with either grout or concrete prior to placing the soil cushion.

Fill Material Type

Fill required to achieve design grade should be classified as Structural Fill or General Fill. Applications for use of Structural Fill and General Fill are presented in the Imported Fill Materials table.

Reuse of Onsite Soil – Structural Fill: Excavated onsite soil is not suitable for reuse as Structural Fill within foundation bearing zones but may be selectively reused as Structural Fill up to 2 feet below floor slabs provided it is sufficiently dry such that it is firm and stable and can be adequately compacted. Additional material property requirements for onsite soil used as Structural Fill are noted in the following table.

Reuse of Onsite Soil – General Fill: In general, excavated onsite soil may be selectively reused as General Fill provided it is sufficiently dry such that it is firm and stable and can be adequately compacted. Additional material property requirements for onsite soil used as General Fill are noted in the following table.

Portions of the on-site soil have an elevated fines content and will be sensitive to moisture conditions (particularly during seasonally wet periods) and may not be suitable for reuse when above optimum moisture content.

Excavated bedrock may be selectively reused as General Fill provided it is blended with soil such that there are no voids and the material properties defined below are achieved.

Property	General Fill [1]	Structural Fill [1,2]
Composition	Free of deleterious material	
Maximum particle size	The lesser of 6 inches or 2/3 of the lift thickness	
Fines content	Not limited provided it is relatively dry such that it can be compacted to the minimum compaction requirements presented below.	

1. Based on subsurface exploration. Actual material suitability should be determined in the field at time of construction.
2. Excavated onsite soil is not suitable for reuse as Structural Fill within foundation bearing zones but may be selectively reused as Structural Fill up to 2 feet below floor slabs provided it is sufficiently dry such that it is firm and stable and can be adequately compacted.

Imported Fill Materials: Imported fill materials should meet the following material property requirements. Regardless of its source, compacted fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade.

Fill Type [1]	Massachusetts Department of Transportation (MassDOT) Item	Application
Structural Fill	M1.03.0 – Gravel Borrow Type B	Beneath shallow foundations, within shallow foundation bearing zones, and as backfill within 5 feet of exterior foundation walls. Structural Fill should also be used as raise-in-grade fill to achieve subgrade elevations beneath floor slabs and settlement sensitive structures.
General Fill	M1.02.0 – Special Borrow	General raise-in-grade fill and landscaping areas. General Fill should not be placed beneath settlement sensitive structures and within foundation bearing zones.
Crushed Stone [2]	M2.01.4 – ¾-inch Crushed Stone	Backfill of underdrains and over wet subgrades as needed. Crushed Stone may be substituted for Structural Fill when approved by the Geotechnical Engineer.
Floor Slab Base Course	M2.01.7 – Dense Graded Crushed Stone for Sub-base	Below floor slabs.
Pavement Sub-base Course	M1.03.1 – Processed Gravel for Subbase	Below pavement areas as sub-base course below aggregate base course.
Non-Frost Susceptible (NFS)Fill [2,3]	M1.03.1 – Processed Gravel for Subbase (Modified per Note 2) or M2.01.4 – ¾-inch Crushed Stone	Below exterior slabs, sidewalk, pavements or other ancillary structures where frost heave may be a concern.
Free-Draining Materials [2,4]	M2.01.4 – ¾-inch Crushed Stone	Backfill of underdrains and over wet subgrades as needed.

Fill Type [1]	Massachusetts Department of Transportation (MassDOT) Item	Application

1. A sample of each material type should be submitted to the Geotechnical Engineer for evaluation prior to use on this site.
2. Crushed Stone should be separated from soil subgrades, excavation sidewalls, and backfill using a non-woven geotextile (such as Mirafi 140N or similar).
3. Non-Frost Susceptible (NFS) Fill should contain less than 5 percent material passing No. 200 sieve size.
4. Free-draining material shall consist of sand, gravel, rock fragments, quarry run stone, broken stone or mixtures thereof. This material shall not have more than 70% by weight passing the No. 40 sieve and not more than 10% by weight passing the No. 200 sieve.

Fill Placement and Compaction Requirements

Structural and general fill should meet the following compaction requirements.

Item	Structural Fill	General Fill	Crushed Stone
Maximum Lift Thickness	Vibratory Rollers: 12 inches or less in loose thickness. Plate Compactors: 6 inches or less in loose thickness when hand-guided equipment (i.e., jumping jack or plate compactor) is used.		
Minimum Compaction Requirements [1,2]	At least 95% of the material's maximum dry density	At least 92% of the material's maximum dry density	Densified and compacted using at least six (6) passes of vibratory roller or large vibratory plate compactor
Water Content Range [1]	±3% of optimum water content	±3% of optimum water content	Not applicable

Item	Structural Fill	General Fill	Crushed Stone

1. Maximum density and optimum water content as determined by the Modified Proctor test (ASTM D1557, Method).
2. If the granular material is a coarse sand or gravel, or of a uniform size, or has a low fines content, compaction comparison to relative density may be more appropriate. In this case, granular materials should be compacted to at least 70% relative density (ASTM D4253 and D4254). Materials not amenable to density testing should be placed and compacted to a stable condition observed by the Geotechnical Engineer or representative.

Utility Trench Backfill

Any soft or unsuitable materials encountered at the bottom of utility trench excavations should be removed and replaced with structural fill or bedding material in accordance with public works specifications for the utility be supported. This recommendation is particularly applicable to utility work requiring grade control and/or in areas where subsequent grade raising could cause settlement in the subgrade supporting the utility. Trench excavation should not be conducted below a downward 1H:1V projection from existing foundations without engineering review of shoring requirements and geotechnical observation during construction.

On-site materials are considered suitable for backfill of utility and pipe trenches from 1 foot above the top of the pipe to the final ground surface, provided the material is free of organic matter and deleterious substances.

Trench backfill should be mechanically placed and compacted as discussed earlier in this report. Compaction of initial lifts should be accomplished with hand-operated tampers or other lightweight compactors. Where trenches are placed beneath slabs or footings, the backfill should satisfy the gradation and expansion index requirements of engineered fill discussed in this report. Flooding or jetting for placement and compaction of backfill is not recommended.

Grading and Drainage

All grades must provide effective drainage away from the building during and after construction and should be maintained throughout the life of the structure. Water retained next to the building can result in soil movements greater than those discussed in this report. Greater movements can result in unacceptable differential floor slab and/or foundation movements, cracked slabs and walls, and roof leaks. The roof should have gutters/drains with downspouts that discharge into the site drainage system or onto splash blocks at a distance of at least 10 feet from the building.

Exposed ground should be sloped and maintained at a minimum 5% away from the building for at least 10 feet beyond the perimeter of the building. Locally, flatter grades may be necessary to transition ADA access requirements for flatwork. After building construction and landscaping have been completed, final grades should be verified to document effective drainage has been achieved. Grades around the structure should also be periodically inspected and adjusted, as necessary, as part of the structure's maintenance program. Where paving or flatwork abuts the structure, a maintenance program should be established to effectively seal and maintain joints and prevent surface water infiltration.

Earthwork Construction Considerations

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, "Excavations" and its appendices, and in accordance with any applicable local and/or state regulations.

Depending upon depth of excavation and seasonal conditions, surface water infiltration and/or groundwater may be encountered in excavations on the site. If dewatering becomes necessary, the contractor should select a dewatering method to lower groundwater at least 2 feet below the excavation subgrade to minimize bearing surface disturbance during fill placement and compaction. Dewatering is a means and methods consideration for the contractor.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety or the contractor's activities; such responsibility shall neither be implied nor inferred.

Excavations or other activities resulting in ground disturbance have the potential to affect adjoining properties and structures. Our scope of services does not include review of available final grading information or consider potential temporary grading performed by the contractor for potential effects such as ground movement beyond the project limits. A preconstruction/ precondition survey should be conducted to document nearby property/infrastructure prior to any site development activity. Excavation or ground disturbance activities adjacent or near property lines should be monitored or instrumented for potential ground movements that could negatively affect adjoining property and/or structures.

Construction Observation and Testing

The earthwork efforts should be observed by the Geotechnical Engineer (or others under their direction). Observation should include documentation of adequate removal of demolition debris, surficial materials (vegetation, topsoil, and pavements), evaluation and remediation of existing fill materials, as well as proofrolling and mitigation of unsuitable areas delineated by the proofroll.

Each lift of compacted fill should be tested, evaluated, and reworked, as necessary, as recommended by the Geotechnical Engineer prior to placement of additional lifts. Each lift of fill should be tested for density and water content at a frequency of at least one test for every 2,500 square feet of compacted fill in the building areas and 5,000 square feet in pavement areas. Where not specified by local ordinance, one density and water content test should be performed for every 100 linear feet of compacted utility trench backfill and a minimum of one test performed for every 12 vertical inches of compacted backfill.

In areas of foundation excavations, the bearing subgrade should be evaluated by the Geotechnical Engineer. If unanticipated conditions are observed, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

Shallow Foundations

If the site has been prepared in accordance with the requirements noted in the Earthwork section of this report, the following design parameters are applicable for shallow foundations.

New foundations should bear entirely on one uniform bearing material; therefore, where shallow bedrock is encountered at or above design footing grade, it should be over-excavated to provide a minimum 12-inch-thick layer of compacted Structural Fill between the bedrock surface and bottom of footing. The Structural Fill layer will act as a soil cushion to help reduce the potential for differential settlement to occur.

Design Parameters – Compressive Loads

Item	Description
Maximum Net Allowable Bearing Pressure [1]	3,500 psf
Required Bearing Stratum [2]	Minimum 12-inch-thick layer of Structural Fill or Crushed Stone placed above proof-rolled native soil and/or prepared bedrock subgrades

Item	Description
Minimum Foundation Dimensions	Columns: 30 inches Continuous: 18 inches
Sliding Resistance [3]	0.45 (Concrete on Structural Fill) 0.55 (Concrete on Crushed Stone)
Minimum Embedment below Finished Grade [4]	Exterior footings in unheated areas: 42 inches Interior footings in unheated areas: 42 inches Interior footings in heated areas: 18 inches
Estimated Total Settlement from Structural Loads [2]	Less than about 1 inch
Estimated Differential Settlement [2, 5]	About 1/2 of total settlement

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. An appropriate factor of safety has been applied. Values assume that exterior grades are no steeper than 2H:1V next to the structure.
2. Existing fill and unsuitable material and/or loose soils should be over excavated and replaced per the recommendations presented in Earthwork.
3. Can be used to compute sliding resistance where foundations are placed on suitable soil/materials. Frictional resistance for granular materials is dependent on the bearing pressure which may vary due to load combinations.
4. Embedment necessary to minimize the effects of frost and/or seasonal water content variations. For sloping ground, maintain depth below the lowest adjacent exterior grade within 5 horizontal feet of the structure.
5. Differential settlements are noted for equivalent-loaded foundations and bearing elevation as measured over a span of 50 feet. Larger foundation footprints will likely require reduced net allowable soil bearing pressures to reduce risk for potential settlement.

Design Parameters – Overturning and Uplift Loads

Shallow foundations subjected to overturning loads should be proportioned such that the resultant eccentricity is maintained in the center-third of the foundation (e.g., $e < b/6$, where b is the foundation width). This requirement is intended to keep the entire foundation area in compression during the extreme lateral/overturning load event. Foundation oversizing may be required to satisfy this condition.

Uplift resistance of spread footings can be developed from the effective weight of the footing and the overlying soils with consideration to the IBC basic load combinations.

Item	Description
Soil Moist Unit Weight	120 pcf
Soil Effective Unit Weight[1]	57.6 pcf
Soil weight included in uplift resistance	Soil included within the prism extending up from the top perimeter of the footing at an angle of 20 degrees from vertical to ground surface

1. Effective (or buoyant) unit weight should be used for soil above the foundation level and below a water level. The high groundwater level should be used in uplift design as applicable.

Foundation Construction Considerations

As noted in Earthwork, the footing excavations should be evaluated under the observation of the Geotechnical Engineer. The base of all foundation excavations should be free of water and loose soil, prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Excessively wet or dry material or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed.

Sensitive soils exposed at the surface of footing excavations may require surficial compaction with hand-held dynamic compaction equipment prior to placing structural fill, steel, and/or concrete. Should surficial compaction not be adequate, construction of a working surface consisting of either crushed stone or a lean concrete mud mat may be required prior to the placement of reinforcing steel and construction of foundations.

If unsuitable bearing soils are observed at the base of the planned footing excavation, the excavation should be extended deeper to suitable soils. The over excavation should be backfilled up to the footing base elevation, with Structural Fill placed, as recommended in the Earthwork section.

Deep Foundations

As an alternative to shallow foundations, the proposed canopy structure can be supported on Deep Foundations such as drilled shafts.

Drilled Shaft Design Parameters

Soil design parameters are provided below in the Drilled Shaft Design Summary table for the design of drilled shaft foundations. The values presented for allowable side friction and end bearing include a factor of safety of 2 and 3, respectively.

Drilled Shaft Design Summary [1]

Stratigraphy [2]			Allowable Skin Friction (psf)	Allowable End Bearing Pressure (psf) [5, 6]
Approximate Depth to Bottom of Stratum (ft)	GeoModel Layer	Material		
1 - 5	2	Fill	0[3]	Neglect[3]
5 - 7	3	Native Soil	350	N/A[4]
7.5 – 8.5	4	Weathered Bedrock	650	6,000
>8.5	5	Bedrock	1,000	10,000

1. Design capacities are dependent upon the method of installation and quality control parameters. Recommendations in the Drilled Shaft Foundation Construction Considerations should be followed for the design parameters presented above to be applicable. The drilled shaft installation process should be performed under the observation of the Geotechnical Engineer. The Geotechnical Engineer should document the shaft installation process including soil/rock and groundwater conditions observed, consistency with expected conditions and details of the installed shaft.
2. See Subsurface Profile in Geotechnical Characterization for more details on stratigraphy.
3. Fill was encountered to depths of about 7.0 feet below existing site grades in the area of the proposed canopy, drilled shafts should not end in fill material.
4. Based on subsurface conditions, and a minimum shaft length of 10 feet, we anticipate drilled shafts will end in weathered rock or bedrock.
5. Applicable for compressive loading only. Reduce to 2/3 of values shown for uplift loading. The effective weight of the shaft can be added to uplift load resistance to the extent permitted by IBC.
6. Shafts should extend at least one diameter into the bearing stratum for end bearing to be considered.

Shafts should be adequately reinforced as designed by the Structural Engineer for both tension and shear to sufficient depths. Buoyant unit weights of the soil and concrete should be used in the calculations below the highest anticipated groundwater elevation.

Drilled shaft should have a minimum (center-to-center) spacing of three diameters. Closer spacing may require a reduction in axial load capacity. Axial capacity reduction can be determined by comparing the allowable axial capacity determined from the sum of individual piles in a group versus the capacity calculated using the perimeter and base of the pile group acting as a unit. The lesser of the two capacities should be used in design.

A minimum shaft diameter of 18 inches should be used. Drilled shafts should have a minimum length of 10 feet and should extend into the bearing strata at least one shaft diameter for the allowable end-bearing pressures listed in the above table.

Post-construction settlements of drilled shafts designed and constructed as described in this report are estimated to range from about ½ to ¾ inch. Differential settlement between individual shafts is expected to be ½ to ⅔ of the total settlement.

Drilled Shaft Lateral Loading

To satisfy forces in the horizontal direction using LPILE, piers may be designed for the following lateral load criteria:

Stratigraphy[1]	LPile Soil Model	Compressive strength (psi)	ϕ[3]	γ' (pcf)[3]	E50	k (pci)	
Material						Static	Cyclic
Fill[2]	Sand (Reese)	---	32°	120	Use Default Value[5]		
Native Soil	Sand (Reese)	---	34°	125	Use Default Value[5]		
Weathered Bedrock	Sand (Reese)	---	36°	130	Use Default Value[5]		
Bedrock	Strong Rock	500	--°	140	Use Default Value[5]		

1. See Subsurface Profile in Geotechnical Characterization for more details on Stratigraphy.
2. Fill was encountered to depths of about 6.7 feet below existing site grades in the area of the proposed canopy, drilled shafts should not end in fill material.
3. Definition of Terms:
   c: Undrained cohesion; ϕ: Friction angle; γ': Effective unit weight
4. Current versions of LPile provide estimated default values of the horizontal subgrade reaction modulus (k) and the strain factor (E50) based on strength and are recommended for the project. Since deflection or a service limit criterion will most likely control lateral capacity design, no safety/resistance factor is included with the parameters.

The shafts should be spaced at least three shaft diameters apart (center-to-center) if they will be used to resist lateral loads. Shaft caps and/or grade beams could be subject to uplift loading due to frost action; thus, perimeter foundation elements beneath unheated areas should extend at least 4 feet below the lowest adjacent finished grade for frost protection.

Drilled Shaft Construction Considerations

The drilling contractor should be experienced in the subsurface conditions observed at the site, and the excavations should be performed with equipment capable of providing a clean bearing surface. The drilled straight-shaft foundation system should be installed in general accordance with the procedures presented in "Standard Specification for the Construction of Drilled Piers", ACI Publication No. 336.1-01.

The contractor is generally expected to use conventional "dry" techniques for installation of the drilled shaft. Subsurface water was not encountered in boring during the drilling activities; however, perched groundwater was encountered in one boring on the site and could be present during construction. Subsurface water levels are influenced by seasonal and climatic conditions, which result in fluctuations in subsurface water elevations. Additionally, it is common for water to be present after periods of significant rainfall. Casing or slurry drilling procedures could be required in soils zones of higher sand content (such as the existing fill) to reduce the potential for excavation sidewall collapse.

The drilled shaft installation process should be performed under the observation of the Geotechnical Engineer. The Geotechnical Engineer should document the shaft installation process including soil/rock and groundwater conditions observed, consistency with expected conditions, and details of the installed shaft.

Floor Slabs and Exterior Slabs

Design parameters for floor and exterior slabs assume the requirements for Earthwork have been followed. Specific attention should be given to positive drainage away from the structure and positive drainage of the aggregate base beneath the slabs.

Existing fill materials were observed at the site in the area of the proposed building and exterior slabs to depths up to about 7.0 feet below existing grade. As previously described, any existing fill or unsuitable material present within the building footprint and beneath exterior slabs should be completely removed.

Floor Slab Design Parameters

Item	Description
Floor Slab Support[1]	Minimum 12-inch-thick layer of compacted Floor Slab Base Course over compacted Structural Fill and/or proof-rolled native soil (following over-excavation of existing fill and organic deposits) Subgrade proofrolled as recommended in Earthwork
Exterior Slab Support [2]	Minimum 36 inches of Non-Frost Susceptible (NSF) Fill over compacted Structural Fill and/or proof-rolled native soil (following over-excavation of existing fill and organic deposits) Subgrade proofrolled as recommended in Earthwork
Estimated Modulus of Subgrade Reaction [3]	150 pounds per square inch per inch (psi/in) for point loads

1. Floor slabs should be structurally independent of building footings or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation.
2. Other design considerations such as cold temperatures and condensation development could warrant a different base course material.
3. Modulus of subgrade reaction is an estimated value based upon our experience with the subgrade condition, the requirements noted in Earthwork, and the floor slab support as noted in this table. It is provided for point loads. For large area loads the modulus of subgrade reaction would be lower.

The use of a vapor retarder should be considered beneath concrete slabs on grade covered with wood, tile, carpet, or other moisture sensitive or impervious coverings, when the project includes humidity-controlled areas, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

Saw-cut contraction joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations, refer to the ACI Design Manual. Joints or cracks should be sealed with a waterproof, non-extruding compressible compound specifically recommended for heavy duty concrete pavement and wet environments.

Where floor slabs are tied to perimeter walls or turn-down slabs to meet structural or other construction objectives, our experience indicates differential movement between the walls and slabs will likely be observed in adjacent slab expansion joints or floor slab cracks beyond the length of the structural dowels. The Structural Engineer should account for potential differential settlement through use of sufficient control joints, appropriate reinforcing or other means.

Settlement of floor slabs supported on existing fill materials cannot be accurately predicted but could be larger than normal and result in some cracking. Mitigation measures, as noted within the Earthwork section of this report, are critical to the performance of floor slabs. In addition to the mitigation measures, the floor slab can be stiffened by adding steel reinforcement, grade beams, and/or post-tensioned elements.

Floor Slab Construction Considerations

Finished subgrade, within and for at least 10 feet beyond the floor slab, should be protected from traffic, rutting, or other disturbance and maintained in a relatively moist condition until floor slabs are constructed. If the subgrade should become damaged or desiccated prior to construction of floor slabs, the affected material should be removed, and structural fill should be added to replace the resulting excavation. Final conditioning of the finished subgrade should be performed immediately prior to placement of the floor slab support course.

The Geotechnical Engineer should observe the condition of the floor slab subgrades immediately prior to placement of the floor slab support course, reinforcing steel, and concrete. Attention should be paid to high traffic areas that were rutted and disturbed earlier, and to areas where backfilled trenches are located.

Pavements

General Pavement Comments

Pavement designs are provided for the traffic conditions and pavement life conditions as noted in Project Description and in the following sections of this report. A critical aspect of pavement performance is site preparation. Pavement designs noted in this section must be applied to the site which has been prepared as recommended in the Earthwork section.

Pavement Design Parameters

A California Bearing Ratio (CBR) of 5 (classified by NAPA as medium subgrade) was used for the subgrade for the asphaltic concrete (AC) pavement designs. A modulus of subgrade reaction of 150 pci was used for the Portland cement concrete (PCC) pavement designs. The value was empirically derived based upon our experience with the silty sand subgrade soils and our expectation of the quality of the subgrade as prescribed by the Site Preparation conditions as outlined in Earthwork. A modulus of rupture of 500 psi was used in design for the concrete (based on correlations with a minimum 28-day compressive strength of 4,000 psi).

Pavement Section Thicknesses

The following table provides our opinion of minimum thickness for AC sections:

Asphaltic Concrete Design

Layer	Thickness (inches)	
	Traffic Class I	Traffic Class II
Asphaltic Surface[1, 2]	1.5	1.5
Asphaltic Base[1]	1.5	2.5
Aggregate Base[3]	12	12

1. All materials should meet the current Department of Transportation (MassDOT) Standard Specifications for Highway and Bridge Construction.
    - Asphaltic Surface – M.03.01
    - Asphaltic Base – M.03.01
2. A minimum 1.5-inch surface course should be used on AC pavements.
3. Aggregate base courses should meet the fill materials described in the Earthwork section of this report.

The following table provides our estimated minimum thickness of PCC pavements.

Portland Cement Concrete Design

Layer	Thickness (inches)	
	Traffic Category A	Traffic Category B
PCC [1]	5	6
Aggregate Base[2]	12	12

1. All materials should meet the current Massachusetts Department of Transportation (MassDOT) Standard Specifications for Highways and Bridges. Portland Cement concrete pavements should meet the specifications for MassDOT concrete using a 28-day compressive strength of 4,000 psi and ¾-inch coarse aggregate.
2. The base course material is listed in the Earthwork section of this report.

Areas for parking of heavy vehicles, concentrated turn areas, and start/stop maneuvers could require thicker pavement sections. Edge restraints (i.e.: concrete curbs or aggregate shoulders) should be planned along curves and areas of maneuvering vehicles.

Where practical, we recommend early-entry cutting of crack-control joints in PCC pavements. Cutting of the concrete in its “green” state typically reduces the potential for micro-cracking of the pavements prior to the crack control joints being formed, compared to cutting the joints after the concrete has fully set. Micro-cracking of pavements may lead to crack formation in locations other than the sawed joints, and/or reduction of fatigue life of the pavement.

Openings in pavements, such as decorative landscaped areas, are sources for water infiltration into surrounding pavement systems. Water can collect in the islands and migrate into the surrounding subgrade soils thereby degrading support of the pavement. Islands with raised concrete curbs, irrigated foliage, and low permeability near-surface soils are particular areas of concern. The civil design for the pavements with these conditions should include features to restrict or collect and discharge excess water from the islands. Examples of features are edge drains connected to the stormwater collection system, longitudinal subdrains, or other suitable outlets and impermeable barriers preventing lateral migration of water such as a cutoff wall installed to a depth below the pavement structure.

Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. In addition, the pavement subgrade should be graded to provide positive drainage within the granular base section.

Pavement Maintenance

The pavement sections represent minimum recommended thicknesses and, as such, periodic upkeep should be anticipated. Preventive maintenance should be planned and provided for through an on-going pavement management program. Maintenance activities are intended to slow the rate of pavement deterioration and to preserve the pavement investment. Pavement care consists of both localized (e.g.: crack and joint sealing and patching) and global maintenance (e.g.: surface sealing). Additional engineering consultation is recommended to determine the type and extent of a cost-effective program. Even with periodic maintenance, some movements and related cracking may still occur, and repairs may be required.

Pavement performance is affected by its surroundings. In addition to providing preventive maintenance, the civil engineer should consider the following recommendations in the design and layout of pavements:

1. Final grade adjacent to paved areas should slope down from the edges at a minimum 2%.
2. Subgrade and pavement surfaces should have a minimum 2% slope to promote proper surface drainage.
3. Install pavement drainage systems surrounding areas anticipated for frequent wetting.
4. Install joint sealant and seal cracks immediately.
5. Seal all landscaped areas in or adjacent to pavements to reduce moisture migration to subgrade soils.
6. Place compacted, low permeability backfill against the exterior side of curb and gutter.

Frost Considerations

The soils on this site are considered frost susceptible, and small amounts of water can affect the performance of the sidewalks, and pavements. Exterior slabs should be anticipated to heave during winter months. If frost action needs to be eliminated in critical areas, we recommend the use of non-frost susceptible (NFS) fill for structural slabs (for instance, structural stoops in front of building doors). Placement of NFS material in large areas may not be feasible; however, the following recommendations are provided to help reduce potential frost heave:

1. Provide surface drainage away from slabs, and toward the site drainage system.
2. Install drains around the perimeter of buildings or structures (if any), stoops, below exterior slabs and pavements, and connect them to the site drainage system.
3. Grade subgrades so groundwater potentially perched in overlying more permeable subgrades, such as sand or aggregate base, slope toward a site drainage system.
4. Place NFS fill as backfill beneath sidewalks, slabs, and pavements critical to the project.
5. Place a 3 horizontal to 1 vertical (3H:1V) transition zone between NFS fill and other soils.

As an alternative to extending NFS fill to the full frost depth, consideration can be made to placing extruded polystyrene or cellular concrete under a buffer of at least 2 feet of NFS material.

General Comments

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Variations will occur between exploration point locations 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 this report, to provide observation and testing services during pertinent construction phases. 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.

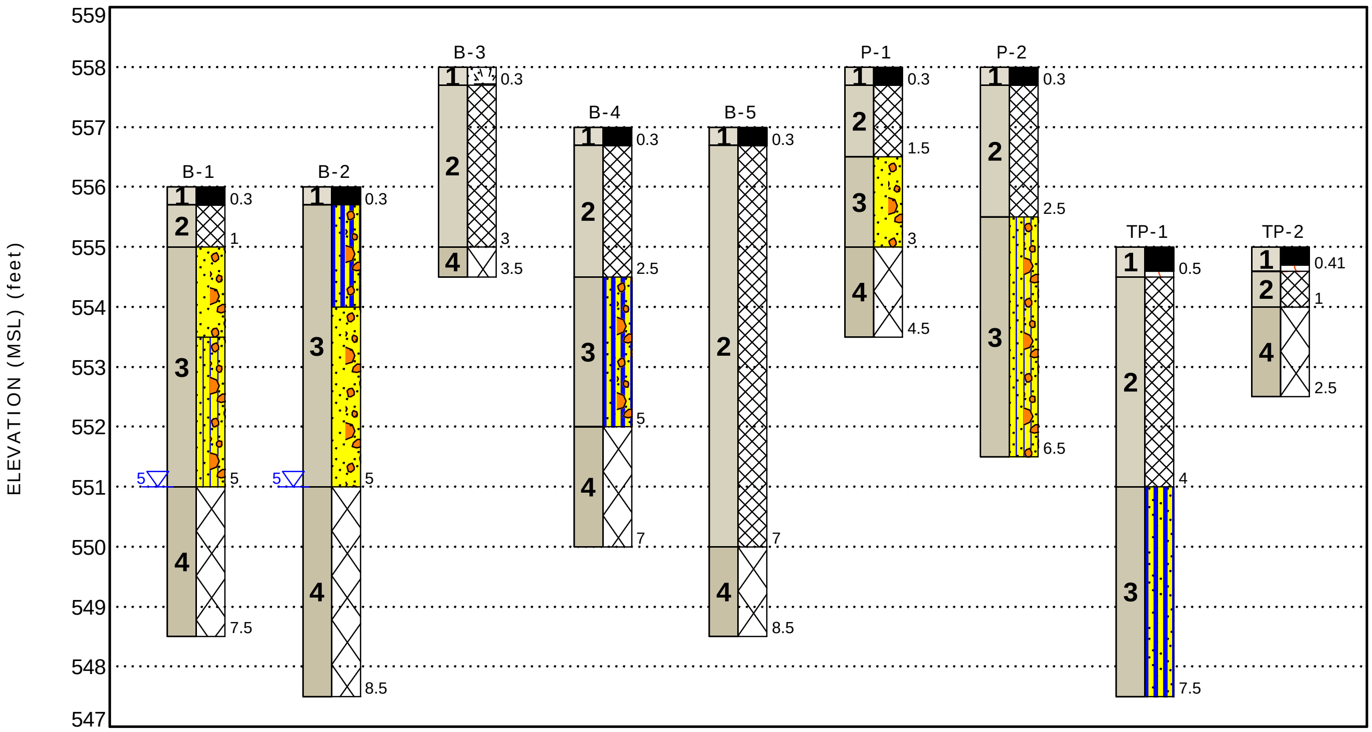
Our services and any correspondence are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. 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 affect 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. Construction and site development have the potential to affect adjacent properties. Such impacts can include damages due to vibration, modification of groundwater/surface water flow during construction, foundation movement due to undermining or subsidence from excavation, as well as noise or air quality concerns. Evaluation of these items on nearby properties are commonly associated with contractor means and methods and are not addressed in this report. The owner and contractor should consider a preconstruction/precondition survey of surrounding development. 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.

Figures

Contents:

GeoModel



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	Surface Material	Topsoil / Bituminous Concrete / Aggregate Base Course
2	Fill	Varying amounts of sand, silt, and gravel, occasional to frequent cobbles and trace deleterious materials, dark brown to brown to brown-gray
3	Native Soil	Poorly graded Sand to Silty Sand to Sandy Silt with fine sand, portions contained gravel, gray to brown, medium dense to dense
4	Weathered Bedrock	Weathered Bedrock, brown-gray to dark gray, very dense
5	Bedrock	Refusal was encountered on probable bedrock at depths ranging from 3.5 to 8.5 feet below existing site grades. Publicly available geologic maps indicate bedrock in the area is likely Calcpelite.

Legend	
■ Asphalt	▨ Fill
▨ Poorly-graded Sand with Gravel	▨ Silty Sand with Gravel
☒ Weathered Rock	▨ Sandy Silt with Gravel
☐ Topsoil	☐ Aggregate Base Course
▨ Sandy Silt	

▽ First Water Observation

Groundwater levels are temporal. The levels shown are representative of the date and time of our exploration. Significant changes are possible over time.
Water levels shown are as measured during and/or after drilling. In some cases, boring advancement methods mask the presence/absence of groundwater. See individual logs for details.

NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project.
Numbers adjacent to soil column indicate depth below ground surface.

Attachments

Exploration and Testing Procedures

Field Exploration

Explorations	Approximate Boring Depth (feet)	Location
B-1 thru B-4	3.5 to 8.5	Building area
B-5	8.5	Drive-thru canopy
P-1, P-2	4.5 to 6.5	Parking/driveway areas
TP-1, TP-2	2.5 to 7.5	Proposed stormwater system

Boring Layout and Elevations: Terracon personnel provided the boring layout and Bohler Engineering (Bohler) personnel provided the test pit layout. The explorations were located in the field using handheld GPS equipment (estimated horizontal accuracy of about ±10 feet) and referencing existing site features. Approximate ground surface elevations were obtained by interpolation from the "ALTA/NSPS Land Title Survey" prepared by Control Point Associates, Inc. and dated 5/23/2024. If elevations and a more precise boring layout are desired, we recommend borings be surveyed.

Subsurface Exploration Procedures (Soil Borings): We advanced the borings with a truck-mounted rotary drill rig using continuous flight hollow stem augers. Depending on drilling and refusal conditions, two to four samples were obtained in the upper 10 feet of each. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a typical 24-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depth. For safety purposes, all borings were backfilled with auger cuttings after their completion. Pavements were patched with cold-mix asphalt.

Proposed Stormwater System Exploration (Test Pits): At the request of Bohler, two test pit locations within the proposed stormwater basin were excavated in areas selected by Bohler. A Massachusetts licensed soil evaluator from Bohler was on site during the excavations to classify the soils using NRCS soil grouping system and to establish the estimated seasonal high ground water levels. Prior to excavations, the asphalt within the area of the test pit locations was sawcut. We advanced the test pits with a mini excavator and a rock bucket. Terracon did not collect soil samples from the excavations but recorded field observations. For safety purposes, the test pits were backfilled with rock/soil cuttings after their completion and tamped in 1-foot lifts with the excavator's bucket. Hot-mix asphalt was placed at compacted at the surface of the test pits.

We also observed the explorations while drilling/excavating and at the completion of drilling/excavating for the presence of groundwater. Groundwater was not observed, but perched water was observed in two boreholes during our field exploration.

Our exploration team prepared field exploration logs as part of the drilling/excavating operations. These field logs included visual classifications of the materials observed during drilling/excavating and our interpretation of the subsurface conditions between samples. The sampling depths, penetration distances, and other sampling information were recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Final boring and test pit logs were prepared from the field logs. The final boring and test pit logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests. The laboratory testing program included the following types of tests:

- Moisture Content
- Grain Size Distribution

The laboratory testing program often included examination of soil samples by an engineer. Based on the results of our field and laboratory programs, we described and classified the soil samples in accordance with the Unified Soil Classification System.

Photography Log

Figure 1: Drill rig setup at B-1

Figure 2: Soil stratigraphy in TP-1

Figure 3: Shallow bedrock in TP-2

Figure 4: Example of hot-mix asphalt placement

Figure 5: Private utility markout near B-5

Figure 6: Drill rig setup at P-1

Site Location and Exploration Plans

Contents:

Note: All attachments are one page unless noted above.

Site Location Plan

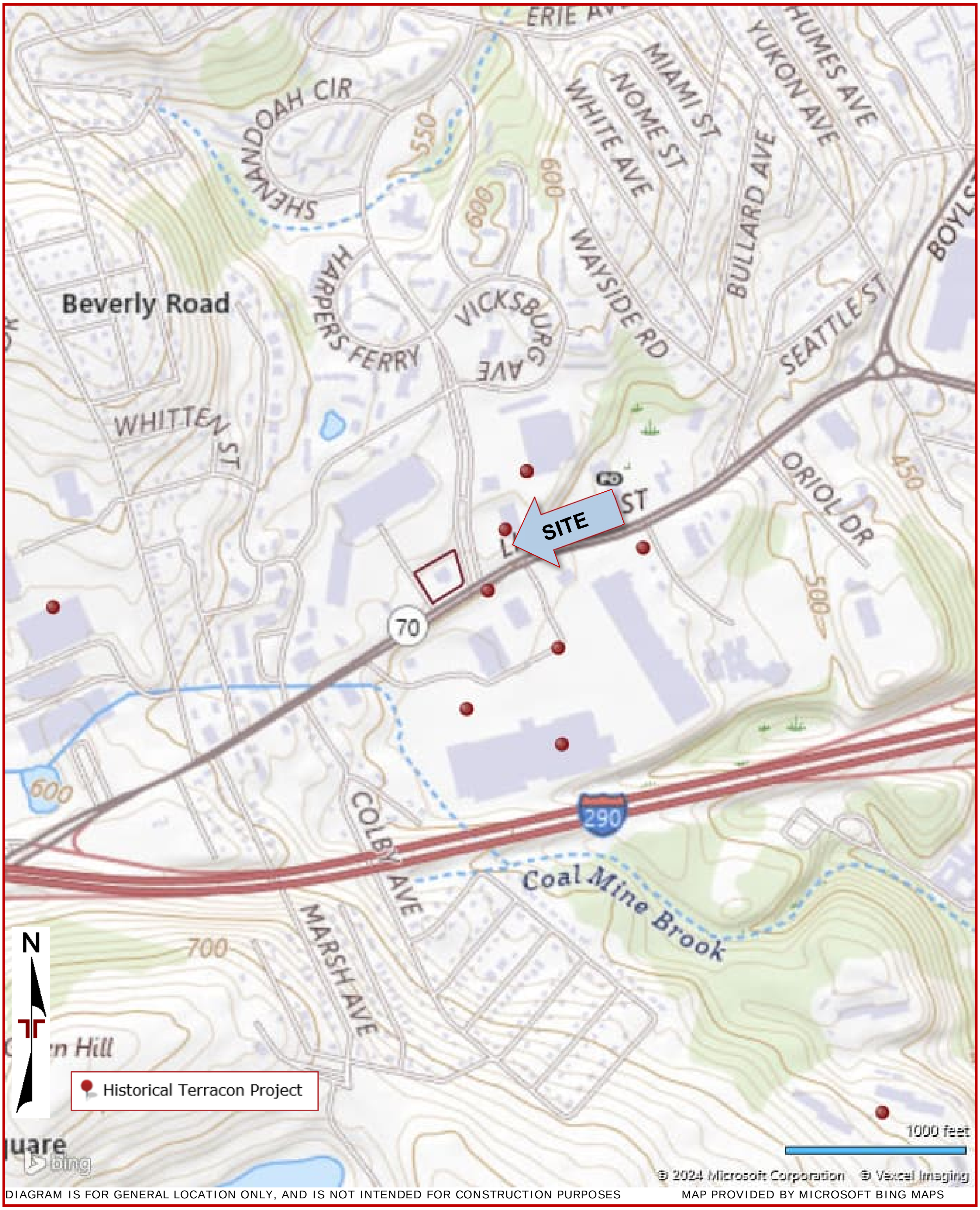


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES MAP PROVIDED BY MICROSOFT BING MAPS

Exploration Plan

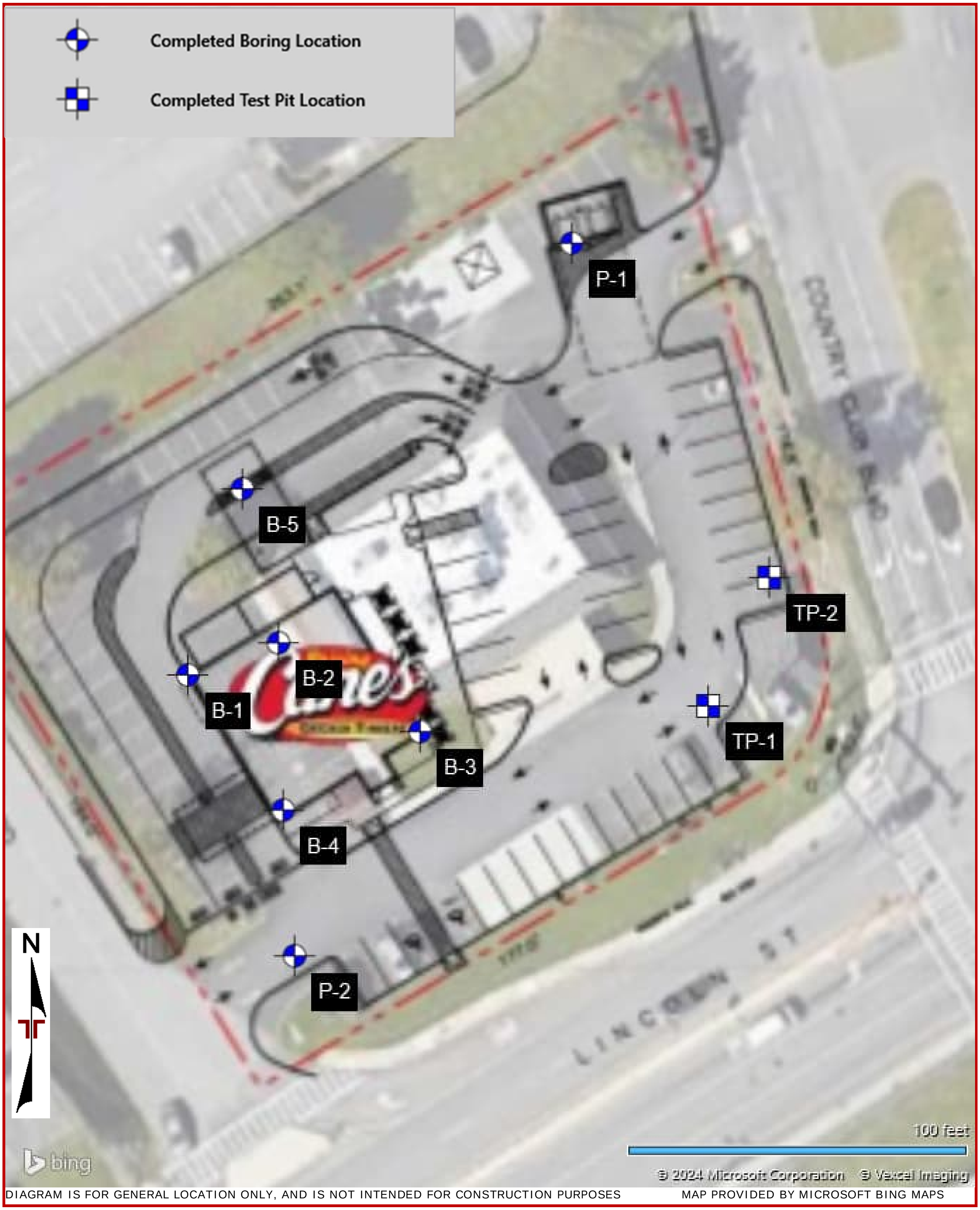


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration Plan (Aerial)

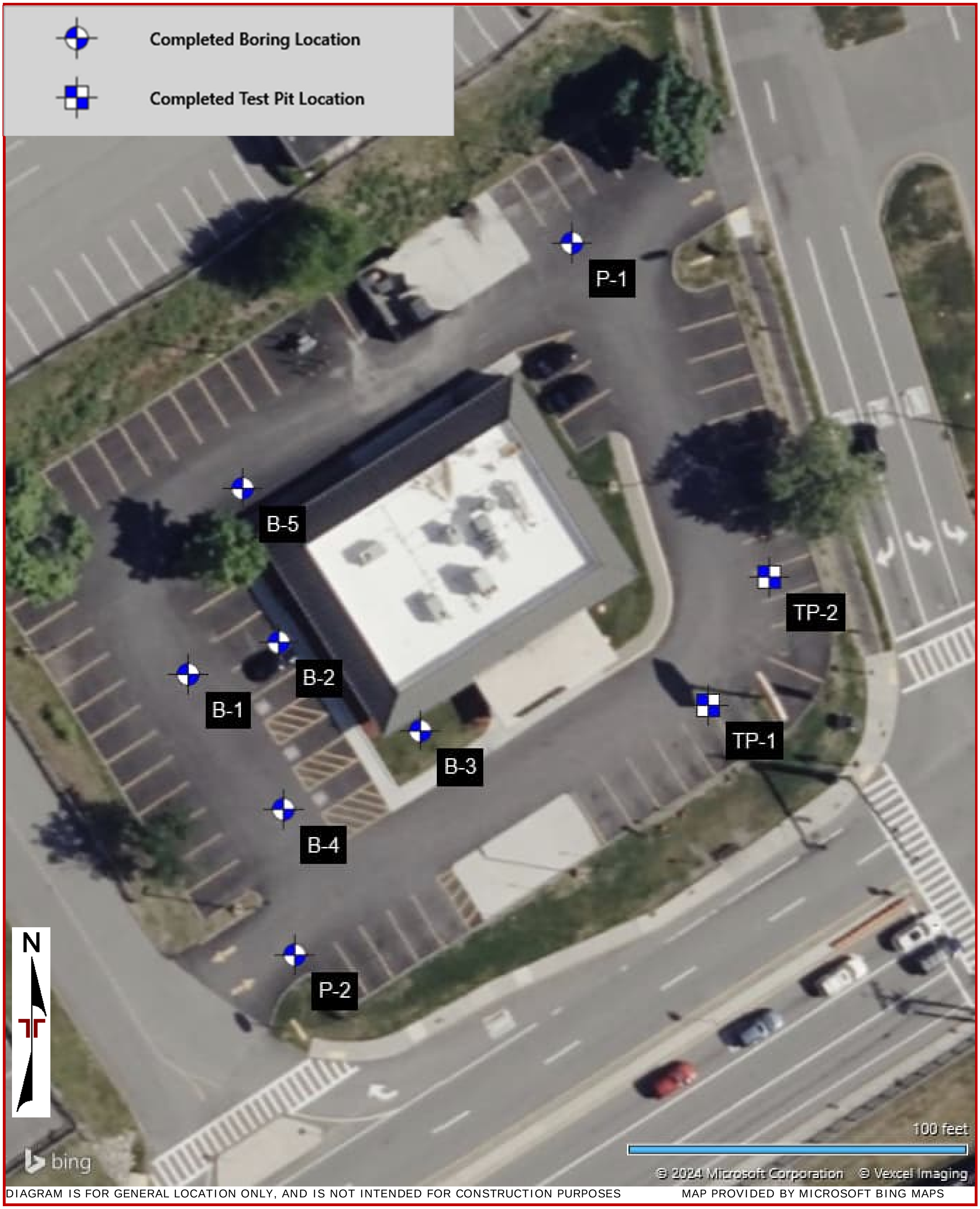


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES MAP PROVIDED BY MICROSOFT BING MAPS

Exploration and Laboratory Results

Contents:

Boring Logs (B-1 through B-5, P-1, P-2, TP-1, TP-2)
Grain Size Distribution

Note: All attachments are one page unless noted above.

Boring Log No. B-1

Location: See Exploration Plan

Latitude: 42.2948° Longitude: -71.7757°

Model Layer	Graphic Log	Depth (Ft.)	Description	Elevation: 556 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)	Percent Fines
1		0.3	3-INCH BITUMINOUS CONCRETE	555.7							
2		1.0	FILL - POORLY GRADED SAND WITH SILT AND GRAVEL, dark brown to brown	555			☒				
3		2.5	POORLY GRADED SAND (SP), with gravel, brown-gray, medium dense	553.5			☒	14	10-10-9-9 N=19		
		5.0	SILTY SAND WITH GRAVEL, brown-gray, very dense	551			☒	16	12-26-25-25 N=51	4.6	15
4		7.5	WEATHERED BEDROCK, brown-gray, very dense	548.5	5	▽	☒	10	29-50/4"		

Auger Refusal on Probable Bedrock at 7.5 Feet

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.
Elevation Reference: Elevations were interpolated from a topographic site plan.
Samples obtained using a 2-in. O.D. split spoon sampler

Water Level Observations
▽ While drilling

Groundwater observation anticipated to be a perched condition.

Drill Rig
CME-75

Hammer Type
Automatic

Driller
GeoSearch

Notes

Advancement Method
0-7.5 ft: 4 1/4-inch continuous flight hollow stem augers

Abandonment Method
Borings backfilled with soil cuttings upon completion.
Sealed with bituminous cold patch at surface.

Logged by
J. Jurnack

Boring Started
06-25-2024

Boring Completed
06-25-2024

Boring Log No. B-2

Model Layer	Graphic Log	Location: See Exploration Plan Latitude: 42.2948° Longitude: -71.7756° Depth (Ft.) Elevation: 556 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)	Percent Fines
1	■	0.3 4-INCH BITUMINOUS CONCRETE 555.7							
3		SANDY SILT WITH GRAVEL (ML), with fine sand, oxidized, trace lamination, gray to brown-gray, medium dense 2.0 554			☒	14	5-8-9-7 N=17	16.1	67
		POORLY GRADED SAND (SP), with gravel, brown-gray to dark gray, loose to very dense 5.0 551			☒	16	16-13-25-32 N=38		
4		WEATHERED BEDROCK, brown-gray to dark gray, very dense	5	▽	☒	5	24-50/2"		
					☒	4	28-50/2"		
		8.5 547.5							
		Auger Refusal on Probable Bedrock at 8.5 Feet							

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.
Elevation Reference: Elevations were interpolated from a topographic site plan.
Samples obtained using a 2-in. O.D. split spoon sampler

Water Level Observations
▽ While drilling
Groundwater observation anticipated to be a perched condition.

Drill Rig
CME-75

Hammer Type
Automatic

Driller
GeoSearch

Notes

Advancement Method
0-8.5 ft: 4 1/4-inch continuous flight hollow stem augers

Abandonment Method
Borings backfilled with soil cuttings upon completion. Sealed with bituminous cold patch at surface.

Logged by
J. Jurnack

Boring Started
06-25-2024

Boring Completed
06-25-2024

Boring Log No. B-3

Location: See Exploration Plan

Latitude: 42.2948° Longitude: -71.7754°

Model Layer	Graphic Log	Depth (Ft.)	Description	Elevation: 558 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)	Percent Fines
1		0.3	4-INCH TOPSOIL	557.7							
2	▨		FILL - SILTY SAND WITH GRAVEL, brown				☒	12	1-4-8-13 N=12	7.8	27
	▨	3.0	FILL - SILTY SAND (SM), trace gravel, dark brown	555			☒	6	10-9-50/1"		
4	☒	3.5	WEATHERED BEDROCK, gray, very dense	554.5							

Auger Refusal on Probable Bedrock at 3.5 Feet

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.

Elevation Reference: Elevations were interpolated from a topographic site plan.

Samples obtained using a 2-in. O.D. split spoon sampler

Water Level Observations
No free water observed

Drill Rig
CME-75

Hammer Type
Automatic

Driller
GeoSearch

Notes
Perform one offset. Auger refusal at 2 feet on probable bedrock.

Advancement Method
0-3.5 ft: 4 1/4-inch continuous flight hollow stem augers

Abandonment Method
Borings backfilled with soil cuttings upon completion.
Sealed with bituminous cold patch at surface.

Logged by
J. Jurnack

Boring Started
06-25-2024

Boring Completed
06-25-2024

Raising Cane's - C1233 Worcester, MA
494 Lincoln Street | Worcester, Massachusetts
Terracon Project No. J2245040

Terracon
201 Hammer Mill Rd, Ste B
Rocky Hill, CT

Boring Log No. B-4

Model Layer	Graphic Log	Location: See Exploration Plan Latitude: 42.2947° Longitude: -71.7756° Depth (Ft.) Elevation: 557 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)	Percent Fines
1		0.3 3.5-INCH BITUMINOUS CONCRETE 556.7							
2		FILL - POORLY GRADED SAND WITH GRAVEL, brown-gray FILL - SILTY SAND, contains cobble and clay pipe fragments, dark brown 2.5 554.5			☒	14	11-9-19-10 N=28		
3		SANDY SILT WITH GRAVEL (ML), dark brown, medium dense 5.0 552			☒	10	4-7-5-6 N=12		
4		WEATHERED BEDROCK, gray, very dense 7.0 550	5		☒	6	21-50/2"		
		Auger Refusal on Probable Bedrock at 7 Feet							

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.

Elevation Reference: Elevations were interpolated from a topographic site plan.

Samples obtained using a 2-in. O.D. split spoon sampler

Water Level Observations
No free water observed

Drill Rig
CME-75

Hammer Type
Automatic

Driller
GeoSearch

Notes
Perform one offset. Auger refusal at 6 feet on probable bedrock.

Advancement Method
0-7 ft: 4 1/4-inch continuous flight hollow stem augers

Abandonment Method
Borings backfilled with soil cuttings upon completion.
Sealed with bituminous cold patch at surface.

Logged by
J. Jurnack

Boring Started
06-25-2024

Boring Completed
06-25-2024

Terracon
201 Hammer Mill Rd, Ste B
Rocky Hill, CT

Boring Log No. B-5

Location: See Exploration Plan

Latitude: 42.2950° Longitude: -71.7756°

Model Layer	Graphic Log	Depth (Ft.)		Elevation: 557 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)	Percent Fines
1	■	0.3	4-INCH BITUMINOUS CONCRETE	556.7							
2	▨		FILL - SILTY SAND, trace gravel, contains bedrock fragments, brown to gray to orange-brown				☒	12	12-9-10-13 N=19		
							☒	6	9-17-11-6 N=28		
			FILL - POORLY GRADED GRAVEL WITH SILT AND SAND, brown to gray		5		☒	4	6-4-1-7 N=5	8.0	6
		7.0		550							
4	▨		WEATHERED BEDROCK, dark gray, very dense				☒	3	50/5"		
		8.5		548.5							
			Auger Refusal on Probable Bedrock at 8.5 Feet								

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.

Elevation Reference: Elevations were interpolated from a topographic site plan.

Samples obtained using a 2-in. O.D. split spoon sampler

Notes

Water Level Observations
No free water observed

Advancement Method
0-8.5 ft: 4 1/4-inch continuous flight hollow stem augers

Abandonment Method
Borings backfilled with soil cuttings upon completion.
Sealed with bituminous cold patch at surface.

Drill Rig
CME-75

Hammer Type
Automatic

Driller
GeoSearch

Logged by
J. Jurnack

Boring Started
06-25-2024

Boring Completed
06-25-2024

Boring Log No. P-1

Model Layer	Graphic Log	Location: See Exploration Plan Latitude: 42.2952° Longitude: -71.7753° Depth (Ft.) Elevation: 558 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)	Percent Fines
1	■	0.3 4-INCH BITUMINOUS CONCRETE 557.7							
2	▩	FILL - SILTY SAND, trace gravel and pockets of asphalt, brown 1.5 556.5			☒	12	12-14-28-50/5" N=42		
3	▒	POORLY GRADED SAND (SP), with gravel, gray, very dense 3.0 555							
4	▧	WETHERED BEDROCK, gray to brown-gray, very dense 4.5 553.5			☒	5	12-36-50/1"		
		Auger Refusal on Probable Bedrock at 4.5 Feet							

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.
Elevation Reference: Elevations were interpolated from a topographic site plan.
Samples obtained using a 2-in. O.D. split spoon sampler

Water Level Observations
No free water observed

Drill Rig
CME-75

Hammer Type
Automatic

Driller
GeoSearch

Notes

Advancement Method
0-4.5 ft: 4 1/4-inch continuous flight hollow stem augers

Abandonment Method
Borings backfilled with soil cuttings upon completion.
Sealed with bituminous cold patch at surface.

Logged by
J. Jurnack

Boring Started
06-25-2024

Boring Completed
06-25-2024

Boring Log No. P-2

Location: See Exploration Plan

Latitude: 42.2946° Longitude: -71.7756°

Elevation: 558 (Ft.) +/-

Model Layer	Graphic Log	Depth (Ft.)	Description	Elevation	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)	Percent Fines
1	■	0.3	3-INCH BITUMINOUS CONCRETE	557.7							
2	▨	2.5	FILL - SILTY SAND WITH GRAVEL, contains pocket of poorly graded sand, brown	555.5			☒	14	11-14-21-18 N=35		
3	⁘	6.5	SILTY SAND (SM), with fine sand, with gravel, orange-brown to brown and brown-gray, medium dense to dense	551.5			☒	14	13-9-10-8 N=19		
					5		☒	16	13-15-16-43 N=31		

Boring Terminated at 6.5 Feet

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.

Elevation Reference: Elevations were interpolated from a topographic site plan.

Samples obtained using a 2-in. O.D. split spoon sampler

Water Level Observations
No free water observed

Drill Rig
CME-75

Hammer Type
Automatic

Driller
GeoSearch

Notes

Advancement Method
0-4.5 ft: 4 1/4-inch continuous flight hollow stem augers

Abandonment Method
Borings backfilled with soil cuttings upon completion.
Sealed with bituminous cold patch at surface.

Logged by
J. Jurnack

Boring Started
06-25-2024

Boring Completed
06-25-2024

Test Pit Log No. TP-1

Location: See Exploration Plan

Latitude: 42.2948° Longitude: -71.7751°

Model Layer	Graphic Log	Depth (Ft.)		Elevation: 555 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)	Percent Fines
1		0.4	5-INCH BITUMINOUS CONCRETE	554.6							
		0.5	1-INCH AGGREGATE BASE COURSE	554.5							
2		4.0	FILL - SILTY SAND WITH GRAVEL, occasional cobbles, dark brown to brown	551							
3		7.5	SANDY SILT (ML), with fine sand, light brown to orange-brown	547.5	5						
			Bucket Refusal on Probable Bedrock at 7.5 Feet								

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.

Elevation Reference: Elevations were interpolated from a topographic site plan.

Notes

Water Level Observations
No free water observed

Advancement Method
Rock Bucket

Abandonment Method
Test pits backfilled with soil cuttings upon completion.
Sealed with hot-mix asphalt at surface.

Excavator
Mini-excavator

Operator
GeoSearch

Logged by
J. Jurnack

Test Pit Started
06-25-2024

Test Pit Completed
06-25-2024

Test Pit Log No. TP-2

Location: See Exploration Plan

Latitude: 42.2949° Longitude: -71.7750°

Model Layer	Graphic Log	Depth (Ft.)	Description	Elevation: 555 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)	Percent Fines
1	■	0.3	4-INCH BITUMINOUS CONCRETE	554.7							
		0.4	1-INCH AGGREGATE BASE COURSE	554.59							
2	▩	1.0	FILL - SILTY SAND WITH GRAVEL, occasional to frequent cobbles, brown to dark brown	554							
4	▨	2.5	WEATHERED BEDROCK, foliated, gray	552.5							

Bucket Refusal on Probable Bedrock at 2.5 Feet

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.

Elevation Reference: Elevations were interpolated from a topographic site plan.

Notes

Water Level Observations
No free water observed

Advancement Method
Rock Bucket

Abandonment Method
Test pits backfilled with soil cuttings upon completion.
Sealed with hot-mix asphalt at surface.

Excavator
Mini-excavator

Operator
GeoSearch

Logged by
J. Jurnack

Test Pit Started
06-25-2024

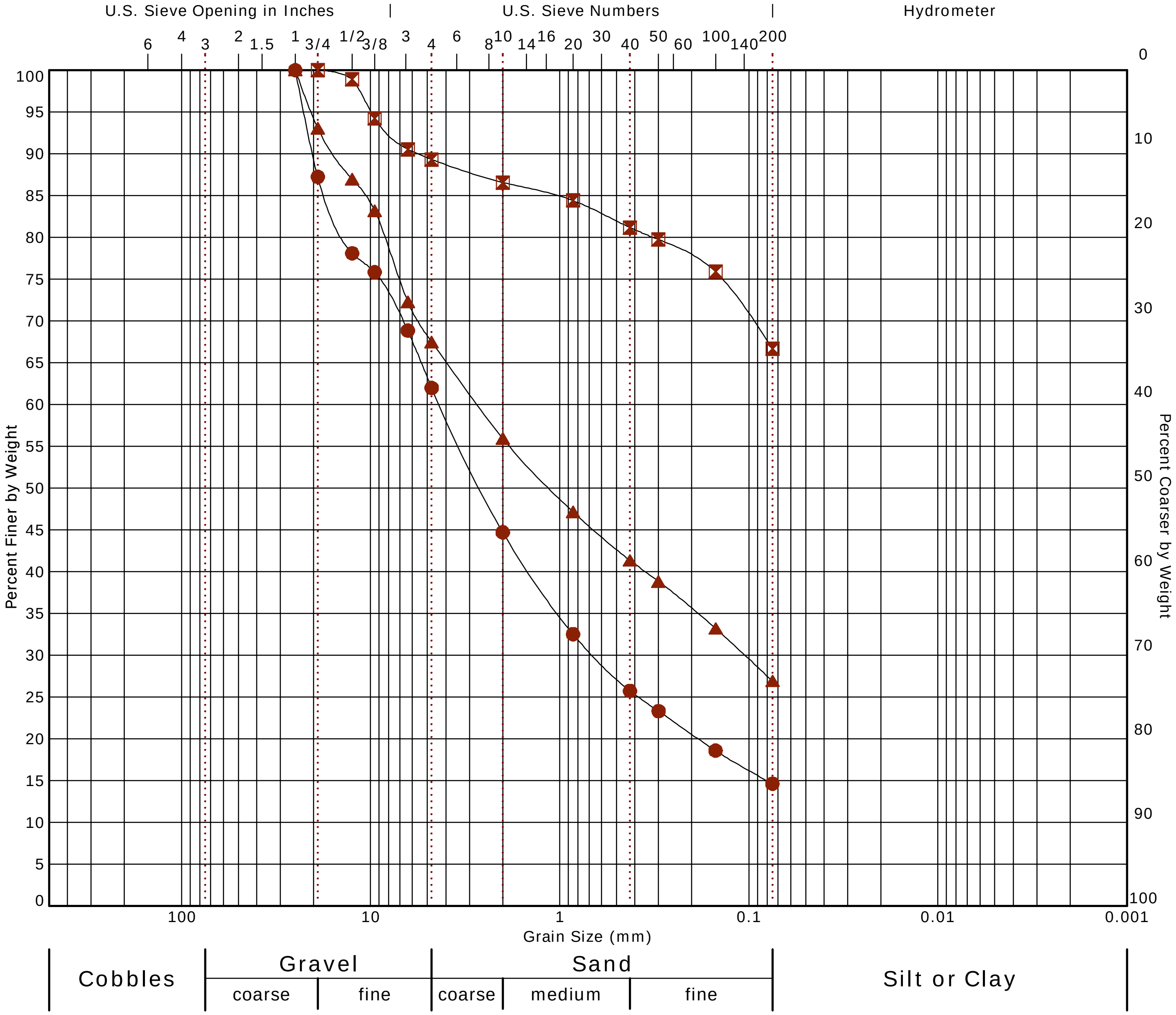
Test Pit Completed
06-25-2024

Raising Cane's - C1233 Worcester, MA
494 Lincoln Street | Worcester, Massachusetts
Terracon Project No. J2245040

Terracon
201 Hammer Mill Rd, Ste B
Rocky Hill, CT

Grain Size Distribution

ASTM D422 / ASTM C136 / AASHTO T27



	Boring ID	Depth	% Cobbles	% Gravel	% Sand	% Fines	% Silt	% Clay	USCS
●	B-1	2.5 - 4.5	0.0	38.0	47.4	14.6			SM
☒	B-2	0.5 - 2.5	0.0	10.7	22.6	66.7			ML
▲	B-3	0 - 2	0.0	32.5	40.6	26.9			SM

	Description
●	Silty Sand with gravel
☒	Sandy Silt with gravel
▲	Silty Sand with gravel

	Remarks
●	
☒	
▲	

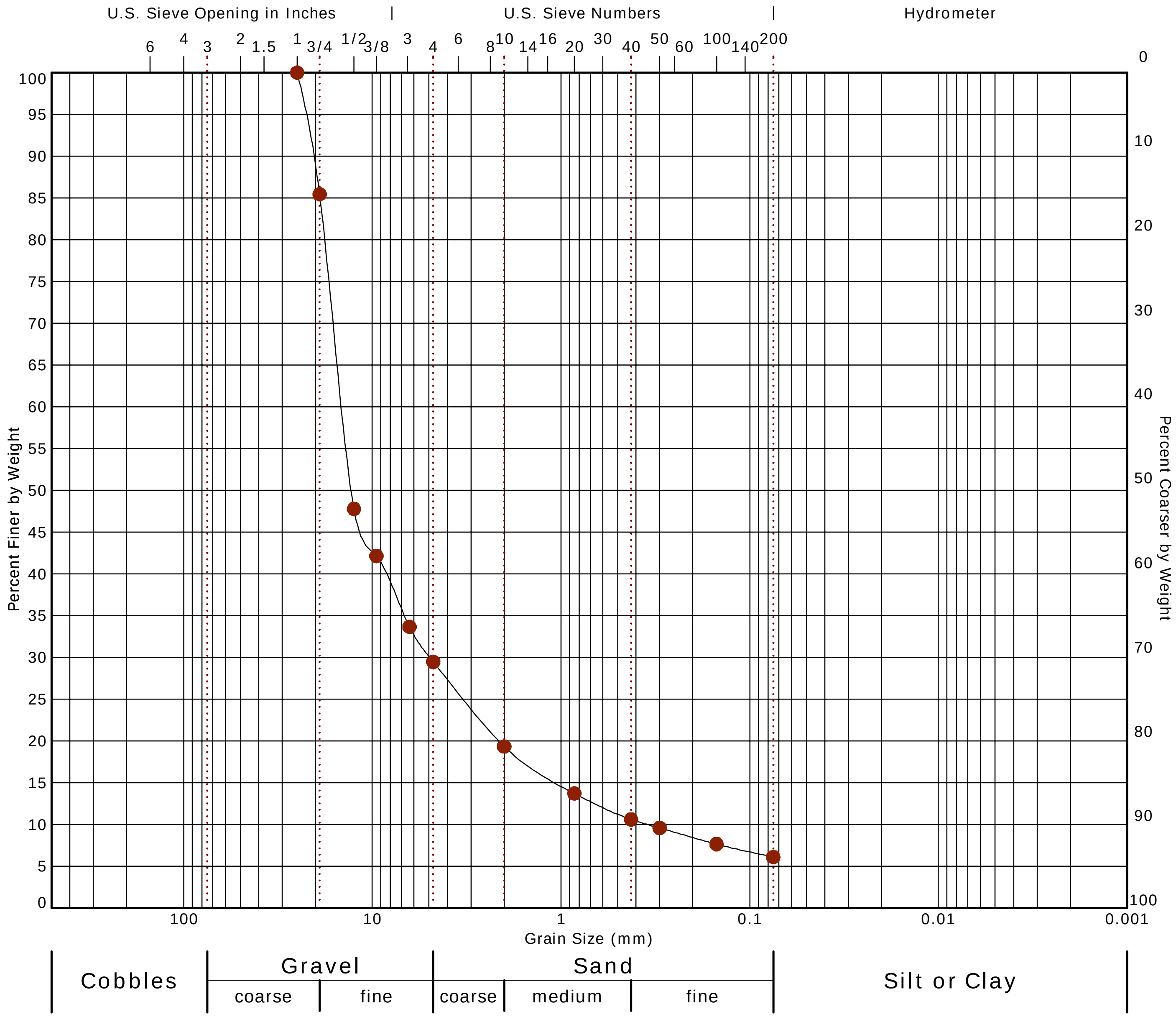
●		☒		▲	
Sieve	% Finer	Sieve	% Finer	Sieve	% Finer
1"	100.0	3/4"	100.0	1"	100.0
3/4"	87.23	1/2"	98.93	3/4"	93.06
1/2"	78.09	3/8"	94.26	1/2"	86.97
3/8"	75.81	1/4"	90.54	3/8"	83.18
1/4"	68.84	#4	89.32	1/4"	72.29
#4	61.98	#10	86.57	#4	67.49
#10	44.7	#20	84.4	#10	55.91
#20	32.51	#40	81.18	#20	47.16
#40	25.73	#50	79.73	#40	41.35
#50	23.31	#100	75.88	#50	38.84
#100	18.58	#200	66.68	#100	33.2
#200	14.63			#200	26.92

Grain Size			
	●	☒	▲
D_{60}	4.302		2.714
D_{10}			

Coefficients			
	●	☒	▲
C_C			
C_U			

Grain Size Distribution

ASTM D422 / ASTM C136 / AASHTO T27



	Boring ID	Depth	% Cobbles	% Gravel	% Sand	% Fines	% Silt	% Clay	USCS
●	B-5	5 - 7	0.0	70.5	23.4	6.1			GP-GM

	Description
●	Poorly Graded Gravel with silt and sand

	Remarks
●	

●					
Sieve	% Finer	Sieve	% Finer	Sieve	% Finer
1"	100.0				
3/4"	85.44				
1/2"	47.77				
3/8"	42.15				
1/4"	33.65				
#4	29.46				
#10	19.33				
#20	13.71				
#40	10.6				
#50	9.58				
#100	7.65				
#200	6.1				

Grain Size			
	●		
D_{60}	14.32		
D_{10}	0.347		

Coefficients			
	●		
C_C	4.90		
C_U	41.32		

Supporting Information

Contents:

Note: All attachments are one page unless noted above.

Terracon
201 Hammer Mill Rd, Ste B
Rocky Hill, CT

General Notes

Sampling

☒ Standard Penetration Test

Water Level

▽	Water Initially Encountered
▽	Water Level After a Specified Period of Time
▼	Water Level After a Specified Period of Time
▨	Cave In Encountered

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.

Field Tests

N	Standard Penetration Test Resistance (Blows/Ft.)
(HP)	Hand Penetrometer
(T)	Torvane
(DCP)	Dynamic Cone Penetrometer
UC	Unconfined Compressive Strength
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer

Descriptive Soil Classification

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

Location And Elevation Notes

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. Surface elevation data annotated with +/- indicates that no actual 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		
Relative Density	Standard Penetration or N-Value (Blows/Ft.)	Consistency	Unconfined Compressive Strength Qu (tsf)	Standard Penetration or N-Value (Blows/Ft.)
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

Relevance of Exploration and Laboratory Test Results

Exploration/field results and/or laboratory test data contained within this document are intended for application to the project as described in this document. Use of such exploration/field results and/or laboratory test data should not be used independently of this document.

Unified Soil Classification System

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification	
				Group Symbol	Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	Gravels: More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels: Less than 5% fines [C]	Cu≥4 and 1≤Cc≤3 [E]	GW	Well-graded gravel [F]
			Cu<4 and/or [Cc<1 or Cc>3.0] [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 [Cc<1 or Cc>3.0] [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 above “A” line [J]	CL	Lean clay [K, L, M]
			PI < 4 or plots below “A” line [J]	ML	Silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	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:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	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] $Cu = D_{60}/D_{10} \qquad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

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

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

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

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

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

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

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

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

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

[O] PI < 4 or plots below “A” line.

[P] PI plots on or above “A” line.

[Q] PI plots below “A” line.